OPTIONAL FIRM ACCESS AEMO FINAL REPORT

FOR THE NATIONAL ELECTRICITY MARKET

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

IMPORTANT NOTICE

Purpose

AEMO has prepared this document to describe its activities and draft conclusions in response to a request from the Standing Council on Energy and Resources to undertake detailed design and testing of an optional firm access framework, as at the date of publication.

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EXECUTIVE SUMMARY

In February 2014, the Standing Council of Energy and Resources (SCER), now the COAG Energy Council, requested AEMO conduct, in collaboration with the Australian Energy Market Commission (AEMC), detailed design and testing of an Optional Firm Access (OFA) framework for the National Electricity Market (NEM) and report back in mid-2015.

AEMO's role is to study access settlement, being the payments within and between generators and interconnectors following network congestion to recognise pre-determined firm access rights. AEMO is also requested to prepare an implementation plan and draft rule for introducing access settlement ahead of other parts of the OFA framework, and to consider introducing it in some regions of the NEM but not others. The early introduction of access settlement is described as "stage one".

The AEMC is tasked with developing the broader OFA framework and economic analysis of the merits of its introduction. The AEMC is also tasked with recommending the optimal implementation plan.

The Terms of Reference (TOR) require collaboration between the AEMC and AEMO. Each organisation has actively assisted the other in meeting its tasks.

AEMO and AEMC each published a first interim report in July 2014. AEMO published a draft report in December 2015 and received five submissions. The AEMC published its draft report on 12 March 2015.

AEMO has considered in detail the integration of access settlement algebra into the existing NEM settlements, and developed a realistic model of access settlement operating directly on the NEM's existing data structures. Constructing this model revealed many intricate design matters, and AEMO and the AEMC collaborated to address these through design modifications. These modifications are listed in Appendix A.

Successful operation of the model on historical congestion events indicates the modified design can be practically implemented, and would operate consistently with the broad objectives of access settlement described in the Transmission Frameworks Review (TFR).

The TOR requested AEMO model likely market outcomes based on historical congestion events. This was achieved in a limited number of relatively simple events, and was useful for demonstrating the workings and practicalities of the design. Results are documented in this report.

The AEMC is assessing the economic merits of the overall reform, which will include an estimate of the economic impact over time of access settlement upon generator dispatch.

In reviewing historical events where congestion coincided with market volatility and inefficient dispatch, AEMO observed these events were primarily caused by market incentives outside the scope of access settlement to address.

Some of these incentives could be addressed by the full OFA reform, while others would require entirely different approaches. That finding suggests that the benefits of implementing stage one ahead of the rest of the OFA, or in the absence of other reforms, are small.

At the same time, it became evident that AEMO could not develop stage one entirely independently, as it would require mechanisms to allocate and trade rights, and those mechanisms are being designed by the AEMC.

AEMO presented a view in its draft report that the benefits of stage one will not exceed its costs, and, given the complexity in developing it independently of the full OFA, that it would not prepare a stage one rule change. This conclusion was supported by all submissions, including supporters of the broader reform. As a result, AEMO is able to report back to the Energy Council ahead of the target timeframe of mid 2015.

Access settlement is also a critical part of the full OFA, and AEMO intends to use the model and knowledge it has developed to assist the AEMC to complete their work under their terms of reference. While we do not propose to develop Rule changes at this stage, we will collaborate with the AEMC on the preparation of any Rules or drafting instructions relevant to AEMO's functions should the AEMC progress them.

The TOR from SCER also ask AEMO to consider any required changes to the settlement residue auction (SRA) arrangements as a result of the proposal to replace them with a firm interconnector right (FIR) procured via a short-term firm access auction (STFA). These new concepts are being developed by the AEMC. Our report describes a planned phase-out of the current arrangements should the OFA proposal be adopted.

AEMO has also prepared a list of information releases that it considers would be useful for participants affected by access settlement, which can be found in Appendix B.

AEMO has assisted the AEMC's estimate of the total industry costs by estimating its own cost to implement access settlement. A copy of this estimate is included in Appendix C and Appendix D.

Whilst all submissions to the draft report supported AEMO's role and conclusions, stakeholders also provided useful commentary on some areas of detail and made suggestions of further dispatch scenarios to study. This has been taken into account in preparing the final report. Otherwise, this report is mostly a repetition of the draft.

Despite AEMO's decision not to prepare draft rules for stage one, AEMO considers there remains opportunity to improve the efficiency of NEM dispatch. AEMO supports investigation towards capturing these efficiencies, through the full OFA or other reforms.

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1. INTRODUCTION

1.1 Background

In February 2014, the Standing Council of Energy and Resources (SCER) now the COAG Energy Council requested AEMO to conduct, in collaboration with the AEMC, analysis of the proposed Optional Firm Access (OFA) reform. AEMO's focus is the "access settlement" part of the reform, being the automatic settlement adjustments within and between generators and interconnectors that would occur following network congestion. This part of the total reform is most relevant to AEMO's market/system operator responsibilities and expertise.

While AEMO's electricity planning functions would also be affected by the proposed OFA regime, these are not covered in this report.

The bulk of the OFA development and economic analysis in the joint project is the responsibility of the Australian Energy Market Commission (AEMC). The two institutions have collaborated closely, and have jointly dealt with technical matters that have arisen. Nevertheless the SCER's Terms of Reference (TOR)[1] establishes a separate governance and reporting structure for each institution, so separate reports are prepared.

This report employs concepts and terminologies introduced in the Transmission Frameworks Review (TFR) Final Report and Technical Report: Optional Firm Access. Familiarity with these documents is assumed, and they are available on the AEMC website.[2] A glossary is included at the end of this report.

1.2 Objectives of this report

In this report, AEMO:

- Describes the scope of its investigation as guided by the TOR, and integration with the AEMC work.
- Describes its work and findings.
- Summarises its proposed findings.
- Responds to submissions to the draft report.
- Proposes a transition path for the Settlement Residue Auction (SRA).
- Provides a high-level cost estimate for the introduction of access settlement within AEMO.
- Provides some detailed scenario analysis of actual historical events had access settlement been applied to them.

1.3 Changes from the Draft Report

As all submissions agreed with AEMO's main observations and findings, this Final Report has much in common with the Draft published 23 December 2014. Nevertheless AEMO received stakeholder feedback on the draft, and made some further progress in its modelling work.

The most changes are contained in the following sections:

- Stakeholder Feedback.
- Further Activities.
- Access Settlement Implementation Costs.
- Access Settlement Modelling Runs.

[1] The TOR can be found at http://www.aemo.com.au/Electricity/Market-Operations/~/media/Files/Other/OFA/SCER%20Transmission%20Frameworks%20letter%20250214.pdf.ashx viewed 11 March 2015
[2] Source: http://www.aemc.gov.au/Markets-Reviews-Advice/Transmission-Frameworks-Review viewed 11 March 2015.

A changed-marked comparison of the Final and Draft Reports is available on request to OFAConsultation@aemo.com.au.

2. AEMO'S ROLE AND DIRECTION

2.1 The Terms of Reference

AEMO and the AEMC received separate, yet linked Terms of Reference (TOR) for this OFA project. While the work is highly interdependent, each institution has separate governance and reporting frameworks. The AEMC is managing most of the development, so both institutions must be clear on the scope of AEMO's work.

2.1.1 Access settlement

The TOR focuses AEMO on access settlement, requesting it to:

- Carry out modelling of likely market outcomes.
- Prepare a functional design consistent with the AEMC's recommendations on the most efficient option for staging implementation.
- Propose an implementation plan.

It became clear that AEMO cannot carry these activities out in isolation: access settlement must be integrated comprehensively with the parts of the OFA design being developed by the AEMC. During the project, both institutions have distributed their access settlement work as described below:

Table 1 Split of access settlement roles

AEMO	AEMC
• Consider in detail how to integrate access settlement into the existing National Electricity Market (NEM). • Build a detailed model of access settlement operating in a near-real environment. • Raise issues with the AEMC and collaborate towards their solutions through design variations. • Model historical congestion events to study whether the design creates the expected outcomes. • Estimate AEMO's costs to implement access settlement. • Collaborate with the AEMC towards developing implementation options.	• Consider AEMO's issues with respect to the objectives of the full reform. • Document agreed design variations to access settlement through working papers. • Facilitate stakeholder engagement on these variations through the Industry Working Group. • Integrate the final access settlement design into rules or prepare appropriate drafting instructions. • Estimate the total economic benefits of access settlement taking a view of AEMO's work and expert consultancies. • Propose and document implementation options of the entire reform, including access settlement and staging options.

AEMO does not intend to independently publish a functional design for access settlement. Instead, this will be incorporated into the AEMC's specification of the entire reform, through draft rules or drafting instructions. This will include design matters developed in conjunction with AEMO.

2.1.2 Settlement Residue Auction

The TOR makes several references to AEMO identifying changes to the settlement residue auction (SRA) and associated instruments. In the OFA reform, the SRA's role for inter-regional price management would be assumed by firm interconnector rights (FIR). FIRs are deeply integrated into the broader reform as a whole and part of the AEMC's scope of work.

AEMO therefore sees its TOR task as limited to recommending a transition path out of the current SRA arrangements, as described in Chapter 7.

2.1.3 Staging OFA implementation

The TOR requests AEMO investigate and develop two forms of staging:

- A "stage one" where access settlement is introduced before other parts of the reform.
- Geographic staging, where some jurisdictions implement OFA before others.

AEMO is to assess these staging options for changes in modelled benefits, specify a design, and prepare a rule change reflecting the AEMC's recommendation on the most efficient staging option.

Chapter 4 discusses AEMO's staging work. Like other parts of AEMO's work, staging recommendations were developed jointly with the AEMC.

2.2 AEMO activities outside TOR

The TOR also requires AEMO to support the AEMC in its wider scope of work. AEMO has provided technical assistance to the AEMC in:

- Providing network electrical data used as a basis for the pricing model.
- Providing historical constraint data to benchmark the network incentive scheme.
- Two example calculations of the transitional allocation logic.
- A high-level estimate of the access settlement implementation cost. This is also reported in Appendix A.

AEMO also participated in many of the AEMC's development discussions and their Industry Working Group. Staff from AEMO's OFA team routinely participated in discussions and provide advice regarding the practicality of many aspects of the broader OFA. These include the firm access planning standard (FAPS), the network incentive scheme, and auction design.

2.3 AEMO's OFA functions beyond access settlement

Should OFA be implemented, AEMO will have additional functions beyond access settlement. The AEMC will present their views on governance in their Draft Report. These functions are outside AEMO's TOR and are not discussed in this report. For this report, AEMO has assumed it will manage a registry function for access settlement and this has been included in the access settlement costing work.

In this report, AEMO has not analysed operation of the proposed new auctions, being the short-term firm access (STFA) auction and the inter-regional firm access auction.

As Victorian planning TNSP, AEMO would also be affected by the OFA. TNSP implementation costs are being surveyed by the AEMC, including those in Victoria.

2.4 AEMO's direction

AEMO has substantially contributed to the joint efforts to research, develop, and specify the reform. Access settlement is a critical part of OFA, and AEMO considers access settlement would function as intended.

The TOR requested AEMO champion an early introduction of access settlement, introducing it ahead of other parts of the reform, either nationally or regionally. This was motivated by an expectation that access settlement alone, by pricing marginal generation locally, might achieve relatively low cost gains through more efficient dispatch.

Chapter 4 covers AEMO's staging considerations and finds that:

- Access settlement could not be introduced entirely independently: it requires several other key parts of the OFA package being developed by the AEMC, such as the initial allocation of rights and a secondary auction process.
- A review of recent events of inefficient dispatch suggests the majority could not be resolved by local marginal pricing, settled on thirty minute intervals.

The conclusion AEMO draws from those findings is that:

- AEMO specifying a "stage one" independently of the AEMC is impractical.
- As the benefits are unclear, a rule change to implement access settlement alone is unlikely to meet the rule-making test which is based on the national electricity objective.

For these reasons, AEMO has not prepared a rule change to introduce access settlement early. This view is supported in all submissions AEMO has received. The institutions agree that a functional description and rules for access settlement are best integrated into the work on the whole package. AEMO will assist the AEMC in that work as required.

AEMO was therefore able to conclude its independent work program under the TOR and report back to the COAG Energy Council earlier than previously anticipated..

AEMO will continue to support the AEMC in relation to its further development of access settlement through to the end of its program. While AEMO considers that access settlement can be implemented and would operate consistently with its objectives as expressed in the TFR, any continued AEMC work would benefit from:

- Operation of AEMO's detailed access settlement model on historical events.
- Further study of access settlement logic in various market pricing conditions.
- AEMO's technical input into related parts of the reform.

AEMO continues to support the OFA objectives expressed in the TFR of more efficient integration of transmission and generation in the NEM and an ability for participants to manage congestion risk, but notes that analysis of the merits of OFA as a whole is outside its role.

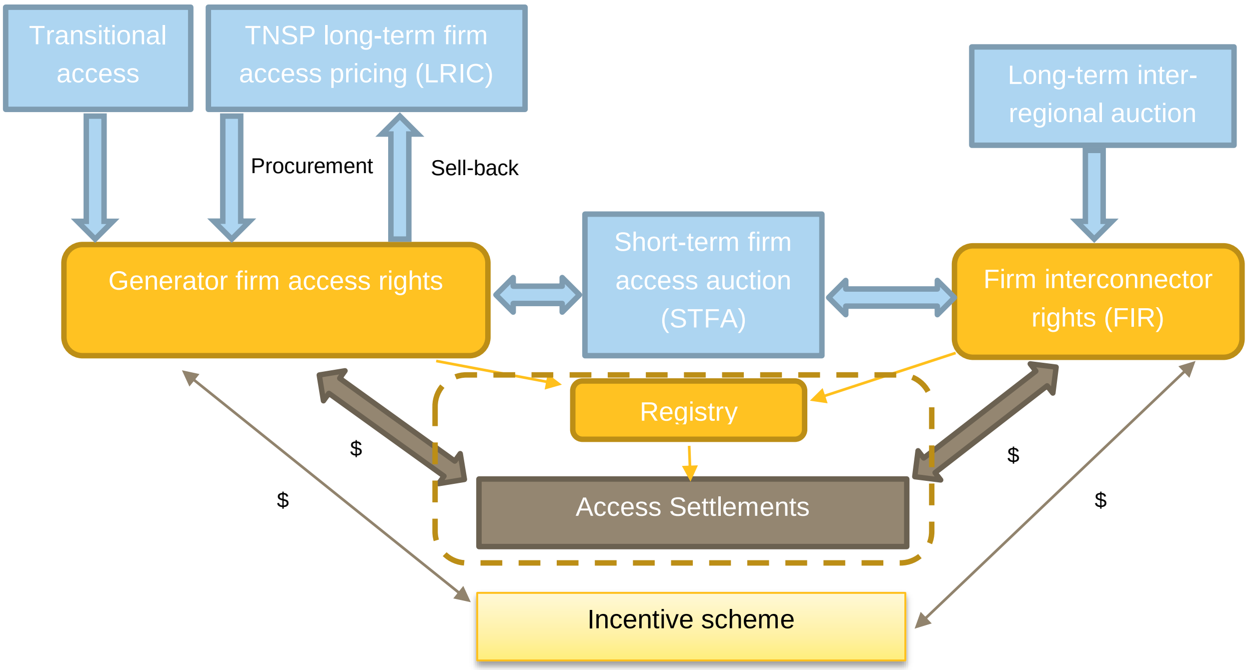
Although AEMO has decided not to progress a "stage one", it maintains the view it expressed in the TFR that the NEM design has shortcomings:

- Market incentives to bid away from cost during congestion leads to dispatch inefficiency, market risks, and negative inter-regional residues.
- Inter-regional competition is harmed by the lack of firmness of the SRA instrument.

AEMO supports research into reforms that can efficiently address these concerns.

3. ACCESS SETTLEMENT DESIGN

Figure 1 Access settlement in the context of broader reform



AEMO's work, and this report, has focussed on the activities in the dotted box above. Access settlement is only one critical part of the broader OFA design, comprising many parts that are heavily interdependent. It is therefore essential that AEMO's and AEMC's work on OFA are considered and progressed together.

As custodian of the broader reform, the AEMC is closest to the economic objectives behind OFA. AEMO's work involved taking the TFR design and considering its application in a realistic NEM environment. In doing this, AEMO identified areas for further refinement, which were progressed collaboratively with the AEMC.

Rather than AEMO documenting the access settlement evolution separately, it was agreed that the AEMC would specify the entire OFA design.

Appendix A describes the key variations from the TFR description of access settlement as AEMO understands them. AEMO and the AEMC have collaborated on these. Ultimately these variations will be specified as part of the AEMC's full design, and there are likely to be further adjustments made to access settlement until the end of their project.

4. IMPLEMENTATION STAGING

4.1 What is staging?

The TOR emphasises a desire for AEMO to investigate staged forms of OFA, where access settlement is introduced before other parts of the reform, either nationally or regionally. AEMO expects this would involve it building new generator settlement arrangements, but not imposing any changes on TNSPs or their regulation.

The TOR describes "stage one" as:

> "…a first stage of the OFA framework where access had been allocated but there was no capacity for participants to purchase additional access."

This implies that generators would receive some static levels of access, presumably consistent with the capacity of the network. The TOR also describes a partial geographic implementation of stage one, where some regions are access settled while others remain regionally settled.

4.2 Why staging was proposed

A major concern raised during the TFR was "disorderly bidding" during congestion leading to:

- Inefficient dispatch outcomes.
- Volatile spot price outcomes (positive and negative) inconsistent with marginal costs.
- Sudden changes in energy flows having to be managed in the power system.
- Reduced and reversed flows on interconnectors, reducing the firmness of the SRA instrument and creating negative residues.

These concerns were raised by AEMO, amongst others. The TFR presumed that regional pricing was the major driver for this bidding, because generators attempted to maximise output when constrained off by offering at the price floor or using some other bid parameter to maximise volume.

One attraction of the OFA reform is that access settlement results in all constrained-off scheduled and semi-scheduled generators' marginal output being priced locally, i.e., upstream of the congestion. This could address the incentive to maximise output during congestion.

The TFR concluded that dispatch efficiency benefits were a relatively minor part of OFA's benefits. However access settlement was also seen to be a relatively simple part of the reform which, if introduced separately, would not have to wait for TNSPs to introduce new arrangements. Therefore it was anticipated that an early introduction of access settlement could deliver some early benefits.

4.3 Stage one

The TOR does not clarify stage one beyond the description above so AEMO has attempted to define it further in the discussion below. The TFR's access settlement design assumes firm access levels would be a fixed input determined through other processes, which may not exist in stage one.

