Under Frequency Management - UFM Initiatives & changes to procurement plan

Consultation Paper

Submissions close: 27 March 2013

29 January 2013

Executive summary

In November 2010 the system operator and Electricity Authority commenced an Under-Frequency Management (UFM) review, to determine strategies and measures that offer the most reliable, secure, and cost effective under-frequency management model.

The project included three work streams:

- review of instantaneous reserves arrangements
- review of asset owner performance obligations (AOPOs) related to frequency management
- stage II of the Automatic Under-Frequency Load Shedding (AUFLS) review.

The results of the first two of the work streams were summarised in the system operator 'Collective Review', while the AUFLS work was progressed separately.[1] The Collective Review provided a suggested development path for UFM in two stages: short term actions, and a long term plan.

The Collective Review found that the iterations performed by the system operators Reserve Management Tool (RMT) result in conservative amount of reserves being procured, with the result that frequency rarely falls below 49.2 Hz following a contingent event (CE). Frequency is allowed (under the reserve management objective) to drop to 48Hz following a CE.

This consultation paper sets out a number of proposed operational changes as well as a related change to the procurement plan which together are intended to remove some of the conservatism in RMT, which is expected to improve the efficiency of instantaneous reserves procurement in the short term.

The changes proposed to be made to the procurement plan are to require the provision of finer resolution post-event data from instantaneous reserve providers. The requirement will be less stringent for the providers of Fast Instantaneous Reserve Interruptible Load (FIR IL) with armed IL behind a meter, equal to or smaller than 2 MW.

To change the procurement plan requires the Authority to incorporate a new procurement plan into the Code by reference, by publication in the Gazette. The Code specifies that the Authority may do this after consulting participants on a draft procurement plan.

The proposed operational changes are to:

(a) change various ancillary service agreements to reflect the changes to the procurement plan

1 All such reports can be found at: http://www.systemoperator.co.nz/ufm

(b) reduce the RMT simulation time from the current 60 seconds, to 10 seconds,[2] to optimise the amount of reserves procured. This would require minor changes to the existing RMT software, but would need to be done in concert with the provision of finer resolution post-event data

(c) amend the modelling to better model IL trip times for FIR in RMT. This would be achieved by amending inputs to RMT, which would also need to be done in conjunction with the provision of finer resolution post-event data.

Finer resolution data (providing a better understanding of how generator and IL FIR respond to an event) and reduced RMT simulation time would produce a more accurate calculation of reserve requirements with associated cost savings in terms of reduced reserve procurement.

Procuring a reduced amount of FIR is likely to result in a greater number of frequency deviations outside the normal frequency band, which at worst may give rise to interruptible load and even AUFLS being called upon. It is likely that:

- there will be an increased likelihood of AUFLS events occurring, as the system frequency will operate closer to 48 Hz following a CE. Whilst the Code specifically allows the frequency to fall to 48 Hz following a CE, the effect of current practice is that – in most cases – post event frequency falls only to 49.2 Hz before returning to the normal band[3]
- there will be more under frequency events in general – i.e. events where frequency falls below 49.2 Hz, which is the trigger frequency for IL to operate.

This does not necessarily reflect a reduced level of system security relative to current practice. Indeed, given the risks identified by the system operator relating to over-frequency collapse following an extended contingent event, it is possible that reducing the level of FIR procured may actually result in a net improvement in overall system resilience to events which could give rise to system collapse.[4]

[2] http://www.systemoperator.co.nz/f4579,57165202/Under_Frequency_Management-_reserve_review_phase_1.pdf

[3] Initial calculations suggest that if reserve procurement had been at a level which meant that system frequency fell to 48 Hz following a contingent event, there would have been two extra AUFLS events in the last fifteen years (in addition to the single AUFLS event that occurred in December 2011).

[4] Generally speaking, a greater amount of reserves will improve resilience to under frequency collapse risk through improving the chances of arresting frequency fall in the largest events. However, if too much reserve and AUFLS are triggered in an under frequency event, system frequency can over recover to above 50 Hz. If frequency rises beyond 52 Hz it is likely that some generators' over frequency protection systems will cause them to disconnect, thereby causing frequency to fall again. If too many generators disconnect, then system frequency will fall below 50 Hz again – but this time without any under frequency resources to arrest it.

The balance between the benefit of increased reserves delivering improved under-frequency support versus exacerbating over frequency collapse risk is not straightforward to evaluate given the difficulties of evaluating very low probability events, and the fact that systemic over provision of AUFLS and IR (of which both are being addressed under separate work streams) by participants means that generally more under frequency resources are delivered in an event than were specifically procured by the system operator.

The proposed changes would improve efficiency and competition in the FIR market in the short to medium term, with no net degradation in system reliability. The move to providing higher resolution data is also likely to support future initiatives such as the alternative approaches to reserve procurement, as discussed in the UFM Collective Review.

The Authority is developing a plan to investigate these and other longer term initiatives so that development work can be completed and any required functionality included in the proposed replacement of RMT (that is provisionally scheduled for 2014/15). The Authority will publish its plans for this further work after having considered the submissions on this consultation paper.

Glossary of abbreviations and terms

Act	Electricity Industry Act 2010
AOPOs	Asset Owner Performance Obligations
ASA	Ancillary Services Agreement
Authority	Electricity Authority
AUFLS	Automatic Under Frequency Load Shedding
CE	Contingent Event
Code	Electricity Industry Participation Code 2010
ECE	Extended Contingent Event
FIR	Fast Instantaneous Reserve
IL	Interruptible Load
IR	Instantaneous Reserve
NRM	National Reserve Market
PPO	Principle Performance Obligation
Regulations	Electricity Industry (Enforcement) Regulations 2010
RMT	Reserve Management Tool – existing system operator reserve procurement software
SIR	Sustained Instantaneous Reserve
SPD	Scheduling Pricing and Dispatch model
SOSPA	System Operator Service Provider Agreement
UFM	Under frequency management
UFE	Under frequency event

Contents

Figures

1. Introduction and purpose of this paper

1.1 Introduction

Role of UFM

1.1.1 Robust management of under frequency events (which occur when there is a significant imbalance between supply and demand) plays a significant role in operating a secure and cost effective power system. Conversely, non-optimal management can result in high procurement costs, inefficient demand interruption or, in the worst case, cascade failure of the power system. The current under frequency standards are achieved mainly through a combination of asset owner performance obligations (AOPOs), procurement of instantaneous reserves (IR), and mandated automatic under frequency load shedding (AUFLS).

UFM project and status

1.1.2 In 2010, the system operator conducted a technical review of the existing AUFLS scheme to evaluate the system operator's ability to manage identified large risks, given that the changing nature of the New Zealand power system makes the system more susceptible to under-frequency events.[5] The review identified (among other findings) the need to improve the way reserves are currently procured and utilised, and to research options for other products.

1.1.3 During 2011, the system operator and the Electricity Authority (Authority) undertook a review of the UFM arrangements in the New Zealand electricity market. The purpose of the review was to determine the strategies and measures that offer the most reliable, secure and cost effective approach to under frequency management, provide greater certainty of system integrity during major under frequency events, and support the operation of an efficient electricity market.

Specific initiatives being pursued

1.1.4 Some of the changes identified in the review are proposed for implementation in the short term (1-2 years), while others would need to be progressed over the longer term (3-5 years). Two shorter term initiatives have been deferred to 'medium term' as they were found to be more complex than initially anticipated.

---

[5] In simple terms, the size of the risk is getting larger with the introduction of Pole 3, while at the same time the resilience of the system is getting less with the growth of generation that doesn't have as much inertia to help counteract a fall in frequency.

1.1.5 This paper progresses the identified short term initiatives, including changes to the procurement plan.[6]

Process for procurement plan changes

1.1.6 Some of the changes proposed by this paper also require changes to the procurement plan, a document incorporated into the Code by reference. A new process for making changes to the procurement plan took effect on 10 January 2013. That process requires the system operator to submit a draft procurement plan to the Authority together with the supporting information specified in the Code, and requires the Authority to consult with participants on the draft procurement plan before deciding whether to incorporate it into the Code by reference, by publishing a notice in the Gazette.

1.1.7 On 29 November 2012, the system operator provided a draft procurement plan to the Authority together with the required supporting information. The proposed changes to the procurement plan are marked up in the draft procurement plan that is attached to this paper as Appendix D.

1.2 Purpose of this paper

1.2.1 The purpose of this paper is to consult interested parties regarding the:

(a) proposed operational changes to the way the system operator manages under-frequency events

(b) draft procurement plan for ancillary services, which implements some of those changes.

1.2.2 This paper also seeks views on the longer-term initiatives relating to instantaneous reserves. These initiatives are discussed in Section 8 - Medium- and longer-term initiatives.

1.2.3 This paper does not detail other proposed changes in relation to other aspects of the UFM arrangements, such as changes to the AUFLS regime. Such changes are being consulted on via separate processes.

1.2.4 The Authority invites submissions on the proposed operational changes, and on the proposed changes to the procurement plan, including drafting comments. Submissions on the procurement plan should address only the changes proposed. Submissions on other aspects of the procurement plan will not be considered as part of this consultation process.

[6] Figure 1: UFM roadmap illustrates the initiatives being pursued.

1.3 Submissions

1.3.1 The Authority's preference is to receive submissions in electronic format (Microsoft Word). It is not necessary to send hard copies of submissions to the Authority, unless it is not possible to do so electronically. Submissions in electronic form should be emailed to submissions@ea.govt.nz with 'Consultation Paper—Under Frequency Management - UFM Initiatives & changes to procurement plan in the subject line.

1.3.2 If submitters do not wish to send their submission electronically, they should post one hard copy of their submission to either of the addresses provided below.

Submissions
Electricity Authority
PO Box 10041
Wellington 6143

Submissions
Electricity Authority
Level 7, ASB Bank Tower
2 Hunter Street
Wellington

Tel: 0-4-460 8860

Fax: 0-4-460 8879

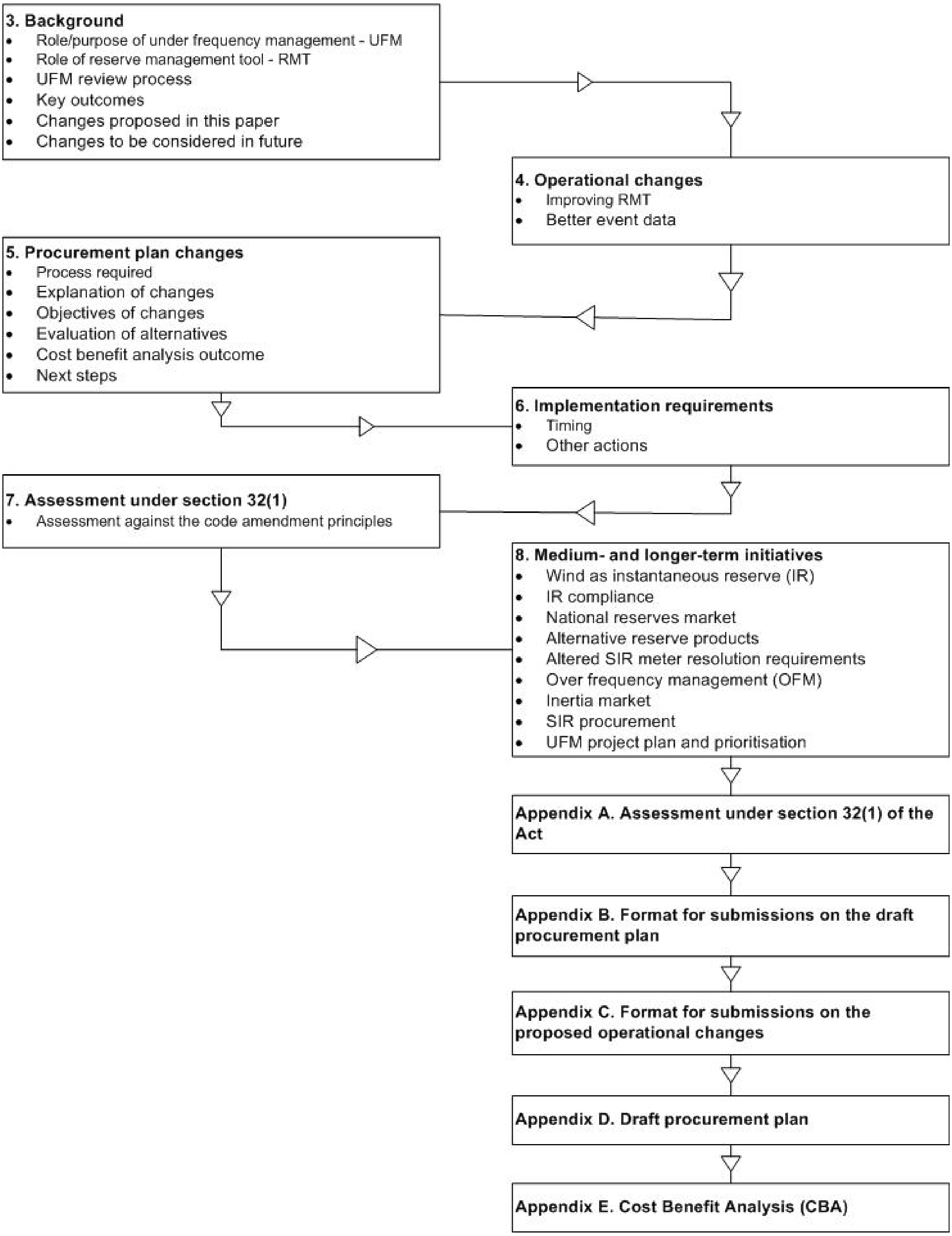
1.3.3 Submissions should be received by 5pm on 27 March 2013. Please note that late submissions are unlikely to be considered.

1.3.4 The Authority will acknowledge receipt of all submissions electronically. Please contact the Submissions' Administrator if you do not receive electronic acknowledgement of your submission within two business days.

1.3.5 If possible, submissions should be provided in the format shown in Appendix B and Appendix C. Your submission is likely to be made available to the general public on the Authority's website. Submitters should indicate any documents attached, in support of the submission, in a covering letter and clearly indicate any information that is provided to the Authority on a confidential basis. However, all information provided to the Authority is subject to the Official Information Act 1982.

2. Structure of this paper

The following diagram illustrates the structure of this paper, to help the reader to navigate through its various sections.



3. Background

3.1 Purpose of UFM

3.1.1 The system operator must procure Instantaneous Reserves (IR) to assist it to:

(a) achieve compliance with clause 7.2(1)(a), 7.2(1)(b) and 7.2(2)(a) of Part 7 of the Code (the principal performance obligations (PPOs) related to under frequency)

(b) prevent frequency going outside defined limits for specified contingencies

(c) comply with the policy statement.

3.1.2 IR is procured to arrest a fall in frequency following a contingent event (CE) or extended contingent event (ECE) on the system, and to return frequency within the normal band.[7] Two types of IR are procured:

(a) FIR is used to arrest frequency drop and may be provided by generation (responding within 6 seconds of an event and sustained for 60 seconds) or interruptible load (responding within 1 second of frequency falling to 49.2 Hz and remaining off for at least 60 seconds)[8]

(b) Sustained instantaneous reserve (SIR) is used to return the frequency to the normal band and must respond within 60 seconds and be sustained for up to 15 minutes (in the case of generation SIR) or until re-dispatched by the system operator (in the case of SIR Interruptible Load (SIR IL)).[9]

3.1.3 For the purposes of settlement, the quantity of IL reserve deemed to be provided (in both cases relative to the load pre-event when frequency was not falling) is:[10]

(a) in the case of FIR IL, the total reduction in load that occurs 1 second after trip time and is sustained for at least 60 seconds

(b) in the case of SIR IL, the average reduction in load over the 60 seconds following trip time.

