

Further development of the SRC's risk management framework

Using a bowtie method to record and assess
potential risk events

15 March 2016

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Executive summary

The function of the Security and Reliability Council (SRC) is to provide independent advice to the Electricity Authority (Authority) on the performance of the electricity system and the system operator, and reliability of supply issues. The SRC has considered the structures through which the electricity industry manages supply reliability risks and how it might use a risk management framework (RMF) to assist it in identifying, understanding, communicating and advising on significant security and reliability risks.

The SRC has considered, at a conceptual level, how the use of a RMF could assist the SRC in undertaking its monitoring role and provide benefits through its application in the broader risk management process. For example, the RMF could improve the communications between risk owners and stakeholders and allow risks arising from multiple triggers to become more visible.

The SRC has discussed criteria for probability and consequence of identified risks which has enabled the SRC to better define and prioritise the security and reliability risks that fall within its terms of reference. Risks that are identified as high priority are now able to be assessed using a bowtie approach.

This paper provides:

- a summary of progress on the development of the RMF demonstration model
- the criteria for filtering and assessing risk priority developed following the RMF workshop at the 22 October 2015 SRC meeting
- examples of how the bowtie approach is applied in the RMF
- questions for the SRC to consider.

1 Introduction

1.1 The purpose of this paper is to provide a demonstration of the RMF

- 1.1.1 The SRC has been considering the potential value that a RMF could provide for its role as advisor to the Electricity Authority on security and reliability matters.
- 1.1.2 This paper demonstrates the RMF that has been developed on the basis of the discussions with the SRC to-date, and provides an opportunity for the SRC to review the input assumptions and the output bowtie briefing sheets for a sample of security and reliability risk events.
- 1.1.3 The paper concludes with some questions that the secretariat intends should clearly identify the next steps for the RMF.

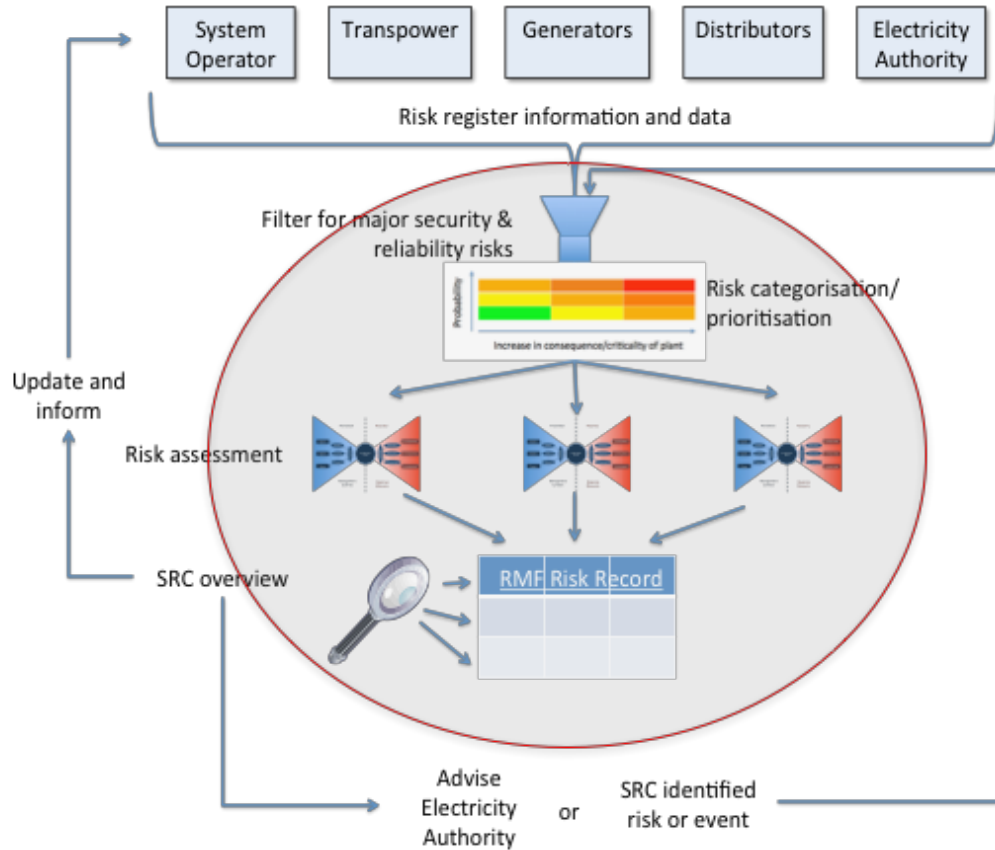
1.2 This paper builds on previous papers, workshop and discussions

- 1.2.1 On 1 July 2015, the SRC discussed the concept of a framework through which material security and reliability risks and their management could be made more visible.
- 1.2.2 The SRC agreed that there is potentially some value in a RMF for the group, and discussed:
 - a) establishing processes that facilitate a meaningful SRC discussion at an appropriately high level
 - b) ensuring that the next development steps stay small and exploratory at this stage
 - c) the potential for the RMF to become big and bureaucratic if it was not appropriately managed, with the risk of it creating unwarranted cost on the industry (particularly in terms of data collection)
 - d) the need to trust that individual risk owners will appropriately manage their own risks.
- 1.2.3 The Authority considers¹ that, consistent with the international standard ISO 31000, risk management processes should:
 - a) identify potential risks
 - b) assess the probability and impact of an identified risk
 - c) rank the priority of identified risks
 - d) form and implement plans to control or mitigate identified risks.
- 1.2.4 At the 22 October 2015 SRC meeting, a workshop session was held to consider metrics that will be used to identify, assess, prioritise and monitor control of security and reliability-related risks.
- 1.2.5 Consistent with the SRC's guidance, the next steps in the development of the RMF are to:
 - a) establish criteria through which identified risks can be prioritised
 - b) using a sample of identified risks, demonstrate how the bowtie approach can be used to monitor the management of individual risks
 - c) assess the steps and potential costs required to fully develop the RMF.

