Experience with Market-Based Ancillary Services in the Australian National Electricity Market

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***Abstract*— electrical energy is transmitted from supply-side equipment to end-use equipment almost instantaneously and in accordance with physical laws. This is facilitated by the deployment of ancillary services that maintain the availability and quality of the electricity being supplied, thereby reducing the likelihood of an expensive supply interruption. Ancillary services play an important role in restructured electricity industries because they enable the commercial transactions of an electricity spot market to be implemented. In order to establish competitive arrangements for the sourcing, pricing, deployment and cost-recovery of ancillary services, issues including the formal specification of the services, the design of commercial decision-making mechanisms and the implementation of interfaces between commercial and technical processes must be addressed. This paper describes how these issues are addressed in the Australian National Electricity Market, reviews the outcomes to date and assesses the strengths and weaknesses of the arrangements.**

***Index Terms*— ancillary services, Australian National Electricity Market, electricity market, frequency control.**

I. Introduction

THE electricity industry has unique properties that distinguish it from other industries. Supply-side equipment converts various primary energy sources into electricity which is transmitted almost instantaneously to end-use equipment in accordance with physical laws. Since there are presently no cost-effective ways to store electrical energy, it is necessary to carefully manage the technical operation of the industry to ensure it remains within a satisfactory (secure) state. On short timescales, this is achieved through control actions that maintain the availability and quality of the electricity being supplied. Such control actions are broadly termed *ancillary services* and they play an important role in restructured electricity industries because they enable the commercial transactions of an electricity spot market to be implemented [1].

In order to establish competitive arrangements for ancillary services, it is necessary to address a number of issues, including the following:

- specification of the ancillary services, their role within the electricity industry and the principles used to source, price and recover their costs – this includes defining a boundary between the primary commodity, energy and ancillary services;
- defining and implementing decision-making responsibilities, accountabilities, mechanisms and rules to ensure that the arrangements encourage technical efficiency, allocative efficiency and dynamic efficiency [1];
- defining interfaces between commercial decision-making processes (e.g. an electricity spot market) and the corresponding technical processes that coordinate the delivery of ancillary services when they are required and that verify their delivery; and
- ensuring that market-based arrangements for ancillary services do not adversely affect other processes in the industry including existing electricity spot market arrangements or the operation of technical processes.

This paper describes how these issues are addressed in the Australian National Electricity Market (NEM), reviews the outcomes to date and assesses the strengths and weaknesses of the arrangements.

II. Key Design Choices for Market-Based Ancillary Services in the NEM

A. Overview of Australia's restructured electricity

Restructuring Australia's electricity industry began in 1991 [2] with a key point in the process being the commencement of the National Electricity Market in December 1998. Initially, ancillary services were not market-based and the system and market operator, NEMMCO[1], contracted market participants to provide frequency control services, network control services (management of voltage and network power flows) and system restart services. However, the National Electricity Rules (Rules) [15] (originally the National Electricity Code) which govern the NEM, put an obligation on NEMMCO to investigate a competitive framework for ancillary services [5]. To achieve this, NEMMCO established an industry working group (the Ancillary Services Reference Group [3]) to gain an industry wide consensus on a framework within which to implement

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market-based ancillary services.

This ultimately resulted in the integration of the frequency control ancillary services (FCAS) into the energy-only electricity spot market which commenced operation on 30 September 2001 [4]. The contracting regimes for the remaining ancillary services (network control and system restart) were maintained. The Rules define the key decision-making responsibilities for the management of ancillary services. The Australian Energy Market Commission (AEMC) (a regulatory body primarily concerned with NEM rule-making) is assigned the responsibility of specifying technical standards while NEMMCO is assigned the responsibility of operating the system in compliance with the standards. Other decision-making responsibilities for ancillary services in the NEM are summarized in Table I.

TABLE I
DECISION-MAKING RESPONSIBILITIES FOR ANCILLARY SERVICES

Organization	**decision-making responsibilities for ancillary services**
AEMC	• specify technical standards for the power system (including frequency standards); and • assesses NEMMCO's performance in operating the power system in conformance to the technical standards.
NEMMCO	• responsible for operating the power system in a secure, reliable manner and in conformance to the standards; • purchase sufficient ancillary services to satisfy technical standards, using resources in an efficient (least cost) manner; • monitor the technical performance of the power system and provision of ancillary services by providers; and • review the performance of ancillary services with a view to recommending improvements to the AEMC that will improve efficiency [16].
Market participants	• deliver the ancillary services that have been agreed upon either through contractual arrangements or through the electricity spot market when required.

