EFFICIENT DISPATCH AND LOCALISED RECOVERY OF REGULATION SERVICES BUSINESS SPECIFICATION

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1. Reference

1.1 Abbreviations

ABBREVIATION	EXPLANATION
MMS	Market Management System; software, hardware, network and related processes to implement the National Electricity Market (NEM); an AEMO department responsible for maintaining the system
MPF	Market Participation Factor a.k.a. Causer Pay Factor
NEMDE	National Electricity Market Dispatch Engine
NER/ Rules	National Electricity Rules
RD	Requirements Description (was Functional Description) ; a business-level description for a MMS project being either a system or modifications to system; intended as primary document specifying a required project outcome

TABLE 1: ABBREVIATIONS

1.2 References

1. Efficient Dispatch of Regulation Services – AEMC Documents http://www.aemc.gov.au/electricity.php?r=20061121.102154
2. Cost Recovery of Localised Regulation Services – AEMC Documents http://www.aemc.gov.au/electricity.php?r=20061025.180651

1.2.1 Documents made obsolete

1. Regional FCAS Recovery Business Specification, version 1.0, by AEMO Market Operations Performance

2. Introduction

2.1 Overview

Frequency Control Ancillary Service (FCAS) enables AEMO to control the frequency of the power system and ensure that the system meets the frequency standards prescribed by the Reliability Panel. There are eight types of FCAS, which can be grouped into two categories: six types of contingency FCAS and two types of Regulation FCAS.

Contingency FCAS are used to restore the prescribed frequency of the power system after a major disturbance, such as the unplanned outage of a large generator or a random failure in

the transmission network. Regulation FCAS are used to control minor variations in frequency around the Australian standard of 50 Hz.

The Australian Energy Market Commission (AEMC) approved the following two Rule amendments on 23 August 2007:

- Efficient Dispatch of Regulation Services
- Cost Recovery of Localised Regulation Services

The above amendments require changes to the AEMO central dispatch and settlements systems.

The changes are summarised below.

2.1.1 Efficient Dispatch of Regulation Services

AEMO recognised that Regulation Service (raise or lower) can service in place of the corresponding Delayed Service. However, it should be noted that the converse is not true as Delayed Service cannot substitute for Regulation Service.

AEMO currently recognises these facts by reducing the quantity of Delayed Service by an amount of Regulation Service. This falls short of efficient dispatch in two ways:

- It does not use additional Regulation Service to reduce the enablement of Delayed Service where Regulation Service happens to be offered at a lower price than Delayed Service, and
- The amount of Regulation Service by which the Delayed Service requirement is reduced is NOT the amount enabled in the current dispatch interval, but rather the amount in the previous dispatch interval.

These issues have persisted because the Market Rules did not make provision for pricing or for cost recovery in the case where the offer of one service is utilised to economically service the requirement for another.

On 19 October 2006, The AEMC received a Rule change proposal from Hydro Tasmania. The proposal seeks to achieve more efficient dispatch of FCAS by allowing the co-optimisation of Regulation and Delayed Services. This proposed Rule change was approved by AEMC and is to commence operation on 1 January 2009.

This Rule change requires modification to the current constraint formulation for all Delayed Contingency Service requirement constraints. For FCAS recovery, AEMO has decided to introduce a new mechanism to split the constraint cost resulting from the co-optimised dispatch of Regulation and Delayed Services into Regulation recovery cost and Delayed recovery cost. The constraint cost for all FCAS constraints and the split constraint costs for applicable Delayed Contingency constraints will be published in dispatch timeframe. These adjusted constraint costs are then used in the settlements process.

2.1.2 Localised Recovery of Regulation Services

When AEMO determines the quantity of Regulation and/or Contingency FCAS, AEMO must determine the required quantity that:

- May be sourced from any region within the NEM (global FCAS requirement); and
- Must only be sourced from one or more nominated regions (local FCAS requirement).

Local FCAS requirements are required in abnormal circumstances where only local market participants have the technical capability to provide FCAS. This is most often the case when a region becomes isolated – or "islanded" – due to planned and/or forced outages of transmission elements.

Currently, there's a disparity between the way that local Regulation FCAS requirements are paid for compared to local Contingency FCAS requirements. Whenever local Contingency FCAS requirements are set, the costs of those local Contingency requirements are recovered solely from market participants within the local region or regions (this is on the basis that only the local market participants can influence the local FCAS prices). However, when local Regulation FCAS requirements are set on the mainland, the cost of those local Regulation requirements are recovered from all mainland participants. Note that under the participant derogation in the Rules which is due to expire on 31 December 2008, the costs of local requirements in Tasmania region are recovered solely from Tasmanian participants.

On 7 September 2006, the National Generator's Forum (NGF) lodged a proposal with the Australian Energy Market Commission (AEMC) to amend the NER to provide for cost recovery of localised Regulation FCAS on a regional basis. The AEMC approved the proposed Rule and issued the National Electricity Amendment (Cost Recovery of Localised Regulation Services) Rule 2007 no. 5, which commences operation on 1 January 2009.

The new settlements process will introduce constraint recovery factors for Regulation Services to assist participants in estimating their Regulation recovery cost in dispatch and pre-disaptch timeframes. These factors are based on the estimated generation output. In settlements timeframe, the factors are recalculated based on the metered data. The participant recovery cost can be determined by multiplying the factors with the participant MPF (ie. Market Participant Factor calculated from the Causer Pays process) or the metered energy.

There are no changes to the current recovery process for Contingency Services.

2.2 Business Drivers

2.2.1 Objectives

The primary objective of this project is to meet the Rule changes.

2.2.2 Benefits

Upon successfully completing this project, we expect:

- A more economical dispatch of offered FCAS services: Facilitating the co-optimising of the procurement of Regulation and delayed FCAS in the NEM by sourcing the residual requirement[1] for delayed FCAS from whichever combination of the Regulation and delayed FCAS markets that has the lowest cost at the time;
- To replace the current Tasmanian participant derogation that provide separate cost recovery of FCAS Regulation Services between Tasmania and the mainland with a permanent solution; and
- Localised cost allocation for the localised FCAS Regulation supply requirement: To implement a NEM-wide solution that enables the cost of local Regulation FCAS requirements to be recovered from those market participants who had both the capacity and the ability to mitigate their liability at the time the requirements were required.

2.2.3 National Electricity Rules (NER)

Changes to the NER include:

- New Clauses 3.9.1(6B) and 3.15.6A(o) to cover the specific situation where a price determined for Regulation Service is based on the purchase of Regulation Services and also purchase of a Delayed Service.
- A requirement for AEMO to regionalise the recovery of Regulation raise and lower FCAS as set out in the Rules under clause 3.15.6A(h)-(k).

2.2.4 Deadlines

The expected date for implementation of the changes is 1 January 2009. This coincides with the expiration of the Tasmania Derogation on 31 December 2008.