¹ Report on the inquiry conducted by the Electricity Authority on the Penrose substation fire 5 October 2014, paragraph 5.28 <https://www.ea.govt.nz/dmsdocument/20148>

- 1.2.6 The highlighted part in Figure 1 indicates the specific RMF development areas that this paper addresses. Section 2 of this paper deals with the prioritisation of risks. Section 3 deals with demonstrating the risk assessment stage using the 'bowtie' method.

Figure 1 – RMF development in this paper



1.3 The SRC provided guidance on risk filtering and prioritisation metrics for the RMF

- 1.3.1 During the 22 October session the SRC provided its views on metrics that could be used to categorise risks. These views have been used to guide the development of criteria for use in the filtering and prioritisation of identified risks.
- 1.3.2 The responses and views given by SRC members at the 22 October 2015 workshop session have been distilled to the following key points:
- the SRC should act both proactively (prior to an event occurring) and reactively (post event) when considering risks
 - economic cost to consumers is the most important criteria
 - impact on the system was the next highest ranked metric. System event risks were ranked in an order that seems to reflect economic cost to consumers, as follows:
 - North or South Island outage
 - extended outage of a major city CBD
 - loss of major industrial load for 2 days or longer
 - loss of supply to a residential area for 2 days or longer

- v) loss of supply to a rural area for 2 days or longer
- d) risks of frequently occurring events are considered as higher priority than those that may lead to rare major events. Accordingly, systemic factors with the potential to cause multiple events should be taken into account with an elevated weighting
- e) risks of total system events are considered as higher priority than component-specific risks (e.g. transformer failure). A criterion relating to an extended reserve activation has therefore been added to those identified at the workshop session.

1.4 Workshop outputs have helped create a list of identified risk events

- 1.4.1 The output from the workshop has been used as guidance to produce a non-exhaustive list of 'risk events' that are within the SRC's terms of reference and should be included in the RMF. Even if an apparently exhaustive list is produced in the future, it will be important that the identified risk events are periodically reviewed to ensure the list remains complete.
- 1.4.2 As the SRC noted the need to take into account the frequency with which related events may occur, a criterion to account for multiple related events has been included for extended reserve events and long duration residential outages. These categories of risk events can be due to potentially systemic factors that, for example, can occur in risk management systems, asset health monitoring and maintenance practices, network design and regulatory incentives and controls.
- 1.4.3 Table 1 provides the risk events identified for inclusion in the RMF.

Table 1 – Risk events identified to be within the SRC's terms of reference

Identified risk events
North and/or South Island outage
Major CBD outage
2 or more extended reserve activations within a 2 year period
Extended reserve activation
Extended period of conservation measures implemented due to failure of supply to meet demand
Short period of conservation measures implemented due to failure of supply to meet demand
Loss of major industrial load 5 days or longer
3 or more events within a 1 year period of loss of supply to a residential area of >100,000 ICPs for 3 days or longer
Loss of supply to a residential area of > 100,000 ICPs for 3 days or longer
Loss of supply to a rural area > 30,000 ICPs for 5 days or longer

- 1.4.4 The next step in the RMF process is to consider the probability of an identified risk event occurring and the likely consequences if it does.

2 The metrics have been developed into criteria

- 2.1.1 In previous discussions on the RMF, the SRC has considered Transpower's, and other electricity network business' approaches to prioritising risks. At a high level, it was found to be common practice to consider risk events on the basis of probability and consequence (and/or criticality). The potential causes of supply security and reliability risk can be numerous so the criteria for prioritising risk in the RMF have been set at a high level (risk event). Criteria are applied using a simple probability/consequence assessment.
- 2.1.2 The SRC's guidance summarised in paragraph 1.3.2 have assisted the secretariat in developing criteria for assessing the probability and consequence of risk events. These criteria are set out in Table 2 below.

Table 2 – Criteria for assessing probability and consequence

Probability of occurrence	
Very Low	Less often than once in every 50 years
Low	Between once in every 25 years and 50 years
Medium	Between once in every 10 years and 25 years
High	Between once in every 5 years and 10 years
Very High	More often than once every 5 years
Consequence of occurrence	
Extreme	Potential loss of life, major economic impact, NZ and industry serious reputation damage, political intervention and scrutiny of the industry, government initiated inquiry
High	Major economic impact, industry reputation damage, potential government initiated inquiry
Medium	Material economic impact, potential industry reputation damage
Low	Some economic impact, inconvenience to consumers, erosion of consumer confidence
Very Low	Low economic impact, inconvenience to relatively small group of consumers

- 2.1.3 The probability and consequence criteria have been applied to each of the identified risk events. To apply the criteria for each risk event, actual historical events and design parameters (e.g. reliability standards) were taken into account. However, the application of the criteria, to an extent, relies on judgement.