4.3.1 Shared Access Congestion Pricing

The shared access congestion pricing (SACP) model incorporates the allocation of firm access within the access settlement itself by allocating rights on the basis of offered availability. The TFR considered and rejected the model as it did not create a framework for the long-term network planning benefits of OFA; and while it may have had dispatch efficiency benefits, it did not provide access stability for generators.

Nevertheless, the SACP does not require any pre-allocation of access nor changes to TNSP arrangements, so it could potentially have been presented as a practical form of stage one. AEMO considered but rejected this as:

- It had no stakeholder support, particularly from generators, who shared the TFR concern about access stability.
- It was inconsistent with AEMO's TOR wording that implies stage one access is to be pre-allocated.

- There remain some key design questions to be resolved in the SACP model, for example the allocation of real-time access to interconnectors. These questions are not relevant to the OFA's access settlement design, so work on these matters would be a diversion from the long-term design.

For these reasons AEMO directed its efforts towards specifying a stage one fully consistent with the final access settlement design, i.e., one that would require no alterations to the settlement algebra upon adoption of the full OFA. SACP is does not meet that criterion.

4.3.2 Stage one requirements

A non-SACP stage one access settlement will need a process to allocate access. At a minimum, this will require the AEMC to develop a transitional allocation process. It will also require:

- A means to reallocate the access to those generators and inter-regional traders who value it most highly.
- Depending on the length of time for which stage one applies, a means to periodically re-calculate transitional access volumes taking into account changes in the network and generator fleet.

Section 10.4.2 of the AEMC First Interim Report[3] describes the first stage of a temporal staging option, which incorporates, as a minimum:

- Access settlement.
- A one-off transitional allocation.
- Secondary trading of access.

The report recommended against re-calculating transitional allocation in order to improve certainty, but noted it may be necessary if stage one was in place for some time.

The appropriate platform for secondary trading of access would be the short-term firm access (STFA) auction, which is an ongoing part of the full OFA design.

4.3.3 TOR implications

AEMO's TOR seeks a detailed functional design and draft rule change proposal to implement stage one, reflecting AEMC's recommendation on the most efficient option for staging implementation. However, many of the key features and decisions are not part of AEMO's role. The following are part of the AEMC's TOR:

- Transitional allocation.
- The STFA auction.
- The preferred implementation timeframe for the full OFA, which affects the need for recalculating transitional allocation.

For this reason, a design and rule change for stage one cannot be prepared prior to the AEMC completing its work on the above matters. This is not expected until its final OFA report, scheduled for mid-2015.

4.4 Geographic staging

AEMO's TOR also asks:

> (In the context of access settlement) "Consider what adjustments might need to be made to the candidate design to allow implementation in some jurisdictions or regions initially and for others to opt in later – e.g. specific changes to the SRA or to the allocation of rights to interconnectors."

Geographic staging of Tasmania versus the mainland is straightforward. This is because:

- Victoria and Tasmania are connected by a single direct-current link, meaning that network constraints do not have cross-boundary terms.
- Basslink is a market network service provider (MNSP), meaning that there are no Victoria–Tasmania SRA or FIR units.

[3] Source: www.aemc.gov.au/getattachment/1f15553d-e513-4d9a-9b96-f9549b9ae589/First-Interim-Report.aspx. Viewed 17 December 2014.

Should access settlement in Tasmania be delayed, geographic staging can be achieved by exempting Tasmania from the new access settlement rules, and retaining for Tasmania the existing trading amount rule 3.15.6.

With respect to staggered implementation within the mainland, the AEMC First Interim Report Section 10.5 concluded against geographic staging:

> "...the Commission considers that, upon initial review, such a means of implementing OFA looks to have many challenges and downsides."

Stakeholder feedback to the AEMC supported that view. In recognition of these views, AEMO's investigation of geographic staging of access settlement was limited to a theoretical and qualitative consideration.

Geographic staging of access settlement between mainland regions is feasible but raises some technical challenges with respect to constraint formulation:

- Some constraints exist with both Victorian and New South Wales generator terms which creates challenges if these regions were to introduce access settlements at different times. Applying access settlement adjustments to only some terms in a constraint equation is problematic; it requires specific arrangements for these constraints and creates unpredictable incentives on generators. It may be better to address these unusual constraints by reformulating the constraints to be fully on one side or other of the boundary, with generators in the remote region described only through the interconnector term. However, this would be a less accurate representation of the network.
- Stability constraints that include each of a Victorian–South Australian, Victorian–New South Wales and a Queensland–New South Wales interconnector term may similarly require reformulation, depending on the choice of regions included at the initial stage and the orientation of those terms.

Given the need to reformulate some constraints, geographic staging is the only implementation pathway that potentially requires AEMO to adjust the way it actually dispatches the market, as well as settling the market.

Mainland geographic staging also requires the SRA and FIR arrangements to be modified depending on the regions included. These have been discussed in Chapter 7.

5. ASSESSING ACCESS SETTLEMENT

5.1 Approach

AEMO's TOR asks AEMO to:

- Ensure practicability of the AEMC's design for access settlement.
- Develop modelling techniques to estimate the likely benefits of a stage one, and test market outcomes that would have occurred for a past period of time, had access settlement been in place during that period.

AEMO reads the reference to stage one above as relating to access settlement in general, whether dispatch benefits would arise due to access settlement incentives in whatever implementation pathway chosen.

The key value that AEMO can add to the project is in answering the practicability question. This is because AEMO would ultimately implement access settlement, and has the skills and tools to consider how the algebra could be applied to the existing NEM arrangements. AEMO has therefore targeted its efforts towards preparing as realistic a model as possible and then applying it to real historical congestion events.

This approach was unanimously supported in stakeholder feedback to the First Interim and Draft Reports. While this "proof of concept" philosophy can be used to postulate some changed behaviours from discrete historical events, it is not a useful approach to assessing economic benefits over time. Assessment of overall economic benefits will require an econometric modelling approach, using a bid simulator responding to the incentives of a simplified representation of access settlement. AEMO's normal functions do not use these skills and tools.

To that end, the AEMC has engaged consultants to assess the benefits of OFA, including the dispatch efficiency gains from access settlement.

AEMO's assessment focus relates to the practicality question, with some historical events used as a basis for understanding the detailed transactions. Simply constructing a modelling environment has already provided insights into practicality, and informed many of the modifications outlined in Appendix A.

5.2 Simulation tools

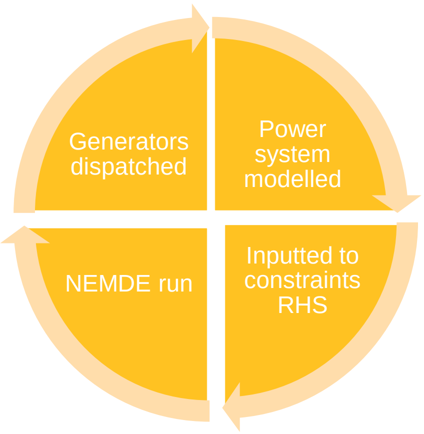


Figure 2 Closed loop simulation

Network constraint equations in the real NEM dispatch engine (NEMDE) are limited by right-hand-side (RHS) terms that receive input data measured from the real power system. These inputs themselves are affected by generator response to the previous five-minute NEMDE run results. A simulation of the power system itself is required to get an accurate representation of these inputs. However standard dispatch models such as the NEMDE Queue assume a static network condition.

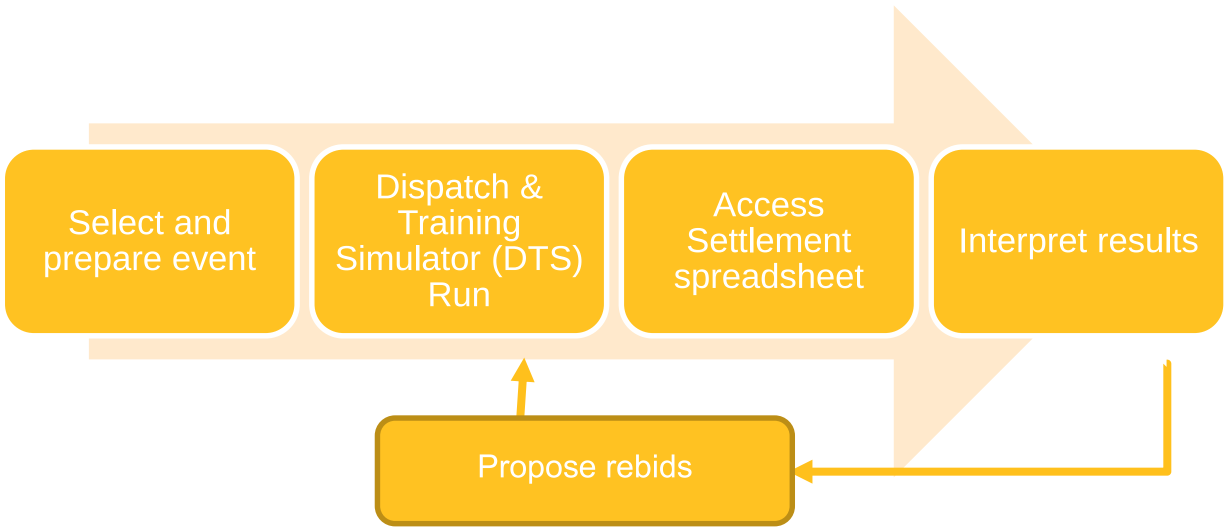
To simulate changes to dispatch resulting from access settlement incentives, it was beneficial to include the full power system feedback via the closed loop approach shown in Figure 2. AEMO has an integrated power system and NEMDE simulation in its Dispatch and Training Simulator (DTS).[4]

The DTS outputs have the same form as those produced by the real Market Management System (MMS). These outputs are fed into an Excel-based simulation of access settlement as shown in Figure 3. This spreadsheet is very complex, requiring numerous translations of MMS data into a form that access settlement can operate upon. Particular challenges included:

- Identification of binding constraints as flowgate constraints from their naming convention.
- Correct representation of loss factors.
- Entitlement scaling between firm, non-firm, and directional interconnector entitlements.
- Conversion of availability figures from “as generated” into a “sent-out” basis.
- Scaling flowgate prices in order to floor local prices at the market floor prices.
- Identification of the correct directional interconnector within a flowgate from the information contained within a network constraint equation.

The challenges in constructing this spreadsheet have provided useful learnings towards construction of an operational access settlement system. As these issues were ultimately addressed, at this time the design appears capable of implementation.

Figure 3 General modelling approach



[4] The DTS is a very detailed tool developed by AEMO for the purposes of training its system controllers and to study the power system and market impacts of hypothetical actions. It provides an energy management system (EMS) and MMS operating environment that is essentially the same as production with the exception that the EMS is linked to a simulated power system instead of the real system.

5.3 Historical event selection

AEMO reviewed historical events to identify cases that would demonstrate the workings of access settlement. The period of review was limited by the DTS' 13-month archive.

The historical review sought events where generators bidding away from costs coincided with network congestion. While there were numerous examples, very few were straightforward. All the high spot price cases were greatly complicated by market design issues outside of the scope of access settlement to address, such as:

- The five-minute dispatch/30-minute settlement arrangement that creates anomalous bidding incentives late in a high-priced half-hour.
- Last-minute rebids to high price bands in order to set a high regional price ahead of competitive response.
- Withdrawal of constrained-on generation.
- Operation of non-scheduled generation.

In order to minimise the impact of these other issues on the access settlement calculation results, AEMO filtered the selected events down to those that were reasonably stable across a half-hour. These were only found to occur in relatively low regional price conditions, below $100 per megawatt-hour (MWh).

As the market conditions in the selected cases were relatively benign, the changes to individual generator margins, and ultimately dispatch efficiencies, were also relatively small. They do, however, present good bases to demonstrate a proof-of-concept for access settlement and to introduce readers to how the calculations work in practice. Three historical half-hours are presented in detail in Appendix E.

AEMO will continue modelling progressively more complex scenarios where it has value to the AEMC's research into the full OFA design.

6. BENEFITS

6.1 Identifying dispatch efficiency benefits in access settlements

An incentive to “disorderly bid” below cost during congestion is a well-known issue driving some inefficiency and risk in the NEM. The incentive is discussed in detail section 11.5 to 11.9 of the AEMC’s Technical Report: Optional Firm Access.[5] A simple example is provided below:

> *Consider a semi-scheduled windfarm and a high fuel-cost open-cycle gas turbine (OCGT) sharing a transmission line with the capacity to evacuate either but not both. Assume the windfarm is initially operating, but as the regional price is low, the OCGT remains shutdown. Then, when the regional price becomes high, the OCGT will be constrained off, because the OCGT’s offer is higher than the windfarm’s. Under current arrangements, the OCGT will re-bid down to the market floor price, reversing the dispatch. The windfarm then retaliates, with dispatch ultimately being shared between the two generators according to tie-breaking rules.*
>
> *Access settlements will effectively create a price up and downstream of the congestion. Each generator will receive a share of the congestion rent - the difference between the two prices - according to their access rights. Marginal changes in output are effectively priced at the upstream price, which removes the incentive to offer below true costs. If the rights are allocated equally, each will earn the profits of the disorderly bidding case plus a share in the dispatch efficiency gain*.

Dispatch efficiency gains from access settlement occur from what might be described as a “nodal pricing incentive”, in that generators’ marginal changes in output are locally priced rather than regionally priced. Gains are expected when:

- Multiple generating units and interconnectors are constrained off from a regional price.
- Power stations respond individually to the settlement prices faced, i.e., not operating as a portfolio.

Where generators and interconnectors are located around loops, potential efficiency gains are larger due to different coefficients in a constraint equation. For example, it is possible for a generator to constrain off a competing interconnector by a factor of fifteen to one by increasing its own dispatch. This underutilises the network’s capacity, paradoxically increasing the regional spot price. AEMO’s analysis shows that in some situations, access settlement incentives are likely to lead to improved incentives and more efficient dispatch outcomes.

However, the access settlement design neither addresses nor is intended to address all the drivers for dispatch inefficiency that are commonly observed. Examples of all the themes described below can readily be found in the AER’s and AEMO’s standard event reports.[6]

Flowgate support

Where a generating unit is constrained-on, i.e., dispatched at a regional price below its offer price, there is an incentive to re-bid above cost, or more frequently, withdraw the capacity entirely from the market. Withdrawal of constrained-on generation has a similarly detrimental effect on dispatch efficiency as the re-bidding of constrained-off generation. The access settlement design describes this as a “flowgate support generation” and deliberately chooses not to provide a local price incentive. Instead, OFA incentives for TNSPs are expected to encourage them to directly engage with such generators to increase total network capability.

Five-30 re-bids

Where dispatch interval prices are high early in a half-hour, there is an incentive for all generators to re-bid below cost in order to maximise energy output over the half-hour. This is frequently observed as a market outcome where the first one or two dispatch interval prices are very high, followed by low and even negative prices. The settlement

[5] Available at: http://www.aemc.gov.au/getattachment/7e308487-d5d8-4170-a277-3d69c3069d12/Transmission-Frameworks-Review-Technical-Report-Op.aspx. Viewed 9 December 2014.

[6] See http://www.aemo.com.au/Electricity/Resources/Reports-and-Documents/Pricing-Event-Reports and http://www.aer.gov.au/taxonomy/term/310 and http://www.aer.gov.au/publications?date%5Bvalue%5D%5Byear%5D=&sector=All&category=324. Viewed 11 December 2014.

price, which is the average of the six dispatch interval prices, remains high. Major changes in merit order, including swings and even reversals of interconnector flows, are common.

- Many examples of this behaviour are observed in cases of no intra-regional congestion, i.e., each generator is reacting purely to its regional price. In these cases access settlement would not change any generators' revenues nor behaviours.
- In other examples intra-regional congestion is present and access settlement would change revenues and incentives depending on the circumstances of the event. However, there is no evident reason to expect that, on average, dispatch inefficiencies caused by the five-30 anomaly would be lessened or increased in the presence of access settlement.

Last-minute re-bids

It is common for high prices to appear when volumes of capacity are re-bid with immediate effect for the remainder of the current trading interval. Because these re-bids occur with immediate effect, they are not forecast and available competitive response is limited. The effect is usually observed as unexpectedly high dispatch prices in the last one or two dispatch intervals of a trading interval, because 30-minute settlement attenuates the loss of volume experienced by the rebidding generator.

Portfolio bidding

The Queensland and New South Wales transmission topology connects most generators via loops to the regional reference node. The most critical network constraint equations include the majority of generation in the region and interconnectors, with constraint coefficients differing by a ratio of up to 15. Access settlement creates a local price for generation, which should drive efficient offers assuming the power station responds independently.

In practice companies with a generation portfolio would be expected to price their generation in order to maximise returns across that portfolio, taking into account the gearing effect of these coefficients. Typically a generator with a small coefficient is offered in such a way as to create a high output which requires a proportionally greater reduction in dispatch from competitors, thereby raising the regional price.

Access settlement would penalise this behaviour to some extent, as the re-bidding power station would be exposed to the market floor price; however, the resulting higher revenues achieved at other parts of the portfolio will offset this penalty. As the absolute values of the market price cap and floor have a relative ratio of 13 to one, AEMO concludes the access settlement penalty would not materially inhibit the behaviour.

Non-scheduled generation

Access settlement only applies to scheduled and semi-scheduled generators and interconnectors. The NEM has 3,000 MW of non-scheduled generation which equally contribute to congestion but, under access settlement, will continue to receive what is effectively priority access to the regional reference node.

Congestion in the lower voltage transmission loops of South-East South Australia and Western Victoria are commonly impacted by non-scheduled generation. Access settlement would provide some benefit, in that scheduled and semi-scheduled generation offers on those loops would be more likely to be reflective of costs. However, the non-scheduled generation would have no incentive to change behaviour, and may represent a greater total generation volume.

Table 2 Dispatch scenario and effect of access settlement

Dispatch scenario	Significance in reviewed events for modelling	Expected effect of access settlement on behaviour	Other potential reforms that could address
Single station congestion	Occurs frequently but usually at times of low price	No change – existing dispatch efficient	Not required
Multiple station/interconnector congestion with: • **Independent stations** • **Congestion stable across dispatch intervals**	Infrequent events at times of low cost	Addressed	
Flowgate support generator withdrawal	Moderately common events often at times of high price	No change	Full OFA (Flowgate support agreements)
Five-30 rebidding	Frequent events. Always occurs at times of high price.	Varies by circumstance, no change on average	Five minute settlement
Last-minute re-bids	Frequent events. Usually during high prices.	No change	Behavioural rules
Portfolio bidding around congested loops	Frequent events. Usually during high prices.	Small beneficial impact	Behavioural rules
Congestion aggravated by non-scheduled generation	Frequent events at times of low and high price.	No change to non-scheduled generators	Registration rules

6.2 Stage one benefits

AEMO is required to assess the benefits of introducing access settlement as a standalone reform. To do this, as discussed in Section 5.3, AEMO reviewed recent events where improved efficiency could be expected. AEMO identified a small number of events where the analysis in Appendix E shows the model does function as intended, and appears to create the expected improved incentives towards efficient dispatch.