3. Current Status Summary

The current constraint formulations for Regulation and Delayed Contingency Services are simplified below for constraints encompassing the same regions:

- Regulation Enablement >= Regulation Requirement
- Delayed Contingency Enablement >= Residue Delayed Contingency Requirement

  where Residue Delayed Contingency Requirement= Delayed Contingency Requirement – Regulation Dispatch from the previous dispatch interval

Under this arrangement, a Delayed Contingency Service constraint includes Regulation requirement on its RHS in order to reduce the dispatch quantity of Delayed Service. However, this quantity is the amount of Regulation Service dispatched in the previous dispatch interval, not the current one. Therefore, it produces a disparity if the Regulation

[1] Residual requirement for Delayed FCAS: Delayed FCAS requirement after subtracting the Regulation FCAS requirement.

Service requirement in the current dispatch interval differs considerably from the previous interval.

Furthermore, Regulation Service offered at a lower price than Delayed Contingency Service can not be used to meet the Residue Delayed Contingency Requirement. This prevents meeting the Market Objective of maximising the spot market trade by minimising the total cost to the market.

During the settlements payment and recovery calculation, the Regulation dispatch quantity that is used to service in place of Delayed Service are recovered from the Regulation cost.

The Regulation Services recovery is done in two ways: Market Participant Factor (MPF)-based recovery and Customer Energy (CE)-based recovery (also known as Residual MPF recovery). MPF-based recovery only applies to connection points with SCADA metering, while CE-based recovery applies to the connection points that have not been included in the MPF-based recovery.

Due to the Tasmania derogation, the Regulation Service cost recovery for Tasmania region is separated from that of the Mainland regions. Thus, there are two separate sets of MPF values produced for Mainland regions and Tasmania region.

The Regulation recovery cost in Mainland is currently recovered globally, in which the settlements process calculates the sum of recovery amount in Mainland regions and then allocates this to the participants based on the proportion of their MPF over the aggregate Mainland MPF, and the proportion of CE over the aggregate Mainland regions CE for CE-based recovery. Due to Tasmania derogation, the Regulation recovery cost in Tasmania has already been recovered locally at the moment.

In the case of global Regulation requirement, the recovery cost is allocated separately into Mainland and Tasmania first in order to calculate individual total recovery amount.

For a local Regulation requirement within Mainland, the recovery cost is smeared over all regions in Mainland.

Contingency Service requirements are currently recovered on a regional basis.

4. Business Requirements

4.1 Scope

The following changes are required to implement the Rule requirements:

- Changes to the Delayed Contingency Service constraint formulation
- Changes to the settlements process

The first change listed above is to meet the Rule change of ‘Efficient Dispatch of Regulation Services’. The new constraint formulation for Regulation and Delayed Contingency Services can be simplified as below:

- Regulation Enablement >= Regulation Requirement *(no change)*

- Regulation Enablement + Delayed Contingency Enablement >= Delayed Contingency Requirement *(change)*

The aforementioned FCAS constraint formulation change is not discussed further in this document as it is to be covered in the AEMO FCAS constraint formulation document.

This document focuses on the settlements process. The next section 5.2 details the changes to the settlements process resulting form the two FCAS Rule changes.

The changes to the settlements process introduce a publication of a set of constraint recovery factors to assist participants in estimating their Regulation recovery cost in dispatch and pre-dispatch timeframe, based on the estimated data. These factors are reproduced in settlements timeframe based on the actual metered data to determine the participant recovery cost.

The constraint costs used in the settlements process will be published in dispatch timeframe.

For Delayed Contingency constraints, the constraint costs may be split into Regulation Service recovery cost and Delayed Contingency Service recovery cost.

There are no changes to the current process of recovering Contingency Services costs. This process is summarised in Appendix A.

To assist in understanding of the changes, examples have been provided in Appendix B. These examples should be used only to discuss the concept.

The changes discussed in this document are not meant to be prescriptive in the design of particular applications and table structures. The latter detail is defined in the technical specifications accompanying the relevant NEM System Change Notice.

4.1.1 Terms and Definition

TERM	DEFINITION
Delayed Contingency Services	FCAS response enabled to recover large frequency changes within 5 minutes following a credible Contingency event. Comprises Delayed Raise Service and Delayed Lower Service.
Regulation Services	FCAS response enabled to regulate small frequency changes. Comprises Regulation Raise Service and Regulation Lower Service.
Target Run	During intervention, dispatch instruction is based on this run. In this solution, the intervention-type direction constraints are applied. Also referred to as: “Outturn” run, “Physical Target” run, “Constraint-on” run.
What-if Run	In this solution the intervention-type direction constraints are not applied, simulating the case of “What if AEMO did not intervene?”. This run is also known as “Intervention Pricing” run or “Constraint-off” run. The pricing information for Dispatch used in Settlements comes from this run.

TERM	DEFINITION
NEM MPF	A set of global Market Participant factor (MPF) for each NEM participant produced from the Causer Pays process. Aka Causer Pays Factor.
NEM RMPF	NEM Residual MPF, a value derived from the NEM MPF, which represents a portion of the NEM participants that don't have an MPF value.
Participant MPF	An MPF value of a participant that is included in the NEM MPF.
Constraint MPF Recovery Factor	A coefficient associated with a particular Regulation Service constraint in a dispatch interval. When a participant multiplies this value with their individual MPF value, they will be able to determine the portion of their recovery amount pertaining to that Regulation Service requirement.
Constraint RMPF Recovery Factor	A coefficient associated with a particular Regulation Service constraint in a dispatch interval. When a participant (that does not have MPF) multiplies this value with their energy consumption or Customer Energy (settlements), they will be able to determine the portion of their recovery amount pertaining to that Regulation Service requirement.
CMPF	Constraint MPF is a factor associated with a Regulation Service constraint in a dispatch interval. This value is the sum of a subset of NEM MPF relevant to the units included in that constraint's LHS.
CRMPF	Constraint Residual MPF is a factor associated with a Regulation Service constraint in a dispatch interval. This value is derived from the proportion of Total Demand of the regions included in the constraint, the NEM Demand, and the NEM Residual MPF.

TABLE 2: TERMS AND DEFINITION

4.2 Requirements

4.2.1 Process Differences Summary

- Regulation requirement may appear in both Regulation and Delayed Contingency requirement constraints (lower and raise services).
- Regional Ancillary Service Price for Regulation Service may also incorporate the marginal value of Delayed Contingency Service constraints, provided that the Delayed Contingency constraints' LHS include Regulation contribution for the relevant region.
- The constraint cost recovery of Delayed Contingency Service may be split between Regulation and Contingency if certain conditions are met (refer to 4.2.2.3 on page 12).
- There will be one set of NEM MPF values applied to all NEM regions.

- For every dispatch interval, calculate the MPF recovery factor and RMPF recovery factor for each Regulation Service constraints with non-zero (Adjusted) Requirement Payment.
- Reporting of constraints' MPF recovery factor and RMPF recovery factor to assist in determining the participant Regulation cost recovery.
- Changes in settlements' Regulation Service recovery calculation in order to localise the Regulation recovery cost.

4.2.2 Process Requirements

Appendix B provides examples of the process explained below.

4.2.2.1 Regional Ancillary Service Payments

For the purpose of determining FCAS cost recovery for Regulation and Delayed Contingency Services, total regional payments must be available to the settlements process. The following calculation needs to be performed for each service and region.

$$\text{Regional Payment} = \text{FCAS Price} \times \text{Regional Amount Enabled} \Big/ \text{nIntervals}$$

Where:

Regional Amount Enabled = The Enablement amount for the Regulation or Delayed Service for that region. During intervention, this is to be based upon the outcomes of the target run.