Table 3 – Probability and consequence assessment of identified risk events

Risk event	Probability	Consequence
North and/or South Island outage	Very Low	Extreme
Major CBD outage	Medium	High
2 or more extended reserve activations within a 2 year period	Medium	High
Extended period of conservation measures implemented due to failure of supply to meet demand	Low	High
Extended reserve activation	High	Medium
Short period of conservation measures implemented due to failure of supply to meet demand	Medium	Medium
Loss of major industrial load 5 days or longer	Medium	Low
3 or more events within a 1 year period of loss of supply to a residential area of >100,000 ICPs for 3 days or longer	Very Low	Medium
Loss of supply to a residential area of > 100,000 ICPs for 3 days or longer	Low	Low
Loss of supply to a rural area > 30,000 ICPs for 5 days or longer	Low	Low

- 2.1.4 Figure 2 below illustrates the assessment from Table 3 when mapped onto a matrix of possible assessments. The colour coding in Figure 2 determines the overall prioritisation, and is another decision involved in the RMF where some subjectivity exists.

Figure 2 – RMF risk event prioritisation matrix

Probability	Very High					
	High			Extended Reserves activation		
	Medium		Loss of major industrial load 5 days or longer	Short period of conservation measures	Major CBD outage 2 or more extended reserves activations	
	Low		Loss to a residential area of > 100,000 ICPs Loss to a rural area > 30,000 ICPs		Extended period of conservation measures	
	Very Low			3 or more events to a residential area of >100,000 ICPs for 3 days or longer		North and/or South Island outage
		Very Low	Low	Medium	High	Extreme
		Consequence				

- 2.1.5 Table 4 below shows the risk events in a risk prioritisation table. The reasons for prioritisation are that higher-rated risk events can be assessed first, reassessed more frequently, and to give the SRC and its stakeholders with a clear understanding of what the SRC sees as its primary areas of focus. Prioritisation could also assist the SRC and the secretariat to establish a forward programme for the SRC's review of security and reliability risks.
- 2.1.6 Risk events that fall in the 'other risks' prioritisation category (dark green) are unlikely to ever warrant detailed risk assessment by the SRC. However, the SRC could make exceptions to this, especially if it is confident such an exception will not detract from its oversight of higher priority risks.

Table 4 – Prioritisation of identified risk events

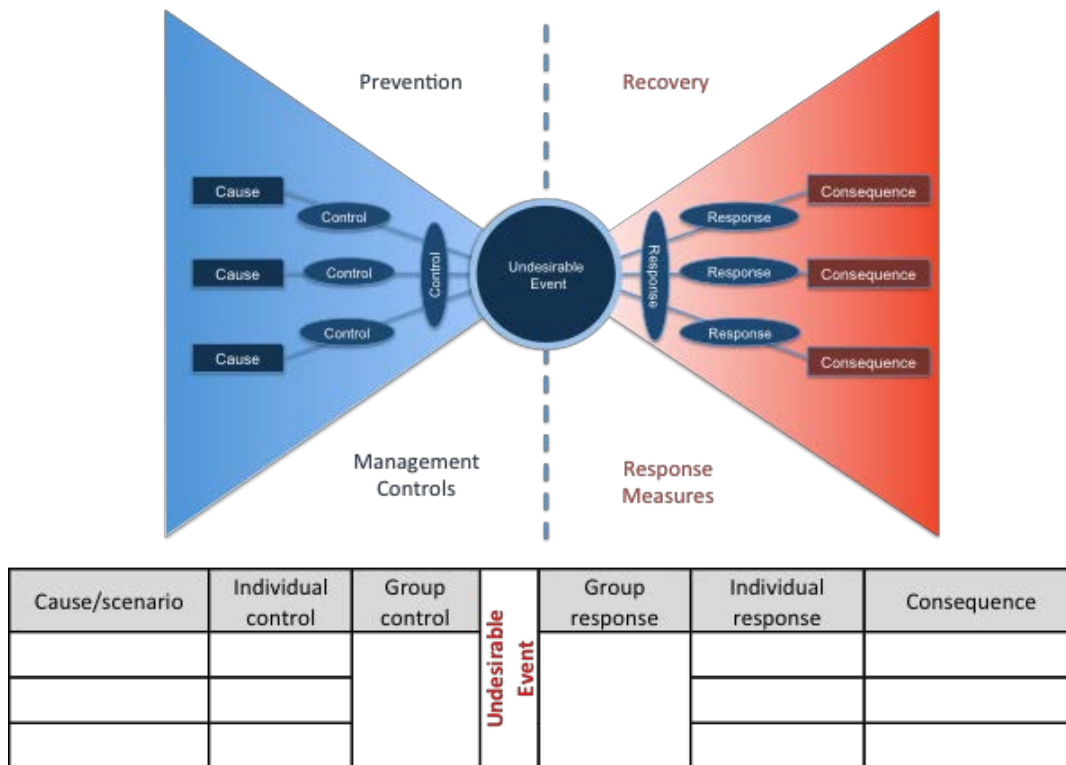
Priority 1	North and/or South Island outage
Priority 2	2 or more extended reserves activations within a 2 year period
	Major CBD outage
	Extended period of conservation measures implemented due to failure of supply to meet demand
Priority 3	Extended reserves activation
	Short period of conservation measures implemented due to failure of supply to meet demand
Priority 4	3 or more events within a 1 year period of loss of supply to a residential area of >100,000 ICPs for 3 days or longer
	Loss of supply to a residential area of >100,000 ICPS for 3 days or longer
	Loss of major industrial load 5 days or longer
	Loss of supply to a rural area > 30,000 ICPs for 5 days or longer
Other risks	All risks below priority 4 are considered to be outside the terms of reference of the SRC by default, unless an exception is made.

3 The bowtie risk assessment method has been used for a sample of risk events

3.1.1 The final stage in establishing the demonstration RMF has been to populate a bowtie briefing sheet for a selection of identified risk events.