However these events were rare, dispatch was only mildly inefficient prior to access settlement being applied to them, and there was no material evidence of regional pricing inconsistent with marginal cost. At the same time there were many events of much greater significance, but each was entirely or largely the result of issues listed in section 6.1. For those issues, AEMO considers that access settlement would either:

- Not change the behaviour and outcome.
- Alter the behaviour, but it could not be predicted that the outcomes would be more or less efficient.

It would be neither practical nor insightful to model these events in the presence of access settlement due to the complex matters beyond flowgate congestion that drove the behaviour.

For this reason, AEMO has concluded that the introduction of access settlement, alone, is not the best way to address the majority of inefficient dispatch outcomes being observed at present. Table 2 indicates other potential reforms that could address those behaviours. AEMO considers, on the basis of recent market history, that there are insufficient clear benefits to justify the cost of implementing stage one on a standalone basis in the current market framework.

It is important to note this conclusion is not relevant to the benefits of the full OFA, which go beyond dispatch efficiency. The conclusion may also not hold if the other potential reforms are introduced.

7. SETTLEMENT RESIDUE AUCTION

7.1 Background

AEMO's TOR requires it to consider "changes to other National Electricity Market (NEM) arrangements such as the settlements residue auction (SRA) and associated instruments".

The SRA allows auction participants to purchase units of the financial surplus associated with the settlement of energy transfers over interconnectors: the inter-regional settlement residue (IRSR). These units can be useful for participants to manage inter-regional price risk. Guides to the SRA[7] and associated instruments are available on AEMO's website.

The potential OFA reform changes market settlements and does not create IRSR in the same manner. OFA includes a firm interconnector right (FIR) intended to assist participants manage inter-regional price risk via:

- Short-term FIRs, to be released a few years in advance from existing network capacity. These are issued, together with generator firm access rights, at the short-term firm access (STFA) auction. The STFA auction design is part of the AEMC's TOR.
- Long-term FIRs, issued through a long-term inter-regional firm access auction that triggers physical network augmentation by the transmission network service provider (TNSP). This is also part of AEMC's TOR.

7.2 Scope

Since OFA largely eliminates IRSR, and management of inter-regional price risk is intended to occur through the new FIR, it is clear there would not be a role for the SRA and associated instruments following a NEM-wide OFA roll-out. Therefore, AEMO interprets its task as proposing a pathway to retire the existing SRA arrangements which is the topic of this chapter.

An SRA retirement plan depends on a yet-to-be-determined approach to implementing OFA, discussed in Section 7.5. AEMO's TOR also requires it to contemplate geographical staging, where OFA is introduced in some regions but not others. This chapter briefly considers the implications of a geographically staged approach for SRA abolition.

This Chapter does not cover the design of the STFA or the long-term inter-regional auction, which are being developed by the AEMC.

For completeness, this investigation also explored a number of related market design matters, including:

- The distribution of remaining positive IRSRs that can continue to accumulate after access settlement, albeit at a much smaller value than presently.
- The recovery of negative IRSRs that can still occur in unusual conditions.
- AEMO's negative IRSR management procedure.

AEMO has consulted with the AEMC on these matters, and understands they will be addressed in the AEMC's next report. These issues are also briefly discussed in Section 7.7.

7.3 Existing SRA arrangements

7.3.1 Governance

Clause 3.18 of the National Electricity Rules (NER) sets out SRA concepts, eligibility, and distribution of proceeds and fees. It requires AEMO to convene a settlement residue committee (SRC) with specified powers, and to develop auction rules.

The auction rules define the auction procedure, timetable, bidding, fees, and the contractual instrument between AEMO and the successful bidder. Any AEMO amendments to the auction rules must be approved by the SRC.

[7] Available at http://www.aemo.com.au/Electricity/Market-Operations/Settlement-Residue-Auction. Viewed 17 December 2014.

The SRC is chaired by AEMO, and includes representatives of market participants, TNSPs, jurisdictions, and retail customers.

AEMO considers that SRA governance operates smoothly, and has successfully managed a number of significant events, including:

- Participant default events, followed by the re-auctioning of units held by these participants.
- The SRA impacts of a trial of the constraint support pricing/constraint support contracting (CSP/CSC) mechanism at the Tumut node, which diverted some inter-regional residue.
- Abolishing the Snowy region.
- Extending the auction from one to three years forward vintage.
- Changes to unit pool sizes.

7.3.2 Issue of units

Units are defined in quarters and on six directional[8] notional[9] interconnectors. Auctions are held quarterly, and progressively release units with vintages up to three years into the future. For example, see Figure 4 describing the release of units in the 17 June 2014 auction.

Figure 4 Auction conducted on 17 June 2014

QUARTER	TRANCHE OFFERED THIS AUCTION	PORTION OFFERED THIS AUCTION *	PORTION AUCTIONED TO DATE
2014 Quarter 3	Tranche 12 of 12	8.33%	100.00%
2014 Quarter 4	Tranche 11 of 12	8.33%	91.67%
2015 Quarter 1	Tranche 10 of 12	8.33%	83.33%
2015 Quarter 2	Tranche 9 of 12	8.33%	75.00%
2015 Quarter 3	Tranche 8 of 12	8.33%	66.67%
2015 Quarter 4	Tranche 7 of 12	8.33%	58.33%
2016 Quarter 1	Tranche 6 of 12	8.33%	50.00%
2016 Quarter 2	Tranche 5 of 12	8.33%	41.67%
2016 Quarter 3	Tranche 4 of 12	8.33%	33.33%
2016 Quarter 4	Tranche 3 of 12	8.33%	25.00%
2017 Quarter 1	Tranche 2 of 12	8.33%	16.67%
2017 Quarter 2	Tranche 1 of 12	8.33%	8.33%

Participants may enter multiple bid prices and volumes for each tranche, and may link their bids across time and/or space. For example, they may wish to bid for a strip of quarters as a block and/or bid for a sequential series of interconnectors. The auction is solved within a linear program maximising value constrained by the links. Each tranche is cleared at its marginal price.

Auction participants are bound by their agreements to pay this purchase price during the tranche's operating quarter. No collateral is required.

7.3.3 Settlement

Unit settlement is not activated until the vintage quarter commences. It then follows the following steps:

[8] "Directional" interconnector means the direction to which IRSR is allocated in a specific half hour. This is determined from the net flow direction of energy across the regional boundary measured over a half hour.
[9] "Notional" interconnector means the total cross boundary energy transfer, which may physically occur across a number of lines.

- The purchase price is fully paid on the fourteenth business day. Proceeds are distributed to the importing TNSP on the same day, otherwise settlement aligns with normal energy settlement: i.e., 20 business days after the end of that settlement week.
- Each unit receives its share of the IRSR distribution. The calculation is described in Section 5 of the auction guide[10].
- IRSR distributions are floored at zero. If negative IRSRs accumulate on a directional interconnector across a trading interval, they are recovered from the importing TNSP which in turn recovers these costs from its customers.
- The holder's first distributions are debited for auction fees until they are cleared. These cover AEMO's SRA administrative costs.
- At the end of the quarter, if total payments for a unit are less than $10, a make-up payment is made to provide this minimum return.

7.3.4 Agreement and termination trigger

To participate in the auction, a bidder must first execute an Auction Participation Agreement (APA) with AEMO. If successful, the bidder then becomes bound by a Settlement Residue Distribution Agreement (SRDA). The legal obligation to complete the transaction is essential, as the bidder promises a future fixed payment in return for future uncertain distributions.

Breaches of the agreement and insolvency of the buyer are grounds for termination by AEMO. The participant, however, may terminate an SRDA:

> "if there is a change in the way in which the settlements residue is calculated during the term of the SRDA that affects the calculation of the settlements residue the subject of the SRDA Units (sic)."[11]

This implies units can be unilaterally annulled by the holder if there is a material change to the settlement residue distribution methodology. This termination right is significant in the context of OFA reform because access settlement would eliminate the distribution of IRSRs to SRDA units.

7.4 Comparison to new arrangements

The proposed STFA auction would be very different in structure and complexity to the existing SRA auction:

- The SRA auction is one-way (i.e., participants can buy but not sell) and issues six independent instruments from six fixed unit pools, with limited provision for linking bids across interconnectors and vintages.
- The STFA auction would be two-way and concurrently clear all NEM generator firm access rights (at approximately 220 locations) and 10 FIRs. The pool of instruments would be mutually dependent, so the auction incorporates a simultaneous feasibility model of the transmission network.

Actual settlement of IRSR units is also very different to the proposed settlement of FIR units:

- IRSR units are settled as the product of metered interconnector flows, adjusted for losses, and inter-regional price differences. Each regional boundary is consolidated into two directional notional interconnectors.[12]
- FIR units would be settled within OFA's access settlement mechanism, earning value from flowgate prices and the relative flowgate usages of directional interconnectors and generators. By design, the access settlement process mostly eliminates IRSR.
- Between Victoria and South Australia, and between Queensland and New South Wales, there would be an FIR for each direction on each dispatchable[13] interconnector. For example, an FIR for each of Murraylink East, Murraylink West, Heywood East, and Heywood West.

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[10] Available at http://www.aemo.com.au/Electricity/Market-Operations/Settlement-Residue-Auction/Guide. Viewed 11 December 2014
[11] See Auction Rules, Sections 13.5 and 13.6 http://www.aemo.com.au/Electricity/Market-Operations/Settlement-Residue-Auction/Guide. Viewed 19 November 2014.
[12] Except for Victoria-Tasmania, which is connected via a market network service provider and is outside both the SRA and FIR regimes.
[13] A "dispatchable" interconnector means a line or cutset of lines that is represented as a controllable variable in the dispatch process. E.g., Murraylink and Heywood are individually dispatched.

7.5 OFA implementation pathways

The AEMC's First Interim Report: Optional Firm Access, Design and Testing, Chapter 10: Staged Implementation discusses potential options for rolling out OFA reform. For each option it describes an implementation sequence of package segments. These are considered below in respect to removing the existing SRA regime.

SRAs are currently forward sold quarterly over a period of three years, so that the SRAs for a quarter are sold in 12 equal vintages. As a result, SRA transition is affected by whether more or less than three years' notice is provided.

7.5.1 Simultaneous implementation option

Several parts of the OFA reform depend on the timing of TNSP regulatory reset processes, which occur over a rolling timetable based on five-year reviews. The simultaneous implementation option effectively delays all parts of the reform until the last TNSP is reset. In this option, the notice period for the wind-up of SRAs is therefore greater than three years.

7.5.2 Temporal staging option

Once access settlement is implemented, the residue necessary to support the instruments sold through the SRA is diverted to the holders of firm access. Therefore the SRA and associated instruments must be wound up concurrently with the introduction of access settlement.

In the staged options, access settlement is introduced in the first stage, with some other parts delayed until reset processes are concluded. In this option the notice period may be shorter than three years.

FIRs can be acquired through the OFA segments described as "secondary trading" or "inter-regional firm access issuance". FIRs would replace the SRA's role in managing inter-regional price risk, so it is preferable that one or both of these is available at the time the SRA is dissolved. This is proposed in the AEMC's roll-out options.

7.5.3 Geographic staging option

This option involves introducing access settlement in some regions but not in others.

As Tasmania is connected via a non-regulated link to Victoria, there are no SRAs nor FIRs on this regional boundary. Therefore a staggered introduction of access settlement of Tasmania versus all other regions appears to be straightforward.

However, staggering access settlement introduction between mainland regions raises challenges, with some directional interconnector residues potentially being available for auction and not others. Understanding the option requires first understanding how access settlement operates in this scenario.

This is turn requires considering which constraints become access settled flowgates. These would need to include all network constraints that include generators in the access settled region. The choice does not relate to the location of the network asset being protected by the constraint.

For New South Wales–Victoria, constraints exist with generators on either side of the boundary. If access settlement is staggered across this boundary, it is likely these constraints will need to be reformulated to include generators in only one region and the interconnector. This will be a less accurate representation of those limits.

For interconnector access, the directional interconnector oriented towards the OFA region should be access settled and support associated FIRs.[14] The directional interconnector towards the non-OFA region may continue to earn flow-based settlement residue and be capable of supporting an SRA.

With the exception of Tasmania, this option will raise a number of technical complexities. It should be noted that in its first interim report, the AEMC concluded geographical staging had "many challenges and downsides". Stakeholder submissions to the AEMC were also unsupportive. AEMO has therefore not invested significant resources in this option.

[14] Note that each of the Victoria-South Australia and New South Wales-Queensland boundaries have two dispatchable interconnectors and therefore each boundary would support two FIRs oriented towards an OFA region.

7.6 SRA transition pathway

The package of OFA National Electricity Rule changes would include consequential changes to or deletion of rule 3.18 which covers the entire SRA framework.

7.6.1 Simultaneous implementation option

As discussed in Section 7.5.1, this option would be implemented with more than three years' notice, enabling time for the expiry of any SRA units on foot prior to the rule changes. In the lead-up to the OFA start date, the auction rules may be adjusted to suspend the sale of units with vintages beyond the start date. This process was successfully used in the lead-up to the abolition of the Snowy Region on 1 July 2008.

Rule 3.18 would be deleted, the auction rules withdrawn, and the SRC abolished. AEMO would reconcile its outstanding auction fees expenses with the last units.

7.6.2 Temporal staging option

As discussed in Section 7.5.2, the temporal staging option may provide less than three years' notice for the introduction of access settlement. Two options emerge:

- In the case of the Snowy Region abolition, NEMMCo and the SRC agreed to suspend sales of affected units while the AEMC was considering the abolition rule change. Had the rule been rejected, affected units would have been behind the normal release timetable, but could have caught up by increasing subsequent releases. Delaying affected unit auctions while the OFA rule change is under consideration could avoid the need to terminate any units.
- If the access settlement rules are made with a timeframe that affects previously sold units, these units will need to be terminated. As they will receive no inter-regional residue, an owner would have rights to unilaterally terminate their holding using the termination clause described in Section 7.3.4. The SRC could issue an advice to assist holders with respect to termination.

AEMO's preference would be the first of these options if circumstances permit.

7.6.3 Concerns caused by short-notice introduction

Stanwell Corporation commented in its submission to AEMO's First Interim Report that it:

- Opposed the cancellation of any units on the grounds this could have adverse consequences on units purchased for hedging and speculative purposes.
- Opposed shortening the forward sale of units in expectation of the introduction of OFA (i.e., as occurred in the Snowy Region case).

Snowy Hydro raised a similar concern in its submission to the Draft Report.

In response to the first point, the introduction of access settlement would unavoidably trigger the cancellation of any affected units if it is introduced with less than three years notice. OFA implementation timing recommendations are within the AEMC's TOR and this issue should be addressed in that process.

In response to the second point this would be a judgement that AEMO and the SRC would take at the time should conditions require. In the Snowy Region case, the parties considered the abolition rule had a reasonable prospect of being made and therefore the units were withheld as this was preferable to auction followed by cancellation. As the rule was subsequently made, this pre-emptive action proved prudent. Similarly, if AEMO in conjunction with the SRC considered the OFA rules had a high chance of being made with less than three years' notice, the units would be withheld.

7.6.4 Geographic staging

In this option, the SRA remains in place, but the relevant directional interconnectors replaced with FIRs are withdrawn.

If partial introduction of access settlement were introduced with less than three years' notice, then:

- Any SRA units on foot oriented towards the OFA regions would be terminated by the holder.

- For units directed to non-OFA regions, the settlement calculation itself would not change, but the value of that settlement would depend on the constraint formulations and generator behaviour. As these would be changed by the partial introduction of access settlement and there would unavoidably be some change in value for any units on foot. The change would likely not constitute grounds for holder termination, but AEMO and the SRC could agree to withdraw all affected units and re-auction.

AEMO does not auction Basslink's inter-regional residue so there are no implications for SRA abolition should Tasmania introduce access settlement at a different time from mainland NEM regions.

7.6.5 Systems

AEMO considered whether the existing systems supporting SRA auctions and SRA settlement could be modified to support the STFA auction and/or FIR settlement. As described in Section 7.4, the new arrangements have a fundamentally different structure to the existing SRA regime and therefore AEMO considers that it is not worthwhile attempting to adapt any of its existing systems. These would be discontinued.

FIR settlement systems would be incorporated into the access settlement build. Development of the STFA auction and the long-term inter-regional firm access auction would be significant projects outside the scope of AEMO's TOR.

7.7 Other matters

When considering the transition from SRA, some additional matters emerge outside AEMO's TOR scope, as indicated below. These have been discussed with the AEMC, and they will be progressed as part of the broader OFA design.

7.7.1 Unallocated residue

Although congestion rents associated with inter-regional flows are largely diverted into access settlement, some inter-regional settlement residue emerges and was observed in AEMO's modelling. AEMO understands these arise due to:

- The surplus that arises due to marginal loss factor equation pricing.
- Where the flowgate effective capacity exceeds the flowgate generators' firm and non-firm access levels and the FIR's firm access. The current design does not allocate a non-firm share to directional interconnectors.
- Where an inter-regional price difference is affected by a non-flowgate constraint, e.g., a frequency control ancillary services (FCAS) constraint.

These surpluses would be smaller than historical residues and are unlikely to be of use for risk management so there is no intention to auction them. AEMO understands they are to be credited to the importing TNSP.

Access settlement rules will need to consider these surpluses, including logic to ensure:

- The correct surplus is measured, separating the surplus from access settlement and intra-regional surplus.
- AEMO credits the correct TNSP, particularly in the case of opposite physical flows across two interconnectors on one regional boundary.

7.7.2 Management of negative residues

The introduction of access settlement is expected to reduce the incidence of negative inter-regional residue, because:

- It should address the incentive to offer in the manner that has provoked the most severe historical events of counter-price flow and negative residue.
- The cost of supporting counter-price flows caused by the binding of flowgate constraints is directly funded out of access settlement.

Under the current arrangements, AEMO attempts to minimise negative inter-regional residue by clamping most counter-price flows through the negative residue management procedure. Continued clamping of negative residues after access settlement adjustments would require complex changes to the procedure and tools. The AEMC intends to consider the need for clamping in its Draft Report; however, AEMO presently assumes clamping is not required and would be discontinued.

7.7.3 Recovery of negative residue

Although access settlement appears to directly address the main existing cause of negative inter-regional residue, there are still some circumstances in which negative residue arises. These are similar to the circumstances AEMO is presently unable to clamp and include:

- Some sub-half-hour flow reversals which result in inconsistent five-minute dispatch and 30-minute settlement outcomes.
- Forced imports into a region to meet a local system security requirement, e.g., where a load in the vicinity of the region boundary requires support from the neighbouring region. In the access settlement logic, this is treated as a flowgate support directional interconnector, and its inter-regional deficit would not be recovered through access settlement.
- In unusual situations, inter-regional loss factors can be greater than one. In this case marginal loss factor pricing can accrue a negative residue.