The key features of Australian NEM include:

- scope covers the south-eastern states of Australia;
- the electricity spot market is operated on a 5-minute dispatch cycle and is an energy-only, regional gross-pool model which prices and dispatches both energy and FCAS;
- while a range of forward-looking processes are implemented to facilitate decision-making over a range of time horizons, only the 5-minute spot market prices have commercial significance;
- in particular, 5-minute spot prices for energy are averaged to produce 30-minute trading prices to be in alignment with past revenue metering practices while the 5-minute prices for FCAS are used directly in settlements [26];
- all prices (including FCAS) are capped at $10,000/MWh;
- market participants may revise the quantities of their bids and offers for energy and FCAS at any time prior to the calculation of electricity spot market dispatch and prices;
- participants hedge exposure to electricity spot market price risk using financial derivatives; and
- the inputs and outputs for all market processes including the 5-minute electricity spot-market are published either immediately following their calculation (such as prices, demand and power flows) or the following day (including participant bids, offers and dispatch targets).

B. Ancillary service definitions

Ancillary services are divided into the following categories [5], [9]:

- *Frequency Control Ancillary Services (FCAS).* These comprise market-based ancillary services for the 8 types of frequency control service that are defined in Table II; the definitions are intended to be technology-neutral;
- *Network Control Ancillary Services (NCAS).* These are non-market ancillary services used to manage voltage magnitude and network power flows; and
- *System Restart Ancillary Services (SRAS).* These are also non-market ancillary services that are used to restart the system following a complete or partial blackout.

TABLE II
MARKET-BASED ANCILLARY SERVICES IN THE NEM [5], [9], [11], [16]

Service class	**Service name**	**Description**
Regulation	Raise regulation (increase generation or reduce load)	Continuous correction of small frequency deviations and time-error correction. The control action is implemented by a centralized Automatic Generation Control (AGC) system. Service providers have their set points continually adjusted to either provide more generation or less net generation.
	Lower regulation (decrease generation or increase load)	
Contingency	6-second raise (fast raise)	Fast-acting response to arrest frequency deviations within the first 6 seconds after a large disturbance; examples include governor response and under-frequency load shedding.
	6-second lower (fast lower)	
	60-second raise (slow raise)	A slower-acting response to stabilize frequency deviations within 60 seconds of a large disturbance.
	60-second lower (slow lower)	
	5-minute raise (delayed raise)	Response to return the system to a normal frequency operating band within 5-minutes of a large disturbance. For example, rapid unit unloading or loading.
	5-minute lower (delayed lower)	

Fig. 1 illustrates in a conceptual manner, the delivery of different FCAS raise contingency services in response to the outage of a generator. It is important to observe the distinction between service *enablement* and *delivery*. Enablement refers to capacity that may otherwise be used for the provision or consumption of energy and that is reserved for delivering the service if necessary. Delivery refers to the physical provision (or usage) of the service. The total enablement for each FCAS is set by NEMMCO every 5-minutes based on measured system conditions and other assumptions and is termed the FCAS *requirement*.

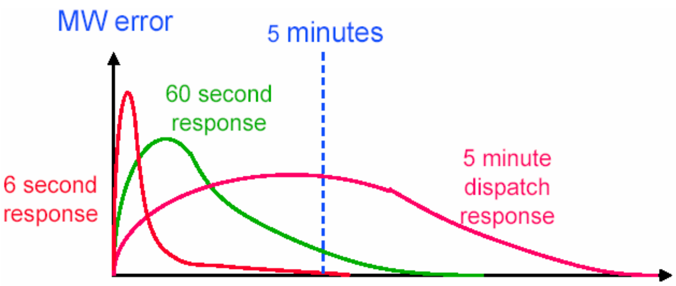

Fig. 1. Conceptual FCAS raise contingency responses to a unit outage [6].

C. Electricity spot-market implementation

The 5-minute electricity spot market is a linear optimization model which computes the prices and dispatch of energy and the prices and enablement for the 8 FCAS. The model includes numerous constraint sets to reflect FCAS requirements and the technical capability of plant for FCAS delivery. These are discussed in [5], [9], [10], [16] and [28] with the key points being:

- in addition to energy bids and offers, participants make commercial offers to provide any of the 8 FCAS. The offers are expressed as price-quantity pairs and the technical capability of their plant is expressed in the form shown in Fig. 2 – this enables co-optimization between energy and the offered FCAS;
- additional constraints are implemented to prevent plant from being enabled to provide FCAS responses which they are physically unable to deliver. One set of constraints are termed *joint energy-FCAS capacity* constraints which co-optimize the dispatch/enablement of plant capacity across energy, regulation and contingency services and ensure that all three can be delivered in the event of a contingency. A second set of constraints are termed *joint energy-FCAS ramping* constraints which ensures that plant receive feasible set points from the AGC taking into account both energy provision and regulation enablement;
- NEMMCO computes requirements for each 5-minute period for the 8 FCAS using the methodology outlined in section III. Constraint sets are implemented (depending on the state of the system) to ensure that the requirements for each service are satisfied and fall into two categories: *global FCAS requirement constraints* and *locational FCAS requirement constraints.*
- the global requirements assume that FCAS can be delivered by participants from anywhere within the connected system;
- local FCAS constraint requirements ensure the services are enabled within a particular network location and are implemented to co-optimize between local FCAS enablement and power flows on interconnectors between pricing regions – for example, it may be cheaper to reduce the flow on a major transmission element to avoid the high cost of local FCAS; and
- the 5-minute prices for the 8 FCAS are based on the shadow prices of both local and global FCAS requirement constraints in the electricity spot market optimization.

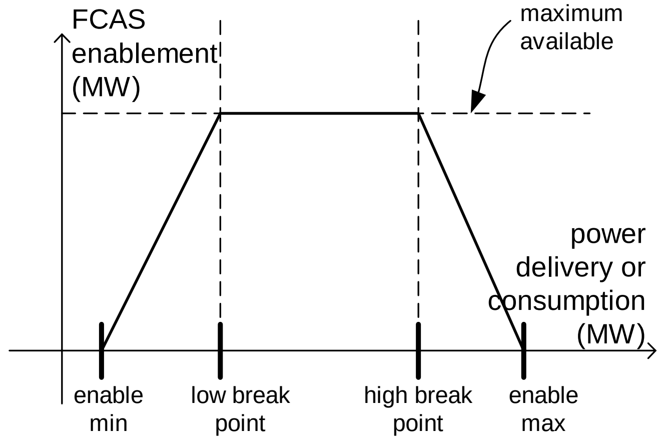

Fig. 2. A generic FCAS capability diagram ("FCAS trapezium") which is a trade-off between energy and FCAS enablement (based on [10]).

D. FCAS revenue and cost recovery

In addition to revenue (or charges) based on the provision (or consumption) of energy and the energy spot market prices, each market participant receives a revenue stream for the FCAS they are enabled to provide. This is based on the product of the enablement level and the corresponding FCAS price[2]. The FCAS revenue is recovered by charging participants in different ways depending on the service class [5], [8]:

- regulation service costs are recovered through the use of a process that assigns costs based on a causer pays principle. SCADA measurements are processed to identify the participants that caused the need for regulation services and they are charged a proportion of the cost;
- contingency raise service costs are recovered from generators in proportion to their energy production; and
- contingency lower service costs are recovered from consumers in proportion to their consumption.

For contingency services, the costs are divided into local and global categories. In this way, only the participants that benefit from locally sourced ancillary services are charged for those services while those that did not receive benefit are not charged[3].

III. Interfaces and Interactions between Commercial and Technical Processes

A. Ancillary service requirements and technical standard processes

The technical standards maintained by the AEMC specify the frequency deviations and time-errors considered

[2] In fact, FCAS revenue is the product of FCAS enablement and the corresponding FCAS price divided by 12 (since it is a 5-minute spot market).

[3] They are also the only participants that are able to influence the prices of the ancillary services within a given network location [14].

acceptable under different operating states (outlined in detail in [17] and [18]). Accordingly, NEMMCO monitors the operation of the power system and sets FCAS requirements in order to purchase sufficient FCSA to satisfy the standards [11], [19].

For regulation services, NEMMCO monitors the distribution of frequency deviations on a monthly basis with a view to adjusting the regulation requirements. Since June 2003, the regulation requirement has been reduced from the initial levels of 250MW for both raise and lower services to 130MW. The historical regulation requirements are shown in Fig. 3 and the corresponding daily standard deviation of frequency deviations. More recently, it has been observed that while the frequency deviations satisfy the standards, the standard for the largest allowable time-error in the system is at risk of not being satisfied during mornings and evenings. Thus the raise regulation requirements were modified[4] to have daily profiles to enable the AGC to correct time-errors and satisfy the standards [16]. The daily profile for the raise regulation requirement over a week is shown in Fig. 4.

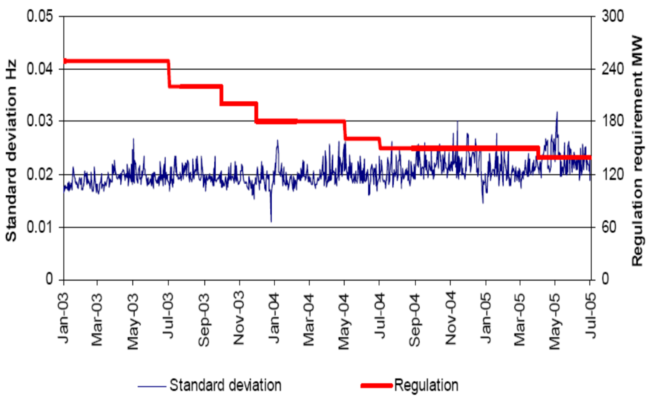

Fig. 3. The measured standard deviation of frequency deviations and FCAS regulation requirements for the period January 2003 - July 2005 [21].

