NZ Battery project

Ministry of Business, Innovation and Employment

Actuarial study on dry year issues

18 October 2023

Disclaimer - Purpose of our report and restrictions on its use

This report was prepared on the instructions of the Ministry of Business, Innovation and Employment (MBIE) solely for the purpose of supporting MBIE by outlining the way insurers might think about a problem similar in nature to the problem the NZ Battery project is seeking to address. The report should not be relied upon for any other purpose.

In carrying out our work and preparing our report, we have worked solely on the instructions of MBIE and for MBIE's purposes. This report was developed as a 'white paper' style report, based on our insights and experience working with insurers and other clients. However, this is not intended to be a comprehensive review these issues and no additional analysis was conducted to further test these findings.

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In preparing this report we have considered and relied upon information from a range of sources believed to be reliable and accurate. We have not been informed that any information obtained from public sources was false.

Our work has been limited in scope and time and we stress that a more detailed report may reveal material issues that this report has not.

Contents

Glossary

Term	Description
ACC	Accident Compensation Corporation
AEP	Accredited Employers Programme
Adverse selection	Adverse selection occurs when high-risk individuals are more likely to take out insurance as the premium does not reflect their true level of risk.
Aggregate deductible	An aggregate deductible is the total maximum amount of risk the direct insurer will retain before the insurance / reinsurance coverage may commence.
BoD	Board of directors
Catastrophe bonds	Catastrophe bonds (or cat bonds) are a financial instrument where the insurance company will receive a fixed payout (the bond principal) if the specific conditions of the bond are met. In return, the insurance company provides a high interest rate on the principal.
Cession limit	The cession limit is the maximum amount that the reinsurer will cover. This limit may be set on an individual policy level, event, or time basis.
Claims ratio	Claims ratio is the ratio of claims to premiums.
Credibility theory	Credibility theory is a statistical approach used by insurers to combine various sources of information.
Direct insurance	A contract between an individual/entity and an insurer, where the insurer indemnifies the individual / entity from loss or damage or the liability to compensate for loss or damage arising from specified contingencies (e.g., fire, injury, death negligence etc.) in return for a payment appropriate to the risk involved.
EQC	Earthquake Commission, Toka Tū Ake
Excess of Loss	A type of policy which only covers the losses exceeding a predefined threshold.
Experience rating	Experience rating is a pricing approach that prospectively adjusts premiums based on an individual / entity's past loss experience.
Facultative reinsurance cover	Facultative reinsurance is a one-off transaction where the amount of risk transferred is defined for a single policy or a group of policies.
Financial ratio	Financial ratios are ratios of two numerical values taken from an entity's financial statements. These ratios are used to assess the financial condition of a business.
Frequency	Frequency is the number of claims that an insurer expects, or more generally, the number of events that are expected to occur.
Government bailout	A government bailout is a situation in which a government pays or lends money to save an entity or industry from failing.
Gross claims ratio	An insurance performance metric. Gross claims ratios are calculated as the ratio of claims to premiums before reinsurance.
GST	Goods and service tax is a New Zealand consumption tax usually charged at 15%.
Home builder's warranty insurance	Home builder's warranty provides insurance to homeowners undertaking building works if the works are not completed and / or there is a fault in the works, and the costs cannot be recouped from the builder.
IBC	Indicative business case
Immunisation	Immunisation is a risk-mitigation strategy that matches the duration of assets and liabilities to minimise the impact of interest rates on cash flows over time.
Information asymmetry	Information asymmetry refers to a situation or transaction where one party has more or better data or information than the other party.

