

Efficient procurement of extended reserves

Second consultation

Submissions close: 5pm 4 March 2014

20 December 2013

Executive summary

To address under-frequency events which are more severe than those covered by instantaneous reserves (IR), the system operator must call upon 'extended reserves'. Currently, only one type of extended reserve is used to cover such severe events – namely arming large blocks of load with automatic under-frequency load shedding (AUFLS) relays. As technology progresses, it is possible that additional types of extended reserve could be used to manage such severe events. However, at the current time AUFLS remains the only practicable option, and is the principal focus of this consultation. Reference to extended reserves occurs at times throughout this paper when discussing potential future arrangements.

In August 2013, the system operator proposed revised technical arrangements for providing AUFLS. The key aspect of the proposal is to move to a four-block scheme, with the blocks sized in a 10%:10%:6%:6% ratio. The revised arrangements will deliver significantly greater system reliability over the current AUFLS regime, with reduced risk of system collapse during an AUFLS event.

In October 2013 the system operator and the Electricity Authority (the Authority) held a series of industry workshops where the system operator's technical scheme design was presented, and the options to procure the AUFLS load were discussed.

The Authority has been considering what *type* of load should be placed under AUFLS, and what mechanisms should be used to select such load and ensure it is available for use.

This review of the 'procurement' aspect of AUFLS is due to concern that the current approach of having a 'one-size-fits-all' common percentage obligation results in some relatively high-cost load being placed under AUFLS.

Some load can have relatively higher-cost consequences from being placed under AUFLS because:

- the load has relatively high interruption cost (a.k.a. VoLL – value of lost load)
- the load could be more valuably used for another purpose (provision of IR)
- the load's within-year and within-day shape is not well suited to meeting the ideal AUFLS load shape
 - ✓ in an ideal situation a higher percentage of AUFLS would be provided at times of low demand, and a lower percentage at times of high demand.
 - × the current regime generally provides the opposite, thereby increasing the risk of system collapse in an AUFLS event.

The problems with the current arrangements have led to all direct-connect industrial customers being granted temporary exemptions on the grounds that the cost of their providing AUFLS is higher than their not providing AUFLS,¹ and that the divisibility of their load to the required blocks is problematic.

The process the Authority followed to develop and evaluate various alternative approaches to address these problems included an initial consultation in October 2012, and the October 2013 workshops.

Based on this process, a range of different AUFLS procurement options were evaluated, as shown in the following table:

Table 1: AUFLS procurement options considered

High-level family	Sub-variant
Common AUFLS percentage obligation	Standard Code mechanisms (equivalence, dispensations and exemptions) used to vary individual stakeholders provision away from the common percentage requirement.
	As above, plus prioritised block coordination (enabling high value load to be put in AUFLS block 4 rather than block 1, ² and allowing small stakeholders to provide a single block of 32%, rather than four blocks of 10%:10%:6%:6%.)
	As above, plus special exclusions to exempt certain stakeholders, including: exempting direct connects from any obligation and allowing IL to be counted towards meeting an AUFLS obligation
	As above, plus profiled minimum and maximum obligations (i.e. varying the percentage obligation by time of day and year, and penalising for over-provision as well as under-provision.)
Varying AUFLS provision via optimisation (the	No compensation, plus central VoLL estimation of lines companies' load
	With compensation, plus central VoLL estimation of lines

¹ The terms of the current exemptions from the provision of AUFLS provide that they will remain in place until 30 September 2015 or the date notified by the Authority that a revised AUFLS regime has taken effect, whichever is earlier.

² Initial analysis suggests that the return period of the first block being called upon would likely be approximately one in five years, whereas the return period of the fourth block being called upon could be of the order of one in 50 years.

High-level family	Sub-variant
amount each stakeholder provides will be based on the relative suitability of the load)	companies' load
	<i>With compensation, plus lines companies' VoLL estimation</i> of lines companies' load
Voluntary AUFLS tender	<i>Simple pay-as-bid tender</i>
	<i>'Sophisticated' AUFLS market</i>

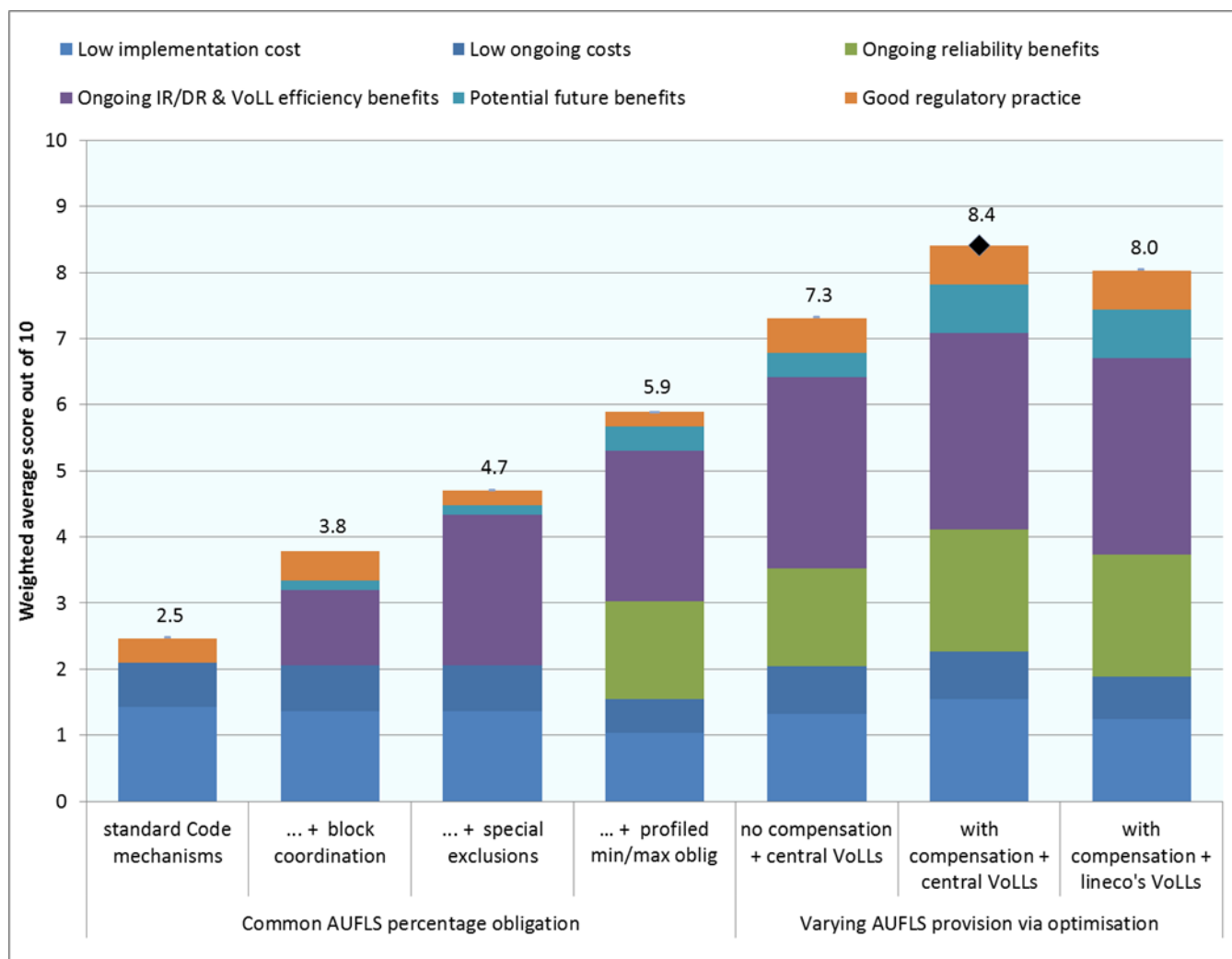
An indicative quantitative analysis of the costs and benefits of these different options was undertaken, in particularly considering the potential:

- (a) reliability benefits from better achieving the "ideal" within-day and within-year AUFLS load shape
- (b) efficiency benefits from:
 - (i) not placing high interruption cost load under AUFLS
 - (ii) enabling load to be more valuably used as IR (or other purposes) if appropriate
 - (iii) not incurring high AUFLS relay costs and other implementation and operation costs associated with the different options.
- (c) future benefits from taking advantage of possible technological opportunities sooner, and at lower cost.

The results of this quantitative analysis, coupled with an evaluation of good regulatory practice, formed the basis of the overall scores out of 10 for each of the options as shown in Figure 1 on the following page.

The voluntary AUFLS tender options are not shown. This is because the analysis identified that lines companies' use of system agreements, and possibly also the price / quality regulatory environment are likely to constrain their ability to participate fully in a voluntary AUFLS market to an extent which would make these options impractical at this time.

Figure 1: Option evaluation summary



Based on this evaluation, the Authority's preferred option for AUFLS procurement is **varying AUFLS provision achieved via optimisation, with compensation plus central estimation of lines company VoLL** per feeder. It is envisaged the new North Island AUFLS regime will be completely in place by the end of 2016.

Glossary of abbreviations and terms

Act	Electricity Industry Act 2010
AUFLS	Automatic Under-Frequency Load Shedding
Authority	Electricity Authority
CBA	Cost-benefit analysis
CBD	Central business district
Code	Electricity Industry Participation Code 2010
CRE	Competition, reliability, and efficiency.
DD	Dispatchable demand
DR	Demand response
GXP	Grid exit point
IL	Interruptible Load
IR	Instantaneous Reserves
NPV	Net present value
PROPs	Participant rolling outage plans
Regulations	Electricity Industry (Enforcement) Regulations 2010
UFM	Under-frequency management
UoSA	Use of system agreement
MUoSA	Model use of system agreement
VoLL	Value of lost load

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1. Introduction and purpose of this paper

1.1 Introduction and background

1.1.1 AUFLS are the 'last resort' mechanism by which large blocks of load are shed to prevent system collapse in the event of a (rare) failure of major parts of the supply system. The Authority, with the assistance of the system operator, has been reviewing the AUFLS arrangements as part of a wider review of the suite of under-frequency management (UFM) arrangements.

- (a) The system operator has focussed on problems with the technical design of AUFLS – how much load should be placed under AUFLS, how should such load be organised into blocks, and what types of triggers should be used to disconnect the load.
- (b) The Authority has focussed on problems with the procurement of AUFLS – what type of load should be placed under AUFLS, and what mechanisms should be used to select such load and ensure it is available for use.

The current technical design of AUFLS is inadequate

1.1.2 The system operator has identified that the current technical AUFLS design of two x 16% blocks with simple frequency threshold triggers creates risks of system collapse for some AUFLS events.

1.1.3 In August 2013, the system operator put forward its revised technical solution.³ The key elements of the system operator's solution are to move to a design where the AUFLS load is configured in four blocks in a 10%:10%:6%:6% size ratio, with the last block additionally triggered by a df/dt mechanism.⁴

The means by which AUFLS load is procured is inadequate

1.1.4 The Authority's procurement review has revealed that the current procurement approach of placing a common percentage obligation on all

³ See:
http://www.systemoperator.co.nz/f5573.84862775/20130807_AUFLS_Scheme_Design_Report.pdf
http://www.systemoperator.co.nz/f5573.84862775/20130807_AUFLS_Scheme_Design_Report.pdf which can be found on the system operator's AUFLS review web page:
<http://www.systemoperator.co.nz/aufls>

⁴ The 'standard' approach to triggering an AUFLS block is if system frequency drops below a certain level. A df (rate of change of frequency) / dt (speed of change) trigger is activated if the *rate of change* of frequency is greater than the trigger level.

transmission-connected stakeholders is resulting in higher costs across three main dimensions:

- (a) system reliability costs from a higher risk of collapse during an AUFLS event
- (b) higher energy and IR market costs from preventing some loads from being more valuably used to provide IR or demand response (DR)
- (c) higher load-shedding costs during an AUFLS event from placing some relatively high interruption-cost load under AUFLS.⁵

AUFLS procurement problem definition

1.1.5 The costs outlined in paragraph 1.1.4 are due to three underlying challenges with procuring AUFLS:

- (a) not all loads are equally suitable for AUFLS
- (b) transaction costs prevent procuring AUFLS from individual customers
- (c) the standard Code provisions to vary obligations on individual stakeholders are inadequate in the case of AUFLS.

Not all loads are equally suitable for AUFLS

1.1.6 The fundamental issue with AUFLS provision is that some loads are more suitable to provide AUFLS than others. This has three main aspects:

- (a) ***variations in the ‘shapes’ of the different loads result in differences in system reliability outcomes.*** The system operator technical analysis identified that the ideal percentage of load to be placed under AUFLS varies significantly with system conditions. At times of low demand a high percentage of load under AUFLS would be desirable, and vice versa. Loads with different within-day and within-year shapes (baseload versus a peaky or seasonal shape) would have varying levels of suitability to meet the optimal AUFLS level
- (b) ***competing uses for load.*** Some load has characteristics that make it suitable to be used in other aspects of the market, e.g. being offered as interruptible load (IL) in the IR market, or other demand-side ‘products’ such as dispatchable demand (DD), or DR. Requiring such load to provide AUFLS may prevent it from being used for these other purposes, which may increase overall system costs

⁵ The cost of interruption is often referred to as the “value of lost load” (VoLL).

- (c) ***variations in VoLL.*** Some loads are more expensive to disconnect in an AUFLS event than others. Central business districts (CBDs) in the main cities, some industrial processes, hospitals and critical civil emergency infrastructure are an example of that. The scale of interruption cost is typically expressed as the VoLL.

1.1.7 It should be noted that some loads which have relatively low VoLL (domestic feeders), may not have an ideal load shape from the system reliability perspective. Identifying the most suitable load will therefore require evaluating the trade-offs between different cost aspects.

1.1.8 There are two other aspects which can affect the suitability of load:

- (a) ***variations in the divisibility of loads.*** A small lines company with a small number of feeders or a direct connect with a small number of large load blocks within its site will find it much harder to arm its load to provide specific-sized AUFLS blocks than a large lines company with many hundreds of feeders. Loads facing such divisibility problems may end up being forced to place a greater amount of load under AUFLS than the obligated (ideal) amount, thereby potentially resulting in a poorer system security outcome
- (b) ***variations in the predictability of loads.*** Some loads have a much less predictable and 'stable' shape than others. For example, some industrial sites have major processes turning on and off at varying times throughout the day and year, making it extremely challenging to configure their sites to provide certain percentage quantities of AUFLS at different times of the day and year.

Transaction costs prevent procuring AUFLS from (most) individual customers

1.1.9 Given the variation in customers' load characteristics, it would be ideal to secure AUFLS only from those individual customers who were most willing (and suitable) to provide AUFLS.

1.1.10 However, given current technological constraints, it is not practicable to adopt such an approach for any but small number of the very largest consumers. This is because the cost of installing AUFLS relays on multiple small consumers (coupled with the associated contractual transaction costs) would rapidly become prohibitive.

1.1.11 Instead, it is much more cost effective to arm AUFLS relays at a substation level and to use a single relay to arm the load of thousands of customers.

- 1.1.12 This technological constraint means that it is really only practicable to procure AUFLS from lines companies and small number of the very largest industrial customers.
- 1.1.13 It is possible that future developments in advanced metering may facilitate arrangements where individual consumers could provide extended reserves. However, it is not the case at present, and could be many years away before this option becomes practicable.

The standard Code provisions to vary obligations on individual stakeholders are inadequate in the case of AUFLS

- 1.1.14 The standard Code mechanisms to address special situations are equivalence arrangements or dispensations. However, as set out in section 3.5, these have some inherent barriers in the AUFLS context that make the use of such arrangements ineffective.
- 1.1.15 Because of these inadequacies in the current arrangements, all North Island direct connect industrial customers have been granted temporary exemptions by the Authority.⁶

The Authority has been reviewing alternative AUFLS procurement options

- 1.1.16 The Authority issued the first consultation paper "*Efficient procurement of extended reserves*" in October 2012. The paper outlined a range of potential options, from a simple centrally-coordinated approach through to highly complex market arrangements. Subsequent analysis resulted in further issues being identified, and additional procurement options were developed in addition to those set out in the October '12 consultation.
- 1.1.17 Following the completion of the system operator's technical analysis, the Authority and the system operator held a series of stakeholder workshops in October 2013. The proposed technical solution was presented in detail and the range of different procurement options was discussed.
- 1.1.18 Having considered all the stakeholder input on the relative pros and cons of the different procurement options, the Authority has identified a preferred option for the procurement of AUFLS as an 'extended reserves' product.

⁶ The first exemptions were granted in 2004, but because arrangements were not put in place to address the inadequacies with AUFLS, have been extended several times.

1.2 Purpose of this paper

- 1.2.1 The purpose of this paper is to consult with stakeholders on the proposed changes to the procurement of AUFLS.
- 1.2.2 This paper is not to consult with stakeholders on the revised AUFLS technical design. The system operator has already engaged with stakeholders on this matter. The Authority will be consulting on the draft AUFLS Code amendment together with the proposed technical solution in April-May 2014.
- 1.2.3 In considering the alternative procurement options, it has been assumed that the revised technical design will be implemented.
- 1.2.4 Stakeholders are invited to submit on whether:
 - (a) they believe the analysis undertaken to identify the preferred AUFLS procurement option is correct
 - (b) there are additional aspects of the proposed procurement options that the Authority needs to address before the revised arrangements can be implemented.
- 1.2.5 Consulting on the preferred AUFLS procurement option is beneficial before drafting and consulting on amendments to the Electricity Industry Participation Code 2010 (Code) to provide for a preferred option.
- 1.2.6 Feedback from the consultation will help with the development of the Code amendment proposal, and will also help the system operator to plan and implement its proposed technical solution as quickly as is practicable.
- 1.2.7 It should be noted that this consultation is focussed on AUFLS arrangements for the North Island. It is considered that the arrangements developed for the North Island are equally capable of being implemented in the South Island.
- 1.2.8 However, the system operator has determined that the current wide frequency envelope in the South Island (45 to 55 Hz, versus 47 to 52 Hz in the North Island) makes the risk of under- or over-frequency collapse in an AUFLS event significantly less in the South Island. This makes the changing of AUFLS arrangements a much less pressing issue in the South Island.
- 1.2.9 The development of the South Island AUFLS arrangements is likely to commence once the Authority has amended the Code to implement the North Island AUFLS regime. The South Island development is also subject to the system operator determining whether the South Island

frequency envelope needs to change to facilitate initiatives such as the National Reserves Market and National Frequency Keeping markets.

- 1.2.10 Lastly, it should be noted that the issues with AUFLS are highly technical, and the analysis undertaken to evaluate the many different costs and benefits is complex. The paper makes extensive use of appendices in order that the main body of the paper remains accessible and readable, while providing more detailed background information for anyone who wants to explore any particular aspect more deeply.

1.3 Submissions

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—Efficient procurement of extended reserves in the subject line.

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

- 1.3.1 Submissions should be received by 5pm on 4 March 2014. Please note that late submissions are unlikely to be considered.
- 1.3.2 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.
- 1.3.3 If possible, submissions should be provided in the format shown in Appendix G. 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. Recommendation - preferred option for AUFLS procurement

2.1 Objectives of the proposed change to AUFLS procurement

- 2.1.1 Our preferred procurement option is **varying AUFLS provision achieved via optimisation, with compensation plus central estimation of lines company VoLL per feeder**. The objectives of the preferred option are to reduce the significant costs associated with the current AUFLS procurement approach of a common percentage obligation, including:
- (a) system reliability costs (i.e. the avoidance of system collapse) due to the current arrangements not delivering the optimal quantity of AUFLS at different times of the day and year
 - (b) IR and other market costs, due to the common percentage obligation preventing some load from being more valuably used in the IR market or for other competing uses of demand (DD and DR)
 - (c) load-shedding costs during an AUFLS event, due to the current arrangements putting relatively high interruption cost load under AUFLS.

2.2 High-level elements of the proposed procurement option

- 2.2.1 The proposed option consists of the following high-level design elements:
- (a) an obligation on transmission-connected stakeholders to provide information to an AUFLS selection process. This information would include:
 - (i) historical load patterns
 - (ii) likelihood of load being used for other demand-side purposes (DD,DR, IR)
 - (iii) VoLL
 - (iv) whether the load has existing AUFLS relay capabilities.
 - (b) the system operator to use an optimisation tool to process such information, and select the optimal mix of loads to provide AUFLS
 - (c) a requirement on selected stakeholders to arm their load to the AUFLS setting determined by the optimisation process (i.e. whether to arm the selected load for AUFLS block one, block two etc.)
 - (d) selected stakeholders (the ones that are required to arm load) to receive compensation payments to cover the cost of providing AUFLS relays, and the expected cost of load interruption from AUFLS events

- (e) the cost of such compensation payments to be recovered from all transmission-connected stakeholders in proportion to their annual demands
- (f) the system operator to repeat such a process at intervals it deems to be appropriate, but at least once every five years. Any future 'adjustment optimisations' would be unlikely to significantly change the AUFLS requirements on stakeholders, except if the NZ electricity system has materially changed.

3. The evaluation criteria and the range of options considered

3.1.1 Detailed description of the preferred procurement option is set out in Appendix A

3.2 What would success look like?

3.2.1 This section of the paper reviews all the various options for AUFLS procurement, and details the evaluation which led to the identification of the preferred option. Before doing so, it is first worth considering what an 'ideal' outcome would look like.

3.2.2 Based on the problem definition set out on page 8, one key aspect of the ideal outcome would be for the amount of AUFLS provided by different stakeholders to be based on their relative suitability, thereby minimising overall costs. This may result in very different levels of AUFLS provision from different stakeholders than under the current common percentage obligation to AUFLS provision.

3.2.3 Offsetting any potential gains from an approach which varied the amount of AUFLS provided based on the relative suitability of different loads, would be the costs of design, implementation and operating any such alternative arrangements. If the costs of implementing such an approach outweighed the incremental benefits relative to a simpler approach, it would not be appropriate for the more complex approach to be pursued.

3.2.4 It is also worth noting that the technology associated with AUFLS and load control is continuing to evolve. Future AUFLS provision may be able to take advantage of opportunities which are not practicable today. For example, a larger number of smaller, faster-acting AUFLS blocks, more active participation of individual consumers, or the arming / disarming of blocks on a real-time basis to meet the on-the-hour need and allow load to be allocated to its highest value use (DD, DR, IR or AUFLS).

3.2.5 A key additional objective is therefore to choose an AUFLS procurement option that facilitates this progression to more 'sophisticated' future arrangements as this will be more dynamically efficient.

3.2.6 This aspect of an ideal AUFLS procurement mechanism is symptomatic of another desirable characteristic – namely being robust and durable such that it has sufficient regulatory flexibility to appropriately adapt to changing circumstances.

3.3 Range of options considered

3.3.1 The October 2012 consultation paper set out six different options, ranging from a slight variation on the current approach, through to a highly sophisticated half-hourly

AUFLS market similar to the current IR market. It identified two main preferred options:

- (a) an AUFLS market via an ancillary service-style tender
- (b) a common obligation approach, but facilitating commercial equivalence arrangements.

3.3.2 During the course of developing these options further, a number of new issues emerged⁷ which led to a third option being developed – centrally coordinated optimisation of AUFLS.

3.3.3 The three main options were outlined in the October 2013 workshops as follows:

- (a) option 1: Central Coordination. This consisted of a common percentage AUFLS obligation, but with facilitation of commercial equivalence arrangements, plus some system operator coordination of which loads were placed in which of the four AUFLS blocks
- (b) option 2: Optimisation. This consisted of using an optimisation approach to select which loads were placed under AUFLS. There were three main sub-options:
 - (i) option 2.1: Optimisation with no compensation, and with a central framework used to value the interruption costs of lines company load
 - (ii) option 2.2: As per option 2.1, but with stakeholders that provided AUFLS receiving compensation
 - (iii) option 2.3: As per option 2.2, but with lines companies determining the VoLL of their different feeders.
- (c) Option 3: Voluntary tender. This would be an AUFLS market, via an ancillary services style tender.

3.3.4 Based in part on the feedback from stakeholders from the workshops, a number of other sub-variants were identified. These relate to the ‘sophistication’ of market-based approaches, the design of any compensation and associated cost-allocation mechanism and the design of any mechanisms to address ‘special cases’ within a common AUFLS obligation framework.

3.3.5 All options are presented in Table 2 below, and can be categorised as three high-level families of approaches, with sub-variants.

⁷ The key issues related to the contractual ability of lines companies to voluntarily place their customers under AUFLS as part of a commercial agreement, and the complexity of arrangements required to facilitate AUFLS trades. These are both addressed later in this paper.