The OFA rule changes need to retain AEMO's ability to recover negative inter-regional losses from the importing TNSP. Similar to crediting surplus, the logic will need to ensure inter-regional negative residue is correctly separated and allocated.

8. STAKEHOLDER FEEDBACK

Four submissions to the First Interim Report[15] were received:

- Origin Energy.
- Stanwell Corporation initial and supplementary submission.
- CS Energy.

The matters raised and AEMO's response were detailed in the Draft Report[16] and have not been reproduced for this Final Report. That discussion provides context for some of the submissions received to the Draft Report.

Five submissions to the Draft Report were received:

- Alinta Energy.
- Origin Energy.
- Snowy Hydro Ltd.
- Stanwell Corporation.
- CS Energy.

AEMO's approach and overall recommendation

All submissions supported AEMO's general approach as outlined in the Draft Report and considered that the overall assessment of OFA had benefited from AEMO's technical analysis work.

All submissions supported AEMO's draft recommendation to not prepare a rule change to promote access settlement ahead of the rest of the reform. This view was shared by Alinta, who consider that the full OFA model has the potential to deliver benefits.

Alinta, Stanwell and Origin agreed with AEMO's observations on the difficulty of promoting a stage one of access settlements alone independently of the AEMC's work on the full OFA, as it would require a number of supporting mechanisms still under development by the AEMC. Origin stated:

> *With the design of transitional access and a secondary trading auction as component parts for stage one (being) yet to be determined by the AEMC it is difficult to conceive how AEMO could have recommended the independent implementation of access settlement.*

Stanwell also supported AEMO's continued involvement as a technical advisor to the AEMC on access settlement modelling until the end of the AEMC's OFA work.

Modelling benefits of access settlement

All submissions supported AEMO's modelling work in order to demonstrate the practicality of access settlement in as realistic an environment as possible. Stanwell hoped that AEMO's modelling approach could become the basis for the AEMC's benefit assessment instead of the simplified representations employed by its consultants. In response AEMO notes that unfortunately the construct of AEMO's model renders it unsuitable to assess benefits over time.

Stanwell proposed a range of further scenarios for modelling and recommended several historical events. Stanwell's suggested "bid to bind" incentive has been analysed in further detail in this Final Report, see Appendix E.2. The example now explores how offers away from SRMC can increase individual access settled returns and how a high SRMC firm generator may be able to undercut a competing non-firm low SRMC generator's offer

AEMO thanks Stanwell for the other suggestions which are noted for further modelling work in support of the AEMC as required. CS Energy disagreed with AEMO's measurement of dispatch efficiency, based on total production cost of generation. CS Energy felt that even if a dispatch outcome appeared inefficient, the overall market outcome considering broader matters, such as trading risk, may be efficient in totality. In response AEMO

[15] Available: http://www.aemo.com.au/Electricity/Market-Operations/Optional-Firm-Access. Viewed 12 December 2014.
[16] Available: http://www.aemo.com.au/Electricity/Market-Operations/Optional-Firm-Access. Viewed 27 February 2014.

notes that the AEMC assessment framework described in their First Interim Report listed nine categories of impact, one being the efficient dispatch of generation. AEMO interprets this to be the minimisation of short-run production cost. The AEMC will assess all the categories for the full OFA, including dispatch efficiency.

Stanwell raised a concern regarding the Short-Run-Marginal-Costs (SRMC) used in the examples. In response AEMO notes that it assumed these values based on the published National Transmission Network Development Plan (NTNDP) data, but in some cases marginally adjusted them to be consistent with the behaviour exhibited at the time studied. In the 16 January 2014 case, Roma was observed to be offering at the market floor price whilst the regional price was marginally lower than the NTNDP data and so the SRMC was slightly adjusted to retain consistency.

Stanwell noted example 2's efficiency benefits arose mainly from modelling "noise" created by the simulation technique rather than more efficient dispatch. AEMO agrees: these small production cost changes are not described as efficiency gains.

Stanwell noted difficulty in reconciling the SRMC rerun flowgate 2 access settlement quantities of the third example. On review AEMO agrees, the draft report did not explain that the binding constraint associated with flowgate 2 had changed, from V>>S_NIL_PWKN_SGKH in the backcast to V>>S_NIL_SETB_SGKH in the SRMC re-run. Whilst the constraints are very similar in effect, the participation factors of the Ladbroke Grove generators were presented incorrectly. This has been corrected in the final report.

Flowgate support generation

Stanwell expressed concern that Table 2 implied the full OFA reform would resolve the incentive to withhold constrained-on generation. In response AEMO notes Table 2 is preceded by the following comment:

> *"Instead (of access settlement incentives) OFA incentives for TNSPs are expected to encourage them to directly engage with such generators to increase total network capability.[17]"*

The expectation was drawn from the Transmission Framework Review and is outside AEMO's scope to validate. Table 2 categorises observed scenarios of inefficient dispatch, and tests each against access settlement incentives as opposed to other reforms. The withdrawal of constrained on generation was observed to be a material issue and therefore pertinent to the assessment.

Stanwell felt AEMO should also have acknowledged simple improvements to the current network support arrangements as an alternative reform. AEMO is not aware of any reform in this regard that is currently under public discussion.

Access settlement design refinements

Origin and Stanwell commented upon AEMO's work with the AEMC to address issues of compatibility of the original access settlement concept developed in the Transmission Frameworks Review with the detailed workings of the existing NEM.

Origin stated these "bring into question whether implementing access settlement would be in any way practicable". In response AEMO considers the main concerns have been addressed during this work and that the design is implementable. Compatibility issues were to be expected since the Transmission Frameworks Review considered the NEM from a more theoretical perspective. The NEM includes many intricacies, arising from previous pragmatic decisions, for example non-standard metering configurations. This "Design and Testing" phase was intended to uncover and address these matters, which, assisted by AEMO's detailed knowledge, it has achieved.

Stanwell considered the matters were "addressed" rather than "resolved". In response AEMO agrees and has adjusted its language.

Stanwell noted that whilst the refinements are now known, the resulting distortions and risks are unknown. In response AEMO notes that when working on the refinements, AEMO and AEMC jointly considered their implications and attempted to describe them through the reports.

[17] Draft Report, page 17.

Stanwell expressed concern that further design refinements may be required to manage administered pricing. In response AEMO notes the AEMC has proposed an approach for access settlement during administered pricing, but at this time AEMO has not yet analysed it in detail. Administered pricing is a very rare market condition where regional prices are constrained to a narrow range and compensation may be payable to affected generators. AEMO considers it a lower priority matter and not relevant to the conclusions reached in this final report or the AEMC's economic assessment. A study of the proposed solution will however ultimately be required for confidence in the design.

Five-minute weighted settlement

Stanwell noted in AEMO's Draft Report that the AEMC were considering a change to access settlement design based on weighting the usage by flowgate price, a suggestion that emerged during preparation of the Draft Report. In response AEMO notes that it has had further discussion with AEMC on weighted settlement since the publication of the Draft Report, who proposed that AEMO's work should continue to assume time-weighted usage values.

Settlement Residue Auction

Snowy cautioned against the cancellation of settlement residue auction (SRA) units on foot. In response AEMO notes this concern is discussed in section 7.6.3. The situation unavoidably arises if access settlement is introduced with less than three years' notice. The concern should be raised in considerations on implementation timing should OFA be progressed towards implementation.

Stanwell suggested that if SRA non-firmness is a problem, then the impact of co-optimised constraints could be studied. Co-optimised constraints refers to the equal treatment of interconnector and generator terms in the left-hand-side (LHS) of constraint equations, a requirement of National Electricity Rule 3.8.10. In response AEMO considers this is outside the scope of its OFA project. Background to the current rule can be found in the Congestion Management Review[18], which considered the challenges of maintaining power system security with alternative constraint formulations.

AEMO costs

Stanwell suggested it would be "prudent to include an allowance for contract labour". In response, AEMO has considered, and agrees, with this suggestion. On the basis of experience of managing similar projects, AEMO has now assumed contract rates for 50% of the estimated labour for development and system testing.

Stanwell suggested the Settlement Residue Auction (SRA) should not be netted off the cost of the build, which will be replaced with yet uncosted access auctions, which, if treated consistently, should be added to AEMO's estimate. In response, AEMO agrees and has altered the presentation of that section.

Stanwell suggested the costing should include an estimate of design alterations caused by future unanticipated complications. In response, AEMO notes that during 2014 it worked closely with the AEMC on the detailed design of access settlement, during which design alterations were made. AEMO considers that the design is approaching an implementable form and therefore assumed no material design changes will be required after the rule is made. AEMO agrees that some on-going refinements are likely to occur post implementation, particularly in the area of participant information. This work would become part of AEMO's existing market development activities and unlikely to materially add to existing costs.

As a result of Stanwell's first two suggestions above, AEMO has changed Appendix C and delivered an updated report to the AEMC.

Information requirements

Stanwell desired access settlement information be published in five-minute predispatch and five-minute dispatch timeframes as well as the 30 minute timeframes described. In response AEMO notes that Appendix B describes that as access settlement is calculated on a 30 minute timeframe, five-minute quantities are not automatically available. The Draft Report described four possible options for estimating values resolved to a five minute interval, noting that each could be misleading. No preference for which of these options was indicated. AEMO now

[18] See http://www.aemc.gov.au/Markets-Reviews-Advice/Congestion-Management-Review viewed 4 March 2015

proposes that option one, the provision of estimates as if access settlement were calculated on a five-minute basis, be provided.

Stanwell stated a desire for the release of any currently private information that is required to enable generators to determine their own position. In response AEMO notes that the proposal presented in Appendix B will enable all generators to determine their own position, even if it means that some data that is currently confidential could be reverse-engineered, such as the sent-out quantities of other generators affected by a shared constraint. AEMO invited comments into whether, in the interest of equal access to information, that all these data fields should be generally published but received no specific views. Therefore it proposes no change to the current release of generally public information.

Commentary

Origin, Snowy and Stanwell each raised concerns with elements of AEMO's commentary related to observations of market inefficiency, with Stanwell suggesting AEMO was acting outside its remit as market operator in making these observations.

In response AEMO suggests the commentary be read in context. AEMO was requested to develop modelling techniques to estimate the likely benefits of stage one, which required:

- Describing the dispatch inefficiencies resulting from offering away from cost that is observed in the NEM.
- Characterising observed events by type and analysing which would be addressed by the incentives of access settlements and which would require other reforms.
- Limiting our conclusion to stage one and not extending it to the full OFA.

AEMO and AER frequently describe relevant observed events in standard reports[19].

Network Outages

Origin mentioned network outages as a key driver of congestion. Snowy stated "transmission outages are the root cause of market volatility".

In response AEMO notes that access settlement operates in all network conditions. Where flowgate effective capacity falls below firm access quantities, there will be scaling back of access, however the design will still price marginal variations in generation output locally. Therefore if dispatch efficiency benefits exist in the system normal case with access settlement, they would similarly be expected in the outage case.

AEMO's analysis of events found that whilst all recent events of market volatility included some network congestion, in the majority there were no contributing network outages. For example, during January 2015, AEMO's pricing event reports cited 13 days where Queensland spot prices exceeded $1700/MWh in one or more trading intervals[20] and in none of these were network outages a factor. AEMO's NEM constraint reports lists 2013 system normal constraints as a larger contributor to the market impact measure than outage constraints[21].

However the critical binding system normal network constraints during the cited January 2015 Queensland events constrained only the New South Wales interconnectors and Kogan Creek power station. Regional settlement accurately priced this congestion with the exception of this generator. And as that generator has a lower SRMC than the New South Wales regional prices during the events, the regional settlement incentive is unlikely to be a relevant factor to the bidding behaviour in these events. It therefore seems unlikely that access settlement would have altered these dispatch and price outcomes.

This is consistent with the theme of the majority of recent market volatility events studied for this project, in that:

- They mostly occurred in system normal conditions (i.e. all network plant in service).
- Locational price inaccuracy of constrained-off plant does not appear to be a key cause.

[19] See http://www.aemo.com.au/Electricity/Resources/Reports-and-Documents/Pricing-Event-Reports and http://www.aer.gov.au/taxonomy/term/310 and http://www.aer.gov.au/publications?date%5Bvalue%5D%5Byear%5D=&sector=All&category=324. Viewed 11 December 2014
[20] See http://www.aemo.com.au/Electricity/Resources/Reports-and-Documents/Pricing-Event-Reports/January-2015. Viewed 3 March 2015
[21] See http://www.aemo.com.au/Electricity/Market-Operations/Dispatch/Annual-NEM-Constraint-Report cited 3 march 2013

9. FURTHER ACTIVITIES

9.1 AEMO work in AEMC project

AEMO considers a stage one rule change does not have merit and is reporting early against its TOR with this key finding.

AEMO will collaborate with the AEMC in its further work as required rather than reporting further to the COAG Energy Council.

The AEMC is concurrently preparing a Draft Report in relation to its own ToR, which is expected to include a preliminary view of the merits of the full OFA. With respect to dispatch efficiency, their view will be informed by AEMO's scenario analysis on access settlement, as well as consultancies that will attempt to quantify benefits over time. It will also be informed by AEMO's internal cost estimate.

AEMO's further work on OFA is dependent on the AEMC's direction.

9.2 Price volatility in Dispatch and Training Simulator back-cast

The modelling approach used by AEMO to study a past period of network congestion has required first re-running the Dispatch and Training Simulator (DTS) with unchanged generator offers. This is not expected to give an identical dispatch outcome, because:

- Inputs to each iteration of the DTS dispatch engine are based on the modelled outcomes of the previous dispatch interval's run, rather than real measurements of the power system.
- Some features of the real power system are not reproducable. These include generator non-conformance in following dispatch targets and power system measurement errors.

For these reasons, the base-case of each modelling run presented in Appendix E is a back-cast DTS run with unchanged generator offers, rather than the actual market outcomes.

As expected, the dispatch outcomes were marginally different in the back-cast. In these sensitive conditions, small changes in dispatch create substantial changes in price.

An unexpected observation was that price volatility was asymmetrically affected: it was significantly reduced in most high-priced scenarios, and never increased. Investigations could not identify any faults in the DTS and so AEMO suspects volatility is suppressed by the assumption of perfect generator conformance and by the removal of real measurement noise.

The effects of metering noise on dispatch and price outcomes could be significant where constraint right-hand sides are sensitive to metered flows on specific elements, which may in turn be sensitive to sampling timing. It is technically possible to replace measured inputs into the dispatch engine with state estimated values; this is a well understood method to smooth measurement noise. AEMO is currently assessing this issue further as a separate initiative that builds on the learnings from this project.

In the historical high price scenarios, the majority of re-bidding appears to be driven by the regional price rather than dispatch volume. This creates another challenge in attempting to realistically model high-priced scenarios: as the DTS back-cast has lower prices, the rebidding observed in the scenario is not necessarily consistent with the prices in the back-cast.

APPENDIX A. ACCESS SETTLEMENT DESIGN REFINEMENTS

The fundamental access settlement design was specified in the TFR documents. This is available in the TFR Technical Report: Optional Firm Access.[22] Refer to Chapter 4 and sections 11.4 to 11.10 and 12.1 to 12.5. The following items describe the refinements as collaboratively developed to this point. These will be accumulated into a full specification of OFA at the end of the AEMC project.

Basis of firm access specification

The TFR had not clarified the metering point that would be used for access settlement. This is important because scheduled generators are dispatched on the basis of unit generator terminal outputs, but are settled on the basis of energy measured at the connection point. Chapter 8 of the AEMC's First Interim Report[23] documents a proposed solution.

In summary, access settlement will be based on "sent-out" energies, but to correctly align these energies with dispatch quantities, a new concept, "Revenue Meter Identifier" (RMID)[24] will be created. This will identify the least granular of the Dispatchable Unit ID (DUID) and revenue meter and, where necessary, adjust for station auxiliary loads.

Table 3 Revenue meter identifier taxonomy

Station type	Dispatch	Revenue meters	RMIDs
1	One DUID per unit	One per unit plus one for station auxiliaries.	One per unit revenue meter less allocated share of station auxiliary.
2	Units aggregated to one DUID	One for station downstream of station auxiliaries.	Revenue meter.
3	Units aggregated to one DUID	One for each unit plus one for station auxiliaries.	One = Σ all revenue meters.
4	One DUID per unit	One for station downstream of station auxiliaries.	Revenue meter.

"Auxiliary load" is therefore netted off from access settlement; this is beneficial for the generator as less firm access needs to be purchased. Auxiliary load usually includes consumption directly associated with generation of electricity, but sometimes extends to mining operations, and occasionally to industrial facilities.

It is intended that:

- All e*xisting facilities* will be grandfathered as auxiliary load, as long as they are electrically close to the generator, i.e., the energy consumed by a mine located in a different part of the network could not be netted off before access settlement.
- All *new facilities* will require auxiliary load to be operationally, commercially, and temporally associated with the generation as well as electrically close.

An RMID configuration list for existing facilities would be determined at the time of determining transitional access. For new facilities this would be a registry activity.

Access adjustment for loss factors

All generator access settlement calculations are made on a regional reference node (RRN) basis, i.e., all quantities, including access, usage and availabilities are marginal loss factor (MLF) adjusted. Directional interconnector quantities, including firm interconnector rights (FIR) are not adjusted by the inter-regional loss factor.

[22] Available at: http://www.aemc.gov.au/getattachment/7e308487-d5d8-4170-a277-3d69c3069d12/Transmission-Frameworks-Review-Technical-Report-Op.aspx. Viewed 4 December 2014.
[23] Available at: http://www.aemc.gov.au/getattachment/1f15553d-e513-4d9a-9b96-f9549b9ae589/First-Interim-Report.aspx. Viewed 5 December 2014.
[24] In its Draft Report, AEMC intend to rename RMID to "access unit identifier" AUID. This has identical meaning.

Thirty-minute settlement

Access settlement is to occur on a 30 minute basis as described in Section 12.4 of the Transmission Frameworks Review Technical Report.

In that report's table 12.1, "generation dispatch" and "trading interval dispatch" will be sourced from the RMID revenue (sent-out) meter. As noted in that table, flowgate prices will be the sum of dispatch interval prices divided by six, even if the flowgate did not bind continuously.

Flowgate price source

For constraint marginal cost values, AEMO will use its marginal congestion cost (MCC) table in which all violated network constraints are relaxed. Violated constraints have a marginal cost affected by the constraint's violation penalty, a multiple of the price cap. The MCC table is developed by relaxing the right-hand-side (RHS) of each violated constraint so that is no longer violated and re-running the dispatch process. Some relaxations occur manually, days after the event. This will need to be expedited and must occur prior to settlement.