As outlined in [11] and [16], the requirements for contingency services are calculated for every 5-minute dispatch period based on the present state of the system in order to contain, stabilize and restore frequency following the occurrence of a credible contingency. A credible contingency is any event that can adversely affect the supply and demand balance, including generator outages, the occurrence of system separation, network failure and load tripping. Broadly, the requirements are based on the size of the largest generator or load block that could fail less an allowance for load relief, which varies as a function of demand. Load relief itself is a term used to reflect the aggregate response of frequency-sensitive power consumption of devices connected to the system such as electric motors which consume less power as the frequency falls (or more as frequency rises). Fig. 4 shows how the total raise contingency service requirements vary over a week to address this issue.

[4] Effective from June 2006.

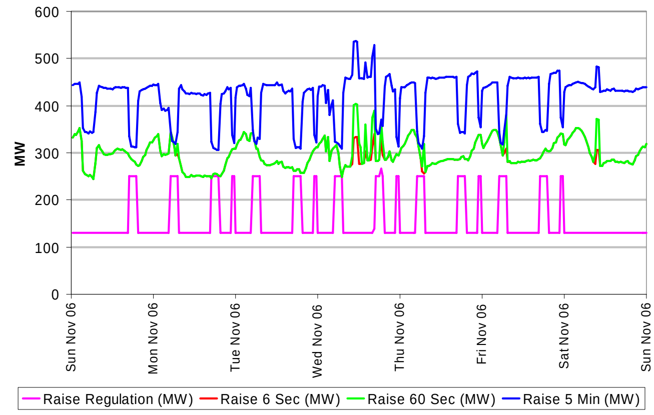

Fig. 4. Total FCAS raise requirements for a week in November 2006.

B. *Electricity spot market and physical processes*

The electricity spot market outcomes are communicated directly to an automatic control system process and plant connected to the grid. Fig. 5. illustrates the high-level interactions between the following processes and their role in managing variations in supply and demand:

- *electricity spot market* – resolves the power imbalances on relatively long-term timescales using an approximate model of the industry and an allowances for the provision of FCAS;
- *automatic generation control systems* – resolve the power imbalances on the timescale of seconds to minutes using resources enabled for raise and lower regulation services; and
- *decentralized control actions* – resolves power imbalances arising on very short timescales utilizing resources contingency ancillary services.

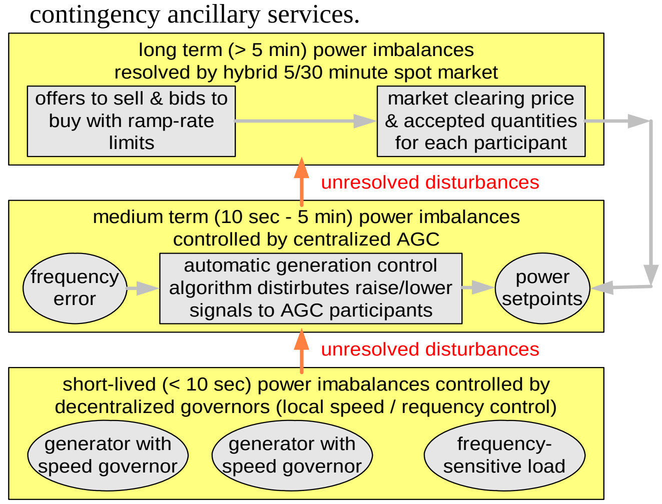

Fig. 5. Interaction between the electricity spot market and control systems [6].

In the case of regulation services, the 5-minute enablement levels assigned to each participant for raise and lower services in the electricity spot market are used to set the regulation participation factors in the AGC, as per the equations:

$$RRPF_i = \frac{RE_i}{\sum_i RE_i} \quad \text{and} \quad LRPF_i = \frac{LE_i}{\sum_i LE_i}$$

where $RRPF_i$ is the raise regulation participation factor for participant i, RE_i the raise enablement level calculated by the spot market for participant i, $LRPF_i$ is the lower regulation participation factor for participant i and LE_i the lower enablement calculated by the electricity spot market for participant i. Since the raise and lower participation factors are not likely to be equivalent, the AGC switches between them based on the sign of the area control error (ACE) after it has been filtered. Generator power targets are adjusted by the appropriate fraction of the AGC regulation control signal as illustrated in Fig. 6.