Table 2: AUFLS procurement options considered

High-level family	Sub-variant
Common AUFLS percentage obligation	Standard Code mechanisms (equivalence, dispensations and exemptions) used to vary individual stakeholders provision away from the common percentage requirement.
	As above, plus prioritised block coordination (i.e. enabling high value load to be put in AUFLS block 4 rather than block 1, and allowing small stakeholders to provide a single block of 32%, rather than four blocks of 10%:10%:6%:6%.)
	As above, plus special exclusions to exempt certain stakeholders, including: exempting direct connects from any obligation and allowing IL to be counted towards meeting an AUFLS obligation
	As above, plus profiled minimum and maximum obligations (i.e. varying the percentage obligation by time of day and year, and penalising for over-provision as well as under-provision).
Varying AUFLS provision via optimisation (i.e. the amount each stakeholder provides will be based on their relative suitability)	No compensation, plus central VoLL estimation of lines companies' load
	With compensation, plus central VoLL estimation of lines companies' load
	With compensation, plus lines companies' VoLL estimation of lines companies' load
Voluntary AUFLS tender	Simple pay-as-bid tender
	'Sophisticated' AUFLS market

3.4 Evaluation criteria and approach

- 3.4.1 In assessing the different AUFLS procurement options, the Authority has considered the extent to which each option promotes any or all of: Competition, Reliability, and Efficiency in the provision of electricity supply for the long-term benefit of consumers.

3.4.2 As well as qualitative analysis, the Authority has undertaken indicative quantitative analysis to estimate the costs and benefits of different options. Such costs and benefits have been grouped under the reliability and efficiency categories as follows:

(a) **reliability:**

- (i) achieving the ideal quantity of AUFLS load for the different times of day and year, thus reducing the risk of system collapse during an AUFLS event
- (ii) facilitating more sophisticated extended reserves technologies being procured in the future (e.g. real-time arming / disarming of AUFLS to fine tune to the on-the-hour risk) to lower the risk of system collapse even further.

(b) **efficiency costs and benefits include:**

- (i) implementation costs, including AUFLS relay capital and installation costs, and transactions costs
- (ii) on-going operating costs: including operation, maintenance, administration and overhead costs associated with AUFLS provision
- (iii) on-going allocative efficiency relates to:
 - extent of interruption costs from load under AUFLS
 - extent to which load can be used to provide IR, DD or DR rather than AUFLS if it is more valuable to do so.
- (iv) dynamic efficiency relates to the extent to which arrangements are adaptable to future changes to achieve additional reliability and allocative gains from new technology without the need to make substantial changes in approach.

3.4.3 Possible competition impacts have only been assessed qualitatively.

3.4.4 Using these evaluation criteria, the rest of this section discusses each option in turn qualitatively, before a final summary comparison is presented which draws upon the quantitative cost benefit analysis set out in Appendix B.

3.5 **Common AUFLS percentage obligation – with standard Code mechanisms to vary individual requirements**

3.5.1 This option is the current procurement approach. Thus, although the technical specification of what is to be provided will change (from providing two x 16% blocks, to providing four blocks in the 10%:10%:6%:6% ratio, with the fourth block additionally triggered using df/dt technology), the means by which it is procured would not change. A common percentage obligation requirement, with only the

standard Code mechanisms of equivalence, dispensation and exemptions would be available to alter such obligations on individual stakeholders.

3.5.2 The key issues with a common percentage obligation requirement are:

- (a) given the predominant within-day and within-year shape of load, the likely level of AUFLS provision will tend to deviate from the ideal amount at different times of day and year. Thus, generally less AUFLS will be provided than is ideal at times of low demand, and more AUFLS provided than is ideal at times of high demand. This will impact on the reliability score of this option
- (b) allocative efficiency issues arising from:
 - (i) some participants (particularly direct connects) may be forced to withdraw load from the IR market if required to provide a common amount of AUFLS. This is due to poor divisibility of their load and/or not wanting to place load under AUFLS because of very high VoLL
 - (ii) some stakeholders being required to place relatively high VoLL load under AUFLS, while other stakeholders have relatively low VoLL load which is not being placed under AUFLS.

3.5.3 These disadvantages of a common percentage obligation approach are particularly focussed on a few types of stakeholder, namely the direct connects and small lines companies (including those lines companies with a very large proportion of major industrial load on their network). Thus:

- (a) most of the potential IR cost impacts are focussed on the four direct connects that currently provide IL
- (b) many of the direct connects would be forced to arm some relatively high VoLL load if they were required to provide AUFLS
- (c) most direct connects and many of the smaller lines companies suffer from poor load divisibility issues which would likely require them to place a greater amount of their load under AUFLS than the obligated amount. This potentially exacerbates any IR, VoLL and system security issues.

3.5.4 There are three main mechanisms within the Code to address situations where it would be impractical, or unduly costly for a stakeholder to comply with an obligation under the Code: equivalence arrangements, dispensations or exemptions.

3.5.5 The efficacy of each of these to address the particular problems faced by direct connects and small lines companies is addressed in the next sections.

Equivalence arrangements

3.5.6 Under sections 8.29 and 8.30 of the Code, stakeholders can seek to be relieved of any obligation if they can put in place alternative arrangements which the system

operator agrees achieve an equivalent outcome. There are two main types of equivalence arrangement:

- (a) technical equivalence
- (b) commercial equivalence.

Technical equivalence arrangements

- 3.5.7 One option that has been considered is some stakeholders having different AUFLS relay settings which are deemed to achieve an equivalent technical outcome. For example, having relays that operate faster (e.g. 250ms rather than 400ms), having a higher trigger setting (e.g. 47.9Hz rather than 47.8Hz), or providing different numbers or sizes of blocks (while still providing the same overall common percentage quantities).
- 3.5.8 From the perspective of arresting system frequency in an under-frequency event, dropping a smaller amount of load faster / earlier in an event can be equivalent to dropping a larger amount of load slower / later in an event.
- 3.5.9 This may go some way to addressing some of the problems faced by some of the direct connects. For example, it could potentially reduce the amount of high interruption cost load dropped by stakeholders, or reduce the extent to which direct connects may need to withdraw IL from the IR market.
- 3.5.10 Based on initial discussions, it appears that technical equivalence solutions could address some of the issues faced by the current set of direct connects from a common obligation. However, it would require detailed engineering studies to establish the extent to which technical equivalence solutions would resolve issues.
- 3.5.11 It is possible that such solutions may not address all issues, and may still result in some stakeholders withdrawing load from the IR market, or placing relatively high VoLL load under AUFLS.

Commercial equivalence arrangements

- 3.5.12 If 'Party A' felt that it would incur excessively high costs from providing AUFLS then, subject to system operator approval, it could come to a commercial arrangement with 'Party B' whereby Party B would increase the amount of load it placed under AUFLS to relieve Party A from needing to provide AUFLS.
- 3.5.13 As set out earlier, generally the stakeholders for whom it would be most costly to provide AUFLS would appear to be direct connects – either because their load has a relatively high VoLL or because it would be more valuably used to provide IR, or

because of poor load divisibility.⁸ Accordingly, in general, the stakeholders that would appear to be most suited to relieve direct connects of their AUFLS obligations would be lines companies.

- 3.5.14 In evaluating this option, it became apparent that lines companies may not have the contractual rights to put their customers under AUFLS as part of a voluntary commercial agreement. Appendix D sets out this issue in more detail but, in brief, the issue is that while lines companies' current use of system agreements (UoSAs) grant them the rights to place their customers under AUFLS to fulfil a regulatory obligation, they may not have the rights to do so as part of a voluntary commercial arrangement. This contrasts with hot water load, where the UoSAs explicitly grant lines companies the rights to control such load (within limits) for whatever purpose it sees fit, including offering such load into the IR market.
- 3.5.15 As also set out in Appendix D, it is not considered practicable within the time-frame required to implement any new AUFLS arrangements to require lines companies to change their UoSAs to enable them to participate in AUFLS trades.
- 3.5.16 Use-of-system agreements developed based on the MUOSA (conveyance) would provide for distributors to put customers under AUFLS: clause 5.4 of the MUOSA provides that the distributor may carry out load shedding in various circumstances, including if automatic under-frequency load shedding is implemented in accordance with the Code.

- Q1. Please provide reasons if you agree that lines companies' UoSAs do not grant them the rights to place their customers' load under AUFLS as part of a voluntary commercial agreement. Please also provide reasons if you disagree.**
- Q2. Please provide reasons if you agree that it is not practical to change the UoSAs within the timeframe required to implement the new AUFLS arrangements. Please also provide reasons if you disagree.**

- 3.5.17 Lastly, even if the above issues were resolved, it is not clear that lines companies would have strong incentives to participate in such commercial deals. This is because it is possible that the costs and revenues associated with a lines company's participation in any commercial equivalence deals could be largely

⁸ Note: If a direct connect were forced to withdraw load from the IR market, it would not 'just' result in a loss of revenue for that direct connect, but would also lead to economic costs through the market needing to find higher cost sources of IR to replace the lost IL.

passed through to the lines company's end consumers through the operation of the Part 4 price control regime of the Commerce Act.⁹

Q3. Please provide reasons if you agree that lines companies will likely face weak commercial incentives to enter into bilateral commercial arrangements to vary their level of AUFLS provision. Please also provide reasons if you disagree.

Dispensations

- 3.5.18 Under section 8.29 of the Code, an asset owner can apply for a dispensation if it “cannot” comply with an asset owner performance obligation (AOPO) or technical code obligation in respect of a particular asset or configuration of assets.
- 3.5.19 The system operator must grant such a dispensation to the asset owner if the system operator has a reasonable expectation that the asset owner can continue to operate the existing system and meet its principal performance obligations (PPO) and if the system operator can readily quantify the costs on other persons of such a dispensation.
- 3.5.20 However, it is not considered that dispensations are a viable option in the case of AUFLS. This is because the system operator has indicated it would not be in a position to grant dispensations because the stakeholders could comply with the Code, if the Code provisions were enforced (the reasons for not enforcing the Code provisions are explained in 3.5.23 below).

Exemptions

- 3.5.21 If a participant considers that it is not necessary, for the purpose of achieving the Authority’s statutory objective under section 15 of the Electricity Industry Act 2010 for that participant to comply with the Code or a specific provision of the Code, and that exempting the participant would reduce the overall administration and compliance costs, it can apply for an exemption.
- 3.5.22 If the Authority Board agrees that this is the case, it may grant the exemption.
- 3.5.23 This is currently the case for the direct connects in relation to their obligation to provide AUFLS. Exemptions have been granted to the direct connects on the grounds that to require them to provide AUFLS would deliver higher cost outcomes than for them not to provide AUFLS, and that the divisibility of their load into the required blocks is problematic.

⁹ Because it is end consumers’ load being used to provide AUFLS (rather than lines company shareholders), the Commerce Commission may decide it would be appropriate for such consumers to benefit from any such deals and require any such revenues to be passed through as lower lines charges.

- 3.5.24 Given that dispensations appear to not be an option in the case of AUFLS, and technical and commercial equivalence arrangements may not adequately address all stakeholders' situations, it is possible that exemptions may be applied for if a common obligation approach were adopted. It is at the Board's discretion to approve or reject such an application.
- 3.5.25 However, it should be appreciated that exemptions are back-stop measures, put in place to avoid inappropriate outcomes to prevent stakeholders breaking the law or breaching the Code.
- 3.5.26 Therefore, the common obligation approach scores very poorly on the regulatory appropriateness criteria.

Summary of 'one-size-fits-all' common AUFLS provision

- 3.5.27 In summary, the above analysis suggests that equivalence and dispensations arrangements would be unlikely to address situations where a common obligation would result in a stakeholder withdrawing IL from the IR market, or placing relatively high VoLL load under AUFLS. Therefore this option does not score as well on the efficiency evaluation criteria.
- 3.5.28 Further, even if such arrangements could adequately address such situations, the quantitative analysis in Appendix B indicates that a common obligation approach does not do as well at targeting the right amount of AUFLS load for the different times of day and year as some of the other options, and thus does not score as highly on the reliability criteria.

3.6 Common AUFLS percentage obligation – with the additional use of prioritised block coordination

- 3.6.1 In addition to the use of equivalence arrangements as described above, one option that was considered was for all small stakeholders to provide the system operator with a ranking, or prioritisation, for all the feeders they were submitting to meet their common AUFLS obligation. This would then be taken into account by the system operator when determining which feeders to place in which AUFLS blocks.
- 3.6.2 This would enable the system operator to place relatively low value loads in block one (whose return period of being used is likely to be of the order of one in five years), and relatively high value loads to be in block four (whose return period could be of the order of one in 50 years).
- 3.6.3 Further, the system operator indicated that it could take into account load divisibility issues for direct connects and small line companies (noting that there would need to be some definition of 'small' to achieve such an outcome). Therefore, these companies may only be required to provide all their load as a single AUFLS block

(one 32% block), whereas large lines companies may be required to provide four blocks in the standard configuration (10%:10%:6%:6%).

- 3.6.4 While this may go some way to address the divisibility issue and differences in the VoLL of different loads, it may not adequately address the issue for direct connects whereby they may be forced to withdraw some load from the IR market. This is because, even if load is allocated to block four, it can't be offered as IL. Although this option scores more highly on the efficiency criteria than the previous option, it doesn't score as highly as options which can better enable IL not to be withdrawn from the IR market.
- 3.6.5 Further, the quantitative analysis in Appendix B indicates that a common obligation approach does not do as well at targeting the right amount of AUFLS load for the different times of day and year as some of the other options, and consequently does not score as highly on the reliability criteria.

3.7 Common AUFLS percentage obligation – with additional exclusions of specific stakeholders in the Code

- 3.7.1 One option that was suggested by a lines company representative during the October 2013 workshops was to acknowledge that it may be inappropriate to require direct connects to provide AUFLS, and thus exclude them from such a requirement. This could be achieved by drafting the Code such that AUFLS was only provided from lines companies and/or stakeholders above a certain size (to exclude small lines companies and some direct connects).
- 3.7.2 This could be implemented in addition to the previous mechanism of prioritised block coordination and use of technical equivalence arrangements.
- 3.7.3 Although this approach may appear to have some merits, it is not considered desirable for a number of reasons:
- (a) it is not clear in the case of excluded stakeholders (namely direct connects) that it will always be inappropriate to exclude them from the provision of AUFLS. It is possible that a new direct connect customer could be built whose load was suitable for the provision of AUFLS
 - (b) if the proposed AUFLS arrangements for the North Island are implemented in the South Island, excluding direct connects may not be possible because the size of the aluminium smelter at Tiwai is such that it may need to be included in AUFLS
 - (c) there may still be the special case lines companies who wouldn't be helped by such arrangements (Northpower with the refinery load within its' network or Horizon with its high proportion of industrial load).

- 3.7.4 Generally, it is not considered good regulatory practice to draft 'special case' Code around a few instances. Instead, it is more appropriate to draft Code that is sufficiently flexible to handle all circumstances in a rigorous fashion.

Q4. Please provide reasons if you agree that excluding direct connects from the obligation to provide AUFLS would be inappropriate. Please also provide reasons if you disagree.

Treating the provision of IL as meeting an obligation

- 3.7.5 In the Australian National Electricity Market, a stakeholder is deemed to have met its requirement to provide AUFLS if it instead provides interruptible load for the IR market.
- 3.7.6 If such an approach were adopted here, it would certainly address situations where a common AUFLS obligation was resulting in load inefficiently being prevented from being used for the provision of IR.
- 3.7.7 However, such an approach would not assist stakeholders with unusually high interruption costs or poor load divisibility.

Summary of options to address special cases

- 3.7.8 In summary, the mechanisms outlined above to deal with 'special cases' within a common obligation approach would likely address to a certain extent problems with IL load inefficiently being withdrawn, or high VoLL load being placed under AUFLS. Therefore they would score more highly against the efficiency criteria of the evaluation (although – as set out in Appendix B – probably not as well as the optimisation option).
- 3.7.9 However, the quantitative analysis in Appendix B indicates that a common obligation approach with mechanisms to address special cases would not achieve the right amount of AUFLS load for the different times of day and year, and would not score as highly on the reliability criteria.

3.8 Common AUFLS percentage obligation – with special exclusions, plus having profiled obligations with maximum as well as minimum compliance requirements

- 3.8.1 All the options for common percentage obligation outlined above suffer from the issue that the typical within-day and within-year variation in load will result in the amount of AUFLS provided deviating significantly from the ideal amount of AUFLS intended for different times of day and year – thereby scoring poorly on the reliability criteria.

- 3.8.2 It is likely that the ability to deliver the right amount of AUFLS load for different times of day and year could be significantly improved for a common obligation approach if the obligation:
- (a) varied on a within-year and within-day basis, plus
 - (b) imposed maximum as well as minimum requirements on stakeholders.
- 3.8.3 Coupled with the above mechanisms to address special cases, this could substantially improve the overall benefits of a common obligation approach.
- 3.8.4 The option of imposing a minimum plus maximum compliance requirement, potentially on a time-varying basis, was discussed with stakeholders in the early stages of the extended reserves project. However, there was generally strong feedback expressing reservations about such an approach if applied under the existing compliance regime – i.e. an obligation to provide the required percentage of AUFLS at all times.
- 3.8.5 However, the approach could be applied under the proposed ex-ante compliance regime set out in Appendix F, with much less compliance impact¹⁰ – particularly if stakeholder's were to use timers to meet their requirement.
- 3.8.6 An indicative assessment of the costs and benefits from this sub-option is provided in Appendix B, and suggests that this option would materially improve the reliability score for this option. However, it may take an extra six months or so to implement as it would require stakeholders developing the analysis to enable them to calculate the best configuration of feeders, timers and the like to satisfy their obligation requirement.

3.9 Varying AUFLS provision via optimisation – no compensation

- 3.9.1 This option consists of the following high-level elements:
- (a) an obligation on transmission-connected stakeholders to provide information to an AUFLS selection process. Such information would include:
 - (i) historical load patterns
 - (ii) likelihood of load being used for other demand-side purposes (e.g. dispatchable demand, IR, etc.)
 - (iii) VoLL (for direct connects only)
 - (iv) existing AUFLS relay capabilities.

¹⁰ The proposed compliance approach is that stakeholders would provide historical half-hourly data which proved that their load would meet the minimum and maximum obligation requirement within certain confidence levels, e.g. 99% of the time.

- (b) the system operator to use an optimisation tool to process the information, and select the optimal mix of loads to provide AUFLS. The VoLL for lines company load would be determined by a central mechanism
- (c) requirement on selected stakeholders to arm their load based on the AUFLS settings determined by the optimisation process (whether the load is suited for AUFLS block 1, block 2 etc.)
- (d) the system operator to repeat such a process at intervals it deems to be appropriate, but no less frequently than once every five years.

3.9.2 The Authority, as part of its cost benefit analysis (CBA), developed a proof-of-concept optimisation model and used it to evaluate the likely magnitude of benefits from this approach. The quantitative analysis set out in Appendix B indicates that varying the amount of AUFLS provided by stakeholders according to their relative suitability can deliver material benefits relative to a common obligation approach across a range of different criteria:

- (a) improved system reliability through better achievement of the optimal amount of load to be placed under AUFLS at different times of the day and year
- (b) minimised impact on IR, energy, and network costs through not preventing load from being more valuably used for such demand-side purposes
- (c) minimised AUFLS load shedding costs through avoiding high interruption cost load being placed under AUFLS
- (d) reduced AUFLS relay costs through being better able to take account of existing AUFLS capabilities, and not requiring AUFLS from very small / inappropriate stakeholders.

3.9.3 Compared to common obligation approach, this approach has some additional longer-term benefits:

- (a) it would likely facilitate the system operator being able to procure more sophisticated AUFLS services from participants (dynamic arming / disarming to meet the on-the-hour need) sooner than would be the case with a common obligation approach.¹¹
- (b) it is closer in form to a market-based mechanism than the common obligation approach (the optimisation tool could be used as the basis for a voluntary tender). It is also considered better suited to facilitating an evolution to more market-based approaches (which the Authority has indicated are generally

¹¹ It may be feasible to use more sophisticated AUFLS services under a common obligation approach but this is likely to increase compliance costs on stakeholders who are not able to provide these services at low cost, and increase the implementation time as the obligation approach would have to be delayed until all stakeholders were able to comply.

preferable to central-planning approaches where appropriate) as the technology to enable such approaches matures.

- 3.9.4 However, it should be noted that future benefits are likely to be muted under this option compared to an option which additionally includes compensation payments.
- 3.9.5 Lastly, because an optimisation approach would take account of what existing AUFLS relays and associated capabilities are currently installed, it is possible that this approach could result in a faster transition to new arrangements as it would more likely to select AUFLS from stakeholders that have existing capabilities rather than from stakeholders that need to acquire those capabilities. However, it is possible that a prioritised block coordination approach could achieve similar timing outcomes.
- 3.9.6 Offsetting any such benefits would be any extra costs associated with implementing and operating such a mechanism.
- 3.9.7 Appendix B sets out the detail behind this evaluation but the implementation and operation costs of such an optimisation approach are not likely to be significant relative to the likely benefits. Further, the implementation and operating costs are unlikely to be materially different to those of the other options. As set out in Appendix B, this is because many of the implementation and operation requirements would be common to all options.
- 3.9.8 Based on all the above, this option scores highest against the reliability and efficiency criteria.

3.10 Varying AUFLS provision via optimisation – with compensation payments

- 3.10.1 The load selection process under this option is the exact same as described in 3.8 above.
- 3.10.2 Parties providing AUFLS incur costs:
 - (a) the 'direct' costs of purchasing and installing AUFLS relays
 - (b) the 'indirect' interruption costs associated with the loss of load during an AUFLS event.
- 3.10.3 Under the current arrangements stakeholders do not receive any direct compensation for such provision, although lines companies will generally be able to

recover relay costs if they have included them within their regulatory asset base for determination of their price controls.¹²

- 3.10.4 Not paying compensation may be considered reasonable in a situation where all stakeholders are required to provide roughly the same amount of AUFLS, but could be considered unreasonable in situations where different stakeholders provide very different amounts of AUFLS.
- 3.10.5 Accordingly, one option that has been considered for the optimisation approach is for stakeholders providing AUFLS to be compensated for such provision, with the costs of any such payments being recovered via a cost allocation mechanism. Appendix C describes the detailed mechanics of such an approach.
- 3.10.6 Table 3 below, taken from Appendix C, illustrates the likely order of magnitude of payments from such a mechanism.

Table 3: Magnitude of compensation payments

	Units	Low	Middle	High
Total NI Load	Avg MW	2,800	2,900	3,000
AUFLS Armed	Avg MW	896	928	960
AUFLS load shedding compensation	\$k/yr	\$986	\$1,276	\$2,773
AUFLS relay compensation	\$k/yr	\$608	\$840	\$1,316
Total compensation payments	\$k/yr	\$1,594	\$2,116	\$4,089
Avg AUFLS compensation rate	\$/MWh	\$0.06	\$0.08	\$0.16
Net cost for 8MWh residential customer				
Maximum if no AUFLS supplied	\$/yr	\$0.5	\$0.7	\$1.2
Typical net cost/benefit	\$/yr	±\$0.2	±\$0.2	±\$0.4

- 3.10.7 As can be seen, the order of magnitude of payments across all stakeholders is not trivial (approximately \$2m/yr across all participants). However, given that the cost allocation approach is proposed to be a beneficiaries-pays approach, the *net* cost to most participants will be relatively small (negative for those stakeholders who provide a greater share of AUFLS than average). And for a typical residential customer the cost impact is estimated to be close to zero, with many customers potentially enjoying a slight reduction in their bills (of the order of 10 to 40 cents per year).
- 3.10.8 Despite these apparently small cost impacts on most participants, there are a number of potential advantages of such a mechanism:
- (a) it may bring forward the time when more 'sophisticated' AUFLS solutions can be implemented

¹² However, there is a risk to lines companies of not being able to fully recover the cost of relays if they are obliged to make significant *unanticipated* investments in AUFLS relays, after the prices for a 5 year regulatory control period have been set.

- (b) it will address potential concerns about stakeholders incentives to submit realistic load interruption costs
- (c) it would be more equitable, and could be considered to be good regulatory practice.