FCAS Price = FCAS price for the Regulation or Delayed Service for that region. This value comes from the NEMDE output and the method of calculation is as per current process (ie. Regional FCAS price = Sum of marginal values of FCAS constraints encompassing that region and service). For example, the Regulation Service price will include the marginal value of Delayed Service requirement constraints encompassing the Regulation Service term of the same region on LHS. During intervention, this is to be based upon the outcomes of the what-if run.

nIntervals = Number of intervals (12 for dispatch, 2 for 30 minute pre-dispatch).

4.2.2.2 Allocation of Regional Payments to Requirements

For the purpose of determining regional FCAS recovery, total regional payments for each service and dispatch interval must be pro-rated over the requirements for that service that encompass that region. These amounts are allocated on the basis of the marginal value of each requirement constraint.

$$\text{ReqPaymentAllocation} = \text{Regional Payment} \times \frac{\text{Requirement Marginal Price}}{\sum_{\text{In that Region}} \text{Requirement Marginal Prices}}$$

This regional requirement payment allocation must then be summed for each requirement over all regions included in that requirement constraint.

$$\text{ReqPayment} = \sum_{\text{Regions included in that requirement Constraint}} \text{ReqPaymentAllocation}$$

Once the Requirement Payment **(aka Constraint Cost)** for each constraint in the dispatch interval are calculated, the new process needs to identify whether or not a cost recovery split between Regulation and Delayed Contingency Services is required. Below section explains how this should be done.

For Fast and Slow Contingency Services, the recovery method is as per current process. This process is provided in Appendix A.

4.2.2.3 Split between Regulation and Delayed Contingency Services Recovery

The generic methodology of allocating the ReqPayments to constraints as discussed in section 5.2.2.2 would allocate the total cost across the binding constraints. Hence, if additional Regulation Service is purchased to meet the contingency requirements and results a zero marginal value for the Regulation constraint, all costs would be allocated to the Contingency Services and none to the non-binding Regulation constraint. However it is clear that in the absence of the Contingency constraints, the Regulation constraint would bind, creating a cost that would be recovered through the Regulation recovery process. The cost allocation to the regulating recovery mechanism should be at least the value obtained from the Regulation constraint requirement priced at the minimal contingency constraint marginal value. This is effectively the price at which the Regulation cost would be recoverable from the Regulation recovery mechanism if the Regulation requirement were increased up to the point where the Regulation constraint was just binding (without affecting the binding of the contingency constraints).

This concept can be delivered by splitting the ReqPayments of Delayed Service constraint(s) into the Regulation cost that would be recoverable from the Regulation recovery mechanism and the Delayed cost that would be recoverable from the Delayed recovery mechanism. This cost splitting will avoid creating a significant shift of the cost to be recovered from the Regulation recovery process to the Contingency recovery process.

The process to identify the cost recovery split for Regulation and Delayed Contingency Services for a dispatch interval is as follows (assume that ReqPayments have been calculated):

For Regulation and Delayed Contingency constraints in a dispatch interval, group them such that:

1. The Regulation LHS terms of the constraints in the group have matching regions; and

2. The coefficients of Regulation LHS terms in (1) are the same for each relevant region.

The result of the grouping would fall into these categories:

1. Split category:

- A constraint group with one or more Regulation constraints and one or more Delayed Contingency constraints, **with all Regulation constraints inside the group not binding**.

2. Non-split category:

- Single Regulation constraint that does not have an associated Regulation or Delayed Contingency constraint.
- Single Delayed Contingency constraint that does not have an associated Regulation or Delayed Contingency constraint.
- Constraint group not included in category 1. This group can be all Regulation constraints group, all Delayed Contingency constraints group, or Regulation and Delayed Contingency constraints group.

The split recovery is not needed for category 2. Hence for each constraint in this category:

For Regulation constraint, recover the ReqPayment using the Localised Regulation Recovery method for the regions included in the constraint (refer to the next section of this document).

For Delayed Contingency constraint, recover the ReqPayment through the Contingency recovery method for the regions included in the constraint. Note: Although the Delayed Contingency constraint may have Regulation terms on the LHS of the constraint, the ReqPayment for this constraint is recovered only through the Contingency recovery mechanism. There is no specific Regulation requirement defined for the encompassed regions that no cost is to be allocated for the Regulation recovery.

For each of the constraint group in category 1…

If the group contains more than one non-binding Regulation constraints, identify the Regulation constraint with the most restrictive RHS value and disregard the other Regulation constraint as their constraint costs would be zero.

At this point, the constraint group would only contain one non-binding Regulation constraint and one or more Delayed Contingency constraints.

The ReqPayment of each Delayed Contingency constraint needs to be split into the cost to be recovered through the Regulation Service recovery mechanism and the cost to be recovered through the Delayed Service recovery mechanism. These recovery costs after the split are called Adjusted Requirement Payments (or Adjusted ReqPayment) in this document. The ReqPayment before the split may be referred as ‘base cost’ and the Adjusted ReqPayments after the split may be referred as ‘adjusted cost’.

The Adjusted Regulation Requirement Payment is calculated by multiplying the RHS value of the Regulation constraint by the marginal value of the Delayed Contingency constraint. This amount is then subtracted from the constraint ReqPayment to determine the Adjusted Delayed Requirement Payment.

If the RHS value of the Regulation constraint is less than zero (ie. constraint is swamped and ineffective), the Adjusted Regulation Requirement Payment becomes zero.

The adjusted ReqPayment to be recovered for each Delayed Contingency constraint as Regulation Service through Localised Regulation Recovery method is:

$$\text{Adjusted Regulation ReqPayment}(c) = \text{MINIMUM}(\text{ReqPayment}_c, \text{MAXIMUM}(\text{RHS}_r/\text{nIntervals} \times \text{MV}_c, 0))$$

Where:

r	=	Regulation constraint with the most restrictive rhs value in the group
c	=	A contingency constraint in the group
ReqPayment_c	=	Constraint Cost of contingency constraint c
RHS_r	=	Right Hand Side (requirement) value of Regulation constraint r
MV_c	=	Constraint Marginal Value of contingency constraint c
nIntervals	=	number of intervals (12 for dispatch, 2 for 30 minute pre-dispatch)

And adjusted ReqPayment to be recovered for each Delayed Contingency constraint in the group through Contingency Recovery method is:

$$\text{Adjusted Contingency ReqPayment}(c) = \text{ReqPayment}_c - \text{MINIMUM}(\text{ReqPayment}_c, \text{MAXIMUM}(\text{RHS}_r/\text{nIntervals} \times \text{MV}_c, 0))$$

Where:

r	=	Regulation constraint with the most restrictive rhs value in the group
c	=	A contingency constraint in the group
ReqPayment_c	=	Constraint Cost of contingency constraint c
RHS_r	=	Right Hand Side (requirement) value of Regulation constraint r
MV_c	=	Constraint Marginal Value of contingency constraint c
nIntervals	=	number of intervals (12 for dispatch, 2 for 30 minute pre-dispatch)

The Adjusted Requirement Payment is to be recovered across all participants who have metered or customer energy in the regions included in that requirement.

