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Ancillary Services: an overview of International Practices

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ANCILLARY SERVICES: AN OVERVIEW OF INTERNATIONAL PRACTICES

Working Group C5.06

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ABSTRACT

This paper describes the main findings of the work carried out on behalf of CIGRÉ Working Group C5-6 ‘Security of Supply in Wide Market Environments’. The findings are based on two questionnaires that were answered by 17 countries covering all continents. This paper provides an overview of various international practices regarding ancillary services. The paper classifies those ancillary services by the tasks they pursue, and describes the related products by means of their technical as well as their economic characteristics.

Keywords: *Ancillary services - Electricity markets - Active power balancing*

1 INTRODUCTION

One of the issues that has received increased attention in the reorganization of the electrical industry is the security and reliability of the electricity supply. To satisfy the challenge of achieving a secure and reliable electrical system and to support the basic functions of producing and delivering electric energy and power to customers, system operators make use of Ancillary Services¹. These services enable the system operator to keep the system’s supply and demand in balance, keeping the voltage and the frequency at the right level, preventing a system collapse in case of contingencies, and restarting the system following a collapse. Ancillary services have always been part of the electricity industry worldwide. Technical characteristics and methods of procurement are dependent on the ancillary service to be pursued as well as on differences in operating, and regulatory methodologies that exist among Transmission System Operators (TSOs) and countries.

The main objective of this paper is to provide a common basis for discussions on the worldwide view on Ancillary Services. Section 2 describes the structure of the underlying questionnaire. Section 3 discusses existing definitions of ancillary services and explains the methodology pursued in assessing the results of the survey. Section 4 analyses the main results of the questionnaire.

¹ Section 3, Table 2 provides definitions used by four regulatory agencies

2 METHODOLOGY OF THE SURVEY

The findings discussed in this paper are based on responses² to two questionnaires regarding Ancillary Services: a first one sent during summer 2006, and a complementary one sent during spring 2007 that was designed to clarify some questions raised by responses to the first questionnaire. The first questionnaire was answered by 17 countries covering 5 continents, the second one by 12 countries. The countries responding to the complementary questionnaire are shown with an asterisk: Argentina (AR), Australia (AU)*, Belgium (BE), Brazil (BR)*, China (CN)*, Czech Republic (CZ)*, Germany (DE), England & Wales (E&W), Spain (ES)*, Finland (FI)*, France (FR)*, Japan (JP)*, South-Korea (KR)*, the Netherlands (NL)*, Portugal (PT)*, PJM (USA)*, and Slovenia (SLO).

Table 1: list of participating countries

Continent	Country	Continent	Country
Asia	China *	Europe	Belgium
	Japan *		Czech Republic *
	South Korea *		Germany
North America	PJM (USA) *		England & Wales
South America	Argentina		Spain *
	Brazil *		Finland *
Oceania	Australia *		France *
			Netherlands *
			Portugal *
			Slovenia

Within the questionnaires, respondents were first asked to enumerate the existing ‘ancillary services’ in their country. Thereupon, questions related to the following topics were answered for each service:

- The tasks served by the service
- The technical characteristics prescribed for the service
- The procurement method used to acquire the service

In addition, the respondents were given the opportunity to add comments and/or additional information.

3 DEFINITIONS AND CLASSIFICATION OF ANCILLARY SERVICES

3.1 Existing definitions of Ancillary Services

As stated in the Introduction “Ancillary services have always been part of the electricity industry worldwide,” and although the basic objectives are the same the terminology employed is sometimes different. This section attempts to make a clear distinction between objectives and terminology by separating generic high level terminology and definitions from the more technical and specific uses of the services.

² The authors gratefully acknowledge the valuable contributions of all persons who answered the questionnaire (A listing of the contributors is provided).

Definitions for ancillary services can differ significantly based on who is using the terms (Table 2). While some definitions emphasize the importance of ancillary services for system security and reliability, others mention the use of ancillary services to support electricity transfers from generation to load and to maintain power quality. Furthermore, some definitions limit the contribution of ancillary services to the transmission network; others include distribution purposes as well.

Table 2: Existing definitions of Ancillary Services in use

Ministerial Council on Energy Australia – National Electricity Rules (1 July 2005) <i>Services that are essential to the management of power system security facilitate orderly trading in electricity and ensure that electricity supplies are of acceptable quality.</i> European Commission - Directive 2003/54/EC (2003) <i>All services necessary for the operation of transmission and/or distribution networks.</i> Eurelectric (2004) <i>All services required by the transmission or distribution system operator to enable them to maintain the integrity and stability of the transmission or distribution system as well as the power quality.</i> FERC ³ (1996) <i>Those services that are necessary to support the transmission of capacity and energy from resources to loads while maintaining reliable operation of the Transmission Service Provider's transmission system in accordance with good utility practice.</i>

Note that the Australian definition has a market and power system focus (likely stemming from a single market and system operator), whereas the others appear to have a network focus.

In general, there are differences in terminology related to Ancillary Services. These terminology differences can lead to confusion. For instance, the term ‘balancing’, mainly used in Europe, is often adopted with different meanings. According to ETSO⁴ (2003), balancing should be interpreted as ‘*those processes and services associated with power system operation, which ensure quality and short term security of supply, in particular active power (MW) balancing and frequency control*’. However, other agencies and countries can and do apply terms and terminology similar to the ETSO terms, but use them for different products.

³ The Federal Energy Regulatory Commission (FERC) - regulates and oversees energy industries in the economic, environmental, and safety interests in the USA.

⁴ The European Transmission System Operators (ETSO) – An International Association of TSOs dedicated in part to maximise the system's reliability and quality of supply, while optimising the use of primary energy and capacity resources.

Table 3 provides an example of similar terms with dissimilar meanings. In the responses to the question of ‘Secondary Frequency Control’, UCTE⁵ has substantially different product characteristics than ‘Secondary Frequency Response’ in England & Wales and ‘Secondary Reserves’ in Nordel⁶.

Table 3: Varying meanings of ‘secondary control’ across different control zones

	Reaction time	Delivery	Instruction	Procurement
E&W	30 secs	30 mins	Automatic response at unit level	Mainly mandatory
UCTE	30 secs	15 mins	AGC ⁷	Mandatory
Nordel	30 secs	15 mins	Manually instructed	Commercially

Partly due to the above mentioned terminology problems, many dissimilar lists of Ancillary Services have been drawn up. While the tasks pursued by the services in these lists are globally similar, the main difference is how the categories of service are split and combined. For example, when FERC (1996) asked for help in defining Ancillary Services it received over a dozen different lists. One list had 38 Ancillary Services just for transmission. NERC⁸ presented a list of 12, though it adopted FERC’s final list of 6 in its Glossary of Terms (1996). This anecdote makes clear that formulating an unambiguous, short and comprehensive list of Ancillary Services is a far from easy task. In general, services are mostly grouped according to their speed of delivery or by how they are provided.

3.2 Structure of the questionnaire and scope of the Technical Brochure

In the first questionnaire, the following 4 tasks were explicitly mentioned:

- Frequency control
- Load following/ Short-term energy balance
- Contingency reserves
- Congestion management

The following additional tasks were either spontaneously mentioned by some respondents answering the first questionnaire, or answered via the complementary questionnaire:

- Black start
- Voltage control
- Compensation for network losses

⁵ The Union for the Coordination of Transmission of Electricity (UCTE) – An Association of TSOs in continental Europe ; currently renamed and replaced by Entsoe – European network of transmission system operators for electricity.

⁶ The Nordic Transmission System Operators (Nordel) – An Organization of TSOs promoting the establishment of a Nordic electricity market as a part of the North – West European electricity market.

⁷ Automatic Generation Control – See paragraphs 3.2 and 4.3.

⁸ The North American Reliability Corporation (NERC) – An Organization that develops and enforces reliability standards in North America.

As shown in the appendix (see 7.3 and 7.4), the survey reveals that respondents identified between 3 and 8 ‘Ancillary Services’ at their disposal. However, these international variations can partly be attributed to the terminology and classification problems discussed above. In some cases, the country representative only responded what was considered as being appropriate or important for ‘ancillary services’. It is also questionable if such aspects as compensation of network losses (although information on this topic was asked in the complementary questionnaire) can really be considered an Ancillary Service: for example, in France losses are purchased by the TSO on the wholesale market and are paid by the network users via the grid access tariff; in Australia, energy prices are adjusted on a location basis to pay for losses. For this paper, only services that support reliability are included. Financial services, such as the aforementioned network losses, therefore were not included.

The Secondary Control functions of Load-following and Congestion management are considered the fundamental tasks of TSOs and therefore are NOT considered Ancillary Services per se. In addition, Network losses and Inter-TSO Reserves were considered as Business Practices and therefore also NOT considered as Ancillary Services. Based on the above list of tasks, the ‘Ancillary Services’ (‘AS’) or ‘products’ can be grouped according to the task(s) they perform. This classification is shown in the Appendix. They are roughly correlated according to their reaction time.

In more traditional terms:

- Primary Control Tasks – generally time frames less than 1-2 minutes
- Secondary Control Tasks – generally 5 – 30 minutes
- Tertiary Control tasks – generally 30 – 120 minutes

Two other reliability service functions are included in this paper:

- Reactive / Voltage services – this primary service is emerging as a market-based service. The service is required in all systems but it is not a easily agreed-to quantifiable service
- Blackstart / Restoration Services

3.3 Classification of Ancillary Services

3.3.1 AS-1 (Primary Frequency Control)

This category of Ancillary Services deals with natural frequency response; both normal continuous adjustments as well as the initial response to frequency deviations resulting primarily from generator contingencies. Note Primary Services also serve to respond to frequency increase that result from loss of load.

There is one Ancillary Service (AS-1) associated with Primary Frequency Control. This service is provided specifically to control system frequency variations, and provides the first line of defence for arresting frequency decay that follows loss of supply (or the frequency increase following loss of load). In general, AS-1 is provided continuously directly from a generator’s governor response. The Reaction time of AS-1 is instantaneous. The Delivery time of AS-1 is generally about 2 minutes.

The response by England and Wales also indicates a separate service (High Frequency response). This service may be supplied by either generators or by demand response. Unlike Primary response which is limited by a governor, High Frequency response units continue to respond until instructed to stop.

3.3.2 AS-2 (Secondary Control - Regulation)

Secondary Control deals with those “directed” services, i.e. services that are commonly driven by Automatic Generation Control programs (AS-2 for the regulation of ACE⁹ deviations); or manually directed (AS-3 Spinning Reserves & AS-4 Non-Spinning Reserves – to supplement the response to contingencies provided by AS-1 services). These three services are needed to address system changes that are sustained over a period of minutes to as long as 30 minutes.

AS-2 service generally focuses on errors associated with normal variations of ACE. These variations are caused by normalized definable variations in generation and loads.

AS-2 is generally provided by suppliers in response to a continually varying control signal. In general, this signal is developed (for non-islanded areas) based on the Area Control Error of the given area.

Finland and Brazil (systems with large concentrations of hydroelectric power) use the primary control Ancillary Service to also serve the objectives of Secondary Control services.

3.3.3 AS-3 (Secondary Control – Reserves spinning)

AS-3 and AS-4 are services that are event-driven. Loss of supply (or demand) requires services that are slower than the primary control responses but faster than the basic economically dispatched load-following units. The magnitude of this service is usually a function of the largest operating unit. This service is provided by holding a magnitude of fast responding capacity in reserve. Based on the amount of risk a system is willing to accept, those reserves will be spinning (i.e. synchronized) AS-3 or they can be non-spinning AS-4.

3.3.4 AS-4 (Secondary Control – Reserves non-spinning)

As noted in the discussion above, this service is generally identical to AS-3, and is designed to respond to loss of supply. The difference is that the suppliers for AS-4 are idle and contain the inherent risk of failing to start. Some operators consider AS-3 and AS-4 as a single service. For this paper they are reported as two independent services.

⁹ See definition in the appendix

The Czech Republic, England & Wales each offers Ancillary Services for both Contingency Reserves (Spinning) and Contingency Reserves (Non-Spinning).

3.3.5 AS-5 (Tertiary Network Control – Replacement Reserves)

Following the utilization of the fast Secondary Reserve Services, Tertiary Reserve Services are used to reset those Secondary Services. This Ancillary Service is generally provided by the traditional supply-demand balancing mechanisms, although many respondents indicated a specific Replacement Reserve Service. Belgium reported the use of Load Reduction to serve as Tertiary Reserves.

The previously defined services are associated with addressing specific operating system conditions. Those services are based on providing fast targeted responses. To make use of those characteristics more than once requires energy provided by those services to be replaced. That energy can be replaced either by Economic dispatched load-following energy or by slower standby units held in reserve.

3.3.6 AS-6 (Voltage Control Service)

The Voltage Control Service is a critical ancillary service used by all system operators. There are on-going attempts to better define how to measure and commercialize this service.

There is a growing interest in creating a Reactive Reserve Market. The respondents indicate the development of Reactive Control as a specific Ancillary Service. Brazil recognizes dividing this service into Reactive Support from Generators, and Reactive support from synchronous condensers. Spain also adopted a two-tiered Reactive service. The first tier is a minimum reactive service required of all generators. A second-tier of reactive service is for services that exceed the minimum requirement.

France includes two reactive services based on response characteristics.

3.3.7 AS-7 (Blackstart Service)

This service is recognized as a necessary service to restore systems following power system (or area) blackouts.

3.4 Classification table and peculiarities to be mentioned

Table 4: Summary of Ancillary Services

Primary Freq Control	Secondary Frequency Control			Secondary Network Control		Tertiary Network Control	Voltage Control	Black Start
	Load Freq Control (regulation)	Contingency Reserves Spinning	Contingency Reserves Non spinning	Load Following (Energy dispatch)	Congestion Management	Replacement Reserves		
Not directed by TSO	Directed by TSO			Directed by TSO		Directed by TSO		
Instantaneous & Continuous Control	Continuous	Event-driven		Continuous	Event-driven	Event-driven	Event-driven	Event-driven
AS-1	AS-2	AS-3	AS-4	Basic task – Not an AS		AS-5	AS-6	AS-7

The analysis of the responses clearly shows that some services can serve more than one objective; they often pursue several tasks. Furthermore, several peculiarities are to be mentioned:

- The Nordic regulating power market allows the Finish TSO to adjust generation or loads whenever necessary on the basis of the prevailing operational situation. A product named “fast disturbance reserve (tertiary reserve)” can be used in extreme peak load situations, i.e. if there are not any market based offers on the regulating power market.
- Brazil mentioned a product, named “Prompt Reserves” used in case of “non-dispatched” plants due to its operational costs which are higher in relation to the ones being currently dispatched. The referred mechanism, named “Prompt reserves”, is a compensatory measure which is applied to avoid possible financial damages to those generating plants. This mechanism comprises the payment of the variable costs (O&M) to the agent in order to cover the fuel consumption necessary to keep the units ready to be synchronized to the system when required by the Brazilian TSO (ONS). This compensation is discontinued whenever the unit is synchronized to the system.
- Only 10 countries mentioned black start services. Korea mentioned black start, but did not define it as a specific product. France and Spain confirmed they have no defined product for black start. In Spain, the TSO has established an emergency restoration plan to be applied in case of blackout with the collaboration of affected facilities. In France, RTE does not use very much black-start service. In case of black-out, RTE requires the generating units to be capable to trip to house load (islanded operation) and to wait to be reconnected to the grid when RTE needs. Nevertheless, Black-start is required if the generating unit does not have the capability to trip to houseload. These services (tripping to houseload and black-start) are required on a mandatory

basis (for existing units of more than 120 MW and new units of more than 40 MW) and are not remunerated

- Of particular note in the Ancillary Service Matrix is the Australian division of AS-1, AS-2, AS-3 and AS-4 services. The Australian system offers two alternatives (Raise and Lower) for each of the four categories.
- The lack of a consistent meaning is one of the reasons Australia does not use terms like “primary” and “secondary” in its National Electricity Market. Australia groups Ancillary services according to speed of delivery (e.g. 6, 60 and 300 seconds), the task they pursue and the direction (to raise frequency or lower frequency). It actually has 8 frequency control services operating as 8 inter-related spot markets: 3 in each direction to deal with contingency events and one in each direction to deal with frequency correction within its 5 minute energy market dispatch cycles.