3.10.9 Each of these is addressed in turn.

Bringing forward the time when more ‘sophisticated’ AUFLS (extended reserves) solutions can be implemented

- 3.10.10 Future technological developments should enable superior technical AUFLS arrangements to those which are currently practicable. For example, communications technologies can facilitate real-time monitoring and arming/ disarming of AUFLS relays to meet the changing system conditions. This could deliver benefits in terms of improved system reliability and lower load shedding costs through being better able to match the load armed for AUFLS with the on-the-hour risk.
- 3.10.11 A payment mechanism could incentivise stakeholders to choose technical options for their relays which the stakeholder may not value now, but which could be of benefit to the system in the future.
- 3.10.12 For technical options which have low incremental costs,¹³ such a compensation mechanism could facilitate future benefits for relatively little cost.
- 3.10.13 The incremental cost of developing a compensation and cost allocation mechanism for the general AUFLS mechanism would not be great if the system operator were intending to develop arrangements to purchase and recover the costs for the procurement of ‘sophisticated’ AUFLS arrangements. In this respect, the system operator has indicated it is considering investigating the procurement of remote AUFLS arming / disarming services from some lines companies to enable it to ‘fine tune’ the level of AUFLS provision on a real-time basis.
- 3.10.14 An alternative would be for such technical options to be mandated.

Aligning stakeholders incentives to submit realistic load interruption costs

- 3.10.15 One of the key inputs into an optimisation approach is the estimated interruption cost of the different types of load. All other things being equal,¹⁴ this would enable

¹³ The marginal cost of providing the full set of capabilities to enable the relay to be used for any block is low when a relay is replaced. Some of this capability may already be available from existing relay protection relays. Also the extra cost of providing time switching capability and remote resetting may be low in many cases depending on the location of the relays and availability of SCADA.

the optimisation approach to select relatively low VoLL load to be placed under AUFLS and avoid higher VoLL load.

- 3.10.16 In options where participants submit their own estimates of the VoLL of their load (which is suggested to be the approach for direct connects for all optimisation options), this could give participants an incentive to submit unrealistically high estimates to avoid being selected to provide AUFLS.
- 3.10.17 The proposed compensation mechanism addresses this to a large extent through the associated cost-allocation mechanism that would allow the system operator to recover the costs of any payments.
- 3.10.18 As set out in detail in Appendix C, stakeholders who end up providing a greater proportion of their load than the average would end up receiving compensation. Stakeholders who end up providing a lower proportion of their load than the average would end up making payments.
- 3.10.19 This cost allocation approach means that a stakeholder which submits a high VoLL estimate for their load to not be selected will end up paying a higher amount through the cost allocation mechanism than if they'd submitted a lower VoLL estimate and were selected to provide some proportion of their load as AUFLS.
- 3.10.20 This proposed cost allocation approach is effectively a 'beneficiary-pays' approach to the provision of AUFLS.
- 3.10.21 During the October 2013 workshops, some participants suggested that a 'causer-pays' approach would be more appropriate. In this case, the 'causers' would be the owners of the large transmission and generation assets, whose potential failure gives rise to the need for AUFLS.
- 3.10.22 Appendix E discusses the relative merits of the two approaches and concludes that a beneficiary-pays approach is more appropriate in the case of AUFLS – in part because to move to a causer-pays approach would result in the loss of the benefit of aligning stakeholders' incentives to submit realistic VoLL costs.

Q5. Please provide reasons if you agree that a beneficiary-pays approach to recovering the cost of any compensation payments is likely to deliver more efficient outcomes than a causer-pays approach. Please also provide reasons if you disagree.

¹⁴ The optimisation approach also takes into account the different shapes of loads and their consequent reliability benefits. This may result in load which has a relatively high VoLL but a very good shape being selected over load with a lower VoLL but a poor shape.

3.11 Varying AUFLS provision via optimisation – with compensation payments, plus lines companies specifying their own VoLL

- 3.11.1 The load selection process under this option is the exact same as described in 3.8, with the only exception of who determines the VoLL.
- 3.11.2 For the optimisation approach, it is necessary to assign VoLL to loads at different feeders. The purpose of this is to avoid where possible placing very high value load under AUFLS (e.g. critical civil defence infrastructure, major CBDs or high VoLL industrial processes).
- 3.11.3 While direct connects have very good information about the VoLL for their load, it is not always the case that lines companies have similarly good information about the VoLL of their different customers. Some lines companies have raised concerns about being required to come up with VoLL which would influence which customers were selected to be on AUFLS.
- 3.11.4 There are two possible answers to this concern: provide lines companies with robust methodology and approach for determining VoLL for feeders; or designate that a single stakeholder is responsible for determining the VoLL for feeders.
- 3.11.5 Requiring lines companies to determine VoLL, without specifying they use a particular methodology, poses a risk of inconsistent values being provided, e.g. the VoLL one lines company ascribing to residential customers being different to another lines company. This could result in one lines company being selected to deliver a higher proportion of AUFLS for no sound underlying reason. This raises the possibility of lines companies elevating the VoLL for some customers to 'get out' of providing AUFLS. A good current example of inconsistent ascribing of VoLL is that some lines companies deliberately avoid feeders with hospitals on them, whereas others are comfortable placing hospitals under AUFLS feeders because they have back-up generation.
- 3.11.6 The risk of inconsistent assessments of VoLL by lines companies could be addressed by requiring them to undertake research of VoLL using the survey based approach developed through the Authority's investigation of the value of lost load. The Authority considers that there is a long-term benefit for consumers if decisions about investment and use of electricity infrastructure are informed by VoLL estimated using the survey-based approach.¹⁵

¹⁵ As detailed in Appendix B, this option does not score as highly on the efficiency criteria as the other optimisation options which use a central framework for estimating the VoLL values of lines company feeders.

3.11.7 Requiring lines companies to determine the VoLL of their customers' load may also result in significant additional cost. Based on the Authority's experience with the investigation of the value of lost load, individual research of the VoLL for a distribution network could potentially cost between \$100,000 and \$200,000. However, a single piece of research of VoLL for each distribution network could potentially cost between \$300,000 and \$400,000.

3.11.8 Consequently, there is an opportunity for lines companies to coordinate research of VoLL using the survey-based approach

A 'hybrid' approach for estimating lines company load

3.11.9 If the VoLL values were centrally determined, it is likely that a more consistent valuation of customer types would be achieved, and administrative costs could be saved. However, it would raise the potential for poor values in the case of 'special case' situations. For example, a number of lines companies said they had certain customers such as dairy factories for which there were particular contractual provisions about interruptions due to the very high interruption cost of such load.

3.11.10 On balance, it would appear appropriate for VoLL values to be centrally determined, but within a process that allows for 'special case' load at particular feeders to be identified and taken into consideration.

3.11.11 As set out on page 103 of Appendix F, it is proposed that the data submitted for the participant rolling outage plans (PROPs) process is used to estimate the different type of customers on each lines company feeder.

Q6. Do you have any comments about the preferred approach to determining the VoLL of lines company feeders?

3.12 Voluntary AUFLS tender - provision varying by stakeholder

3.12.1 An alternative to using a centrally-determined optimisation approach to achieve the goal of varying AUFLS provision based on participants' relative suitability, would be to develop an AUFLS tender-based 'market'.

3.12.2 At a high level, a tender option could work through stakeholders bidding in:

- (a) how much load they would be prepared to offer for AUFLS for different times of the day and year
- (b) a price they would be prepared to receive for making such load available, with such a price being based on participants' own assessments of the VoLL, and the opportunity cost of not being able to use their load for other purposes such as the IR market.

- 3.12.3 Such information would feed into a market tender ‘engine’ which would select the least cost stakeholders to provide AUFLS. This ‘engine’ could be largely based on the optimisation tool outlined for the previous option.¹⁶
- 3.12.4 In theory, an AUFLS market could deliver superior outcomes to a centrally-determined optimisation approach, given that markets are generally superior at achieving efficient resource allocation outcomes than central planning approaches. This is because individual stakeholders are generally better than a central body at determining the benefits and costs *to them* of their individual consumption and supply decisions. Markets provide the forum for all the various stakeholders to interact and express such relative values, thereby enabling efficient resource allocation outcomes.
- 3.12.5 This general presumption about the superiority of markets is reflected in Principle 6 of the Authority’s Code Amendment Principles: “*A preference for market solutions*”.
- 3.12.6 However, it is not necessarily the case that markets will always deliver superior outcomes to centrally-coordinated approaches. In order for markets to deliver good outcomes, market participants need the information, incentives and ability to reflect the value of their consumption and supply decisions appropriately in the market.
- 3.12.7 However, in the case of AUFLS it is not clear that the main stakeholders, the lines companies have the information, incentives, or the ability to interact fully in an AUFLS market.
- 3.12.8 This stems from the fact that the load that is being used to provide AUFLS comes from individual consumers, not the lines companies themselves.
- 3.12.9 Because of this, many lines companies have expressed reservations at being asked to determine the VoLL of their customers’ load, as they do not have good information on:
- (a) which types of customers are connected to which feeders
 - (b) a basis on which to estimate the VoLL of different types of customers.
- 3.12.10 Further, it is possible that lines companies would not have strong incentives to offer their customers’ load into an AUFLS market. This may be the case if the costs and revenues associated with a lines company’s participation in an AUFLS market were largely passed through to the lines company’s end consumers through the operation

¹⁶ It should be noted that this would only be appropriate for a highly simplified “pay-as-bid” auction with a number of restrictions on offers (e.g. stakeholders only bid a single VoLL number rather than a separate VoLL for each AUFLS block). Significant extra work would be required to derive or approximate “market clearing” prices for the different AUFLS blocks by time zone.

of the price control regime.¹⁷ In that case it would significantly dilute any incentive of the lines companies to participate in such a market.

- 3.12.11 Without well-informed and incentivised participants, there is a very real likelihood that this approach would result in inefficient outcomes relative to a central coordination approach. Central coordination approach has superior resources (and incentives) to undertake the necessary analysis to establish the likely value of different consumers' loads.¹⁸
- 3.12.12 Lastly, it is not clear that lines companies currently even have the contractual ability to voluntarily offer their customers load into an AUFLS market. Appendix D sets out this issue in more detail but, in brief, the issue is that while lines companies' UoSAs grant them the rights to place their customers under AUFLS to fulfil a regulatory obligation, they may not have the rights to do so as part of a voluntary commercial arrangement. This contrasts with hot water load, where the UoSAs explicitly grant lines companies the rights to control such load (within limits) for whatever purpose it sees fit, including offering such load into the IR market.
- 3.12.13 As also set out in Appendix D, it is considered that requiring lines companies to amend their UoSAs to enable them to participate in an AUFLS market is not a practicable option at this stage.
- 3.12.14 The above issues could be overcome if *individual consumers* were the stakeholders directly involved in bidding their load into an AUFLS market – as would be the case for direct connect consumers. However, as set out in the problem definition on page 9, while this may be practicable for very large industrial consumers, it is impracticable for smaller consumers, and is likely to remain so for many years to come.
- 3.12.15 Because of the fundamental issues associated with lines companies' participation in a voluntary AUFLS market, this option has not had any quantitative assessment applied to it, and is thus not included in the summary evaluation of the different options that follows.

Q7.	Please provide reasons if you agree that issues with lines companies' incentives and contractual ability are likely to severely reduce the potential
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¹⁷ Because it is end consumers' load being used to provide AUFLS (rather than lines company shareholders), the Commerce Commission may decide it would be appropriate for such consumers to benefit from any such deals.

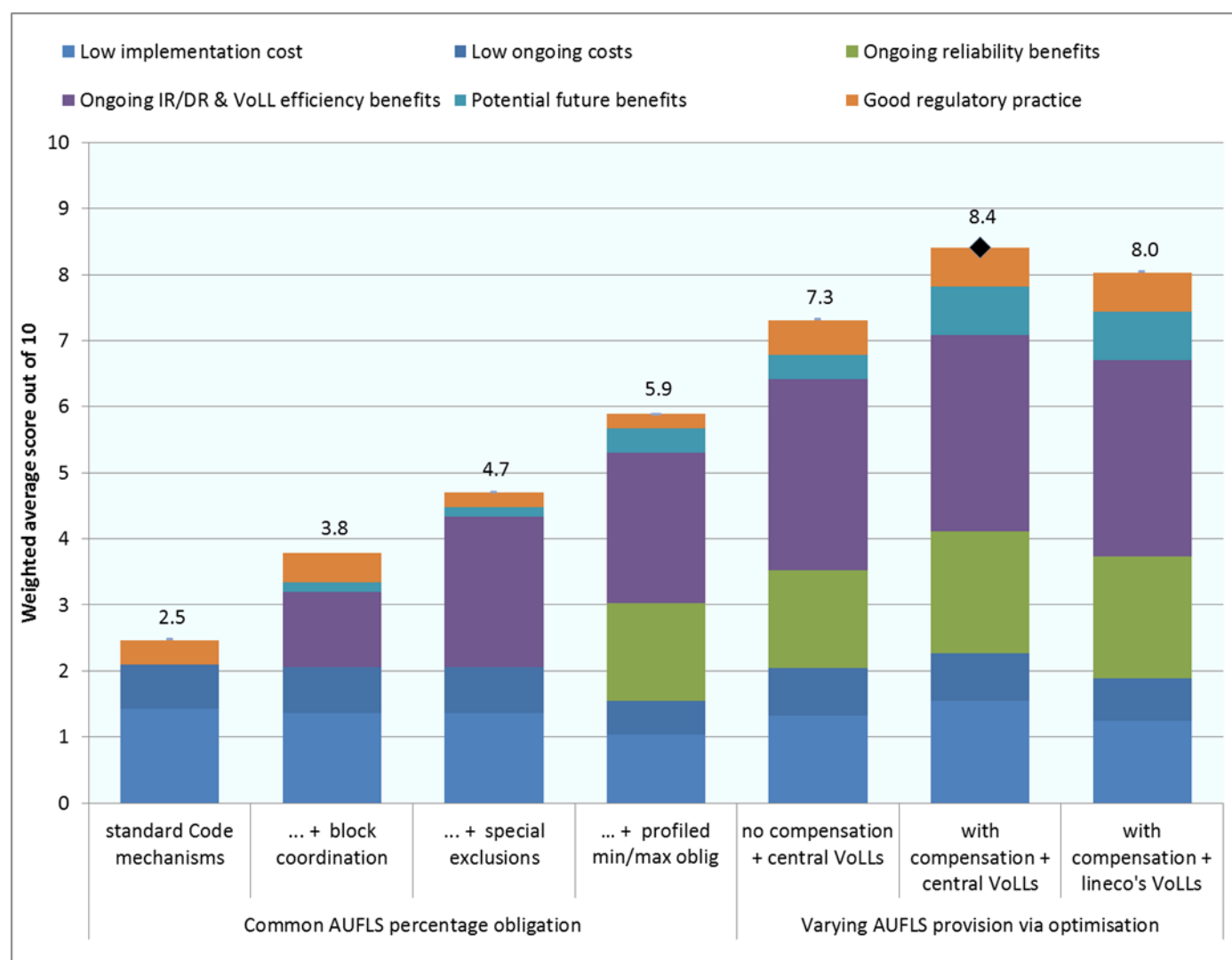
¹⁸ This is similar to the approach and conclusions the Authority has reached with regards to its review of Transmission Pricing Methodology (TPM) options. The TPM work identified a broad hierarchy of options which, from highest to lowest were: Market; Market-like; Exacerbator-pays; Beneficiary-pays; Administrative. In the same way that market options appear not to be practicable for AUFLS, the Authority concluded that market options were not practicable for the TPM. However, the AUFLS situation is slightly different, in that the preferred AUFLS option has a mix of market-like, beneficiary pays, and administrative elements.

effectiveness of a voluntary AUFLS tender. Please also provide reasons if you disagree.

3.13 Summary evaluation of the different AUFLS procurement options, and recommendation

3.13.1 A quantitative evaluation of the different options was undertaken to establish their likely costs and benefits. This evaluation, described in detail in Appendix B, formed the basis for the final scoring out of 10 of the different options as shown in Figure 2 below.

Figure 2: Option evaluation summary



- 3.13.2 The weightings and scores for each option and variant are detailed further in Table 4. As described below, these values are derived from the net present values (NPVs) of reliability and efficiency quantified in the cost benefit analysis outlined in Appendix B. They also include scores for other quantitative factors such as speed/ease of implementation of the new four block AUFLS design and good regulatory practice.¹⁹
- 3.13.3 Reliability benefits provide 25% of the score. These are highest for the common obligation with profiled minimum and maximum percentage supply, and the optimisation approach. Both enable improved targeting of the optimal level of AUFLS over the day and year and hence reduce the risk of system collapse.
- 3.13.4 The cost and ease of implementation accounts for 16% of the score. This includes the speed of implementation which is scored relative to the cost of a two year delay in implementing the new technical design (approx. \$13m NPV). Option scores for this criteria are similar for different reasons. Optimisation approaches involve a greater change from existing arrangements and requires development of an optimisation tool. This is offset by scope for lower capital costs (relay costs) and earlier implementation due to the ability of the optimisation approach to better choose feeders with existing AUFLS capabilities.
- 3.13.5 Imposition of a common profiled minimum and maximum percentage requirement to achieve extra reliability benefits might delay implementation if extra time is needed for all stakeholders to achieve this. The optimisation approach can more easily incorporate better targeting of AUFLS provision over time as and when the individual stakeholders are able to provide more sophisticated AUFLS services (timers, remote switching etc.) at a low incremental cost.
- 3.13.6 Incremental on-going operating costs account for 7% of the score. These are slightly lower for the “one size fits all” common obligation which scores the highest for this criteria. The scores for optimisation approach are not much lower as on-going optimisation costs are offset by:
- (a) potential savings in operating costs from economies of scale and scope
 - (b) better use of existing capabilities where this is available
 - (c) faster introduction of remote arming capabilities
 - (d) the optimisation trading off the costs of relays and capabilities against the benefits they provide.

¹⁹ The relative weighting of the categories was based on the size of the maximum achievable \$m benefits for each category, and the score given to each option was based on the extent to which it achieved this maximum level of benefit. The good regulatory practice category has no potential \$m benefit assigned to it to enable a pro-rata weighting to be calculated. Instead a notional 7% weighting was assigned to this category.

- 3.13.7 On-going IR/DR and VoLL allocative efficiency benefits account for 30% of the score. The common obligation with special exclusions and optimisation options score more highly as these do not risk any inefficient reduction in the supply of IL or other forms of demand response. The optimisation options also provide the scope to select AUFLS feeders and allocate to blocks so as to minimise the cost of AUFLS load-shedding.
- 3.13.8 Potential future benefits account for 15% of the score. These relate to reliability improvements from the earlier introduction of more dynamic monitoring and provision of AUFLS and better accounting for changing circumstances. These benefits are likely to be achieved more easily and quickly under the optimisation options as new dynamic AUFLS services can be procured as and when they become available. The payment mechanism could also be structured to incentivise stakeholders to include more sophisticated capabilities when new relays are installed.
- 3.13.9 The score for good regulatory practice accounts for the last 7% of the score and relates a range of qualitative factors discussed above including:
- (a) the risk of exemptions or special exclusions/treatments being required, which is higher for the common obligation options
 - (b) the acceptability and durability of the arrangements which are greater for the optimisation options which can be seen more enduring. These options can more easily accommodate the inevitable changes arising from new technology and the introduction of more diverse and dynamic forms of demand response.

Evaluation scoring conclusions and recommendation

- 3.13.10 The preferred option has the highest score of 8.4, which is similar to the main variants of the optimisation approach:
- (a) compared with the common percentage obligation options, the optimisation options offer significant reliability benefits, they:
 - (i) reduce the cost of AUFLS load shedding
 - (ii) reduce the risk of inefficient loss of IL and the loss of other demand side initiatives.
 - (b) optimisation options also provide a framework which can provide significant future reliability and other benefits from more dynamic monitoring and supply when this becomes feasible
 - (c) the use of explicit compensation payments and beneficiary-pays cost allocation provides for additional reliability benefits from the earlier introduction of new technology and better targeting of AUFLS supply. This also better aligns the incentives for direct connects to set accurate VoLL values, and

reduces the need for audit processes. The score falls to 7.3 without a payments mechanism

- (d) a centralised process for VoLL determination avoids the potential delay, duplication and inconsistencies of an individual lines company approach. VoLL estimates are inherently uncertain, and where it is cost effective lines companies can provide information about large sensitive loads which can be accounted for in the centralised methodology. Fully decentralised VoLL determination reduces the score to 8.1.

3.13.11 The best of the common percentage obligation options scores 5.9. This includes block coordination, special exclusions to avoid the IL/DD/DR cost impacts and a more complex profiled minimum and maximum obligation regime to increase the reliability benefits. This option does not score as well as the optimisation options as:

- (a) it will still require some small and high VoLL stakeholders to provide AUFLS (although with the block coordination approach, this impact should be significantly reduced)
- (b) imposing a profiled obligation requirement with minimum and maximum levels would likely take stakeholders longer to implement
- (c) it is more difficult to accommodate changes in technology
- (d) it does not score as highly in terms of good regulatory practice.

Q8. Do you have any comments on relative ranking of the options?
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Table 4: Option scoring summary

Option Scoring Table											
Common provision				Varying provision				Voluntary AUFLS tender			
Common AUFLS percentage obligation				Varying AUFLS provision via optimisation				AUFLS tender			
standard Code mechanisms				... + block coordination		... + special exclusions		... + profiled min/max oblig		with compensation + Ineco's VoLLs	
common level AUFLS armed common by party				no compensation + central VoLLs		with compensation + central VoLLs		with compensation + Ineco's VoLLs		none	
4				varies by party		varies by party		varies by party		none	
no coordination				limited		special exclusions		full coordination		IL/DR factored into optimisation	
technical/commercial equivalence				special exclusions		special exclusions		IL/DR factored into optimisation		optimisation includes VoLL costs or "bids"	
none				priority ranking within coy		none		central methodology		relay/VoLL payments and cost allocation	
n/a				n/a		n/a		central methodology		line company	
n/a				n/a		n/a		direct connects		direct connects	
Criteria				Score out of 10							
Weight				Score out of 10							
Reliability	25%	-	-	-	-	6	6	8	8	8	Not scored, as costs depend on market design and the option relies on developments in advanced metering and line companies having incentives and legal rights via LoS agreements.
Low implementation cost	16%	9	8	8	8	6	8	9	8	8	
Faster implementation of new scheme	10%	9	8	8	8	7	8	10	7	7	
Low code/systems cost	2%	9	9	9	9	6	6	6	6	6	
Low relay etc capital costs	4%	8	9	9	9	5	9	10	10	10	
Low ongoing operation costs	7%	9	10	10	10	7	10	10	9	9	
Allocative efficiency	30%	-	4	8	8	8	10	10	10	10	
Avoids inefficient "loss" of IL/DR	23%	-	5	10	10	10	10	10	10	10	
Lower AUFLS load shedding cost	7%	-	-	-	-	-	9	10	10	10	
Potential future benefits	15%	-	1	1	1	3	3	5	5	5	
Facilitates dynamic AUFLS supply	10%	-	1	1	1	2	2	4	4	4	
Facilitates dynamic demand side markets	5%	-	1	1	1	3	3	7	7	7	
Good regulatory practice	7%	5	6	6	3	3	7	8	8	8	
Weighted average score				2.5	3.8	4.7	5.9	7.3	8.4	8.0	
Key Issues:											
Relies on lines coy having rights and incentives to do voluntary transactions?	yes	some				no		yes			
Risk that exemptions or special exclusions are required?	yes	includes special exclusions				no risk					
Risk that direct connects may overstate VoLL?		n/a				high		low		lower	
Risk of inconsistent lines coy's VoLL ranking?		n/a				yes through choice of feeders and/or timers		higher			
Can target varying AUFLS by day/season?		no				yes via oblig		low		higher	
Makes best use of economies of scale/scope?	low	moderate				low		higher			
Makes best use of existing infrastructure/systems?	low	moderate				low		higher			
Can procure varying AUFLS supply capability if/w hen real time monitoring is introduced?	possible but not easily incorporated within 'standard' AUFLS procurement framework				more easily incorporated within 'standard' AUFLS procurement framework						
Facilitate efficient coordination of demand-side options?	possible but difficult/costly				payments can incentivise delivery of functionality		yes when real time monitoring introduced				

3.14 Other aspects of AUFLS procurement

- 3.14.1 The proposed AUFLS option has other aspects which could be different to the current arrangements, and which have not been discussed in detail in the above sections. In particular:
- (a) the compliance aspects of AUFLS provision
 - (b) the coordination of AUFLS with PROPs for dry-year security
 - (c) accounting for IL and other competing uses for demand for lines company load
 - (d) the detail of information requirements on stakeholders.
- 3.14.2 However, these aspects are generic to all the AUFLS options considered above, and therefore are not pertinent to determining which AUFLS procurement option to choose.
- 3.14.3 That said, they are issues that are likely to be of interest to stakeholders, and that need to be fully specified for the eventual implementation. Appendix F sets out a detailed description of these issues.