Term	Description
Insurance	Unless otherwise defined, insurance in this document is used in general to refer to both direct insurance and reinsurance.
Lapse rate	Lapse rate is a measure of the number of policies issued by an insurer that are not renewed compared to the number of policies at the start of a period.
Market testing	Market testing is the process of assessing customer reaction to a product before it is launched.
MBIE	Ministry of Business, Innovation and Employment
Moral hazard	Moral hazard is a situation where an individual's behaviour changes because they are insured.
No-fault scheme	A no-fault scheme is a compensation system that pays claims to the injured individual / entity regardless of who is at fault.
Non-proportional reinsurance cover	Under a non-proportional reinsurance arrangement, cover is provided for claims costs above a predetermined threshold but below a set limit.
NZ	New Zealand
Occurrence limit	An occurrence limit is the maximum amount an insurer or reinsurer will pay to cover claims for a single loss event.
Perils modelling	Perils modelling is a process of modelling the distribution of losses related to natural catastrophes.
Pooling	(Risk) pooling is the mechanism underpinning insurance. When an insurer combines the premiums for all the individual it insures, poor loss experience of some individuals is offset by the better loss experience of other individuals.
Premium liabilities	Premium liabilities are the value of claims held on an insurers balance sheet for events that will occur after the valuation date, but the insurer is liable for, as premiums have already been collected to cover these claims.
Probability of adequacy / Probability of sufficiency	The probability that available capital will be sufficient.
Product excess	The excess of an insurance product is an agreed amount of a claim that the insured must pay before the insurer covers the outstanding balance of the claim, if any.
Product exclusions	The exclusions of an insurance product are the loss events which are not covered by the insurance product.
Profit testing	Profit testing models are statistical models used to determine the profitability of an insurance contract according to a defined set of parameters. The product's cashflows will be projected and the present value of expected premiums will be derived based on external factors such as stakeholder return and profit margin.
Proportional reinsurance cover	Under a proportional reinsurance arrangement, the amount of risk transferred can be expressed as a proportion of sum insured.
Projection model	Projection models are statistical models that indicate what can occur if assumptions regarding future trends and patterns occur.
RBNZ	Reserve Bank of New Zealand
Reinsurance / Reinsurance treaty	Insurance (as defined in direct insurance) where the contract (referred to as a treaty) is between an insurer (rather than the individual / entity) and another insurer (the reinsurer).
Residual risk	Residual risk is the level of risk that remains following the implementation of risk management actions.
Retention limit	Retention limit is the amount of risk to be retained by the direct insurer before reinsurance coverage may commence.
Retrocession	Retrocession is reinsurance where the contract is between a reinsurer (rather than the insurer) and another reinsurer.
Reverse stress testing	Reverse stress testing is a process where scenarios and assumptions are developed that would deliberately result in failure.

Term	Description
Risk appetite	Risk appetite is a measure of the amount and type of risk an entity is willing to take to meet its long-term objectives.
Risk exposure	Risk exposure is a measure of the potential loss that may arise from a specific event or activity.
Risk margin	A risk margin is an additional amount in the claims and premium liabilities held on insurer's balance sheets to allow for the risk that the liabilities may be underestimated.
Risk rate	To risk rate, or risk rating, refers to the insurer charging a different premium for different individual based on their underlying risk characteristics.
Risk transfer	Risk transfer is a risk management technique that involves transferring the financial consequences of a risk to another party.
Sensitivity testing	Sensitivity testing is a process where the values of a single input variable is changed to determine the flow on effects on the outcome or result.
Scenario testing	Scenario testing is a process where scenarios and assumptions are developed and applied to understand their impact on an outcome or result.
Stochastic modelling	Stochastic models are a type of analytical method which allows for random variation in one or more parameters over time. These types of models are useful for estimating the distribution of potential outcomes.
S&P AA	Standard and Poor (*"S&P"*) Global Ratings is an American credit rating agency. Companies rated *"AA"* by S&P will be considered to have very strong capacity to meet its financial obligations.
Stop-loss reinsurance	A type of excess of loss arrangement. Under a stop-loss reinsurance treaty, a reinsurer takes on all losses for a portfolio once a specified amount is reached for a given year
Solvent / Solvency	Solvency is a business concept which indicates whether an entity possess enough resources to meet long-term debts and financial obligations owed. Insurers are considered solvent if they can pay for claims as they come due.
Sum insured	The sum insured of an insurance product is the amount of money that an insurance company is obligated to cover in the event of a covered loss.
Superannuation (Australia)	Superannuation (*"super"*) in Australia is a compulsory form of retirement savings scheme where a minimum percentage of an individual's income is directed to a fund and then accessed during retirement.
Tail risk	Tail risk refers to low probability risks or risks arising from rare events.
Tail value at risk (TVaR)	Tail value at risk is the expected loss given that an event outside the specified VaR has occurred.
Technical premium	The technical premium reflects the cost of claims (after risk mitigation activities, including reinsurance), costs associated with the policy (such as reinsurance and commissions), a share of corporate overheads, the cost of capital required to support the policy, and the planned profit margin.
Underinsured / Underinsurance	To be underinsured, or underinsurance, refers to insufficient insurance coverage that leaves the individual / entity response for a large proportion of total loss and may lead to financial hardship.
Underwriting	Underwriting is the process by which an insurer evaluates its risks and decides what coverage will be provided to the insured, if any.
Uptake rate	Uptake rate is a measure of the number of policies issued by an insurer compared to the number of quotes provided.
Value at risk (VaR)	Value at risk is the severity of a loss which occurs with a given probability.

