Wholesale Advisory Group

Review of Instantaneous Reserve Markets Recommendations Paper

By the Wholesale Advisory Group

January 2015

Note: This paper has been prepared for the purpose of making recommendations to the Electricity Authority Board. Content should not be interpreted as representing the views or policy of the Electricity Authority.

883041-7

Contents

The Wholesale Advisory Group

The members of the WAG, as at the date of the publication of this paper, are:

- John Hancock (Chair)
- Phillip Anderson
- Neal Barclay
- John Carnegie
- Graeme Everett
- Alan Eyes
- Chris Jewell
- Stephen Peterson
- Bruce Rogers
- Richard Spearman

Electricity Authority request

The Electricity Authority (Authority) has requested input and advice of the Wholesale Advisory Group (WAG) on whether the approach to procuring instantaneous reserves can be improved.

1 Introduction

1.1.1 In October 2013, the Electricity Authority (Authority) requested the input and advice of the Wholesale Advisory Group (WAG) on whether the approach to procuring instantaneous reserve can be improved. This included considering whether the current fast instantaneous reserve (FIR) product could be improved and/or complemented by adding another FIR product or products.

1.1.2 This paper presents the WAG's recommendations following its investigations.

2 Recommendations

2.1.1 The long-term benefits of revising instantaneous reserve (IR) procurement arrangements appear to outweigh the likely implementation costs. Therefore, the WAG recommends that investigations continue to determine the most appropriate approach to realise such benefits.

2.1.2 However, the WAG strongly recommends these investigations do not focus on FIR independently (as has largely been the case to-date), but that changes to FIR *and* sustained instantaneous reserve (SIR) [1] are considered together as the distinction between them is largely a result of technical computing constraints from the 1990s when the NZ electricity market was established and the IR products were defined.

2.1.3 Further, the WAG recommends reviewing the reserve management objective for IR procurement in the Electricity Industry Participation Code 2010 (Code), particularly the balance between using IR and re-dispatch of interruptible load (IL) and generation for bringing frequency back to 50 Hz.[2] The current practice to rely entirely on IR is inconsistent with the objective specified in the Code that assumes re-dispatch will play a significant role. Determining the appropriate balance between the two approaches involves technical and economic trade-offs. Given that there have been significant changes to the system since the objective in the Code was determined, it would seem appropriate to review this fundamental principle at the same time as reviewing the approach to procuring IR.

2.1.4 Progressing the investigations of IR product-design and scoping of the market systems changes are highly technical in nature. As such, the WAG believes that the Authority and system operator are best placed to continue such investigations, appraising the WAG of recommendations and findings as work progresses provided that such changes remain net beneficial.

2.1.5 Industry engagement is also paramount in that it needs to be understood what the costs to the industry might be in order to best participate in the revised IR market. Only by understanding the cost to the industry can a true national benefit analysis be undertaken.

[1] FIR is used to arrest frequency fall, SIR is used to restore frequency to or above 49.25Hz.

[2] Schedule 8.4 of the Code specifies that the reserve management objective is to "*schedule a minimum quantity of instantaneous reserve*" to achieve the under-frequency standard, which for the North Island is to "*return to or above 49.25 Hz within 60 seconds after the event*". It is understood that the intent of this is for IR to restore and sustain system frequency to some point above 49.25 Hz, and for system re-dispatch to then be used to fully restore system frequency to 50 Hz and a stable state.

This could be best done by establishing an industry working group with representatives from generation IR and IL IR providers.

3 Description of problem

3.1 Purpose of IR and description of current procurement approach

3.1.1 A sudden loss of supply resulting in a supply/demand imbalance will cause frequency to fall. Unless supply and demand are re-balanced, frequency will continue to fall until system collapse occurs.