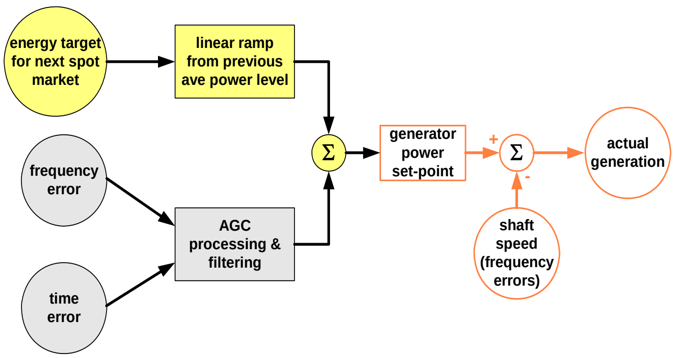

Fig. 6. Interaction between the electricity spot market, AGC and a generator [6].

It is interesting to observe the emergence of patterns in measured frequency deviations that arise most likely as a consequence of the 30-minute (average) pricing for energy. For instance, Fig. 7 shows that across a typical 30-minute period, on average, for the first 5 to 10 minutes the frequency is below nominal while for the remainder of the period it is generally higher than the nominal frequency.

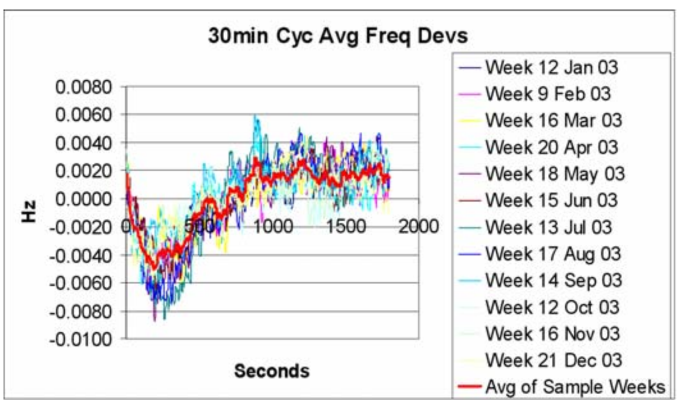

Fig. 7. 30-minute cyclic average frequency deviations for selected weeks over the year 2003 [12].

A likely explanation of this effect is the tendency for there to be more transitions in generators from one output level to another in alignment with the 30-minute energy prices on which derivative contracts are based. While the effect does not have a significant impact on the physical performance of the system, it does highlight the potential for interactions between commercial and physical processes within a restructured electricity industry.

IV. Spot Market Dispatch and Pricing Outcomes

The performance of the ancillary services was assessed in 2003 [4] with the review process being stalled due to a reorganization of energy regulatory functions in Australia. The review process has since recommenced in late 2006 [16]. The main conclusions in regards to dispatch and pricing outcomes are reported in [4], [16] and [20] as follows:

- the costs associated with ancillary services under market-based arrangements have generally fallen from pre-market levels of around 3-4% of the value of energy to about 0.4% – although it is important to recognize that these reductions are also attributable to the commissioning of an interconnector between southern NEM regions and the northern most region, QLD which coincided with the commencement of market-based arrangements for ancillary services and more recently, the commissioning of a DC link between the southern most region Tasmania and mainland Australia which is operated in a mode that enables it to transfer frequency control actions between the regions within limits (discussed further in [24] and [25]);
- FCAS prices have generally trended downwards since the commencement of the market-based arrangements – as illustrated in Fig. 8 and Fig. 9. This trend is attributable to a number of factors. Firstly, network maintenance in the early months of the new arrangements resulted in significant price volatility – this lead to improvements in the mathematical formulation to reflect the tradeoff between interconnector flow and provision of local FCAS. Secondly, NEMMCO has refined the requirement setting processes so that generally the requirement levels more closely match the minimum levels required in order to satisfy the frequency standards. Thirdly, since market commencement, market participants have generally tended to offer more service types – increasing competition. Finally, some of the ancillary service price volatility in the early months was also attributable to ancillary service providers experiencing difficulties in managing offers for ancillary services and energy – over time participants have been able to better manage their offers;
- prices for the services can be roughly grouped into two regimes; a "system-normal" regime where the prices are generally low as the result of typical operating conditions and a "rare-event" regime where prices can increase dramatically in response to sudden increases in global or local requirements as a consequence of events such as network outages or other system conditions that require sourcing the services locally – between 2001 and 2003, rare events such as these occurred 5% of the time, but account for 50% of the total costs. The breakup of costs for the period 2005-2006 is shown in Fig. 10 and total weekly costs for the market-based ancillary services over 2005-2006 is shown in Fig. 11, finally Fig. 12 shows the variation of price with raise requirements;
- generally, generators are paid more for the provision of FCAS than they are charged for its use – thus a commercial incentive exists to participate in FCAS markets; and

- the market shares for FCAS enablement is generally spread across a diverse portfolio of market participants.