3.1.2 Figure 3 below shows an archetype structure of a generic bowtie briefing sheet.

Figure 3 – An archetype structure of a bowtie briefing sheet



3.1.3 A classic bowtie revolves around a hazard which has the potential to cause damage or harm, and the top event which describes an undesired system state. In the SRC bowtie the hazard and top event have been collectively called 'the undesirable event'.

3.1.4 The bowtie model records the:

- threats, which are possible direct cause for the undesirable event
- controls, which are actions that can be applied to mitigate or eliminate the threat
- consequences, which are the loss or damage resulting if the undesirable event occurs
- responses, which are the measures which reduce the likelihood or mitigate the severity of the consequence arising from the undesirable event.

3.1.5 When interpreting a bowtie, it is useful to know that:

- individual controls are linked to individual threats
- individual responses are linked to individual consequences

- c) individual threats are not necessarily linked to individual consequences
- d) group controls apply to some or all of the individual threats
- e) group responses apply to some or all of the individual threats.

3.1.6 A range of proprietary bowtie software, apps and databases are available to be used for creating bowtie briefing sheets. However, until the extent of the information that will need to be held on the SRC's RMF is known, an Excel workbook has been used to demonstrate how the bowtie assessment can be applied to the identified risk events. This is discussed further in section 3.3.

3.2 Of the ten risk events listed, four bowtie briefing sheets have been produced

3.2.1 To enable the SRC to consider how it might use the RMF and its value to the SRC's role, the secretariat has populated four bowtie briefing sheets. The four briefing sheets have one risk event from each of the four priority levels. At this stage, the research and assessment has been limited to publically available information and the briefing sheets will require much more work should RMF be developed further.

3.2.2 The four briefing sheets appear in Appendix A.

3.2.3 Any SRC members who would prefer to view these briefing sheets in Microsoft Excel should contact the secretariat to request a soft copy.

3.3 The presentation of bowtie briefing sheets could be further developed

3.3.1 The secretariat has undertaken preliminary research on the type of risk management systems that are available. The research found that:

- a) a range of systems exist from very detailed and complex models for providing very detailed systems analysis of complex processes to relatively simple and basic options that provide a basic risk identification and assessment framework
- b) the complex systems hold more information than the SRC is expected to require and would be 'data hungry' and expensive to implement and maintain
- c) the simpler models provide a lower cost option and would be relatively simple to populate and maintain, although these models can be quite rigid in design and difficult to adapt to specific requirements.

3.3.2 Transpower, including the system operator, is currently reviewing its risk management process which includes the bowtie approach. The Authority is keen to identify areas for synergies between its processes and those of the system operator. Aligning the RMF with the system operator's process is likely to realise synergy benefits.

3.3.3 Similarly, the better the SRC's RMF aligns with standard industry practice the lower the costs involved would be if the SRC were to decide that sourcing some risks (and their assessments) from participants is desirable.

3.3.4 The secretariat will continue to assess how best to manage and present the RMF's bowtie risk assessment.

4 Questions for the SRC to consider

4.1.1 The SRC is asked to consider the following questions for discussion at its 15 March 2016 meeting.

- | | |
|-------------|---|
| Q1. | Does the SRC consider the identified risk events (Table 1) are set at an appropriately high level? Are there any modifications or additions the SRC would like to make to this list at this time? |
| Q2. | Does the SRC consider the criteria for assessing probability and consequence of the risk events (Table 2) are appropriate? |
| Q3. | Does the SRC consider that the criteria have been applied correctly to each risk event in Table 3? |
| Q4. | Does the SRC consider that the risk event prioritisation method (the colour-coding in Figure 2) is appropriate? |
| Q5. | Does the SRC consider that the format and presentation of the bowtie briefing sheets is adequate in the short-term? |
| Q6. | Does the SRC consider that the bowtie briefing sheets will be a useful way of presenting the components that form the current management of risk events? |
| Q7. | Does the SRC consider that the bowtie briefing sheets will be a useful method of identifying omissions and gaps in the current management of risk events? |
| Q8. | Does the SRC consider that the information contained in the bowtie briefing sheets is at an appropriate level of detail or should additional detail be added? |
| Q9. | Overall, does the SRC consider that the continued development of the RMF is likely to be of worthwhile benefit to the SRC? |
| Q10. | What further information, if any, does the SRC wish to have provided to it by the secretariat? |
| Q11. | What advice, if any, does the SRC wish to provide to the Authority? |