The authors realize the form of any given questionnaire drives the responses. Despite any bias introduced by the structure of the questionnaire follow-up activities by the authors confirm that terminology remains an issue. The first questionnaire only explicitly mentioned 4 tasks and since not all countries answered the complementary questionnaire no absolute conclusions can be drawn regarding the products available to fulfill the other tasks. However, identifiable specific responses can be highlighted to show the growing number of alternatives now being offered as Ancillary Services. Although the highlighted alternatives may not be applicable to all TSOs the alternatives do spotlight the diversity of opportunities being afforded to suppliers of energy and capacity.

4 ANALYSIS OF THE QUESTIONNAIRE

In this section a detailed discussion is provided of some technical and economic characteristics of the different products classified in the previous section.

The main technical characteristics treated in the questionnaire are the time properties (reaction time and delivery time) of a product and the method of instruction and control. The most important economic characteristics mentioned in the questionnaire are: the method of procurement; the type of providers; and the existence of penalties on non-delivery.

This section provides an analysis of the economic characteristics mentioned above, the method of instruction and control, and their relationship with the time properties of the various products.

4.1 Method of procurement

Several resource allocation mechanisms exist for the procurement of ancillary services products. Within the survey, a distinction was made between the following 5 methods of procurement:

- Mandatory – unpaid
- Mandatory – paid (at regulated / administrated prices)
- Bilateral contracting
- Public tendering
- Real-time market

While the first 2 methods are definitely non-market based, the other 3 methods can be considered as market based mechanisms. Furthermore, while procurement on the basis of the first 4 methods takes place beforehand, procurement via the 5th method occurs in real-time.

Figure 1 shows the percentage of observations for the real time Ancillary Services (i.e. it does not include Blackstart and Voltage Control) for each method of procurement:

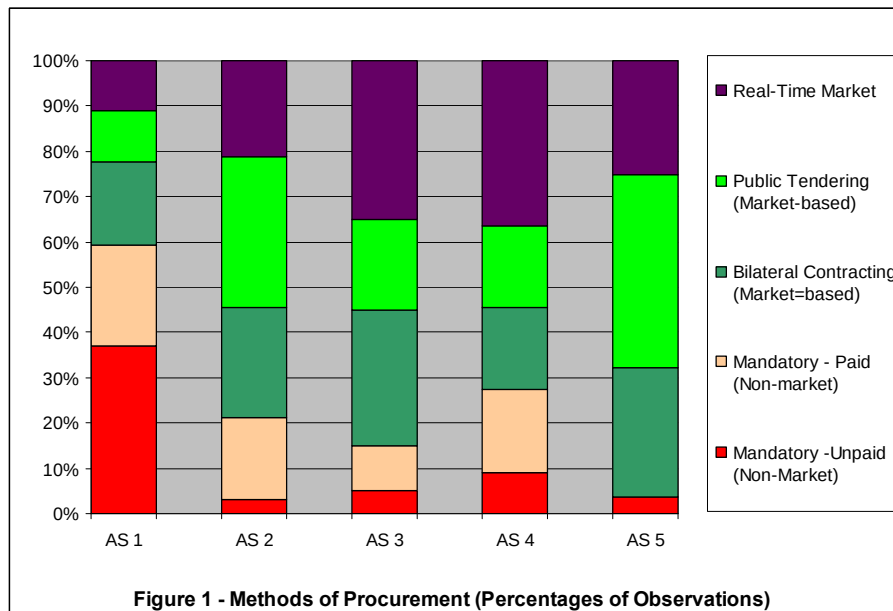


Figure 1 indicates that the Mandatory - unpaid payment procurement method is almost exclusively used for AS – 1 (Primary Control), which is the fastest service and generally not under direct control of the System Operator. Figure 1 also shows the other Ancillary Services are principally procured via one of three market-based procurement methods.

In Table 5, the procurement of products is indicated per product for each country and is subdivided into the procurement of capacity/availability on the one hand, and the procurement of energy/utilization on the other hand. The procurement of Energy/utilization refers to the metered (or approximated) MWh of energy delivered. The procurement of capacity/availability generally takes two different forms and is based on capacity provided or contracted (MW).

Either the system operator purchases and pays for the capacity/availability of a service or the system operator purchases and pays for the usage of the service when actually selected (ETSO, 2006). In the latter case, the system operator pays an availability fee only at the moment that an energy bid is submitted to the real-time market.

**Table 5: Ancillary Service Procurement Methods
Capacity / Availability vs. Energy / Utilization**

	AS-1 Frequency Control		AS-2 Regulation		AS-3 Reserves (Spinning)		AS-4 Reserves (Non-Spinning)		AS-5 Replacement Reserves	
	Capacity	Energy	Capa- city	Energy	Capa- city	Energy	Capa- city	Energy	Capa- city	Energy
Mandatory Unpaid	BR, PT, SLO, ES	AR, BE, BR, NE, PT, SLO, ES	AR, BR		BE		BR		FR	
Mandatory Paid	E&W(2), FI (2)	JP	E&W, JP	AR, CZ, JP, SLO	FI	AR		AR, JP		
Bilateral Contracting	BE, E&W(2), FR	FR	BE, E&W, FR, PT, SLO	BE, FR, PT	BE, E&W, FR	BE, E&W, FR	E&W	E&W	BE (2), PT, SO (2)	PT, SO (2)
Public Tendering	BE, CZ, DE		BE, CZ (2), DE, NE, SLO, ES	BE, DE, SLO, ES	E&W, NE	E&W, ES	CZ	AR	BE (2), CZ, DE, SLO(2)	BE (2), DE, SLO(2), ES
Real-Time Market	AU (2)	AR	AU (2), USA	AR, BE, CZ, NE	AR, AU (2), ES, USA	AR, NE	AU (2)	AR, CZ	ES	BE (2), CZ, FR, NE, USA

This table shows that in some countries, several mechanisms (market based and non-market) are used in parallel for the procurement of the same product. It is worth noting some of the questionnaire comments received:

- In the USA (PJM), AS2 and AS3 capacities although procured on a mandatory paid mechanism the suppliers are paid through a real time market. Also note that capacity procurement of AS1 is not purely based on a mandatory mechanism: every PJM generator has to install governors for technical reasons but if the generator owner does not, there is neither control nor penalty.

- In the Czech Republic real time energy market acts as a supplemental mechanism (liquidity of this market is very low) to capacity and energy procurement via public tendering for AS3 and AS4.
- Some AS in Argentina are provided on a "mandatory- paid at regulated/administrated prices" because these AS are needed to ensure the electrical system control, for instance Primary Frequency Control (PFC). However even though generation units must provide 3 % of reserve for PFC, some offer more than 3 % during real time market operation and so receive more income for that service, while those that offer less than 3 % have to pay to the others for the extra reserve. AS-4 (Secondary Frequency Control) and AS-3 (Short Term Reserves), are both optional but generators may present competitive public offers in advance and secure remuneration for such services.

The existence of capacity procurement gives a system operator the possibility to limit the risks associated with the procurement of energy via a real-time market. Note however that a partial reliance on capacity procurement reduces the advantages associated with a real-time market, namely the efficient use of generation capacity - either via forward markets, or via the real-time market - and the charging of current costs in case of an imbalance.

4.2 Providers

Products for ancillary services can be provided by different parties. Within the survey, a distinction was made between:

- Generation within the control area
- Demand within the control area
- Other system operators (SOs)
- Generation from other control areas
- Demand from other control areas

The last 3 bullet items can be collectively considered as the exchange of products with other control areas. As indicated in Table 6, generators (within the control area) are the main providers of products in all countries. Demand side participation (within the control area or from other control areas) was mentioned by the majority of countries, 14 respondents out of 17. In 8 countries, products are partly provided from outside the control area.

Table 6: Providers of Ancillary Services

	Generators (within CA)	Demand (within CA)	Other SOs	Generators (other CA)	Demand (other CA)
AR	X	X			
AU	X	X		X	X
BE	X	X			
BR	X				X
CN	X	X	X		
CZ	X			X	X
DE	X	X	X	X	
E&W	X	X			
ES	X	X	X		
FI	X	X	X	X	
FR	X	X	X	X	X
JP	X				
KR	X				
NL	X	X			
PJM	X	X			
PT	X	X			
SLO	X	X		X	X
TOTAL	17	13	5	6	5

The survey shows that all products are mainly provided by generation. The relative share of other types of providers seems to be higher for AS-3 and AS-4. In France, whereas AS-1 to AS-4, are only provided by generation, AS-5 (balancing mechanism) can also be provided by demand, other SOs, generators and demand from other control areas.

Only three countries mention the provision of AS-1 by generators from other control areas. This answer can be explained by the following fact: according to UCTE-rules, the provision of primary control - i.e. AS-1 within UCTE – is a shared obligation of all UCTE-countries. It means that every TSO within UCTE has to enter into contractual agreements with generating units within its own area in order to establish its own reserve. In real time however, the energy resulting from primary control can be supplied by all the countries within UCTE. Finally, note that the figure does not yet take into account the projected demand side participation for AS-1 and AS-2 in Belgium.

4.3 Method of instruction

Products for ancillary services can be instructed in several ways. The following methods were included in the survey:

- Automatic response at unit level
- Automatic instruction based on closed-control loop
- Automatic instruction based on real-time optimisation (AGC)¹⁰
- Manual instruction

¹⁰ Automatic instruction based on closed-control loop implies that all generators within a country receive a signal to produce the same amount of extra energy required. On the contrary, in case of automatic instruction based on real-time optimisation (AGC), generators receive a signal differing according to merit order, such that each generator has to produce a different amount of extra energy.

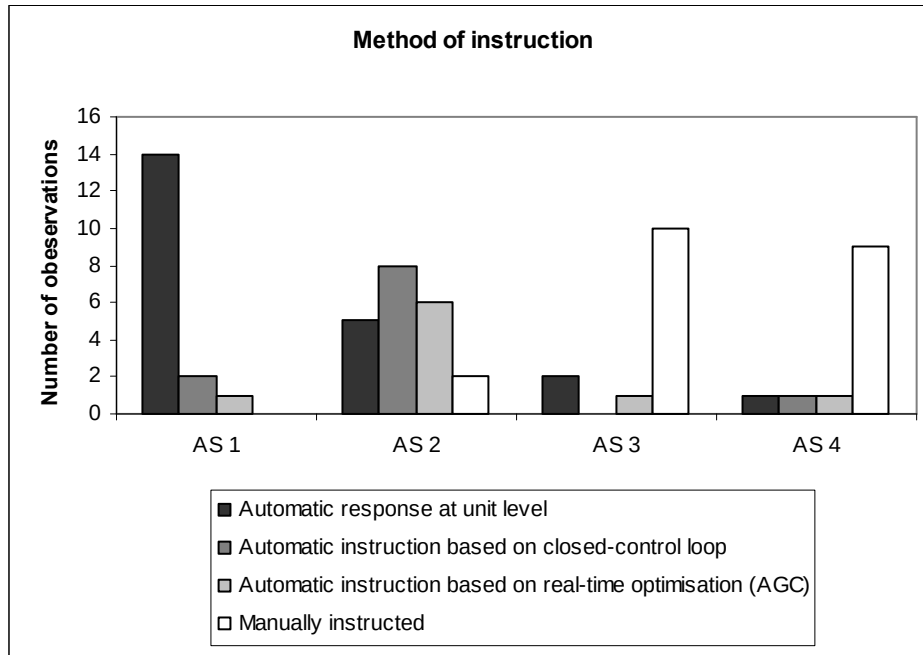


Figure 2: Methods of instruction

In figure 2, AS are classified in a slightly different way from the remaining of the survey: they are classified according to their reaction time (AS 1 being the fastest one and AS 4 the slowest).

As indicated in figure 2, AS-1 and AS-2 are mainly instructed in an automatic way. AS-3 and AS-4 on the contrary are to a large extent instructed in a manual way. This observation confirms the general expectation that fast AS are automatically instructed and slower AS manually.

4.4 Monitoring and penalty on non-delivery

In most countries, actual delivery of ancillary services is monitored and a penalty imposed in case of non-delivery. Further observations resulting from the questionnaire, include:

- The performance monitoring can be real-time (e.g. in Spain for AS-2 and AS-5) or on a historical basis/ex post (e.g. in France). Finland mentioned monitoring in real-time as well as on an historical basis.
- Monitoring can take place continuously using SCADA (e.g. France, Argentina), daily (e.g. Czech Republic), monthly (e.g. Australia) or 'periodically' (PJM). South-Korea stated different check times depending on the product, varying from twice a month to once a month or at random.
- In Spain and the Netherlands, the penalty simply equals the cost of imbalance. This cost can concern both non-availability and non-delivery (the Netherlands). While in China, the amount of the penalty is a fixed rate, the penalty is linked to the remuneration the unit would have been paid in case of compliance or to the bid price as in France, South-Korea, Czech Republic and Argentina.

- In the majority of countries, the penalty is issued by the TSO. However, in Australia the regulator can impose a fine as well and in South-Korea, imposing penalties is the exchange's (KPX) task.
- Only France mentions to explicitly check conformity restoration in case a performance test has shown non-compliance of a unit.

5 CONCLUSIONS

The objective of this work was to describe the research carried out under the CIGRÉ Working Group C5-6, which aimed to provide a common basis for discussions on the worldwide view on ancillary services. The significant differences of definitions or understanding that exist between control zones have made comparisons difficult. However, the WG members tried to make an inventory of the AS and to highlight some general features regarding the main aspects of ancillary services. It shows that most ancillary services are procured via market-based methods, that they are mainly provided by generators and, in a lesser extent, also by demand within the control area. Moreover, the fast ancillary services are mainly instructed in an automatic way whereas slower services are generally manually instructed. Finally, monitoring and penalties for non-delivery are common features.