4. Timeline and next steps

- 4.1.1 Upon conclusion of this consultation, and after having considered all the submissions, the Authority intends to develop a draft Code amendment for the Authority Board to consider in April 2014.
- 4.1.2 It is planned that consultation on the draft Code will take place in April-May 2014.
- 4.1.3 Subject to the feedback received, it is planned that the recommendation on the final Code can be made to the Authority Board in June 2014.
- 4.1.4 Gazetting of the Code is planned for July 2014, subject to Board's approval of the final Code.
- 4.1.5 Given the desire to materialise the benefits of increased system security through new technical scheme design, the system operator will start developing the AUFLS implementation plan in early 2014.
- 4.1.6 Also starting in 2014, the system operator will begin the early phases of implementation work which will include:
 - (a) liaison with lines companies and direct connects about gathering necessary information about each feeder, ²⁰ prior to the Code amendment being made. Such information will include:
 - (i) historical half-hourly demand
 - (ii) information on the types of customers on each feeder (drawing upon the information already developed for PROPs)
 - (iii) other information which may be material to whether a feeder is suitable for AUFLS.
 - (b) developing the optimisation tool to a fully-formed prototype
 - (c) developing and consulting on the specific design of the compensation and cost allocation mechanism
 - (d) developing the central framework for valuing the VoLL of lines company feeders
 - (e) developing the arrangements to improve the visibility of what IL is likely to be located behind each feeder
 - (f) developing the arrangements to ensure coherence with the PROPs mechanism.

²⁰ As detailed in Appendix F, it is the intention that stakeholders are required to provide data about all their feeders at an appropriately granular level – i.e. at the zone sub feeder level where such data is available.

- 4.1.7 It is intended that the first stages of implementation of the new AUFLS regime will commence in the fourth quarter of calendar year 2014. This will consist of running the selection process and identifying those feeders that are required to provide AUFLS in the four different AUFLS blocks.
- 4.1.8 Given that some stakeholders are likely to be able to implement the new AUFLS regime sooner than others, a transition process will need to be undertaken, coordinated by the system operator. It is envisaged that this transition process will be complete by the end of 2016.
- 4.1.9 The above timeline will require resource from transmission-connected stakeholders at various points in the process. In particular:
- (a) providing information on historical half-hourly demand and other feeder characteristics. This provision will take place 'informally' during the first quarter of 2014 as part of the development phase, and 'formally' in September 2014 (or thereabouts) for the full implementation
 - (b) changing the settings on all existing AUFLS relays,²¹ and potentially installing new relays, coupled with testing, from Jan/Feb 2015 onwards.
- 4.1.10 It is envisaged the new North Island AUFLS regime will be completely in place by the end of 2016.

- Q9. Do you have any comments on the proposed timetable?**
- Q10. Do you need any more information to help you plan your resource availability to meet the requirements set out in paragraph 4.1.9**

- 4.1.11 The development of the South Island AUFLS arrangements is likely to commence once the implementation of the North Island AUFLS regime has been completed.

²¹ The revised frequency threshold triggers for the proposed new AUFLS technical design means that every existing AUFLS relay will need to its setting changed.

Appendix A Detailed description of the preferred procurement option

- A.1.1 The current approach to AUFLS provision sets a common obligation on stakeholders, and relies on mechanisms such as technical or commercial equivalence to address situations where it would be inappropriate for stakeholders to provide AUFLS. The proposed revised approach for AUFLS procurement seeks to identify *up-front* the relative suitability of stakeholders to provide AUFLS, and sets varying requirements accordingly.
- A.1.2 The revised approach achieves this through the use of an optimisation tool which considers all the different loads which could provide AUFLS, and selects the combination of loads which are expected to deliver the least overall cost.
- A.1.3 The specifics of how this are achieved are set out in the following paragraphs.

Parties would provide information to a regular selection process

- A.1.4 All stakeholders connected to the transmission network (lines companies and direct connect industrial customers) would be obliged to provide information for an AUFLS selection process that would occur relatively infrequently (at least once every five years). This information would be:
 - (a) Historical half-hourly data for all their loads. For lines companies this would be at the zone sub feeder level, for direct connects this would be based on the main divisible elements of their site that could be independently interrupted²²
 - (b) Information to help assess the interruption cost of such load:
 - (i) for lines companies, this information would be information about the type of loads on each of their feeders. (e.g. residential, commercial, industrial, specific high cost 'sensitive' load). This information would be used to estimate the interruption cost of each feeder, based on a common central framework for valuing different types of load
 - (ii) for direct connects, the information required would be the direct connect's own estimates of the VoLL associated with each load element.

²² In this respect it is worth noting that many loads within a direct connects site are connected via the industrial process, even if they are not part of the same electrical circuit. Thus, stopping one part of the site may lead to other parts of the site shutting down shortly after.

- (c) whether any of the load would likely be used for IR or other types of demand response such as dispatchable demand²³
- (d) the location, type, current settings, capability²⁴ and certification status of any existing AUFLS relays.

A.1.5 Further discussion on the information provision requirements, including the specifics of exactly what is to be provided, is set out in Appendix F.

An optimisation tool would select the lowest cost combination of loads to provide AUFLS

A.1.6 The information provided by stakeholders would be fed into an optimisation tool. The other key inputs to this tool would be:

- (a) the optimal percentage of system load to be placed under AUFLS for the different times of day and year. (Noting that, as set out in Appendix B, this is greater at times of low demand, than at times of high demand)
- (b) estimates on how, for the different times of the day and year, the risk of system collapse during AUFLS events will increase with increasing deviations away from this optimal amount
- (c) the estimated return period of different-sized AUFLS events (and thus the estimated return period of the different AUFLS blocks being called upon)²⁵
- (d) the nature of any limitations on the geographic spread of AUFLS²⁶
- (e) the cost of buying installing and testing the different types of relays and any associated 'extra' functionality (e.g. remote communications, timers).

²³ The requirement to provide such information may be different depending on whether the stakeholder is a direct connect or a lines company. Due to lines companies not having good visibility of what load is offered for IR or DD/DR underneath their feeders, a central process may estimate this based on information sourced directly from IR or DD/DR providers connected to distribution networks, Appendix F sets out this issue in more detail.

²⁴ The type of capability information would include whether the relay has: df/dt ability; remote arming / disarming; remote programming; and timer capability (i.e. the ability to turn on and off at pre-programmed times of the day and year).

²⁵ Initial high-level analysis suggests that the return period of the first block being called upon would likely be approximately one in five years, whereas the return period of the fourth block being called upon could be of the order of one in 50 years.

²⁶ This is because if the geographic disposition of AUFLS around the North Island were very imbalanced – e.g. predominantly in the Lower North Island. For instance, there could be major problems with the subsequent massive shifts in the flow of power across the transmission network following an AUFLS event which could overload transmission and network assets.

- A.1.7 The optimisation tool would seek the combination of loads to be placed under AUFLS that would result in the lowest overall cost to New Zealand. The key cost categories for this evaluation would be:
- (a) system collapse costs from having too little or too much AUFLS during an event
 - (b) increased electricity system costs associated with requiring some loads to provide AUFLS when they could be used for another purpose (e.g. IR, dispatchable demand, demand response initiatives.)
 - (c) the interruption costs during an AUFLS event of the load assigned to provide AUFLS
 - (d) the capital, installation and operating costs of the AUFLS relays.

- A.1.8 Having identified the least cost combination of loads to be placed under AUFLS, the system operator would notify the stakeholders responsible who would then be required to arm them accordingly.

The selection process would be run relatively infrequently

- A.1.9 It is intended that this selection process be run as frequently as the system operator deems appropriate. This has yet to be determined, but is not likely to be more often than once a year, and may be as infrequently as once every five years. It has yet to be determined whether it would be appropriate to place statutory requirements on the system operator with regards to how often it runs such a process.
- A.1.10 Further, it is intended that, after the initial optimisation, each subsequent time the process is run (known as ‘adjustment optimisations’) there would not be significant changes in terms of re-assigning feeders to provide AUFLS. This is achieved through the optimisation program knowing which loads have existing AUFLS capabilities, and assigning a cost for changing AUFLS capabilities (including taking into account whether a relay has remote programming / arming capabilities). A change such as having one feeder de-selected and another selected would only occur if the overall benefits were estimated to outweigh the incremental costs.
- A.1.11 The only time major changes to the AUFLS required of stakeholders may be likely to occur is if there were major changes to the NZ electricity system – e.g. the closure of the Tiwai smelter – or if the system operator were to significantly revise the technical requirements for the AUFLS scheme – e.g. a move to six blocks, and/or a greater use of df/dt triggers.

A new compliance approach is designed to minimise the burden on AUFLS providers

- A.1.12 From a compliance perspective, it is intended that the stakeholders responsible for the different loads would *not* be required to actively monitor on a half-hour-by-half-hour basis how much of their load is armed for AUFLS. Rather, the nature of the obligation would ‘just’ be to ensure that the selected load was armed to the specified AUFLS trigger settings using an AUFLS relay that meets the system operator’s specifications.
- A.1.13 As is set out in more detail in Appendix F, this revised compliance approach is intended to minimise compliance costs for stakeholders, and to address the systematic surplus provision. This arises from the current compliance approach that increases the risk of over-frequency collapse in an AUFLS event.²⁷
- A.1.14 It is possible that, where stakeholders have indicated they have a timer capability, the obligation may specify different time periods when the feeder should be armed and disarmed, using a relatively simple time of day/year structure. As is set out in Appendix B, the use of time-specific arming/disarming requirements could result in material reductions in AUFLS load shedding costs for similar (or even better) security outcomes (noting that only a portion of the AUFLS relays would be required to have this capability.)
- A.1.15 Based on informal discussions with stakeholders, it is possible that the use of pre-programmed timers could enable stakeholders to meet this time-specific obligation with minimal compliance overhead. However, a full investigation has not been undertaken on the use of timers, and it has yet to be determined whether they will be of net benefit for the provision of AUFLS.

Q11. Do you have any issues with the potential use of timers for arming AUFLS load?

Parties providing AUFLS will receive compensation, with the costs recovered from all stakeholders in proportion to their load

- A.1.16 Parties who provide AUFLS will receive a compensation payment to cover:
- (a) the cost of buying, installing, and operating any AUFLS relays
 - (b) associated communications equipment

²⁷ If too much load is dropped in an AUFLS event, the system frequency can shoot back up beyond the normal range, potentially above 52 Hz. Such over-frequency levels may cause some generators to trip, thereby causing system frequency to fall again, but this time without the benefit of under-frequency resources such as IR or AUFLS to arrest such fall given that they would have been used in the first under-frequency fall.

- (c) the expected annual interruption cost of their load during an AUFLS events.²⁸

A.1.17 The cost of such compensation payments will be recovered from all stakeholders in proportion to their annual load. This means that stakeholders who are required to provide a greater proportion of their load for AUFLS compared with the average would likely be net recipients of payments. Those who provide less AUFLS than the average would be net payers into the mechanism.

A.1.18 Given that it is consumers who ultimately benefit from having a secure system, recovering AUFLS compensation costs from stakeholders in proportion to their load is a 'beneficiaries-pays' approach to cost allocation.

Lines companies subject to control under Part 4 of the Commerce Act 1986 should not be disadvantaged (or advantaged) from this proposed AUFLS mechanism

A.1.19 Based on the Authority's initial discussions with the Commerce Commission, these AUFLS arrangements may be treated under the price / quality regulation of electricity distribution businesses as follows:²⁹

- (a) interruptions due to AUFLS events would not contribute to the SAIDI³⁰ / SAIFI³¹ / CAIDI³² statistics as they pertain to the quality aspect of the price / quality regulation. There would be no dis-benefit to any lines companies being required to provide a greater proportion of AUFLS than the average
- (b) any costs / revenues associated with AUFLS provision and the associated compensation & cost-allocation mechanism would be treated as a pass-through under the price aspect of the Part 4 control. Thus:
 - (i) any lines company would not be disadvantaged from being required to invest in a greater quantity of AUFLS relays than the average

²⁸ This expected *annual* interruption cost will take into account the expected return period of each AUFLS block being used. The expected annual interruption cost of load assigned to the fourth AUFLS block (which has an expected return period of approximately 1 in 50 years), is going to be approximately 1/10th of the interruption cost of load assigned to the first AUFLS block (which has a return period of approximately 1 in 5 years).

²⁹ The Commerce Commission's position is that until it has received a full specification of the new AUFLS arrangements, it is not in a position to definitively state how they would be treated under the Part 4 regime.

³⁰ System Average Interruption Duration Index.

³¹ System Average Interruption Frequency Index

³² Customer Average Interruption Duration Index

- (ii) end consumers would appropriately benefit from any compensation payments flowing through to reduced lines charges, given that it is their load that is being dropped, not the lines companies'.

A.1.20 With respect to this last point, it is not considered that lines companies would be required to develop arrangements which ensured that any such compensation payments flowed down through to the specific customers that were behind the feeders armed for AUFLS. This is because the billing-related transaction costs (both for networks and retailers) to achieve such outcomes would likely outweigh the size of such payments. These, as illustrated in Table 3 on page 31 are likely to be of the order of a few tens of cents per customer per year. Not only would such targeted compensation be economically inefficient, but would likely *increase* bills to consumers – including those who were receiving compensation.

A.1.21 Accordingly, it would be appropriate for compensation payments to reduce lines charges for all customers in a lines company's network.

A few points of detail remain to be fully specified

A.1.22 It should be noted that some specific points of detail still need to be fully specified. For example the detailed specifications around the information required, the formal mechanics of the payment mechanism. The important aspects of these are all addressed in Appendix F.

A.1.23 However, none of these remaining points are considered likely to fundamentally alter the expected costs and benefits of this proposed mechanism. Or, more importantly alter the *relative* benefits of this approach versus the other AUFLS procurement options that were considered.

Appendix B Indicative cost benefit analysis

Introduction

- B.1 This appendix analyses the costs and benefits of the alternative procurement options for implementing the system operator's recommended technical design for the North Island (four blocks of load on AUFLS in the ratio of 10%:10%:6%:6% with block four being on a df/dt relay).
- B.2 In other words, all options assume a change from the status quo in that significant changes are going to have to be made anyway to implement this revised technical design.

Evaluated options

- B.3 Section 3 sets out three broad families of options, with sub-options within each family

(a) Common percentage obligation

- (i) Using standard Code mechanisms to deal with special cases, particularly relating to small lines companies or direct connects who would find it impractical or very costly to provide the full four blocks.³³ This is the current approach to AUFLS procurement, except that for this cost-benefit analysis temporary exemptions are assumed to have ended. The existing exempted stakeholders have to rely on existing technical and commercial equivalence arrangements where it is impractical or costly to meet the obligation themselves. As discussed in Appendix D, lines companies may not have incentives or legal rights to enter into commercial arrangements to provide AUFLS to direct connects. In this case some direct connects may be forced to withdraw MW from the IR or dispatchable demand markets. In other cases, due to load divisibility issues, it may be expensive or impractical for direct connects or small lines companies to provide the four blocks in the required proportions. If commercial equivalence arrangements with lines companies are not feasible, then costly technical work might be required, or very high interruption cost load may need to be added for AUFLS

³³ There are approximately 21 (16 lines companies and 5 direct connects) stakeholders in the North Island. Of these, 14 (9 lines companies and the 5 direct connects) would be considered "small". These account for around 25% of the North Island load, with 75% in the 7 "large" line companies.

- (ii) As above, plus using prioritised block coordination to deal with special cases, particularly relating to small lines companies or direct connects who would find it impractical or very costly to provide the full four blocks. In addition to technical and commercial equivalence there would be a central block co-ordination mechanism whereby small lines companies and direct connects would provide a prioritised set of feeders. Each would still be required to meet minimum 26% overall, but they would not be required to provide all the individual blocks in the specified proportions. The system operator would allocate these feeders to individual blocks to meet the overall scheme design and taking into account the feeder priorities
- (iii) As above, plus using special exclusions for special cases, e.g. excluding direct connects or excluding stakeholders who are prepared to offer an equivalent level of IL with a maximum price
- (iv) As above, plus using profiled obligations with minimum and maximum limits, would specify that stakeholders must arm feeders to achieve AUFLS supply between a minimum and maximum limit. This limit varies according to time of day, day type and season.

(b) Varying provision via optimisation

This option would enable AUFLS provision to vary by stakeholder according to the suitability of their load. Lines companies and direct connects would be obliged to offer load for allocation to AUFLS blocks, and these would be selected via an optimisation tool. The optimisation tool would select the combination of loads which minimises costs (relays, AUFLS load-shedding, system collapse, and IR/DR) while meeting the technical and regional AUFLS design requirements. Sub-options in this family are:

- (i) no compensation payments, plus central VoLL estimation of lines companies' loads
 - (ii) with compensation payments, plus central VoLL estimation of lines companies' loads
 - (iii) with compensation payments, plus lines companies' VoLL estimation of lines companies' loads.
- (c) **Voluntary AUFLS tender**: This would also allow AUFLS provision to vary by stakeholder, but there would be no obligation to offer AUFLS feeders for selection. VoLL and relay compensation would be as "bid" by individual stakeholders. Payments would be made for AUFLS services supplied, and costs would be allocated in proportion to annual MWh load shares. The market could be an annual "as-bid"

tender with feeders selected using the same optimisation tool described above. Participants would be direct connects and lines companies. A sub variant includes the use of a more complex “market clearing” tender run more frequently.

- B.4 While the voluntary tender is a future option, it is not explicitly quantified or considered further in this cost benefit analysis. This is because, as set out in Appendix D, it is not clear that lines companies (who provide around 80% of AUFLS) currently have incentives or legal rights to offer their end-use customers’ load into a voluntary market.
- B.5 It is possible that future developments in advanced metering may facilitate such arrangements where AUFLS participation is at the individual consumer level and an AUFLS market may become a practical option. Until then many of the benefits of a tender based market approach can be achieved via a centrally coordinated optimisation approach. The optimisation approach can also be readily modified to form the basis of a voluntary market if and when this is justified.

Affected groups

- B.6 Costs and benefits apply to different groups:
- (a) the system operator:
 - (i) responsible for developing, operating and administering the systems required for each option. The system operator may use the Grid Owner as a service provider
 - (b) the Authority
 - (i) responsible for Code changes required to implement the technical design and procurement arrangements and to develop procedures or guidelines for assigning a relative VoLL value for each feeder based on information provided by participants
 - (c) 16 North Island lines companies:³⁴
 - (i) responsible for meeting any obligations, maintaining and installing relays, providing information to the system operator, and liaising with end-use customers and providers of demand response products behind feeders
 - (ii) may face consequential costs or benefits relating to the handling of AUFLS costs/benefits by the Commerce Commission in relation to the regulation of revenues and

³⁴ As set out on page 11, this evaluation is solely focussed on the North Island, hence only the North Island lines companies are affected.

service levels. This will determine if and how any cost allocation is passed through to end-use customers

- (iii) may also be required as part of the AUFLS procurement process to develop methods for assigning VoLL to each feeder or to rank feeders according to relative VoLL
- (d) 5 North Island direct connect industrial customers:³⁵
 - (i) also responsible for meeting obligations concerning installing and maintenance of relays and provision of information, but do not face flow on costs related to Commerce Commission regulation
 - (ii) gain the benefit of avoiding system collapse, but face the occasional loss of load to the extent they are on AUFLS relays. They may also face the cost of being inefficiently excluded or restricted from providing alternative demand product (such as IL).
- (e) end-use customers.
 - (i) these are represented by their lines companies and all gain the benefits of avoiding system collapse, but also face the costs of occasional loss of load if they are on AUFLS relays
 - (ii) depending on the AUFLS procurement option, end-use customers (as a group, or individually) may see a small benefit or cost association with the pass-through of AUFLS cost allocation or payments. These are treated as wealth transfers and do not contribute directly to the CBA.

B.7 While it is useful to identify the different stakeholders bearing costs or receiving benefits, the cost benefit analysis focuses on the net economy wide incremental benefits and costs ignoring wealth transfers.

Implementation costs

B.8 The following table summarises estimated implementation costs for the different procurement options. These are high level indicative estimates that will need to be refined and confirmed following consultation.

³⁵ The 5 stakeholders are: Norske Skog, Pan Pac Forest Products, Winstone Pulp International, NZ Steel, and KiwiRail. There are a number of other large users (some of whom are larger loads than some of the above direct connects such as the NZ Refinery) who are embedded within lines companies.

Table 5: Indicative implementation costs

Implementation Costs		Common AUFLS percentage obligation				Varying AUFLS provision via optimisation		
		standard Code mechanisms	... + block coordination	... + special exclusions	... + profiled min/max oblig	no compensation + central VoLLs	with compensation + central VoLLs	with compensation + lineco's
Num relays	num	450	437	437	450	405	405	405
% replaced	%	50%	48%	48%	53%	40%	40%	40%
"equivalence" or special agreements	Num	8	4	-	-	-	-	-
Cost to replace and test	\$m (1)	\$3.4	\$3.1	\$3.1	\$3.6	\$2.4	\$2.4	\$2.4
Cost to program and test	\$m	\$1.1	\$1.1	\$1.1	\$1.1	\$1.2	\$1.2	\$1.2
Contingency (25%)	\$m	\$1.1	\$1.1	\$1.1	\$1.2	\$0.9	\$0.9	\$0.9
Total Relay Cost	\$m	\$5.6	\$5.3	\$5.3	\$5.8	\$4.6	\$4.6	\$4.6
EA and parties code change & consultation	\$m (2)	\$0.5	\$0.5	\$0.5	\$0.5	\$0.5	\$0.6	\$0.6
SO Transition coordination	\$m	\$0.5	\$0.5	\$0.5	\$0.5	\$0.5	\$0.5	\$0.5
SO setup compliance systems & data base	\$m	\$0.1	\$0.1	\$0.1	\$0.1	\$0.1	\$0.1	\$0.1
Parties consult/setup compliance systems	\$m (3)	\$1.3	\$1.3	\$1.3	\$1.3	\$1.6	\$1.6	\$1.6
Negotiate technical/commercial equivalence	\$m (4)	\$0.5	\$0.2					
SO develop/implement block allocation	\$m		\$0.1	\$0.1	\$0.1			
SO develop/test optimisation tool	\$m (5)					\$0.6	\$0.6	\$0.6
Changes to ancillary payments system	\$m						\$0.1	\$0.1
Cost to develop and apply VoLL methodology	\$m						\$0.1	\$0.6
Total Overhead/Transaction cost	\$m	\$2.8	\$2.7	\$2.5	\$2.5	\$3.3	\$3.6	\$4.1
Total Implementation Cost	\$m	\$8.5	\$8.0	\$7.8	\$8.3	\$7.8	\$8.2	\$8.6
	<i>Low</i>	<i>\$6.4</i>	<i>\$6.1</i>	<i>\$6.0</i>	<i>\$6.3</i>	<i>\$6.2</i>	<i>\$6.5</i>	<i>\$6.9</i>
	<i>High</i>	<i>\$10.9</i>	<i>\$10.2</i>	<i>\$9.8</i>	<i>\$10.4</i>	<i>\$9.9</i>	<i>\$10.3</i>	<i>\$10.8</i>

Notes:

- 1: assumes \$15k for new relay installed and tested and \$5k to reprogram and test existing relay
- 2: assumes extra \$0.1m for payments and cost allocation
- 3: assumes 50 FTE days for 22 parties is 25% higher for optimisation
- 4: allows \$30k for each party cost per agreement
- 5: assumes a stand-alone tool for ad-hoc use annually.