Local price floor

All local prices are to be floored at the market floor price. This is to be achieved by identifying the local price most below the floor, then progressively scaling back each relevant flowgate price, starting at the largest flowgate price, until that local price equals the market floor price. The process repeats until all local prices are at or above the floor. As per all access settlements calculations this occurs on a 30 minute basis.

Flowgate directional interconnectors identification

Access settlement provides a firm interconnector right for each direction on each dispatched interconnector. However the dispatch engine dispatches the interconnector as a single flow quantity, which can be positive or negative. This means a logical test is required for each hybrid flowgate to determine which directional interconnector (DIC) is participating and whether it is a flowgate term or flowgate support term.

To determine whether the interconnector term is flowgate or flowgate support: arrange constraint equation inequality such that left-hand-side (LHS) is less than or equal to right-hands-side (RHS), then transpose flowgate support generators (with negative coefficients) to RHS. If RHS is less than zero, then interconnector term is flowgate support.

If RHS is positive, then the sign of the interconnector term indicates a flowgate DIC according to interconnector sign convention, i.e., flows away from Tasmania are positive.

Market Network Service Provider

The importing and exporting region is defined on the market network service provider (MNSP) measured flow direction. In the exporting region the flow is treated as load and flowgate usage set to zero like a flowgate support generator. In the importing region flow is treated like a flowgate generator, after adjusting polarity based on interconnector sign convention (i.e., reversed for flow towards Tasmania).

All MNSP access settlement is accredited to the MNSP and not required to be divided into directional interconnectors.

Inter-regional residue allocation

Although most inter-regional residues and shortfalls are resolved by access settlement, some will remain, caused by:

- Loss factor residue associated with the marginal pricing of losses on interconnectors.
- DIC non-firm entitlements which are not credited to firm interconnector rights (FIR) holders.
- The cost of DIC flowgate support, i.e., where an interconnector is forced to flow counter-price to support a load pocket.
- Non-flowgate constraints affecting interconnectors.

These residues are paid to or recovered from the importing TNSP, assessed from the measured flow.

In the case of circulating flows between two parallel interconnectors, the non-firm entitlement for each DIC will be accredited to the importing TNSP relevant to that DIC. All other residues will be netted and allocated to the net importing TNSP.

Re-settlement

Metering corrections lead to re-settlement processes up to 20 weeks in arrears. This is relatively uncommon for scheduled generators, however when an access settled meter is corrected it will trigger re-settlement of all generators in that flowgate for that settlement week.

Determination of capacity

A generator's "capacity" limits its actual entitlement when it is super-firm. This is to be determined from the highest actual half-hour metered value at the RMID during the preceding two rolling years. AEMO interprets this to mean a periodic re-assessment, such as weekly, would be used and published in the registry, but this period is yet to be determined.

Distribution network constraints

Congestion between a generator connection point and a transmission connection point is not to be managed by access settlement. However loops in the distribution network sometimes need to be managed through generation dispatch with network constraints. These are defined as dual function assets in National Electricity Rule 6.24. Network constraints protecting these assets will be flowgate constraints. This is consistent with current practice.

Administered pricing

When administered pricing is occurring and a regional price has been reduced to the regional price cap the access settlement would first be calculated with the original price, but then would be subject to a regional scaling factor to ensure all settlement balances. This technique is yet to be modelled in detail.

Other price replacements

When prices are discarded due to a manifestly incorrect input, or replaced in the case of intervention pricing, mandatory restriction pricing, market price cap over-ride or over-constrained dispatch, access settlement is to operate using the final regional price.

Market suspension

During market suspension, access settlement will be suspended.

APPENDIX B. INFORMATION REQUIREMENTS

AEMO considers that implementation of access settlement will be assisted by the provision of additional information to assist participants understand their positions. This would apply to the following timeframes:

- Access registration.
- Predispatch.
- Dispatch.
- Settlements.

While AEMO has not yet prepared a full proposal of all data fields. It made some preliminary assumptions for the purposes of costing, which are described in Appendix D. AEMO intends to continue to work on this area and provide a detailed list in time for the AEMC's final report. Thereafter there will be more opportunities for participants to propose additional fields, for example, through the annual congestion information resource consultation.

Some suggested data fields may indirectly release information that was previously not public. It is preferable that these are fully detailed prior to the completion of the AEMC work, so that their release can be explicitly included in the rule drafting instructions.

Registry publication

AEMO has assumed it would maintain a registry of access settlement quantities. As part of this AEMO could publish the following key parameters:

- A Revenue Meter Identifier (RMID) to Dispatch Unit Identifier (DUID) mapped relationship.
- A sent-out proportional estimate, i.e., RMID = so * DUID for use in predispatch and dispatch timeframes.
- Access settlement capacities per RMID.
- Current firm access levels per RMID.
- Current firm interconnector rights (FIR) on foot per directional interconnector.

The registry would also contain, but not publish, the current FIR holdings per participant.

Five-minute data publication

Access settlement will occur on a 30-minute basis. There are no readily available values to use in tables that are resolved to a five-minute basis: the five-minute predispatch and dispatch tables. Some estimation approaches are potentially possible, such as:

- Presenting access settlement calculations in these tables as if they were settled on a five-minute basis.
- Presenting "tallies" of the access settlement quantities achieved across a partially completed trading interval.
- Extrapolating running tallies to the end of a partially complete trading interval.
- Combining data from dispatch information with five-minute predispatch information to estimate a single 30-minute access settlement during a partially complete trading interval.

Any of these approaches could be misleading as each would be a poor predictor of the final access settlement during a volatile trading interval. In the Draft Report, AEMO proposed that the initial design provide no access settlement information in the five-minute predispatch or five-minute dispatch tables. Stakeholder feedback did desire provision of estimated five-minute data, but did not indicate a preference for any of the above options, or others.As a result of that feedback, AEMO now proposes that the initial design should include five-minute data estimations, using the first option above of presenting calculations as if they were done on a five-minute basis. If time permits, choice of this option should be further discussed with participants.

Predispatch and trading timeframes

Access settlement information would be provided in the 30-minute predispatch tables and the 30-minute trading tables; the latter are published just after the end of each trading interval. The presentation of each would be similar. AEMO suggests publishing:

- The name, effective date and version number of every binding constraint that is tagged as a flowgate constraint.
- Flowgate prices (after 30 minute conversion and floor price scaling).
- Flowgate total and directional interconnector(s) target enablement volumes.
- Flowgate total and directional interconnector(s) actual enablement volumes.
- FIR payments.

AEMO suggests publishing in participant confidential tables:

- Firm access level for that RMID.
- For each flowgate in which an owned RMID appears:
  - Flowgate name, effective date, and version number.
  - The unit's participation factor.
  - Local price (after flowgate scaling).
  - The unit's target entitlement.
  - The unit's actual entitlement.
  - The unit's flowgate usage.
  - Access settlement payment.
- Per RMID energy market settlement after all access settlement adjustments.
- Held FIR settlement.

As sent-out RMID metering values are unknown in these timeframes, an estimate from as-generated metering values would be created from the sent-out proportional factor listed in the registry.

Settlement timeframe

In the settlement timeframe the same information would be provided as listed above; however, the estimated RMID sent-out metered energies would be replaced with actuals. Inter-regional settlement residues and deficits (remaining after FIR settlement) would also be published.

Data currently confidential

Access settlement uses some data inputs that are currently confidential in some or all of the above timeframes. These include:

- Sent-out metered energies.
- Unit offered availabilities.
- DUID dispatched outputs.

The publication proposals above do not explicitly reveal any of these quantities; however, when smaller flowgates bind it will be possible to reverse-engineer them. In the Draft Report AEMO noted participants may consider itfairer for this information to become public for all scheduled and semi-scheduled units in all timeframes where the data exists. As no submissions explicitly engaged with this question, AEMO proposes not to adopt this approach in the initial design.

APPENDIX C. ACCESS SETTLEMENT IMPLEMENTATION COSTS

C.1 Introduction

This appendix provides an "order of magnitude" cost estimate of the changes relating to access settlement that may be required at AEMO should the OFA framework implementation go ahead. It is likely that AEMO would also be responsible for performing some functions outside access settlement which are not costed here. The scope of work of the cost estimate is discussed in Chapter C.2 of this report.

While AEMO is not required to perform any costing for OFA implementation as that task is assigned to the AEMC in the TOR, a joint decision was made with the AEMC that AEMO would perform this costing exercise to assist the AEMC in understanding the cost of implementing OFA at AEMO. AEMO notes that the AEMC will conduct its own research into the implementation cost of the broader OFA, and this is expected to consider generator and transmission costs as well as AEMO's costs as the market operator that are presented in this report.

This report was included as an appendix within AEMO's Draft Report into Optional Firm Access published in December 2014. A number of comments were received to that appendix which has caused AEMO to adjust these costs. AEMO's response to those comments can be found in chapter 8.

C.2 Scope

C.2.1 In scope

The scope of this costing exercise is limited to the components of OFA that are directly associated with AEMO's market operator function, the cost of which would be recovered through NEM participant fees. Specifically, the following components are costed in this report:

- Maintenance of a list of firm access quantities and access settled meters as advised by TNSPs or other processes.
- Changes to settlements processes to operate access settlement, covering both generator firm access and firm interconnector access.
- Changes to constraint formulation or tagging processes necessary to support the access settlement concept.
- Testing of new systems.
- Provision of additional market information to assist participant engagement with OFA settlements.
- Retirement of the existing SRA arrangements

AEMO approached the costing from the perspective of a full, non-staged OFA implementation. However, a similar access settlement system build would be required for a "stage one" implementation or a partial geographic implementation. In all implementation scenarios, the outcome of this cost estimate should not materially differ.

C.2.2 Out of scope

At the time of writing this report, the AEMC has not made governance recommendations regarding the operation of key new systems supporting OFA. For example, it is possible the AEMC may recommend that AEMO is the most appropriate agency to take on functions beyond access settlement, such as the:

- Pricing model.
- Auction and trading platforms.
- TNSP incentive calculation.
- Transitional Access Allocation work.
- Nomination of access settled meters.

These components of the OFA framework are excluded from the scope of estimation.

In addition, the following items are also out of scope:

- Non-AEMO costs (e.g., participant and TNSP costs).
- Costs associated with adapting the Victorian TNSP model to OFA.[25]
- Costs associated with the South Australian advisory function.
- Victorian generator to TNSP (AEMO) contracting costs.
- New National Transmission Planner costs (e.g., any functions associated with the pricing model).
- Costs incurred by AEMO prior to the AEMC issuing the final determination on OFA rule change.

This costing assumes the model is fully specified by the conclusion of the rule change process. It includes the cost of converting this design into business requirements, but does not include any design or redesign of the model itself.

C.3 Assumptions

C.3.1 Accuracy level

All project estimates involve assumptions, uncertainty and risk. Therefore, the confidence level of estimates is directly related to the activity and task definition and available information. Project estimates should be refined as more information becomes available, making project estimation an iterative and evolving process.

The accuracy level used for this initial cost estimate is “an order of magnitude” and the cost will be represented as a range. Should OFA implementation proceed to the project initiation phase, it is highly recommended that the estimate be refined, as more detailed design and other information should be available by that time.

C.3.2 Estimation process

The key input for this costing exercise is the draft concept design developed by AEMO; refer to Appendix D for further details. Based on this document, assumptions of the required system changes at AEMO are made by the relevant subject matter experts; these are listed Section C.3.4. Following this, an estimation of the amount of effort required to implement the system changes are made and these are summarised in Chapter C.4.

As this costing will eventually be used in the overall cost-benefit analysis of OFA, AEMO’s policy is to capture the total cost of the project, which includes corporate overhead costs.

C.3.3 Project assumptions

For costing, an assumption was required regarding implementation date. It was assumed that the OFA implementation project, should it go ahead, will be delivered during the 2017–18 financial year and be completed by mid-2018 (AEMO’s deliverables only). The project would be delivered as part of AEMO’s standard electricity release program and there would be a dedicated project manager looking after the delivery and day-to-day management of the project in accordance with AEMO’s project management methodology.

In the earlier version of this report AEMO assumed that the project would wholly utilise AEMO’s internal labour, and noted that should contract labour be required to backfill any resource gaps, it is likely to have a significant impact on the cost of the project. However, following stakeholder feedback, the assumption is updated to include the use of some contract labour consistent with typical practices on similar projects at AEMO which will make up 50% of the labour requirements for IT development and system testing work. Contract labour will not be required for other aspects of the project. AEMO’s labour rates for 2017-18 are yet to be determined, but they have been estimated for purpose of this costing exercise based on the 2014-15 rates being compounded by 3% p.a. All costs provided in this report are shown as present value.

It is not expected that any new hardware or external software are required to be procured for this project.

[25] Victorian TNSP costs will be assumed by AEMC as similar to other states.

C.3.4 System change assumptions

The following system changes are assumed in determining the effort required to deliver the project.

Overall goal of OFA

- Generator settlements are adjusted by the access settlement logic, implying that during congestion:
  - At the margin, all scheduled and semi-scheduled generators are exposed to a local (nodal) price.
  - A firm access right entitles a generator to receive a priority share of the resultant congestion residue.
- Owners of Firm Interconnector Rights (FIR) will also receive payment based on congestion residue. FIRs are only available on regulated interconnectors, not MNSPs.

Settlement changes

- NEMDE is to remain unchanged.
- Access settlement applies only to scheduled and semi-scheduled generators and regulated interconnectors. There is no change to customer settlements.
- Access settlement estimates need to be calculated in pre-dispatch, p5, and dispatch timeframes.
- Real settlement happens at settlement time and re-settlement time.
- Settlement is based on an entity called Revenue Meter Identifier (RMID). A RMID will be a combination of one or more DUIDs. It is assumed that this is the same concept as the existing RMIDs used at AEMO.
- Access settlement is based on flowgate prices (FGP), which are the shadow prices of flowgate constraints. Flowgate constraints will need to be tagged as such.

OFA settlement algorithm

- The algebra is formulaic and is assumed to be resolved by the design process prior to implementation by AEMO.

Access entitlement scaling and flowgate price scaling

- These scaling functions require optimisation searches across one variable and a monotonic function.

Abnormal market pricing conditions

- The logic for handling these will be fully specified prior to implementation by AEMO.
- The general logic is described in Appendix D.

Metering versus dispatch

- Access settlement is to operate on a 30-minute basis. Thirty-minute settlement data would be used wherever possible. However, constraint information is inherently based on five minute dispatch quantities.
- This implies:
  1. An estimated auxiliary load (EAL) factor is required in all time frames other than settlement
  2. Generation quantities in any of the settlement formulas are different depending on timeframe:
     a) SCADA meter – EAL
     b) Dispatch quantity – EAL
     c) Revenue meter
  3. Rather than using the NEMDE calculated right-hand-sides, the quantities would be scaled from the left-hand-side quantities from two.

FIR settlement algorithm

- Each dispatchable interconnector variable has two associated directional FIRs, e.g. there is one each for Heywood east, Heywood west, Murraylink east, Murraylink west.

- The relevant constrained directional interconnector in a particular flowgate constraint equation can be determined from the polarity of the interconnector's left-hand-side coefficient, the constraint's inequality sign and the polarity of the right-hand-side.
- Access settlement will consume the majority of inter-regional settlement residue. A small amount of residue can still accumulate, associated with loss factor pricing and non-firm capacity of interconnectors. These are to be identified and credited to the importing TNSP.

Settlement residue auction

- This function is to cease. Ongoing savings can be included. Note the processes that release FIRs are not in scope of this costing study.

Negative residue

- Although most negative residue is funded by access settlement, some small quantities can remain.
- AEMO's negative residue management process will be withdrawn.
- After access settlement, residual negative residues will be allocated to the importing TNSP using the same process as occurs currently.

Prudential forecaster

- To the extent prudentials are affected by generator settlements, e.g. for netted generator-market customer position, then the prudentials forecaster will need to be changed to account for access settlement adjustments.

Process flow

1. Registration data: Firm access level. Access settlement meter identifiers. Capacities. Estimated auxiliary load factors.
2. Constraints tagged as flowgate.
3. NEMDE run which gives FGPs and dispatch quantities.
4. OFA engine:
    1. Calculate local marginal prices (LMPs) for each generator.
    2. Scale LMPs to above the market price floor by scaling FGPs.
    3. For each flowgate (needs metering/EAL):
        i. Calculate effective flowgate capacity.
        ii. Calculate entitlement and usage for each generator and directional interconnector.
    4. Settlements (or settlements estimate). Will need new inputs detailing entitlements, FGPs, constraint coefficients, firm, non-firm and (for FIRs) non-firm residual entitlement scaling factors, FIR amount.
    5. Reporting.

C.4 Resource and cost estimate

C.4.1 Access settlement

The expected project activities and resource requirements in order to implement access settlement at AEMO are summarised in Table 4.

As the access settlement system is expected to be fully automated, it will not require significant resources to support and maintain the system; therefore, any ongoing support and maintenance costs are assumed to be absorbed into business-as-usual costs.

The estimated project cost is between $990,000 and $2,650,000.

Table 4 Project activities and resource estimates

Project activities	Description	Resources (teams)	Effort (FTE weeks)
Project Initiation & Planning	Project set up, planning workshops, business case, risk assessment	PM, CD, MOP, S&P, IMT	20 – 60
Detailed Design	Business analysis, Requirements Description (RD), Design Description (DD), IMT Impact Assessment.	BA, MOP, S&P, IMT, CD	20 – 60
Development	Develop codes, database build, release plan, etc.	IMT Dev, Contract Labour	30 – 80
System Test	Test script, test environment setup, perform system tests of the above codes, correct defects, regression tests, reporting.	IMT Test, Contract Labour	40 – 90
User Acceptance Test	User tests from Operations (incl. test scripts, user tests, defect fix, end-to-end testing, sign-offs)	MOP, RTO, S&P	20 – 60
Pre-production	Include participant tests	Test	8 – 20
Production/ Deployment	(DBA 4 + Platform 4) x 2 environments, to be changed once RD/DD is made available	Test, DBA, Platform	8 – 20
Project Management	Day-to-day management, monitoring, reporting, issues & risk management, governance, admin, etc.	PM	40 – 80
Stakeholder engagement	External communications, forums, working group	MOP, S&P, IMT, CD	4 – 12
Training	Documentation, training material, training sessions	MOP, S&P, IMT, CD	4 – 12

BA = Business Analyst; CD = Corporate Development; DBA = Database Administrator; MOP = Market Operations and Performance; PM = Program Manager; S&P = Settlements & Prudentials; IMT = Information Management and Technology

C.4.2 Auctions

The OFA reform will change market settlements and no longer create inter-regional settlement residue, which supports the Settlement Residue Auction (SRA) mechanism. Rather, the management of this risk is intended to occur through the new firm interconnector right (FIR), the settlement of which is included in the above estimate.