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7 APPENDIX

7.1 Definition of Area Control Error

Area Control Error (also known as ACE) is a common control method in North America and Europe – the term was included in UCPTE' Policy 1 - Appendix 1A. ACE is a calculation based on Net Interchange scheduled values; Actual Net Interchange power flows; scheduled system frequency; actual system frequency; and a constant that relates 'governor response' to a change in frequency. Specifically the equation for ACE is:

$$ACE = (NIA - NIS) - 10B (FA - FS) \quad \text{where:}$$

- NIA is the algebraic sum of actual flows on all inter-TSO tie lines.
- NIS is the algebraic sum of scheduled flows on all inter-TSO tie lines.
- B is the Frequency Bias Setting (MW/0.1 Hz) for the Balancing Authority. The constant factor 10 converts the frequency setting to MW/Hz.
- FA is the actual frequency.
- FS is the scheduled frequency. FS is normally 60 Hz but may be offset to effect manual time error corrections.

Therefore if a TSO were over-generating then the first term would be positive. A positive ACE indicates over-generation (by the TSO) and would therefore require the suppliers to reduce generation.

If the frequency were low, then the generators with governors would increase generation. Thus the frequency term would be negative showing under-generation (by the system not necessarily by the TSO). The B constant multiplied by the frequency error would approximate how much power was provided by the real generators within the TSO. Thus if the generators produced 10 MWs because the system frequency was slow; and if that TSO was matching its load to its generation such that the first term showed 10 MWs being exported, then the ACE would be zero for a good performing TSO.

7.2 Participants in Survey

I. ARNOTT	(Australia)
R. BEUNE	(Netherlands)
D. BRASIL	(Brazil)
J. BRAGULAT	(Argentina)
K. HANNINEN	(Finland)
T. NAKASE	(Japan)
M. PANTOS	(Slovenia)
R. PEREIRA	(Portugal)
J. PROCHAZKA	(Czech Republic)
H. ROO	(Korea)
E. TORRES	(Spain)
L. XIAOMENG	(China)

7.3 Summary of Ancillary Services

Names of the ancillary services mentioned by questionnaires respondents, with basic specifications (reaction time, delivery time) and classification (indicated by the color). * *Italic indicates data provided by the complementary questionnaire.*

See next pages.

7.4 Summary of procurement methods

Names of the ancillary services mentioned by questionnaires respondents, with basic specifications of procurement methods for capacity (CAP) and energy (ENERGY) : Mandatory Unpaid (MU), Mandatory Paid (MP), Bilateral Contracting (B), Public Tendering (PT), Real Time Market (RTM) * *Italic indicates data provided by the complementary questionnaire.*

See next pages.

SUMMARY OF ANCIL- LARY SERVICES	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)		Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Congestion Management	Replacement Reserves				
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous		Event-driven				Continuous	Event-driven					
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
Argentina	Primary frequency control		Load Freq Control (regulation)		Short term reserves		Secondary frequency control								Black start capability
Rtime	2-3 s		few min				2 min								
Dtime	30 to 60 s		few min to 1h		5 / 10 / 20 min		a few min								few min to few h
Australia	Fast Raise	Fast Lower	Regulating raise	Regulating lower	Slow raise	Slow lower	Delayed raise	Delayed lower					Reactive power		System restart
Rtime	0	0	4 s	4 s	6 s	6 s	60 s	60 s							
Dtime	6 s	6 s	5 min	5 min	60 s	60 s	300 s	300 s							
Belgium	Primary reserve		Secondary reserve		Daily bids of reserve power						Interruptible load (tertiary reserve)	Tertiary reserve			
Rtime	0		10 s												
Dtime	30 s		7,5 min		15 min						3 min	15 min			
Brazil	Primary frequency control		Secondary frequency control		* (uses primary control)		Prompt reserves						Reactive support to voltage control (generator) *	Reactive support to voltage control (gen unit operating as synch. Condenser) *	Black start capability *
Rtime	0		8 s				5 min						Permanent	as requested	as requested
Dtime	30 s		10 min				30 min						Permanent	some minutes	some minutes

SUMMARY OF ANCIL- LARY SERVICES	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)	Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Conges- tion Manage ment	Replacement Reserves					
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous	Event-driven				Conti- nuous	Event- driven						
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
China	Primary frequency control		Secondary frequency control		Minute Reserve								Voltage control		Black start *
Rtime	4s		30s												
Dtime	45s		10 min		10 min										
Czech Republic	Primary frequency control		Secondary frequency control	Tertiary control			Quick start reserve					Replacem ent reserve	Secondary U/Q control *		Black start capability *
Rtime	0		20 s	1 min			1 min					90 min			
Dtime	30s		10 min	30 min			10 min					120 min			
Germany	Primary frequency control		Secondary frequency control								Minute reserves				
Rtime	0		30 s								7,5 min				
Dtime	30 s		5 min								15 min				
England & Wales	Primary frequency response	High frecuence response	Secondary frequency response		Fast reserve		Fast start								
Rtime	0	0	0		2 min		0 - 2 min								
Dtime	10 s	30 s	30 s		>= 2 min		5 / 7 min								
Spain	Primary reserve			Secondar y reserve							Tertiary reserve	Deviation managem ent reserve	Voltage control (minimum requireme nt)*	Voltage contrl (optional provision beyond minimum requirement)*	Black start (not considered as a remune- rated AS)*
Rtime	0			0											
Dtime	30 s			5 min							15 min	30 min			

SUMMARY OF ANCILLARY SERVICES	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)	Contingency Reserves Spinning	Contingency Reserves Not Spinning				Load Following (Energy dispatch)	Congestion Management	Replacement Reserves				
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous	Event-driven					Continuous	Event-driven					
	AS 1		AS 2	AS 3		AS 4			Basic Task - Not an AS		AS 5		AS 6		AS 7
Finland	Frequency controlled normal operation reserve (primary reserves)	Frequency controlled disturbance reserve (primary reserves)	* (uses primary control)	Fast disturbance reserve							Slow reserve		Voltage control		Black start *
Rtime	0	0			5-10 mins										
Dtime	2-3 mins	30 secs			15 mins						15 - 240 min				
France	Primary frequency control			Secondary frequency control	Short term reserve						Balancing mechanism		Primary voltage control	Secondary voltage control	
Rtime	< 20 s			< 60 s										< 60 s	
Dtime	< 30 s			< 60 s	13 or 30 min									< 60 s	
Japan	Spinning reserve		LFC				Hot reserve						Voltage control *		Black start *
Rtime	10 s						10 min								
Dtime															
Korea	Primary frequency control		Secondary frequency control	Short term reserve / Stand by reserve							Long term reserve / Replacement reserve				Black start (mentioned but not as a specified AS)
Rtime	10 s		0	0											
Dtime	10 s / 60 s		30 s	10 - 20 min							2 h				

SUMMARY OF ANCIL- LARY SERVICES	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)	Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Conges- tion Manage ment	Replacement Reserves					
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous	Event-driven				Conti- nuous	Event- driven						
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
Netherlands	Primary control *		Regula- tion power / Secondary control *		Emer- gency power						Reserve power / 15 min tertiary reserve *				Black start
Rtime	0		0 - 30 s		0 - <= 15 min						0				
Dtime	30 s		15 min		<= 15 min						15 min				
USA (PJM)	Primary control (non market)		Secondary control (regula- tion market)	Secon- dary control (synchro nized reserve market)							Energy imba- lance (energy market)			Reactive (revenue requirem ent)	Black start (cost allocation)
Rtime	0			10 min *											within 1 h *
Dtime			5 min	10 min - 30 min *											90 min - 4 h *
Portugal	Primary frequency control		Secondary frequency control								Tertiary frequenc y control				
Rtime	0		4 s								< 15 min				
Dtime	30 s		5 min								15 min				
Slovenia	Primary frequency control		Secondary frequency control								Tertiary Reserves (Minute)	Tertiary Reserves (Hourly)			
Rtime	< 1 s		30 s								< 15 min	> 15 min			
Dtime	30 s		15 min												

Legend: MU: Mandatory – unpaid / MP: Mandatory – paid (at regulated / administrated prices) / B: Bilateral contracting / PT: Public tendering / RTM: Real Time Market															
SUMMARY OF PROCUREMENT METHODS	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)		Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Congestion Management	Replacement Reserves				
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous		Event-driven				Continuous	Event-driven					
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
Argentina	Primary frequency control		Load Freq Control (Regulation)		Short term reserves		Secondary frequency control								Black start capability
CAP			MU		RTM										
ENERGY	MP		MP		MP		MP								MP
ENERGY	RTM		RTM		RTM		RTM								
ENERGY							PT								
Australia	Fast Raise	Fast Lower	Regulating raise	Regulating lower	Slow raise	Slow lower	Delayed raise	Delayed lower					Reactive power		System restart
CAP	RTM	RTM	RTM	RTM	RTM	RTM	RTM	RTM					MU		
CAP													PT		PT
ENERGY													PT		PT
Belgium	Primary reserve		Secondary Reserve		Daily bids of Reserve Power						Interruptible load (tertiary reserve)	Tertiary reserve			
CAP	B		B		B						B	B			
CAP	PT		PT		MU						PT	PT			
ENERGY	MU		B		B										
ENERGY			PT								PT	PT			
ENERGY			RTM								RTM	RTM			

CIGRE TECHNICAL BROCHURE – Ancillary Services : an overview of international practices

Legend: MU: Mandatory – unpaid / MP: Mandatory – paid (at regulated / administrated prices) / B: Bilateral contracting / PT: Public tendering / RTM: Real Time Market

Legend: MU: Mandatory – unpaid / MP: Mandatory – paid (at regulated / administrated prices) / B: Bilateral contracting / PT: Public tendering / RTM: Real Time Market															
SUMMARY OF PROCUREMENT METHODS	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)		Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Congestion Management	Replacement Reserves				
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous		Event-driven				Continuous	Event-driven					
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
Brazil	Primary frequency control		Secondary frequency control		* (uses primary control)		Prompt Reserves						Reactive support to voltage control (generator)*	Reactive support to voltage control (gen unit operating as synch. Condenser) *	Black start capability *
CAP	MU		MU				MU						MU	MU	MU
ENERGY	MU												MU		
China	Primary frequency control		Secondary frequency control		Minute Reserve								Voltage control		Black start *
CAP													MP		MP
ENERGY													MU		
ENERGY													MP		MP
Czech Republic	Primary frequency control		Secondary frequency control	Tertiary control			Quick start reserve					Replacement reserve	Secondary U/Q control *		Black start capability *
CAP	PT		PT	PT			PT					PT	B		B
ENERGY			MP	RTM			RTM					RTM			
Germany	Primary frequency control		Secondary frequency control								Minute Reserves				
CAP	PT		PT								PT				
ENERGY			PT								PT				

CIGRE TECHNICAL BROCHURE – Ancillary Services : an overview of international practices

Legend: MU: Mandatory – unpaid / MP: Mandatory – paid (at regulated / administrated prices) / B: Bilateral contracting / PT: Public tendering / RTM: Real Time Market															
SUMMARY OF PROCUREMENT METHODS	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)		Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Congestion Management	Replacement Reserves				
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous		Event-driven				Continuous	Event-driven					
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
England & Wales	Primary frequency response	High frequency response	Secondary frequency response		Fast reserve		Fast start								
CAP	MP	MP	MP		PT		B								
CAP	B	B	B		B										
ENERGY					PT		B								
ENERGY					B										
Spain	Primary reserve		Secondary reserve		Deviation management reserve						Tertiary reserve		Voltage control (minimum requirement)*	Voltage control (optional provision beyond minimum requirement)*	Black start (not considered as a remunerated AS)*
CAP	MU		PT		RT						RT		MU		
ENERGY	MU		PT		PT						PT				
Finland	Frequency controlled normal operation reserve (primary reserves)	Frequency controlled disturbance reserve (primary reserves)	* (uses primary control)		Fast disturbance reserve						Slow reserve		Voltage control		Black start
CAP	MP	MP			MP								MU		MU
ENERGY															

CIGRE TECHNICAL BROCHURE – Ancillary Services : an overview of international practices

Legend: MU: Mandatory – unpaid / MP: Mandatory – paid (at regulated / administrated prices) / B: Bilateral contracting / PT: Public tendering / RTM: Real Time Market															
SUMMARY OF PROCURE- MENT METHODS	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)	Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Conges- tion Manage ment	Replacement Reserves					
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous	Event-driven				Continuo us	Event- driven						
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
France	Primary frequency control		Secondary frequency control		Short term reserve					Balancing mechanism		Primary voltage control	Secondary voltage control		
CAP	B		B		B					MU		B	B		
ENERGY	B		B		B					RTM		MU	MU		
Japan	Spinning Reserve		LFC				Hot Reserve					Voltage control *		Black start *	
CAP			MP									MU		MU	
ENERGY	MP		MP				MP								
Korea	Primary frequency control		Secondary frequency control		Short term reserve / Stand by reserve					Long term reserve / Replacem ent reserve				Black start (mentionn ed but not as a specified AS)	
CAP															
ENERGY															
Netherlands	Primary control *		Regu- lation power / Secondary control *		Emergen cy power					Reserve power / 15 min tertiary reserve *				Black start	
CAP			PT		PT									PT	
ENERGY	MU		RTM		RTM					RTM					

CIGRE TECHNICAL BROCHURE – Ancillary Services : an overview of international practices

Legend: MU: Mandatory – unpaid / MP: Mandatory – paid (at regulated / administrated prices) / B: Bilateral contracting / PT: Public tendering / RTM: Real Time Market															
SUMMARY OF PROCUREMENT METHODS	Primary		Secondary						Secondary		Tertiary		Other		Other
	Frequency Control		Frequency control						Network control		Network Control		Voltage control		Black start
			Load Freq Control (Regulation)		Contingency Reserves Spinning		Contingency Reserves Not Spinning		Load Following (Energy dispatch)	Congestion Management	Replacement Reserves				
	Not directed by TSO		Directed by TSO						Directed by TSO						
	Instantaneous & Continuous Control		Continuous		Event-driven				Continuous	Event-driven					
	AS 1		AS 2		AS 3		AS 4		Basic Task - Not an AS		AS 5		AS 6		AS 7
USA (PJM)	Primary control (non market)		Secondary control (regulation market)		Secondary control (synchronized reserve market)						Energy imbalance (energy market)			Reactive (revenue requirement)	Black start (cost allocation)
CAP			RTM		RTM									MP	B
ENERGY											RTM				
Portugal	Primary frequency control		Secondary frequency control								Tertiary frequency control				
CAP	MU		B								B				
ENERGY	MU		B								B				
Slovenia	Primary frequency control		Secondary frequency control								Tertiary Reserves (Minute)	Tertiary Reserves (Hourly)			
CAP	MU		B								B	B			
CAP			PT								PT	PT			
ENERGY	MU		MP								B	B			
ENERGY			PT								PT	PT			

7.5 ANCILLARY SERVICES: THE BRAZILIAN EXPERIENCE

**Dalton de Oliveira Camponês do Brasil, Roberto José Ribeiro Gomes da Silva,
Sérgio Cordeiro Sobral, João Carlos Ferreira da Luz, Luiz Renato Monteiro Regino**

**ONS
Brazil**

SUMMARY

This article presents the gist of the characteristics of the Brazilian Interconnected Power System – BIPS, and also the new structure of the Brazilian Electric Sector comprising:

- Brazilian Electrical System (transmission lines extension and the transformation capacity);
- structure of the Brazilian Transmission Model; and
- structure of the Brazilian Generation Model.

This article also details the types of Ancillary Services that are regulated by ANEEL – Agência Nacional de Energia Elétrica (the Brazilian Electric Energy Agency), and provided by Agents.