B.9 As can be seen, many of the costs are required to implement the new technical design and do not vary significantly with the procurement option. These include:

- (a) Code amendment required to implement the technical design. This includes:
 - (i) changes to the obligations to North Island distributors and South Island grid owners within the Asset Owner Performance Obligations of the Code
 - (ii) an obligation on the system operator to develop a new "AUFLS Policy" document which outlines all the technical information for

the AUFLS framework, including the AUFLS requirement (per island)

- (iii) AUFLS scheme design technical details (such as number of blocks, block sizes, technology and relay settings).
- (b) an additional \$0.1m is allowed for the additional Code changes required to implement the compensation and cost allocation arrangements as discussed below
- (c) transitional costs – it is assumed that the system operator will need a full time equivalent for two years to design, manage and implement the transition to the new AUFLS design. An extra 800 hours is allowed to develop the compliance systems, procedures and databases
- (d) technical or commercial equivalence arrangements are likely to be required in the common obligation options if exemptions or special exclusions are not introduced.³⁶ These arrangements are not required in the optimisation options. It is difficult to know how many special arrangements might need to be developed, however it is likely to be at least five (the current number of exemptions excluding Northpower) and could be as many as 16 (the number of direct connects and “small” lines companies). The cost benefit assumes there are eight arrangements required under a rigid “one-size-fits-all” obligation as small stakeholders will probably find it impractical to provide all four blocks in the required proportions, and four with block coordination. It is assumed that the cost to negotiate and document these agreements is \$60k (or \$30k for each of two stakeholders)
- (e) provision of data – 400hrs for each of 21 obligated stakeholders is allowed to consult and setup systems and provide compliance data including:
 - (i) historical half hourly data for feeders
 - (ii) information on the level of IL (or other DD/DR) behind each feeder
 - (iii) information on relay type, verification of relay arming, disconnection dependencies etc.
- (f) relay change costs – it is assumed that there are around 450 relays which will need to be reprogrammed to achieve the new AUFLS design. The portion that will need to be replaced is uncertain but could be in the range 50% ± 10%. A conservative \$15k is allowed for

³⁶ It is noted that there are doubts that lines companies have the legal rights and incentives to enter voluntary commercial equivalence arrangements, but some mechanism will be required.

replacement and testing with a modern df/dt capable relay and \$5k for reprogramming and testing. A 25% contingency is allowed for a range of additional unknown costs. Relay numbers and costs are likely to vary according to the procurement option.

- (i) it is assumed that block coordination will reduce the number of relays required by 3%, compared with the “one size fits all” standard code approach. It is also assumed that the percentage of relays that need to be replaced to be reduced from 50% to 48%
- (ii) an obligation for all stakeholders to arm feeders to achieve AUFLS supply between a minimum and maximum limit which varies according to time of day, day type and season. This is likely to require more relays in total and a higher percentage of relays that need be replaced (possibly with timers). An extra 3% more relays and an extra 3% relay replacement is allowed
- (iii) the optimisation approach explicitly trades off the cost of resetting and replacing relays against the expected AUFLS load shedding cost and risk of system collapse. This approach can take advantage of economies of scale and scope available across the island (while recognising regional constraints). It is not known what cost savings may arise, but a 10±5% saving in the number of relays and 10±5% reduction in the percentage of relays needing to be replaced is feasible. The optimisation approach can achieve an AUFLS supply that better matches the ideal AUFLS profile by selecting feeders from of the full diversity available in the region, and by selectively using a small subset of feeders on timers as and when they are available.

B.10 Other costs which are specific to the procurement option are more relevant to the cost benefit analysis. These include:

- (a) an estimated \$100k cost to develop and consult on a common methodology to determine VoLL costs from information provided by lines companies, and the schedules for determining VoLL and relay compensation payments
 - (i) the cost for all lines companies to each develop, consult and apply their own VoLL methodology is not known with certainty, but could easily be \$30k each (on average), implying a 16*30k = \$480k.
- (b) an estimated \$100k for system operator development and testing of procedures and criteria for allocating AULFS to blocks for small participants

- (c) the cost of development, testing and initial use of the optimisation tool is estimated to be \$500k.³⁷ This assumes that the optimisation tool is a stand-alone tool design for ad-hoc occasional use. It will use data that required from the compliance system. Although a prototype has already been developed, the final cost is uncertain and will depend on the functional and non-functional requirements. It is expected that the non-functional requirements will not be too extensive, given that the tool will be relatively independent from other systems and will only be used occasionally (once a year). A range of \$300k to \$1m is allowed to account for the potential uncertainty in this cost estimate, which has been based on the cost of developing similar such tools.

Q12. Do you have comments on the indicative implementation costs used in the CBA?

On-going costs

- B.10.2 The following Table 6 provides estimated on-going operation costs under the different procurement options.

³⁷ A proof of concept prototype routine has been written in Matlab (which is also the tool currently used by the system operator for its Reserve Management Tool), but with an Excel front-end. Inputs to the tool include samples of half-hourly traces of load for each feeder from a full year, target AUFLS amounts to meet the security standard (differentiated by different times of the day and year), VoLL values for the different feeders, and IL load for each feeder. This routine uses a heuristic search procedure which starts from an initial “reasonable” selection of feeders and then progressively refines the selection by adding and removing feeders. The objective function uses penalty functions on deviations from the desired total AUFLS level pattern and allocation to blocks. Other penalty functions can be incorporated to deal with within-island regional allocation issues, or other desired secondary objectives. Given the uncertainty in VoLL costs and other inputs, the routine is not designed or guaranteed to find a unique optimum, but rather to identify a “sufficiently” good solution. Given that this tool would only be used occasionally the computational speed is not considered to be an issue.

Table 6: Indicative on-going costs

Total on-going operating costs		Common AUFLS percentage obligation				Varying AUFLS provision via optimisation		
		standard Code mechanisms	... + block coordination	... + special exclusions	... + profiled min/max oblig	no compensation + central VoLLs	with compensation + central VoLLs	with compensation + lineco's VoLLs
Business as usual relay replacement	num/yr	10	10	10	10	10	10	10
Extra Relays reset from optimisation	num/yr	-	-	-	-	10	10	10
SO AUFLS plan, compliance, liaison	\$m/yr	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3	\$0.3
Parties data/monitoring for compliance	\$m/yr	\$0.4	\$0.4	\$0.4	\$0.9	\$0.4	\$0.4	\$0.4
Administer technical/commercial equivalence	\$m/yr	\$0.1	\$0.0					
Relay business as usual replacement cost	\$m/yr	\$0.2	\$0.2	\$0.2	\$0.2	\$0.2	\$0.2	\$0.2
Relay fixed operating and maintenance cost	\$m/yr	\$0.2	\$0.2	\$0.2	\$0.2	\$0.2	\$0.2	\$0.2
Extra relays re-set in optimisation	\$m/yr					\$0.1	\$0.1	\$0.1
Total ongoing cost	\$m/yr	\$1.1	\$1.1	\$1.0	\$1.6	\$1.1	\$1.1	\$1.1
Total ongoing cost (1)	\$m NPV	\$9.8	\$9.3	\$8.9	\$13.5	\$9.2	\$9.2	\$9.2
	<i>Low</i>	<i>\$7.8</i>	<i>\$7.6</i>	<i>\$7.3</i>	<i>\$11.9</i>	<i>\$7.2</i>	<i>\$7.2</i>	<i>\$7.2</i>
	<i>High</i>	<i>\$11.9</i>	<i>\$11.2</i>	<i>\$10.5</i>	<i>\$15.1</i>	<i>\$11.5</i>	<i>\$11.5</i>	<i>\$11.5</i>

Notes:

1: Assumes 8% discount rate over 15 years

- B.11 As can be seen the common obligation options with additional mechanisms and the optimisation options are considered to have slightly *lower* on-going costs than the standard Code approach. The exception is the common obligation approach which is assumed to have extra compliance costs as discussed below.
- B.12 There will be a common overhead cost for the system operator to do the AUFLS plan, liaise with stakeholders on compliance. The cost of a little over one full time equivalent is allowed for this.
- B.13 This is not expected to vary significantly by option as the additional cost of running adjustment optimisations should be minor once the common data required for compliance monitoring is available.³⁸
- B.14 150 hours for each of the 21 stakeholders is allowed to provide data and monitor compliance. This is likely to be similar for each option, except for the profiled minimum and maximum common obligation. It is not clear what the extra costs would be for each stakeholder to comply with these

³⁸ As set out in Appendix A, it is considered that such adjustment optimisations would probably be undertaken relatively infrequently – e.g. once a year or possibly even less frequently. A full re-optimisation may occur only once every five years, or if there a major change to the system was to occur (e.g. the closure of the Tiwai smelter).

obligations, but it is likely to involve more careful and frequent relay adjustments and monitoring. An extra \$25k/yr per stakeholder is allowed.

- B.15 It is assumed that there will be an annual cost of \$10k to administer and deal with issues associated with each “equivalence” arrangement.
- B.16 The relay fixed operating, maintenance and business as usual replacement/testing/certification costs are assumed to be based on the number of relays required under each option.
- B.17 It is possible that there may be more relays that are required to be reset as a result of adjustment optimisation. An allowance of \$50 to \$200k is made for this, however it is the intention that adjustment optimisations will account for the costs associated with reprogramming or replacing relays. Changes would only be made if there was sufficient benefit to justify it. If a separate payment is made for stakeholders who have remote control capabilities, then any adjustments may be limited to these stakeholders and the cost would be minimal.

Q13. Do you have comments on the indicative on-going costs assumed in the CBA?

Benefits

- B.18 The scale of indicative benefits is outlined in Table 7 below. These are made up of reliability benefits and allocative efficiency improvements. The modelling used to calculate these benefits is described later in this Appendix.
- B.19 All benefits are measured relative to the status quo (i.e. the current 2-block technical design coupled with the common percentage obligation procurement approach).

Table 7: Indicative benefits

Benefits		Common AUFLS percentage obligation				Varying AUFLS provision via optimisation		
		standard Code mechanisms	... + block coordination	... + special exclusions	... + profiled min/max oblig	no compensation + central VoLLs	with compensation + central VoLLs	with compensation + lineco's VoLLs
Reliability Benefit								
Reduction in collapse risk	% per event	4.0%	4.0%	4.0%	4.8%	5.0%	5.0%	5.0%
Optimised - Time zone target (timers)						5.2%	5.2%	5.2%
Optimised - Ideal target (timers)						5.4%	5.4%	5.4%
Optimised - Full dynamic supply						6.1%	6.1%	6.1%
Base Case Reliability Benefit	\$m NPV	\$95	\$95	\$95	\$115	\$120	\$120	\$120
Optimised - Time zone target (timers)						\$124	\$124	\$124
Optimised - Ideal target (timers)						\$128	\$128	\$128
Optimised - Full dynamic supply						\$145	\$145	\$145
Allocative Efficiency								
Reduction in expected AUFLS load shedding costs	\$m NPV					\$9	\$9	\$9
	Low					\$7	\$7	\$7
	High					\$14	\$14	\$14
Saving from avoiding "loss" of IL or DR	MW lost	45	23	-	-	-	-	-
	\$m NPV		\$15	\$30	\$30	\$30	\$30	\$30
	Low		\$6	\$11	\$11	\$11	\$11	\$11
	High		\$27	\$54	\$54	\$54	\$54	\$54
Total Base Benefit								
	\$m NPV	\$95	\$110	\$125	\$145	\$160	\$160	\$160
	Low		\$101	\$106	\$126	\$138	\$138	\$138
	High		\$122	\$149	\$169	\$188	\$188	\$188

Notes:
1: Assumes 8% discount rate over 15 years

Notes:

1: Assumes 8% discount rate over 15 years

Reliability benefits

- B.20 As described elsewhere, the ideal quantity of AUFLS to have armed on the system varies with system conditions. Thus at times of low demand a relatively high proportion of load armed for AUFLS is desirable, and vice versa.
- B.21 However, the profile, level and volatility of AUFLS provided can vary materially according to the procurement option. This impacts the risk and cost of system collapse per AUFLS event. This is quantified using risk curves derived from the system operator's technical analysis as set out in B.59 and assumes a \$1.5 billion cost of system collapse and a return period for AUFLS events of 5.4 years.
- B.22 The base level of reliability benefits assumes that the common percentage obligation is to achieve a minimum 26% AUFLS at all times, and that the optimisation targets a uniform 32% level on average. However, as described in paragraphs B.66 the amount of AUFLS provided varies from

this ideal amount such that generally less than the target is provided at times of low demand, and more than the target at times of high demand. This deviation from the ideal will increase the risk of system collapse in an AUFLS event.

- B.23 It is feasible to better achieve the ideal AUFLS target at different times of the day and year under a common obligation approach if a more complex obligation is imposed on stakeholders. The table identifies the potential reliability benefit from imposing a minimum and maximum obligation limit around the desired 32%. Additional reliability benefits could be obtained by imposing profiled minimum and maximum limits which varied by time of day etc. It is assumed that 80% of the benefits from full optimisation can be achieved in this way.
- B.24 It is not known what the practicalities and compliance costs would be from imposing a min & max compliance requirement (particularly for smaller stakeholders and direct connects). However, there was considerable resistance from the industry to these more complex obligation structures being imposed across the board when they were discussed early on in the investigation.³⁹ As described in paragraph 3.8.5, if an ex-ante compliance approach was introduced, it is likely that the compliance burden of such an approach could be significantly reduced.
- B.25 The optimisation approach allows for the benefit of this form of targeting to be achieved without having to impose any more onerous compliance requirements on stakeholders. As described in paragraph B.71 (and again later in paragraph F.10) it achieves this through the selection of feeders whose combined diversified load closely matches the desired within-day and within-year shape of AUFLS. As further described in paragraph B.73, this can be improved further though taking advantage of timers on a small subset of feeders (supplied by stakeholders who are compensated for the costs involved) as and when they become available.⁴⁰

Allocative efficiency benefits:

- B.26 Allocative efficiency benefits include two separate components:
- (a) The lower cost of AUFLS load-shedding: The optimisation approach can reduce the expected cost of AUFLS load shedding by around \$0.9 to \$1.6m/yr (or \$7 to \$14m NPV) relative to a common percentage obligation with standard Code mechanisms as described in B.80

³⁹ It was also assumed that this more complex obligation would require real-time monitoring and control which many stakeholders would find costly or difficult.

⁴⁰ The use of timers was not explicitly considered in the earlier, but have the potential (subject to further investigation by the system operator) to provide additional reliability value without requiring real-time monitoring and control and without imposing significant additional costs.

- (b) The lower cost of IL/DR: A common percentage obligation approach has the potential to inefficiently exclude some direct connects from supplying alternative demand products (initially IL but potentially also DD or other DR products). The benefit of preventing this is estimated on the basis that the common percentage obligation with standard Code mechanisms could result in the loss of 25 to 60MW of IL at a cost of \$30m NPV and that 50% of this loss can be avoided with block coordination, and 100% can be avoided under the optimisation (and voluntary tender) options as set out in B.89.

Potential future benefits

- B.27 The system operator's technical study has identified the following developments which could further improve system reliability:
- (a) a move to a faster relay response time
 - (b) increasing the use of df/dt relays as confidence in their performance is gained through experience
 - (c) the use of timers to automatically arm and disarm relays to further reduce the risk of system collapse at different times of the day and year⁴¹
 - (d) the use of dynamic monitoring and remote arming/disarming to adjust the level of load on AUFLS in response to changing conditions (including the dynamic use of demand response for other purposes). This could be provided by a small number of "slack" providers who could be compensated for the service and would not require dynamic adjustment of the vast majority of AUFLS feeders.
- B.28 The compensation mechanism allows new services and technology to be adopted as they become available from those individual stakeholders who can provide them at low incremental cost. Some stakeholders have these capabilities already, or are planning them as a result of other initiatives or general infrastructure upgrading projects. Other stakeholders don't have the capabilities, or the scale economies to justify them. The optimisation or tender approach avoids the costs of imposing additional obligations on all stakeholders while enabling benefits to be obtained from utilising the additional capabilities from those stakeholders that can provide them at low incremental cost.

⁴¹ The possibility of using timers was not explicitly considered in the technical study, but is a potential option for the future

Future reliability benefits:

B.29 The use of more sophisticated targeting of AUFLS supply to meet the ideal profile through the use of a subset of feeders with relays on timers is estimated to reduce the risk of system collapse per AUFLS event by an additional 0.2 to 0.3% (relative to the reduction achieved without timers, (see Table 7 above).

- the value of this is estimated to be \$0.5 to 0.9m per annum, or \$3-6m NPV assuming that these benefit arises after 3 years.

B.30 More dynamic AUFLS monitoring and supply could potentially increase this reduction in the risk of system collapse per event by an additional 0.7%.

- the extra value of this is estimated to be \$2m/yr, or \$8m NPV assuming that the benefit arises after 6 years.

B.31 The total expected range of future value of reliability benefits available for the optimisation with compensation option is thus \$3 to \$13m. The cost benefit assumes a middle estimate of \$6m, which is at the upper end of the value achievable with timers without going to dynamic monitoring and supply as this option with probably involve some additional costs.

Future allocative benefits:

B.32 If there is a move to more dynamic monitoring and supply of AUFLS then it is likely that a better coordination of the different potential uses (IL, DD, DR, AUFLS) for demand side-response can be achieved.

B.33 The current proposal allows for a limited degree of co-ordination in that an estimated level of IL/DD/DR behind feeders is accounted for when feeders are selected for arming. This approach is likely to be somewhat conservative, and thus is likely to result in IL/DD/DR being restricted. If it is possible to monitor the level of AUFLS and the requirements more dynamically then it is likely that additional demand response can be made available for dynamic supply as IL/DD/DR. In the extreme, it would be possible for AUFLS to be co-optimised with IL/DD in SPD. This would achieve the highest level of co-ordination.

B.34 It is difficult to estimate the potential net benefit, but it is feasible that an additional 10-30MW of these products might be provided at a net value of \$6/MWh (based on the \$8/MWh price of FIR and SIR over the last 7 years minus an assumed interruption cost of \$2/MWh).

B.35 This would provide \$0.5 to \$1.6m/yr net benefit or \$2 to 6m NPV assuming that the benefit arises after 6 years.

Future restructuring cost savings:

- B.36 There is a general move to greater use of dynamic demand-side products as discussed above, and technology is changing all the time. These changes can be relatively easily accommodated as they arise within the optimisation (or voluntary tender) frameworks (particularly with compensation). However they are much more difficult and costly to accommodate under a common percentage obligation approach, as this will require that the common obligation be changed or a new approach to be taken. Any change in common obligation will affect all stakeholders and will need to be consulted on and negotiated with the whole industry. If past experience is a guide this is likely to be a time consuming and costly exercise.
- B.37 The potential future benefit of avoiding the need for this process is estimated to be between \$1-3m NPV assuming a \$1-\$3m cost saving in 6 years.

Q14.	Do you have comments on the indicative base level and future benefits assumed in the CBA?
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Summary cost benefit analysis

- B.38 The table below provides a summary of the costs and benefits of the different options.
- B.39 Note that this includes the risk and cost of potential delay in the implementation of the new AUFLS technical design if:
- (a) extra time is required for all stakeholders to meet more complex minimum and maximum percentage requirement
 - (b) profiled common obligations are required
 - (c) for all lines companies are each to develop, consult and implement their own methodologies to estimate VoLL.

Table 8: Indicative costs and benefits summary \$M NPV

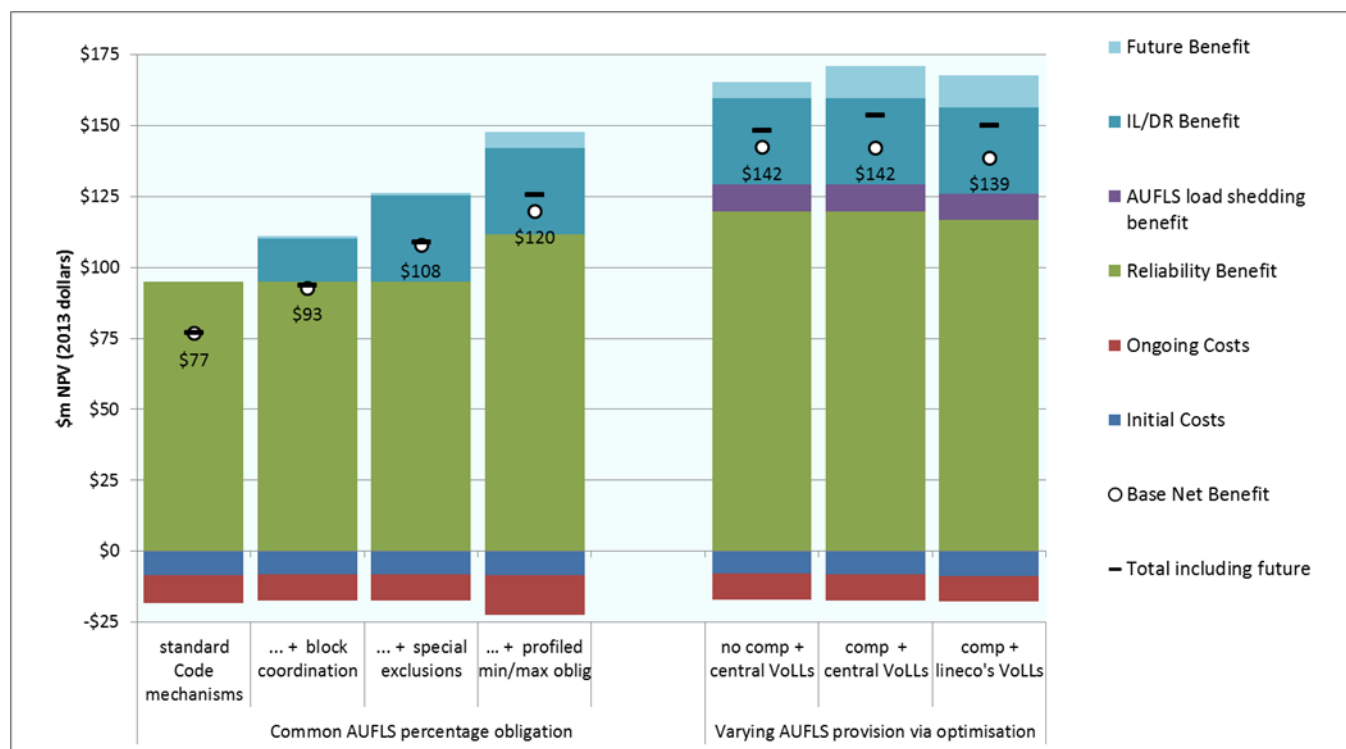
Summary Costs and Benefits	Procurement Option						
	Common AUFLS percentage obligation				Varying AUFLS provision via optimisation		
	standard Code mechanisms	+ block coordination	+ special exclusions	+ profiled min/max oblig	no compensation + central VoLLs	with compensation + central VoLLs	with compensation + lineco's VoLLs
Initial and Transitional Costs							
Total	\$8.5	\$8.0	\$8.0	\$8.5	\$8.0	\$8.2	\$8.7
On-going Costs							
Total	\$9.8	\$9.3	\$9.3	\$13.8	\$9.2	\$9.2	\$9.2
Base Benefits							
System Reliability	\$95.1	\$95.1	\$95.1	\$114.9	\$119.8	\$119.8	\$119.8
Cost of delay	\$0.0	\$0.0	\$0.0	-\$3.1	\$0.0	\$0.0	-\$3.1
AUFLs load shedding efficiency	\$0.0	\$0.0	\$0.0	\$0.0	\$9.4	\$9.4	\$9.4
IL & DR allocative efficiency	\$0.0	\$15.2	\$30.4	\$30.4	\$30.4	\$30.4	\$30.4
Total	\$95.1	\$110.3	\$125.5	\$142.2	\$159.6	\$159.6	\$156.5
Potential Future Benefits							
Facilitates dynamic AUFLS supply	\$0.0	\$0.0	\$0.0	\$2.8	\$2.8	\$5.7	\$5.7
Facilitates dynamic demand side markets	\$0.0	\$0.0	\$0.0	\$2.1	\$2.1	\$4.1	\$4.1
Future restructuring avoided	\$0.0	\$0.8	\$0.8	\$0.8	\$0.8	\$1.6	\$1.6
Total	\$0.0	\$0.8	\$0.8	\$5.7	\$5.7	\$11.4	\$11.4
Summary Net Benefits							
Base net benefit	\$77	\$93	\$108	\$120	\$142	\$142	\$139
Total net benefit (inc future benefits)	\$77	\$94	\$109	\$126	\$148	\$154	\$150

Notes:

All amounts are in 2013 million dollar present value terms, assuming an 8% real pre tax discount rate and 15 year period.

B.40 The components of these benefits and costs are compared in Figure 3 below. This also shows the base net benefit (excluding future benefits) and the total net benefit including the present value of future benefits. This shows that there is a significant common net benefit of \$77m in going to the four block AUFLS design regardless of the procurement option. This arises because the reliability benefits significantly outweigh the costs. However, the common obligation with additional mechanisms and the optimisation approaches provide significant additional benefits.