3.1.4 The quantity of generation IR provided (relative to the pre-event output of the generator) is:

---

7 Reserves are scheduled to cover a CE (loss of single generating unit or single HVDC Pole). The frequency for a CE must not go below 48 Hz. ECEs (loss of HVDC bipole, a bus bar or an interconnected transformer) are covered by a combination of instantaneous reserves and AUFLS. For an ECE, the frequency must not drop lower than 47 Hz in the North and 45 Hz in the South Island.

8 Generation FIR is measured as the additional capacity provided within 6 seconds after a CE and sustained for at least 60 seconds. FIR IL is measured as the drop in load that occurs within 1 second of frequency falling to or below 49.2 Hz and sustained for at least 60 seconds.

9 SIR IL is measured as the average drop in load over 60 seconds after frequency drops to or below 49.2 Hz. Generation SIR is measured as the average additional output provided during the first 60 seconds after a CE and sustained for at least 15 minutes (unless a new dispatch instruction is given within that time).

10 Procurement Plan, 1 December 2012, clauses B34.1 and B34.2.

(a) in the case of FIR, the total increase in output measured 6 seconds after the event, sustained for 60 seconds

(b) in the case of SIR, the average response over the first 60 second period following the event, sustained for 15 minutes.

3.2 Role of RMT

3.2.1 RMT is the system operator software used to calculate the FIR needed in each trading period to maintain the system frequency within the levels prescribed by the Reserve Management Objective (Schedule 8.4 of the Code), should a CE or ECE occur. SIR quantities are not determined by RMT but rather procured on a one-to-one basis (i.e. equal to the output of the largest generator or single pole of the HVDC link, whichever is greater). [11]

3.2.2 RMT models the frequency response of the power system in advance of real time (and assuming forecast generation and demand) by tripping a critical amount of supply and scheduling FIR sufficient to maintain frequency above 48 Hz in the event of a CE, and above 47 Hz in the event of an ECE (RMT models both events to determine the risk setter). The supply RMT will trip equates to the largest source of supply (generation or HVDC) likely to be lost in an event. The quantity of FIR scheduled is based on the largest risk setter for the trading period (whether CE or ECE).

3.2.3 RMT contains governor models of individual generating stations. These models are based on asset capability statements (ACSs) provided to the system operator by asset owners.[12] The governor models and the HVDC response to a CE and ECE are used in the calculation of FIR requirements.

3.2.4 There are no separate models of IL provider response. Rather, RMT has a single gross assumption that all such load will respond exactly at one second after the frequency reaches 49.2 Hz.

3.2.5 RMT is a simplification of reality. For example:

(a) it does not have the functionality to:

(i) model reserve sharing between Islands

(ii) determine SIR requirements; or

(iii) model AC transmission constraints.

(b) it includes a number of assumptions regarding station availability and response times of reserve providers

[11] RMT does not have the capability to calculate SIR.

[12] Asset owners are required to provide an ACS to the system operator following commissioning (Part 8, Schedule 8.3, Technical Code A, Clause 2(2)), and carry out periodic testing of their assets (Clauses 3 and 8)). Note these are not specific requirements on reserve providers.

(c) the inaccuracies in modelling inputs mean there will be differences between modelled and actual outcomes.

3.2.6 The existing RMT has been in place since 2001. The system operator expects that it will need to be replaced with a new model in 2014/15.[13] As well as addressing issues with 'ageing' software, it is intended that the replacement will enable new functionality be implemented to better meet the needs of the New Zealand electricity market in the coming decade. New functionality to enable implementation of longer term initiatives, that will potentially be included, is discussed further in Section 8 - Medium- and longer-term initiatives.

3.3 UFM review process

3.3.1 In November 2010, the system operator and the Authority commenced a review to determine strategies and measures that offer the most reliable, secure, and cost effective UFM approach during major under frequency events (UFEs).

3.3.2 The current approach has, with minor amendments, been in place since the commencement of the New Zealand Electricity Market in 1996. Reviewing such arrangements periodically to ensure they remain fit for purpose and optimal is an important aspect of market regulation.

3.3.3 The review was initiated by new generation technologies, the change in generation mix on the system, and the commissioning of HVDC Pole 3. In addition, step changes in information technology and reduced costs of managing data may provide opportunities to mitigate under frequency events more efficiently.

3.3.4 The UFM review has three work streams:

1) review of the current instantaneous reserves procurement arrangements, including the RMT assumptions and approach, and the existing under frequency PPOs

2) review of AUFLS, focusing on furthering the work from the AUFLS technical review to ensure that frequency management products better meet the requirements of the power system. The AUFLS work stream is being pursued separately as a stand-alone project

3) a review of AOPOs related to frequency management potentially enabling wind generation FIR offers, and improved over frequency arming arrangements.

3.3.5 Following a series of stakeholder workshops, the results of all three work streams were summarised in the system operator's 'Collective Review'.[14] The report provided a suggested development path for UFM in two stages: short term actions and longer-term developments.

---

[13] The system operator considers that RMT will reach the stage in the next few years where it is no longer fit for purpose. This is because of the accumulation of many 'patches' to address various individual issues, which collectively are starting to impair the ability of the tool to appropriately procure reserve in some situations.

[14] All reports relating to the UFM project can be found at: http://www.systemoperator.co.nz/ufm.

3.3.6 This paper focuses on the proposed short-term changes arising from work stream (1) relating to procurement of reserves. The medium- and longer-term developments for reserves procurement, and the initiatives coming out of the other work streams are discussed, as needed, for context. Figure 1 illustrates the UFM road map.

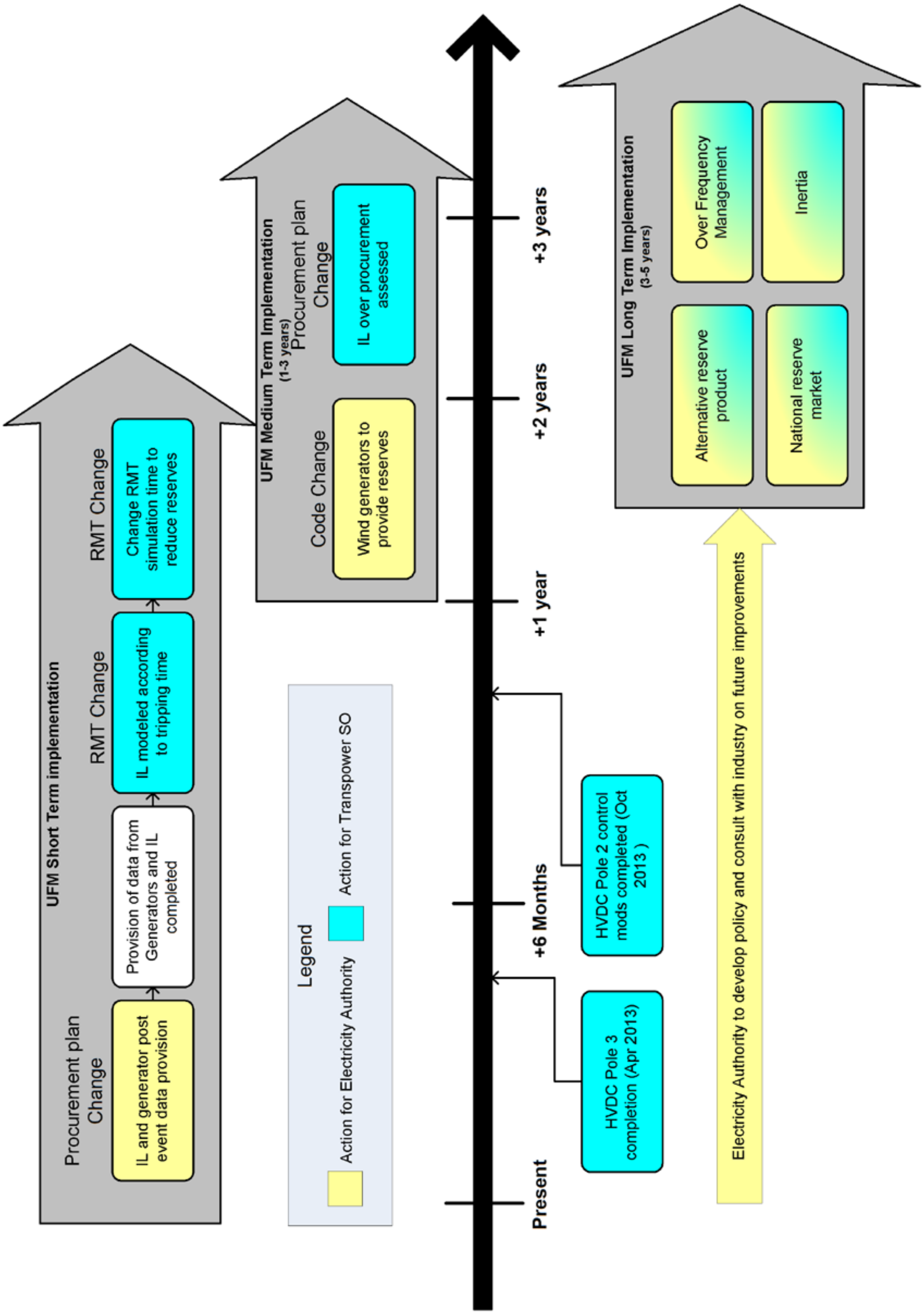


Figure 1: UFM roadmap

3.4 Key outcomes

3.4.1 The system operator has a principal performance obligation (PPO) requiring it to maintain frequency above 48 Hz following a CE. Some of the inputs to RMT are not representative of the dynamics of the power system, hence the reserve calculations have been observed to be conservative.

3.4.2 This conservative approach has meant that frequency has rarely fallen below 49.2 Hz following a CE in the past 15 years, well above the minimum level specified in the PPOs.

3.4.3 In seeking to consider whether this level of conservatism is appropriate, the IR review team was asked to:

(a) identify why actual frequency response is often considerably different than the outcome modelled using RMT

(b) review the modelling philosophy and assumptions employed in RMT with a view to amending the model to better reflect reality

(c) research opportunities for amendments to the reserve procurement arrangements that might better meet the requirements of under frequency management.

3.4.4 Outcomes of the review showed that:

(a) one of the largest sources of difference between modelled and actual reserve quantities was that the modelled ‘risk setter’ (the single largest potential contingency) is generally not the unit that actually trips – it is however a ‘worst case’ assumption, that cannot be avoided or refined

(b) the expected performance of each machine or station on the system differed at times from actual performance

(c) the frequency curve modelled in RMT can only be an approximation of the actual frequency curve, and the inability of RMT to model some aspects of reserve (e.g. the interaction of SIR and FIR) meant that RMT was significantly under-estimating the impact of reserve on arresting frequency decline – more reserve responded than RMT had calculated

(d) the operation time of FIR IL is modelled as 1 second after frequency falls to 49.2 Hz. In reality, a significant proportion of IL operates faster, so that actual recovery of frequency is faster than modelled

(e) in general, significantly more IL trips than is offered, as IL is often offered conservatively, and some IL providers do not disarm their load if they are not cleared in the IR market

(f) the modelling of HVDC response differs from the actual response (generally actual response is greater than that modelled)

(g) a mix of reserves is essential and it is important that one type of reserve is not inappropriately incentivised over another.

3.4.5 Overall, the review found that the above factors were resulting in significantly more reserve being procured than was required to meet the reserve management objective. This not only results in higher reserve costs, but may also have negative implications for managing system security outcomes by exacerbating over-frequency collapse risk following an AUFLS event.[15]

3.4.6 The outcomes of the review were discussed with stakeholders at a workshop held in August 2011. Following this, proposals for IR development were set out in the system operator's Collective Review and consulted on with stakeholders.

3.5 Summary of changes proposed in this paper

3.5.1 This paper proposes implementing the following short-term initiatives resulting from that work, with an aim to better optimise the reserve quantity procured for under-frequency events:

(a) reduce RMT simulation time from 60 seconds to 10 seconds

(b) model actual delivery times for IL, i.e. tripping them at 0.4 seconds, 0.7 seconds, etc., depending on the provider, rather than all at 1 second after frequency hits 49.2 Hz.

3.5.2 Neither of these initiatives requires a Code amendment. They simply require the system operator to change some operating parameters within RMT.

3.5.3 However, to facilitate both initiatives the system operator has indicated it would require higher resolution post-event meter data from FIR providers than the 6 second resolution data that is currently required. This is needed to provide sufficient confidence in the performance of FIR providers in order to mitigate the risk of under-procurement.

3.5.4 Accordingly, it is proposed that the procurement plan (which is incorporated into the Code by reference) should be changed so that:

(a) FIR providers greater than 2 MW in FIR capacity are required to provide post-event meter data with at least 100 ms resolution

(b) FIR providers smaller than or equal to 2 MW in FIR capacity are required to provide both of the following:

(i) 1 second resolution data metered at the site

(ii) 100 ms resolution end-to-end test data, to be provided for all sites initially, with re-tests to be carried out at least every five years.

---

15 If too much under frequency resource (i.e. IR and AUFLS) is triggered following an event, system frequency will *over* recover – to above 50Hz. If this level of over recovery should go beyond 52Hz then generator protection systems will start to respond by disconnecting generators. If too many generators disconnect this could result in frequency falling again – but this time without the under frequency safety net to prevent total collapse. The review identified that significantly more IL and AUFLS were being provided at most times than were procured, and that this over provision was exacerbating the general over-procurement of IR outlined above.

3.6 Summary of changes to be considered in the future

3.6.1 The Authority's role includes ensuring that reserve arrangements remain efficient as the generation mix and other factors change over time. Therefore, in addition to the immediate initiatives that are the subject of this consultation paper, the system operator and the Authority are also considering medium- and longer-term developments in UFM arrangements.

3.6.2 The medium-term initiatives are:

(a) enabling wind generators to offer FIR. It is expected that this may have benefits in future, when the must-run generation quantity begins to exceed the quantity available in the must-run dispatch auction. However, implementation would require changes to system operator tools as well as the Code, the cost of which has not yet been investigated, but is expected to be more than 'minor'. Feedback is sought (refer Section 8.1) on whether stakeholders consider this initiative to be of value

(b) increasing compliance of IL providers with dispatch quantity. This initiative is being undertaken for reasons of system security. At the moment, compliance is expressed in terms of ensuring participants provide at least the amount of IL that they have been dispatched to provide. However, conservative offering of IL to ensure the dispatch quantity is provided in response to a UFE, together with failure to disarm offered but not dispatched FIR IL, often means over-provision in practice. This can result in post-event over-frequency issues which could lead to system collapse. It is proposed to change compliance arrangements to address such over-provision, potentially through introducing maximum limits on the quantity provided, as well as addressing participants' failure to disarm offered but not cleared IL

Feedback is sought (refer Section 8.1) on whether stakeholders consider this initiative to be of value.