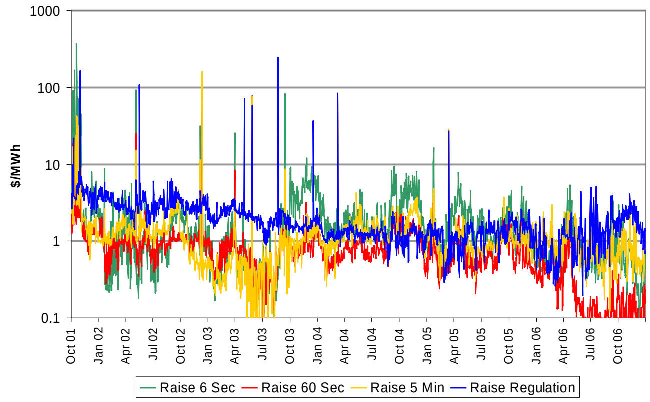

Fig. 8. Daily average raise FCAS prices from commencement of the market to December 2006 for mainland NEM regions (based on the data of [27]).

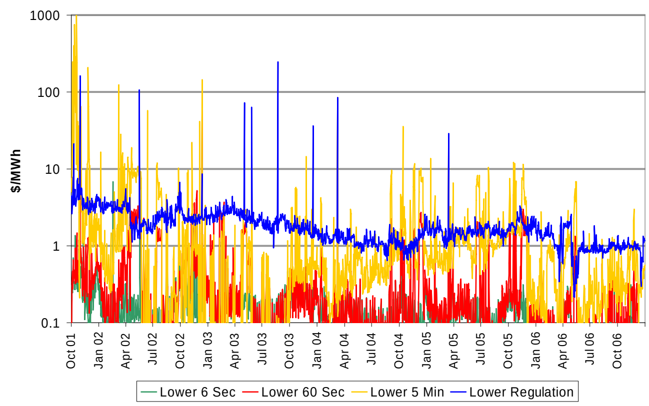

Fig. 9. Daily average lower FCAS prices from commencement of the market to December 2006 for mainland NEM regions (based on the data of [27]).

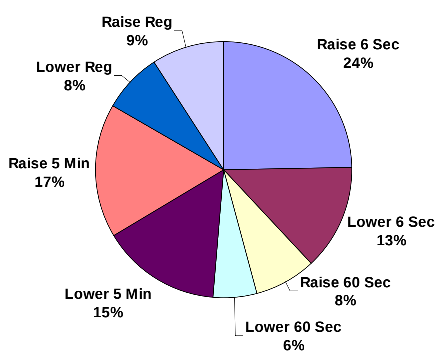

Fig. 10. FCAS cost breakdown over the period 2005-2006 (data from [13]).

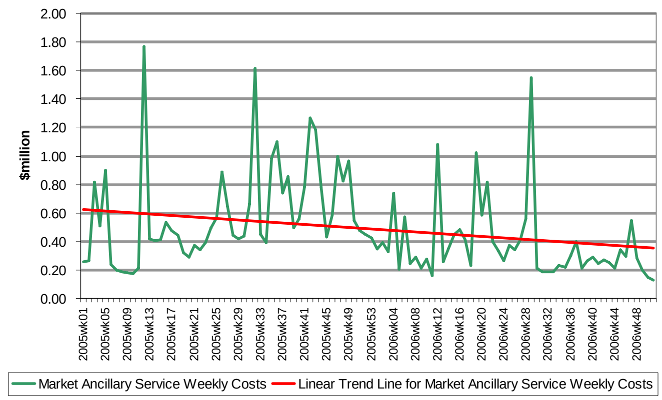

Fig. 11. Weekly FCAS costs 2005-2006 (data from [13]).

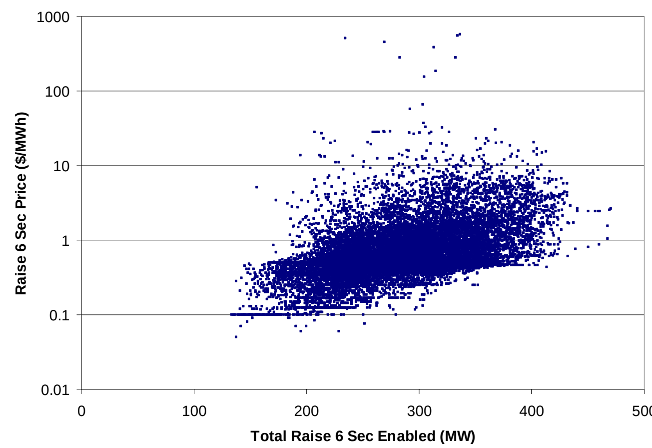

Fig. 12. Scatter plot of raise 6sec prices vs. Raise 6sec requirements (based on the data of [27]).