From hereafter, this document will explain about the recovery process for Regulation Services only. The cost to be recovered for Regulation Services are the Requirment Payments from Regulation constraints and Adjusted Regulation Requirement Payments from Delayed Contingency constraints. The other FCAS cost recovery including the recovery of Adjusted Requirement Payment for Delayed Contingency Services is recovered as per current process (refer to Appendix A).

4.2.2.4 Constraint MPF and RMPF for Regulation Services

Regulation Service cost is recovered through the causer pays process by utilizing the pre-calculated MPF values as input. Before the payment is allocated to each Regulation requirement, the process must calculate the CMPF and CRMPF values for dispatch, pre-dispatch and settlements timeframes:

For each dispatch interval in dispatch and settlements and each trading interval in pre-dispatch…
For each FCAS constraint with non-zero ReqPayment or Adjusted ReqPayment for Regulation Service …
Identify region(s) included in the constraint and select those MPF values from NEM MPF which apply to relevant participants in the identified region(s). Relevant participants are:

For dispatch and 30 minute pre-dispatch: participants with scheduled, semi-scheduled or non-scheduled generating units or loads in the identified region(s).
For settlements: participants who have metered or customer energy for the identified region(s).

Sum the MPF of these participants to obtain the Constraint MPF (CMPF) value.

1. Calculate the Constraint Residual MPF (CRMPF).

   For dispatch, it is estimated using Total Demand figures:

$$CRMPF = NEM\ RMPF \times \frac{\sum_{\text{Regions included in the requirement}} \text{Total Demand}}{\sum_{\text{All Regions}} \text{Total Demand}}$$

   In settlements, the total demand would be replaced by ATCE values:

$$CRMPF = NEM\ RMPF \times \frac{\sum_{\text{Regions included in the requirement}} \text{ATCE}}{\sum_{\text{All Regions}} \text{ATCE}}$$

Where:

Total demand	=	Total demand for the relevant dispatch interval. This value would be different for every dispatch interval.
ATCE	=	Aggregate Total Customer Energy, the half-hourly sum of TCE of a region. ATCE values would be the same for every dispatch interval within the trading interval.

4.2.2.5 Recovery Allocation for Regulation Services

The Regulation Service payments allocation needs to be calculated for each dispatch interval. The followings must be determined when allocating the requirement payment for **each FCAS constraint of Regulation Service type with non-zero (Adjusted) Requirement Payment/Constraint Cost** in dispatch and settlements timeframes:

	PURPOSE
Constraint MPF Recovery Factor	For participant's MPF-based recovery reconciliation. Participants can multiply their MPF value with this factor to determine the recovery cost for that constraint.
Constraint RMPF Recovery Factor	For participant's RMPF-based recovery reconciliation. Participants can multiply their energy consumption (in dispatch) or Customer Energy (in settlements) with this factor to determine the recovery cost for that constraint.

TABLE 3: PAYMENTS ALLOCATION COMPONENTS

4.4.2.2.5 Dispatch and Pre-dispatch Timeframe

Once the CMPF and CRMPF values are calculated for FCAS constraints identified in the previous section, the Constraint Recovery Factors are determined in dispatch using Total Demand values as an estimate.

The Regional and Participant Requirement Payment Allocation cannot be calculated at this stage since the metered energy values are not available yet. The Constraint Recovery Factors are provided to assist participants in estimating the recovery cost for each FCAS constraint identified in 4.2.2.5.

The following calculation is used to determine the Constraint Recovery Factors for a Regulation constraint for a dispatch interval (DI).

For MPF-based recovery:

$$\text{CMPF Recovery Factor}(c) = \frac{1}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment}$$

For RMPF-based recovery:

$$\text{CRMP Recovery Factor}(c) = \frac{1}{\sum_{\text{Regions included in the requirement}} \text{Total Demand}} \times \frac{\text{CRMPF}}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment}$$

Where:

C	=	An fcas constraint as identified in 4.2.2.5
CMPF	=	MPF for the constraint as calculated in 4.2.2.4
CRMPF	=	RMPF for the constraint as calculated in 4.2.2.4
ReqPayment	=	ReqPayment as calculated in 4.2.2.2 for Regulation constraint, or Adjusted Regulation ReqPayment in 4.2.2.3 for Delayed Contingency constraint
Total Demand	=	Total demand for DI (this value would be different for every dispatch interval)

Note:

- It's assumed that the denominators in above equation are always greater than 0.

For 30minute pre-dispatch, the above calculations used in dispatch timeframe are applied to pre-dispatch data.

5.4.2.2.5 Settlements Timeframe

In settlements timeframe, the payment allocation for each FCAS constraint identified in 4.2.2.5 must be determined using Customer Energy values.

The following calculation is used to determine the Constraint Recovery Factors for a Regulation constraint for a dispatch interval (DI).

For MPF-based recovery (this value is the same for dispatch and settlements timeframe):

$$\text{CMPF Recovery Factor}(c) = \frac{1}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment}$$

For RMPF-based recovery:

$$\text{CRMPF Recovery Factor}(c) = \frac{1}{\sum_{\text{Regions included in the requirement}} \text{ATCE}} \times \frac{\text{CRMPF}}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment}$$

For Participant Requirement Recovery Allocation (PRRA):

$$\text{PRRA}(p, c) = \text{MPF}_{(p,c)} \times \text{CMPF Recovery Factor}(c) + \sum_{\text{Regions indudedin the requirement}} \text{TCE}_p \times \text{CRMPF Recovery Factor}(c)$$

Where:

C	=	An fcas constraint as identified in 4.2.2.5
p	=	A participant who has metered or customer energy for the region(s) included in constraint c
CMPF	=	MPF for the constraint c calculated in 4.2.2.4
CRMPF	=	RMPF for the constraint c calculated in 4.2.2.4
ReqPayment	=	ReqPayment as calculated in 4.2.2.2 for Regulation constraint, or Adjusted Regulation ReqPayment in 4.2.2.3 for Delayed Contingency constraint
$MPF_{(p,c)}$	=	Sum of participant p's MPF value for all relevant region(s) included in constraint c
TCE_p	=	Total Customer Energy, the half-hourly participant p's CE for a region. This excludes connection points with non-zero MPF. TCE values would be the same for every dispatch interval within the trading interval.
ATCE		Total Customer Energy, the aggregate half-hourly CE for a region.This excludes connection points with non-zero MPF. ATCE values would be the same for every dispatch interval within the trading interval.

Note:

- It's assumed that the denominators in above equation are always greater than 0.
- The sum of PRRA for all Regulation Service type constraints relevant to a participant is the total Regulation Service recovery cost that needs to be recovered from that participant.

4.2.2.6 Publication of Data

This section should be read in conjunction with the technical specifications to be issued with the relevant NEM System Change Notice to obtain details of the table structures and field names.