3.6.3 The longer-term initiatives under consideration are set out in Section 8 – Medium- and longer-term initiatives, and comprise a national reserve market, alternative reserve procurement, altered SIR meter resolution requirements, generation inertia incentives and over-frequency management.

3.6.4 Each of these longer-term initiatives has the potential to deliver material cost savings, or address issues that could adversely impact on system reliability, or both. However, none of the issues is trivial, with many having implications for other parts of the market, or requiring substantial changes to the approach and associated software for reserves procurement, or both.

3.6.5 While the work required to develop the issues to the point of implementation is complex, the timeframe is constrained, to some extent, by the need to replace RMT by 2014/15. Where an initiative will require new functionality to be included in RMT, the policy development will need to be well underway by that time.

3.6.6 Given that most of the initiatives require changes to market design, their development will be led by the Authority. However, such development will be done in collaboration with the system operator, including through the system operator providing various technical analyses where necessary.

3.6.7 The Authority is in the process of developing a plan for investigating and developing proposals for longer term UFM developments. The Authority expects to publish the plan by March 2013.

4. Operational changes

4.1 Improving RMT

Two initiatives are proposed to improve RMT. Both of these initiatives require FIR providers to provide higher resolution post-event meter data:

(a) Reduce the modelled simulation time in RMT

(b) More accurately model FIR IL trip times within RMT.

The above are the within the domain of the system operator and do not require changes to the Code or the Procurement Plan.

Reducing the RMT simulation time

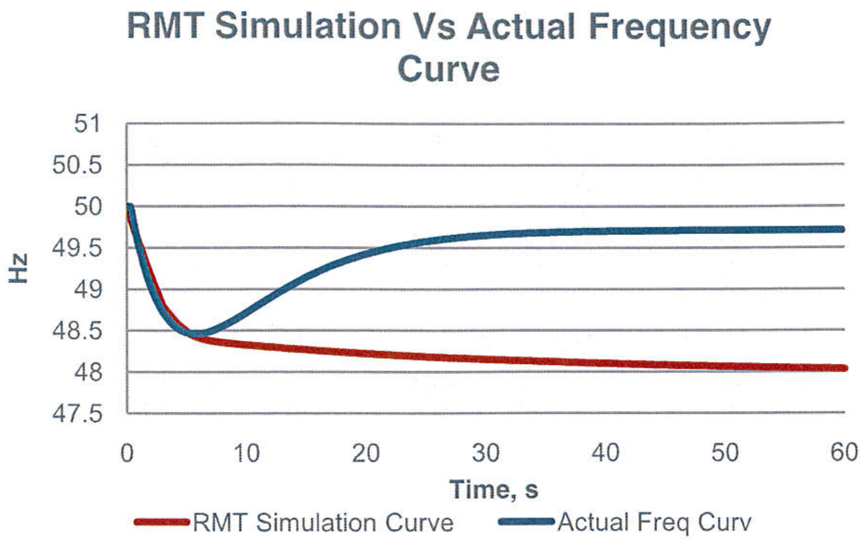
4.1.2 As set out in detail in the 5 August 2011 work stream 1 UFM report and the 22 May 2012 UFM Collective Review report, one source of IR procurement conservatism relates to the RMT modelling approach and simulation time (time taken to calculate reserve procurement quantities in RMT).[16] RMT does not model SIR,[17] and the design of RMT is such that using a solve time of 60 seconds results in RMT assuming a reserve response over 60 seconds that is actually equal to the expected 6 second FIR response (as shown in Figure 2, below). This is because the reserve quantity is 'clamped' at its 6 second value. In fact, governor and SIR IL responses will restore the frequency to its normal operating range well within 60 seconds.

4.1.3 Figure 2 illustrates the difference between an actual under frequency curve and the curve produced from RMT simulation. The blue (higher) curve reaches a minimum frequency within a short time before reserve response returns the frequency to the normal band, meaning less FIR is required than is currently procured for the event.

[16] All such reports can be found at: http://www.systemoperator.co.nz/ufm

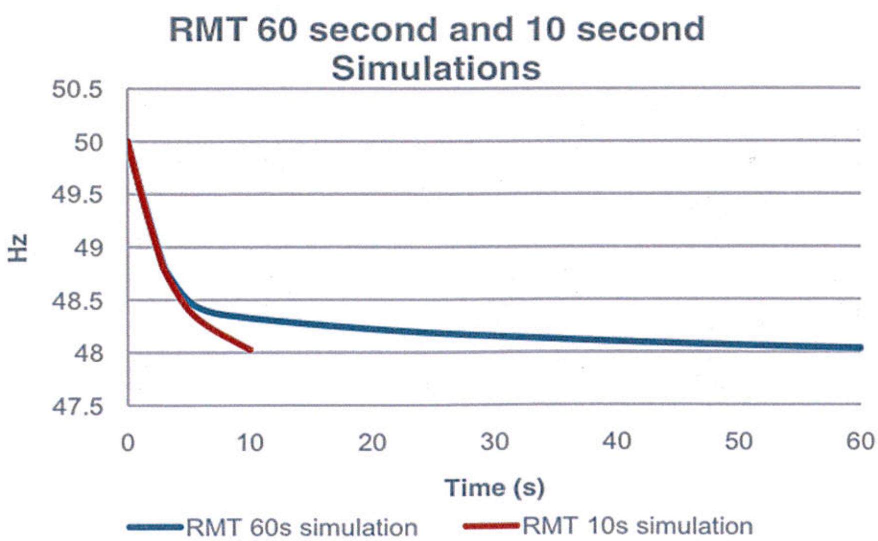
[17] This is not possible in the current RMT model as it causes instabilities and oscillations between RMT and SPD. However, this issue would be considered as part of any project to upgrade the RMT software.

Figure 2: RMT Simulation Vs Actual Frequency Curve



4.1.4 Shortening RMT solve time would produce a result that more closely approximates what will actually occur during an event, as shown in Figure 3, modelling a 10 second response for a 6 second product is likely to be more accurate than modelling a 60 second response for the 6 second product. The system operator estimates that this approach could result in a reduction of 40-60MW (average across all trading periods) of FIR required – while still maintaining frequency above 48 Hz following a CE.

Figure 3: RMT 60 second and 10 second simulations



4.1.5 Moving to a faster RMT solve time is only possible if the system operator has sufficient confidence that the reserve providers will perform as modelled within RMT. If providers do not perform as expected, and in particular if they deliver reserve more slowly than what is modelled, then there is increased risk of insufficient reserve to arrest the frequency drop, leading to AUFLS operation and a potential system collapse.

4.1.6 Analysis presented in section 3.1.2 of the 22 May 2012 UFM Collective Review report shows that the impact of reserve provider response being slower than expected becomes progressively more severe for shorter RMT simulation times.

4.1.7 This need for improved confidence in reserve performance is the reason behind the proposal for FIR meter resolution set out in section 4.2 below.

Q1. What comments do you have on the proposal to shorten RMT simulation time using higher resolution post-event data from IR providers?

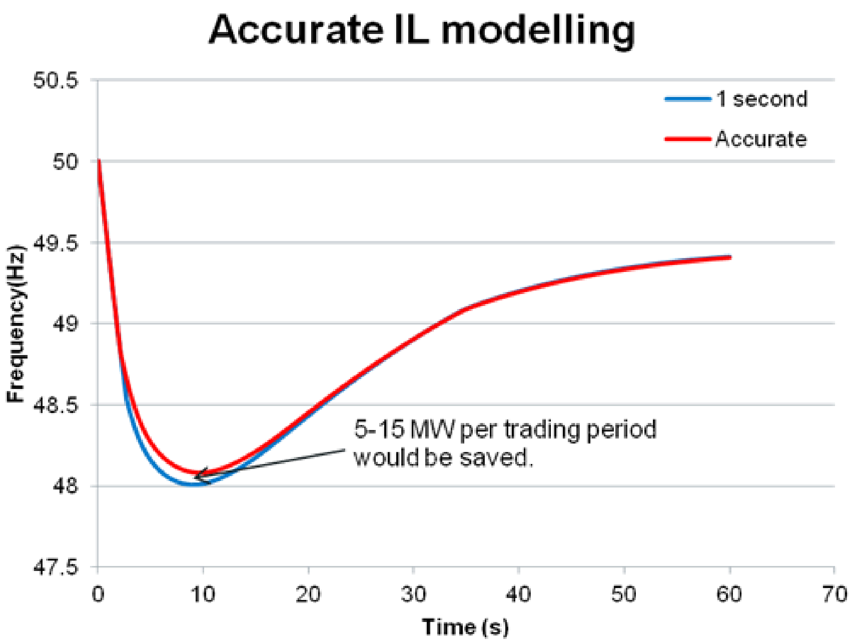
Accurately modelling FIR IL trip times

4.1.8 The Code currently requires FIR IL to trip within 1 second of the system frequency reaching 49.2 Hz. In reality, a high proportion of this IL trips after about 400 ms, but the FIR IL is modelled in RMT as responding at 1 second (assumed trip time) in line with Code requirements.

4.1.9 The earlier-than-modelled actual performance of IL helps to arrest the frequency fall sooner. If modelled IL performance was aligned with more realistic expected levels of performance, this would reduce reserve procurement and would also help minimise potential over-frequency collapse concerns (as detailed in footnote 15 on page 12).

4.1.10 Section 3.1.3 of the 22 May 2012 UFM Collective Review report produced a chart that illustrates this impact. This has been reproduced as Figure 4 below, which shows that between 5 and 15 MW of FIR would be saved each trading period (depending on system conditions) by more accurately modelling the FIR IL response time.

Figure 4: Impact of more accurate IL modelling on FIR procurement



4.1.11 The Authority and system operator consider that there is likely to be value – in terms of reserve procurement cost savings, and reduced over-frequency collapse risk – in more accurately modelling the actual IL trip times.

4.1.12 However, as with the proposal to shorten the RMT simulation time outlined in the previous section (paragraphs 4.1.2 to 4.1.7), the system operator would need to be confident of the expected performance of IL providers (in terms of trip time) to be able to do this. It does not consider it can have this confidence using the existing 6 second data.

Q2. What comments do you have on the proposal to model actual IL trip times, facilitated by higher resolution post-event data from providers?

4.2 Better data

Current situation

4.2.1 Currently the generation asset performance models within RMT are developed from test data, together with data from generators' asset capability statements (as this is the only available data of sufficiently high resolution). However, the system operator believes that if shorter RMT simulation times are to be implemented, it is imprudent to rely solely on test data to predict reserve provider performance. This is because of the risk that actual performance may be materially different to that predicted from test data.[18]

4.2.2 The system operator considers that metered data of reserve provider performance during *actual* events (of which several occur each year) can provide exactly the type of good quality data necessary to develop models of expected performance that could be used with sufficient confidence within RMT or its replacement.

4.2.3 Actual event data is considered superior to test data because:

(a) it removes the potential for human error in testing[19]

(b) it removes the potential for the test to not appropriately reflect the actual system conditions that would be experienced in an event[20]

(c) testing cannot deal with potential changes to the reserve provider's equipment, which may inadvertently affect subsequent performance.[21]

4.2.4 Using actual event data would have the effect of making reserve providers subject to a 'continuous' testing regime, which would help provide early warning of unanticipated changes in an asset's behaviour.

4.2.5 These conclusions regarding the relative merits of test data versus actual event data apply both to spinning reserve and interruptible load.

4.2.6 However, to be useful, such actual meter data would need to be of a sufficiently high resolution.

4.2.7 The minimum meter resolution requirement for reserve providers is set out in the Procurement Plan. Currently this requires the ancillary services agents to provide monitoring equipment that accurately records IR response at no greater than 6 second intervals for FIR, and no greater than 10 second intervals for SIR.[22] This monitoring is required for all periods in which the provider's equipment is dispatched to provide IR, and the data provided must cover the period commencing no less than 6 seconds prior to the under-frequency event or trip time, and end no earlier than 60 seconds later for FIR, or 15 minutes later in the case of SIR.

18 Generator tests are much more complex than testing the tripping time of IL hence the proposal for post-event data from generators. 100ms IL test data can be relied upon to a great degree but on-going reliance is dependent on an on-going testing regime e.g. 5 yearly or so repeated tests.

19 It is understood that the unanticipated machine performance in the 1 August 2009 event was due to the original test being incorrectly performed. In this case, the actual behaviour of the units of one generator were materially slower than that predicted using test data.

20 For example, injecting an under-frequency curve into a governor of a machine which is synchronised to a system which is not experiencing an under-frequency event will never be able to truly represent how that machine will perform during an actual under-frequency event.

21 For example, there is a risk that a change to the control system of a reserve provider to address one issue may inadvertently affect the reserve provider's speed of delivery for reserve provision.

22 Procurement Plan, 1 December 2012, Clause B38

4.2.8 As set out in paragraphs 3.1.3 and 3.1.4, the delivery requirement for FIR is the offered quantity delivered within 6 seconds after the event occurs for spinning reserve, and within 1 second of frequency reaching 49.2 Hz for IL. As such, 6 second interval metered data is considered barely adequate for compliance purposes, and completely inadequate for developing models of how a reserve provider would respond during the course of an under-frequency event, the most severe of which could result in frequency dropping to 48 Hz within two seconds.

Alternatives

4.2.9 If 6 second interval data is not fit for either compliance purposes or developing models of provider performance, the question then is what would be an appropriate level of meter resolution?

4.2.10 The system operator considered a range of meter resolution options:

(a) one second

(b) 100 ms

(c) 20 ms.

4.2.11 One second data is already available from most generators and some IL providers. However, from a compliance perspective this is still considered inadequate – particularly for demonstrating the provision of IL within 1 second of frequency hitting 49.2 Hz. Further, from RMT modelling perspective, the system operator found that though better than 6 second data, 1 second data can still mask time delays, may skew actual versus assessed performance, and does not demonstrate whether the response occurs with the same rate of change of output as it should.

4.2.12 The system operator concluded that it would be unable to implement the 10 second RMT solve time with data at only a 1 second resolution. At best, a 30 second solve time could be achieved, which would only deliver a fraction of the possible benefit in terms of reduced reserve procurement and reduced over-frequency collapse risk.

4.2.13 100 ms data was considered to be sufficient from both a compliance perspective, and in terms of developing more accurate models of reserve provider performance for use in RMT. The system operator has indicated that 100 ms data would give sufficient confidence to enable most of the conservatism in RMT to be removed, enabling a 10 second solve time. Most generators, and some of the larger IL providers, already have 100 ms capable metering systems in place (or at least elements of the meter solution), many of which are capable of even higher resolution (e.g. 50 ms or 20 ms).

4.2.14 20 ms data was considered to be ‘ideal’ from the perspective of developing models of provider performance and may enable even better ‘fine-tuning’ of reserve procurement. However, the system operator has indicated that the current RMT tool would not be able to take advantage of such higher-resolution data to enable even more accurate reserve procurement. That said, if the revised longer-term reserve procurement approaches and tools indicated in section 3.6 were implemented, it is likely that 20 ms data would facilitate improved outcomes relative to 100 ms data.