Figure 3: Indicative costs and benefits compared to status quo

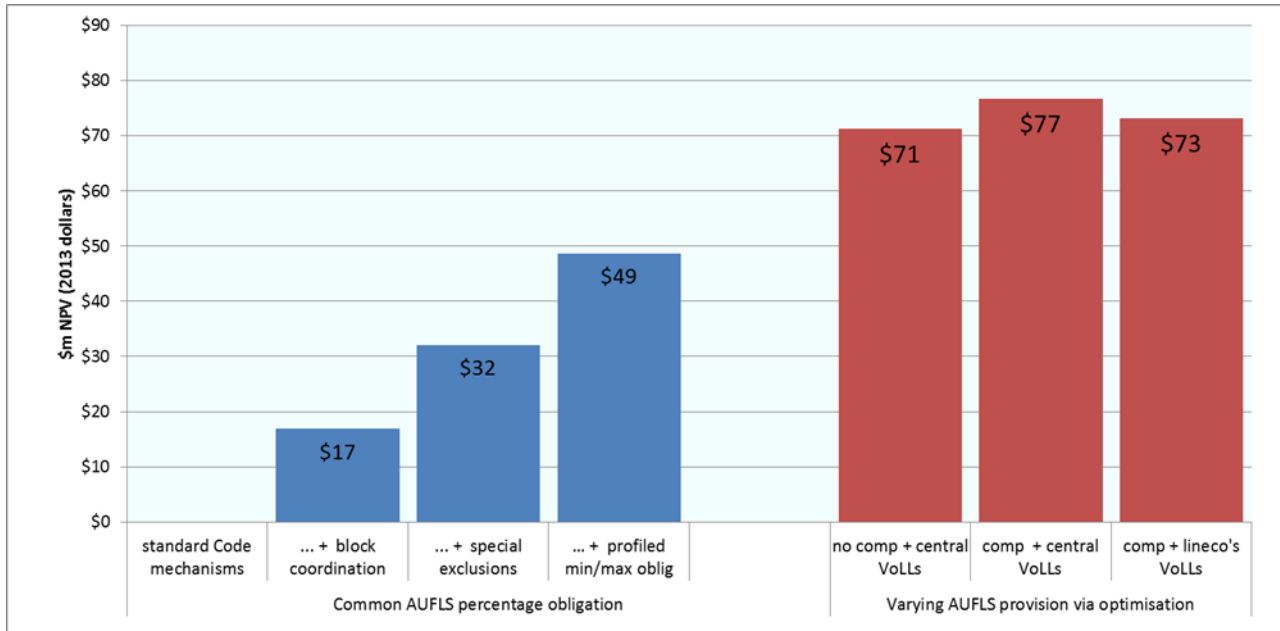


- B.41 Initial costs for the common obligation with mechanisms and optimisation options are relatively similar to the common obligation with standard Code mechanisms option as both provide savings in relay costs which offset the additional systems and transactions costs.
- B.42 It seems likely that there will be similar overheads for running the adjustment optimisations and adjusting the priority block allocations. There will be slightly higher transactions costs for the optimisation approach as it is likely to result in slightly greater relay resetting.⁴² There are likely to additional compliance costs for stakeholders if a more complex profiled minimum and maximum common obligation is applied.
- B.43 From the analysis undertaken by the Authority, there is reliability, AUFLS load shedding and IL/DR benefits from the optimisation family of options (immediate and future) compared with the common obligation family of options.
- B.44 Figure 4 shows the indicative total net benefit (including future benefits) for the different variants *relative* to the common obligation with standard Code mechanisms option. This option is effectively the “do-nothing” option, as it represents the current “one-size-fits-all” approach that would have to be

⁴² Note that the cost of this may be minor if adjustments are made to relays with remote arming capability.

used to implement the new AUFLS technical design if there was no change in the procurement approach.

Figure 4: Indicative net benefits compared to “do-nothing” procurement factual



- B.45 The common obligation with block coordination mechanisms provides approx. \$17± 11m NPV net benefit.
- This would increase by \$15m to \$32m NPV if dispensation, customised obligations or exemptions could be introduced to avoid any inefficient loss of IL/DR
 - If, in addition, the common obligation were to include profiled minimum and maximum limits, then the net value would increase an estimated \$17m to \$49m NPV.
 - this arises from \$25m NPV (80% of the \$25m NPV increased reliability value and 50% of the potential future value available under compensated optimisation) minus an extra \$25k/yr per participant compliance cost (=\$0.5m/yr or \$4.5m NPV), and a 6 month delay in implementing the new AUFLS design costing \$3m NPV ($\$77m \times 8\% / 2$).
- B.46 The optimisation option with compensation payments and Authority determined VoLL for lines companies provides \$77 ± 38m NPV benefit relative to the standard Code approach
- If there were no compensation payments there could be some minor savings related to Code changes and administration of the payments system. These cost savings are likely to be modest (probably less than \$0.2m NPV) and more than offset by the lost benefits from no

longer aligning incentives for direct connects, and not so easily facilitating the procurement of more dynamic and special AUFLS services in the future. The total cost of this is estimated to be up to \$5m NPV

- (b) If the 16 lines companies each determined VoLL for their own feeders rather than the Authority, there is potential for greater accuracy. However, as set out in Appendix D, this could only be achieved by surveying end-use customers. This has been shown to be expensive and time consuming and still produces highly uncertain estimates, with a significant risk of inconsistent estimates. A centralised, co-ordinated approach (based on information provided by lines companies and, potentially, from very large customers within lines company regions) will have a lower cost. This method is likely to provide reasonable estimates quickly and a much more consistent ranking of VoLL for feeders
 - (i) the additional cost of lines companies determining VoLL individually is estimated to be \$0.5m (\$30k per stakeholder) plus \$3m NPV ($\$77m \times 8\%/2$) for a 6 month delay in implementing the new AUFLS design.
- (c) The base case value for the optimisation does not include the benefit of using timers on a subset of AUFLS feeders to target the ideal profile of AUFLS supply. Allowing for this would increase the incremental net value by around \$8m to \$85m NPV.

Approach to quantifying AUFLS load-shedding and system collapse costs

- B.47 The estimated benefits of reduced AUFLS load-shedding and system collapse costs for the options compared to the standard Code approach have been calculated through undertaking detailed modelling.
- B.48 Actual data is not available for all the AUFLS feeders by participant in the North Island and so benefits of reduced AUFLS load shedding and system collapse costs are estimated using synthetic data.
- B.49 While this data is not fully reflective of actual participant data, it is reasonably realistic and includes the range of different participant situations. It can be used to estimate the relativities and order of magnitude of costs expected under each procurement option.
- B.50 Costs have been estimated as follows:
 - (a) establishing a common set of illustrative synthetic half-hourly data for 226 feeders based on GXP profiles from 2012 as discussed in section B.56 below

- (b) simulating the selection of feeders for arming according to the procurement option:
 - (i) by manual selection in the individual obligation approach
 - (ii) by use of a prototype optimisation model for other options.
- (c) calculating the expected annual AUFLS load shedding and relay costs as outlined in B.94
- (d) calculating the expected cost of system collapse taking into account the level and half hour variability of AUFLS supply for the procurement option as outlined in B.59.

Manual simulation - common percentage obligation option

- B.51 This option is manually simulated by allocating the illustrative feeders to meet the obligation of providing at least 26% at all times or around 32% on average over the year.
- B.52 The typical degree of conservatism observed from the past (systematic over-provision of AUFLS load as described in Appendix F) was factored in, so that around 35% AUFLS supply was made available overall. The assumed level of IL behind each feeder was accounted for.
- B.53 Where possible, feeders were allocated on the basis of assumed availability of existing relays, feeder size relative to block requirements, and VoLL ranking within participant. There was no attempt to fully optimise.
- B.54 Where there were an inadequate number of feeders to meet the requirements for all blocks, the overall 32% was allocated to 1 or 2 blocks as appropriate. Not all participants could achieve 26% at all times, and some has to provide more than the minimum due to lumpiness.

Software optimisation - rest of the options

- B.55 These options are optimised using the prototype optimisation tool, developed by the Authority. This accounted for VoLL and new relay costs as well as the assumed level IL behind each feeder. It was assumed that all feeders were made available for the optimisation to select. The objective function was set up to achieve the desired total island supply of AUFLS to achieve the lowest overall risk of system collapse. Two variants were tested, one aiming to achieve 32% on average at all times, and the other aiming to best meet the ideal profile (45%, 32% and 25% at low/middle/high load respectively, as derived by the Authority based on the system operator's technical report). In all cases the distribution of AUFLS between blocks was targeted to be in the proportions 10%:10%:6%:6%. Within-region constraints were not simulated in this

prototype, but would need to be accounted for in the final model. This is not expected to substantially affect the conclusions.

Assumptions used in the analysis

Feeder data

- B.56 Data for actual feeders is not yet available. However, it is possible to come up with reasonable illustrative data derived from GXP profiles from the last year. The cost benefit analysis is based on an illustrative set of feeder participant data which reflects the range of different participant sizes and situations.

Table 9: Illustrative demand and feeder data

Participant	Avg MW in 2012	%	Num Feeder	Avg IL /DR MW	Avg VoLL \$/MWh
A	484	18%	14	84	\$18
B	342	13%	32	77	\$22
C	161	6%	30	14	\$21
D	143	5%	12	24	\$22
E	265	10%	18	36	\$18
F	98	4%	22	2	\$23
G	281	10%	30	10	\$22
H	222	8%	22	14	\$24
I	44	2%	4	4	\$17
J	134	5%	4	13	\$24
K	128	5%	8	12	\$22
Ind 1	63	2%	4	33	\$17
Ind 2	109	4%	4	34	\$16
Ind 3	67	2%	6	30	\$13
Ind 4	21	1%	2	9	\$18
Ind 5	30	1%	2	15	\$14
Ind 6	52	2%	2	18	\$13
Total	2,686	100%	226	453	\$21

- B.57 Note that typically only 100 of the modelled 226 feeders are required to meet the AUFLS requirements in the North Island with this illustrative data. This is less than the current 460 AUFLS relays in the North Island, but serves to illustrate the potential benefits of the different approaches, and the results are not particularly sensitive to this assumption. Where appropriate, results from the illustrative data are scaled to reflect current number of feeder relays.

- B.58 It is assumed that there is a varying quantity of IL or other demand response products behind each feeder. This is accounted for when feeders are selected to be armed for AUFLS. The assumed level of IL/DR is somewhat higher than current levels, but the results are not sensitive to this.

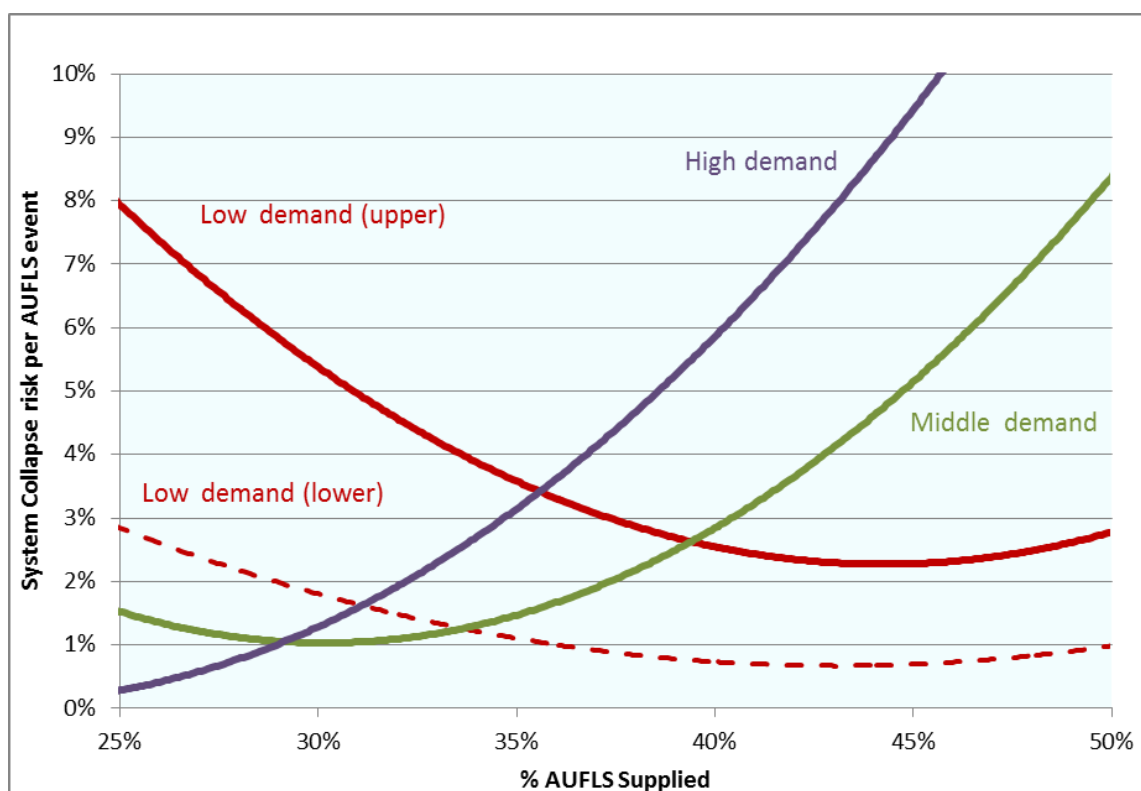
Cost of system collapse

- B.59 The expected cost of system collapse is derived as follows:
- (a) $\text{expected cost} = \text{Cost of system collapse} / \text{AUFLS return period} * \text{risk of system collapse per AUFLS event}.$
- B.60 The Authority has estimated the risk of system collapse per AUFLS event using the approach developed by the system operator as described in “AUFLS Scheme Design”, 7 Aug 2013 section 7.3.1. The risk is based on the chosen technical design, allowing for a 25% chance of non-performance of the df/dt component of the relays.
- B.61 The risk of system collapse is expressed as a function of the total level of AUFLS supplied, for 3 demand levels (low, middle and high). For the middle and high demand cases, the system operator simulated a wide range of disturbances for a DC risk (e.g. HVDC bi-pole), and an AC risk (using the proxy of the Huntly site which currently represents an AC risk of a similar magnitude to the DC risk). The AC risk was assumed to be four times less likely than the DC risk (bi-pole trip). For the low demand case the system operator considered the varying magnitude of an AC risk when the HVDC was not operating. This AC risk is considered to have similar consequences to a DC risk. Hence the same simulation can be used to represent either eventuality.
- B.62 These risk curves are sensitive to the assumptions concerning the probability distributions for both HVDC flows and Huntly site generation.
- B.63 For each procurement option the Authority has estimated an overall risk measure by deriving the risk for each half hour (accounting for the expected pattern and variability of AUFLS supply and linearly interpolating between the risk of system collapse curves) and then averaging over all half hours. The level and variability of AUFLS supply is estimated based on the feeders assumed to be armed for AUFLS under the procurement option and the historical half hourly data of load per feeder.
- B.64 This risk measure is then converted to an expected cost per annum and a NPV based on 15 years at an 8% pre-tax real discount rate and assumptions relating to the cost of system collapse and the AUFLS return period.

Table 10: System Reliability cost assumptions

Assumption	Middle Value	Low Value	High Value
Cost of system collapse	\$1.5 billion	\$1.0 billion	\$2.0 billion
AUFLS return Period	5.4 yrs	4 yrs	6 yrs
Risk of system collapse per AUFLS event	Risk curves derived by the system operator based on detailed simulation of a range of double and extended contingency risks.	Lower Risk (see figure 2)	Upper Risk (see figure 2)

Figure 5: Risk of system collapse curves



B.65 The chart above indicates that the system collapse risk can be minimised by targeting around 45% AUFLS supply at times of low load, 25% at times of high load and 32% at times of medium load. These are used for illustrative analysis, but further work would be required from the system operator to confirm them.

B.66 Thus the overall level of system collapse risk depends on the profile, level and variability of total AUFLS supply. This will vary depending on the

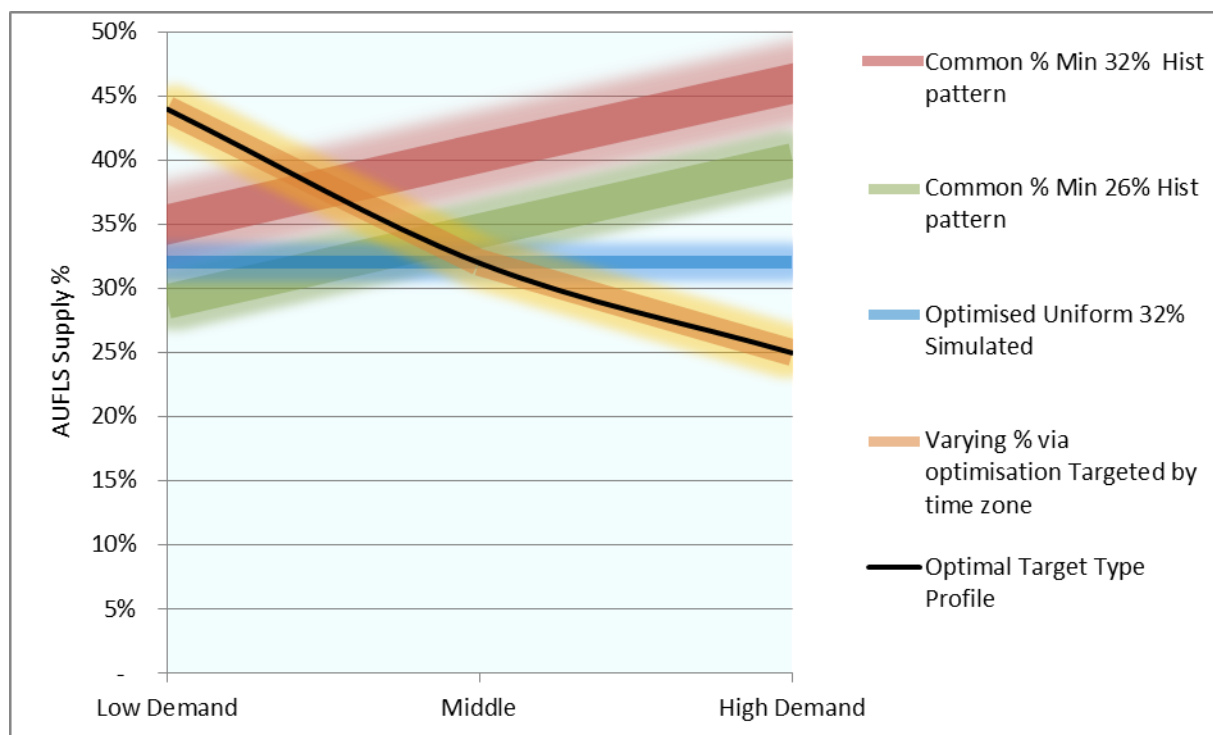
procurement option and the selection of feeders which are armed for AUFLS. This is illustrated in Figure 6 below.

- B.67 The black line shows the ideal pattern of AUFLS supply as discussed above. This will deliver the lowest overall risk of system collapse at high, middle and load loads.
- B.68 It has been observed that the existing minimum 32% obligation has resulted in an overall level of AUFLS provision of around 35% at low loads and around 46% at high loads.⁴³ There is an additional random variation around this pattern as indicated by the thickness of the red line shown in the chart.
- B.69 If the common minimum percentage obligation procurement approach is continued, then the system operator has proposed that the minimum be lowered to 26% to reduce the risk of system collapse as a result of over provision at peak times. The resulting level of AUFLS supply is shown by the green line below.
- B.70 If the historical pattern of supply continues then there is a reduction on the risk of system collapse, but the pattern of supply is far from ideal. It is not entirely clear what is driving the observed historical profile, and this may change as a result of the move to an ex-ante compliance regime. The simulation of a 26% minimum obligation based on illustrative data indicates that a flat profile could emerge, but this is highly uncertain.
- B.71 A move to an optimisation procurement approach enables much greater certainty as to level and profile of AUFLS supply, as feeders can be chosen to target a desired profile and to minimise the variability in supply fully accounting for the diversity of load across the relevant region.
- B.72 Simulation studies using the illustrative feeder data shows that it is feasible to achieve a uniform 32% supply with a 92% percentile range of $\pm 1.7\%$ as illustrated by the blue line.
- B.73 However it would also be possible to achieve a pattern close to the ideal target. As shown by the orange line. This can be achieved by changing the mix of feeders which are armed, but at the expense of a higher AUFLS load-shedding cost. However if some feeders could be selectively armed for different time zones⁴⁴ then this ideal pattern could be achieved without increasing the AUFLS load-shedding cost.

⁴³ See "SO report: AUFLS II – Appendix G", Aug 2011, page 6-7.

⁴⁴ As can be achieved by having the AUFLS relays being automatically armed and disarmed using timers. The technology for doing this is understood to be relatively simple, but is not typically used in the North Island now, but is used by Orion in the South Island (although it is not known for what purpose). Further work would be required on the reliability and suitability of timers on AUFLS relays as this option was not explicitly considered by the system operator in their technical studies.

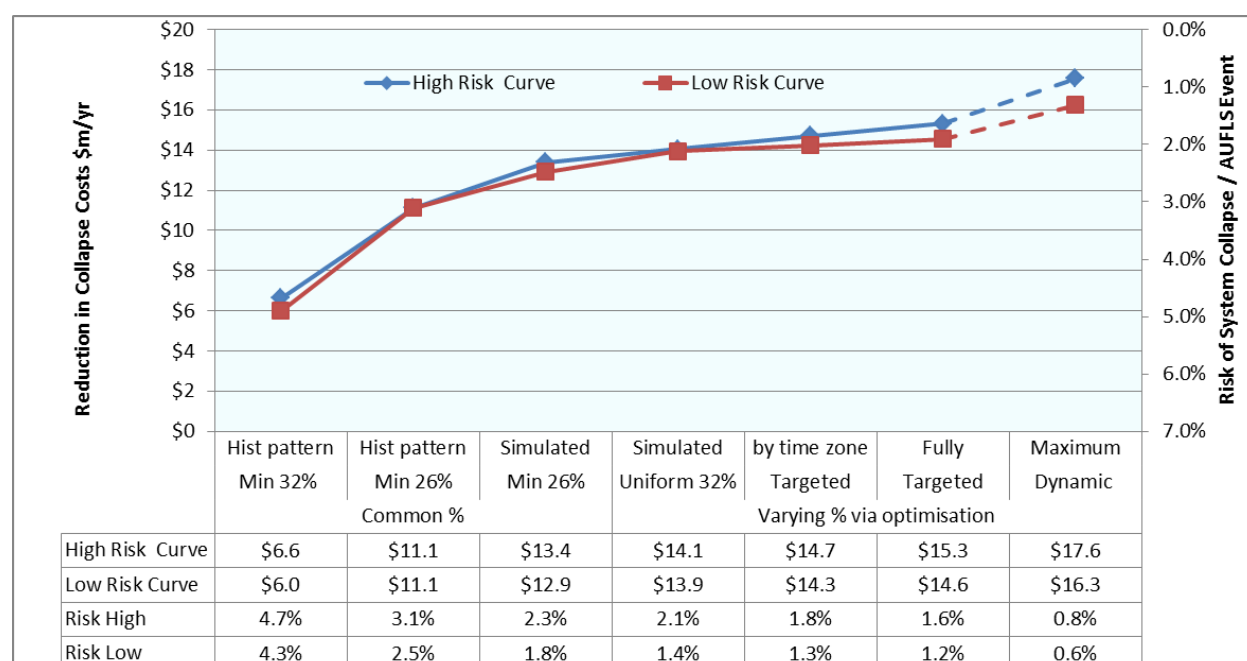
Figure 6: AUFLS supply shape and volatility



- B.74 The incremental benefit from reducing expected system collapse costs is shown in the following Figure 7.
- B.75 The blue and red lines show the incremental benefit resulting from applying the higher and lower risk of system collapse curves as shown in Figure 5.
- B.76 The incremental benefit is measured in \$m per annum saving in system collapse costs relative to the current standard code procurement approach. This involves a 26% minimum obligation at all times with the observed historical pattern of AUFLS supply – the second of the seven options shown in Figure 7 below.
- B.77 Also shown is the benefit of a 26% minimum obligation, if this could be achieved as a “flat” profile as simulated using the illustrative feeder data, would be \$1.8 to \$2.3m/yr.
- B.78 The incremental benefit for the optimisation approach depends on the desired target used in the optimisation tool. It is possible to the target to be set as uniform or varying by time zone. Optimising to a uniform 32% target would achieve a \$2.8-2.9m/yr benefit. This could be increased \$0.3 to \$0.7m/yr to \$3.1 to 3.6m/yr by optimising by time zone, or to a maximum of \$3.4 to 4.2m/yr by fully optimising to the ideal target (given by the black line above).

B.79 All of the analysis above assumes that AUFLS supply is inherently uncertain. The obligation and optimisation approaches reduce this level of uncertainty but do not eliminate it entirely. Hence there is a residual risk of system collapse of approximately 1.5% per event. In the future it may be possible to monitor AUFLS supply much more closely and to adjust the supply dynamically by remotely arming and disarming selected blocks of feeders as required. This has the scope to further reduce the risk of system collapse. It is difficult to know what the value of this is, but it is plausible that the residual risk could be halved. The incremental benefit of this is an extra \$2m/yr as indicated by the maximum dynamic point below.