3.1.2 The system operator has three principal resources to call upon to bring supply and demand back into balance:[3]

a) ***IR***, which can be in the form of an increase in generation or a decrease in demand. The system operator uses IR to manage the loss of a single supply asset. The purpose of IR is to arrest a decline in frequency and restore it to a stable level at or above the statutory minimum (49.25 Hz), after which the system operator can re-dispatch the system to get frequency back to 50 Hz.

b) ***Automatic Under-Frequency Load Shedding (AUFLS)***, which is the shedding of large blocks of load at distribution feeders or transmission grid exit points. AUFLS (in conjunction with IR) is only used to help manage the loss of the HVDC bipole or multiple supply assets.

c) ***Re-dispatching*** generation and demand. This is used to bring frequency back to 50 Hz after IR and (if necessary) AUFLS have acted to arrest frequency decline and restore it to a stable level.

3.1.3 The system operator procures IR via an auction, with parties offering an availability price. This price is expressed in $ per MW per hour. The system operator procures the cheapest MW offered, up to the total quantity required to cover the largest potential risk for that half hour. In doing so, it also co-optimises the procurement of IR with energy, given that many IR providers, principally generators offering spinning reserve, but potentially *IL* (which could also be offered as demand response) can provide either IR or energy.

3.1.4 All parties selected to provide IR are paid an availability fee, being the $/MW/hr offer price of the most expensive IR resource procured for that half hour.[4]

3.1.5 However, it is not just a question of procuring the MW with the cheapest $/MW/hr availability cost. There is also a time dimension to reserve provision.

3.1.6 System frequency will start to fall the instant when demand exceeds supply. Inertia on the system will slow the rate of decline, but in the event of a large loss of supply, system

[3] The system operator has an additional fourth resource which it uses to manage under-frequency events, the Asset Owner Performance Obligations (AOPOs) on generators to remain connected during under frequency events. These are requirements on all generators to operate in a certain fashion during an under-frequency event. These AOPOs are intended to ensure that the generators 'hang-on' during the event and thus prevent it getting worse, rather than being used to restore system frequency to normal operating levels.

[4] Strictly speaking, the price is equal to the price of meeting an additional MW of demand for IR. In the majority of situations this incremental MW will come from the marginal provider selected, although it is possible that the optimisation algorithm may find a change to a different resource would be a lower cost means of meeting this requirement.

frequency will decline at a rapid rate – potentially dropping below the point of no return within a couple of seconds, if unchecked.

3.1.7 Some IR with a low availability cost may not be of any use if it is too slow to respond to the event. The system operator therefore needs to procure a mix of different types of IR to replace the MW lost in a supply interruption. The system operator may need to procure some IR which has a higher availability cost but which is particularly fast-acting. This fast-acting IR can act to arrest the rate of frequency decline, giving time for cheaper (but slower) IR to respond.

3.1.8 Currently this trade-off between fast-acting and slower-acting IR is achieved rather crudely by procuring two different 'types' of IR: FIR and SIR.

3.1.9 The system operator procures FIR using a dynamic model of the system – the Reserve Management Tool (RMT). This models system performance for the projected mix of generation and demand for each half-hour, and takes account of the different performance characteristics of reserve providers. RMT ensures that enough fast-acting IR is procured to arrest the fall in system frequency in the event of the loss of the largest supply asset.

3.1.10 SIR is not modelled at all, but is procured on a simple one-for-one basis. For example, if the largest potential loss of supply in a half hour is 400 MW, then 400 MW of SIR is procured.

3.2 Problems with current IR procurement approaches

3.2.1 IR is artificially split into two separate products. At the time it was first implemented by the system operator, the two products were considered to provide the best trade-off between the speed and cost of IR delivery, given the computational limitations faced at that time.

3.2.2 Work done by the Electricity Authority and system operator over the last few years has identified that there may be other approaches that would better promote the Authority's statutory objective. A previous WAG paper sets out the details of this work[5]. In summary, the current arrangements result in in over procurement of IR due to a range of factors:

a) Over-procurement of SIR through using a simple one-for-one procurement approach[6], rather than dynamic modelling to determine how much SIR is required in order to restore frequency to the target stable level.

b) Over-procurement of IR in total, due to FIR and SIR procurement not being co-optimised between each other.[7]

---

5 "*Potential gains from altering reserve procurement arrangements*", 5 June 2014