4.2.15 There is currently little incentive for reserve providers to incur the cost of higher resolution meters of their own accord. In the future, alternative procurement options such as 'area-under-the-curve' (see 8.4 for more details) would be likely to reward providers who have higher resolution data with higher IR payments.[23] However, developing and implementing market arrangements would be expected to take several years, and in the meantime, retaining the current data requirements would require retaining the conservatism in FIR procurement. Accordingly it is proposed that a mandated approach be adopted whereby reserve providers are required (via the Code) to implement higher resolution metering data if they wish to provide FIR reserve.

4.2.16 Mandating a minimum metering resolution is not new – the current 6 second resolution requirement is achieved via mandate. Accordingly, the proposal involves changing the metering resolution which is currently required by mandate from six second resolution to a higher, more appropriate resolution level.

4.2.17 Cost-benefit analysis indicates that the metering resolution which will deliver the highest net benefit is 100 ms.[24] This analysis (refer to Appendix E for more details) takes account of the fact that a large proportion of the current FIR spinning reserve providers (and some IL providers) already have compliant high resolution meters. As such, implementation costs would not be substantial for the 100 ms option, which has an estimated 10 year present value net benefit of approximately $14.2m based on current market settings and tools (potentially rising to $37.7m if the longer term reserve procurement developments set out in section 8 - Medium- and longer-term initiatives were implemented).

4.2.18 If alternative procurement options such as 'area under the curve' are implemented in the future, this is likely to provide further benefits for provision of even higher resolution data than 100 ms, as faster proven performance would be recognised with higher payments. As such, any reserve providers who would need to invest in faster resolution metering technology to meet the proposed new 100 ms requirement may wish to consider implementing faster than 100 ms solutions to future proof themselves from having to upgrade at some point in the future. It is understood from the main metering technology provider for large-scale sites (i.e. multi-MW sites) that the incremental costs from implementing a 20 ms solution rather than a 100 ms solution are minimal.

[23] 'Area-under-the-curve' procurement and payment approaches are intended to recognise the benefits of faster reserve provision through greater payments. Thus an IL provider which delivered in 0.4 seconds would receive a higher payment than one that delivered in 1 second. However, if a provider was not able to adequately demonstrate that their reserve was provided at these faster timeframes, they would not receive such higher payments.

[24] The estimated net benefit of a 20 ms requirement based on current market settings and tools is also positive, but due to the additional costs without any additional benefit under current market settings, the benefit would not be as great as with the 100 ms option.

4.2.19 It is worth noting that the National Electricity Market in Australia has an even higher meter resolution requirement of 50 ms – and has had for over a decade. [25] This appears to support the 100 ms requirement for New Zealand. Indeed, the New Zealand system actually has greater susceptibility to very fast rate-of-change-of-frequency events than the Australian system, suggesting that New Zealand would have greater need for high resolution metering than Australia.

4.2.20 In implementing this proposed approach to mandate higher resolution FIR meters, there are three further aspects to consider:

(a) providing frequency traces along with MW output

(b) whether the requirement should be extended to small-scale providers

(c) timing of the mandated change.

Frequency data is also required

4.2.21 In order to properly assess the reserve being delivered from the ancillary service provider, delivery reported by the reserve provider in its meter records must be consistent with the time recorded by the system operator for the event. For recording events at a 100ms resolution or less, this exact synchronisation of clocks is a challenge.

4.2.22 A universal GPS time stamp is one method of synchronising all of the clocks. However, it is not clear that this would be sufficient to appropriately measure reserve provider performance. This is because the frequency seen at different points of the grid can vary slightly from site to site, including the extent of noise on the frequency signal. If one site responds later to an event than another, it may be due to local frequency conditions rather than relatively poor performance.

4.2.23 Given that ancillary service units can only react to the frequency that they see at the given point of the grid, a more appropriate option than GPS time-stamping to assess the delivery of FIR is for the reserve provider to provide a record of the frequency they experienced in line with their metered MW output.

4.2.24 It is proposed that the procurement plan will be changed to reflect the need for local frequency to be recorded and provided on the same time-stamped metering basis as the megawatts provided. Recording the frequency will be used to confirm the amount of load dropped against the change in frequency. GPS time stamping was also considered – but was considered likely to be inadequate.

Requirements for small-scale FIR providers

4.2.25 The majority of the FIR currently provided is from sites that are relatively large-scale – large enough to justify direct connections to the transmission grid in most instances. As such, the

[25] AEMO, Market Ancillary Services Specification, 1 May 2012, Clause 2.5(a)(iii).. The requirement applies to all IL, without any MW limit.

cost of higher resolution metering systems is relatively small compared with the scale of IR revenue that can be earned from the provision of FIR. Based on the system operator's field surveys, it is known that some direct connect IL providers already have metering systems of at least 100 ms resolution.

4.2.26 However, several load aggregators are offering FIR IL aggregated from a large (and increasing) number of small to medium sized commercial and industrial sites connected to distribution networks. In aggregate, these providers are providing up to 30% of cleared FIR during some trading periods.

4.2.27 On-site metering at these distribution level connected sites is typically at one second resolution. The cost of providing high resolution site metering (at 100 ms or greater) would likely be prohibitive for many, and they may choose to exit the market, resulting in higher FIR costs. This could negate the gains from procuring fewer reserves as per this proposal.

4.2.28 The Authority considered whether an alternative method could be allowed for smaller providers. The Authority notes it is of key importance that the data provided by all FIR providers must be adequate to give the system operator confidence in performance – both quantity and speed – of reserve provision. In addition, if an alternate approach is proposed for these smaller providers, it must not impose undue costs on other providers.

4.2.29 The Authority asked the system operator to consider whether it would be technically feasible to impose a lesser requirement on providers from smaller sites, but still retain sufficient confidence that FIR will be delivered as contracted (in terms of both quantity and speed). The likely scenario where the reserve volumes provided from small providers increase over time was also considered as part of this assessment.[26]

4.2.30 The system operator has advised that for small sites, to be confident about provider response, the following minimum requirements would need to be met:

(a) provision of 1 second resolution data at the site (at the point of delivery)

(b) provision of 100 ms end-to-end test data from all sites.[27] This would need to be provided for all sites for which this data has not already been supplied, and tests for each site would need to be conducted at least every five years.

4.2.31 It was determined that it was more efficient to impose these lesser metering requirements on smaller sites as they provide considerable diversity benefit. Thus, if an FIR provider delivers its reserve 0.5 seconds later than expected, the impact is much less if the provider is only

[26] Currently, during some trading periods, FIR IL from load aggregators makes up close to 30% of dispatched FIR. It is expected that the amount of FIR IL from load aggregators is likely to continue to increase, as aggregators continue to seek further sources.

[27] 'End-to-end' testing would require testing of the performance of the *site*, rather than just the relay. This would require on-site testing through injecting a frequency signal into the relay while it is installed in the IL site. The system operator considers that this full site testing is appropriate, as it will also capture the impact of potential delays between the relay triggering and the breaker eventually opening (noting that there can be delays in breaker operation, and potential delays caused by site control systems).

500 kW in size than if it is 50 MW in size.[28] Accordingly, having FIR provided by a large number of small providers gives genuine security benefits through diversity compared with having FIR provided by a small number of large providers.

4.2.32 Determining an appropriate threshold point for de minimis arrangements is inherently hard for this issue. Two types of analysis were done to inform this issue:

(a) The first considered the scale of impact of late reserve delivery from different-sized sites on system frequency – i.e. how much lower system frequency would drop if a particular-sized site were to deliver its reserve 0.5 seconds later than expected. This analysis suggested that late delivery from small sites would have relatively small impact on system frequency – and certainly within the tolerances within which RMT would be operated after these revised arrangements were implemented.[29]

(b) The second consideration related to the potential cost impact of requiring high resolution meters on smaller sites, and the threshold point below which the cost would result in such sites exiting the market. Based on such analysis, using what metering cost data was available the conclusion was reached that sites of 2 MW and above could absorb the cost of installing higher resolution meters and not be forced to exit the market. [30]

4.2.33 Given that sites of 2 MW were considered able to absorb the cost of the meters, it was considered that choosing this more conservative value was appropriate.

4.2.34 This approach of allowing small providers to have 1 second resolution meters while larger providers are required to have 100 ms meters is considered consistent with the general ‘costs to causers’ principle that underpins the common quality arrangements within the Code. Thus, uncertainty over the performance of large reserve providers is imposing a cost in terms of requiring the system operator to operate the system more conservatively. It is thus appropriate for such large reserve providers to be required to have higher resolution meters to reduce such uncertainty. However, any uncertainty over the individual performance of small reserve providers does not result in such system costs due to the diversity benefits

---

[28] In this example, although the 50 MW provider is 100 times larger than the 500 kW provider, the scale of impact in terms of system frequency dropping more than expected is materially more than 100 times worse due to the complex interaction of different reserve providers performing over different timescales within the few seconds of the event.

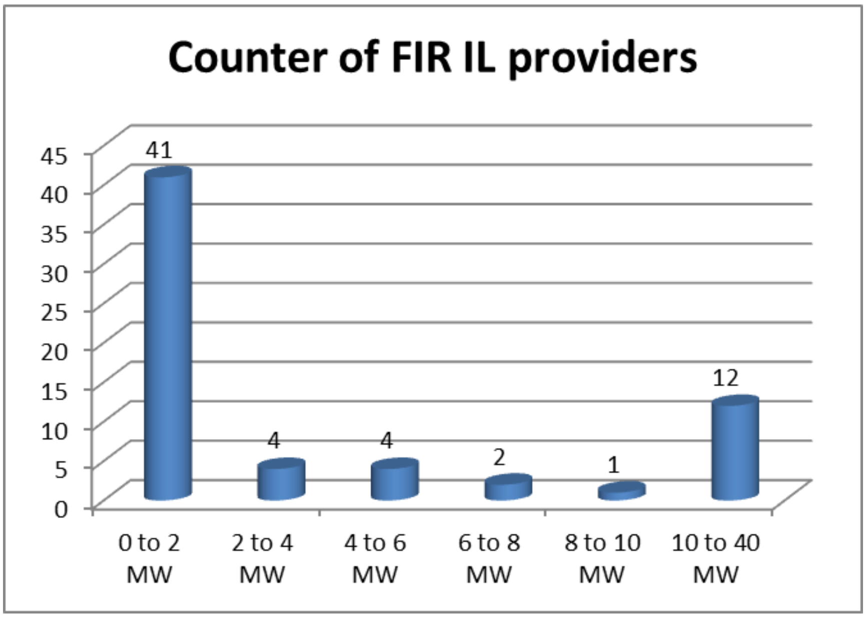
[29] It is understood that RMT will still need to be operated with some tolerances / conservatism to take account of continuing uncertainties over reserve provision – e.g. the so-called block dispatch of hydro schemes (rather than unit-specific dispatch of individual machines within each scheme) gives rise to material variation in the FIR performance of the scheme depending on which individual machines a generator decides to run to meet this block dispatch.

[30] A simple calculation can help estimate how small a load would need to be before it would be uneconomic to install high resolution metering. If a high resolution meter has an installed cost of $20k, and a customer’s investment criteria requires the cost to be recovered in 5 years, then the average annual FIR income would need to be $5,000 per annum (using an 8% discount rate). Assuming average FIR prices across the year of $4/MWh (based on historical averages), the size of load necessary to earn $5,000 in FIR revenue is 143 kW. However, if management time and effort is included in the cost calculation, the threshold size would be greater than this value.

which the small reserve providers collectively provide. It is therefore appropriate that they should not be required to have the same level of meter resolution.[31]

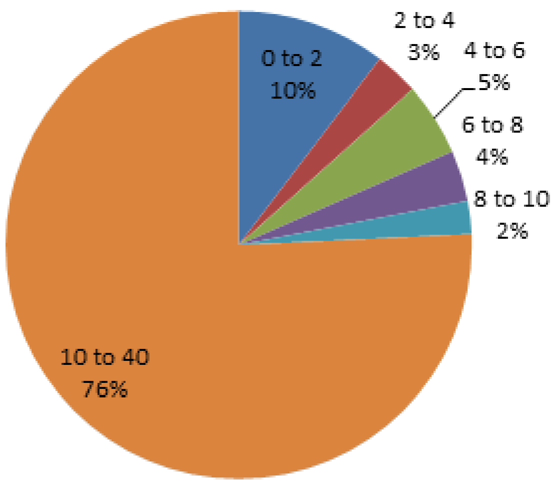
4.2.35 As shown on Figure 5, the majority of FIR sites fall into the zero to 2 MW (in FIR capacity) category, with relatively few providers offering between 2 and 10 MW. With regard to quantity, the proportion of reserve offered by providers in the zero-2 MW category is approximately 10%, with a further 14% offered by providers of 2-10 MW size, as shown in Figure 6. As such, 2 MW was also considered to be a reasonable cut-off point from a practical perspective.

Figure 5: Size of IL providers



[31] It should be noted that the system operator has some concerns with the practice of how some load aggregators are currently providing data. However, this is an operational issue which the system operator is addressing. Accordingly, it should not affect the conclusions with regards to the *principle* of allowing smaller providers to provide lower resolution data.

Figure 6: Proportion of FIR provided by providers of various sizes



4.2.36 The Authority proposes that the option for smaller providers to provide a combination of 1 second site meter data and 100 ms test data be included in the proposed procurement plan amendment.

4.2.37 However, it is mindful that the setting of the de-minimis threshold requires good understanding of the costs of higher resolution (i.e. 100 ms or better) metering. In this respect, it has been basing its analysis to-date on information from a small sub-set of meter providers.

4.2.38 Similarly, the Authority has not had access to comprehensive information about the implications (particularly the costs) of end-to-end five yearly testing for de-minimis IR providers. Informal advice it has received are that the costs of such testing should be fairly small.

4.2.39 Accordingly, the Authority is particularly keen that IR participants use this consultation to provide good quality cost data on different metering and testing requirements. Such cost data should enable appropriate decisions on de-minimis thresholds and testing requirements.

Q3. What comments do you have about the differing requirements for smaller scale FIR IL providers?

Q4. What are your views on the different costs of different resolution meters?

Q5. What are your views on the expected costs of the proposed 100 ms testing arrangements?

Requirements for hot water load

4.2.40 The above analysis relates to IL from small to medium commercial and industrial load. There is also some hot water load offered as FIR by distributors (sometimes via load aggregators).

4.2.41 Currently such sites are measured in aggregate via GXP-level metering, rather than via on-site meters. Such GXP-level metering is high resolution, and the system operator regards it as being sufficient to demonstrate performance.

4.2.42 Accordingly, it is proposed that this approach to metering hot-water load be retained, rather than require site-level meters, but that the formal requirement be at the 100 ms level (rather than the one second level proposed for other small FIR).

Q6. What comments do you have on keeping the current approach on hot water load metering?

5. Procurement plan changes

5.1 Process required

5.1.1 The procurement plan is a document incorporated by reference under the Electricity Industry Act 2010 (Act). The process for amending or replacing the procurement plan is governed by clauses 8.43 to 8.44B of the Code, and generally by Schedule 1 of the Act. Material incorporated by reference is amended or replaced by the Authority publishing a notice in the Gazette.

5.1.2 Although the Act does not require consultation to amend or replace the procurement plan (as it does for Code amendments) consultation is required under the Code. Furthermore, consultation is consistent with the principles set out in the Authority's Consultation Charter.

5.1.3 The Authority is consulting on a proposal to replace the procurement plan in its entirety with a new version that would incorporate the changes outlined in this paper.