Therefore, the SRA would retire. This would result in the elimination of the costs of administering SRA, which are recovered from settlements residues by way of fees. These costs are regularly forecasted by AEMO and historical cost information exists, which makes estimation more accurate.

The total savings is calculated over a 5-year period from when SRA is assumed to be retired, which is at the beginning of 2018-19.

It is estimated that the saving is between $865,000 and $1,057,000 (present value). Note that these transactional costs are recovered from auction fees, i.e. they are recovered from successful bidders and not recovered from Participant Fees.

The AEMC continued their development of two new auctions, namely the long term inter-regional access and the short term firm access auctions. AEMO understands that the AEMC intends to recommend that these be operated by AEMO. Therefore, their build cost should be included in AEMO's implementation costs.

Unfortunately AEMO is unable to estimate the build and operating cost of these two auctions at this time. This is because:

- The proposal that AEMO operate them emerged recently.

- The auctions have only been conceptually described to date and AEMO considers they need further development before they can be reasonably costed.

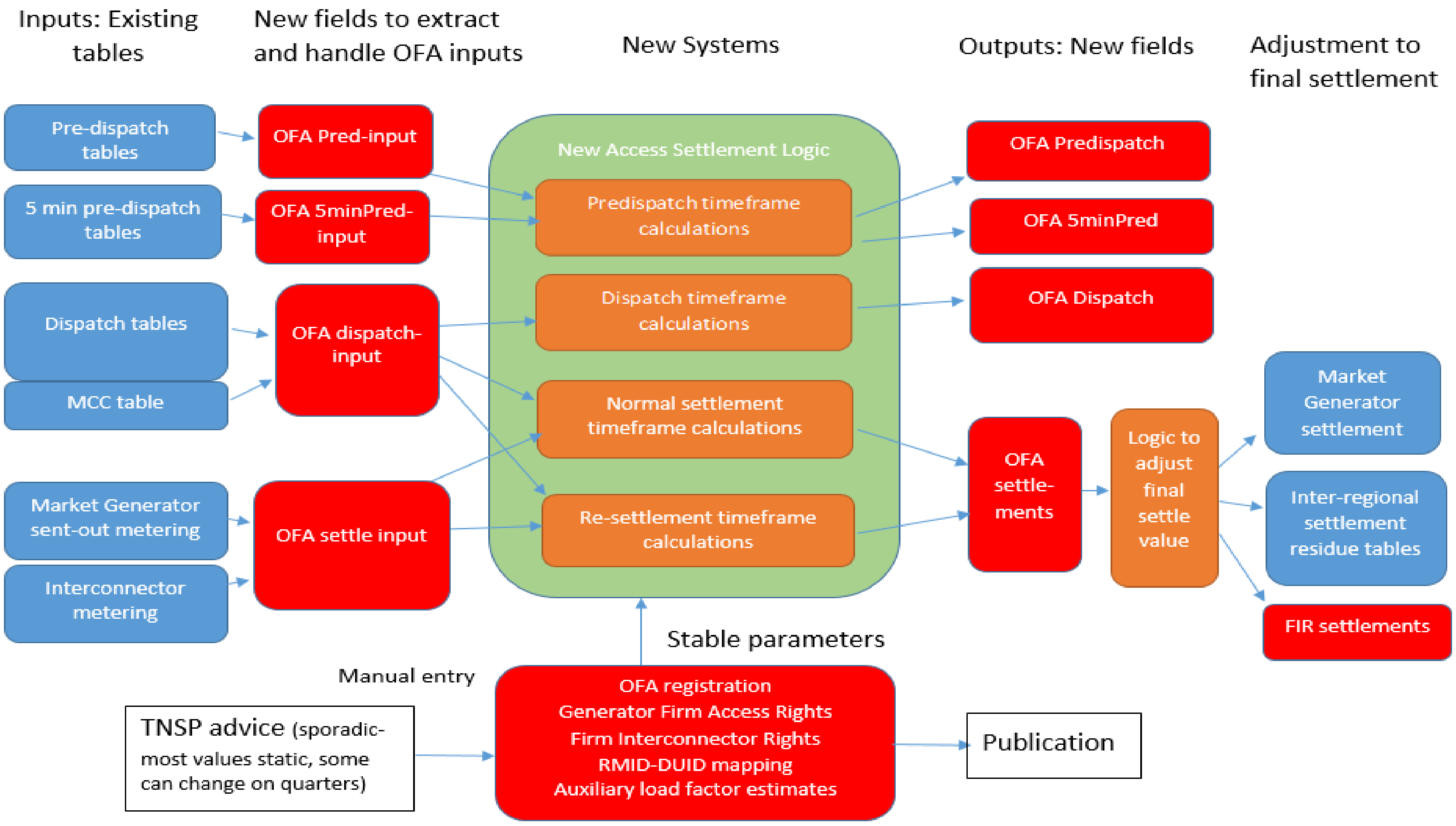
It is hoped these auctions' designs will progress during the remainder of the AEMC's project and AEMO will engage with AEMC on them and a view on their costs should emerge through that.

In the meantime, AEMO considers it reasonable to assume that the operating costs of these auctions would be no less than the operating costs of the existing SRA. For the purposes of estimating OFA transactional costs, at this time the saving of SRA retirement should not be netted off AEMO's total implementation costs.

Further, there is a yet uncosted build cost for both auctions. AEMO recommends that any preliminary OFA transactional cost estimates note this omission.

APPENDIX D. CONCEPT DESIGN FOR COSTING

This diagram identifies, at a conceptual level, those areas of AEMO's infrastructure to be affected by OFA operation. The general architecture of AEMO's Access Settlement Build is shown below (example for costing purpose only):



(Red=new fields, Blue=existing table, Brown=New process logic)

Assumed data inputs and outputs to be used

Function	Timeframe
Manage "fixed" OFA input quantities. (Equivalent to "registration" values for OFA). Includes access levels, RMID-DUID mapping, auxiliary load estimates.	Used in all timeframes. Values to be manually entered, changed ~ annually upon provision of external (TNSP) advice. ~10 values per DUID.
Forecast Access settlement in pre-dispatch.	Pre-dispatch timeframes. Logic run immediately after half hourly pre-dispatch. (Not sensitivities).
Forecast Access settlement in 5-minute pre-dispatch.	5-minite pre-dispatch timeframes. Run immediately after 5-minute dispatch.
Estimate Access settlement in real-time	Real-time 5-minute dispatch. One calculation run immediately after NEMDE executes.
Access Settlement Processing	Processing for preliminary statement, Processing for final statement.
Access Settlement Resettlement Processing	Twenty week revision, thirty week revision.

Access settlement logic (for the purpose of visualising build, test and procedural complexity)

Condition	Process logic	Notes
1. "Normal" pricing conditions	Standard access settlement formula	Uses constraint marginal prices (MCC table), RRP, fixed values, actual sent-out generation (estimated sent-out if not yet available). Will require a simple goal-seek/LP.
2. Released over-constrained dispatch	Standard access settlement using new RRP	As above
3. Rejected RRP due to manifestly incorrect inputs	Standard access settlement using new RRP	As above
4. Intervention pricing	Standard access settlement using what-if RRP not ROP	As above, using what-if marginal prices
5. Mandatory restriction pricing	Standard access settlement using RRP not ROP	As above
6. LMP scaling: occurs when an LMP (i.e., RRP - constraint penalty$/gen coefficient) would be below -$1,000	Access settlements scaled back to bring lowest LMP to -$1,000	Requires additional "goal-seek"/LP.
7. Administered pricing	Regional Scaling factor to be applied to all access settlements in order to sum payments to zero	Scaling factor equation is linear
8. Over-constrained flowgate (constraint) price failed to release in first MCC run	MCC manual release to be performed prior to final statement	Not a new process-an acceleration of existing MCC manual relaxation timetable

Condition	Process logic	Notes
9. Detect and resolve residual negative inter-regional residue	Adjust existing settlement mechanism to detect and recover negative inter-regional residue but calculation to be performed after access settlement payments	Adjustment to existing process. Access settlement intends to fund negative inter-regional residues directly, but in very exceptional circumstances, a negative inter-regional residue may remain even after access settlement.

APPENDIX E. ACCESS SETTLEMENT MODELLING RUNS

E.1 Background

AEMO's access settlement test environment uses the Dispatch and Training simulator (DTS) to model the market and power system and an access settlement adjustment model on an excel platform.

The following are simple half hourly examples derived from real historical events conceptually demonstrating the approach and some results.

The "back-cast" is a DTS run on actual events without changing any offers or other inputs. This back-cast results in slightly changed outcomes than actual dispatch due to the power system representation. The rebidding scenario incorporates the constrained generators had they offered consistent with SRMC.

Auxiliary loads and short-run-marginal-costs (SRMC) were selected from AEMO's National Transmission Network Development Plan (NTNDP) database, although some SRMCs were adjusted to be consistent with observed offers (i.e., plants were observed to be operating when regional prices were below the NTNDP SRMC). The access levels have been drawn from the transitional access allocation project performed by AEMO for AEMC in June 2014. All of these values have been used only for demonstrative purposes and should not be interpreted as real or preferred market outcomes.

The historical cases were chosen for evidence of:

- Congestion and generators bidding below SRMC.
- Stability, particularly in terms of intra-half-hour rebidding.
- Simplicity, but with progressively increasing complexity.

The stability and simplicity criteria were only observed in relatively low regional reference price congestion events. These cases therefore show relatively small value transfers and efficiency gains.

A key objective of this work is to identify anomalies and to use the model as a basis for analysing more intricate dispatch situations, and to more thoroughly test the marginal bidding incentives.

E.2 Case 1: Radial constraint affecting two competing plants

The constraint is named Q>NIL_TR_TX1_4 and constrained the combined-cycle gas turbine (CCGT) Condamine and the open-cycle gas turbine (OCGT) Roma power stations with equal unity participation factors during 16 January 2014. Both generators responded to the constraint by offering all capacity at prices at or near the market floor price[26]. The dispatched volume of the CCGT was observed to reduce in favour of the OCGT, contrary to the expected merit order.

[26] On 16 January 2014 the Condamine band one offer was close, but not equal to the market floor price after loss factor adjustment. This is an unusual situation as band one, including those at Condamine, are usually offered at the floor. The situation appears to result from an unintentional misunderstanding about the current loss factor. The unusual offer does not undermine the example, nothing that were it at the floor price, the efficiency gain from SRMC bidding would be slightly less.

Figure 5 Generators involved in Q>NIL_TR_TX1_4 constraint 14:30 16/1/2014

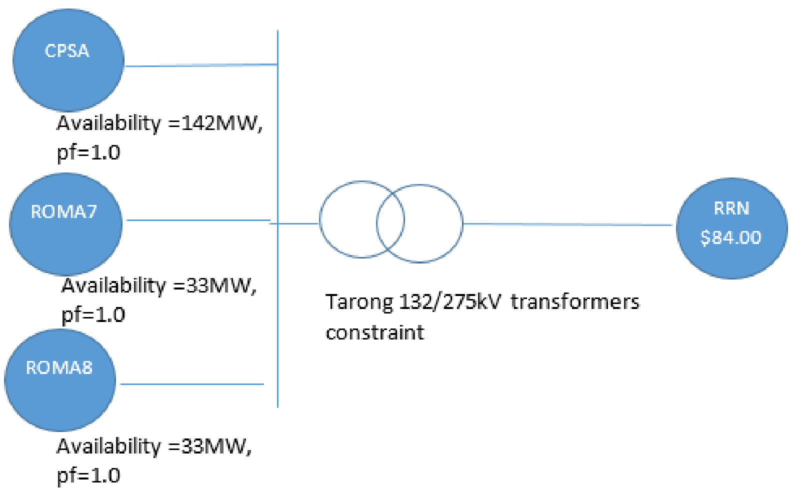


Table 5 Back-cast of the trading interval 14:30. Current settlements

Gen	MLF	Aux load	Bid /MLF ($/MWh)	As gen dispatch (MWhh[27])	Sent-out dispatch (MWhh)	Sent-out *MLF[28] (MWhh)	Trading Amount ($)[29]	SRMC[30] ($/MWh) Sent-out	Margin ($)
CPSA	0.9543	3%	-$932.10	115.80	112.3	107.17	$4,501.14	$18.77	$3,446.99
ROMA7	0.9188	3%	-$1,000	33.18[31]	32.2	29.585	$1,242.78	$55.15	$354.74
ROMA8	0.9188	3%	-$1,000	33.18	32.2	29.585	$1,242.78	$55.15	$354.74
Total:				33.18		166.34	$6,986.70		$4,156.47

Qld RRP $84.00. Total generator input costs $2,830.20

Table 6 Settlement outcomes were access settlement applied to back-cast

Gen	Access level S/O[32] (MW)	Avail-ability @RRN (MW)	Firm ent. (MW) RRN	Non-firm ent. (MW)	Entitle-ment less usage (MW)	Access Settlement ($)	Total revenue ($)	Margin ($)
CPSA	98.6	131.41	94.09	17.49	4.42	$2,244.83	$6,745.97	$5,692
ROMA7	27.5	29.40	25.27	1.94	-2.38	-$1,209.20	$33.58	-$854
ROMA8	28.2	29.40	25.91	1.64	-2.04	-$1,035.63	$207.15	-$681
Total:	154.3	190.21	145.27	21.07	0.0	$0.00	$6,986.70	$4,157.00

Flowgate effective capacity 166.34MW. Flowgate price =$1,016.10.

Bidding at -$1,000 results in negative margin for Roma.

27 "MWhh" = "Megawatthalfhour", i.e., 5-minute values averaged over a TI.
28 Sent-out quantities are currently not published. To avoid disclosing data, this sent-out figure has been derived from as gen figures (shifted 5 minutes) and NTNDP auxiliary load factors.
29 Modelled back-cast settlement. Results may not exactly match due to rounding.
30 CPSA SRMC from NTNDP assumptions data, expressed at unit, sent-out. Roma SRMC slightly reduced from NTNDP assumptions data in order to keep below regional price.
31 The DTS simulated a small quantity of non-conformance resulting in these units' measured outputs exceeding availability, possibly caused by modelled frequency response.
32 Indicative sent-out access levels from demonstration run of Transitional Access as performed for AEMC first interim report.

Table 7 Dispatch outcome were both stations offering at SRMC. Current settlement

Gen	MLF	Aux load	Bid /MLF ($/MWh)	As gen dispatch (MWhh)	Sent-out dispatch (MWhh)	Sent-out*MLF (MWhh)	Trading Amount ($)	SRMC ($/MWh) Sent-out	Margin ($)
CPSA	0.9543	3%	$19.67	140.05	135.80	129.59	$5,442.78	$18.77	$4,168.11
ROMA7	0.9188	3%	$60.02	20.58	20.00	18.38	$771.96	$55.15	$220.35
ROMA8	0.9188	3%	$60.02	20.58	20.00	18.38	$771.96	$55.15	$220.35
Total:				181.21		166.35	$6,986.70		$4,608.81

RRP $84.00.

Table 8 Outcomes were both stations offering at SRMC. Access settlement

Gen	Access level S/O (MW)	Avail-ability @RRN (MW)	Firm ent. RRN (MW)	Non-firm ent. RRN (MW)	Ent. less usage (MW)	Access Settlement ($)	Total revenue ($)	Margin ($)
CPSA	98.6	131.41	94.09	17.50	-18.00	-$215.84	$5,226.94	$3,952.27
ROMA7	27.5	29.40	25.27	1.94	8.83	$105.87	$877.83	$326.22
ROMA8	28.2	29.40	25.91	1.64	9.17	$109.97	$881.93	$330.31
Total:	154.3	190.211	145.27	21.08	0.0	$0.00	$6,986.70	$4,608.80

Flowgate effective capacity slightly increases to 166.35 MW due to re-dispatch. Flowgate price $23.98. Total generator input costs = $2,377.90. All generators' margins positive.

E.2.1 Marginally changed offer prices

As discussed in the Transmission Frameworks Review-Technical Report section 11.5.4, in this situation of a pair of generators facing a radial constraint a theoretical incentive exists to bid away from marginal cost, depending on whether the generators' are "access short" or "access long"[33]. In submission Stanwell encouraged AEMO to explore this incentive.

In the 16 January 2014 case, the incentive is quite simple and clear. As long as the offer price of Roma is higher than Condamine, dispatch will result in Roma being access long and Condamine access short. Within that dispatch result, there is an incentive for Condamine to structure ifs offer in order to ease the flowgate price and similarly for Roma to exaggerate the flowgate price.

For example, were Roma to reduce its offer price from $60.02 to $21.00 (@RNN), i.e. slightly higher than Condamine's $19.67 and Condamine remained unchanged, then dispatch would be unchanged but the access settlement in Table 8 would change to the result in shown in Table 9. By doing this Roma has gained $351.16 of Condamine's access settlement, consistent with the value predicted by Stanwell.

Table 9 Outcomes with Roma shawdowing Condamine. Access settlement

Gen	Total revenue ($)	Margin ($)
CPSA	$4,875.73	$3,601.06
ROMA7	$1,050.11	$498.49
ROMA8	$1,060.87	$509.25
Total:	$6,986.71	$4,608.80

Flowgate price $63.00

Whilst Roma has an incentive to exaggerate the flowgate price by lowering its offer to just above Condamine's, Condamine also has an incentive to ease the flowgate price by raising its offer to just below Roma's. However this

[33] "Access short" is used in the context as that term is used in elsewhere in the Technical Report, meaning generating above the firm access level. The term "short" is used in 11.5.4 of that report with an opposite meaning.

incentive changes should the offer prices cross, which would reverse the dispatch in the flowgate and reverse which party is access long and access short.

There is no single nash equilibrium to this game. The offers could rest anywhere in a space defined by the following:

- Greater or equal to the cheapest generator's SRMC.
- Less than or equal to the most expensive generator's SRMC.
- The more expensive generator's offer being at least one cent higher than the cheapest generator.

Generators are limited to 10 pricing bands, so in practice there would be a finite number of combinations that meet these criteria. All those combinations are equally efficient as dispatch will not change.

E.2.2 Changed dispatch scenarios

Stanwell postulated that in the Table 9 scenario, "Condamine would then be incentivised to reduce output slightly to reinstate its margin - either by raising the local price or unbinding the constraint..at which point Roma would be incentivised to generate more, creating an iterative positioning process."

Rebidding some of Condamine's capacity into higher priced bands such that its physical output fell 10MW, the flowgate price would remain at $63.00, but Condamine's dispatch would fall and Roma's increase.

Table 10 Outcomes with slightly reduced Condamine dispatch but maximum flowgate price.