Among the tasks of the Brazilian Electric System Operator - ONS are the hiring and administration of Ancillary Services needed to operate the BIPS. For the regulations of ANEEL the Ancillary Services that contribute to ensure the operability of the BIPS are the primary and secondary frequency controls and the respective power reserves, the prompt reserve and the reactive power support, the self-restoration of generating units (black start), and the Special Protection System (SPS). These services are provided mainly by Generation Agents. In addition, the regulation establishes some services to be supplied also by Transmission and Distribution Agents.

The Agents which provide AS secondary frequency control, reactive power support by means of synchronous compensation, black start and special protection system will be remunerated by the Ancillary Services Agreement - ASA. These contracts are intended to refund the Agents fixed implementation costs and variable costs (O&M) on the provision of such AS. These services will be accounted by the CCEE - Câmara de Comercialização de Energia Elétrica (Brazilian chamber of electricity trade) through the charges of system services (Encargos de Serviços do Sistema - ESS).

This article finally presents an overview of the amount of ASA that has been signed since 2004.

KEYWORDS

Brazilian Interconnected Power System, Regulations and Ancillary Services.

1. INTRODUCTION

The restructuring of the Brazilian Energy Sector brought to the System's Planners and Agents new paradigms, as for the separation of the activities of generation, transmission and distribution. In this context of industry segmentation, the purchase of energy involves the payment of a product, energy itself, and the payment of a set of services that will enable the final consumer to have a product with the desired quality.

Among the consequences of this restructuring process, one of them relates to the set of intrinsic services involved in the operation of the utilities to be provided by users of the transmission system and transmission utilities themselves. These services are known as ancillary services (AS). The AS are additional services that ensure the efficient functioning of the power grid and, when required, are mandatory because of its importance.

The AS are required to the transmission system to maintain operational security within and between areas served by this system, i.e., to maintain the operation in the transmission system stable and secure. These special services are required, mainly in order to ensure the continuity and quality of a satisfactory energy supply, both in frequency and voltage, as well as to provide support for restoring the power supply after any sort of faults in the system.

Among the tasks of the Brazilian Electric System Operator - ONS are the hiring and administration of Ancillary Services needed to operate the Brazilian Interconnected Power System - BIPS. For the regulations of ANEEL – Agência Nacional de Energia Elétrica (the Brazilian Electric Energy Agency), the Ancillary Services that contribute to ensure the operability of the BIPS are the primary and secondary frequency controls and the respective power reserves, the prompt reserve and the reactive power support, the self-restoration of generating units (black start), and the Special Protection System (SPS).

These services are provided mainly by Generation Agents. In addition, the regulation establishes some services to be supplied also by Transmission and Distribution Agents.

The Agents which provide AS secondary frequency control, reactive power support by means of synchronous compensation, generating units self-restoration (black start) and special protection system will be remunerated by the Ancillary Services Agreement - ASA. These contracts are intended to refund the Agents fixed implementation costs and variable costs (O&M) on the provision of such AS. These services will be accounted by the CCEE - Câmara de Comercialização de Energia Elétrica (Brazilian chamber of electricity trade) through the charges of system services (Encargos de Serviços do Sistema - ESS).

The other¹¹ AS will not require ASA and will be remunerated by other mechanisms of purchase and sale of Electric Energy. The equipment of the transmission utilities for the provision of Ancillary Services for Reactive power support are remunerated according to the charges specified in Transmission Services Agreement - TSA.

This article aims to present the gist of the characteristics of the Brazilian Interconnected Power System - BIPS as well as detailing the types of Ancillary Services that are regulated by ANEEL and provided by Agents. An overview of the amount of ASA been signed since 2004 will also be presented.

¹¹ The primary frequency control and the respective power reserve; the prompt reserve and the reactive power support been realized by generators or by the transmission utilities equipment.

2. GIST OF THE CHARACTERISTICS OF THE BRAZILIAN INTERCONNECTED POWER SYSTEM – BIPS

A model that has been functionally unbundled characterizes the new structure of the Brazilian electric sector that was implemented since 1998. This implies on a segregation of the prime segments –generation, transmission, distribution and commercialization. The model features three very important institutions, namely: ANEEL, CCEE and ONS.

ANEEL (Agencia Nacional de Energia Elétrica – Brazilian Electricity Regulatory Agency) is a semi-autonomous governmental organization established under a special regime whose mission is to provide favorable conditions for the electricity market to develop in a balanced environment amongst agents, for the benefit of society.

CCEE (Câmara de Comercialização de Energia Elétrica - Electric Power Commercialization Chamber) is a non-profit, private, civil organization company whose main purpose is to carry out the wholesale transactions and commercialization of electric power within the Brazilian Electric System, for both Regulated and Free Contracting Environments and for the spot market.

ONS (Operador Nacional do Sistema Elétrico – National Power System Operator) is a non profit civil entity, established by Law in 1998 and regulated by ANEEL. It is supported by all sector players and a small percentage of the consumer tariff. ONS has the mission to coordinate and control the operation of the electric power generation and transmission system, assuring quality, reliability and economy of the electric power supply for all consumers.

2.1 Brazilian Electrical System

Brazilian Interconnected Power System comprises facilities covering 91,332 km of transmission lines extension and 212,206 MVA of transformation capacity. Some of the BIPS basic data (based on 2008) are shown on Table I. The dimensions of the area covered by the Brazilian Transmission System are presented in Figure 1.

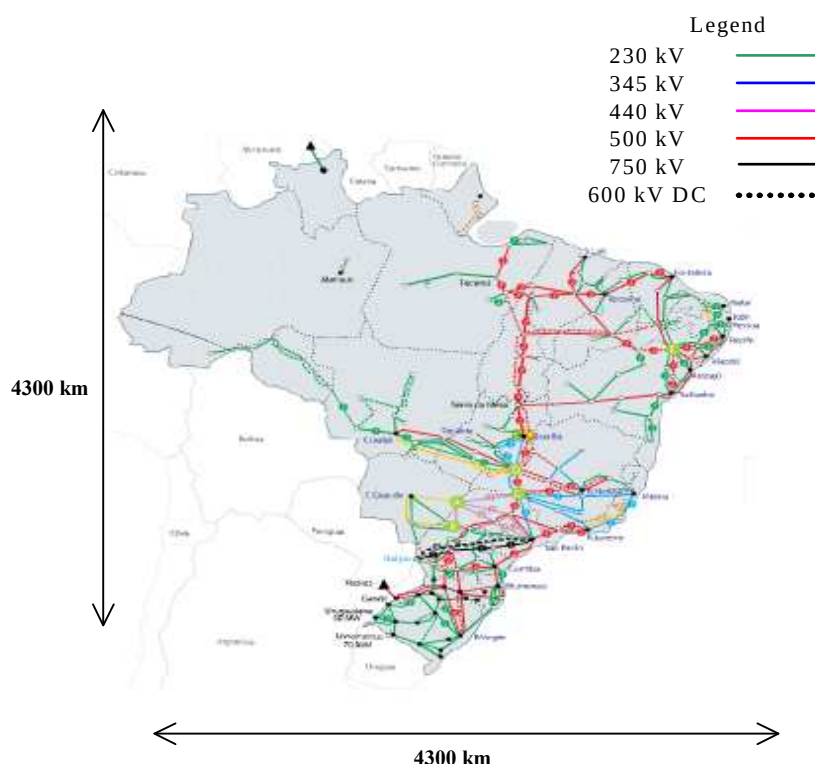


Figure 1 – Brazilian Transmission System

Table I

Voltage Level (kV)	Transmission Lines Extension (km)
230	38,343
345	9,772
440	6,671
500	32,251
600 (HVDC)	1,612
750	2,683
Total	91,332

2.2 Brazilian Transmission Model

The transmission service in the BIPS depends upon the granting of public concessions. Contrasting with distributors, who explore the service in a certain area, the concession of the transmission is granted for each new facility build. Existing transmission assets before restructuring formed the Initial TRANSCO. Despite those TRANSCO, for each new auction of circuits, a public bidding is announced for the granting of concession for a company to render electric power transmission services, including construction, operation and maintenance of grid facilities of the BIPS.

The winning bidder will be the one who undertakes to render the services for the lowest yearly allowed revenue (RAP) – through a reverse auction (Dutch approach) - included on the concession agreement. Invitations to bid are required to make the transmission facilities

available to the main transmission network¹² operated under ONS supervision and control. All transmission equipments will be subject to quality control according to technical rules, and to grid procedures regulated and approved by ANEEL. Concession agreements for transmission services are made between Federal Government – represented by ANEEL– and companies for clear rules relating to rate, consistency, continuity, security, upgrading and quality of services and assistance to consumers. The concession to operate the transmission system is provided for 30 years.

The agreement establishes that the more efficient the concessionaires prove to be in relation to the maintenance and operation of the transmission facilities, thus preventing failures and large maintenances for any reason whatsoever, the closer the utility revenue will be to the RAP originally established by ANEEL. RAP is equal to the payment received by transmission concessionaires for the availability of their facilities pertaining to the BIPS, which is not bound to the energy load transmitted.

The criteria and parameters complied with by ANEEL for calculating the cap of RAP on transmission auctions are: (i) investments composed by the standard costs of the related equipment; (ii) weighted average depreciation rate for each type of equipment; (iii) standard costs for operation and maintenance; (iv) optimal capital structure for the transmission business; (v) own or third parties' cost of capital obtained according to the CAPM (Capital Asset Pricing Model) and WACC (Weighted Average Cost of Capital) models; (vi) taxes and charges as established by the legislation. Transmission RAP is charged by transmitters against users of the BIPS monthly, corresponding to one-twelfth of RAP, as established in TSA. RAP of new concessions may be subject to a penalty resulting from operating unavailability.

2.3 Brazilian Generation Model

The Brazilian Interconnected Power System – BIPS presents as main characteristic the predominance of energetic resources of hydroelectric origin (around 90% of generating capacity installed), supported by a small complement of thermal electric origin.

The energetic planning of this System, as well as its operation, has the unstoppably pursued objective of optimizing the usage of these energy production sources.

In a general way, the energetic optimization may be defined as the result of the group of actions aiming at attending BIPS load at minor cost. Hydrological pouring in the power plant reservoirs, minimizing the usage of thermal generation and equalizing, as much as possible, the operation marginal costs among regions. This optimization signposts the need – or not – of thermal generation usage in substitution to hydraulic generation and of energy transferences among regions or basins, as well as indicates the proper energy production by basin, always observing the operation restrictions related to each usage and dedicating, also, special attention to the future risk of non-attending to the consumption market.

The thermal electric energy production involves, among others, expenses with fuel acquisition and normally presents operational cost higher than the one with hydroelectric energy, whose “fuel” is the water affluent and accumulated in the reservoirs that, for a start, has no significant cost for acquisition and/or usage. Therefore, for economic reasons, the thermal generation usage restricts itself to abnormal or special circumstances, in which are included attending to the System's electric restrictions.

¹² Brazilian main transmission network comprises facilities with voltage level equal or higher than 230kV unless customer-owned facilities.

However, the usage of thermal generation replacing hydraulic generation usually occurs in occasions in which the natural affluences verified and/or predicted to the reservoirs and/or its storages show themselves insufficient (energetic necessity), putting at risk the BIPS load attending in a certain horizon, having, then, the possibility of rationing situations or similar.

The energy transference among regions is usually characterized with the occurrence/imminence of turbinable pouring in a region or the existence of significant unbalance between the storage conditions and/or the natural energies affluent in these regions.

As some BIPS' hydrographic basins, located in distinct geographic regions, present complementary hydrological regimes (ex: the Southeast region rain period, usually, occurs during the South region dry period) it is possible, through the Transmission System, to transfer energy from a region to the other and, then, minimize pouring, reduce thermal generation usage, reduce rationing risks and increase the stock of energy stored in BIPS.

It is also possible to occur energy transferences among regions with similar hydrological regimes but that present storage conditions and/or predictions of unbalanced affluent natural energies resulting in lags among their respective operation marginal costs.

According to what has been previously mentioned, the BIPS energetic optimization as a whole indicates, also, the participation of each hydrographic basin (power plants and reservoirs) in the attending to BIPS load and it is obtained through the calculation of computer models, whose function consists in the guarantee of the electric energy consumption market's attending, at minor cost.

This energetic optimization takes permanently into account the group of operative restrictions related to each basin, regarding the multiple usage of the water and, specially, those related to reliability and safety conditions of the Electric System. With the odd characteristics of BIPS, the necessary procedures for the optimization of its energetic resources present a high complexity level, with direct reflex in the System Operation Planning and Scheduling Process.

The BIPS Operation Planning and Scheduling Process takes place, basically, with its singular characteristics, which are: hydroelectric predominance, waterfall usage with large regularity reservoirs and multiple owners, different hydrographic basins, with hydrological diversities, extensive grid transmission and short thermal complement.

It is important to point out that ONS, despite being an institution of private right, does not own physical actives of the Interconnected System. It is ONS' function to coordinate and/or elaborate studies and the proposition of final power plants dispatches, based on all the information provided by the Agents of generation, transmission, distribution, commercialization and import of electric energy. These dispatches happen within a unit vision of the electric system, without previous concern regarding the identification of companies which own the dispatched facilities. The Agents declare, in each planning step – medium term studies, short term and daily scheduling – the availabilities of the generation and/or transmission equipment and its consumption predictions. ONS consolidates all the information and establishes affluences scenarios to all the hydroelectric power plants in a way to signpost the future risk of non-attending of market, operation plans and the power plants dispatches, always respecting the plans of Ministério de Minas e Energia - MME, of ANEEL and the Water National Agency – WNA.

3. TYPES OF ANCILLARY SERVICES REGULATED BY ANEEL AND PROVIDED BY AGENTS

For the Current Regulations¹³ of ANEEL – Agência Nacional de Energia Elétrica (the Brazilian Electric Energy Agency), the ancillary services that contribute to the guarantee of operability of BIPS are:

- primary and secondary frequency controls and primary and secondary power reserves¹⁴;
- prompt reserve¹⁵;
- reactive power support;
- Self-restoration of Generating Units (“*black start*”); and
- Special Protection System (SPS).

Each ancillary service regulated by ANEEL for BIPS is being characterized as follows:

Primary Frequency Control

Primary Frequency Control is the control carried out by automatic speed regulators of the generating units which aim to limit the variation of frequency when unbalance between load and generation occurs.

Secondary Frequency Control

Secondary Frequency Control is the control carried out by generating units participating in the Automatic Generation Control (AGC), in order to re-establish the programmed value of the system frequency as well as keep or re-establish the programmed values of the exchanges of active Power.

Power Reserve for Primary Control

The Power Reserve for Primary Control is the reserve provision of active power made by generating units to carry out the Primary Frequency Control.

Power Reserve for Secondary Control

The Power Reserve for Secondary Control is the reserve provision of active power made by generating units participating in AGC to carry out the Secondary Frequency Control and/or programmed liquid exchange of active power among areas of control.

¹³ ANEEL Resolution N° 265, June 3rd, 2003, has established the procedures for AS of generation and transmission. The Resolution N° 251, February 13th, 2007, has complemented it, and Resolution N° 309, April 29th, 2008, allowed the Distribution Utilities to provide the referred AS.