5.1.4 When the system operator submits a draft procurement plan to the Authority, the system operator is also required to provide the following information:

(a) a explanation of the proposed change and a statement of the objectives of the proposed change

(b) an evaluation of alternative means of achieving the objectives of the proposed change

(c) an evaluation of the costs and benefits of the proposed change.

5.1.5 This section sets out the information provided by the system operator, which was developed jointly with the Authority.

5.2 Explanation of the proposed changes

5.2.1 The UFM work developed proposals to better optimise the fast instantaneous reserve quantity procured to mitigate under frequency events.

5.2.2 The system operator is obligated to maintain power system security taking into account many variables, a number of which are subject to uncertainty. Owing to this uncertainty, elements of conservatism have been introduced that result in a sizable difference between calculated and actual reserve requirements. The effect of this conservatism has been that post event frequency rarely falls below 49.2Hz (while the target minimum frequency is 48Hz)[32] after a large event occurs on the system.

5.2.3 Recent UFM work has identified how this difference between calculated and actual reserve requirements is made-up, and assessed what changes can be made to better optimise procurement calculations. The proposed changes are:

[32] Reserve Management Objective, in Schedule 8.4 of the Code.

- reduce RMT simulation time
- model actual IL trip times
- amend data resolution requirements (in the Procurement Plan and ASAs) to enable both of the above.

5.2.4 Implementing the proposed changes listed above will enable the system operator to procure less FIR while continuing to achieve the Reserve Management Objective.[33] It is not considered that these proposals would result in a net degradation of system security.

5.3 Objectives of the proposed changes

5.3.1 The objectives of the proposed changes that are contained in the draft procurement plan are to:

(a) improve efficiency and competition in the energy and reserves market by optimising the quantity of fast instantaneous reserves procured in each trading period. This would be achieved by removing some of the uncertainty around existing assumptions in RMT, and by improving the modelling of IL trip times and generator response

(b) improve reliability (and certainty about reliability) by:

(i) reducing the risk of over-frequency collapse associated with over-provision of under-frequency resources

(ii) improving the confidence associated with the performance of under-frequency reserves

(iii) facilitating provision of reserve by a greater number of smaller reserve providers, thereby delivering diversity reliability benefits.

(c) procure reserves of a quantity consistent with the standard set out in the Reserve Management Objective.

5.4 Evaluation of alternatives

5.4.1 Better modelling IL trip times:

Three alternatives to the status quo (6 second data from IL providers) were identified.

(a) use of test data – The system operator did not consider this alternative met its requirements for modelling, as it would not show actual trip times. In addition, data is obtained under artificial conditions and may not represent what would actually occur in real world conditions

[33] For a CE in any island, island frequency must not drop below 48Hz and must return to 49.25Hz within 60 seconds of the event. (Standards also exist for ECE for each NI and SI).

(b) mandate 100 ms data for all IL sources – This option would meet the needs of the system operator but would be onerous for some IL providers, and may result in those providers exiting the IL market, thus reducing the total supply of FIR, contrary to the objectives; or

(c) require all sites with IL site potential exceeding 2 MW to provide 100 ms data, and all sites smaller or equal to 2 MW to provide 1 second resolution data plus 100 ms end-to-end test data on a five yearly basis (proposed approach).

5.4.2 The system operator considers that the proposed approach achieves the objectives at minimum cost to participants.

5.4.3 Reducing RMT solve time:

In order to reduce RMT simulation time, the system operator must have finer resolution data than is currently provided. No other approach can reduce RMT simulation time or reduce reserve procurement quantities to this extent.

Thus, the key alternatives to consider are the potential data resolutions:

(a) data at 1 second resolution – this approach would not allow RMT solve time to be reduced to 10 seconds. Reducing the solve time to 30 seconds (consistent with 1 second data) would still have benefits in terms of reduced reserve procurement, but as discussed in the cost benefit assessment in Appendix E, this has not been quantified

(b) data at 20 ms resolution – this option would 'future proof' equipment, and has a relatively minimal incremental cost over the 100 ms option. However, 100 ms data is expected to be sufficient to meet all initiatives planned to be implemented within the next several years, and additional benefits over 100 ms are unclear at this stage. As some providers already have 100 ms equipment installed, the Authority did not consider that it would be reasonable to put a more onerous requirement in place at this time. However, providers that do need to invest to meet 100 ms may wish to go straight to 20 ms; or

(c) data at 100 ms resolution (proposed approach).

5.4.4 The system operator considers that the proposed approach achieves the objectives at minimum cost to participants.

5.5 CBA outcome

5.5.1 The system operator has provided an evaluation of the costs and benefits of the changes that are proposed in the draft procurement plan.

5.5.2 As set out in the detailed cost-benefit analysis in Appendix E, the 10 year present value net benefit of the proposed approach is $15.4 m based on current market settings. If new reserve procurement approaches such as area-under-the-curve are implemented in the longer term, this 10 year benefit could rise to $39m.

5.6 Next steps

5.6.1 Submissions (Appendix B) on the draft procurement plan (Appendix D) are invited by 5pm Friday 27 March 2013. Submissions on the procurement plan should address only the changes proposed. Submissions on other aspects of the procurement plan will not be considered as part of this consultation process.

5.6.2 In accordance with clause 8.44(4) of the Code, the Authority will provide a copy of each submission to the system operator and publish the submissions.

5.6.3 Copies of all submissions will be provided to the system operator at the close of business on the submission expiry date, which commences the 10 business day cross-submission period for the system operator. The system operator may make its own submissions of the draft procurement plan. The Authority will publish the system operator's cross-submission when it is received.

5.6.4 The Authority will consider all submissions it receives on the changes shown in the draft procurement plan. It will then decide whether to approve the final procurement plan. If the Authority approves the procurement plan it will incorporate the procurement plan by reference into the Code, in accordance with Schedule 1 of the Act.

5.6.5 Submissions on other aspects of this proposal are also invited by 5 pm Friday 27 March 2013 (Appendix C).

5.6.6 All submissions on the other aspects will be considered by the Authority, and the feedback received will be used to aid the Authority to develop its plan for the longer term UFM initiatives.

6. Implementation requirements

6.1 Timing

6.1.1 There are two aspects to consider with respect to the timing of when such a change in mandate should be enforced:

(a) how long participants may need to implement higher meter resolution capabilities

(b) the implications for existing contractual arrangements.

6.1.2 With regard to the first, the Authority is aware that too short an implementation timeframe could result in a number of providers temporarily exiting the market, potentially result in higher FIR costs. Based on considerations of when it is practicable to make such changes, the Authority considers that one year is sufficient time.

6.1.3 With regard to the second aspect, the Authority notes that some providers have existing contractual commitments (ancillary services agreements) with the system operator that are not due to expire for up to several years. Any change in mandate will need to be reflected in these agreements.

6.1.4 The system operator is also able to work with participants to amend existing contracts, provided participants are willing. This is possible as the system benefits (including increased security with respect to reducing the risk of over-frequency collapse) accrue to all parties. The expected lower reserve costs under this proposal may incentivise some providers to reopen agreements early, for example, those with the largest units, as these are the parties who pay the most for reserve charges.

6.1.5 Accordingly, it is considered appropriate that participants are required to make such changes within one year, or the expiry date of their existing contracts, whichever is later.

Q7. What comments do you have on the suggested transition periods?

6.2 Other actions

6.2.1 No Code amendments are needed for the system operator to change the simulation time in RMT or to model actual trip times for IL. However, changes would be required to the RMT functional specification, which is appended to the system operator service provider agreement (SOSPA). Therefore, any change to the specification requires a contract variation to be negotiated between the Authority and the system operator. It is thought, however, that the required changes to achieve the shorter simulation time are straightforward, and will require minimum resources and time to implement.

6.2.2 A change to clause B38 of the procurement plan would also be needed to require provision of post-event reserve meter data with a resolution of 100 ms, (rather than the current 6 seconds). Changes to the Ancillary Service Agreements (ASAs) between the system operator and FIR providers will also be required.

6.2.3 A draft procurement plan showing the changes that are proposed to be made is shown in Appendix D. The information to support the change to the procurement plan, which is required by the Code, is shown in Section 5 and Appendix E.

7. Assessment under section 32(1)

7.1.1 Section 32(1) of the Act provides that Code provisions must be consistent with the Authority's objective and be necessary or desirable to promote any or all of the following:

(a) competition in the electricity industry

(b) the reliable supply of electricity to consumers

(c) the efficient operation of the electricity industry

(d) the performance by the Authority of its functions

(e) any other matters specifically referred to in this Act as a matter for inclusion in the Code.

7.1.2 Appendix A contains a table setting out an assessment of the proposed amendment against the requirements of section 32(1) of the Act.

Q8. Do you have any comments on the changes that are shown in the draft procurement plan in Appendix D?

7.2 Assessment against the Code amendment principles

7.2.1 The Authority has assessed the draft Procurement Plan against the following Code amendment principles:

7.2.2 ***Principle 1 – Lawfulness:*** The Authority and its advisory groups will only consider amendments to the Code that are lawful and that are consistent with the Act (and therefore consistent with the Authority's statutory objective and its obligations under the Act).

7.2.3 The Authority considers the proposed amendment to be lawful.

7.2.4 ***Principle 2 – Clearly Identified Efficiency Gain or Market or Regulatory Failure:*** Within the legal framework specified in Principle 1, the Authority and its advisory groups will only consider using the Code to regulate market activity when:

(a) it can be demonstrated that amendments to the Code will improve the efficiency of the electricity industry for the long-term benefit of consumers[34]

(b) market failure is clearly identified, such as may arise from market power, externalities, asymmetric information and prohibitive transaction costs; or

(c) a problem is created by the existing Code, which either requires an amendment to the Code, or an amendment to the way in which the Code is applied.

[34] Where efficiency refers to allocative, productive and dynamic efficiency, and improvements to efficiency include, for example, a reduction in transaction costs or a reduction in the scope for disputes between industry participants.

7.2.5 The proposed amendments deliver improvements to the efficiency of the electricity industry for the long-term benefit of consumers by enabling the system operator to procure an amount of reserves that more accurately reflect the reserve requirement for each trading period without putting the system security at risk.

7.2.6 The reserve provider performance will also became clear through the data initiative – leading to more transparent and more efficient market operation.

7.2.7 ***Principle 3 – Quantitative Assessment:*** When considering possible amendments to the Code, the Authority and its advisory groups will ensure disclosure of key assumptions and sensitivities, and use quantitative cost-benefit analysis to assess long-term net benefits for consumers, although the Authority recognises that quantitative analysis will not always be possible. This approach means that competition and reliability are assessed solely in regard to their economic efficiency effects. Particular care will be taken to include dynamic efficiency effects in the assessment, and the assessment will include sensitivity analysis when there is uncertainty about key parameters.

7.2.8 A quantitative assessment of costs and benefits has been undertaken for the proposed amendments.

7.2.9 As set out in the detailed cost-benefit analysis in Appendix E, the 10 year present value net benefit of the proposed approach is $15.4 m based on current market settings. If new reserve procurement approaches such as area-under-the-curve are implemented in the longer term, this 10 year benefit could rise to $39m.

Q9. Do you have any comments on the Authority's evaluation of the proposed changes? If not, what alternative would you propose and why?

8. Medium- and longer-term initiatives

The Authority's role includes ensuring that reserve arrangements are evolved to remain applicable and efficient as the generation mix and other factors change over time. Therefore, in addition to the immediate initiatives that are the subject of this consultation paper, the system operator and the Authority have discussed the need for work to commence looking at several medium-term and a number of longer-term developments in UFM arrangements.

Medium-term initiatives

8.1 Wind as IR

8.1.1 If wind was offered as IR this is likely to require some relatively sizable changes to system operator tools in addition to Code amendments, so further analysis is required regarding the likely costs and benefits of any such proposal.

8.2 IR compliance

8.2.1 Improving IR compliance involves altering requirements on providers of FIR IL so that providers are subject to obligations relating to *maximum* as well as minimum quantities delivered.[35] This change is needed to avoid potential over-frequency issues resulting from too much reserve response to an under frequency event.

8.2.2 The Authority has commenced work on these two initiatives.

Q10. What comments do you have on the medium-term proposal to enable wind generators to provide FIR, if they have the capability to do so?

Q11. For those with wind generating capacity, would you envisage entering the FIR market, and if so, under what circumstances?

Q12. What comments do you have on the initiative to increase the compliance of IL providers with dispatch quantity?

The longer-term initiatives under consideration are set out below. The Authority is developing a detailed work plan (in consultation with the system operator) for investigating and developing the initiatives and intends to publish this by March 2013. This is necessary because where an initiative will require new functionality to be included in RMT, the policy

[35] At the moment, providers face penalties only if they provide less than their offered quantities. This asymmetric compliance requirement, coupled with significant inherent variability in load, results in significant 'conservatism' in terms of the amount of load offered by many IL providers. As a result, when an under-frequency event occurs, it is generally the case that significantly more IL is actually tripped than was offered. This will exacerbate any over-frequency risks facing the system.

development will need to be well underway prior to model development. The new RMT is scheduled to replace the current model by 2014/15.

Longer-term initiatives

8.3 National reserves market

8.3.1 The concept of a national reserves market has long been considered for New Zealand, and a number of studies have been undertaken in the past decade to determine whether this could be implemented with the existing HVDC link.[36]

8.3.2 However, the inability of the Pole 1 and 2 HVDC link to quickly change its transfer direction has been a physical limitation to establishing a national market.

8.3.3 The upcoming commissioning of HVDC Pole 3 and associated control system upgrades will provide the capability to the HVDC to operate in a fashion that could enable a national reserves market. However, the functionality to introduce a national reserves market is not available in the current RMT. The Authority considers that a national reserves market has the potential to deliver significant market efficiencies, and has started the work to progress this initiative. The initiative is in the Authority's Wholesale Advisory Group (WAG) work plan.

8.4 Alternative reserve products

8.4.1 This initiative would consider whether the existing 6 second and 60 second (FIR and SIR) reserve products remain optimal given the changes to generation and demand on the New Zealand system, or whether there might be alternatives that are more cost-effective and deliver better security. Options considered include additional "very fast reserve"[37] product, and an "area under the curve" procurement approach.

8.4.2 "Area-under-the-curve" is a shorthand way of describing a reserve procurement methodology which procures and pays for reserve based on each reserve provider's actual contribution to restoring the system frequency. In other words, taking account of how fast MW were provided during the event, rather than simply procuring and paying based on the amount of MW provided at a notional point in time during the event (e.g. at six seconds as is currently the case). The true measure of a provider's contribution to frequency restoration is the integral of their MW contribution during the course of the event (i.e. measured over time). If this is expressed graphically, this integral measure is the same as the area under the curve.

---

36 More detail on the preliminary investigations conducted by the system operator is available at: http://www.systemoperator.co.nz/f4579,62752112/UFM_AOPO_Frequency_Envelope_Review.pdf

37 More detail on very fast reserve can be found at: http://www.systemoperator.co.nz/f4579,57165202/Under_Frequency_Management-_reserve_review_phase_1.pdf

8.4.3 The advantage of this methodology is that it recognises that MW that are delivered very quickly during an event are more valuable at arresting frequency drop than those which are delivered more slowly. This will enable a more cost-effective reserve procurement approach – e.g. IL which has a higher $/MW/h availability cost but which is delivered in 0.4 seconds may actually be a cheaper overall resource than IL which has a lower $/MW/h availability cost but which is delivered in 1 second. This methodology also enables recognition for spinning reserve providers who provide a significant inertia-driven boost in output in the first few seconds of an event but which then rapidly tails away.