Appendix A: Bowtie briefing sheets

Priority 1 Bowtie assessment

Threat (cause/scenario)	Individual control	Group control	Undesirable Event	Group response	Individual response	Consequence
Failure of extended reserves operation during an under or over frequency event or Insufficient reserves scheduled to cover an event that leads to frequency fall below 47Hz	System operator Undertakes modelling, forecasting and planning to ensure that sufficient extended reserves are scheduled and armed Reserves providers are required under the Code to arm feeders to provide the required schedule load.	Part 8 Common Quality provision Part 8 relates to common quality. In particular, Part 8 concerns the performance obligations of asset owners, arrangements concerning ancillary services, a process for procuring extended reserve, and technical codes.	North and/or South Island outage	System operator Coordinates restoration of system using the Black start arrangements Undertakes post event review of extended reserves provider compliance and performance. If appropriate informs the Authority of any identified breaches of the Code.	Electricity distributors Provide safety communication through media and rapid response to safety related enquiries.	Risks of a fatality or serious injury to members of the public increases - e.g. medically dependent consumers may be affected as duration of outage is likely to be longer than capability of backup features on their equipment.
Bipole HVDC event and failure (e.g. due to multiple tower failures or coincident undersea cable failures on each pole, protection system fault etc.) combined with inability of extended reserves to address North Island frequency falling below 47Hz	Transpower Asset inspection, monitoring and asset management activities	System operator and asset owner principal performance objectives The Code requires that the system operator, grid owner and asset owners comply with their performance objectives as defined in the Code.. Code provisions for management of frequency (Part 8) Part 8 provisions for the management of frequency Covering for the single larges credible event Clause 8.17 Contribution by injections to overall frequency management Clause 8.18 Contributions by purchasers to overall frequency management Clause 8.19 Contributions to frequency		Transpower (grid owner) Operational management responding to event Provides advice to its customers who in turn communicate with affected consumers on coping without power Transpower (grid owner) and transmission customers respond to system operator instructions for black start and coordinate restoration including ensuring safety as supplies are restored	Electricity distributor Operational management responding to event Provides advice to its customers (e.g. electricity retailers)	Consumers lose benefits of electricity supply leading to inconvenience and comfort. If the event occurs in cold weather In winter the effects on the elderly and young can be severe.
	Grid owner Must comply with AOPOs Risk management assessment should identify risks and eliminate or mitigate the potential causes of a critical component failure Grid owner risk management practices aligned with ISO 31000				Electricity distributor Coordinates local restoration including ensuring safety as supplies are restored Electricity retailers Obtain information from the electricity distributor on outages and forecast duration and pass this onto their customers - the communication medium will differ between retailers Consumers having difficulty < what do they do?> safety concerns with power system - distributors Issues with critical electrical medical equipment - health professional or emergency services	Probable economic costs for consumers e.g. contents of freezers may be lost and inability to cook at home may cause additional cost to provide meals.
Bipole HVDC event and failure due to coincident undersea cable failures on each pole combined with inability of extended reserves to address North Island frequency falling below 47Hz	Transpower Cable monitoring (e.g. patrols) Good industry practice asset management (e.g. ISO 55000 accreditation, CBRM and asset lifecycle methods)	Compliance monitoring Clause 8.28 Responsibility for compliance Each asset owner must comply with the asset owner performance obligations and technical codes at all times Clause 8.27 System operator to monitor compliance To the extent possible, given the information made available by asset owners, the system operator must monitor, in the manner set out in the policy statement, the ongoing compliance of asset owners with the asset owner performance obligations and the technical codes		Government Provisions to request an inquiry under section 18 of the Electricity Industry Act 2010	Commerce Commission Investigations into specific breaches of quality limits Potential legal action for enforcement. Identifies potential actions to mitigate future events	Transpower or the electricity distributor is likely to breach its quality limits set under the Commerce Commission's price/quality regulation,
Failure of multiple generation plant	Application of good industry practice risk management (e.g. ISO 31000) including compliance risk management Good industry practice asset management (e.g. ISO 55000 accreditation, CBRM and asset lifecycle methods) Instantaneous reserves and AUFLS (extended reserves cover for generator failure	System Operator security of supply Role Clause 8.15 Requirement for the system operator to prepare and review system security forecast			<how will responses to media be coordinated?> Electricity Authority communications plan ?? System operator - technical systems spokes person < is there a plan for this?>	Media enquiries and questions intensify - media seeking an 'industry spokesperson' for live interviews. Reputation issues beginning to emerge through unanswered questions.
Cyber attack on grid and generator control systems Infiltration through deliberate hacking into transmission, generator, distributor information technology, communication, protection and control systems. Causes loss of control of the system leading to a drop in frequency which causes a cascade failure event. Possible extended event if black start operations are hampered by the attack.	ITC protection and surveillance systems Membership of and involvement in local and international industry associations (e.g. (Institution of Engineering and Technology (IET), Council on Large Electric Systems (CIGRE) etc.)	Extended reserves development and implementation Economic merit order of feeder arming resulting in a lower economic cost of an extended reserves event		Electricity distributors Coordinate restoration of local supplies with Transpower (grid power) Communicate with electricity retailers and the community on the affect of the outage and forecast restoration times May have customer compensation schemes	Electricity Authority communications plan ?? Asset owners Relevant asset owners undertake reviews and if appropriate notify the Authority of a breach of the Code requirements	Questions raised by government - opposition begins strong questioning of the government performance record on energy - calling for heads to role and reforms.
Other cause	Other individual response			Electricity Authority May initiate compliance investigation	Electricity distributors Operational management planning with lifeline organisations for responding to an event is implemented Provide advice to consumers on coping without power May provide generator back up supply	Lifeline organisations and systems may be disrupted by the loss of electricity supply. Traffic control systems may not function Fuel supply systems may be adversely effected (e.g. pumps at petrol stations cannot operate)
Other cause	Other individual response				Other response	Other consequence