AEMO will publish the recovery factor for every binding or violating Regulation Service constraint for each dispatch/30 minute pre-dispatch interval in the following format:

DATA	DESCRIPTION
Settlement Date*	Settlement date and time
Dispatch Interval*	Dispatch interval identifier
Pre-dispatch Sequence Number+	Unique identifier of pre-dispatch run in the form YYYYMMDDPP with 01 at 04:30
Period ID+	Unique period identifier, in the format yyyymmddpp. The period (pp) is 01 to 48, with 01 corresponding to the half-hour ending at 04:30am.
Constraint ID	Regulation or Delayed Contingency constraint identifier
Region ID	NEM region identifier
Service Type	Lower or Raise Regulation
Constraint MPF recovery factor	As calculated in 4.4.2.2.5. Participants with non-zero MPF value can multiply their participant MPF with the MPF recovery factor to estimate the portion of constraint recovery cost payable to AEMO.
Constraint RMPF recovery factor	An **estimate** of the RMPF recovery factor as calculated in 4.4.2.2.5. Participants without or with zero MPF value can multiply their enablement amount with RMPF recovery factor to obtain the estimate of their recovery cost.
Requirement Payment	Constraint Cost (aka Base Cost)
Adjusted Requirement Payment	Adjusted Constraint Cost

*only in dispatch, +only in 30 minute pre-dispatch

The following information will be published in the settlements timeframe for estimate run and settlement run using metered energy:

DATA	DESCRIPTION
Settlement Date	Settlement date and time
Period ID	Trading interval identifier
Version no	Settlement run version number
Dispatch Interval	Dispatch interval identifier
Service Type	Ancillary service type identifier (LOWERREG or RAISEREG) for Lower or Raise Regulation Service), and Lower or Raise Delayed Contingency Service (LOWER5MIN or RAISE5MIN)
Constraint ID	Regulation or Delayed Contingency constraint identifier
Region ID	NEM region identifier
Constraint MPF recovery factor	As calculated in 5.4.2.2.5. Participants with non-zero MPF value can multiply their participant MPF with the MPF recovery factor to estimate the portion of constraint recovery cost payable to AEMO.
Constraint RMPF recovery factor	RMPF recovery factor as calculated in 5.4.2.2.5. Participants without or with zero MPF value can multiply their metered energy with RMPF recovery factor to obtain the estimate of their recovery cost.

5. Summary

5.1 Requirements

This Business Specification details the changes required to allow AEMO to meet the following Rule changes:

- Efficient Dispatch Regulation Services
- Cost Recovery of Localised Regulation Services

The first point above requires AEMO to make the following changes:

- Revise the constraint formulation for Delayed Contingency Service requirements

- Split the Delayed Contingency constraint cost into Regulation and Delayed Contingency Service requirement payments if
  - Additional Regulation Service is procured to meet Contingency Service requirements; and
  - The constraint cost of the relevant Regulation constraint is set to zero as a result.

Under the second Rule change above, AEMO must change the settlements process to recover Regulation Service payments on a regional basis. This settlements change should also incorporate the adjusted Regulation Service requirement payments resulting from the Split Contingency Constraint Cost process.

With the settlements process change, a set of constraint recovery factors will be introduced to assist participants:

- In estimating their Regulation recovery cost in dispatch and pre-dispatch timeframe; and
- In determining the Regulation recovery cost in settlements timeframe.

6. Appendix A

This section explains the current process of recovering Contingency Service costs once the Contingency constraint requirement payment is calculated.

It is the continuation of the process outlined in section 5.2.2.2 for Fast and Slow Contingency Services. For Delayed Contingency Services, this section is the subsequent process of section 5.2.2.3 which details the calculation of adjusted Contingency requirement payments.

The process in this appendix is the current process and remains unchanged.

6.1 Allocation of Contingency Requirements back to Regions

The total dispatch interval cost of each requirement (as calculated in section 5.2.2.2 or 5.2.2.3) must then be allocated back to the regions included in that requirement, pro-rated on the basis of:

- For contingency raise services, aggregate regional generator energy figures for all market generators in the region, for the trading interval in which the dispatch interval belongs;
- For contingency lower services, aggregate regional customer energy figures for all market customers in the region, for the trading interval in which the dispatch interval belongs;

Note that this step must be performed on a dispatch interval basis as requirement constraint configurations can change between dispatch intervals inside the same trading interval.

$$\text{RegionPaymentAllocation} = \text{Requirement Payment} \times \frac{\text{Regional Aggregate Energy (TI)}}{\sum_{\text{Regions included in that requirement}} \text{Regional Aggregate Energy (TI)}}$$

These values are then summed over all requirements for that service to determine single dispatch interval recovery amounts for each region.

The final step is for the amounts for each dispatch interval in a trading interval to be summed over that trading interval to determine half hourly based regional recovery amounts. These amounts are the pro-rated over generators (for contingency raise) or customers (for contingency lower) on the basis of aggregate generator or customer energy figures for the generator or customer in that region only.

In order to assist participants in reconciling their share of recovery costs, the following data is made available to all participants:

Trading Interval

Service

Region

Regional Energy (MWh)

Regional Recovery Amount ($)

The regional energy amount would be generator energy where the service is a contingency raise service, and customer energy where the service is a contingency lower service.

7. Appendix B

7.1 Efficient Dispatch of Regulation Services - Example

Assume the following three constraints invoked for a dispatch interval:

GR: $RR_1 + RR_2 + RR_3 \geq X$

GC: $RR_1 + RR_2 + RR_3 + R5_1 + R5_2 + R5_3 \geq Y$

LC: $RR_1 + RR_2 + R5_1 + R5_2 + IC_2 \geq Y$

Where:

GR = Global Raise Regulation constraint

GC = Global Raise 5 Minutes constraint

LC = Local Raise 5 Minutes constraint for Region 1 and 2

RRn = Raise Regulation amount enabled for Region n

R5n = Raise 5 Minutes amount enabled for Region n

ICn = Interconnector flow for Region n

X,Y,Z = RHS values

Consider the following cases for the payments and recovery for above requirements.

CASE 1: ALL CONSTRAINTS BINDING

CONSTRAINT	RR_1	RR_2	RR_3	$R5_1$	$R5_2$	$R5_3$	IC_2	RHS	MV
GR	60	24	36					120	$3
GC	60	24	36	12	24	36		192	$2
LC	60	24		12	24		8	128	$4

Regional Payment (calculated using the equation in 5.2.2.1)

Raise Regulation

Region 1: $(3+2+4) x 60/12 = $45

Region 2: $(3+2+4) x 24/12 = $18

Region 3: $(3+2) x 36/12 = $15

Total = $78

Raise 5 Minutes

Region 1: $(2+4) x 12/12 = $6

Region 2: $(2+4) x 24/12 = $12

Region 3: $2 x 36/12 = $6

Total = $24

Requirement Payment Allocation (calculated using the equation in 4.2.2.2)

SERVICE	REGION	CONSTRAINT	REGIONAL PAYMENT	CONSTRAINT MV	REQPAYMENT ALLOCATION
Raise Reg	R_1	GR	$ 45.00	$ 3.00	$ 15.00
		GC	$ 45.00	$ 2.00	$ 10.00
		LC	$ 45.00	$ 4.00	$ 20.00
Raise Reg	R_2	GR	$ 18.00	$ 3.00	$ 6.00
		GC	$ 18.00	$ 2.00	$ 4.00
		LC	$ 18.00	$ 4.00	$ 8.00
Raise Reg	R_3	GR	$ 15.00	$ 3.00	$ 9.00
		GC	$ 15.00	$ 2.00	$ 6.00
Raise 5 Min	R_1	GC	$ 6.00	$ 2.00	$ 2.00
		LC	$ 6.00	$ 4.00	$ 4.00
Raise 5 Min	R_2	GC	$ 12.00	$ 2.00	$ 4.00
		LC	$ 12.00	$ 4.00	$ 8.00