8.4.4 Work undertaken to date by the system operator on possible options is set out in its report on work stream one.[38] Analysis indicates that such changes to reserve products could deliver material benefits. However, such changes cannot be implemented with the existing RMT tool.

8.4.5 Given the scale of potential benefits, the Authority intends to progress the development of this initiative as set out later in this section.

8.5 Altered SIR meter resolution requirements

8.5.1 The System Operator has indicated that if the alternative reserve product initiatives outlined above could successfully reduce over-provision of SIR, they may also need to be accompanied by improved meter resolution requirements for SIR providers.

8.5.2 This has been suggested as being required because the current 10 second meter resolution requirement gives too great a degree of uncertainty as to SIR delivery times within the 60 second period. This uncertainty is currently more than compensated for by significant over-provision of SIR. However, as this over-provision is reduced, it will become more critical that actual SIR delivery matches that modelled in RMT (or its replacement). Accordingly, it may be necessary to require SIR metering to have higher resolution (e.g. 1 second resolution).

8.5.3 This is analogous to the current initiative outlined in the main body of this paper whereby reducing FIR over-procurement needs to be accompanied by improved FIR meter resolution.

8.5.4 The Authority appreciates that it would ideally have been better for changes FIR and SIR meter resolution to have been progressed together such that participants could make decisions on all their metering requirements in one go.

8.5.5 That said, the Authority is considering progressing consideration of improving SIR metering requirements as a matter of urgency. The intention of this 'fast-tracking' of SIR metering considerations is in order that participants would be able to make informed decisions on all their reserve metering requirements, rather than having first to decide on FIR metering, and then wait one to two years before being able to make fully-informed decisions on SIR metering.

[38] Work stream one can be found at: http://www.systemoperator.co.nz/ufm

Q13.	**Do you think that the Authority and System Operator should fast-track consideration of SIR metering requirements, or wait until the initiatives considering alternative reserve products have been completed?**

8.6 Over-frequency management

8.6.1 Historically, frequency management has focused primarily on under frequency management. The system operator currently procures over frequency arming on an availability basis and dispatches it according to certain power system conditions such as when HVDC north transfer is expected to exceed 600 MW and is approximately 50% of South Island generation. This arrangement is not modelled within RMT.

8.6.2 Recent studies by the system operator conclude that the existing arrangements for managing over frequency events are effective.[39] However, with the commissioning of HVDC Pole 3 in 2013 and the system topology changing, the system operator considers that over-frequency risks are likely to become more material.

8.6.3 Accordingly, both the system operator and the Authority consider it appropriate to review whether current arrangements for managing over-frequency risk will be adequate for the future, or whether new arrangements need to be developed. New arrangements could include:

(a) changing the modelling approach for the procurement of under-frequency reserves to specifically consider over-frequency risk. (At the moment, over-frequency thresholds are not considered within RMT)[40]

(b) introducing new market arrangements for the procurement of over-frequency reserves

(c) altering the requirements for the procurement of interruptible load, such that providers are subject to obligations relating to *maximum* as well as minimum quantities delivered.[41]

8.6.4 Items (a) and (b) above would require new reserves procurement functionality not currently available within RMT. As such they would be progressed via the longer term initiatives as set out later in Section 8 - Medium- and longer-term initiatives.

8.6.5 Item (c) would not require software changes. Accordingly, the Authority, aided by the system operator, is progressing this initiative (as discussed earlier in this section), with a view to considering Code amendments early in 2014.

---

[39] More details at: http://www.systemoperator.co.nz/f4579,62752112/UFM_AOPO_Frequency_Envelope_Review.pdf

[40] More details at: http://www.systemoperator.co.nz/f4579,62752154/UFM-WS3-Appendix_2_OFA.pdf

[41] At the moment, providers face penalties only if they provide less than their offered quantities. This asymmetric compliance requirement, coupled with significant inherent variability in load, results in significant 'conservatism' in terms of the amount of load offered by many IL providers. As a result, when an under-frequency event occurs, it is generally the case that significantly more IL is actually tripped than was offered. This will exacerbate any over-frequency risks facing the system.

8.7 Inertia market

8.7.1 Grid inertia is the inherent ability of the power system to oppose changes in frequency. If system inertia is high, frequency will fall more slowly following a CE than if inertia were low. Therefore, higher inertia is preferable during under-frequency events as it allows more time for governor response to arrest the frequency decline.

8.7.2 Grid inertia has decreased in recent years with the connection of more wind farms and open cycle gas turbines to the grid. These types of generators provide little or no inertia and therefore the falling inertia trend will continue with further investment in generation of this kind. With progressively lower inertia, the New Zealand power system is becoming more sensitive to disturbances.

8.7.3 However, there is no procurement of inertia by the system operator, as historically this has not been necessary, and nor is there a requirement in the Code.

8.7.4 The system operator considers that the decreased grid inertia has the potential, in the long run to materially adversely affect the cost of maintaining system security, and the reliability of the New Zealand system, if no counter measures are taken.

8.7.5 Options to address this include setting an AOPO requiring low or no inertia generators to provide an artificial response to falling frequency (in place of inertia), or establishing a market for procuring inertia. Some of these options could require significant changes to the current procurement approach for reserves, with associated changes required to reserve management software.

8.7.6 The Authority considers it appropriate to progress work on this issue via the longer-term initiatives set out below.

8.8 SIR procurement

8.8.1 Together with the other longer-term reserve arrangements, the procurement of SIR will also need to be looked at. More efficient procurement of SIR in conjunction with area-under-the-curve type of procurement of reserves is likely to realise further market benefits, but will require the replacement of RMT.

Q14. What are your views on the longer-term UFM initiatives?

8.9 UFM project plan and prioritisation

8.9.1 The above initiatives have the potential to deliver material cost savings or address issues which could have an adverse impact on the system reliability, or both. However, none of the issues are trivial, with many having implications for other parts of the market, or requiring substantial changes to the approach and associated software for reserves procurement, or both.

8.9.2 Given that most of the initiatives require changes to market design, the Authority will be responsible for progressing these longer term initiatives. Development will be carried out in collaboration with the system operator, including by the system operator providing technical analyses where necessary. The Authority will prioritise these initiatives for incorporation into its future work programme.

Appendix A Assessment under section 32(1) of the Act

Section 32(1) requirements:	Response
The proposed change to the procurement plan is consistent with the Authority's objective under section 15 of the Act, which is as follows:	
(a) to promote competition in, reliable supply by, and the efficient operation of, the electricity industry for the long-term benefit of consumers	The proposal delivers improvements to the reliable supply of electricity to consumers and efficient operation of the electricity industry by increasing the level of transparency in the operation of the reserves market through the data initiative, and more efficient procurement of reserves.
The proposed change to the procurement plan is necessary or desirable to promote any or all of the following:	
(b) competition in the electricity industry;	No impact.
(c) the reliable supply of electricity to consumers;	Increases the supply reliability by decreasing the risk of an over frequency event in the event of AUFLS being called upon.
(d) the efficient operation of the electricity industry;	Refer to (a) above.
(e) the performance by the Authority of its functions;	No impact.
(f) any other matter specifically referred to in this Act as a matter for inclusion in the Code.	Not applicable.

Appendix B Format for submissions on the draft procurement plan

Question No.	Question	Response
Q1	Do you have any comments on the draft procurement plan changes?	
Q2	Do you have any other comments in relation to this part of the proposal?	

Appendix C Format for Submissions on the Proposed Operational Changes

Question No.	Question	Response
Q1	What comments do you have on the proposal to shorten RMT simulation times using higher resolution post-event data from IR providers?	
Q2	What comments do you have on the proposal to model actual IL trip times, facilitated by higher resolution post-event data from providers?	
Q3	What comments do you have regarding the differing requirements for smaller scale FIR IL providers?	
Q4	What are your views on the different costs of different resolution meters?	
Q5	What are your views on the expected costs of the proposed 100 ms testing arrangements?	
Q6	What comments do you have on retaining the current approach on hot water load metering?	
Q7	What comments do you have on the suggested transition periods?	

Q8	Do you have any comments on the changes that are shown in the draft procurement plan in Appendix D?	
Q9	Do you have any comments on the Authority's evaluation of the proposed changes? If not, what alternative would you propose and why?	
Q10	What comments do you have on the medium-term proposal to enable wind generators to provide FIR, if they have the capability to do so?	
Q11	For those with wind generating capacity, would you envisage entering the FIR market, and if so, under what circumstances?	
Q12	What comments do you have on the initiative to increase the compliance of IL providers with dispatch quantity?	
Q13	Do you think that the Authority and System Operator should fast-track consideration of SIR metering requirements, or wait until the initiatives considering alternative reserve products have been completed?	
Q14	What are your views on the longer-term UFM initiatives?	

Q15	What comments do you have on the CBA, the assumptions made, the methodology used or any comments on any parts of the CBA that could be potentially improved upon?	
Q16	Do you have have any views on the relative priorities, and any information that might assist us to undertake an initial assessment of costs and benefits (to assist us with our prioritisation of these projects in the work plan).	
Q17	Do you have any other comments in relation to this part of the proposal?	

Appendix D Draft Procurement Plan

Appendix E The System Operator's Cost-Benefit Analysis (CBA)

Introduction

E.1.1 The proposal that is considered in this CBA is a change to the meter specifications for FIR providers in the procurement plan (incorporated into the Code by reference) to require higher resolution post-event meter data than the current 6 second resolution requirement.

E.1.2 This is to facilitate the system operator operating RMT without the same degree of conservatism as is currently the case, specifically through reducing the simulation time from 60 seconds to 10 seconds, and through better modelling interruptible load.

E.1.3 Three different levels of possible meter resolution are considered: 1 second, 100 ms and 20 ms.

E.1.4 The different benefit and cost 'buckets' considered in this evaluation are:

(a) the benefit of reduced FIR procurement

(b) the cost of increased tripping of AUFLS and IL

(c) the potential net benefit (or cost) of altered system resilience to events which could cause system collapse

(d) the cost to participants of installing higher resolution metering.

Estimating the value of reduced FIR procurement

E.1.5 This section of the analysis considers the likely value of reduced FIR procurement arising from reducing RMT simulation time.

E.1.6 Section 3.1.1 of the system operator's May 2012 report indicated that reducing RMT simulation time from 60 seconds to 10 seconds would, on average, reduce the amount of FIR that would be required to be procured by approximately 40-60 MW per period.

E.1.7 However, further information provided by the system operator indicates that the magnitude of such a saving would likely vary materially across different periods. This is illustrated in the following table provided by the system operator, which shows the difference in FIR requirements across the different cases studied by the system operator.[42] (For each case, the binding risk which determines the overall FIR procurement requirement has been shaded yellow).

---

[42] Although 30 different cases were studied by the system operator (as set out in Appendix 6 of the August 2011 report), the impact of a change in simulation time from 60 seconds to 10 seconds in terms of altered FIR requirements was identical across many of the scenarios. In effect, the two key parameters which altered the

Table 1: System operator estimates of the change in amount of NI FIR required under 60s and 10s RMT simulation times

Case parameters		FIR requirements (MW)								Overall FIR procurement savings (60s-10s) (MW)
		60 second simulation				10 second simulation				
System Load (MW)	AC CE risk (MW)	DC CE	AC CE	DC/AC ECE	Overall	DC CE	AC CE	DC/AC ECE	Overall	
High = 4,600	HLY5 = 390	67	273	0	273	0	223	0	223	50
	HLY1 = 240	74	115	0	115	0	0	0	0	115
Med = 3,600	HLY5 = 390	40	254	1	254	1	221	-2	221	33
	HLY1 = 240	47	90	118	118	2	4	2	4	114
Low = 2,000	HLY5 = 390	52	259	567	567	3	254	376	376	191
	HLY1 = 240	58	-6	592	592	4	-6	414	414	178

E.1.8 As can be seen, the change in the amount of FIR required to be procured varies significantly across the different cases, raising the question of the likely value of such reductions at such different times.

E.1.9 Examination of historic half-hourly FIR prices reveals that they are extremely volatile, and driven by a number of complex inter-linked factors including hydrology, demand, generator outages, and the extent to which the system is in a general situation of over- or under-capacity.

E.1.10 Accordingly, trying to simulate the impact of the proposed change on FIR prices is likely to be fraught with uncertainties.

E.1.11 Instead, a long-term framework was used to value the benefit of this proposed change. This approach considers that prices must, in the long-run, recover the costs of the marginal source of reserves. If there is no such cost recovery, reserves will not be brought to the market (either through not being built, or being retired).

E.1.12 In the long term it is considered that the cost of IR comprises:

(e) the ***fixed carrying costs*** of holding capacity available to provide IR over and above the amount of capacity required to be carried on the system to meet energy requirements

(f) any ***short-run costs of reserve operation***.

E.1.13 Accordingly, the economic benefit of these reduced FIR requirements for these different times was estimated based on each of these considerations.

Fixed carrying costs of IR

E.1.14 Because many generating plants can provide either energy or reserves, the key consideration for fixed carrying costs is the extent to which altered IR

FIR requirement between the two simulation times were the load scenario (High, Medium, or Low) and the AC CE risk scenario (390 MW or 240 MW).

arrangements alter the *overall requirement* for capacity to be held on the system to meet both energy and reserve requirements.

E.1.15 Increasingly New Zealand is becoming capacity constrained, such that its capacity requirements are driven by a relatively few periods of capacity scarcity due to extremely high demand and/or significant plant outages.

E.1.16 Therefore, the extent to which altered FIR arrangements alter the overall requirement for capacity to be held on the system will predominantly be driven by how such arrangements alter the requirement for FIR at such periods of extremely high demand and/or significant plant outages.

E.1.17 Thus, considering the different 'state of the world' cases illustrated in Table 1, it is only those cases associated with high demand that are likely to drive the extent of this particular type of benefit.

E.1.18 As can be seen, there are two estimates of the impact of reduced FIR requirements at times of high demand: a 50 MW reduction and a 115 MW reduction. It is considered that the 50 MW case is the appropriate one to base the valuation upon as this is the case which corresponds to the highest AC CE risk (i.e. the loss of the HLY5 unit while operating at full output)[43] given that at times of peak demand the HLY5 unit would be likely to be operating at full output.

E.1.19 Assuming that the altered FIR procurement requirements enable the system to carry 50 MW less of total installed capacity (noting that this assumption may be questionable, and is examined further below), the question then becomes how the reduction in installed capacity should be valued.

E.1.20 In this respect it is considered that a reduction in system capacity requirements should be valued at the carrying cost of an open cycle gas turbine generator (OCGT), as this is the most likely marginal source of capacity to provide infrequently-used generation at times of peak demand. This is true even if an OCGT doesn't provide reserve duty itself, because its operation in the energy market will free-up other sources of generation to provide reserves.

E.1.21 It is also considered that IL should not be regarded as the marginal source of capacity because at such times of capacity shortage, load that potentially could be used to provide IL often has a higher value use: namely pre-emptively reducing load to avoid peak network and generation costs.