Priority 2 Bowtie assessment

Threat (cause/scenario)	Individual control	Group control	Undesirable Event	Group response	Individual response	Consequence
Energy storage in South Island hydro lakes at critical levels, low expectation of sufficient rainfall, (Risk of shortage (as assessed under the SOSFIP) exceeds 10% and is forecast to continue to do so for at least one week.) Upper North Island peak demand at record levels for extended daytime periods due to high use of air conditioning	Reserve Supply Determination The Authority publishes the standing reserve supply determination to ensure continued access to hydro lakes at a trigger point that reflects the original expectations of the consenting authorities.	Electricity Authority - Security of supply policy framework - Specifies the system operator's security of supply functions and how they are to be performed and reported on - Security and Reliability Council to provide independent advice to us on the performance of the electricity system, the performance of the system operator, and reliability of supply issues security of supply forecasting and information policy		System operator Implement the emergency management policy (EMP) Increased monitoring of hydro storage levels by system operator and generators Official conservation campaigns System operator calls on New Zealanders to voluntarily reduce their electricity usage. <i>The system operator may declare an official conservation campaign in respect of the South Island only, or all of New Zealand.</i> <i>Public information campaign</i> <i><who and how?></i> Customer compensation scheme When an official conservation campaign is in force, retailers are required to compensate qualifying consumers in accordance with the customer compensation scheme See retailer obligations under a customer compensation scheme	Public information campaign <who and how?> Emergency and back-up generation Emergency and back up generation is considered for use and if appropriate, connected and operated. <by whom and how> Consumers having difficulty < what do they do?> Safety concerns with power system - contact electricity distributors Issues with critical electrical medical equipment - contact health professional, community support or emergency services	Risks of a fatality or serious injury to members of the public increases - e.g. medically dependent consumers may be affected as duration of outage is likely to be longer than capability of backup features on their equipment.
Availability of region specific generation (e.g. North Island hydro) is limited. Constraints on national energy transfer into the region is constrained (e.g. HVDC pole outage, low South Island hydro storage) Affected region's peak demand at record levels for extended daytime periods due to high use of air conditioning	Reserve Supply Determination The Authority publishes the standing reserve supply determination to ensure continued access to hydro lakes at a trigger point that reflects the original expectations of the consenting authorities.	Probability of an event is significantly reduced by market price signals and incentives on participants through customer compensation campaign Impact of outages reduced Improved information and communications assists consumers to better manage conservation period Improved management of the conservation leading to greater responses to the conservation campaign . Period of required conservation campaign likely to be shorter due to swifter response and improved coordination.			Electricity distributors Operational management responding to event Provides advice to its customers (e.g. electricity retailers) Electricity distributors Coordinate restoration including ensuring safety as supplies are restored Electricity retailers Obtain information from the electricity distributor on outages and forecast duration and pass this onto their customers - the communication medium will differ between retailers	Consumers lose benefits of electricity supply leading to inconvenience and comfort. If the event occurs in cold weather In winter the effects on the elderly and young can be severe. Probable economic costs for consumers e.g. inability to cook at home may cause additional cost to provide meals.
Limited region specific generation is limited (e.g. North Island thermal generation due to recent decommissioning of plant and no new thermal generation capacity constructed), The region is experiencing voltage support issues during extended periods due to high energy transfers and limited generation capacity within the region. The region's peak demand is at record levels for extended daytime periods due to high use of air conditioning	Wholesale price incentives Wholesale prices provide a locational signal which indicates where and when opportunities exist for investment in generation. Hedge and futures markets provide longer term signals for generation investments. Transmission infrastructure investment Commerce Commission regulatory approval of reliability investments through the GIT for reliability investments. Energy and network price structures Time of use price structures for energy, distribution and transmission provide incentives for consumers to reduce demand at system peak times.	System operator - security of supply forecasting and information policy (SOSFIP) - an emergency management policy (EMP) - system operator rolling outage plan (SOROP) Note the Electricity Authority approve or decline any SOSFIP, EMP or SOROP that the system operator puts forward. System operator modeling and monitoring reduces risk of an event through improved information to participants. Probability of an event is significantly reduced by market price signals PROPs provide improved management of regional conservation efforts as rolling outage sequences are preplanned. Customer compensation scheme Incentives created through retailer obligations under a customer compensation scheme Wholesale market price incentives The wholesale electricity market provides price signals to participants to appropriately manage the balance of supply and demand. System operator annual security of supply assessment Electricity Authority sets assumptions that the system operator must use when preparing the annual security of supply assessment. The system operator may use alternative assumptions, though it must always include an assessment against the Authority's assumptions.	Extended period of conservation measures implemented due to failure of supply to meet demand	Rolling outages Last resort measure in which the system operator is required to plan and implement compulsory electricity outages in order to prevent a complete system failure If the voluntary savings of an official conservation campaign are insufficient, then compulsory savings in the form of rolling outages may be required.	Participant Rolling Outage Plans (PROP) Distribution networks, direct connect consumers implement PROPs Voluntary load management Customers encouraged to undertake voluntary load shedding at peak demand times <by whom?> Use of backup and emergency generation Customers run existing backup and emergency generation. Local emergency generation is sourced, connected and operated during peak demand times.<by whom and how>	Consumers implement individual energy conservation initiatives
					<how will responses to media be coordinated?> Electricity Authority communications plan ?? System operator - technical systems spokes person < is there a plan for this?>	Media enquiries and questions intensify - media seeking an 'industry spokesperson' for live interviews. Reputation issues beginning to emerge through unanswered questions.
					Electricity Authority communications plan - relevant components implemented <does the SRC have a role> System operator role in providing information on the status of energy situation and system issues <how is this coordinated?>	Questions raised by government - opposition begins strong questioning of the government performance record on energy - calling for heads to role and reforms.
				Simultaneous conservation campaign and rolling outages In the event of catastrophic asset failure, it is possible that an official conservation campaign and rolling outages will be implemented simultaneously.	Electricity distributors Operational management planning with lifeline organisations for responding to an event is implemented Provide advice to consumers on coping without power May provide generator back up supply	Lifeline organisations and systems may be disrupted by the loss of electricity supply. Traffic control systems may not function Fuel supply systems may be adversely effected (e.g. pumps at petrol stations cannot operate)
					Other response	Other consequence
Other threat	Other control	Wholesale market price incentives The wholesale electricity market provides price signals to participants to appropriately manage the balance of supply and demand.			Other response	Other consequence