SERVICE	REGION	CONSTRAINT	REGIONAL PAYMENT	CONSTRAINT MV	REQPAYMENT ALLOCATION
Raise 5 Min	R_3	GC	$ 6.00	$ 2.00	$ 6.00

For example, ReqPaymentAllocation for the first row of above table is:

45 x 3/(3+2+4) = $15

Requirement Payment:

GR = $15 + $6 + $9 = $30

GC = $10 + $4 + $6 + $2 + $4 +$6 = $32

LC = $20 + $8 + $4 + $8 = $40

Constraints GR and GC are to be grouped together since they have the same Regulation LHS terms, however split of recovery cost is not required since Regulation constraint GR is binding. Constraint cost for GR is recovered using Localised Regulation Recovery Method and for GC is recovered using Contingency Recovery method.

Constraint LC cannot be grouped since there's no Regulation constraint with matching Regulation LHS terms. This constraint cost is recovered through Contingency recovery method.

CASE 2: ALL CONSTRAINTS BINDING EXCEPT CONSTRAINT GR

CONSTRAINT	RR_1	RR_2	RR_3	$R5_1$	$R5_2$	$R5_3$	IC_2	RHS	MV
GR	60	24	36					119	$0
GC	60	24	36	12	24	36		192	$2
LC	60	24		12	24		8	128	$4

Regional Payment (calculated using the equation in 4.2.2.1)

Raise Regulation

Region 1: $(0+2+4) x 60/12 = $30

Region 2: $(0+2+4) x 24/12 = $12

Region 3: $(0+2) x 36/12 = $6

Total = $48

Raise 5 Minutes

Region 1: 1$(2+4) x 12/12 = $6

Region 2: $(2+4) x 24/12 = $12

Region 3: $2 x 36/12 = $6

Total = $24

Requirement Payment Allocation (calculated using the equation in 4.2.2.2)

SERVICE	REGION	CONSTRAINT	REGIONAL PAYMENT	CONSTRAINT MV	REQPAYMENT ALLOCATION
Raise Reg	R_1	GR	$ 30.00	$ -	$ -
		GC	$ 30.00	$ 2.00	$ 10.00
		LC	$ 30.00	$ 4.00	$ 20.00
Raise Reg	R_2	GR	$ 12.00	$ -	$ -
		GC	$ 12.00	$ 2.00	$ 4.00
		LC	$ 12.00	$ 4.00	$ 8.00
Raise Reg	R_3	GR	$ 6.00	$ -	$ -
		GC	$ 6.00	$ 2.00	$ 6.00
Raise 5 Min	R_1	GC	$ 6.00	$ 2.00	$ 2.00
		LC	$ 6.00	$ 4.00	$ 4.00
Raise 5 Min	R_2	GC	$ 12.00	$ 2.00	$ 4.00
		LC	$ 12.00	$ 4.00	$ 8.00
Raise 5 Min	R_3	GC	$ 6.00	$ 2.00	$ 6.00

For example, ReqPaymentAllocation for the last row of above table is:

6 x 2/2= $6

Requirement Payment:

GR = $0

GC = $10 + $4 + $6 + $2 + $4 +$6 = $32

LC = $20 + $8 + $4 + $8 = $40

Constraints GR and GC are to be grouped together since they have the same LHS Regulation terms, and in this case split of recovery cost is required since Regulation constraint GR is not binding.

The Adjusted constraint costs are as follows:

Regulation Recovery Cost for GC = MINIMUM($32, MAXIMUM(119/12 x $2, 0)) = $19.83

Contingency Recovery Cost for GC = $32 - MINIMUM($32, MAXIMUM(119/12 x $2, 0)) = $12.17

Regulation recovery cost for GC ($19.83) is recovered using Localised Regulation Recovery Method and Contingency recovery cost for GC ($12.17) is recovered using Contingency Recovery method.

Constraint LC cannot be grouped since there's no Regulation constraint with matching Regulation LHS terms. This constraint cost ($40) is recovered through Contingency recovery method.

CASE 3: ALL CONSTRAINTS BINDING EXCEPT CONSTRAINT GC

CONSTRAINT	RR_1	RR_2	RR_3	$R5_1$	$R5_2$	$R5_3$	IC_2	RHS	MV
GR	60	24	36					120	$3
GC	60	24	36	12	24	0		100	$0
LC	60	24		12	24		8	128	$4

Regional Payment (calculated using the equation in 4.2.2.1)

Raise Regulation

Region 1: $(3+0+4) x 60/12 = $35

Region 2: $(3+0+4) x 24/12 = $14

Region 3: $(3+0) x 36/12 = $9

Total = $58

Raise 5 Minutes

Region 1: $(0+4) x 12/12 = $4

Region 2: $(0+4) x 24/12 = $8

Region 3: $0 x 0/12 = $0

Total = $12

Requirement Payment Allocation (calculated using the equation in 4.2.2.2)

SERVICE	REGION	CONSTRAINT	REGIONAL PAYMENT	CONSTRAINT MV	REQPAYMENT ALLOCATION
Raise Reg	R_1	GR	$ 35.00	$ 3.00	$ 15.00
		GC	$ 35.00	$ -	$ -
		LC	$ 35.00	$ 4.00	$ 20.00
Raise Reg	R_2	GR	$ 14.00	$ 3.00	$ 6.00
		GC	$ 14.00	$ -	$ -
		LC	$ 14.00	$ 4.00	$ 8.00
Raise Reg	R_3	GR	$ 9.00	$ 3.00	$ 9.00
		GC	$ 9.00	$ -	$ -
Raise 5 Min	R_1	GC	$ 4.00	$ -	$ -
		LC	$ 4.00	$ 4.00	$ 4.00
Raise 5 Min	R_2	GC	$ 8.00	$ -	$ -
		LC	$ 8.00	$ 4.00	$ 8.00
Raise 5 Min	R_3	GC	$ -	$ -	$ -

For example, ReqPaymentAllocation for the first row of above table is:

35 x 3/(3+4)= $15

Requirement Payment:

GR = $15 + $6 + $9 = $30

GC = $0

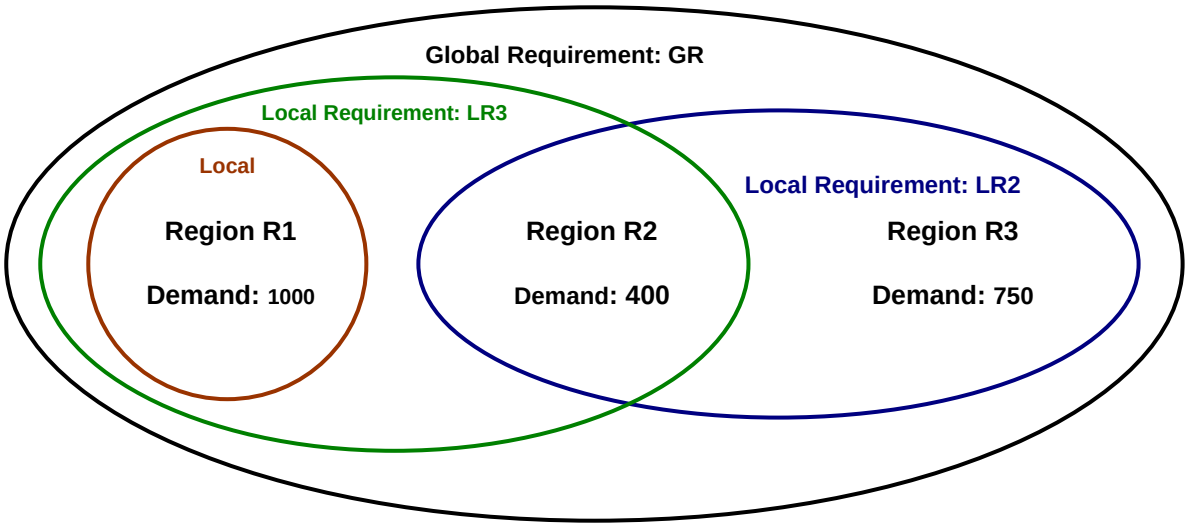
LC = $20 + $8 + $4 + $8 = $40

Constraints GR and GC are to be grouped together since they have the same Regulation LHS terms, however split of recovery cost is not required since Regulation constraint GR is binding. Constraint cost for GR is recovered using Localised Regulation Recovery Method.

Constraint LC cannot be grouped since there's no Regulation constraint with matching Regulation LHS terms. This constraint cost is recovered through Contingency recovery method.

7.2 Localised Recovery of Regulation Services - Example

In order to assist in the discussions in this section, the following Regulation FCAS example is used:



This simplified example consists of the three regions, with the total demand levels in each as shown. A global Regulation raise requirement applies over all three regions. In addition to this, three local requirements apply for the same Regulation raise service, LR1 over R1 only, LR2 over regions R2 and R3, and LR3 over R1 and R2 only. For a particular dispatch interval (DIn) all three constraints bind and the marginal values for the constraints are as follows:

- Marginal Value GR: $1.50
- Marginal Value LR1: $5.00
- Marginal Value LR2: $15.00
- Marginal Value LR3: $20.00

The amount of the Raise service enabled in each region during the dispatch interval in question is:

- R1: Enabled Raise_Reg = 120MW
- R2: Enabled Raise_Reg = 60MW
- R3: Enabled Raise_Reg = 90 MW

7.2.1.1 Determining Binding FCAS Constraint Information

The first information that should be provided to the settlements system is the binding/violating FCAS constraint information for each dispatch interval.

For the purpose of this example, the dispatch interval binding/violating constraint information is stored in a table with the following fields:

- Dispatch interval
- Service
- Constraint ID
- Region ID
- Marginal Value

The following records would result from the example:

DISPATCH INTERVAL	SERVICE	CONSTRAINT ID	REGION ID	MARGINAL VALUE
DIn	Raise_Reg	GR	R1	$1.50
DIn	Raise_Reg	GR	R2	$1.50
DIn	Raise_Reg	GR	R3	$1.50
DIn	Raise_Reg	LR1	R1	$5.00
DIn	Raise_Reg	LR2	R2	$15.00
DIn	Raise_Reg	LR2	R3	$15.00
DIn	Raise_Reg	LR3	R1	$20.00
DIn	Raise_Reg	LR3	R2	$20.00

7.2.1.2 Ancillary Service Prices

As currently being practiced, regional ancillary service prices are to be equal to the sum of the marginal prices of all constraints for that service, encompassing that particular region.

Raise_Reg Price Region R1: $26.50

Raise_Reg Price Region R2: $36:50

Raise_Reg Price Region R3: $16:50

7.2.1.3 Regional Ancillary Service Payments

For the purpose of determining regional contingency FCAS recovery, total regional payments are calculated as follows.

$$\text{Regional Payment} = \text{AS Price} \times \text{Regional Amount Enabled} / 12$$

DISPATCH INTERVAL	SERVICE	REGION	AS PRICE	AMOUNT ENABLED	REGIONAL PAYMENT
DIn	Raise_Reg	R1	$26.50	120 MW	$265.00
DIn	Raise_Reg	R2	$36.50	60 MW	$182.50
DIn	Raise_Reg	R3	$16.50	90 MW	$123.75

7.2.1.4 Allocation of Regional Payments to Requirements

Total regional payments for each service and dispatch interval are then pro-rated over the requirements for that service that encompass that region. These amounts are allocated on the basis of the marginal value of each requirement constraint.

$$\text{ReqPayment Allocation} = \text{Regional Payment} \times \frac{\text{Requirement Marginal Price}}{\sum_{\text{In that Region}} \text{Requirement Marginal Prices}}$$

DIS-PATCH INTERVAL	SERVICE	REGION	CONST-RAINT	REGIONAL PAYMENT	REQUIREMENT MARGINAL PRICE	REQUIREMENT PAYMENT ALLOCATION
DIn	Raise_Reg	R1	GR	$265.00	$1.50	$15.00
DIn	Raise_Reg	R1	LR1	$265.00	$5.00	$50.00
DIn	Raise_Reg	R1	LR3	$265.00	$20.00	$200.00

DIS-PATCH INTERVAL	SERVICE	REGION	CONST-RAINT	REGIONAL PAYMENT	REQUIREMENT MARGINAL PRICE	REQUIREMENT PAYMENT ALLOCATION
DIn	Raise_Reg	R2	GR	$182.50	$1.50	$7.50
DIn	Raise_Reg	R2	LR2	$182.50	$15.00	$75.00
DIn	Raise_Reg	R2	LR3	$182.50	$20.00	$100.00
DIn	Raise_Reg	R3	GR	$123.75	$1.50	$11.25
DIn	Raise_Reg	R3	LR2	$123.75	$15.00	$112.50

This regional requirement payment allocation must then be summed for each requirement over all regions included in that requirement.

DISPATCH INTERVAL	SERVICE	REQUIREMENT	REQUIREMENT PAYMENT
DIn	Raise_Reg	GR	$33.75
DIn	Raise_Reg	LR1	$50.00
DIn	Raise_Reg	LR2	$187.50
DIn	Raise_Reg	LR3	$300.00

Note that these values could have been determined, in this example, by simply multiplying the marginal value of each constraint by the total enabled MW encompassed by that constraint (divided by 12). For example, in the case of the global requirement, marginal price ($1.50) x total amount enabled (270 MW) / 12 = $33.75. This is consistent with the CRA report in which supply and demand prices for FCAS are defined (supply price being the payment price and the demand price being each marginal constraint price). However, this simplified calculation fails in any of the following cases:

- Where one or more constraints are violated (with the marginal prices being capped)
- Where a constraint is not violated, but the ancillary service price (sum of all marginal prices) exceeds VoLL and must, under the Rules, be capped to VoLL.
- Where there has been dispatch engine degeneracy of any type.

The pro-rating allocation above must be performed to balance FCAS payments and recovery. Otherwise, there is a risk over or under recovery in the cases listed above.