Figure 7: Incremental reduction in system collapse costs \$m/yr



AUFLS load-shedding cost assumptions

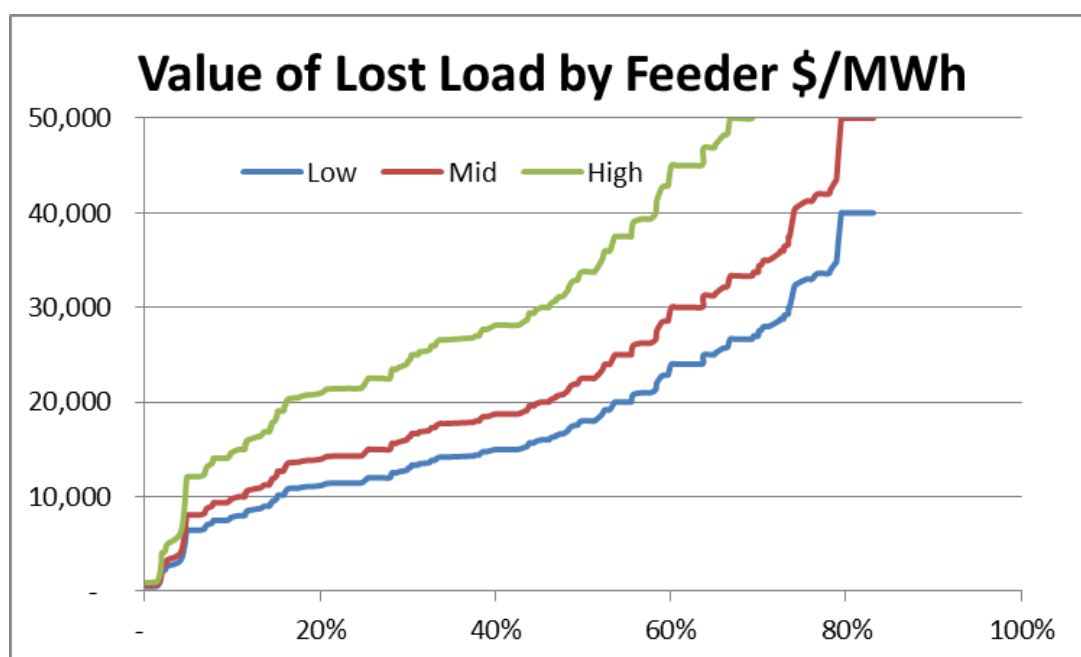
B.80 The expected AULFS load-shedding costs are estimated on the basis of a VoLL per feeder and the expected number of hours of AUFLS load-shedding per annum. The latter is expected to vary significantly by block number, as indicated in the table below.

Table 11: Assumed AUFLS block return periods⁴⁵

	Return period yrs	Hours per event	Hours/yr
Block 1	5.4	1.4	0.250
Block 2	11.3	1.5	0.133
Block 3	27.0	1.8	0.067
Block 4	60.0	2.0	0.033

- B.81 VoLL costs per feeder are not known at this stage, however the potential of alternative procurement options can be assessed by assuming an illustrative distribution of VoLL costs per feeder as illustrated in the figure below.

Figure 8: Assumed value of lost load



- B.82 The expected AUFLS load-shedding costs have been calculated using the illustrative feeder data for 3 different procurement options:
- the individual obligation approach
 - the optimisation approach targeting a uniform 32% level of AUFLS

⁴⁵ These return periods and durations are the indicative values assumed for the analysis. These are inherently difficult to assess and will involve a degree of judgement. These will need to be consulted on and agreed by the industry as they are an element of the proposed compensation payments system.

- (c) the optimisation approach targeting the ideal AUFLS profile (but assuming that feeders are armed for the whole year rather than being switched on/off by time zone). The results are given in Table 12 below.

Table 12: Estimated incremental value from reduced AUFLS load shedding costs

		Common AUFLS percentage obligation	Varying AUFLS provision via optimisation	
		Min 26%	Uniform 32%	Targeted (no time switching)
	Hours /yr	AUFLS Avg MW		
Block1	0.250	309	270	301
Block2	0.133	320	270	301
Block3	0.067	155	162	180
Block4	0.033	158	162	180
Total		942	863	962
AUFLS Expected Load Shedding				
MWh/yr	VoLL	135	119	133
Avg VoLL	\$/kWh	\$17	\$10	\$14
Total VoLL	\$m/yr	\$2.3	\$1.2	\$1.9
Incremental	\$m/yr	\$0.0	\$1.1	\$0.4
High	\$m/yr	\$0.0	\$1.6	\$0.6
Low	\$m/yr	\$0.0	\$0.9	\$0.3
Middle	NPV \$m	\$0	\$9	\$4
High	NPV \$m	\$0	\$14	\$5
Low	NPV \$m	\$0	\$7	\$3

B.83 As can be seen the potential reduction in total AUFLS load-shedding costs from the optimisation approach is of the order of \$0.9 to 1.6m/yr if the optimisation is set to meet a uniform 32%.

- (a) this benefit would be reduced by around \$0.7m/yr if the “ideal” AUFLS profile was targeted without any time switched relays being available. But if these were available then the reduction would be negligible.

B.84 The estimated \$0.9-1.6m/yr benefit assumes that the optimisation can choose from all feeders. In reality it is likely some feeders may be excluded from the optimisation (e.g. if they contain sensitive loads). This is unlikely to have significant impact on the estimated benefit since these feeders would have had a high VoLL assigned and would not have been selected in any event.

- B.85 The estimated benefit is also sensitive to the assumed level of “optimisation” achieved within each participant, and through the system operator allocation of feeders to blocks for small participants. The results in the table assume that the focus under the minimum obligation approach is to meet the required design quantities with minimum relay costs, rather than to minimise the load-shedding cost. If a more sophisticated approach was used by participants, the incremental benefit from central optimisation might be reduced by around \$0.5m/yr.
- B.86 The illustrative analysis suggested that most of the reduction in AUFLS load-shedding costs can be achieved using relatively crude assessments of feeder VoLL costs. There would be little additional value to be obtained by from the use of sophisticated or costly methods to determine VoLL.

Cost of “lost” interruptible load or other demand services

- B.87 Currently direct connects offer around 100-170MW of IL into the IR market. A number of these have indicated that due to issues such as other parts of their load having very high interruption cost, and/or divisibility of their load being constrained, they might have to reduce their offers into the IR market. This is if they were required to supply 32% (or at least 26%) of their load for AUFLS as required under a common obligation approach.⁴⁶ They may also be restricted from participation in other demand response products such as DD.
- B.88 The impact could be a reduction of as much as 25 to 60 MW at peak times if the standard code mechanisms were used, and 13-30MW under the common obligation approach with block co-ordination. This assumes:
- (a) commercial equivalence arrangements are not a viable option due to lack of incentives
 - (b) limitations in UoSAs
 - (c) there are no exemptions, dispensations or modified obligations.
- B.89 The marginal value of this lost IL is estimated to be between \$8/MWh (the average price of FIR & SIR reserves over the last 7 years) and \$14/MWh (the incremental cost of new capacity). This represents a national cost of \$0.6 to 6.3m/yr if it is assumed that IL supplied by the direct connects has a low interruption cost of, say, \$2/MWh.⁴⁷

⁴⁶ Informal discussions with Norske Skog, Pan Pac, Winstones, and NZ Steel resulted in the estimates used in this analysis. The stakeholders indicated that to give “firmer” estimates of the likely impact would require detailed engineering studies.

⁴⁷ Or \$3,600/MWh for each IL event assuming 10/yr lasting 0.5 hrs.

Table 13: Incremental reduction in IR/DR costs

		Common AUFLS percentage obligation				Varying AUFLS provision via optimisation	Voluntary AUFLS tender
		standard Code mechanisms	... + block coordination	... + special exclusions	... + profiled min/max oblig		
Low	MW	25	13	-	-	-	-
Mid	MW	45	23	-	-	-	-
High	MW	60	30	-	-	-	-
Incremental Benefit							
Low	\$k/yr	\$0	\$657	\$1,314	\$1,314	\$1,314	\$1,314
Mid	\$k/yr	\$0	\$1,774	\$3,548	\$3,548	\$3,548	\$3,548
High	\$k/yr	\$0	\$3,154	\$6,307	\$6,307	\$6,307	\$6,307
IL MW Marginal Value		\$/MWh					
Low Value		\$8					
Mid Value		\$11					
High Value		\$14					
Marginal Cost		\$2					

- B.90 This inefficient loss of IL could be largely avoided if:
- (a) lines companies were willing and able to provide commercial equivalence
 - (b) current exemptions were continued
 - (c) dispensations or special exclusions could be introduced
 - (d) the obligation was modified to account for IL offers as discussed in paragraph 3.7.5.
- B.91 However, as set out in paragraph 3.7.8 none of the options are considered to be particularly desirable or practicable. Plus, none deliver the reliability and other benefits provided by the optimisation approach.
- B.92 The optimisation and AUFLS market tender arrangements will not result in any inefficient reduction of IL supply from direct connects.
- B.93 Note that this is not an issue with lines companies under the optimisation approach. As set out in paragraph F.23, estimates of the IL behind each lines company feeder is taken into account by the optimisation and not counted towards AUFLS. This means lines companies will not need to remove any IL from feeders, even if they are required to provide AUFLS.

Annuitized relay costs

- B.94 The analysis accounts for the incremental costs of new relays required. This is accounted for by including a \$2k/yr annual payment for new normal relays and \$2.5k/yr for df/dt relays. This covers annual fixed operating

costs of \$0.5k/yr and \$1.5k/yr recovery of the capital cost (approx. \$10-15k installed for a normal relay). The cost of reprogramming and testing a relay is assumed to be \$5k.

Q15. Do you have any other comments on the CBA?

Appendix C Description of compensation / payments mechanism

Introduction

- C.1 A very simple payment system is proposed for the optimisation option.
- C.2 As discussed in section 3.10 this approach would explicitly compensate stakeholders for the costs involved in arming feeders for AUFLS, with the compensation payments being recovered on the basis of annual demand following a beneficiary pays approach). There would be no net cost recovery from participants as the costs allocated would equal the AUFLS payments made.
- C.3 Rather than having separate payments and costs it is proposed that the costs allocated to each stakeholder would be offset by the payments. Each stakeholder would receive a net charge if their cost allocation exceeded their payments for AUFLS supplied, or a net payment otherwise.
- C.4 For the optimisation options, it is proposed that these net charges would be made each year based on data provided for the previous year. This simple method is appropriate since feeders are allocated once a year on the basis of data supplied for the previous year.
- C.5 Payments would consist of two components:
- (a) an expected AUFLS load-shedding compensation payment
 - (b) a relay compensation payment .
- C.6 The expected AUFLS load shedding payment would be calculated as:
- (a) $LS(j) = \sum_i MW(j,i) * ExpectedHours(b) * VoLL(j,i)$
 - (a) $MW(j,i)$ = the average MW (from the previous year) of load enabled for AUFLS excluding load being offered for IL (or other demand products) in feeder (i) belonging to stakeholder(j) in the relevant island.
 - (b) b = the AUFLS block number assigned to feeder (i) belonging to stakeholder (j).
 - (c) $ExpectedHours(b)$ = the expected hours of AUFLS load shedding for block b as agreed by the industry after consultation
 - (d) $VoLL(j,i)$ = the VoLL used in the optimisation for feeder (i), belonging to stakeholder (j) in the island.
- C.7 The relay compensation cost would be based on a standard rate for each feeder selected to be armed for AUFLS, or possibly a schedule of rates

reflecting the costs for different situations and services.⁴⁸ For example, there might be extra payment for df/dt relays, or relays on timers or relays with remote arming capability. There may also be a separate payment for reprogramming and testing any relays if this was required. Some form of escalation would also be required.

- C.8 It will be important that these compensation payments incentivise stakeholders who are required to re-invest in relays to incorporate new technology. This would enable reliability of the AUFLS regime to be improved over time by enabling faster response and facilitating remote arming/disarming and resetting where this can be achieved economically.
- C.9 The payment mechanism should also incentivise stakeholders to minimise the cost of installing, maintaining and testing the relays. This can be best achieved by providing a standard schedule reflecting the desired capabilities. This would be simpler, lower cost and provide better incentives than an individual cost-plus approach which would require some form of audit.
- C.10 A separate payment incentive for remote setting and arming would have significant future benefits. This would enable low cost resetting, arming or disarming the future adjustment optimisations. This would also avoid the cost of manual resetting and retesting the relays.
- C.11 If issues related to “stranded” relay costs are considered to be significant then it would be possible to provide separate capital and annual operating cost compensation payments as follows:
 - (a) the annual relay compensation would cover the fixed operation and maintenance cost (including testing as required)
 - (b) the relay capital cost compensation payment could cover the full costs of installing, modifying and testing relays selected for arming.⁴⁹ This capital cost could take account of the actual circumstances facing each stakeholder (e.g. if relays were already available) or could be a standard rate.⁵⁰
- C.12 Parties would be compensated for the relay capital costs when they were initially selected for arming, and would be required to offer these

⁴⁸ The structure of this schedule of payments would need to be consulted on and agreed by the industry.

⁴⁹ This payment might be spread over, say, 5 years to smooth out the payments.

⁵⁰ In theory the capital cost of existing relays should be accounted for in the lines company's regulated price path and so separate additional capital cost compensation may not be appropriate. However there may be transitional issues for some lines companies who have invested in new relays in anticipation of the new AUFLS design being implemented. In the future, the cost of new investment in relays could be recovered via a pass-through of net AUFLS payments into lines charges.

relays/feeders in future adjustment optimisations.⁵¹ They would receive the relay reprogramming and operating cost compensation only if they were selected to be re-set or armed.

- C.13 The optimisation tool would take into account the new capital costs and the operating costs in the initial optimisation when the new technical design was implemented. Subsequent adjustment optimisations would account for annual operating costs, but would only account for relay capital costs if additional new investment was required.

Expected level of payments

- C.14 The total payments would vary depending on the VoLL costs for selected feeders, the number of feeders armed and the relay compensation rates.
- C.15 The VoLL methodology and standard relay compensation rates would be set after consulting the industry and updated for inflation each year.
- C.16 The likely range of costs is estimated in the following table.⁵²

Table 14: Range of expected AUFLS payments

	Units	Low	Middle	High
Total NI Load	Avg MW	2,800	2,900	3,000
AUFLS Armed	Avg MW	896	928	960
AUFLS expected lost load	MWh	124	128	133
AUFLS Relays	Num	380	420	470
VoLL Blk 1	\$/kWh	\$5.6	\$7.0	\$12.5
VoLL Blk 2	\$/kWh	\$9.9	\$12.3	\$26.2
VoLL Blk 3	\$/kWh	\$12.2	\$15.3	\$41.6
VoLL Blk 4	\$/kWh	\$16.4	\$20.5	\$48.7
AUFLS VoLL weighted avg	\$/kWh	\$7.9	\$9.9	\$20.9
AUFLS load shedding compensation	\$k/yr	\$986	\$1,276	\$2,773
AUFLS Relay rate	\$k/relay/yr	\$1.6	\$2.0	\$2.8
AUFLS Relay Compensation	\$k/yr	\$608	\$840	\$1,316
Total Compensation	\$k/yr	\$1,594	\$2,116	\$4,089
Avg AUFLS Cost	\$/MWh	\$0.06	\$0.08	\$0.16

Note: The expected AUFLS lost load is based on the expected on the assumed AUFLS return period per block and restoration time given in Table 11.

⁵¹ A process for managing and implementing any changes to relay settings resulting from adjustment optimisations will need to be developed. The intention is to minimise changes to relays that need to be manually reprogrammed to avoid costs and account for resource constraints etc.

⁵² This table is based estimates for the North Island in total.

- C.17 The table shows the average AUFLS cost per MWh of load. This is the maximum charge that could be faced by any stakeholder that is not providing any AUFLS services.
- C.18 If the payments included full compensation for the capital cost of new relays selected in the initial optimisation, there could be an extra transitional cost of up \$0.5m/yr. This assumes recovering new relay capital compensation payments over 5 years.
- C.19 The VoLL values for each line company's feeder would be determined by the Authority based on information provided by the lines company and an agreed transparent methodology. This would account for the nature of the loads on the feeder and the presence of "sensitive" or very large loads. This methodology would only be reviewed from time to time (maybe 5 yearly).
- C.20 Note that even though direct connects determine their own VoLL values, they are not able to significantly influence the overall load shedding compensation cost. If they set their VoLL cost high then they will not be selected for AUFLS and will have to face a net cost equal to the average VoLL cost as determined by the Authority methodology.
- C.21 The actual net payment for each participant will vary according to the type and quantity of AUFLS services they supply. The following Table 15 illustrates the net payments for individual stakeholders based on the full optimisation using the illustrative feeder data discussed earlier.

Table 15: Illustrative net AUFLS payments

Participant	Avg Load MW	AUFLS Supply Avg %	AUFLS VoLL Compensation \$k	Relay Compensation \$k/yr	Total Compensation \$k/yr	Allocated Cost \$k/yr	Net Cost \$k/yr	Net Cost \$/MWh	Net Cost for 8 MWh residential customer \$/yr
A	513	41%	\$350	\$63	\$413	\$370.01	-\$43	-\$0.01	-\$0.1
B	362	23%	\$94	\$163	\$257	\$261	\$4	\$0.00	\$0.0
C	171	32%	\$98	\$88	\$185	\$123	-\$62	-\$0.04	-\$0.3
D	151	6%	\$14	\$13	\$27	\$109	\$82	\$0.06	\$0.5
E	280	34%	\$188	\$88	\$276	\$202	-\$73	-\$0.03	-\$0.2
F	104	29%	\$26	\$88	\$114	\$75	-\$39	-\$0.04	-\$0.3
G	298	36%	\$121	\$100	\$221	\$215	-\$7	\$0.00	\$0.0
H	235	22%	\$103	\$75	\$178	\$170	-\$9	\$0.00	\$0.0
I	46	39%	\$13	\$13	\$25	\$33	\$8	\$0.02	\$0.2
J	142	15%	\$46	\$13	\$58	\$102	\$44	\$0.04	\$0.3
K	136	63%	\$107	\$25	\$132	\$98	-\$34	-\$0.03	-\$0.2
Ind 1	66	-	\$0	\$0	\$0	\$47.91	\$48	\$0.08	\$0.7
Ind 2	116	40%	\$47	\$25	\$73	\$84	\$11	\$0.01	\$0.1
Ind 3	71	31%	\$5	\$38	\$43	\$51	\$8	\$0.01	\$0.1
Ind 4	23	28%	\$6	\$13	\$18	\$16	-\$2	-\$0.01	-\$0.1
Ind 5	32	25%	\$6	\$13	\$18	\$23	\$5	\$0.02	\$0.1
Ind 6	56	36%	\$3	\$13	\$16	\$40	\$24	\$0.05	\$0.4
2,847		875	\$1,227	\$827	\$2,054	\$2,054	\$0	\$0.03	
Avg \$/MWh							\$0.08		

- C.22 As can be seen the net cost/revenue is typically less than \$80k even for the large participants, and the typical net cost is of the order of \$0.03/MWh. The maximum net cost is \$0.08/MWh as illustrated by Ind 1 which is not providing any AUFLS service.
- C.23 There is no net impact on customers overall since the total payments and cost allocation balance. The maximum net cost to any individual customer is approximately \$0.08/MWh. This represents 0.03% of the typical residential end-user delivered price, or 0.1% of the typical major user delivered price.
- C.24 For residential customers who are in networks that are providing more AUFLS than the national average, the operation of the compensation mechanism is such that they should see a slight reduction in their bills (of the order of 10 to 30 cents per year).

- | | |
|-------------|--|
| Q16. | Do you have comments on the proposed compensation payment mechanism? |
| Q17. | Please provide reasons if you agree that, in an arrangement where different stakeholders are required to provide different proportions of their load as AUFLS based on their relative suitability, it is appropriate to compensate stakeholders for the costs they incur in providing AUFLS. Please also provide reasons if you disagree. |

Appendix D Rights of distributors, via their UoSAs, to voluntarily place their customers under AUFLS

- D.1 As set out in the main body of the paper, some of the AUFLS procurement options being considered require stakeholders to voluntarily decide to put their load under AUFLS as part of commercial arrangements. This compares with approaches where stakeholders are mandated to put their load under AUFLS via an obligation under the Code. The two main options where voluntary commercial arrangements are required are:
- (a) **commercial equivalence arrangements within a common obligation approach.** This approach would be to mandate a common amount of AUFLS provision from each participant, but enabling stakeholders to undertake bilateral trades to subsequently vary the amount each stakeholder provides. For example, distributor 'A' could agree to increase the amount of its load placed under AUFLS in a commercial deal with direct connect 'X' who could then reduce the amount of load they place under AUFLS
 - (b) **AUFLS tender approach.** This would involve the system operator going out to tender for people to voluntarily offer load to be placed under AUFLS in return for payment.
- D.2 However, it appears that such options may not be feasible due to the fact that if distributors were to *voluntarily* place customers under AUFLS they could be in breach of their UoSAs with their customers.
- D.3 The UoSA between a distributor and its customers specifies the respective rights and responsibilities of the different stakeholders in relation to the provision of electricity distribution services. There are many different agreements in place for each of the different distribution companies. This note specifies the rights and responsibilities according to the Model Use of System Agreement (MUoSA) as developed by the Electricity Authority, without having reviewed each individual UoSAs.
- D.4 One key aspect of the MUoSA relates to the quality of supply, in particular interruptions to supply.
- D.5 MUoSA does not guarantee consumers an uninterrupted supply, but does require that the Distributor delivers electricity to the quality level specified in the Service Standards.
- D.6 Such Service Standards are set out in a Schedule to the MUoSA, and distinguish between Uncontrolled and Controlled supply categories.
- (a) for the Uncontrolled category, the Service Standard policy specifies that *"the Distributor will endeavour in accordance with Good*

Electricity Industry Practice to maintain continuous supply where the Consumer has elected to receive Uncontrolled Supply and be charged on the basis of the relevant Uncontrolled Supply Price Category”

- (b) for the Controlled category the Service Standard policy specifies that *“if the consumer has elected to receive Controlled Supply and be charged on the basis of the relevant Controlled Supply Price Category, the distributor may effect Load Shedding.”*

D.7 In addition to the Service Standards, there is also a specific Load Management clause and a Load management Schedule.

D.8 The Load Management clause specifies that a Distributor or a Retailer may only control part, or all, of a Consumer’s load if the Consumer elects to take up the Price Category or Tariff Option associated with the Controlled Load Option.

D.9 The Load Management Schedule states that *“the purposes for which load control can be used ... include:*

- (a) *System Security: managing Grid System Security in accordance with the Code.*
- (b) *Network management:*
 - (i) *Managing Network system security;*
 - (ii) *Reducing transmission charges; and*
 - (iii) *Optimising Network investment;*
- (c) *Market participation:*
 - (i) *Managing wholesale electricity purchase cost risk (e.g. the time-shifting of consumption); and*
 - (ii) *Providing interruptible load into the reserves market.”*

D.10 The Agreement also has a Service Interruptions clause which, amongst other things, specifies that *“the Distributor may carry out Load Shedding in the following circumstances:*

- (a) *Maintenance of network equipment*
- (b) *Provision of supply within the service standards: as permitted by the Service Standards, if the Consumer has elected to receive an interruptible or otherwise non-continuous supply of electricity;*
- (c) *Compliance with instructions from the system operator;*
- (d) *Maintain security and safety;*

- (e) *Compliance with the Code*
- (f) *Automatic Load Shedding: if Automatic Under-Frequency Load Shedding is implemented in accordance with the Code; or*
- (g) *Other circumstances: for any other purpose that, in the Distributor's reasonable opinion and in accordance with Good Electricity Industry Practice, requires the interruption or reduction of delivery of electricity to any ICP."*

D.11 The key points from all the above are:

- (a) a distributor or retailer can only "control" load if a consumer has actively elected to go onto a controlled tariff. This enables distributors to offer consumers' hot water load into the IR market, but not any of their other load
- (b) a distributor can only "shed" load on an uncontrolled tariff for the purposes of AUFLS if such shedding "*is implemented in accordance with the Code*".