Priority 3 Bowtie assessment

Threat (cause/scenario)	Individual control	Group control	Undesirable Event	Group response	Individual response	Consequence
Loss of generation >500MW leads to tripping of AUFLS block 1 - this could occur under normal operating conditions or under testing and commissioning of assets/systems	Generator performance The Code requires generators to remain connected within the specified frequency limits	Part 8 Common Quality provision Part 8 relates to common quality. In particular, Part 8 concerns the performance obligations of asset owners, arrangements concerning ancillary services, a process for procuring extended reserve, and technical codes. System operator and asset owner principal performance objectives The Code requires that the system operator, grid owner and asset owners comply with their performance objectives as defined in the Code.. Code provisions for management of frequency (Part 8) Part 8 provisions for the management of frequency Covering for the single larges credible event Clause 8.17 Contribution by injections to overall frequency management Clause 8.18 Contributions by purchasers to overall frequency management Clause 8.19 Contributions to frequency support in under-frequency events Clause 8.20 Contributions by grid owners to frequency support Compliance monitoring Clause 8.28 Responsibility for compliance Each asset owner must comply with the asset owner performance obligations and technical codes at all times	Extended reserves (or AUFLS) activation	Code provisions for restoration of supply Clause 8.5 If an event disrupts the system operator’s ability to comply with the principal performance obligations, the system operator must act as a reasonable and prudent system operator to re-establish normal operation of the power system as soon as possible System Operator Manages return to operation within required frequency range: Communication and coordination with distribution networks and directly connected loads System operator undertakes a post event review SRC SRC review of System Operator post event review report	Transpower (grid owner) Operational management responding to event Provides advice to its customers who in turn communicate with affected consumers on coping without power Transpower (grid owner) and transmission customers	Consumers lose benefits of electricity supply leading to inconvenience and comfort. As restoration of supplies is likely to be achieved within 60 minutes the impact on consumers will be limited. Extent of the outages will be broader if blocks 1 and 2 are activated .
Transmission equivalent to a loss of >500MW leads to tripping of AUFLS block 1 - this could occur under normal operating conditions or under testing and commissioning of assets/systems	Grid owner Grid owner is required to meet its AOPOs . Grid owner risk management practices aligned with ISO 31000				Electricity distributors Operational management responding to event Provides advice to its customers (e.g. electricity retailers) Electricity distributors Coordinates restoration including ensuring safety as supplies are restored	Media enquiries and questions intensify - media seeking information and an 'industry spokesperson' . Potential for reputation issues if information is not timely and questions remain unanswered. Extent of media attention will be greater if blocks 1 and 2 are activated .
Insufficient load tripped in block 1 during a response to an under frequency event leading to trip of block 2 with a resulting loss of supply to 1200MW of load	Extended reserves development Move to 4 block scheme better matches load trip with frequency event minimises economic cost of an event				Electricity retailers Obtain information from the electricity distributor on outages and forecast duration and pass this onto their customers - the communication medium will differ between retailers Consumers having difficulty < what do they do?> safety concerns with power system - distributors Issues with critical electrical medical equipment - health professional or emergency services	
Insufficient reserves scheduled to cover an event that leads to frequency fall below 47Hz Insufficient load tripped during a response to an under frequency event leading to trip of block 2 with a resulting loss of supply to 1200MW of load	System operator Undertakes modelling, forecasting and planning to ensure that sufficient extended reserves are scheduled and armed Reserves providers are required under the Code to arm feeders to provide the required schedule load.	Clause 8.27 System operator to monitor compliance To the extent possible, given the information made available by asset owners, the system operator must monitor, in the manner set out in the policy statement, the ongoing compliance of asset owners with the asset owner performance obligations and the technical codes		Communication with affected customers Electricity distribution networks use local communication channels to provide information to affected consumers Electricity distribution networks inform electricity retailers of affected customers Electricity retailers communicate with their affected customers	System operator Undertakes post event review of extended reserves provider compliance and performance. If appropriate informs the Authority of any identified breaches of the Code. Asset owners Relevant asset owners undertake reviews and if appropriate notify the Authority of a breach of the Code requirements	Risks of a power outage related fatality or serious injury to members of the public increases - e.g. medically dependent consumers may be affected, however the duration of outage is likely to be within the capability of backup features for critical medical equipment.
Operation at RAFS at zero leads to insufficient scheduled extended reserves to avoid frequency falling below 47Hz	Reserves providers Are required under the Code to arm feeders to provide the required schedule load.	System Operator security of supply Role Clause 8.15 Requirement for the system operator to prepare and review system security forecast Extended reserves development and implementation Economic merit order of feeder arming resulting in a lower economic cost of an extended reserves event		Electricity Authority May initiate an Code Compliance investigation May undertake a review of performance of the system operator under the provisions of the relevant service provider contracts Has published guidelines for the management of medically dependent consumers	Electricity distributors Operational management planning with lifeline organisations for responding to an event is implemented	Lifeline organisations and systems may have temporary disruptions but the impact should be manageable. The impact of the outages will be broader if blocks 1 and 2 are activated .
Insufficient load tripped in block 1 during a response to an under frequency event leading to trip of block 2	Extended reserves development and implementation Implementation of 4 block structure will more closely match arming of extended reserves to requirement.				Other response	Other consequence
Failure of a critical component of the HVDC assets and/or control/protection systems	Grid owner Must comply with AOPOs Risk management assessment should identify risks and eliminate or mitigate the potential causes of a critical component failure			Electricity Distributors and direct connected loads Electricity distributors and directly connected loads cooperate with system	Other response	Other consequence