¹⁴ The form of provision for power reserves is defined in the Module 10 of Grid Procedures (Submódulo 10.6 *Controle da geração em operação normal*).

¹⁵ “Prompt Reserves” are used in case of “non-dispatched” plants due to its operational costs which are higher in relation to the ones being currently dispatched.. The referred mechanism, named “Prompt reserves”, is a compensatory measure which is applied to avoid possible financial damages to those generating plants. This mechanism comprises the payment of the variable costs (O&M) to the agent in order to cover the fuel consumption necessary to keep the units ready to be synchronized to the system when required by the Brazilian ISO (ONS). This compensation is discontinued whenever the unit is synchronized to the system.

Prompt Reserve

The Prompt Reserve is the generating units' availability to restore the Power Reserves for Primary and Secondary Controls, in case of unavailability or re-indication of generation, if the limit of reserve provision of active power in the system is reached.

Reactive power support

The Reactive power support has the objective of controlling the voltage of the BIPS, through provision or absorption of reactive energy, to maintain the network voltage within the limits of variation defined in the Grid Procedures.

Those ancillary services provided by the sources below are considered reactive power support ancillary services:

- (a) Generating Units;
- (b) Generating Units which operate as synchronous compensators; and
- (c) Transmission and Distribution Utilities' equipment for voltage control.

Self-Restoration of Generating Units (Black Start)

The Self-Restoration (Black Start) is the capability of a generating unit or generating plant of leaving a totally standstill condition for a condition that allows operation, regardless of an external supply source of its auxiliary services.

Special Protection System (SPS)

The Special Protection System is a system that, from the detection of abnormal operational condition or multiple contingencies, carries out automatic actions to preserve the integrity of BIPS, its equipment and transmission lines. This system includes the Emergency Control Plans (ECE – Esquemas de Controle de Emergência), the Security Control Plans (ECS – Esquemas de Controle de Segurança) and the protections which have systemic character.

3.1 Commercial Arrangements for Ancillary Service

The following table presents the description of the commercial arrangements of the ancillary services provided by generation, transmission or distribution agents.

Table II

Ancillary Services Type	Service Providing Form	Remuneration by ASA (Y / N)	Recovered Costs		
			Fixed Costs	Variable Costs	
				O&M	Additional Losses
Primary Frequency Control and Primary Power Reserve	Mandatory	N	-	-	-
Secondary Frequency Control and Secondary Power Reserve	Mandatory (AGC participant plants)	Y	YES (AGC non-participans units). Replacement of existing systems	YES (rental of the communication channel)	-

Ancillary Services Type	Service Providing Form	Remuneration by ASA (Y / N)	Recovered Costs		
			Fixed Costs	Variable Costs	
				O&M	Additional Losses
Prompt Reserve	Mandatory (Non-dispatched plants for systemic reasons)	N	-	YES (Fuel Consumption)	-
Reactive power support (Generator)	Mandatory	N	-	-	-
Reactive power support (Generating Unit Operating as Synchronous Compensator)	Mandatory	Y	YES (Units not operating as SC). Replacement of existing systems	YES (Ancillary Service Tariff)	YES (ONS and CCEE elaborated specific procedure)
Reactive power support (Equipment of Distribution Agents)	Mandatory	Y	YES (If required by ISO). Replacement of existing systems	-	-
Black Start	Mandatory	Y	YES (Equipment not having Black Start). Replacement of existing systems	YES (effectively occurred or by global mean values)	-
Special Protection System (Generator, Equipment of Transmission and Distribution Agents)	Mandatory	Y	YES (If required by ISO). Replacement of existing systems	YES (rental of the communication channel)	-

3.2 Overview of the Amount of ASA been signed by Agents of the BIPS

The following table presents the amount of ASA been signed by agents of the BIPS since 2004.

Table III

Ancillary Services Types with ASA	Amount of ASA
AGC	14
Black Start	14
Reactive power support (Generating Unit as SC)	16
Special Protection System	2
Total	46

The following figure presents the per cent amount of ASA been signed by Agents.

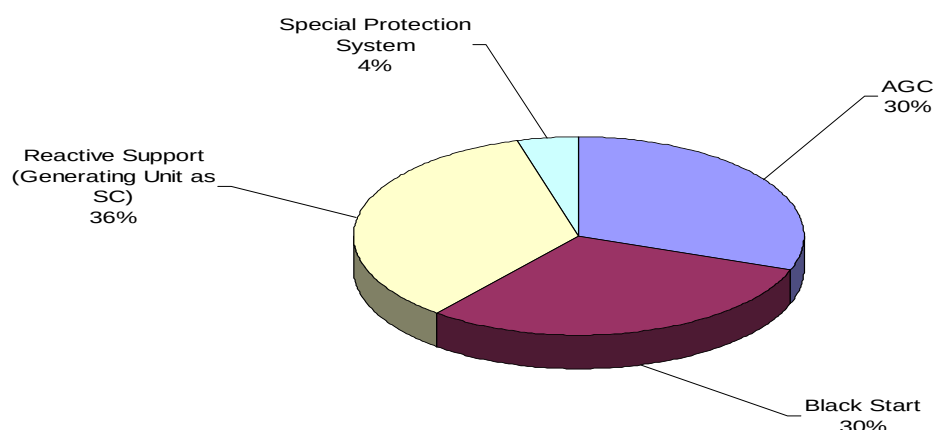


Figure 2 – Per Cent Amount of ASA been signed by Agents

4. CONCLUSIONS

This article presented the gist of the characteristics of the Brazilian Interconnected Power System - BIPS as well as detailed the types of Ancillary Services that are regulated by ANEEL and provided by Agents. An overview of the amount of ASA been signed since 2004 has also been presented.

It is to be mentioned that the Brazilian experience with the AS management has been successful, not only for the Operator but also to the Agents. In addition, the treatment provided to the contract hired for Ancillary Services has brought substantial benefit to the restructured Brazilian Electric Sector.

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7.6 ANCILLARY SERVICES IN FRANCE

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SUMMARY

According to the law dated 10th February 2000, RTE ensures ancillary services (voltage and frequency control) are available and negotiates the necessary contracts with the producers.

The working security of the power network lies at the heart of the responsibilities legally entrusted to RTE as operator of the French public transmission system. It states: "The public transmission system operator shall ensure the balance of electricity flows on the network at all times, as well as the security, safety and efficiency of the network, taking into account the technical constraints to which it is subject. The operator shall also ensure compliance with the rules governing the interconnection of the different national electricity transmission systems" (Law of February 2000, Art. 15.)

Several mechanisms have been implemented to allow RTE to carry out its public service missions in an electricity market open to competition:

- an ancillary services contract, governing:
 - the UCTE primary and secondary reserves,
 - and the power plant primary and secondary voltage control reserves,
- a balancing mechanism, designed for the UCTE tertiary reserve,
- some specific regulations related to reactive energy at the interface with distribution networks,
- requirements or contracts without remuneration for "black start" (the capability to trip to house load is required for large generating units).

Those mechanisms lead to a regulated system between mandatory and market solutions.

- The ancillary services contract:
 - ensures no discrimination, transparent rules of allocation and a cost basis,
 - defines the requirements, the mechanisms of allocation, the remuneration and compensation in case of non respect,
 - includes a performance checking.
- The balancing mechanism is a tool that works according to market rules, and, through continuous tenders, enables RTE to:
 - mobilize reserves to ensure the generation-consumption balance in real time,
 - contribute to solving network congestion,
 - produce a legitimate reference price which can be used for the settlement of imbalances of Balance Responsible Entities.

The cost of automatic controls (primary and secondary frequency control and voltage control) are included in the grid access tariff and the costs of the balancing mechanism are passed through the Balance Responsible Entities. The Regulator approves the rules of the balancing mechanism and determines the pattern for the automatic control remuneration when building the grid access tariff.

The authors intend to present the state-of-the-art of Ancillary Service techniques that are in current operation in France.

KEYWORDS

Ancillary services ; reserve ; balancing mechanism ; margin ; institutional context

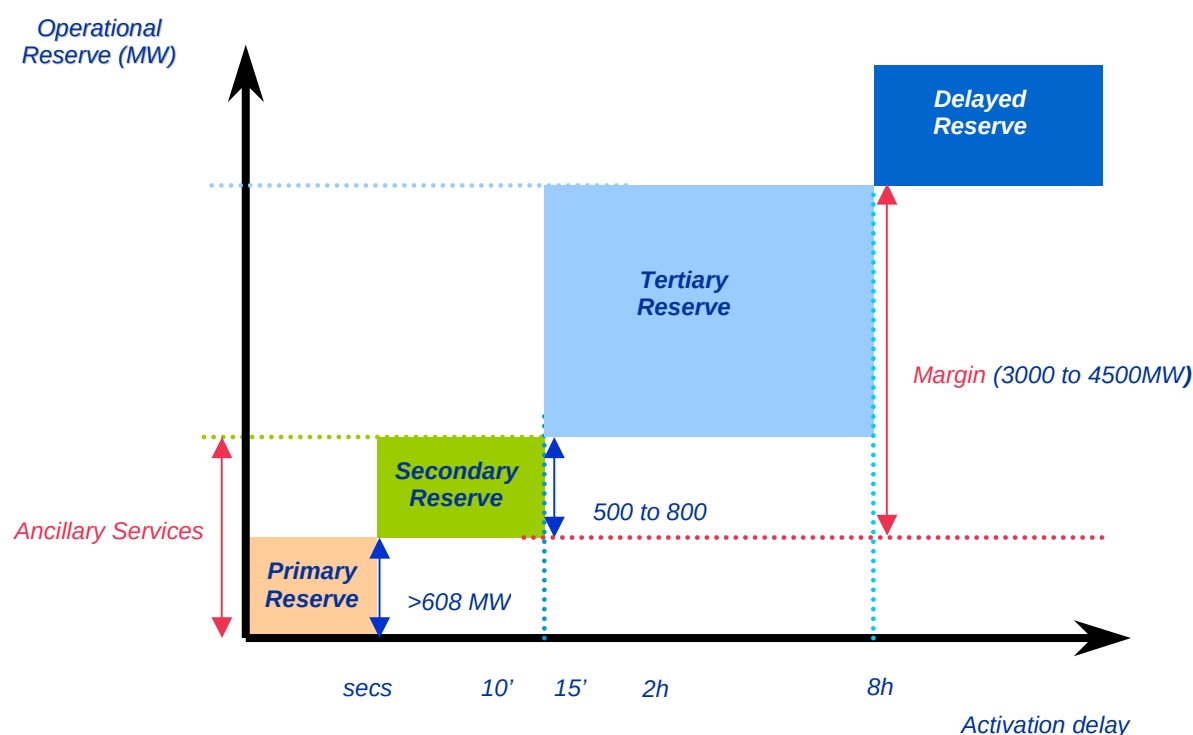
1. Introduction

RTE, the French Transmission System Operator (TSO), is in charge of constantly maintaining the balance between supply and demand of electricity in France. This goal is achieved through the use of ancillary services: UCTE primary and secondary reserves (frequency control), and the primary and secondary voltage control. A long term contract is signed with all the producers to ensure the availability of ancillary services. A balancing mechanism is designed to provide the UCTE tertiary reserve according to market rules. In case of wide-area outage, specific requirements and contracts ensure the procurement of black start services, without remuneration.

The present document describes these mechanisms and how they have been implemented in France, in the context of the opening up of the French electricity market.

2. Volume of Reserves (frequency control)

The following graph provides some quantitative elements about frequency reserves in France:



RTE computes the operating margins necessary to respect specific levels of risk, taking into account 3 different hazards: generation, consumption prediction, and wind energy prediction.

The available tertiary reserve is the volume offered on the balancing mechanism. If it is not sufficient to cover the required margin together with the contracted secondary reserve, RTE sends signals to the actors, asking them to find technical means to offer more reserve on the balancing mechanism.

3. The institutional context

French statutory texts stipulate the requirements imposed on generating units wishing to be connected to the transmission system, in order for them to be entitled to participate in frequency and voltage controls ("connection" decrees and orders from 2008 [1]). These texts describe in detail the construction requirements that generating units must comply with. They apply to generating units that have requested to be connected since April 2008, or recently connected, and specify that these units have an obligation to participate in these controls.

For existing generating units, there is no regulatory text defining the construction requirements and performance levels in relation to ancillary services participation. These requirements are defined in the internal construction specifications of each generating unit and in bilateral agreements with RTE.

Participation in controls is negotiated with RTE and is determined by the Ancillary Services participation contract, in application of article 15-III of law no. 2000-108 dated 10th February 2000, which stipulates that RTE ensures the reserves are available (in particular the reserves associated with frequency and voltage controls) and for this purpose negotiates the necessary contracts with the producers.

The Ancillary Services participation contract guarantees identical participation terms and conditions for all the energy generators. It distributes in a fair manner the services expected from each scheduling manager and pays for the services rendered on the basis of public unit prices that are identical for all energy generators. These prices are based on the expenses borne by the energy generators.

The costs paid by RTE to remunerate the energy generators, in the framework of the ancillary services participation contracts, are recovered via the Use of the Transmission System Tariff issued by the French regulator .

The French balancing mechanism is run by RTE since April 2003. It is a direct application of article 15-II of law no. 2000-108 dated 10th February 2000, which states: "The Transmission System Operator ensures at all times the equilibrium of electricity flows on the network [...] taking technical constraints into account [...] and the economical merit order of the balancing propositions it receives. The criteria of its choices between offers are objective, non discriminatory and published."

Article 15-III of law no. 2000-108 dated 10th February 2000 also says that: "The totality of the unused and technically available power of every production unit [...] must be offered on the balancing mechanism."

The costs paid by the balancing mechanism to remunerate the energy generators are recovered via the penalties paid by Balance Responsible entities who caused imbalances, or by RTE if the offer is used to solve network congestion problems.

4. Ancillary Services

4.1 The Ancillary Services Contract

The Ancillary Services participation contract describes the technical, legal and financial terms and conditions for RTE's acquisition of the contributions of generating units to frequency and voltage controls. The model contract, including current remuneration prices, is published on the RTE web site [4]. In particular it specifies:

The aptitude requirements and performance levels required of the generating units, in particular for existing groups that are not subjected to the statutory text of 2008 [1].

The arrangements for remuneration of the voltage and frequency control services ; they are fixed by RTE with respect to the Use of the Transmission System Tariff and are not negotiable. The all-inclusive prices for the different components of the remuneration are defined in the contract. For example, for frequency control the remuneration is based on a fixed rate per MW of control capability upwards and by hour of availability. In the case of a secondary control demand, the energy supplied is in addition remunerated and the saved energy is reimbursed to RTE, both at the same price. For voltage control, the remuneration depends on the unit's geographic zone. RTE defines reactive power sensitive zones, where some of the energy generator's investment costs are remunerated. The sensitive zones cover roughly a third of French territory ; these areas are coloured in brown on the map below. In the other zones, this remuneration of investment costs is not payable.



However, regardless of the zone, the energy generator's operating expenses are remunerated at a fixed rate per Mvar per hour when the unit is run. This remuneration is increased by 50% if the unit participates in secondary automatic voltage control.