D.12 Although it is not clear-cut, initial advice is that this could mean a distributor:

- (a) is able to put customers under AUFLS if they are obliged to under the Code; but
- (b) would not be able to voluntarily:
 - (i) place consumers under AUFLS as part of a bilateral agreement with another stakeholder
 - (ii) participate in a voluntary AUFLS market.

D.13 That said, the UoSA could be interpreted as allowing distributors to voluntarily participate in an AUFLS market if the arrangements for such a market were specified in the Code. Again, although it is not clear-cut, it is not considered that having the arrangements for such a market specified in the Code would be sufficient to grant the distributor the rights to place consumers under AUFLS.

D.14 In this respect, it is worth comparing a voluntary AUFLS market with the IR market. The operation of the IR market is specified in the Code, yet it is not considered that lines companies have secured the rights to offer *whole feeders* as IL into the IR market (as distinct to hot water load for which they have secured the rights). A voluntary AUFLS market would be very similar in *nature* to the IR market, in that both would be securing interruptible load for use in the event of a supply interruption. The only difference would be the *degree* to which such load would be used: once every couple of months in the case of IR, once every five or six years in the case of AUFLS.

- D.15 It is not considered that this difference in *degree* between the IR market and a voluntary AUFLS market is sufficient to justify that lines companies have the rights to offer whole feeders into an AUFLS market but not the IR market.
- D.16 In theory it would be possible for lines companies to amend their UoSAs to grant themselves the right to completely drop all their customers' load as part of commercial arrangements. In practice, this would likely be contentious, costly, and time consuming to achieve. Accordingly, for the purposes of this evaluation, it has been assumed that requiring lines companies to amend their UoSAs to allow them to voluntarily offer their customers load into an AUFLS arrangement would not be practicable for several years at least.

Appendix E Beneficiary or causer-pays approach to AUFLS cost allocation

- E.1.1 In options where compensation is paid to providers of AUFLS, it is necessary to recover the costs of such compensation through allocating them to appropriate stakeholders in some way. There are two main types of option for such cost-allocation:
- (a) beneficiary pays. This approach recovers the costs of a service from those stakeholders who benefit from the service. In the case of AUFLS, it is customers who ultimately benefit from AUFLS preventing black-out, so a beneficiary-pays approach would allocate the cost of AUFLS to customers (or their representatives, as in the case of lines companies)
 - (b) causer pays. This approach recovers the cost of a service from those who cause the need for a service.
- E.1.2 The Authority considers that, in general, causer-pays approaches are preferable to beneficiary-pays approaches due to the fact that allocating the costs to causers can signal to such participants the consequences of their actions. This in the long-term incentivise such stakeholders to make decisions which reduce the scale of such costs.
- E.1.3 The costs of procuring IR are allocated on a causer-pays basis, and the IR market is a good example of the types of issues and outcomes that could be desirable from allocating the costs for any AUFLS payments.
- E.1.4 IR costs are recovered from the owners of large generating units and the HVDC, as it is the potential failure of such plant which gives rise to the need for IR to be procured in the first place.
- E.1.5 Allocating the costs of IR to causers provides a signal to participants to:
- (a) only invest in large units if the economies of scale are such as to outweigh any extra IR costs
 - (b) operate their plant with appropriate care and attention to minimise trips. (This is achieved through an event charge which is allocated to owners of plant whose tripping causes an under-frequency event).
- E.1.6 This causer-pays approach is designed to deliver efficient outcomes in the long-term through incentivising stakeholders to minimise the need for IR.
- E.1.7 In theory, similar outcomes could be achieved through recovering the costs of AUFLS from the causers of AUFLS.
- E.1.8 However, it is not clear that adopting a causer-pays approach to recover AUFLS costs would result in any different outcomes with regards to the

amount of AUFLS needed to be procured, or the frequency with which AUFLS events would occur.

- E.1.9 This is because the need to cover the potential failure of the HVDC bipole which will causes the need to procure AUFLS for the majority of the time, and which will almost certainly represent the biggest risk that needs to be covered by AUFLS.
- E.1.10 The process to approve future capacity upgrades to the HVDC is based on a regulatory approval process which already considers all the costs and benefits associated with any upgrade, including any AUFLS cost implications. This doesn't take into account who faces such costs.
- E.1.11 Allocating AUFLS procurement costs to Transpower would be a wealth transfer in this evaluation framework, and would therefore not be expected to change the result of any decisions on the net benefit of future HVDC upgrades.
- E.1.12 Also, it is not considered that a causers-pay approach would result in Transpower, or the owners of the large power stations whose plant could also cause AUFLS,⁵³ to operate their plant in materially different ways so as to reduce the likelihood of their plant failing. This is because AUFLS events are rare (once in every five to ten years), and are generally caused by unusual factors which weren't generally anticipated or were outside of stakeholders control (a natural disaster). It is considered that Transpower and the power station owners are already highly incentivised to operate their plant in a way which avoids these major supply interruptions – both to prevent damage to their own plant from such failures, and through operation of the event charge associated with recovery of IR costs.⁵⁴
- E.1.13 Also, it is not clear how costs should be allocated to 'causers' to cover the procurement of AUFLS. In particular, given that AUFLS is required to cover a range of potential risks, not just the HVDC bipole, it would be challenging to come up with an allocation methodology that appropriately allocates costs to cover additional risks like:
- (a) potential sympathetic trip of a second generator in response to an initial event
 - (b) whole-of-site-failure (particularly when it could be transmission-related assets that result in such a site failure)

⁵³ Although sufficient IR is procured to cover the failure of the single largest generation unit, power stations can cause AUFLS if they have whole-of-site failures (e.g. in the case of the Huntly site), or if their plant tripped sympathetically in response to an initial under-frequency event caused by another generating unit failing.

⁵⁴ In an under-frequency event (one where frequency falls below 49.2Hz – which would definitely be the case in an AUFLS event), the causer of the event needs to pay \$1,250 for each MW of supply they dropped.

- (c) a multi-transmission or generation asset failure due to a natural disaster.

- E.1.14 Lastly, given that Transpower, as owner of the HVDC, would likely pay the majority of any AUFLS costs under a causer-pays cost allocation framework, it is possible that end consumers could face such costs anyway if Transpower passed on AUFLS costs through its transmission charges.
- E.1.15 In short, a causer-pays approach to AUFLS cost recovery would be unlikely to reduce the amount of AUFLS needed to be procured, or the frequency with which AUFLS events would occur.
- E.1.16 Plus, a causer-pays approach would remove the positive aspect of the beneficiary-pays approach outlined in paragraph 3.10.15 whereby stakeholders are incentivised to submit realistic VoLL values for their loads. If, through submitting unrealistically high VoLL to a selection process, stakeholders manage to avoid being selected for AUFLS and don't face any consequences, not only would such an outcome be inequitable, but it would also be likely to be economically inefficient in that less suitable loads would be selected instead.
- E.1.17 The Authority believes a beneficiary-pays approach would result in more economically efficient outcomes.

An AUFLS event charge

- E.1.18 One potential sub-option that was raised in discussion with stakeholders would be to retain a beneficiary-pays approach for the year-to-year recovery of AUFLS costs to preserve the incentive on stakeholders to submit realistic VoLL. This entails having an *extra* event charge (over and above the IR-related existing event charge) levied on stakeholders who were deemed to have caused AUFLS events. Monies recovered from this extra event charge could be netted off the AUFLS cost-recovery from beneficiaries.
- E.1.19 Such an approach may be more expensive to administer (particularly in terms of costs incurred by stakeholders during any dispute). If this altered Transpower's or generators' behaviour so that there is a reduction in the incidence of AUFLS events, then there could be a positive net outcome. A simple calculation illustrates whether this is likely to be the case:
 - (a) Analysis suggests that the average return period of an AUFLS event would be one in five years, dropping approximately 350 MW of AUFLS load on average. If the average VoLL of such load were approximately \$15,000/MWh, and the average duration of outage were 1 hours per event, this would result in an average cost of \$5.25m per event, or an expected annual cost of approximately $\$5.25\text{m} \div 5 \text{ years} = \1.05m per year .

- (b) assuming that dispute costs over AUFLS event charges were \$250k per event (considered to be a conservative estimate), then for it to be worth incurring such costs, it would have to be expected that:
 - (i) frequency of AUFLS events would drop from one in five years to at least one in every 5.24 years. (i.e. $(\$5.25\text{m} + \$0.25\text{m}) \div \$1.05\text{m} = 5.24$).

- E.1.20 This is a 5% improvement in terms of asset reliability. Given that many of the causes of AUFLS events could be outside of any stakeholders control, there would have to be an even greater improvement in the behaviour of stakeholders in relation to the aspects of asset operation they could control.
- E.1.21 However, it is not clear that the incentives created by an event charge would result in the desired change in behaviour:
- (a) in many cases financial risk limits may mean that stakeholders are required to insure against these eventualities. It is possible that an event charge may cause the insurance cost to increase to cover the worst case, and actual performance may not improve
 - (b) also assigning “blame” and very high financial penalties may reduce the incentives on stakeholders to provide information for everyone to learn from each event, and reduce the risks of it happening again. This may actually increase the risks of AUFLS events.
- E.1.22 Lastly, there is a risk of having overly onerous event charges that could incentivise potential causers to operate their assets in an excessively conservative fashion (not making their full capacity available for operation as happened in the last decade when Transpower withdrew capacity from the HVDC to minimise its exposure to the IR-related event charge). This could result in increased costs elsewhere in the system which outweighed any benefit from the reduced incidence or severity of AUFLS events.
- E.1.23 Based on the above analysis, the Authority does not believe that imposing an AUFLS event charge would materially alter the incentives on Transpower and the generators.

Appendix F Other aspects of AUFLS procurement design which are generic across all procurement options

Compliance approach

- F.1 The current obligation is for stakeholders to provide two blocks of at least 16% of their load at all times. This effectively imposes a compliance requirement on stakeholders to prove *after* an event that:
- (a) their AUFLS relays operated correctly
 - (b) they dropped sufficient load to meet this 16% minimum requirement.
- F.2 Given the natural variability of load, and the requirement only being to meet a *minimum* threshold, this creates an incentive on stakeholders to over-provide AUFLS through arming a greater number of feeders than is probably necessary. This is to ensure compliance even at times when their load is at unusually low levels. This surplus provision is problematic in that it accentuates the risk of over-frequency collapse in an AUFLS event.
- F.3 This surplus provision is significantly further exacerbated by the general within-day shape of mass-market load (the type of feeder which is predominantly armed by lines companies). This ranges from low overnight, to high during the morning and evening peaks. Therefore, lines companies typically arm feeders to ensure they meet the two x 16% requirement during an unusually low level of overnight demand. At times of high demand this means however that, instead of having approximately 32% of load armed for AUFLS, they have closer to 50% armed – and in some cases greater than 60%.
- F.4 As is illustrated in Figure 6 on page 77, this pattern of AUFLS provision (i.e. high at times of high demand and low at times of low demand) is exactly the opposite of what is ideally required to maximise system security outcomes.
- F.5 One option to address the current incentives on stakeholders to provide surplus AUFLS is to have a maximum as well as a minimum compliance requirement. For example, having at least 30% and no more than 34%.
- F.6 This could potentially be improved even further (from a system security perspective) by altering the requirement according to times of the day/year (a higher percentage during the night, and a lower percentage during the day).
- F.7 However, feedback from lines companies and direct connects early on in the AUFLS evaluation process was that achieving such a level of AUFLS provision would be difficult (and costly) to achieve – particularly for

stakeholders with poor load divisibility such as direct connects and small lines companies.

- F.8 Accordingly, an alternative compliance approach has been proposed, the core elements of which are common to all the AUFLS procurement options considered.
- F.9 The first element is to make the requirement for stakeholders to prove *ex-ante* that their load is likely to be suitable through provision of historical information on their load patterns. This historical information will be considered a reasonable proxy for future load patterns, and assessed for suitability to meet an AUFLS requirement.
- F.10 The key advantage of this approach is that it takes account of the diversity of multiple loads. This means, for the common obligation option, it would be possible to express the requirement as being to meet the percentage requirement within an X% confidence level, e.g. 99% or 95%. This would allow for individual loads to have unusually low or high levels, without compromising the overall requirement given that the diversity of all loads will significantly reduce the overall variation.
- F.11 The second element is to move away from expressing the obligation at an individual GXP level. For the common obligation approach the obligation could be expressed at a network level. Again, this would help take advantage of the diversity of many different loads within a network.
- F.12 However, it is possible that even with the ex-ante requirement within certain percentage confidence levels, it could be difficult for stakeholders with poor divisibility (direct connects and small lines companies or particularly unusually shaped load) to meet a common requirement. Particularly if it were to vary with time of day/year.
- F.13 Accordingly, the AUFLS optimisation option takes things to the logical extreme by:
- (a) taking advantage of the diversity of all loads within a much larger geographic area (potentially one of a small number of geographic regions in the North Island)
 - (b) selecting loads based on their suitability in terms of load variability and shape.
- F.14 With this ex-ante approach to proving load suitability, the only ex-post compliance aspect is proving that your AUFLS relay operated correctly during an AUFLS event.
- F.15 The only exception to this is if a stakeholder is aware that:
- (a) its load is likely to change materially from that submitted in the historical data series (a direct connect experiencing a change in

demand due to the commissioning or retirement of a production facility)

- (b) if maintenance were to result in a feeder that had been armed for AUFLS being out of service.

F.16 In both cases it is suggested that there be a requirement on stakeholders to report such matters as soon as they becomes aware of them – potentially subject to a materiality threshold for point (a) above.

Coordination with participant rolling outage plans

F.17 One of the key goals of all the AUFLS procurement options considered is to minimise the incidence of high interruption cost load being placed under AUFLS.

F.18 However, this is also an objective of the PROPs mechanism. Accordingly, there needs to be a process to ensure consistency between the two mechanisms.

F.19 At the moment, there is a requirement that stakeholders undertaking a rolling outage to comply with a PROPs instruction, do so in a fashion which also maintains their requirement to have a minimum of 32% of their load armed for AUFLS.

F.20 While the minimum 32% requirement is likely to change with the revised AUFLS arrangements, there will still need to be appropriate coordination with the PROPs process. This is to ensure that the integrity of the system to withstand an AUFLS event is not unnecessarily compromised during a rolling outage event.

F.21 Given that this is an issue which is common to all the AUFLS procurement options, it has not been considered in detail as it will not influence identification of the preferred option.

F.22 However, it is an important issue which needs to be resolved before moving to the implementation phase of the revised AUFLS arrangement. The Authority will be working with the system operator and other stakeholders to address this matter before the Code recommendations are developed.

Q18. Based on your experiences of the existing AUFLS and PROPs arrangements, do you have any views on the appropriate approach to ensure consistency of the two arrangements?

IL visibility / coordination (and other competing uses for demand)

- F.23 For all options, it will be necessary to estimate the quantity of IL (or other competing uses of demand) to determine the likely quantity of load available for AUFLS under a feeder.
- F.24 It is proposed that lines companies and direct connects provide an objective estimate of the level of IL (or other competing uses of demand) behind feeders. This information will be used in the optimisation to avoid selecting load to provide AUFLS which could be more valuably used for these other purposes, and in any evaluations for common obligation approaches to ensure that the required amount of AUFLS has been secured.
- F.25 It is recognised that providing such information will be difficult since the provision of IL is dynamic and varies within the day and year. This is a common issue for all procurement options since this is a feature of the proposed new compliance arrangements.
- F.26 It would be possible to use historic data on the level of say IL offered and cleared from the previous year as a proxy for the following year.
- (a) in this case the relevant information would be data on the average level and variability of offers and cleared IL as a percentage of demand by time zone (e.g. business/non-business day and night by season)
 - (b) this data could be used to derive a conservative maximum level of IL to be accounted for when assessing ex-ante compliance under the common obligation approach
 - (c) this same data could be used in the optimisation option, although in this case the level and variability of this on the total AUFLS supply in the region could be accounted for explicitly in the optimisation tool when determining the value of AUFLS supply from feeders with IL. This would avoid the possibly over-conservative treatment under the obligation approach.
- F.27 It is also recognised that some lines companies may not have access to information of IL offers from aggregators at a feeder level:
- (a) in principle, data on IL offers should be available on a GXP basis from aggregators or individuals within feeders (if not from the lines companies themselves), however there may be confidentiality issues in accessing this
 - (b) if there is no information to allocate this to feeders then it may be adequate to apply the GXP based percentage measures to each associated feeder.

- F.28 Direct connects and lines companies who are offering IL may be obliged to notify the system operator if the level of IL offering changes from the agreed level by more than some specified level in MW.⁵⁵ The specified level could be set so that it provided for a degree of variability without causing a significant impact on system security.
- F.29 In summary, visibility on IL and other forms of demand-response is an important issue that needs to be addressed for all AUFLS procurement options. While it will not influence the choice of the preferred option, the Authority and system operator will work to develop arrangements to improve such visibility taking into account the need for coherence with all the various aspects of demand-side participation in the market.

Information provision

- F.30 All AUFLS procurement options will require stakeholders to submit data to a selection process to enable the system operator to determine whether the load meets its requirements. There are a number of aspects of this requirement which still need to be fully specified.

Historical half-hourly data

All feeders or a sub-set of feeders?

- F.31 Early discussions with lines companies were around stakeholders submitting historical data on some proportion of their feeders (sufficient to meet a common percentage obligation).
- F.32 However, only submitting a fraction of feeders would reduce the ability of the optimisation tool to select the combination of loads across all stakeholders that delivered the greatest overall benefit.
- F.33 Accordingly, it is proposed that stakeholders are required to provide historical data for all their feeders.

How many years' worth of historical data?

- F.34 It is suggested that the requirement be to submit one or two years' worth of data, up to and including the month two months prior to the date specified by the system operator in its information request.

⁵⁵ It is possible that the criteria could be a combination of a MW limit and a percentage supply limit to account for the combined impact of many suppliers each increasing their supply simultaneously.

What if the stakeholder does not have such historical data?

- F.35 Although all stakeholders spoken to have indicated that they keep records of all their demand data, it is possible that a stakeholder may not have all such data (this could be due to a new facility being developed).
- F.36 In such cases it is proposed that stakeholders should indicate:
- (a) why they do not have such data
 - (b) what measures they are putting in place to capture such data for future processes.
- F.37 If it is possible that the stakeholder can develop reasonable estimates of the load (e.g. from GXP-level metering) it could be sufficient for the process.
- F.38 It is possible that a sanction may need to be developed for stakeholders who continue to not provide data for subsequent optimisations, although standard Code provisions with regards to failure to meet an obligation may be appropriate. Further, it should be recognised that the cost-allocation mechanism should provide an additional incentive for stakeholders to provide data as requested in that stakeholders who don't provide sufficient information won't be selected to provide AUFLS, but in doing so will pay the full amount under the cost-allocation mechanism.

What meter accuracy is required for historical data?

- F.39 It is considered that revenue grade metering data is not required for this process, and that Scada⁵⁶ data would be sufficient.

How 'low' into a stakeholder's network should data be provided?

- F.40 At one extreme stakeholders could simply provide GXP level metering data. However, for lines companies it is suggested that zone sub feeder-level data would be more appropriate. The Authority is considering how to express the requirement to deliver sufficiently 'granular' data in a Code obligation. In particular, it is necessary to recognise the meshed, 'ring-fed' nature of distribution systems such that placing a relay high up in a distribution system may not necessarily result in load being dropped. The intent is to have historical data at a level of granularity which is the 'highest' in the distribution system below the GXP level, where loads can be independently dropped.
- F.41 For direct connects, the issue is even more acute in that there is no standard configuration of electricity supply within the different sites.

⁵⁶ Supervisory control and data acquisition system

- F.42 Accordingly, it is suggested that the obligation be to supply meter data information on the main divisible loads i.e. those that can genuinely be independently interrupted within a timeframe appropriate for AUFLS.⁵⁷ Again, the Authority is considering how best to express this in a Code requirement.

What if there is an expectation of significant future changes to such load?

- F.43 It is possible that some stakeholders may anticipate major changes to their loads (a direct connect experiencing a change in demand due to the commissioning or retirement of a production facility).
- F.44 It is suggested that stakeholders be required to indicate whether this is likely to be the case, but only if it were to exceed a materiality threshold, expressed in terms of average MW.

Q19. Do you have any comments / suggestions about the historical load information requirements on stakeholders?

Information to estimate VoLL values of lines company load

- F.45 As set out in section 3.11, it is proposed that VoLL values for lines company feeders to be centrally determined, but within a process that allows for 'special case' load at particular feeders to be identified and taken into consideration.
- F.46 The "Value of Un-served Energy" analysis undertaken by the Authority seems the most appropriate source of such VoLL values for such a process.
- F.47 With respect to determining the different types of customer on the different lines company feeders, it is proposed to draw upon the process lines companies have already been through in terms of drawing up participant outage plans. These plans are to enable rolling outages in the event of an extreme dry year or other major sustained loss of supply. Through this process, lines companies have already evaluated the different types of customers on their feeders.
- F.48 Not only would drawing upon this existing PROPs approach, minimise administrative costs, but it would also be good practice in terms of

⁵⁷ If an industrial load is dropped which causes a related process within the same site to stop shortly afterwards, it is not considered that the two loads are divisible. From an AUFLS perspective they should be treated as a single load with respect to data provision and overall VoLL estimate, and armed via a single AUFLS relay if selected. The system operator is considering what should be the appropriate delay after an AUFLS event beyond which a related load coming off can be considered a separate load. (E.g. a related load which comes off after five minutes may not be a problem, but one which comes off after ten seconds may be).

ensuring consistency of assumptions across different processes. Appendix F discusses some of the other issues with ensuring consistency of approach between assigning feeders for AUFLS versus assigning feeders for PROPs.

Other information to help select feeders

- F.49 It is potentially the case that there may be other, technical reasons why a feeder may not be suitable for being armed for AUFLS. For example due to the particular configuration of a lines company's network, or some other aspect of a sub-station.
- F.50 The Authority is keen to understand whether such technical difficulties may exist for certain feeders, and what the nature of the issues may be.

Q20.	Are there any other technical reasons (other than load shape, or the VoLL of customers connected to it) why a feeder may not be suitable for AUFLS?
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Appendix G Summary of questions, and format for submissions

Question No.	General comments in regards to the:	Response
Q1	Please provide reasons if you agree that lines companies' UoSAs do not grant them the rights to place their customers' load under AUFLS as part of a voluntary commercial agreement. Please also provide reasons if you disagree.	
Q2	Please provide reasons if you agree that it is not practical to change the UoSAs within the timeframe required to implement the new AUFLS arrangements. Please also provide reasons if you disagree.	
Q3	Please provide reasons if you agree that lines companies will likely face weak commercial incentives to enter into bilateral commercial arrangements to vary their level of AUFLS provision. Please also provide reasons if you disagree.	
Q4	Please provide reasons if you agree that excluding direct connects from the obligation to provide AUFLS would be inappropriate. Please also provide reasons if you disagree.	
Q5	Please provide reasons if you agree that a beneficiary-pays approach to recovering the cost of any compensation payments is likely to deliver more efficient outcomes than a causer-pays approach. Please also provide reasons if you disagree.	

Q6	Do you have any comments about the preferred approach to determining the VoLL of lines company feeders?	
Q7	Please provide reasons if you agree that issues with lines companies' incentives and contractual ability are likely to severely reduce the potential effectiveness of a voluntary AUFLS tender. Please also provide reasons if you disagree.	
Q8	Do you have any comments on relative ranking of the options?	
Q9	Do you have any comments on the proposed timetable?	
Q10	Do you need any more information to help you plan your resource availability to meet the requirements set out in paragraph 4.1.9	
Q11	Do you have any issues with the potential use of timers for arming AUFLS load?	
Q12	Do you have comments on the indicative implementation costs used in the CBA?	
Q13	Do you have comments on the indicative on-going costs assumed in the CBA?	
Q14	Do you have comments on the indicative base level and future benefits assumed in the CBA?	
Q15	Do you have any other comments on the CBA?	
Q16	Do you have comments on the proposed compensation payment mechanism?	

Q17	Please provide reasons if you agree that, in an arrangement where different stakeholders are required to provide different proportions of their load as AUFLS based on their relative suitability, it is appropriate to compensate stakeholders for the costs they incur in providing AUFLS. Please also provide reasons if you disagree.	
Q18	Based on your experiences of the existing AUFLS and PROPs arrangements, do you have any views on the appropriate approach to ensure consistency of the two arrangements?	
Q19	Do you have any comments / suggestions about the historical load information requirements on stakeholders?	
Q20	Are there any other technical reasons (other than load shape, or the VoLL of customers connected to it) why a feeder may not be suitable for AUFLS?	
Q21	Do you have any other comments?	