6 As a technical aside, the key driver of SIR over-procurement is not so much that SIR is procured on a one-for-one basis, but that the SIR is effectively procured on an area-under-the-curve basis over the 60 second period. (i.e. the MW of a provider is not considered to be what they deliver at the end of the 60 second period, but rather their average output during the 60 second period). This approach will effectively result in SIR bringing frequency back to 50 Hz within 60 seconds. This is considered to be inconsistent with the intent of the reserve management objective (set out previously in footnote 2 on page 4 which specifies that sufficient IR is to be procured to bring frequency back "to or above 49.25 Hz" – i.e. not 50 Hz – with the implied intent that the system operator can then re-dispatch the system back to 50 Hz from this point.

c) Over-procurement of FIR due to the FIR procurement mechanism:

i) not differentiating payments to providers based on the speed of their response

ii) excluding some types of IR from being offered as FIR.[8]

3.2.3 It is also likely that the current approach to procuring IR is resulting in *over-payment* for the quantity of reserves being procured - in particular due to not co-optimising between FIR and SIR.[9] However, this has not been a key aspect of the investigations to date, as the consequences of this are likely to be wealth transfers between parties, although the scale of this over-payment could be material.

3.2.4 As the previous WAG paper highlighted, the nature of these different issues is complex, and the extent to which they result in over-procurement of reserve is inter-connected and will differ according to different system states (e.g. whether demand is low or high).

3.2.5 The analysis suggests that the scale of over-procurement is likely to be in the order of tens of MW. The WAG has used a conservative estimate of 20 MW for the cost-benefit analysis for this investigation.

3.2.6 Importantly, the analysis also highlighted that this over-procurement can only be significantly addressed if FIR and SIR are addressed together i.e. just implementing revised approaches for one of the products would not result in material savings. This is because even if over-procurement in one product is addressed, over-procurement in the other product will continue to drive over-procurement of IR overall.

3.2.7 The Authority's analysis also highlighted that if the over-procurement can be addressed, the nature of the cost savings is twofold:

a) A reduction in the amount of peak generation capacity needed to be held on the system

b) A reduction in the operating costs from plant operating in reserve mode.

3.2.8 The scale of peak capacity reduction would be equivalent to the reduction in IR procured at times of peak demand. Given that the carrying cost of the marginal source of peak capacity is estimated to be \$145/kW/yr[10], each MW of peak capacity saved would deliver a present value of approximately \$1.3m for a system with a balanced supply/demand mix.[11] However, the 2014 Annual Security Assessment indicates that there is currently a

---

[7] This is considered a separate issue to the previous point about SIR not being dynamically modelled. It is possible that proper dynamic modelling of SIR could take account of the contribution from FIR providers. However, even though FIR is dynamically modelled at the moment, the current approach does not take properly take account of the contribution from SIR providers, thereby leading to over-procurement.

[8] IL providers who respond slower than 1 second are excluded from offering FIR. This contrasts with spinning reserve providers who must provide their reserve within 6 seconds. These simple exclusion approaches have been put in place as crude proxies to account for the fact that the current FIR procurement process does not differentiate payments to providers based on the speed of their response.

[9] The fact that reserve is procured via two independent products (FIR & SIR) that are not co-optimised between each other, can give rise to situations where the sum of the clearing prices for each product is greater than is required to cover the costs of the marginal reserve provider.

[10] Based on work undertaken for the Electricity Authority a couple of years ago for the scarcity pricing initiative.

[11] Assuming an 8% discount rate over 15 years.

surplus of peak generation and that no new capacity will be required until 2022. Taking this factor into account, a 20 MW saving in peak capacity would deliver a $10m PV benefit.

3.2.9 This estimate is likely to be conservative for the following reasons:

a) the annual security assessment does not take into account potential retirement of generation plant in response to over-capacity

b) the process of retiring plant can cause a lumpy rate of reduction in over-capacity

c) some capacity may not be offered into the market by plant owners to manage price volatility

3.2.10 With respect to the benefit of reduced operating costs from plant operating in spinning reserve mode, it is estimated that such operating costs are approximately $1.5/MW/h. For a saving of 20 MW, this equates to ≈ $0.25m/yr, or a 15 year PV of $2.3m.

4 Work done on potential alternative approaches

4.1.1 The Authority and system operator have been examining potential alternative approaches to IR procurement.

4.1.2 There are two key aspects to considering alternative approaches:

a) The *nature* of the revised IR procurement approach

b) The *tool* used to implement the revised approach.