Executive Summary

The New Zealand *("NZ")* Battery project has been established to help ensure security of supply of a highly renewable electricity system and to provide resilience to dry year events. The issues being explored by the NZ Battery project are analogous to the reinsurance market. Reinsurers (or in this case, the NZ Government) must manage the risk of having insufficient resources (capital or energy supply) within the context of uncontrollable and unpredictable events (e.g., earthquakes or dry-year events), where these events are firstly being managed by another party (the direct insurers or electricity market participants).

Given the similarities, it is worth considering how an insurance business may approach understanding and managing a risk similar in nature to that faced by the NZ Battery project, as well as what processes or tools may be useful in this context.

The below table outlines the activities an insurance company may perform in a similar situation[1].

1	**Understand the risk exposure**	Utilise stochastic modelling and other analyses to understand and quantify the likelihood and consequence of an event occurring in the future given a current realistic forecast of their business. In this way it is possible to use the results of the stochastic modelling to quantify the tail risks of an event occurring. In stochastic modelling, a forecast of future inflows and outputs is developed, like standard projection models. However, within a stochastic model, assumptions around the distribution and correlation of key input variables will be set. Rather than providing a single forecast or a limited number of scenarios, a stochastic model provides the full distribution of results which helps to determine the likelihood of specified events occurring. Additional modelling or analysis (e.g., detailed economic modelling) may also be required to quantify the consequence associated with these events.
2	**Compare the risk exposure to the risk appetite statement**	A risk appetite statement is a written definition of the amount and type of risk an entity is willing to take to meet its long-term objectives. Clear definitions of the types and limit of risks that are acceptable (including the risk of failure to supply sufficient energy to the New Zealand public) to the insurer act to guide its future decisions and activities. An insurer would compare the existing risk exposure to their risk appetite statement to determine if the level and type of risk is acceptable or if action must be taken.
3	**Identify and model the options to manage the risk**	Identify potential options to manage the risk and consequences of an event to an acceptable level. The effectiveness of the risk management options can be modelled via incorporation into the stochastic model and by performing scenario testing. Scenario testing will allow decision makers to understand how effective each solution may be in managing risk if one or a series of adverse events were to happen. To perform scenario testing, the impact of one or more cumulative events are tested with the resulting outcome incorporating the expected result of risk mitigation activities and reasonable management actions. Events tested may range from a series of likely events to a single highly improbable event.

[1] We note that insurance concepts explored in this paper could also be relevant to managing the risk of damage to an asset being considered within the NZ Battery project. This discussion however, focuses on how an insurer would conceptually view a problem similar in nature to that faced by the NZ Battery project, not on how an insurer would approach insuring an asset developed as part of the NZ Battery project. The activities outlined have been developed to help MBIE understand how an insurance business may approach this situation and does not provide an overview or critique of the works undertaken to date.

		When considering options, consideration will also be given to the potential for *moral hazard*; when individuals behave differently after having insurance.
4	**Identify the appropriate approach to recoup costs**	Expenses relating to the entity's activities and risk mitigation will need to be recouped by the insurer as part of the premium or levy. The insurer will need to determine the appropriate group of customers and the period over which to recoup the costs, especially for investments with high upfront capital costs. Consideration must be given to the feasibility and equity of each approach (including current market conditions) and how the approach may impact the insurer's financial position and its stakeholders.
5	**Identify the *"optimal"* solution**	Determination of the final *"optimal"* risk mitigation activity (or activities) should consider how the risk mitigation activities perform against a range of factors including: alignment to the insurer's long-term objectives, the effectiveness of the activity to manage the risk (through comparison to the risk appetite statement); the economic, social and environmental costs; and the resilience and long-term sustainability of the solution, including to emerging risks.
6	**Implement the solution and monitor**	The agreed upon solution will be implemented by the insurer, following which the insurer will closely monitor their exposure to risk, including the performance of the risk mitigation solution, and make adjustments when required.