V. Physical Outcomes

Since the electricity spot market alone can't ensure the physical delivery of the services, additional processes are implemented to monitor the extent to which the system is operated in compliance with the standards. NEMMCO implement a monitoring process (see [7] and [19]) to check that the delivery (when required) of the ancillary services occurs in an acceptable manner and to also ensure that the technical standards are satisfied. In terms of physical outcomes for the market-based ancillary services, the following observations have been made in [4], [7], [16] and [21]-[23]:

- in general, the violation of the frequency standards occurs when the system is under strained conditions. These tend to occur infrequently as a consequence of events that are difficult to predict and plan for, such as multiple contingencies or the operation of the system when it breaks into islands. Fig. 13 shows the number and duration of frequency events for the period July 2004 – June 2005, this shows that the majority of frequency events were cleared within a short period and in a way that did violate technical standards; and
- while in the main, the standards across the system are adhered to, the observation is often made in NEMMCO's power system performance monitoring that when

contingency services are delivered, the response is not in agreement with the enablement levels assigned in the electricity spot market. For example some participants may over-deliver services while others may under-deliver or not deliver at all. NEMMCO comments in [16] that quite often, there is an over-supply of the 6 and 60 second service categories which tend to diminish the need for the 5 minute service which to date has seldom been required.

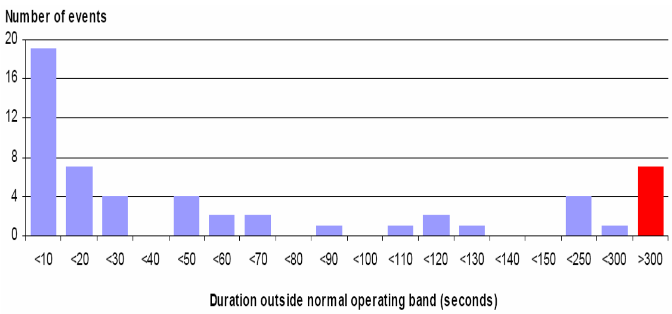

Fig. 13. Duration of frequency events as reported in [21].

VI. Participant Behavior in Market-Based Ancillary Services

Since the introduction of market-based ancillary services, new participants have become ancillary service providers, or have increased their ability to provide more services [4]. Accordingly, the amount of capacity available to provide the services has increased. This has contributed to increased competition in providing the services and has contributed to downward trends in FCAS prices. From time to time, there have been insufficient service providers at times when the services needed to be sourced locally.

For the FCAS markets, participants are allowed to change not only their offers but also their offered technical capability (that is, the shape of the trapezium shown in Fig. 2). This raises the question of balancing two opposing issues in market design: the need to allow market participants to make offers that are consistent with the present physical capability of their plant vs. the potential for technical parameters to be gamed.

The observation is made in [4] that rebidding (changing offers) in FCAS occurs frequently over the course of a trading day with majority of revisions to offers occurring in the 3 hours leading up to each 5-minute spot market interval. This enables participants to avoid undesirable interactions between energy service provision and ancillary service enablement – accordingly they need the ability to alter their physical capability to effectively relax constraints in the linear program optimization and receive the targets for energy they desire. However, rebidding in ancillary services can also be used by participants to assist in gaming their position in the energy market because the constraints used to ensure the feasibility of physical delivery can also be used to be constrained on to generate electricity.

VII. Strengths and Weaknesses of Ancillary Services in the NEM

The main strengths of the market-based ancillary service arrangements in the NEM include the following:

- *General agreement on the guiding principles and the framework within which to implement market-based ancillary services*. Ahead of NEM commencement in 1998 the Ancillary Services Reference Group was established to develop a conceptual framework within which to consider market-based ancillary services (see [3]) which were implemented in 2001. This resulted in industry-wide consensus on the basic decision-making responsibilities and principles covering both commercial and technical aspects of industry operation that are described in this paper which are generally regarded to be a successful implementation of market-based ancillary services;
- *System and market operations are managed by the same organization, NEMMCO*. Such industry structure ensures that the operation of the market occurs in an environment that is well-informed by system operations experience and vice-versa. This results in an efficient and robust interface between commercial and technical processes;
- *The Rules require NEMMCO to review the operation of the market-based ancillary services and identify potential improvements*. Undertaking such a review should assist in increasing the efficiency of the arrangements, although the review process is focused only on the arrangements that are presently in place which narrows the scope for finding efficiency gains;
- *Reduction in the overall costs of ancillary services compared to pre-restructuring costs*. As discussed the cost of ancillary services has generally fallen to comprise only a very small fraction of the overall costs of energy delivery – it should be noted that in the case of the NEM, not all of the reductions in costs are necessarily attributable to the implementation of market-based ancillary service arrangements since some benefits are attributable to increased interconnection between the NEM regions; and
- *The power system is generally operated within the standards*. Overall the power system satisfies the standards with only rare events causing issues; thus most of the time, the market-based ancillary services contribute toward achieving desired physical outcome.

Some of the weaknesses (or remaining challenges) in the present implementation include the following:

- *Increased electricity spot market complexity* – participants submit offers to provide the 8 FCAS including the technical capability for each service; the specific electricity spot market implementation can result in situations where participants have difficulty in managing trade-offs between provision of ancillary services and provision of energy;
- *Mismatch between electricity spot market model and physical outcomes* – while the standards are generally satisfied, the mismatches between actual physical delivery of the services may indicate that the electricity spot market model could be improved to be better aligned with the

physical reality of service delivery;

- *Improvements to the spot market model and requirement-setting process are possible*. As suggested in [16], the spot market model could optimize the requirements rather than compute fixed quantities every 5-minutes and there is the potential for reducing the number of services (in particular the 5-minute delayed services and regulation services overlap raising the question of whether to combine these services);
- *Minimal participation of the demand-side and generators connected to low voltage distribution*. [16] summarizes several different views on why this is the case. One is that despite efforts to construct market mechanisms that are technology-neutral, the framework within which market-based ancillary services operate in the NEM is largely biased toward the operation of generators connected to the high-voltage transmission system ([16] cites the fact that only single-point suppliers are supported which precludes the operation of demand-side aggregates). A second view is that since demand-side participation in energy is minimal in the NEM in general, thus it is unrealistic to expect demand-side participation in ancillary service markets as well. A third view is that there is only minimal value to be obtained from low-voltage generation, although thorough assessments of the potential value have not been conducted. A fourth view is discussed in [14], where the suggestion is made that the ancillary service market rules require technical compliance with ancillary service standards that require the installation of potentially expensive equipment which acts as a barrier to entry for service providers that are either small or that have previously not considered offering ancillary services;
- *The scope of market-based ancillary services is limited to only those concerned with the management of frequency*. The extent to which commercialization of voltage and other ancillary services has largely ceased primarily because there is a lower value attached to those services and a higher degree of complexity involved in terms of their commercialization; and
- *Lack of hedging instruments for market-based ancillary services*. As outlined in [14], there are presently no options available to market participants to hedge the financial risks associated with the outcomes of market-based ancillary services. The reasons suggested in [14] for this include the general difficulty in terms of finding a natural counter-party, defining appropriate contracts, the rare occurrence of there being significant cash flows in the ancillary services and the general complexity surrounding how contracting arrangements could be managed. Thus it is unsurprising that hedging instruments have failed to emerge at this stage and it is unlikely that they will.

VIII. Conclusions

The implementation of market-based ancillary services within a restructured electricity industry is a complex and challenging task. In the NEM, the frequency control ancillary services have been commercialized while other ancillary service types are managed through contracting regimes. The outcomes are generally regarded as being successful because they have contributed to an overall reduction in ancillary service costs compared to the previous non-market arrangements without compromising frequency standards.

This paper suggests that the success of the market-based ancillary service arrangements in the NEM can be attributed to a number of factors. Firstly, the guiding principles for market-based ancillary services were identified in the early stages of market development well ahead of their final implementation. This allowed for the key issues to be agreed and the implications considered across a wide range of industry stakeholders. Secondly, the responsibilities and accountabilities have been assigned between centralized and decentralized decision-makers in a way that has seen the implementation of processes that effectively manage both the commercial and technical operation of the system. Finally, the Rules encourage ongoing evolution of the arrangements with a view to identifying and removing deficiencies.

While the present arrangements proceed to work well, there are opportunities for improvements to the existing arrangements as well as the potential to make improvements to the arrangements in a broader sense. The improvements within the existing arrangements largely comprise refinements to the existing electricity spot market model and cost-recovery mechanisms to make the dispatch more closely resemble the reality and thus reflect this in the prices and cost-recovery processes. The broader improvements include expanding the scope of market-based arrangements to commercialize a wider range of ancillary services and to also investigate the benefits in extended market-based arrangements to facilitate the participation of the demand-side and small scale / low-voltage generators.

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