The consequences of failure to abide by the provisions. The purpose of this clause is to prevent the energy generator from mobilising the reserves demanded by the RTE for its own benefit, in order to sell more energy on the market, when the prices are higher than the remuneration stipulated in the contract [4]. For this purpose, an energy generator who does not schedule the reserves required by RTE pays a penalty equal to the energy cost on EPEX Spot¹⁶, at the relevant time, for the missing MWs of reserve compared to the RTE provision. However this penalty is suspended or reduced when failure to comply with the provision is caused by unintentional non availability.

The mechanisms for returning to conformity if the performance levels are not achieved. These mechanisms include a sliding scale of financial penalties according to the magnitude and duration of the discrepancies. These financial measures aim at encouraging energy generators to quickly make their units available for controls again, in conformity with a lead-time agreed with RTE.

4.2 Performance monitoring by RTE

The CdP-Prod diagnosis tool (French acronym for "verification of generators performance"), developed by RTE since 2003, makes it possible to analyse the units' response to the natural surges of the controls and to compare this response to the performance expected within the contractual framework. This software analyses the measurements of frequency, active and reactive power and voltage at the connection point, computes the indicators and supplies diagnosis information concerning conformity of the participation in control. This diagnosis information is available subsequently, at D+1. The monitoring is carried out using only RTE measurements (no specific measurements have been installed on RTE or generation side).

The first years of implementation of this monitoring tool enables RTE to insure that operation reliability regarding frequency control has not deteriorated in France in the context of the opening up of electricity markets. Furthermore, the mechanism of financial penalties in case of performance discrepancies has enabled to enter in a virtuous circle of progress actions allowing the maintaining and in some cases the improving of the generating unit performances.

4.3 The role of Distribution Networks in voltage control

Voltage control cannot be only performed at the transmission level, without concern about reactive energy consumption at the distribution level. There needs to be a coordinated policy for voltage quality, and incentives for distribution companies to maintain low reactive energy consumption.

When a distributor asks RTE to study the connection of a distribution substation, it must inform RTE of the electrical characteristics of its network and of the compensation means of reactive power at its disposal. RTE then studies that the linking would not create any threat to

¹⁶ www.epexspot.com

the transmission network security. This study leads to a technical requirement: the distributor must not exceed a specific value of power factor at the interface between the transmission and the distribution network [7].

In complement, the distributor and RTE sign a contract specifying that if during a month from November to March, the quantity of reactive energy consumed during working days between 6 am and 10 pm exceeds 40% of the quantity of active energy consumed on that network, the reactive energy above these 40% is invoiced by RTE at a price agreed in the contract [8].

For existing distribution networks, a historical requirement states that the average $\tan(\phi)$ must not exceed 0.4. The actual performance of distribution networks being much better, the French regulator (CRE) proposed that new agreements should be made to strengthen these requirements. RTE regional units have studied the values of $\tan(\phi)$ required in each connexion point between the distributor and RTE for the global security of the network, based on existing performance. There are ongoing negotiations on this subject.

5. The Balancing Mechanism

5.1 The Balancing Mechanism

The Balancing Mechanism is an independent entity, run by RTE. Its rules are established by RTE in consultation with the actors, through the Balancing Mechanism Operation Committee (CFMA). The French Energy Regulatory Authority (CRE) approves the rules and "supervises the regularity of offer presentation and of criteria for the selection of offers".

The Balancing Mechanism is a tool that works according to market rules: actors offer their reserve at a price they choose freely, detailing the technical constraints associated with it. RTE then selects the offers complying technically with its needs, sorts them by price and chooses the best price.

For an upward offer, the actor receives its bid price. For a downward offer, the actors pays the Balancing Mechanism at its offer price. Hence in case of upwards offers, RTE chooses the lowest price, and in case of downwards offers, RTE chooses the highest price.

The Balancing Mechanism is used to:

- mobilise reserves for generation-consumption balance reasons ($G=C$)
- rebuild short term reserves, i.e ancillary services or operating margin
- solve network congestions (in that case RTE chooses the cheapest offer able to solve the congestion)

It is also important to note that these continuous tenders produce a legitimate reference price for the compensation of imbalances.

Producers have an obligation to offer the totality of the unused and technically available power of their units. But it is not the only source of offers on the Balancing Mechanism:

- foreign actors can bid too
- a consumption decrease is a valid upward offer

There were approximately 30 actors making offers on the Balancing Mechanism at the beginning of 2009.

5.2 Balance Responsible entities

As a general safety rule and good practice, RTE considers that all the actors should participate to the system's security. This is one of the reasons of the existence of Balance Responsible entities.

A Balance Responsible (BR) is a financial entity taking in charge the energy imbalances settlement within a perimeter on behalf of the market participants. It merges the imbalances related to all market transactions allocated within its perimeter. All the market participants (producers, traders, retailers, etc..) must be linked to a BR, which they can choose freely. There were approximately 150 BRs in France at the beginning of 2009.

The imbalance in a BR perimeter is computed every half hour according to the following formula:

$$\text{Imbalance} = \text{Energy Injection} - \text{Energy Extraction}$$

5.3 Settlement of the Balancing Mechanism and of imbalances

As an independent entity, the Balancing Mechanism is financially balanced. Thus the general idea is that costs of balancing are fully covered by imbalance penalties paid by BRs. To reach this goal in the fairest manner as possible, the following process is applied:

- For every half hour, a trend is calculated. This trend can be:
 - upward if most of activated offers were upward
 - downward if most of activated offers were downward
 Knowing the global trend is important as it indicates whether an imbalance helped the system (ex: positive imbalance in an upward trend) or if it made the situation worse (ex: negative imbalance in an upward trend).
- For every half hour, the Average Weighted Price (PMP) is computed. This PMP represents the average cost of a MW of imbalance against the trend during this half hour. Hence it is the price that BRs are going to pay for their imbalances that created this situation.

It should be noted that RTE sometimes uses offers with a higher cost because of congestion issues, and the BRs are not responsible for these problems. It is then fair not to make them pay for this extra-cost.

The extra costs:

- caused by congestion problems are fully paid by RTE (and recovered via the Use of the Transmission System Tariff)
- caused by rebuild of operational margin operations are fully paid by the BRs
- caused by rebuild of ancillary services operations are split between RTE and the BRs, according to the trend

- A Settlement of Imbalances Price (PRE) is then computed:

	<i>Upward Trend</i>	<i>No Trend</i>	<i>Downward trend</i>
<i>Positive Imbalance</i>	Spot_{EPEX}	Spot_{EPEX}	min{PMP / (1+K) , Spot_{EPEX}}
<i>Negative imbalance</i>	max{PMP * (1+K) , Spot_{EPEX}}	Spot_{EPEX}	Spot_{EPEX}

The coefficient K currently has a value of 0.05. It is a tool to balance the cost of activated offers and the revenue of penalties.

The PRE is the price BRs pay or are paid for their imbalances. It is important to note that BRs whose imbalances are helping (involuntarily) the system are remunerated/pay for their extra/missing energy at the EPEX spot price, meaning there is no penalty for them. On the other hand, if a BR imbalance is making the situation worse, the extra/missing energy will have a respectively low/high price.

The PRE is market based and hence volatile. Together with the asymmetry of these prices, it is a good incentive for BRs to make sure they are not in a short position.

RTE publishes a lot of data about the Balancing Mechanism, so that the actors are able to check what they pay for, and to forecast the cost of their imbalances using past data. Some information is not disclosed for confidentiality reasons, such as bid prices on the Balancing Mechanism.

6. Black Start (tripping to house load capability)

In exceptional situations, it is possible that, despite RTE efforts, the network completely collapses. RTE would then have to rebuild the network with two objectives:

- Act as fast as possible, to limit the consequences of the black out on the country's economic and social life
- Act in a safe way, as the network is very fragile in such a situation

It is compulsory for all generating units of a power of more than 40 MW to be able to trip to house load and separate themselves from the network in such a situation and keep running until RTE links them back. This is a technical requirement for every unit requesting access to the network, and therefore not negotiable [1].

RTE's strategy to rebuild the network without help from other countries is to use large generating units which have tripped successfully to house load and are ready to be connected again to the grid.. It is therefore crucial to have enough black start units in the country and almost all the existing generating units of more than 120 MW have the capability to trip to house load. .

The black start ability of the largest generating units (above 900 MW) is subject to a contract with RTE, in particular to schedule field tests of tripping to house load and agree a rate of successfulness for the tripping. These agreements do not lead to any remuneration [7].

Conclusion

RTE bears the responsibility of the French public transmission network security and balance, achieved through the use of ancillary services and of a balancing mechanism. In order for RTE to carry out its public service missions in an electricity market open to competition, several mechanisms have been implemented:

- Ancillary services availability is ensured through the use of a contract , which:
 - is mandatory for the producers,
 - ensures no discrimination, transparent rules of allocation and a cost basis,
 - defines the requirements, the mechanisms of allocation, the remuneration and compensation in case of non respect,
 - includes a performance checking.
- The balancing mechanism, designed for the UCTE tertiary reserve:
 - works according to market rules (continuous tenders),
 - on which producers have the obligation to make offers,
 - produces a legitimate reference price which can be used for the settlement of imbalances of Balance Responsible Entities.
- Specific regulations related to reactive energy at the interface with distribution networks aim at maintaining a low power factor.

Requirements or contracts without remuneration for black start.

Those mechanisms lead to a regulated system between mandatory and market solutions, adapted to the characteristics of the French electricity market, and which allocates fairly the costs of system operation and security.

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- [7] Documentation Technique de Référence RTE ; Chapitre 4.2 (RTE ; <http://www.rte-france.com>)
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7.7 ANCILLARY SERVICES IN THE AUSTRALIAN NATIONAL ELECTRICITY MARKET (NEM)

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SUMMARY

Various mechanisms are in place in the National Electricity Market (NEM) to meet electricity demand and maintain system security and reliability in the most competitive manner. Ancillary services are used to manage power system security and reliability. This paper discusses the various ancillary services in the NEM. These include:

- Frequency Control Ancillary Services (FCAS)
- Network Control Ancillary Services (NCAS)
- System Restart Ancillary Services (SRAS)

At the commencement of the NEM, over a decade ago, all ancillary services were provided through long-term agreements between the market operator (as the purchaser of ancillary services on behalf of the market) and ancillary service providers. An obligation to investigate more competitive ways ancillary services could be provided, led to the introduction of FCAS spot markets. These markets commenced trading in September 2001 and provide the NEM with simple, dynamic and transparent arrangements for delivering FCAS that have further increased competition and have contributed to improved overall market efficiency.¹⁷

Eight FCAS markets are co-optimised with the Energy Market within an overall security constrained dispatch. This co-optimisation is a unique feature of NEM. It ensures that energy and FCAS requirements are met at the lowest cost to the market.

NCAS and SRAS are non-market ancillary services. NCAS are provided partly by the mandatory performance standards of market participants connected to the grid, and partly through contractual agreements with service providers, obtained through a tendering process. The provision of SRAS is through contracts for service availability by service providers. SRAS is also procured via a tendering process. Tendering process guidelines for non-market ancillary services ensure the procurement of the most competitively priced services.

Ancillary service costs are dependant upon the amount of service required at any particular time and, as these amounts can vary significantly from period to period, costs also vary, and are recovered by market participants.

The majority of this paper is based on information provided by the Australian Energy Market Operator (AEMO), all of which is publicly available on the AEMO website¹⁸.

¹⁷ An Introduction to Australia's National Electricity Market
(<http://www.aemo.com.au/corporate/publications.html>).

¹⁸ <http://www.aemo.com.au/>

1. An Introduction to the National Electricity Market (NEM)

The NEM began operating as a wholesale market in 1998, supplying electricity to retailers and end-users in Queensland, New South Wales, the Australian Capital Territory, Victoria and South Australia. Tasmania joined the NEM in 2005. Operations today are based in five interconnected regions that mainly follow state boundaries.

The NEM operates one of the world's longest interconnected power system – from Port Douglas in Queensland to Port Lincoln in South Australia – a distance of around 5,000 kilometres. More than \$10 billion of electricity is traded annually in the NEM to meet the demand of more than eight million end-use consumers.

Some assets that comprise the NEM's infrastructure are owned and operated by state governments; others are owned and operated under private business arrangements.ⁱ

The NEM is based on a pooled exchange between electricity producers and consumers where the output from all generators is aggregated and scheduled to meet demand. The electricity pool runs according to the provisions of National Electricity Law and National Electricity Rules (the Rules) made under that Law, developed by the Australian Energy Market Commission (AEMC) and enforced by the Australian Energy Regulator (AER).ⁱⁱ

Responsibilities of the AEMC includeⁱⁱⁱ:

- Rule making in regard to electricity wholesale and transmission regulation in the NEM;
- Rule making in relation to economic regulation of electricity distribution network services;
- Market development; and
- Providing advice to the Australian Ministerial Council on Energy in relation to the NEM.

The AER is responsible for the economic regulation of the transmission and distribution networks in the NEM, including^{iv}:

- making regulatory decisions;
- developing and publishing service standards;
- making and amending guidelines for operations and information flows of a regulated entity; and
- enforcing the National Electricity Law and the Rules and investigating and bringing proceedings in connection with breaches.

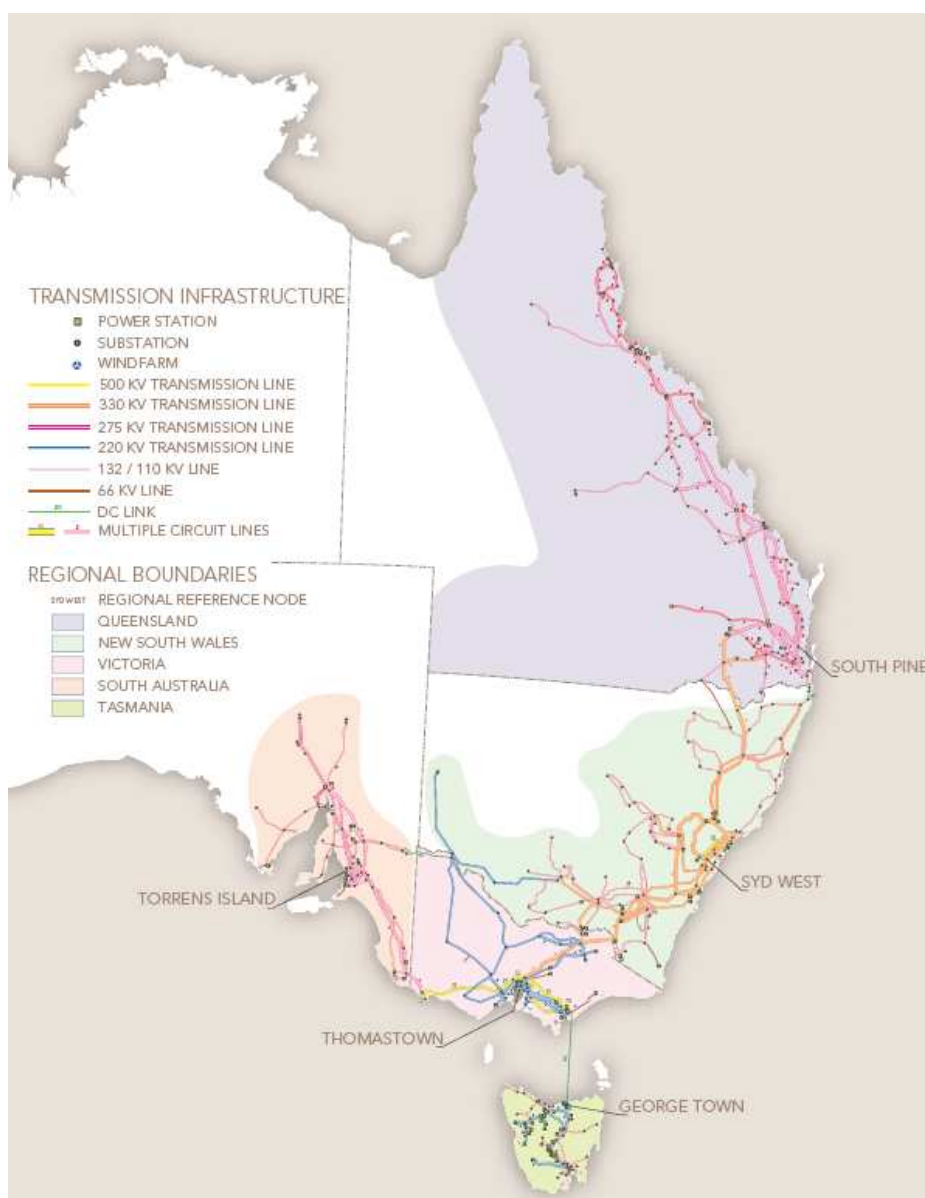


Figure 1: Regions and networks in Australia's National Electricity Market^v

Energy Market Operation

The NEM is operated by the Australian Energy Market Operator (AEMO), an independent, member-based organisation providing a range of gas and electricity market, operational and planning functions.^{vi}

Wholesale electricity trading is conducted as a compulsory spot market through a centrally-coordinated dispatch process. The NEM operates as an energy-only market – there is no capacity market.