4.1.3 With respect to the nature of the revised procurement approach, two different approaches have been considered to-date:

a) An area-under-the-curve (AUTC) approach to procurement. This would involve taking into account the speed of response of IR providers for the purposes of procurement.

b) An additional “very fast” reserve product.

4.1.4 Both approaches are focussed on addressing over-procurement in FIR provision. The results of the examination of a potential additional “very fast” reserve product have not been promising, whereas the results from the AUTC analysis are hopeful.

4.1.5 Neither approach has explicitly considered addressing the over-procurement of SIR and the artificial distinction between FIR and SIR. However, it is understood that the AUTC approach would be well suited to an approach that removed this artificial distinction and instead treated IR as a single product. Such an approach would trade-off speed and cost between providers as required, in order to meet the system condition and risk for each trading period.

4.1.6 Conversely, the Authority considers that introducing a new “very fast” reserve product is not well-suited to such co-optimisation.

4.1.7 In addition, there could be a compliance trade-off between quality and quantity of IR delivered because the providers of FIR would need to prove their capability to the system operator in terms of the quantity of response (MW) and speed of response (sub seconds

to seconds). There is a cost associated particularly with high resolution metering. The cost however could be largely off-set by higher payments for faster IR products. Specifically, two questions need to be answered:

a) Is it better (for NZ Inc.) to specify and procure the exact amount of product that is required and have an onerous compliance regime that ensures/guarantees that the product will be delivered exactly as specified by a relatively small number of participants?

b) Is it better (for NZ Inc.) to procure more product than is actually required, with the expectation that not all of it will be delivered, but with a compliance regime that is less strict but likely to attract a wider pool of participants and therefore be more competitive?

4.1.8 With respect to the tool used to implement a revised approach there are two main options:

a) Continue to dynamically model the IR requirements using a separate tool such as RMT

b) Incorporate the dynamic modelling of IR requirements directly within SPD.

4.1.9 Both approaches appear to be feasible, and the Authority has developed a proof-of-concept approach for modelling AUTC procurement within its vectorised scheduling, pricing and dispatch tool (vSPD).

4.1.10 There are advantages and disadvantages of both approaches, including cost to implement, speed of solves, and accuracy of procurement. However, no formal evaluation has been undertaken to date on the relative merits of the different approaches.

4.1.11 The WAG has not prepared estimates of the costs to make changes to software tools such as SPD and RMT. However, the software changes are not considered to be as great as those associated with implementing national frequency keeping, which also required substantial additional pieces of technology to be implemented. The system operator and market system costs for implementing national frequency keeping were estimated to be $5.2m.

4.1.12 The WAG estimates that the costs of implementing alternative reserve procurement would be less than half this amount.

5 Linkage with other initiatives

5.1.1 The Authority and the system operator are considering other changes to IR procurement, which may be relevant to the potential benefits of altered reserve procurement approaches.

5.1.2 The most significant potential change to reserve procurement is the development of a national IR market. An initial high-level review of the national IR market initiative and the initiative to alter IR procurement approaches suggests:

a) The two are not mutually inconsistent. There is nothing to suggest that a revised IR procurement approach couldn't be implemented on a national basis.

b) There are potential cost implications acting in two different directions:

   i) On the one hand, there may be implementation cost savings from making changes to the software to implement both new arrangements (i.e. new IR procurement approach, and a national IR market) at the same time.

   ii) On the other hand, the investigation into altered IR procurement approaches is at a much earlier stage of development than the national IR market. It is likely that delaying implementation of a national IR market to coincide with implementation of new IR arrangements could substantially delay realisation of the benefits of a national IR market.

On balance, the WAG considers that the cost from delaying the benefits from a national IR market would likely outweigh the potential benefits from implementing altered IR procurement approaches and the national IR market at the same time.

5.1.3 The second potential change to reserve procurement is for the planned review of the allocation of IR procurement costs. A high-level review of this suggests this potential cost-allocation initiative is a completely separate issue, and should not have any bearing on whether or how to progress with initiatives to change reserve procurement approaches.