Gen	As gen dispatch (MWhh)	Sent-out*MLF (MWhh)	Ent. less usage (MW)	Trading Amount ($)	Access Settlement ($)	Total revenue ($)	Margin ($)
CPSA	130.05	120.34	-8.80	$5,054.28	-$277.26	$4,777.02	$3,593.34
ROMA7	25.77	22.97	4.23	$964.74	$133.24	$1,097.98	$408.61
ROMA8	25.77	22.97	4.57	$964.74	$144.02	$1,108.76	$419.40
Total:	181.59	166.28	0.0	$6,983.76	$0.00	$6,983.76	$4,421.35

Thus a marginal reduction in output that failed to change the flowgate price would penalise Condamine.

Condamine would need to reduce its output by at least 23.92MW to bring Roma to full its full available capacity in order to affect the flowgate price. At which time the constraint would unbind and no access settlement would occur.

Table 11 Outcomes with Condamine dispatch reduced sufficiently to just relieve constraint

Gen	As gen dispatch (MWhh)	Sent-out*MLF (MWhh)	Trading Amount ($)	Margin ($)
CPSA	116.13	107.45	$4,512.90	$3,456.00
ROMA7	33.00	29.40	$1,234.80	$352.46
ROMA8	33.00	29.40	$1,234.80	$352.46
Total:	182.13	166.25	$6,982.50	$4,160.92

Thus a further reduction in output in order to just unconstrain the flowgate would also penalise Condamine. Roma's margin has reduced from the shadowing case but has increased from the SRMC case. Roma may choose to leave its position unchanged, in which case it seems likely Condamine would revert to the SRMC offer of Table 9.

Alternatively, Stanwell anticipated the game beginning with Roma shadowing Condamine with a shadow priced band volume of only 21MW per unit rather than full capacity, followed by Condamine progressively reducing its volume and Roma increasing its until an equilibrium was reached near access neutrality. To consider whether individual margins optimise at access neutrality, Roma units' dispatch was increased to 30MW and 31MW.

Table 12 Outcomes with maximum flowgate price and dispatch at access neutrality

Gen	As gen dispatch (MWhh)	Sent-out*MLF (MWhh)	Ent. less usage (MW)	Trading Amount ($)	Access Settlement ($)	Total revenue ($)	Margin ($)
CPSA	120.95	111.94	-0.36	$4,701.48	-$11.28	$4,690.20	$3,589.14
ROMA7	30.00	26.74	0.47	$1,123.08	$14.73	$1,137.81	$335.30
ROMA8	31.00	27.66	-0.11	$1,161.72	-$3.45	$1,158.27	$328.15
Total:	181.95	166.34	0.0	$6,986.28	$0.00	$6,986.28	$4,252.59

Roma’s margin is lower at access neutrality than the unbound case, so there does not appear to be an equilibrium at access neutrality.

E.2.3 Changed access scenarios

Stanwell proposed that if Roma held more firm access it would strengthen the benefit of an increased flowgate price such that it would be optimal for it to change its offer such that it increased dispatch to full output, against the efficient merit order. This was tested by increasing Roma’s firm access to 64MW sent out and commensurately reducing Condamine’s (loss factor adjusted).

Table 13 Outcomes were both stations offering at SRMC with greater access level at Roma and lower at Condamine

Gen	Access level S/O (MW)	Firm ent. RRN (MW)	Non-firm ent. RRN (MW)	Ent. less usage (MW)	Access Settlement ($)	Total revenue ($)	Margin ($)
CPSA	90.70	86.56	20.99	-22.05	-$264.40	$5,178.38	$3,903.71
ROMA7	32.00	29.40	0.00	11.03	$132.20	$904.16	$352.54
ROMA8	32.00	29.40	0.00	11.03	$132.20	$904.16	$352.54
Total:	154.7	145.36	20.99	0.01	$0.00	$6,986.70	$4,608.79

Flowgate price $23.98.

Then Roma’s dispatch was increased to full output and Condamine’s commensurately reduced, and flowgate price adjusted to $63 as a result of Roma’s changed offer.

Table 14 Outcomes with high access level and increased dispatch at Roma

Gen	As gen dispatch (MWhh)	Sent-out*MLF (MWhh)	Ent. less usage (MW)	Access Settlement ($)	Total revenue ($)	Margin ($)
CPSA	116.13	107.45	0.00	$0.00	$4,512.90	$3,456.00
ROMA7	33.00	29.40	0.00	$0.00	$1,234.80	$352.46
ROMA8	33.00	29.40	0.00	$0.00	$1,234.80	$352.46
Total:	182.13	166.25	0.0	$0.00	$6,982.50	$4,160.92

Flowgate price $63.00.

Whilst dispatch is less efficient, the margin loss has been absorbed by Condamine rather than Roma. Condamine would not respond by offering a lower price, as any additional output would be non-firm and locally priced. This outcome partially confirms Stanwell’s concern that a radially congested generator with a high access level would not suffer a disincentive in offering up to that volume at a price below its SRMC and causing inefficient dispatch.

This example presents a potentially realistic situation worth of further exploration. It seems likely that an OCGT would seek a level of firm access close to capacity whilst a wind farm may rationally choose a lower level of firm access. If the two stations were to share a congested radial constraint, the above example suggests the OCGT may be immune from offering at a price that leads to inefficient dispatch.

E.2.4 Observations

This case involves a simple radial constraint with three generators. Total flowgate capacity exceeds firm entitlements, so some non-firm entitlement is distributed according to availability shares.

Roma's profitability in Table 7 is less than Table 5, demonstrating that its bidding at floor price is rational in current arrangements.

However Roma's profitability in Table 8 is greater than Table 6 demonstrating that, in the presence of access settlement, offering at SRMC is rational for the generators. As a result of the restoration of an efficient merit order, total industry cost is reduced by $452.30.

As demonstrated in Table 9, if one generator offer is held constant, there is an incentive for the other generator to shadow its offer, but not cross to its offer. The game theory outcomes of this scenario are indeterminate, within an efficient dispatch space.

The observation that the individually optimal ourcomes seem to result in efficient dispatch may appear to contradict section 11.5.4 of the Transmission Frameworks Review Technical Report, but that analysis assumed each generator could unilaterally adjust the flowgate price to a specific optimum, which is rarely the case in realistic scenarios.

The examples appear to confirm Stanwell's view that a firm, high SRMC generator can offer below a non-firm low SRMC generator without penalty.

E.3 Case 2: Hazelwood-Jeeralang No. 4 220kV line affecting five competing units

V>V_NIL_RADIAL_9 manages thermal overload on the Hazelwood to Jeeralang No4 220kV line. Network topology in the area is complex and configurable. The configuration chosen on the day lead to Hazelwood unit 6 and Yallourn unit 1 having participation factors of 1.0. No other Hazelwood or Yallourn units are included in the constraint. Generators at Morwell and Bairnsdale had various participation factors.

During the trading interval ending 29/8/2014 15:00, all operating generators were offering at the price floor or using a zero ramp rate, which gives the unit an effective offer below the price floor. Bairnsdale unit 2 was offered at market floor price prior to the congestion emerging, therefore it is presumed the offer strategy for this unit was not caused by the congestion and the access settlement offers are unchanged. The same approach was taken for Morwell units 1 and 2.

This case demonstrates units with various participation factors. Also several units were not operating, but have been allocated firm access through the test allocation methodology and will therefore receive some access settlement benefit.

Figure 6 Generators involved in V>V_NIL_RADIAL_9 constraint 15:00 29/8/2014

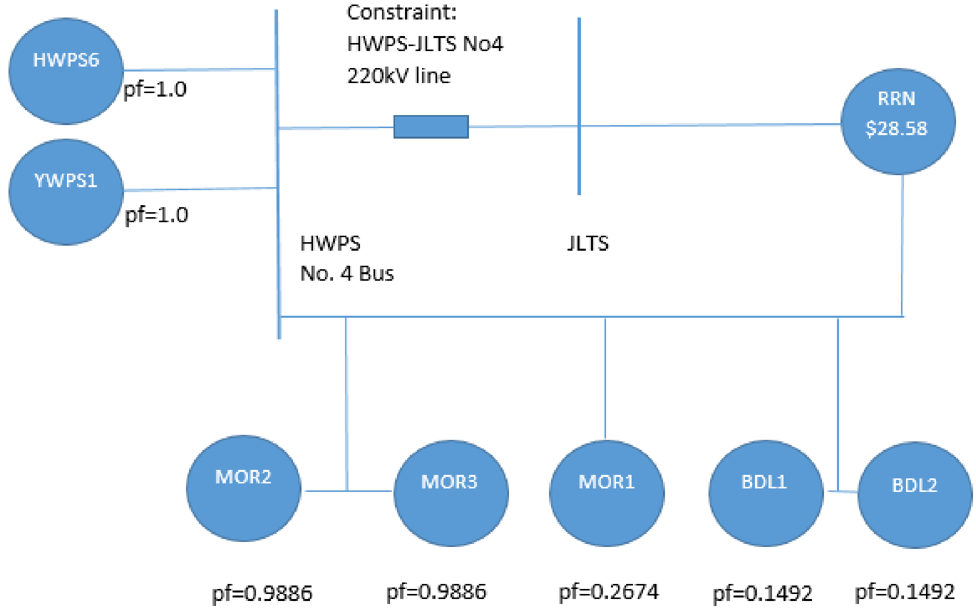


Table 15 Back-cast with unchanged offers and existing settlements

Gen	MLF	Aux load	Bid /MLF ($/MWh)	As gen dispatch (MWhh)	Sent-out dispatch (MWhh)	Sent-out*MLF (MWhh)	Trading Amount ($)	SRMC ($/MWh) Sent-out	Margin ($)
BDL1	1.0320	3%	N/A	0.00	0.00	0.00	$0.00	$76.49	$0.00
BDL2	1.0320	3%	-$1,000	43.91	42.60	43.86	$628.19	Fixed[34]	$0.00
HWPS6	0.9691	10%	-$1,000	200.85	180.80	174.53	$2,503.75	$13.36	$1,296.03
MOR1	0.9682	15%	Zero ROC	44.12	37.50	35.73	$518.87	$11.12	$310.36
MOR2	0.9698	15%	Zero ROC	19.02	16.20	15.32	$224.50	$11.12	$134.43
MOR3	0.9698	15%	N/A	0.00	0.00	0.00	$0.00	$11.12	$0.00
YWPS1	0.9538	8%	-$1,000	370.28	340.70	324.77	$4,643.68	$13.54	$2,337.14
Total:				678.18		594.21	$8,518.99		$4,077.96

Table 16 Settlement outcomes were access settlement applied to back-cast.

Gen	Access level S/O (MW)	Firm Target (MW)	Entitle-ment (MW)	Usage (MW)	Entitle-ment less usage (MW)	Access Settlement ($)	Total revenue ($)	Margin ($)
BDL1	43.4	6.68	6.04	0.00	6.04	$3,095.84	$3,095.84	$3,095.84
BDL2	45.5	7.01	6.33	6.56	-0.23	-$117.53	$510.65	-$117.44
HWPS6	201.6	195.37	176.53	175.21	1.31	$673.03	$3,176.78	$1,969.06
MOR1	70.6	18.28	16.52	9.71	6.81	$3,489.91	$4,008.77	$3,800.26
MOR2	27.0	25.89	23.39	15.53	7.86	$4,028.85	$4,253.35	$4,163.28
MOR3	56.3	53.98	48.77	0.00	48.77	$25,006.53	$25,006.53	$25,006.53
YWPS1	295.2	281.56	254.40	324.96	-70.56	-$36,176.63	-$31,532.95	-$33,839.49

[34] This unit was bidding at floor price outside the congested period, so it has been assumed that this was not motivated by the congestion. Its NTNDP SRMC is higher than RRP so this is considered not relevant to the demonstration. For the purpose of this exercise, it has been given an SRMC equivalent to RRP to demonstrate changes in margin caused by access settlement.

Gen	Access level S/O (MW)	Firm Target (MW)	Entitle-ment (MW)	Usage (MW)	Entitle-ment less usage (MW)	Access Settlement ($)	Total revenue ($)	Margin ($)
Total:	739.6	588.77	531.98	531.97	0.0	$0.00	$8,518.97	$4,078.0404

Flowgate effective capacity 531.98 MW. Flowgate price = $1,025.47. Total generator input costs = $4,440.94

Table 17 Dispatch outcomes with SRMC offers and existing settlements

Gen	MLF	Aux load	Bid /MLF ($/MWh)	As gen dispatch (MWhh)	Sent-out dispatch (MWhh)	Sent-out*MLF (MWhh)	Trading Amount ($)	SRMC ($/MWh) Sent-out	Margin ($)
BDL1	1.0320	3%	N/A	0.00	0.00	0.00	$0.00	$76.49	$0.00
BDL2	1.0320	3%	-$1,000	43.84	42.50	43.86	$626.76	Fixed	$0.09
HWPS6	0.9691	10%	$13.79	200.15	180.10	174.53	$2,494.03	$13.36	$1,291.00
MOR1	0.9682	15%	Zero ROC	43.40	36.9	35.73	$510.58	$11.12	$305.40
MOR2	0.9698	15%	Zero ROC	18.63	15.80	15.32	$218.92	$11.12	$131.09
MOR3	0.9698	15%	N/A	0.00	0.00	0.00	$0.00	$11.12	$0.00
YWPS1	0.9538	8%	$14.19	370.09	340.50	324.77	$4,640.96	$13.54	$2,335.77
Total:				676.11		594.21	$8,491.25		$4,063.35

RRP = $28.58

Table 18 Settlement outcomes were access settlement applied to SRMC offers

Gen	Access level S/O (MW)	Firm Target	Scaled Entitle-ment (MW)	Usage (MW)	Entitle-ment less usage (MW)	Access Settlement ($)	Total revenue ($)	Margin ($)
BDL1	43.4	6.68	6.02	0.00	6.02	$30.41	$30.41	$30.41
BDL2	45.5	7.01	6.31	6.54	-0.23	-$1.17	$625.59	-$1.07
HWPS6	201.6	195.37	176.05	174.53	1.52	$7.67	$2,501.70	$1,298.67
MOR1	70.6	18.28	16.47	9.55	6.92	$34.93	$545.52	$340.33
MOR2	27.0	25.89	23.33	15.15	8.18	$41.30	$260.22	$172.39
MOR3	56.3	53.98	48.64	0.00	48.64	$245.63	$245.63	$245.63
YWPS1	295.2	281.56	253.72	324.77	-71.05	-$358.78	$4,282.18	$1,976.99
Total:	739.6	588.77	530.54	530.54	0.0	($0.01)	$8,491.25	$4,063.35

Flowgate effective capacity 530.54 MW. Flowgate price = $10.10. Total generator input costs = $4,427.91

E.3.1 Observations

The case demonstrates that access settlement will redistribute congestion rents according to whether the individual units are access short (e.g. YWPS1) or long (e.g. MOR3). As per the design, access settlement payments may be earned non-operating units, demonstrating that the non-operating units do not need to inefficiently start in order to benefit. Access payments are scaled by the units' participation factors, with small access settlement for BDL1, BDL2 and MOR1. The flowgate's effective capacity of 531 MW was less than the target firm entitlements of 589 MW, so all firm entitlements were scaled back.

The large flowgate price in Table 16 is an expected outcome of the floor price offers. This in turn provoked large access settlement payment, including a large negative margin incurred by YWPS1 indicating that these offers would not have been stable were access settlement in place. With bidding at SRMC, the flowgate price falls to a small quantity, and access settlement become much smaller, and therefore margins in Table 18 are relatively similar to those in Table 8: the status quo.

In this case, the back-cast merit order was close to the efficient merit-order, and so offers at SRMC made negligible difference to total industry cost.

E.4 Case 3: South-East South Australian constraints affecting units in loop and interconnector in opposing directions

The complex parallel 132 kV and 275 kV networks in South-East South Australia create multiple constraints on the Heywood Interconnector and the generators connected to the 132 kV. These units can be simultaneously constrained by two constraints in which the interconnector is constrained in opposite directions. This case demonstrates such an example in system normal.

The first constraint manages the flow on the SESS 275/132 kV transformers. This flow reduces for more westerly flow on the Victoria to South Australia interconnector at Heywood. The second constraint manages an overload (western direction) on the Snuggery-Keith 132kV line upon the contingent loss of the Penola West-Kincraig 132 kV line. This flow reduces for more easterly flow in the interconnector. Both flows are reduced by reducing generation at each of Lake Bonny, Ladbroke and Snuggery.

The half hour modelled ends 13:30 20 Dec 2013. The binding constraints were S>>V_NIL_SETX_SETX (flowgate 1) and V>>S_NIL_PWKN_SGKH (flowgate 2) in the base case and S>>V_NIL_SETX_SETX (flowgate 1) and V>>S_NIL_SETB_SGKH (flowgate 2) in the SRMC re-run. In this example, both directional FIRs on the Heywood Interconnector have been assessed with an access level of zero.