The NEM facilitates trade between the producers and wholesale consumers of electricity by;

- establishing demand levels;
- receiving offers to supply from generators;
- scheduling generators;
- dispatching generators into production;

- calculating the spot price;
- measuring electricity use; and
- financially settling the market.

Generators submit offers to supply the market with specific amounts of electricity at particular prices, every five minutes of each day. MW Offers are made for each of ten price bands (Price Band 1 to Price Band 10). From all offers submitted, AEMO's NEM Dispatch Engine (NEMDE¹⁹) determines which generators to dispatch into production based on meeting demand the most cost-efficient way²⁰.

NEMDE utilises numerical 'constraint' equations, to model physical limitations in the power system. Constraint equations are applied for both system normal and outage conditions.^{vii}

AEMO issues dispatch instructions electronically via the automatic generation control (AGC) system or the AEMO Market Management System (MMS) interfaces. The AGC system dispatches generating units which are on remote control.^{viii}

A dispatch price is determined every five minutes. Six dispatch prices are averaged every half-hour to determine the spot price for each (half-hour) trading interval for each of the regions of the NEM. AEMO uses the spot price as the basis for the financial settlement of physical spot transactions for all energy traded in the NEM.

The Rules set a maximum spot price, the 'Market Price Cap', of \$10,000 per megawatt hour (MWh). This price is automatically triggered when AEMO directs network service providers to interrupt customer supply in order to keep supply and demand in the system in balance. The minimum spot price, the 'Market Floor Price' is currently set at -\$1,000/MWh.

Factors contributing to variations in spot price in different regions of the NEM include:

- total system load;
- plant outages;
- differing fuel sources for local supply in different NEM regions;
- interconnector capacity limitations;
- frequency control;
- voltage control;
- testing; and
- transmission outages.

AEMO calculates the financial liability of all market participants on a daily basis and settles transactions for all trade in the NEM weekly. This involves AEMO collecting all money due for electricity purchased from the pool from market customers, and paying generators for the electricity they have produced, based on the spot price. The settlement price for both generators and market customers is equal to the amount of energy produced or consumed multiplied by both the spot price that applies in the region of their operation and any loss factors that apply.

NEM financial settlement operates four weeks in arrears and includes millions of dollars of trading funds. To ensure generators are paid for their electricity production, AEMO has a

¹⁹ NEMDE is a linear dispatch program that attempts to minimise the objective function within the market model every time that it is run.

²⁰ The objective function can be simplified as:

$\sum_{\text{generation offers}} (\text{MW} \times \text{offer price}) - \sum_{\text{dispatchable load bids}} (\text{MW} \times \text{offer price}) + \sum_{\text{ancillary services offers}} (\text{MW} \times \text{offer price})$

robust risk management program and strict prudential arrangements in place. As part of this, AEMO requires the deposit of bank guarantees and security deposits against an established maximum credit limit for each market customer.

AEMO has the authority to suspend a market participant who fails to respond adequately to a default notice, and to reinstate that market participant only when their required financial position is re-established.^{ix}

2. Ancillary Services in the NEM

Ancillary services are used by AEMO to safely manage power system security and reliability. Ancillary services are used by AEMO to safely manage power system security and reliability. Key technical characteristics maintained by ancillary services include:

- Frequency standards;
- Voltage standards; and
- System Restart processes

AEMO operates eight separate real-time spot markets for the delivery of Frequency Control Ancillary Services (FCAS), and purchases Network Control Ancillary Services (NCAS) and System Restart Ancillary Services (SRAS) under agreements with service providers.

Ancillary service costs are dependant upon the amount of service required at any particular time and, as these amounts can vary significantly from period to period, costs will also vary. Payments for ancillary services include payments for availability and for the delivery of the services.

2.1. Frequency Control and FCAS Markets

FCAS are concerned with balancing power supply and demand over short time intervals throughout the power system. The ancillary services types traditionally used are Automatic Generation Control (AGC), Governor Control, Load Shedding, Rapid Generator Unit Unloading (RGUU) and Rapid Generator Unit Loading (RGUL) services.^x

AEMO operates eight separate real-time spot markets for delivering FCAS, compared with one energy market. FCAS providers bid their services into the 8 FCAS markets in a similar way to generators bidding into the energy market. AEMO publishes eight FCAS spot prices along with energy prices every 5 minutes, with half hour settlement for each FCAS market. All Providers in a region are paid at the same rate.

The eight FCAS markets consist of two Regulating Services and six Contingency Services. Regulating Services maintain frequency during normal demand variations. Contingency Services ensure frequency remains within operating standards following a credible contingency event.

SERVICE	PURPOSE	DESCRIPTION
Regulating Raise Service	Regulation Deviation	Generation / load response to remote signals from AEMO in order to control frequency
Regulating Lower Service	Regulation Deviation	Generation / load response to remote signals from AEMO in order to control frequency
Fast Raise Service (6 seconds)	Large Deviation Contingency Service	Rapid generation / load response to locally sensed low frequency
Fast Lower Service (6 seconds)	Large Deviation Contingency Service	Rapid generation / load response to locally sensed high frequency
Slow Raise Service (60 seconds)	Large Deviation Contingency Service	Generation / load response to locally sensed low frequency
Slow Lower Service (60 seconds)	Large Deviation Contingency Service	Generation / load response to locally sensed high frequency
Delayed Raise Service (5 minutes)	Large Deviation Contingency Service	Generation / load response to locally sensed low frequency beyond a threshold
Delayed Lower Service (5 minutes)	Large Deviation Contingency Service	Generation / load response to locally sensed high frequency beyond a threshold

Table 1: Description of the eight FCAS services^{xi}

An FCAS offer submitted for a raise service represents the amount of MWs a participant can add to the system, in the given time frame, in order to raise the frequency. An FCAS offer submitted for a lower service represents the amount of MWs a participant can take from the system, in the given time frame, in order to lower the frequency. When FCAS is enabled, it does not mean a generating unit is actually providing FCAS.

During each 5-minute dispatch interval of the market, NEMDE must enable a sufficient amount of each of the eight FCAS products to meet the FCAS MW requirement. NEMDE will enable FCAS offers in merit order of cost. The highest cost offer to be enabled will set the price for the FCAS service.

FCAS markets are co-optimised with the energy market to minimise the total cost to the market. It may be necessary for NEMDE to move the energy target of a scheduled generator or load to obtain the most economic dispatch. This co-optimisation process is inherent in NEMDE's dispatch algorithm. The co-optimisation of energy and FCAS markets is a particular feature of the NEM.^{xii}

FCAS requirements may be global or local. In a system normal situation, FCAS requirements are generally distributed globally from all interconnected regions, except Tasmania, where some FCAS may be sourced locally. When regions are separated or at risk of separating, both global and local FCAS will be sourced, with local regulation required on each side of the separation.

AEMO maintains system frequency according to the NEM frequency standards which are set by the AEMC's Reliability Panel²¹.

²¹ "The National Electricity Law requires the AEMC to establish the Reliability Panel in accordance with the National Electricity Rules. The role of the Panel is:

- to monitor, review and report on, in accordance with the Rules, the safety, security and reliability of the national electricity system;
- at the request of the AEMC, to provide advice in relation to the safety, security and reliability of the national electricity system; and

CONDITION	CONTAINMENT	STABILISATION	RECOVERY
Accumulated time error ²²	5 seconds		
No contingency event or load event	49.75 to 50.25 Hz, 49.85 to 50.15 Hz 99% of the time	49.85 to 50.15 Hz within 5 minutes	
Generation event or load event	49.5 to 50.5 Hz	49.85 to 50.15 Hz within 5 minutes	
Network event	49 to 51 Hz	49.5 to 50.5 Hz within 1 minute	49.85 to 50.15 Hz within 5 minutes
Separation event	49 to 51 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes
Multiple contingency event	47 to 52 Hz	49.5 to 50.5 Hz within 2 minutes	49.85 to 50.15 Hz within 10 minutes

Table 2: NEM Mainland Frequency Operating Standards – Interconnected System^{23xiii}

2.1.1 Regulation FCAS

Minor variations in NEM system frequency (50 Hz) occur continually as a result of normal fluctuations in consumer demand and generating unit performance, even without contingency events.

Two regulation services are used to maintain frequency during normal demand variations in the system. Regulation FCAS consist of:

1. Raise Regulation
2. Lower Regulation

Regulation services are provided by generators that are on AGC. Generators on AGC receive control signals from AEMO to:

- increase/decrease MW output to match bid targets; and
- provide frequency regulation to enabled generators to maintain system frequency within the normal operating band.

Calculation of Regulation requirements are based on predetermined numbers and are used to correct frequency variations within each five-minute period. These range between 120 MW to 250 MW depending on the time of day^{xiv}.

When a unit switches from AGC to Local Control, AEMO disables FCAS regulation automatically.

• any other functions or powers conferred on it under the Law and the Rules.”
(<http://www.aemc.gov.au/Panels-and-Committees/Reliability-Panel.html>)

²² The AEMC defines Accumulated Time Error as “the integral over time of the difference between 20 milliseconds and the inverse of that system frequency, starting from a time published by AEMO.”
(<http://www.aemc.gov.au/Media/docs/Final%20Determination-5cb81281-be55-4f5b-820b-39a457a30a00-0.pdf>)

²³ ‘Mainland’ regions incorporate all regions except Tasmania. Separate frequency operating standards apply for the Tasmanian power system, for an islanded system and during electricity supply scarcity in the NEM.

2.1.2 Contingency FCAS

Six contingency services are used to ensure system frequency remains within operating standards following a credible contingency event. A contingency event is an event affecting the power system, most likely to involve the failure/removal of one or more generating unit(s) and/or load blocks.²⁴

The requirement for contingency service is a function of the largest generation output or load blocks on the power system, as well as the combined system demand. In most instances, the largest generation and load blocks on the power system are relatively constant, so the contingency service requirement becomes a function of the System Demand.^{xv}

FREQUENCY CONTROL SERVICE	TYPICAL METHOD OF PROVISION
Fast raise (6 second raise)	Generator Governor Response, Load Shedding
Fast lower (6 second lower)	Generator Governor Response
Slow raise (60 second raise)	Generator Governor Response, Load Shedding
Slow lower (60 second lower)	Generator Governor Response,
Delayed raise (5 minute raise)	Rapid Generator Unit Loading, Load Shedding
Delayed lower (5 minute lower)	Rapid Generator Unit Unloading

Table 3: Contingency frequency control services and typical method of provision for each service^{xvi}.

2.1.3 FCAS Markets – Bidding and Dispatch

FCAS bids take the form of a trapezium defined by enablement limits and breakpoints. The trapezium indicates the maximum amount of FCAS that can be provided (“N” MW) for a given output/consumption for a generator/load (“n” MW). FCAS bids must comply with similar bidding rules that apply to the energy market.^{xvii}

Plant dispatched for FCAS between an enablement limit and a corresponding breakpoint can be moved in the energy market to obtain more FCAS. For example, if a generator is dispatched between the upper enablement limit and the upper breakpoint, the NEMDE may constrain the unit in the energy market in order to obtain more FCAS, provided this led to the lowest overall cost.^{xviii}

²⁴ Clause 4.2.3 of the National Electricity Rules

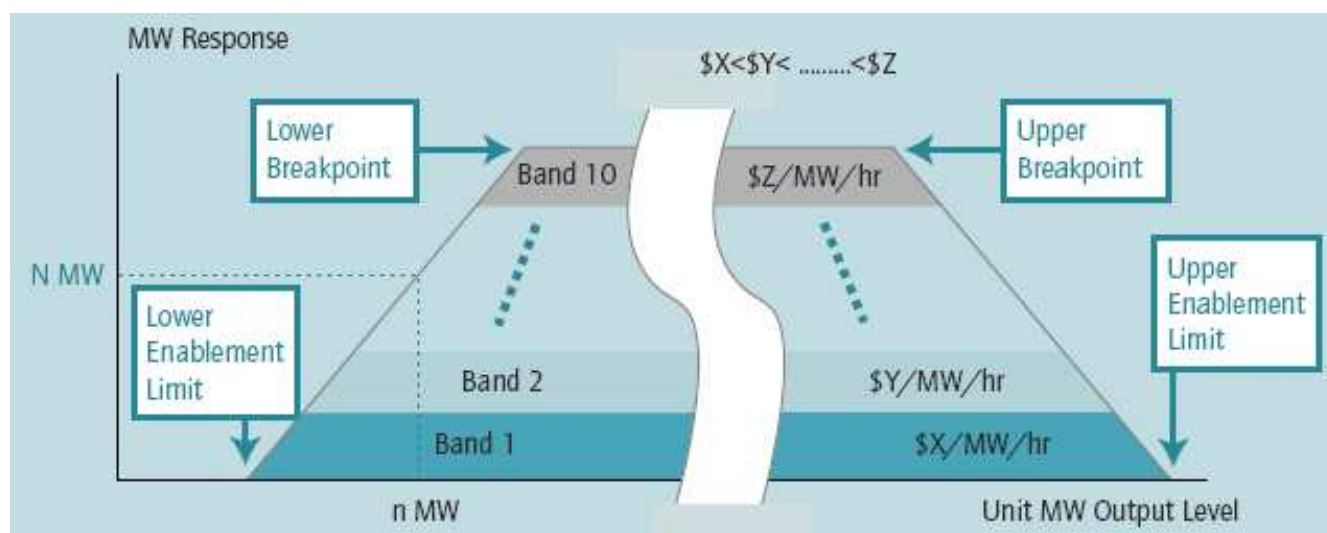


Figure 2: Generic FCAS Bids and Offers Trapezium^{xx}

The generic trapezium shape can be altered to suit the type of technology providing FCAS. For example, a load shedding service is fully available when the load is dispatched fully in the energy market, and availability would reduce linearly to zero as the energy dispatch point moves towards the origin.^{xx}

2.1.4 Calculating FCAS Requirements

Constraint equations are used by NEMDE to determine the amount of FCAS required for each of the 8 services. NEMDE co-optimises each service separately as discrete products. However, the delayed raise and lower requirements dispatched by NEMDE will take into account the amount of regulating raises and lowers dispatched. For example, a regulation raise requirement of 50MW may also contribute 50MW towards the delayed raise requirement. The same applies to the delayed Lower / Regulation requirements.^{xxi}

Calculating Regulation FCAS Requirements

The calculation of Regulation requirements are based numbers predetermined by AEMO, ranging from 70MW to 250MW, depending on the time of day.^{xxii}

Calculating Contingency FCAS Requirements

Following a contingency event, frequency deviation must remain within the contingency band, as shown earlier in Table 2. Until a contingency event occurs which requires large deviation contingency services, the regulating services are the primary frequency control services.