7.2.1.5 Calculation of CMPF and CRMPF values for Requirement

The total dispatch interval cost of each requirement (as listed in the table above) is allocated back to the participants in the regions servicing that requirement, using factors that are derived from the single set of factors calculated for the entire NEM and published in advance.

These factors are determined ultimately in the settlement runs using the Total Customer Energy in the relevant trading intervals for each region. For the purposes of estimation in the dispatch timeframe, the Total Demand (ie targets for regional demand) figures are used as a proxy. The calculation procedure is otherwise identical.

- Identify the regions in each requirement constraint
- Select those MPF from the global set (NEM MPF) which apply to providers in the selected regions
- Calculate an estimated CRMPF:

$$\text{CRMPF} = \text{NEM RMPF} \times \frac{\sum_{\text{Regions included in that requirement}} \text{Total Demand}}{\sum_{\text{All Regions}} \text{Total Demand}}$$

The pro-rating allocation above must be performed to balance FCAS payments and recovery. Otherwise, there is a risk over or under recovery in the cases listed above.

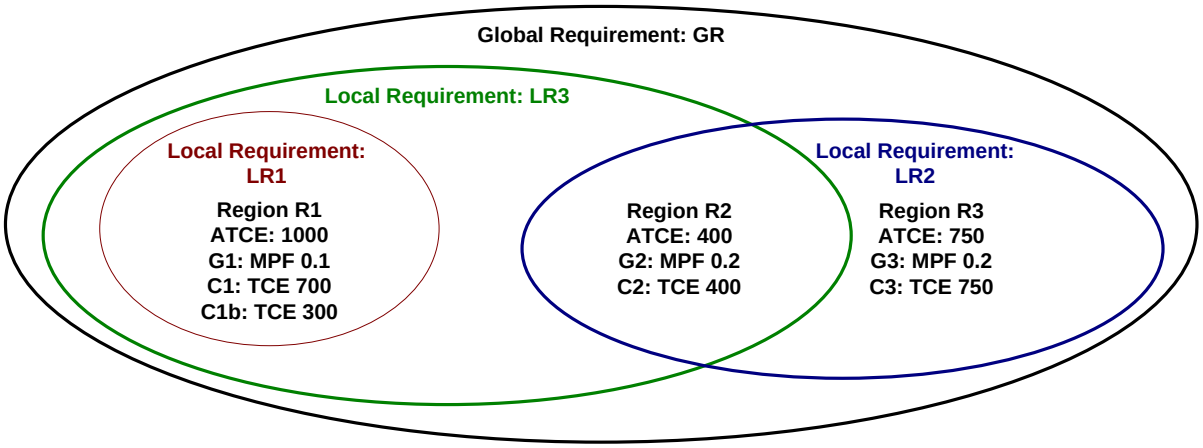
DISPATCH INTERVAL	SERVICE	CONSTRAINT	CMPF	CRMPF	TOTAL DEMAND (MW)
DIn	Raise_Reg	GR	0.5	0.5	2150
DIn	Raise_Reg	LR1	0.1	0.2326	1000
DIn	Raise_Reg	LR2	0.4	0.2674	1150
DIn	Raise_Reg	LR3	0.3	0.3256	1400

7.2.1.6 Requirement Recovery Allocation

The amount to be recovered from causers with a contribution factor (MPF) and to the market customers with a residual contribution factor (RMPF) can be determined directly by allocating the cost of each binding constraint across the participant in each relevant group of regions, using the CMPFs and CRMPFs applicable to the constraint.

Refer to the same example, with added information on the TCE and ATCE values for dispatch interval DIn in trading interval TIn for each customer as follows:

In this example, assume that the regional ATCE value in settlements timeframe is the same as the regional demand in dispatch timeframe. Therefore, the CMPF and CRMPFs in settlements timeframe is the same as the CMPF and CRMPFs calculated in dispatch timeframe.



where G1 is Generator 1, C1 is Customer 1, C1b is Customer 1a and so on.

Looking at above figure as well as pre-calculated CMPF and CRMPF and Requirement Payment from previous steps, we have the following information to determine the Recovery Allocation for DIn:

CONSTRAINT	CMPF	CRMPF	REQ PAYMENT	ΣATCE
GR	0.5	0.5	$33.75	2150
LR1	0.1	0.2326	$50.00	1000
LR2	0.4	0.2674	$187.50	1150
LR3	0.3	0.3256	$300.00	1400

The Participant Requirement Recovery Allocation for Regulation Service for DIn in TIn is:

	R1		R2		R3	
CONSTRAINT	MPF BASED RECOVERY (G1)	RMPF BASED RECOVERY (C1&C1B)	MPF BASED RECOVERY (G2)	RMPF BASED RECOVERY (C2)	MPF BASED RECOVERY (G3)	RMPF BASED RECOVERY (C3)
GR	$ 3.38	$ 7.85	$ 6.75	$ 3.14	$ 6.75	$ 5.89
LR1	$ 15.03	$ 34.97				
LR2			$ 56.19	$ 26.13	$ 56.19	$ 48.99
LR3	$ 47.95	$ 111.53	$ 95.91	$ 44.61		

The subsequent steps explain how the calculation is done for requirement recovery allocation for constraint LR3 in region R1:

- **MPF-based Recovery**
  G1 has an MPF value of 0.1, the PRRA for G1 for constraint LR3 is:

$$PRRA = \frac{\text{MPF of G1}}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment} + \frac{0}{\sum_{\text{Regions included in the requirement}} \text{ATCE}} \times \frac{\text{CRMPF}}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment}$$

= 0.1/(0.3+0.3256) x 300 + 0/1400 x 0.3256/(0.3+0.3256) x 300

= 47.95 + 0

MPF based recovery | RMPF based recovery

Since G1 has a non-zero MPF value, the PRRA comes from the MPF based recovery.

- **RMPF-based Recovery**

  C1 has no MPF value, the PRRA for C1 for constraint LR3 is:

$$PRRA = \frac{0}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment} + \frac{\text{TCE for C1}}{\sum_{\text{Regions included in the requirement}} \text{ATCE}} \times \frac{\text{CRMPF}}{\text{CMPF} + \text{CRMPF}} \times \text{ReqPayment}$$

= 0 + 700/1400 x 0.3256/(0.3+0.3256) x 300

= 0 + 78.07

MPF based recovery RMPF based recovery

C1b has no MPF value, the PRRA for C1b for constraint LR3 is:

$$PRRA = \frac{0}{CMPF + CRMPF} \times ReqPayment + \frac{TCE\ for\ C1b}{\sum_{Regions\ included\ in\ the\ requirement} ATCE} \times \frac{CRMPF}{CMPF + CRMPF} \times ReqPayment$$

= 0 + 300/1400 x 0.3256/(0.3+0.3256) x 300

= 0 + 33.46

MPF based recovery RMPF based recovery

(For information only) The Requirement Recovery Allocation for Regulation Service for Dispatch Interval DIn is:

		REQUIREMENT RECOVERY ALLOCATION		
CONSTRAINT	REQ PAYMENT	R1	R2	R3
GR	$ 33.75	$ 11.22	$ 9.89	$ 12.64
LR1	$ 50.00	$ 50.00		
LR2	$ 187.50		$ 82.32	$ 105.18
LR3	$300.00	$ 159.48	$ 140.52	