E.1.22 The carrying cost of an OCGT is currently estimated to be $145/kW/yr.[44] When multiplied by 50 MW, this gives a saving of approximately $7.25m per year.

---

[43] HLY5 is Genesis' e3p CCGT which is located on the Huntly site, along with the original Huntly station (comprised of 4 units – HLY1 to HLY4), and the 'P40' OCGT (HLY6).

[44] This value was most recently calculated by the Authority in 2011 as part of its design of scarcity pricing arrangements. Although this value is subject to change based on movements in, amongst other things, the international price of turbines and changes in the NZ$ exchange rate, it is considered that neither have moved sufficiently or systematically in such a fashion as to warrant re-estimation of this cost.

Short run costs of reserve operation

E.1.23 In addition to the recovery of fixed costs as estimated in the previous section, reserve providers will need to recover any costs associated with operating in a mode which allows reserve provision.

E.1.24 For IL reserve providers, this cost is considered to be zero. However, spinning reserve providers incur costs in terms of:

(g) reduced machine efficiency (only for some generators) in terms of operating partially loaded;[45] and

(h) drawing power to operate a hydro machine in tail-water depressed mode.

E.1.25 Estimating the average short-run marginal cost of reserve provision over time requires consideration of the likely extent to which each will be the marginal source of reserves at these different times, and their cost of fuel / water for the spinning reserve providers for these different times.

E.1.26 This is considered to be inherently subject to such a significant degree of uncertainty such that attempting to forecast the likely extent of different IR providers and their costs for the range of possible different futures would be futile.

E.1.27 Instead, as illustrated in Figure 8, observation of historic reserve prices suggest that, other than those relatively few periods of extreme reserve scarcity where prices are predominantly driven by the need to recover the fixed costs of capacity, average reserve prices are of the order of $1.0/MWh.

E.1.28 Accordingly, this is considered a reasonable estimate of the average short-run costs of the marginal source of reserve.

E.1.29 The analysis in Table 1 appears to suggest that the average reduction in FIR requirements over all periods is approximately 115 MW (being the arithmetic average of the column on the right).

E.1.30 However, it is considered that the cases shown are not representative of the full range of system states, in that the cases generally don't consider situations of medium or low load in combination with lower AC or DC MW risks.

E.1.31 Accordingly, to be conservative, for the purposes of this cost-benefit analysis the average reduction in FIR requirement across all periods has been dropped to 50MW.

E.1.32 When multiplied by $1/MWh, this gives an annual benefit of 50 MW * $1/MWh * 8,760 hours = $0.44m per annum.

[45] This is an issue for some thermal plant operating at part load in a fashion which could respond to an event within FIR timeframes, but not really an issue for hydro plant – most of which achieve highest efficiencies when operating at around 80% of full load.

Consideration of SIR impacts

E.1.33 The above analysis considers that the reduction in FIR requirements will directly translate into a reduction in overall reserve costs.

E.1.34 However, New Zealand's IR requirements are split into two categories: *Fast* Instantaneous Reserves (FIR) and *Sustained* Instantaneous Reserves (SIR).

E.1.35 Generally most types of reserve are able to provide both FIR and SIR. Accordingly, the marginal source of reserves will need to earn sufficient revenue across *both* the FIR and SIR markets.

E.1.36 Building on the conceptual framework set out in the previous sections, the estimated reduction in reserves costs will only eventuate if the reduction in FIR results in the *overall* requirement for reserves to be reduced.

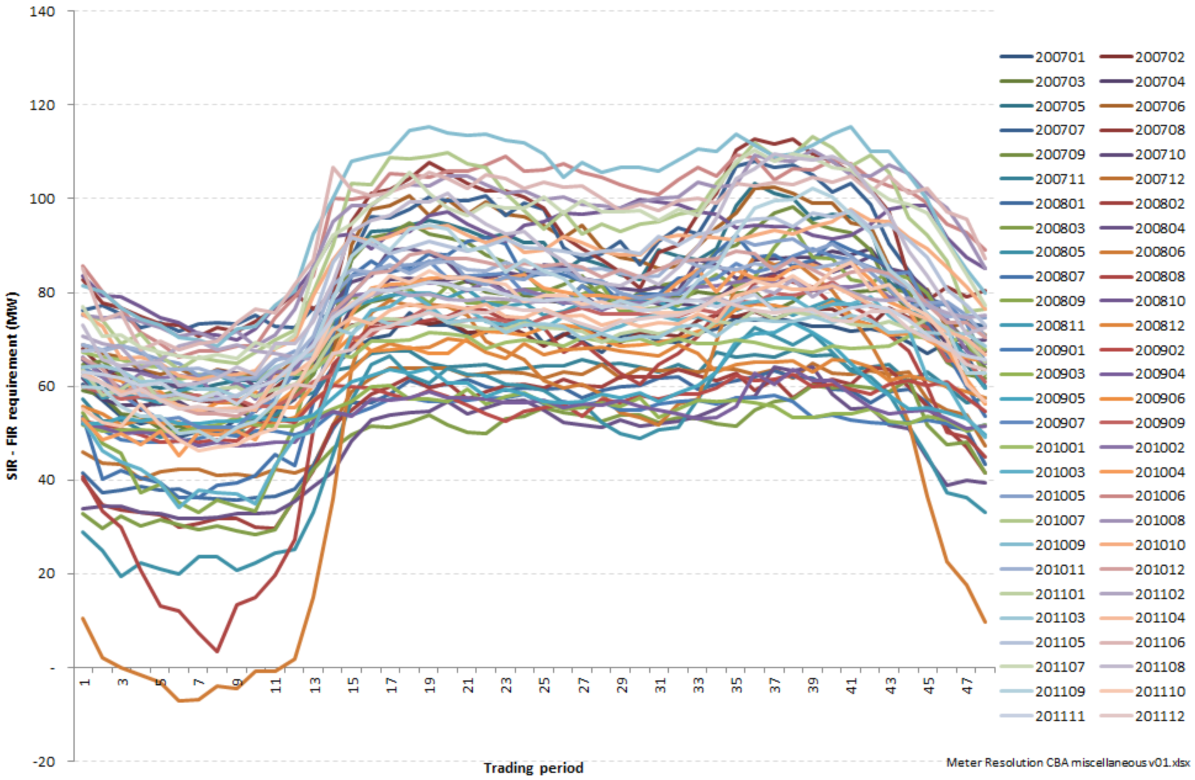
E.1.37 Put another way, the capacity the system needs to carry to meet times of peak demand is based on the peak energy requirement plus the extra capacity required to provide all reserves i.e. FIR *and/or SIR*.

E.1.38 For example, if the SIR requirement driving the system's capacity needs at times of peak were 400 MW, but the FIR requirement at such times were only 300 MW, then reducing the FIR requirement to 250 MW *may* have little or no impact on the overall amount of capacity needed to be carried on the system, as this is driven by the SIR requirement.

E.1.39 Generally, under current arrangements, it appears that at times of peak the SIR requirement is greater than the FIR requirement. For example, looking at the top row in Table 1 above, the FIR requirement is estimated to be 273 MW using the 60 second RMT methodology and 223 MW using the 10 second methodology. However, in both situations, because SIR is currently procured on a "1 for 1" basis the amount of SIR required would be 390 MW – being the size of the largest CE risk.

E.1.40 Similarly, in most other periods, the SIR requirement is greater than the FIR requirement. This is illustrated in Figure 7 below which shows the average extent to which the SIR requirement has exceeded the FIR requirement across the day for historic months.

Figure 7: Difference between North Island SIR and FIR requirements



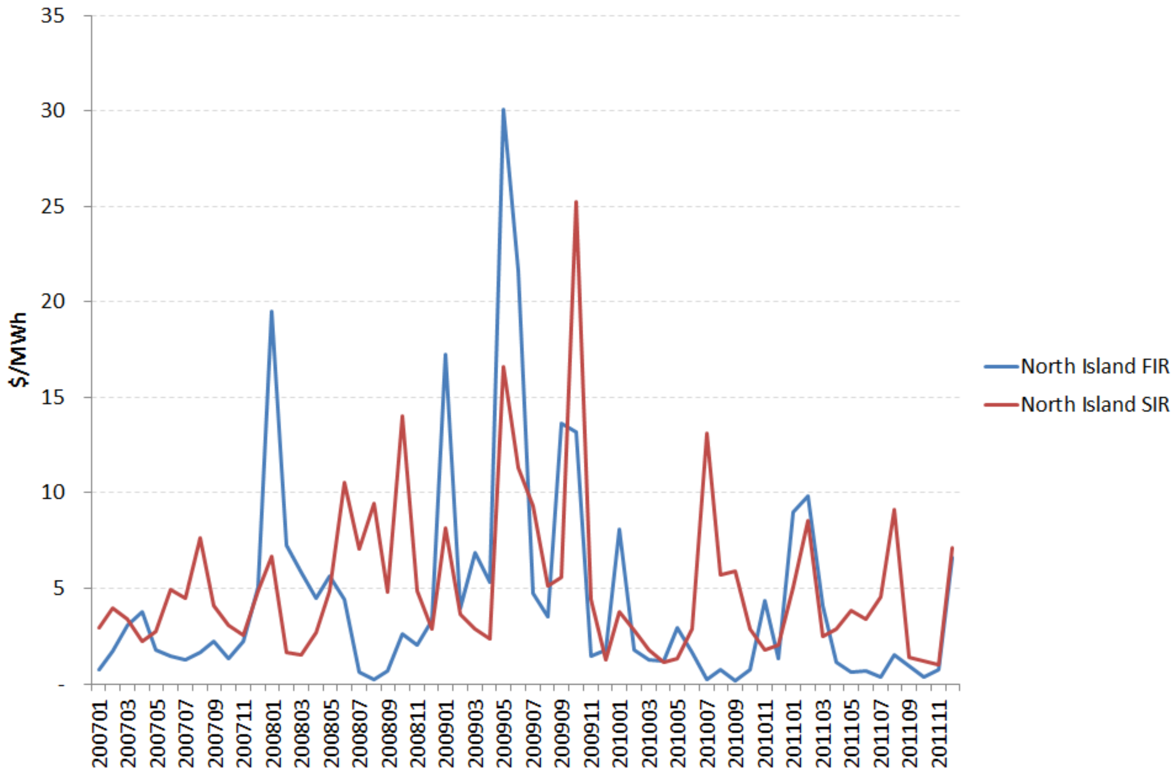
E.1.41 As can be seen, under current arrangements, the amount of SIR required is almost always materially greater than the amount of FIR required. Further, the extent of this difference appears to be greatest at times of high demand – i.e. those periods which are considered to have the greatest cost impact on reserve requirements through giving rise to increasing the amount of capacity required to be carried on the system.

E.1.42 At first glance, therefore, it could be considered that the proposed reductions in the quantity of FIR to be procured will have minimal impact on overall reserve costs due to the fact that SIR requirements will drive the system capacity requirement.

E.1.43 However, while most types of reserve can provide FIR and SIR, there are some types of reserve whose performance is not fast enough to provide FIR, and thus can only provide SIR.

E.1.44 In general, therefore, there is more SIR available than FIR. This explains why, as illustrated by Figure 8 below, FIR prices have been just as material as SIR prices, given that at times the capacity available to provide FIR has been a scarcer resource relative to the capacity available to provide SIR.

Figure 8: Monthly average IR prices



E.1.45 Analysis of past reserve offers indicates that the scale of this extra SIR available outweighs the extent to which there is this greater requirement for SIR relative to FIR. Over all trading periods from 2007 to 2011, the scale of this SIR 'surplus' relative to FIR is approximately 21 MW.[46]

E.1.46 However, when considering only those periods of high demand, it appears that SIR is slightly more scarce than FIR, although not to the extent indicated by Figure 8 above. Thus, using the above methodology to estimate the scarcity of the different types of reserve, the average extent to which SIR is more scarce than FIR during trading period 38 in the months June to August (considered a reasonable proxy for peak demand periods) is 5 MW.

E.1.47 Accordingly, it is considered that a reduction in the amount of FIR required may result in some reduction in overall reserve requirements, but that this is likely to be limited by the fact that as the requirement for FIR reduces, SIR will increasingly become the binding factor on overall reserve requirements.

E.1.48 Based on the analysis set out above, it is possible that this binding SIR requirement could be dominant, particularly at times of peak demand (i.e. those periods which drive overall system capacity requirements).

---

[46] For each trading period the extent of any SIR 'surplus' is calculated as (SIR_offered – SIR_cleared) – (FIR_offered – FIR_cleared), where the cleared amount is considered to be equivalent to the required amount of SIR or FIR.

E.1.49 Accordingly, it is considered that the 50 MW reduction in the overall amount of capacity the system needs to carry (as set out in paragraph E.1.18) should be factored down to being a 5 MW reduction.

E.1.50 The reduction in average reserve requirements over all time periods is not considered likely to be capped by this ‘binding SIR’ phenomenon by as much. Accordingly, the average reduction in IR requirements has been factored down to being 30 MW rather than 50 MW.

E.1.51 Overall, this results in the economic benefit of the reduction in FIR requirements to being as follows:

5 MW * $145/kW/yr + 30 MW * $1/MWh * 8,760 hrs = $1m per year

E.1.52 As can be seen, this is considerably lower than the value calculated earlier, and is principally due to the fact that SIR requirements will not be reduced.

E.1.53 However, it should be noted that the UFM project has identified that addressing the current method of procuring SIR (which has also been identified as likely resulting in over-provision) is an important priority for future development.

E.1.54 Further, it is likely that the ‘area-under-the-curve’ approach which has been identified as one of the main means of achieving such gains would require higher resolution metering.

Estimating the cost of increased occurrences of AUFLS and IL load shedding

Increased AUFLS occurrences

E.1.55 It is likely that if the ‘buffer’ from excessive procurement of IR is reduced, then AUFLS will be more likely to trigger during extreme under-frequency events – i.e. the infrequent ECEs for which AUFLS are intended to cover.

E.1.56 The cost of such load shedding during AUFLS events needs to be taken into account for any cost-benefit evaluation.

E.1.57 It is considered that, on average, the effect of the over-provision has been to result in one less AUFLS block being triggered than would otherwise have been the case. For example, if an event would have resulted in two blocks being triggered, it is considered that the over-provision would have resulted in only one being triggered. Similarly, for a smaller AUFLS event which would have resulted in only one block being triggered, it is estimated that the over-provision would have resulted in no AUFLS blocks being triggered.

E.1.58 Under the current AUFLS settings, AUFLS provision is comprised of two blocks, each of a minimum of 16% of load. However, under the proposed revised AUFLS regime this will move to AUFLS being comprised of four smaller blocks. At the time of writing, the size of such blocks has yet to be finalised (it is potentially the case that the size may vary according to the time of day and year). However, for the purposes of this analysis it is assumed that the average size of a block would be 8% of load.

E.1.59 Assuming that if an AUFLS block is shed, the average time to restore the AUFLS load is 1.5 hours, and assuming the value of lost load (VoLL) of such load is $10,000MWh, then the interruption cost of an 8% AUFLS block being shed (assuming a system load of ~3,200MW) is approximately $3.8m.

E.1.60 However, such a cost needs to be factored by the likelihood of the system suffering an ECE. In this respect, a central estimate has been chosen that one ECE will occur every five years.

E.1.61 Thus, the expected annual cost of such increased load shedding = 3.8 ÷ 5 = $0.77m per year.