The amount of FCAS contingency required is based on the potential contingency MW change, minus the effect of “load relief” resulting from the change in system demand²⁵. AEMO has assessed the load relief effect factor as 1.5% for the mainland regions²⁶.

²⁵ Due to the effect of frequency changes on the rotational speed of AC motors and thus changes to the amount of power consumed by these machines; any demand changes that occur in the power system will alleviate that frequency deviation by a certain factor.

²⁶ If the frequency changes by 1%, the demand changes by 1.5%. The load relief factor is thus 1.5%, which represents the percentage change in demand for every 1% (0.5 Hz) of frequency deviation.

The FCAS contingency requirement can be expressed as:

$$\text{FCAS Contingency Requirement} = \text{Contingency Risk} - \text{Load Relief}$$

Where:

Contingency Risk: potential contingency MW change

Load Relief = Load Relief Factor x Initial System Demand

2.1.5 FCAS Settlement and Payment

FCAS settlement is determined on the basis of the normal 30-minute trading period. Payments to service providers are based on enablement of FCAS rather than actual use.

$$\text{Generator Payment for each FCAS service} = \text{MW Enabled} \times \text{FCAS Pool Price}$$

Payments for Regulation FCAS

Payment recovery for regulation services is based on a Causer Pays methodology. Under this methodology the response of measured generators and loads to frequency deviations, is monitored and used to determine a series of “contribution factors”. Participants whose responses assist in correcting frequency deviations are assigned a positive contribution factor (which is set to zero). Participants whose responses exacerbate frequency deviations are assigned a negative contribution factor; the higher the contribution to frequency deviation, the higher the factor²⁷.

Contribution factors represent 4-second deviations from a reference MW point, averaged over a 5-minute dispatch interval. Contribution factors are determined based on 28 days of five-minute factors. AEMO publishes the contribution factors in advance every four weeks^{xxiii}. In general, generators contribute to around 30% of deviations, with customer loads contributing to around 70% of deviations.

For each trading interval of the market, total regulation payments are recovered from participants on the basis of these causer pays factors. Costs are essentially assigned to Market Participants causing the need for FCAS.

For the purpose of FCAS payments and recovery, the market is treated globally, meaning participants are treated equally, regardless of region.

FCAS Regulation payment

$$= \text{Regulation requirement enabled (MW)} \times \text{Contribution Factor} \times \text{Regulation FCAS price (\$/MWh)}$$

Payments for Contingency FCAS

As contingency ‘raise’ requirements are set to manage the loss of the largest generator on the system, all payments for the three Raise Contingency services are recovered from generators.

²⁷ Non measured entities are assigned causer pays factors based upon the remainder and based upon their energy consumption in the trading interval being settled.

On the other hand, as contingency lower requirements are set to manage the loss of the largest load/transmission element on the system, all payments for three Lower Contingency services are recovered from customers. Recovery for contingency services is pro-rated over market participants based on energy generation or consumption in the trading interval.^{xxiv}

2.2 Non-Market Ancillary Services

Non-market ancillary services are purchased by AEMO under agreements with service providers. Contracts for non-market ancillary services are procured via a tendering process to ensure service provision at the lowest cost. Non-market ancillary services consist of Network Control Ancillary Services (NCAS) and System Restart Ancillary Services (SRAS).

AEMO are obligated under to develop procedures for the dispatch of non-market ancillary services.²⁸

2.2.1 Network Control Ancillary Services (NCAS)^{29 xxv xxvi}

NCAS provides AEMO with the capability to control active or reactive power flow into or out of a transmission network in order to^{xxvii}:

- Maintain power system security³⁰; and
- Enhance the value of spot market trading in conjunction with the central dispatch.

NCAS is divided into:

- Network Loading Control Ancillary Service (NLCAS); and
- Reactive Power Ancillary Service (RPAS).

Network Loading Control Ancillary Service (NLCAS)

NLCAS is used to control the power flow into or out of a transmission network to:

- maintain Transmission Power Lines³¹ within very short-term current ratings following a credible contingency event; and
- enhance network transfer capability when the expected increase in NLCAS costs will not exceed the expected increase in benefits of trade from the spot market.

The power flow on network elements can be controlled through demand-side load shedding or generating units on AGC (the same technology used for Regulation FCAS).

²⁸ Clause 3.11.6 of the National Electricity Rules

²⁹ AEMO is currently reviewing Network Support and Control Services in the NEM (the ‘NSCS Review’) in accordance with Clause 3.1.4(a1)(4) of the National Electricity Rules (<http://www.aemo.com.au/electricityops/168-0089.html>).

³⁰ The maintenance of the transmission network to within its current, voltage, or stability limits.

³¹ A transmission line or group of transmission lines that (i) connects the transmission networks in adjacent regions; or (ii) impact on the active power flow across adjacent regions.

NLCAS to maintain power system security

If a Transmission Power Line trips, the amount of NLCAS required is the largest amount of loading of the remaining Transmission Power Lines above their continuous ratings. The amount of NLCAS required is limited by the current ratings of the Transmission Power Lines and pre-contingent flows.

NLCAS to enhance network transfer capability

To ascertain the NLCAS required to enhance network transfer capability, AEMO reviews the operation of inter-regional system normal constraint equations with the most binding instances for the previous financial year. This allows greater utilisation of Transmission Power Line capability where the transmission network is limited by a current rating. Without NLCAS, AEMO would need to limit pre-contingent flows to ensure more conservative short-term ratings were not exceeded, which could result in supply shortfall and inappropriate load shedding.

NLCAS to enhance network transfer capability is only used when the expected increase in NLCAS costs will not exceed the expected increased benefits of trade from the spot market.

Reactive Power Ancillary Service (RPAS)

RPAS is used to control the reactive power flow into or out of the transmission network to:

- maintain the transmission network within its voltage and stability limits following a credible contingency event; and
- enhance the network transfer capability when the expected increase in RPAS costs will not exceed the expected increase in benefits of trade from the spot market.

The typical modes of operation of RPAS are:

- Synchronous Compensator: a generating unit with reactive power capability that can generate or absorb reactive power while not generating active energy; and
- Generation Mode: a generating unit with reactive power capability that can generate or absorb reactive power in excess of its mandatory performance standard (as specified in the National Electricity Rules) for reactive power while dispatching active energy into the market.

2.2.2 System Restart Ancillary Services (SRAS)

SRAS are reserved for contingency situations where the electrical system must be restarted following a blackout, or where there has been a major disruption in electricity supply. The SRAS objective³² is to "minimize the expected economic costs to the market in the long term and in the short term, of a major supply disruption, taking into account the cost of supplying system restart ancillary services".

AEMO are obligated to procure a certain quantity and type of SRAS, for each electrical sub-network³³, according to the System Restart Standard³⁴. SRAS consist of Primary and

³² Clause 3.11.4A(a) of the National Electricity Rules.

³³ The NEM is divided into 10 electrical sub-networks. SRAS Quantity Guidelines specify the requirement of least two SRAS per electrical sub-network (<http://www.aemo.com.au/electricityops/sras.html>).

³⁴ <http://www.aemo.com.au/electricityops/160-0279.html>

Secondary restart services. Specific requirements by AEMO for SRAS are defined during the tendering process.

	PRIMARY	SECONDARY
Timeframe - Supply to Delivery Point	Within 60 minutes	Within 30 minutes
Delivery Point	The auxiliary power supply point at a specified generating unit	An agreed point on the power system
Assessment Requirements	Physical tests to start the specified generating unit	Physical tests up to the delivery point, simulations beyond the delivery point
Availability & Reliability	At least 90% in any rolling 12 Month period	At least 60% in any rolling 12 Month period

Table 4: Differences between Primary and Secondary SRAS^{xxviii}

SRAS can be provided by generators that are able to^{xxix}:

- start up and supply energy to the grid without any external source of supply; or
- ‘trip to house load’ (on sensing a system failure, fold back onto its own internal load and continue to generate) until AEMO is able to use it to restart the system.

2.2.3 Payment for Non-Market Ancillary Services

NCAS

Payments to NCAS providers are made for every trading interval that the service is available. NCAS payments are recovered by Transmission Network Service Providers (TNSPs) via each TNSP’s Transmission Use-of System (TuoS) charges.

Providers of NLCAS enable a set amount of load to be shed automatically to allow the use of increased Transmission Power Line flow limits. Contracts limit the number of occasions that the service can be used, and at times AEMO may elect to reserve the service for system security purposes in preference to spot market trading benefits.^{xxx}

A generating unit providing RPAS in Generation Mode beyond its mandatory reactive power requirement is considered to be available at all times that the unit is synchronised, with the service paid for as an availability payment.

A generating unit providing RPAS in Synchronous Compensator mode enables their service as required at an additional cost to the market.

SRAS

Payments to SRAS providers are made for every trading interval that the service is available. Payments are also made for usage and testing. SRAS payments are recovered from both customers and generators on a 50 / 50 basis.^{xxxi}

2.3 NEM Customer Costs for Ancillary Services Payment Recovery

During the 2008-2009 financial year AEMO paid, on average, around \$3.5M per week to all ancillary service providers. The following figure gives an indication of the cost to NEM customers per MWh hour, for payment recovery of all NEM Ancillary Services.^{xxxii}

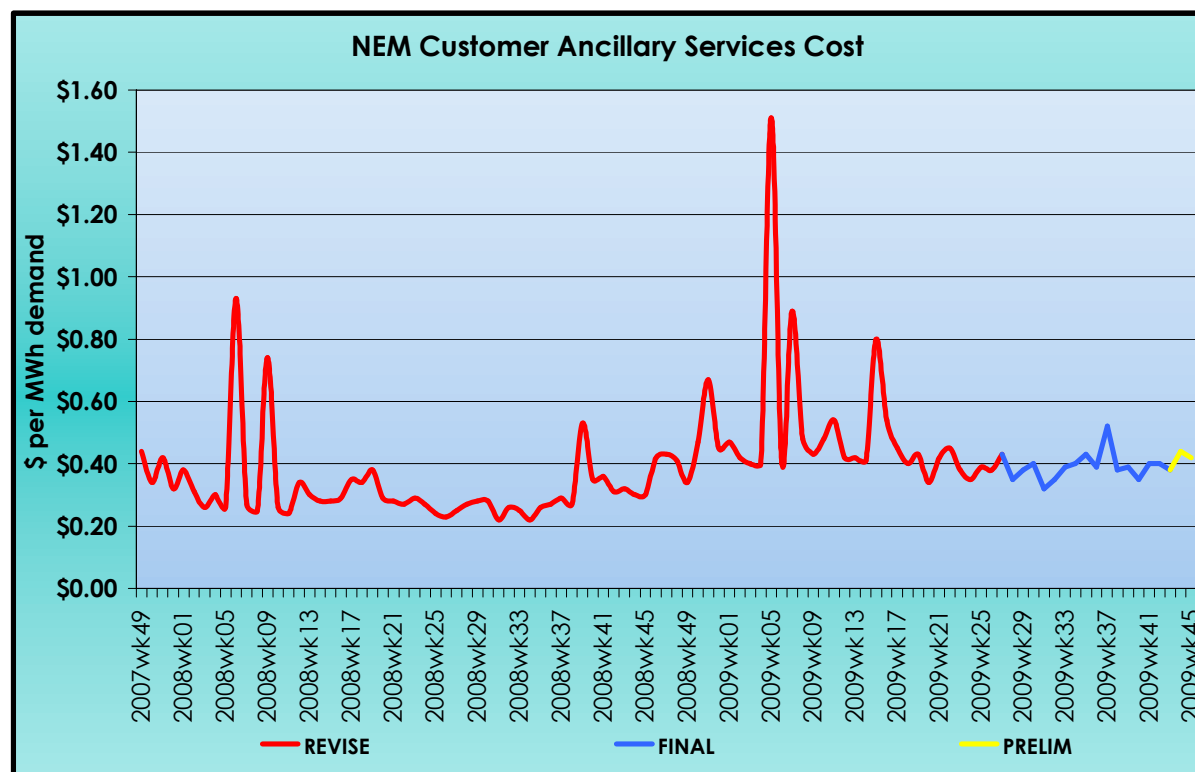


Figure 3: Costs to NEM Customers for Ancillary Services Payment Recovery.

3. Conclusion

Co-optimisation of the FCAS markets with the energy market within a security constrained dispatch is a unique feature of NEM. It ensures that energy and FCAS requirements are met at the lowest cost based on dispatch offers from generation and dispatchable load.

Additional ancillary services are procured via tendering processes according to pre-determined Rules and Guidelines for each service. The tendering guidelines ensure the most competitive services are procured for each ancillary service requirement.

Ongoing reviews of ancillary service Rules and Guidelines ensure:

- Optimal provision of services for maintaining system security and reliability for the lowest cost to the NEM; and
- Fair costs to market participants for the provision of non-market ancillary services

Since the introduction of the FCAS market in 2001 reliability standards have been achieved and a sound level of security has been maintained across the system. Ancillary service costs have also declined and competitive sourcing of FCAS has been achieved via eight spot markets.

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- ⁱ Page 4, An Introduction to Australia's National Electricity Market, July 2009, <http://www.aemo.com.au/corporate/publications.html>
- ⁱⁱ AEMO: "Energy Markets", <http://www.aemo.com.au/aboutaemo.html>
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- ^{iv} AER: "About the AER", <http://www.aer.gov.au/content/index.phtml/itemId/659161>
- ^v Page 25, An Introduction to Australia's National Electricity Market, July 2009, <http://www.aemo.com.au/corporate/publications.html>
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- ^{vii} AEMO: "Constraints in the NEM" <http://www.aemo.com.au/electricityops/constraints.html>
- ^{viii} AEMO Operating Procedure - Dispatch, http://www.aemo.com.au/electricityops/operating_procedures.html
- ^{ix} Page 13, An Introduction to Australia's National Electricity Market, July 2009, <http://www.aemo.com.au/corporate/publications.html>
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