Priority 4 Bowtie assessment

Threat (cause/scenario)	Individual control	Group control	Undesirable Event	Group response	Individual response	Consequences	
Major failure of a transmission asset affecting Transpower's ability to provide the required energy transfer capacity to a single large and/or multiple small distribution networks. Examples include failure and loss of a regional substation (e.g. double transformer failure at Edgcombe in 2000) loss of an important substation, for example due to fire, subsidence, weather event, earthquake, flood etc.	Transpower Submission for Commerce Commission approval of grid investment proposals required to maintain reliability of supply Asset management practices that includes risk assessments (e.g. HILP risk identification and management) Vegetation management - controls risks of falling and flying material during a storm Operational management planning - for responding to an event	Commerce Commission Suppliers of electricity lines services are subject to regulatory provisions under the Commerce Act 1986. The relevant components of the Commissions regulation of electricity lines businesses are: - information disclosure (e.g. asset management plans) - price/quality (monitoring and enforcement of reliability performance SAIDI and SAIFI measures - customised price path determinations for distribution businesses - individual price path determinations for Transpower - approval of major grid reliability investment projects Note that not consumer owned distributors are exempt from the price/quality regulation. industry associations Industry associations undertake researched and provide advice and guidance to the electricity industry. Examples include: ENA, EEA, CIGRE	Loss of supply to a residential area of >100,000 ICPS for 3 days or longer	Transpower (grid owner) Operational management responding to event Provides advice to its customers who in turn communicate with affected consumers on coping without power Transpower (grid owner) and transmission customers Coordinate restoration including ensuring safety as supplies are	Electricity distributors Provide safety communication through media and rapid response to safety related enquiries.	Risks of a fatality or serious injury to members of the public increases - e.g. medically dependent consumers may be affected as duration of outage is likely to be longer than capability of backup features on their equipment.	
Failure of a major electricity distribution asset (e.g. Penrose tunnel) that causes damage and failure to multiple assets (e.g. zone substations, cables or overhead lines)	Electricity distributors Asset management practices aligned with ISO 55000 and good electricity industry practice - including asset health monitoring and appropriate asset lifecycle management Risk management practices aligned with ISO:31000 and good electricity industry practice - including HILP risk assessment Contingency planning - e.g. network switching and interconnection plan to provide an alternative to the damaged subtransmission Operational management planning - for responding to an event			Government Provisions to request an inquiry under section 18 of the Electricity Industry Act 2010	Electricity distributor Operational management responding to event Provides advice to its customers (e.g. electricity retailers) Electricity distributor Coordinates restoration including ensuring safety as supplies are restored Electricity retailers Obtain information from the electricity distributor on outages and forecast duration and pass this onto their customers - the communication medium will differ between retailers Consumers having difficulty < what do they do?> safety concerns with power system - distributors Issues with critical electrical medical equipment - health professional or emergency services	Consumers lose benefits of electricity supply leading to inconvenience and comfort. If the event occurs in cold weather In winter the effects on the elderly and young can be severe. Probable economic costs for consumers e.g. contents of freezers may be lost and inability to cook at home may cause additional cost to provide meals.	
Systemic failure of critical distribution sub transmission assets leading to loss of capacity in multiple zone substations (e.g. age related mode type failure of subtransmission cables) For example systemic failures may become apparent following earthquakes and/or floods or extended periods of high temperature and high loading.	Electricity distributors Asset management practices aligned with ISO 55000 and good electricity industry practice - including asset health monitoring and appropriate asset lifecycle management Risk management practices aligned with ISO:31000 and good electricity industry practice - including HILP risk assessment Contingency planning - e.g. network switching and interconnection plan to provide an alternative to the damaged subtransmission Operational management planning - for responding to an event	Guideline on arrangements to assist medically dependent consumers The Guideline articulates the Electricity Authority's expectations of electricity retailers in respect of medically dependent consumers. It represents a minimum standard that the Authority expects retailers to meet. The guideline includes expectations regarding the establishment of planning for back up of critical electrical medical equipment during supply outages. The guideline states that DHBs, private hospitals and GPs should check that the patient/caregiver has been informed of all relevant aspects of using the critical electrical medical equipment.		Electricity distributors Communicate with electricity retailers and the community on the affect of the outage and forecast restoration times May have customer compensation schemes		Commerce Commission Investigations into specific breaches of quality limits Potential legal action for enforcement. Identifies potential actions to mitigate future events	Transpower or the electricity distributor is likely to breach its quality limits set under the Commerce Commission's price/quality regulation,
Serious weather event causing significant damage to distribution networks	Electricity distributors Asset management practices aligned with ISO 55000 and good electricity industry practice - including asset health monitoring and appropriate asset lifecycle management Risk management practices aligned with ISO:31000 and good electricity industry practice - including HILP risk assessment Vegetation management - controls risks of falling and flying material during a storm Operational management planning - for responding to an event	Electricity distributors Set network planning criteria for their individual networks. Network planning criteria generally define the level of redundancy (e.g. N-1) that is provided for different load groups (size and importance) Planning criteria is usually disclosed by electricity distributors in their published asset management plans		Electricity Authority <no role??>	<how will responses to media be coordinated?> Electricity Authority communications plan ?? System operator - technical systems spokes person < is there a plan for this?>	Media enquiries and questions intensify - media seeking an 'industry spokesperson' for live interviews. Reputation issues beginning to emerge through unanswered questions.	
				Energy Safety May investigate if the event gives rise to or risks a death or injury.	Electricity Authority communications plan ??	Questions raised by government - opposition begins strong questioning of the government performance record on energy - calling for heads to role and reforms.	
				Electricity distributors Operational management planning with lifeline organisations for responding to an event is implemented Provide advice to consumers on coping without power May provide generator back up supply Other response	Lifeline organisations and systems may be disrupted by the loss of electricity supply. Traffic control systems may not function Fuel supply systems may be adversely effected (e.g. pumps at petrol stations cannot operate) Other consequence		