Figure 7 Generators and Interconnector involved flowgate 1 and flowgate 2 13:30 20 Dec 2013

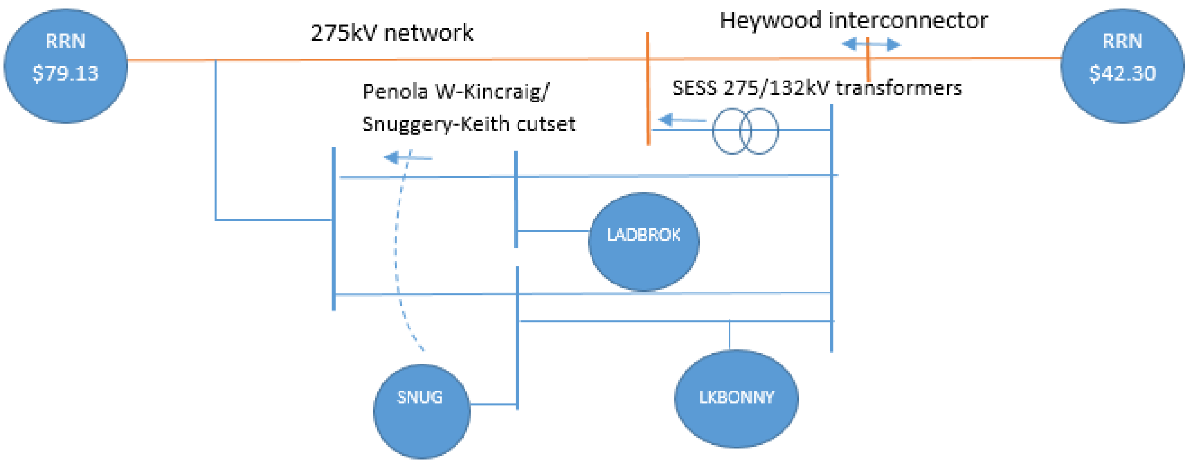


Table 19 Back-cast with unchanged offers and existing settlements

Gen	MLF	Aux load	Bid /MLF ($/MWh)	As gen dispatch (MWhh)	Sent-out dispatch (MWhh)	Sent-out*MLF (MWhh)	Trading Amount ($)	SRMC[35] ($/MWh) Sent-out	Margin ($)
LADBROK1	0.9674	3%	-$1,000	37.02	35.90	34.73	$1,374.09	$70	$117.58
LADBROK2	0.9674	3%	-$1,000	37.02	35.90	34.73	$1,374.09	$70	$117.58
LKBONNY2	0.9426	0	-$1,000	105.75	105.80	99.73	$3,945.82	-$28	$5,427.06
LKBONNY3	0.9426	0	-$997.67	0.00	0.0	0.0	$0.00	-$8	$0.00
SNUG1	0.9579	3%	$13,098.80	0.00	0.0	0.0	$0.00	$505.33	$0.00

35 SRMC's chosen for demonstration purposes only. Interconector SRMC = Difference between regional prices.

Gen	MLF	Aux load	Bid /MLF ($/MWh)	As gen dispatch (MWhh)	Sent-out dispatch (MWhh)	Sent-out*MLF (MWhh)	Trading Amount ($)	SRMC[35] ($/MWh) Sent-out	Margin ($)
Heywood (east)		0	N/A			0.00	0	-$36.83	$0.00
Heywood (west)			N/A	19.33	19.33	19.33	$355.96[36]	$36.83	$355.96
Total:				199.12		188.52	$7,049.96		$6,018.18

Total generator input costs = $1,031.78

Table 20 Settlement outcomes were access settlement applied to back-cast flowgate 1

Gen	Access level S/O (MW)	Avail-ability @RRN (MW)	Partic-ipation factor	Entitle-ment (MW)	DIC[37] usage (MW)	Entitle-ment less usage (MW)	Access Settlement ($)
LADBROK1	42.7	34.73	0.9624	22.55		-10.87	-$3,740.72
LADBROK2	42.5	34.73	0.9624	22.44		-10.98	-$3,777.06
LKBONNY2	137.2	149.87	1.0000	73.36		-26.37	-$9,071.80
LKBONNY3	33.6	36.76	1.0000	17.96		17.96	$6,180.08
SNUG1	47.8	50.19	1.0000	25.97		25.97	$8,934.60
Heywood (e)	0	N/A	-0.2218	0.00	-4.29	4.29	$1,474.91
Total:				162.28		0.0	$0.01

Flowgate effective capacity 162.28 MW. Flowgate price $688.02. SA price $79.13, Vic Price $42.30. DICe usage payment= -$1,474.91[38]

Table 21 Settlement outcomes were access settlement applied to back-cast flowgate 2

Gen	Access level S/O (MW)	Avail-ability @RRN (MW)	Partic-ipation factor	Entitle-ment (MW)	DIC usage (MW)	Entitle-ment less usage (MW)	Access Settlement ($)
LADBROK1	42.7	34.73	0.6887	16.94		-6.98	-$1,365.40
LADBROK2	42.5	34.73	0.6887	16.86		-7.06	-$1,380.91
LKBONNY2	137.2	149.87	1.0000	76.99		-22.74	-$4,446.42
LKBONNY3	33.6	36.76	1.0000	18.85		18.85	$3,687.11
SNUG1	47.8	50.19	0.9996	27.25		27.25	$5,328.37
Heywood (w)	0	N/A	0.4822	0.00	9.32	-9.32	-$1,822.75
Total:	303.8			156.88		0.0	($0.00)

Flowgate effective capacity 156.88 MW. Flowgate price $391.11. SA price $79.13, Vic Price $42.30. DICw usage payment = $1,822.75

Table 22 Interconnector payments: Heywood Interconnector

IRSR ($)	FIR east ($)	FIR west ($)	Flowgate 1 usage	Flowgate 2 usage	Total imbalance	Paid to Importing TNSP
$355.96	0	0	-$1,474.91	+$1,822.75	+$8.12	SA

[36] This quantity is the existing inter-regional settlement residue IRSR estimated to be attributable to the Heywood Interconnector (i.e., residue associated with Murraylink is excluded).
[37] Directional Interconnector (DIC) as defined in the Transmission Frameworks Review.
[38] Note-this is offset by the positive access settlement payment because FIRs=0.

In this example DIC East and DIC West have zero FIR entitlements. Payments to TNSPs are expected to remain non-zero due to marginal loss factor pricing. The imbalance is settled with the (physically measured) importing TNSP.

Table 23 Total margin outcomes were access settlement applied to back-cast flowgate 1 & 2 combined

Gen	Existing Settlement ($)	Access Settlement (1) ($)	Access Settlement (2) ($)	To net DIC Usage ($)	Total revenue ($)	Margin ($)
LADBROK1	$1,374.09	-$3,740.72	-$1,365.40		($3,732.03)	-$4,988.54
LADBROK2	$1,374.09	-$3,777.06	-$1,380.91		($3,783.88)	-$5,040.39
LKBONNY2	$3,945.82	-$9,071.80	-$4,446.42		($9,572.40)	-$8,091.16
LKBONNY3	0	$6,180.08	$3,687.11		$9,867.19	$9,867.19
SNUG1	0	$8,934.60	$5,328.37		$14,262.97	$14,262.97
Heywood (W-ENet)	$355.96	0	-$1,822.75	-$347.84	$8.12	$8.12
Heywood (E-AEMOV)	$0.00	$1,474.91			$0.00	$0.00
Total:	$7,049.96	$0.01	($0.00)		$24,138.287	$6,018.199

Negative margins earned by first three generators suggest existing bidding strategy not supported.

Table 24 Dispatch at SRMC offers with existing settlements

Gen	MLF	Aux load	Bid /MLF ($/MWh)	As gen dispatch (MWhh)	Sent-out dispatch (MWhh)	Sent-out*MLF (MWhh)	Trading Amount ($)	SRMC ($/MWh) Sent-out	Margin ($)
LADBROK1	0.9674	3%	$72.36	0.00	0.00	0.00	0	$70	$0.00
LADBROK2	0.9674	3%	$72.36	0.00	0.00	0.00	0	$70	$0.00
LKBONNY2	0.9426	0	-$29.71[39]	146.10	146.10	137.71	$5,563.48	-$28	$7,608.83
LKBONNY3	0.9426	0	-$8.49	16.68	16.68	15.74	$635.90	-$8	$702.69
SNUG1	0.9579	3%	$13,098.80[40]	0.00	0.00	0.00	0	$505.33	$0.00
Heywood (e)		0	N/A			0.00	0	-$40.49	$0.00
Heywood (w)			N/A	12.67	12.67	12.67	$256.50	$40.49	$256.50
Total:				12.67		166.12	$6,455.88		$8,568.02

Vic price $40.31, SA price $80.80. Total generator input costs = -$2,112.14.

Table 25 Settlement outcomes were access settlement applied to SRMC rebid flowgate 1

Gen	Access level S/O (MW)	Avail-ability @RRN (MW)	Partic-ipation factor	Entitle-ment (MW)	DIC usage (MW)	Entitle-ment less usage (MW)	Access Settlement (incl. DIC usage) ($)
LADBROK1	42.7	34.73	0.9624	20.93		20.93	$116.91
LADBROK2	42.5	34.73	0.9624	20.83		20.83	$116.36
LKBONNY2	137.2	149.87	1.0000	68.09		-69.62	-$388.83
LKBONNY3	33.6	36.76	1.0000	16.68		0.93	$5.22
SNUG1	47.8	50.19	1.0000	24.11		24.11	$134.65
Heywood (east)	0	N/A	-0.2218	0.00	-2.81	2.81	$15.69
Total:				150.64		-0.01	$0.00

[39] NTNDP SRMCs of windfarms are typically negative due to the value of renewable energy certificates.
[40] Snuggery's rebid to SRMC was inadvertently omitted; however, this had no impact on re-dispatch outcomes.

Flowgate effective capacity 150.64 MW. Flowgate 1 price $11.17. DIC East usage payment = -$15.69.

Table 26 Settlement outcomes were access settlement applied to SRMC rebid flowgate 2

Gen	Access level S/O (MW)	Avail-ability @RRN (MW)	Partic-ipation factor	Entitle-ment (MW)	DIC usage (MW)	DIC usage payment ($)	Entitle-ment less usage (MW)	Access Settlement (inc DIC usage) ($)
LADBROK1	42.7	34.73	0.4353	11.88			11.88	$466.17
LADBROK2	42.5	34.73	0.4353	11.82			11.82	$463.98
LKBONNY2	137.2	149.87	1.0000	85.44			-52.27	-$2,051.14
LKBONNY3	33.6	36.76	1.0000	20.92			5.18	$203.39
SNUG1	47.8	50.19	0.9996	30.24			30.24	$1,186.57
Heywood (w)	0	N/A	0.4822	0.00	6.85	$268.97	-6.85	-$268.97
Total:	**303.8**			**160.30**			**0.0**	**($0.00)**

Flowgate effective capacity 160.30 MW. Flowgate 2 price $78.48. Vic price $40.31, SA price $80.80. DIC West usage payment $268.97.

Table 27 Interconnector Payments: Heywood interconnector

IRSR ($)	FIR east ($)	FIR west ($)	Flowgate 1 usage	Flowgate 2 usage	Total imbalance	Paid to Importing TNSP
$256.50	0	0	$15.69	-2	+$3.22	SA

In this example DIC East and DIC West have zero FIR entitlements. Payments to TNSPs are expected to remain non-zero due to marginal loss factor pricing. The imbalance is settled with the (physically measured) importing TNSP.

Table 28 Total margin outcomes were access settlement applied to SRMC rebid flowgate 1 & 2 combined

Gen	Existing Settlement ($)	Access Settlement (1) ($)	Access Settlement (2) ($)	To net DIC Usage ($)	Total revenue ($)	Margin ($)
LADBROK1	0	$116.91	$466.17		$583.07	$583.07
LADBROK2	0	$116.36	$463.98		$580.34	$580.34
LKBONNY2	$5,563.48	-$388.83	-$2,051.14		$3,123.51	$5,168.86
LKBONNY3	$635.90	$5.22	$203.39		$844.50	$911.30
SNUG1	0	$134.65	$1,186.57		$1,321.22	$1,321.22
Heywood (W-ENet)	$256.50	0	-$268.97	-$253.28	$3.22	$3.22
Heywood (E-AEMOV)	$0.00	$15.69	0		$0.00	$0.00
Total:	$6,455.88	$0.000	($0.00)		$6,455.8686	$8,568.0101

Total generator costs = -$2112.14. (Negative total cost due to REC value from wind generators).

9.2.1 Observations

This case demonstrates the allocation of directional interconnector access within flowgates that include interconnector terms. The polarity of the interconnector term in the constraint equation, and the sign of the RHS are used to determine which DIC is participating and whether it is a flowgate or flowgate support DIC. In this case both binding constraints have flowgate DICs but are different DICs.

The FIR allocations for both DICs in this case is zero. Therefore the IRSR attributed to the Heywood Interconnector is consumed within the access settlement equations and is distributed amongst the firm generators, leaving a small residue associated with loss factor pricing, which would be combined with any IRSR attributed to the Murraylink Interconnector (not shown) and settled with the net total importing TNSP.

In Table 19 all margins are positive, indicating with status quo settlements, floor price bidding is stable. The result however is that the wind generation is substantially constrained beneath its unconstrained capacity. The negative margins in Table 23 indicate that such bidding would be unstable with access settlement.

SRMC bidding in Table 28 shows all positive margins. The restoration of an efficient merit order made considerable reductions in generator costs as negative SRMC wind generation increased output.

MEASURES AND ABBREVIATIONS

Units of measure

Abbreviation	Unit of measure
kV	Kilovolt
MW	Megawatt
MWh	Megawatt hour
MWhh	Megawatt half hour

Abbreviations

Abbreviation	Expanded name
AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
DIC	Directional Interconnector
DTS	Dispatch and training Simulator
DUID	Dispatch Unit Identifier
FIR	Firm Interconnector Right
IRSR	Inter-regional Settlement Residue
MLF	Marginal Loss Factor
MNSP	Market Network Service Provider
NTNDP	National Transmission Network Development Plan
OFA	Optional Firm Access
RMID	Revenue Meter Identifier
SRA	Settlement Residue Auction
SRMC	Short-run Marginal Cost
TNSP	Transmission Network Service Provider

GLOSSARY

Term	Definition
access settlement	A new settlement process in the OFA model through which access-long generators and interconnectors receive payments and access-short generators amd interconnectors make payments.
Access long	A situation where a generator is has a greater level of access rights than its actual generation.
Access short	A situation where a generator has less access rights than its actual generation.
administered price cap	A temporary market price cap applied during administered pricing under clause 3.14 of the National Electricity Rules
availability	For a conventional generator, the offered availability; for an intermittent generator, the Unconstrained Intermittent Generation Forecast
congestion residue	A settlement surplus that accrues when electricity is transported across a priced network constraint. Distinguied from loss factor residue.
constrained off	(For a generator) dispatched below its preferred output.
constraint	A mathematical representation in NEMDE of a power system limit.
constraint RHS	Constraint Right-Hand-Side, the static part of the constraint equation
dispatch	The real-time process of determining the optimal pattern of generation to meet demand.
dispatch unit identifier	A registered identifier used for each dispatchable entity in the NEMDE
directional interconnector (DIC)	An individual dispatchable interconnector flowing in a specific direction as represented within a flowgate
firm access planning standard (FAPS)	The required level of network capacity TNSPs would plan to provide
firm interconnector	An interconnector for which AEMO holds some agreed access in trust.
firm interconnector right (FIR)	A right to receive a specified proportion of the IRSR proceeds of a firm interconnector.
flowgate	A point of potential congestion on the transmission network; the notional location on a transmission network represented in NEMDE by a transmission constraint
flowgate support generator	(With respect to a flowgate) a generator with a participation factor less than zero.
hedging	The use of financial derivatives to reduce commercial risks caused by spot market volatility.
hedging risks	Risk of the derivative position being unmatched to the physical due to being unable to transact the physical commodity.
interconnector	A notional entity that is dispatched by NEMDE to transfer power from one RRN to a neighbouring RRN across a regulated interconnector.
inter-regional access	Network access provided to a directed interconnector, from the RRN in the exporting region to the RRN in the importing region.
inter-regional settlement residue (IRSR)	The fund, held in trust by AEMO, into which, or from which, settlement payments relating to directed interconnectors are paid.
Intra-regional loss factor residue	The loss factor residue that emerges due to flows and pricing of losses within a region.
issuance	The process by which access rights are released.
local price	The marginal value that a generator at a node provides to economic dispatch; the locational marginal price
looped constraint	A constraint managing a meshed part of the network, characterised by different participation factors.
loss factor pricing	Adjustment of the geographical price of electricity according to marginal loss factors.
loss factor residue	The settlement surplus that emerges due to the pricing of marginal loss factors. Distinguished from congestion residue.
manifestly incorrect inputs	A situation where prices may be rejected due to a suspicion of manifestly incorrect inputs as described in clause 3.9.2B of the National Electricity Rules.
marginal loss factor (MLF)	A multiplier used to describe the marginal electrical energy loss for electricity used or transmitted.

Term	Definition
market floor price	A price floor on regional reference prices as described in clause 3.9.6 (of the NER)
market network service provicer (MNSP)	A network service provider who has classified any of its network services a s a market network service in accordance with Chapter 2 (of the NER) and who is also registered by AEMO as a market network service provider under Chapter 2 (of the NER).
market price cap (MPC)	A price cap on regional reference prices as described in clause 3.9.4 of the National Electricity Rules.
market suspension	The application of an administered price in the circumstance described in clause 3.14 of the National Electricity Rules.
mispricing	(In the current NEM design) a generator being settled at a price different to its local price
NEM participant fees	The fees collected by AEMO from NEM participants to cover its own costs of operating the NEM
NEMDE	National Electricity Market Dispatch Engine: The computer system through which AEMO dispatches scheduled plant in the NEM and sets market prices.
NEMDE Queue	An offline version of the NEMDE which can be used to simulate NEMDE outputs, using fixed power system inputs.
network congestion	When a transmission network cannot accommodate the dispatch of the least-cost combination of available generation to meet demand.
network support agreement (NSA)	An agreement between a network service provider and a market participant or any other person providing network support services to improve network capability by providing a non-network alternative to a network augmentation.
non-scheduled generator	A generator in respect of which any generating unit is classified as a non-scheduled generating unit in accordance with Chapter 2 of the National Electricity Rules. Unlike scheduled generators, these generators are not dispatched by NEMDE.
participation factor	The coefficient of a variable in a constraint equation
pre-dispatch	Forecast of dispatch performed one day before the trading day on which dispatch is scheduled to occur.
pricing model	The model which determines the price at which firm access can be procured or sold back to a TNSP
region	An area determined by the AEMC in accordance with Chapter 2A (of the NER), being an area served by a particular part of the transmission network containing one or more major load centres or generation centres or both.
regional reference price (RRP)	The price paid to a dispatched generator in regional settlement
regional reference node (RRN)	The node where the regional reference price is set.
revenue meter identifier (RMID)	A concept described in the AEMC first interim report on OFA to determine which meter would be used for access settlement quantities. In its Draft Report AEMC intend to rename this to access unit identifier (AUID)
scheduled generator	A generator in respect of which any generating unit is classified as a scheduled generating unit in accordance with Chapter 2 of the National Electricity Rules.
semi-scheduled generator	A generator in respect of which any generating unit is classified as a semi-scheduled generating unit in accordance with Chapter 2 of the National Electricity Rules.
settlement residue auction (SRA)	The auction through which AEMO sells SRA rights.
settlement residue committee	The committee tasked with overseeing the design of the settlement residue auction
shared access congestion pricing (SACP)	An alternative model to OFA where access rights are determined real-time pro-rata on bid availability
short-run marginal cost	Fuel costs and other costs that vary directly with dispatch volume
short-term firm access auction (STFA)	A two-way periodic auction whereby firm access can be traded subject to a simultaneous feasibility constraint modelling FAPS capacity
simultaneously feasible auction	An auction of access rights incorporating constraints representing the limits of the power system such that the total sale is simultaneously supportable by the physical power system.

Term	Definition
spot market	The physical market for electricity, as operated by AEMO. Distinguished from the financial markets for electricity derivatives.
SRA right	The right to receive a specified proportion of the inter-regional settlement residue for a specified directed interconnector
stability constraint	A power system limit that is not a thermal constraint and cannot be linked to a specific asset
stage one	The introduction of the access settlement part of the reform, which affects AEMO's systems and generator bidding incentives, but not the broader parts of the reform that affect TNSPs.
thermal constraint	A power system limit controlling the maximum current flow on a specific network asset
transitional access or transitional allocation	A level of firm access service that is allocated to existing generators at the commencement of the optional firm access regime and for which no access charge is payable