E.1.62 This value would need to be subtracted from the estimate of any benefit from reduced IR procurement costs.

E.1.63 However, such subtraction would need to be internally consistent with the underlying assumption regarding the amount of reserves reduced. In this respect, as set out previously, it is likely that the overall amount of reserve procured won't be materially reduced until the SIR arrangements are altered. It is considered that while such reserve levels remain at their high levels driven by SIR requirements, then it will continue to be the case that the IR 'buffer' will continue to result ECE-scale events not triggering AUFLS for about 90% of such events. Thus, the AUFLS load shedding cost to be included in this CBA should be $0.77m * 10% = $0.077m per year. If at some point in the future initiatives such as 'area under the curve' enable SIR over-provision to be addressed, then the full $0.77m cost of increased AUFLS load shedding should be taken into account.

Increased IL load shedding costs

E.1.64 It is also likely that reducing FIR procurement will mean there will be a greater number of under-frequency events dropping below 49.2 Hz.

E.1.65 Such events trigger the payment of under-frequency event charges by the causer of the event. In and of themselves, these charges are merely wealth transfers, and thus should not be considered in any economic evaluation of the costs of reducing RMT simulation times.

E.1.66 However, the level of the $1,250/MW charge was set to approximate the costs incurred by IL providers in shedding load during an event. These are genuine economic costs which would need to be included in an evaluation.

E.1.67 A cost of these extra events has been calculated on the following basis:

(a) average cost of load shedding = $1,250/MW

(b) number of extra <49.2 Hz events per year (compared with status quo) = 6[47]

(c) average quantity of IL shed during event = 200 MW

(d) average duration before load is restored after event = 30 minutes.

E.1.68 Using such assumptions the average extra cost of IL load shedding is $0.75m per annum, and would need to be subtracted from the estimate of any benefit from reduced IR procurement costs.

E.1.69 However, as with considering the extra cost due to increased AUFLS events, such subtraction would need to be internally consistent with the underlying assumptions regarding the amount of reserves reduced. In particular, the extent to which SIR arrangements will result in the continuance of a significant 'buffer' which will make it less likely that under frequency events will result in the frequency falling below 49.2 Hz. A central estimate of this effect of this continuing over- provision is that the IL load shedding costs calculated above will be reduced by 70% i.e. the cost of increased IL load shedding = $0.75m * 30%.If at some point in the future initiatives such as 'area under the curve' enable SIR over- provision to be addressed, then the full $0.75m cost of increased IL load shedding should be taken into account.

Estimating the net impact of altered resilience to events which could cause system collapse

E.1.70 Generally speaking, reducing the amount of reserves procured will reduce system resilience to under-frequency collapse following very extreme large events – i.e. those very rare 'black swan' events of a size greater than the extended contingent event for which sufficient reserves and AUFLS are currently procured.

E.1.71 As such, reducing the amount of reserves may at first sight be regarded as increasing the risk of system collapse to these, albeit rare, events.

E.1.72 However, if too much reserves and AUFLS are triggered in an under-frequency event, system frequency can over-recover to above 50 Hz. If frequency rises beyond 52 Hz it is likely that some generators' over-frequency protection systems will cause them to disconnect, thereby causing frequency to fall again. If too many generators disconnect, then system frequency will fall below 50 Hz again – but this time without any under-frequency resources to arrest it.

E.1.73 The system operator has identified over-frequency collapse risk due to having 'too much' AUFLS and reserves as a very real concern, and is consequently proposing a set of medium term measures aimed at preventing over-provision of AUFLS and reserve by providers.

[47] This is based on analysis on the frequency of actual events whose size was a minimum of 150 MW less than the size of the Contingent Event at the time.

E.1.74 Given the above, on balance it is considered that reducing over-provision of reserve will result in a net *improvement* in system resilience to events which could cause system collapse. However, it is extremely hard to quantify such benefit given that it requires considering:

(a) the relative probabilities of very infrequent events, versus the (more frequent) 'mid-sized ECE' AUFLS-sized events which could give rise to over-frequency collapse)

(b) variability and uncertainty surrounding the level of over-provision of AUFLS and reserves from providers.

E.1.75 That said, a feel for the likely order of magnitude of such benefits can be estimated via considering the net increase in the proportion of AUFLS events which don't result in system collapse. If an extra 0.5% of all AUFLS events were saved due to reduced over-frequency collapse (net of any increase in under-frequency collapse following extreme black swan events), [48] then the expected annual value of such an improvement would be:

Cost of Blackout * 0.5% ÷ Avg return period of AUFLS events =

$1.5bn * 0.5% ÷ 5 years = $1.5 m/yr

Estimating the cost of requiring increased meter resolution

E.1.76 For the purposes of this cost-benefit, metering costs were considered separately for two different types of FIR participant:

(a) large FIR providers (i.e. of a scale of ≈ 2MW+)

(b) small FIR providers (i.e. < ≈ 2MW)

E.1.77 This distinction is necessary because it is understood that the type of meters that larger generators have implemented are 'higher spec', and thus higher cost than those which are suitable for a smaller-scale IL provider of a few hundred kW.

E.1.78 It is also necessary because for smaller-scale FIR providers, the cost of high-spec meters can start to outweigh the value of the FIR which they provide. Accordingly, it is not just appropriate to consider the cost of the meter, but also the potential cost of such FIR providers exiting the market if the metering costs become too high.

[48] Given the expected return period of an AUFLS event is approximately 5 years, this 0.5% figure corresponds to events of a return period of 5 ÷ 0.5% = 1,000 years.

Metering costs for large FIR providers

E.1.79 This section considers the likely metering costs for generators providing spinning reserve, and for large-scale IL providers such as direct connect industrial consumers.

E.1.80 Metering technology has improved markedly over the past decades such that it is now that case that for ‘greenfield’ implementations using new meters for large-scale generation and demand sites, the differences in cost between a metering system that can record meter data at 100 ms resolution and one that can record at 20 ms resolution are minimal. Indeed, in many cases the metering and data storage equipment will be identical, with the resolution for recording the data being a parameter setting chosen by the user.

E.1.81 However, for IR providers that have existing metering systems, it may be that some of them will not have the capability to increase the resolution at which they record simply by changing a parameter. In such cases, there will be a difference in cost between continuing to provide the meter data at a lower resolution (i.e. zero incremental cost), and providing the data at a higher resolution (i.e. requiring the purchase and implementation of new metering systems).

E.1.82 That said, it is understood that all generators currently offering spinning reserve and all IL providers have solutions that can deliver 1 second resolution, and many have all or some aspects of solutions to deliver 100ms and even up to 20 ms resolution.

E.1.83 In undertaking this cost-benefit analysis, estimates were provided by one of New Zealand’s largest metering solutions providers on:

(a) the likely costs of the different meter solutions

(b) which current IR providers already have high-resolution metering capabilities.

E.1.84 Such estimates are set out in Table 2 and Table 3 below.

Table 2: Estimates of implementation costs of new metering systems

		Standalone costs			Incremental costs		
		1sec	100ms	20ms	1sec vs. 100ms	1sec vs. 20ms	100ms vs. 20ms
Per Company	Back-end IT	50,000	70,000	70,000	20,000	20,000	0
Per Site	Software	3,600	3,600	3,600	0	0	0
	Installation & test	15,000	17,000	17,000	2,000	2,000	0
	Meter	5,000	14,000	14,000	9,000	9,000	0
	Total per site	*23,600*	*34,600*	*34,600*	*11,000*	*11,000*	*0*

E.1.85 Interrogating historic FIR offers provides a good basis to estimate the number of current sites where large-scale providers offer FIR. This data was combined with the estimates provided by the meter provider as to which companies had which reserves metering of a particular resolution, to give an overall estimate of the number of companies and sites where metering capabilities exist of a particular resolution. This is set out in Table 3 below.

Table 3: Estimates of which current FIR providers (excluding IL providers other than directly connected loads) have metering solutions of a given resolution

		1sec	100ms	20ms
Number of companies	*Generators*	1	3	2
	Direct connects	4	1	0
Number of sites	*Generators*	1	25	26
	Direct connects	4	3	0

E.1.86 Using the estimates set out in out in Table 2 and Table 3, an initial high-level estimate of the *net* implementation costs (i.e. taking account of which companies already have metering systems of a given resolution) of requiring FIR metering to be provided at a given resolution was undertaken. The results of this are set out in Table 4 below.[49]

[49] This calculation is simply the number of generators needing to upgrade to the higher resolution, multiplied by the cost of such an upgrade as. It is based only on those parties who currently offer IR.

Table 4: Estimated net implementation costs of requiring different meter resolutions for current FIR providers ($m)

	1sec	100ms	20ms	20-100ms incremental cost
Generators	0.00	0.05	0.48	0.43
Direct connects	0.00	0.20	0.26	0.05
Total	0.00	0.26	0.73	0.48

E.1.87 As can be seen, requiring 1 second resolution instead of 6 second resolution would not result in any extra costs as it is understood that all current generator and direct connect IL FIR providers have metering systems which currently have this capability. Requiring higher meter resolutions would involve greater costs, as not all current IR providers have metering systems which are capable of such higher resolutions.

E.1.88 It should be noted that these are initial rough estimates, intended to provide order-of-magnitude estimation of the likely costs. It is likely that the estimates are subject to a margin of error. For example, it is understood that some companies have partial solutions capable of operating at 20 ms resolution – i.e. they have some, but not all, aspects of such solutions. Thus it is possible that the incremental costs of moving to 20 ms provision may not be as high as stated. Similarly, it is likely that there will be some inaccuracy regarding which existing sites / companies have solutions of a given resolution.

E.1.89 Accordingly, in order to get a feel for what an upper bound of such costs could be, an estimate was undertaken which assumed that all current providers only had metering systems which had a resolution of 1 second, and thus a move to 100 ms or 20 ms would result in them incurring the full costs of buying completely new systems for all their meters. This upper bound of implementation costs was estimated to be $2.8m.

E.1.90 It should also be noted that some meters and meter systems are likely to be replaced anyway over the next five to ten years due to having reached the end of their economic life. As such, the cost of requiring a higher meter resolution will fall dramatically. This is because it is only the *incremental* costs of requiring a higher meter resolution which should be considered which, as set out in Table 2 and Table 3 above, are likely to be very small.

E.1.91 It is not known how many of the existing meters fall into such categories. However, if a conservative assumption is made that one-third of such meters would have been replaced anyway over the next ten years, then the values set out in the 100 ms and 20 ms columns would need to be reduced by approximately 24%.[50]

E.1.92 Table 5 sets out the estimate of the revised net implementation costs.

Table 5: Revised net implementation costs of requiring differing levels of meter resolution ($m)

	1sec	100ms	20ms	20-100ms incremental cost
Total from Table 4	0.00	0.26	0.73	0.48
Less estimate of meter replacement costs that would have occurred anyway	0.00	-0.06	-0.17	n/a
Revised total[51]	0.00	-0.19	-0.56	0.36

Metering costs for small FIR providers

E.1.93 It is understood that the cost of the 1 second resolution meters currently used by the small-medium commercial & industrial IL providers is approximately $1.5k to $2k. This is significantly less than the cost of the higher spec meters detailed in the previous section.

E.1.94 However, it is understood that if these current IL providers were required to implement a higher meter resolution solution of 100ms or greater, they would face a significant cost increase. Such a cost increase would be due to implementing higher spec site meters, as well as implementing revised back-office infrastructure to handle this greater data requirement.

E.1.95 EnerNOC (the principal current provider of small-medium scale aggregated IL) have suggested that the back-office infrastructure costs in particular could be considerable. They further indicated that if a requirement to implement higher resolution metering were mandated, it would no longer be economic for a large proportion of their sites to continue to offer FIR.

E.1.96 A simple back-of-the-envelope calculation suggests that this could indeed be the case: If a high resolution meter has an installed cost of $20k, and a customer has an investment criteria that requires 5 years to recover this cost, then the average annual FIR income would need to be $5,000 (using an 8% discount rate) just to break even. If it is assumed that average FIR prices across the year are likely to be $4/MWh (a reasonable estimate based on historic prices), then the

[50] This assumes that such costs are discounted by spreading them evenly over a 10 year period, using an 8% discount rate.

[51] This table is copied from a spreadsheet. Rounding in displaying the data in the rows means that the rounded total may not exactly equal the sum of the rounded individual elements that make up the total.

size of load necessary to earn $5,000 in FIR revenue is 143 kW. However, given that a site would need to do more than just break-even and would also need to recover the costs associated with management time and effort, it is likely that considerably larger sites than 140kW would exit the market if a high meter resolution requirement were implemented.

E.1.97 At the moment it is understood that approximately 50MW of FIR is provided by aggregated IL providers – the majority of which is understood to be from sub 1MW sites. If it is assumed that 2/3 of this 50MW would exit the market if this higher meter resolution requirement were implemented then almost all the benefit detailed previously in the first part of the CBA with regards to reducing the amount of FIR that would need to be procured would be wiped out.

E.1.98 This 2/3 * 50 MW could be a conservative number if potential additional FIR IL which hasn't yet, but could, enter the market is taken into account.

E.1.99 Accordingly, for the purposes of this CBA, it is assumed that sites of < 2MW would not incur any extra metering costs as it is understood they already have 1 second resolution meters.

E.1.100 As set out in paragraph 4.2.32 in the main body of the paper, it is considered that the diversity benefit of many smaller IR providers means that having 1 second resolution would be appropriate for these smaller providers.

E.1.101 For the IL sites of > 2MW, based on the numbers provided in paragraph 4.2.35 of the main report and the cost estimates of high resolution metering solutions set out in above, then an additional $0.87m would need to be added to the cost of the proposal.

Summary of cost-benefit assessment

E.1.102 Table 6 below shows the summary of the overall cost-benefit estimated for requiring 100 ms meter resolution except for < 2 MW sites where 1 second resolution would be required. The table shows the cost-benefit estimation for two situations:

(c) assuming the present situation of SIR over-provision continues to limit any benefit of reduced FIR procurement

(d) assuming such SIR over-provision is addressed by introduction of area-under-the curve procurement of reserves in a few years' time.

Table 6: Net cost-benefit of requiring 100ms meter resolution ($m)

	At present (limited by SIR over-provision)	*After 'area-under-the-curve' implemented[52]*
Annual benefits / (costs) ($m/yr)		
Reduced fixed carrying costs	0.73	7.25
Reduced short-run costs of reserve provision	0.26	0.44
Increased IL shedding during UF events	-0.23	-0.75
Increased AUFLS load shedding	-0.08	-0.77
Reduced over-frequency collapse	1.50	1.50
Total	**2.19**	**7.67**
10 year PV*	15.24	38.80
One-off implementation (costs) / benefits		
Cost of implementing 100ms requirement ($m)	-1.12	
add back cost of meters that would anyway be replaced	0.06	
Net implementation costs	-1.06	
Overall 10 year NPV	**14.2**	**37.7**

* The 10 year PV for the area-under-the-curve option assumes such benefits do not start until after three years.

Q15.	**What comments do you have on the CBA, the assumptions made, the methodology used or any comments on any parts of the CBA that could be potentially improved upon?**

[52] To address the SIR over-provision, RMT needs to be replaced first. Hence the focus on realising shorter-term improvements through the proposed changes.