While there is no single correct answer, supplementing future activities on the NZ Battery project with an approach founded in insurance principles would provide a robust framework to understanding, quantifying, and prioritising the trade-off of risks and costs for the NZ Battery project.

1. Background

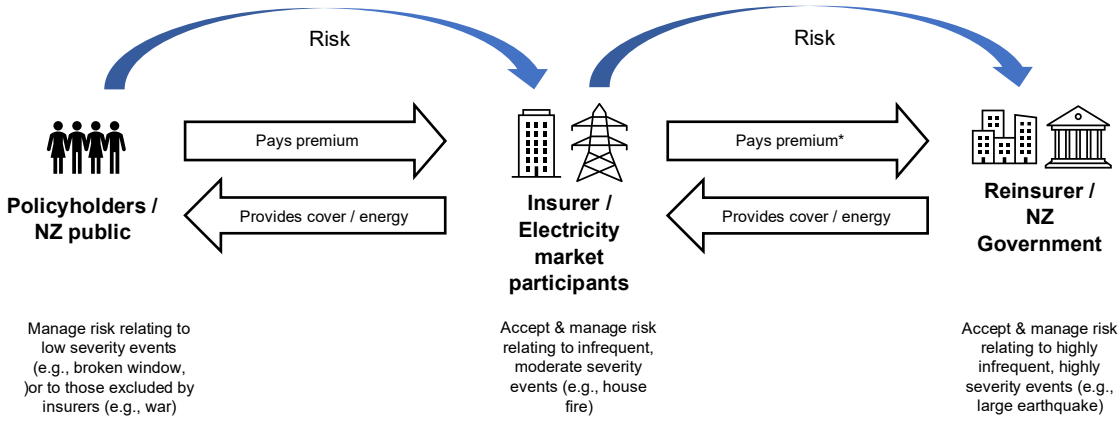
The NZ Battery project has been established to help ensure security of supply in a highly renewable electricity system and, in particular, to provide resilience to dry year events. These events, by definition, occur infrequently, vary in terms of severity, and are largely unpredictable.

The NZ Battery project is a multi-phase, multi-year project. It is currently entering its second phase, focussed on preparation of a detailed business case, which aims to identify a preferred solution between three options:

1. Pumped hydro at Lake Onslow.
2. A multi-technology Portfolio option that might include private delivery of services and / or creation of a capacity market.
3. Not making an investment, while continuing to work on improvements to the function of the current electricity trading market operations and associated investment incentives to improve peaking and dry year security of supply (base case / counterfactual).

The NZ Battery project is analogous to the reinsurance environment as both reinsurers and the NZ Government must carefully manage the risk of having insufficient resources within the context of uncontrollable events that are first managed by another party (the direct insurers or electricity market participants). More specifically, reinsurers must maintain sufficient capital to remain solvent, even when impacted by large uncontrollable and unpredictable events, such as large natural disasters, where small events are first absorbed and managed by the direct insurers. Similarly, the NZ Government seeks to support an environment where the energy needs of the population are continuously met when both the supply and demand of energy can be both unpredictable and outside of the Government's direct control. The electricity market participants are expected to manage moderate fluctuations of supply and demand, with the NZ Government (via the NZ Battery project) only aiding when these fluctuations cannot otherwise be managed. Figure 1 below demonstrates this risk transfer process.

Figure 1: Risk transfer process between policyholders, insurers, and reinsurers or NZ public, electricity market participants and the NZ Government.



Note: The approach for cost collection for the NZ Battery project is yet to be determined.

Given the similarities, it is a useful exercise to consider how an insurance business would conceptually approach understanding and mitigation of a risk similar in nature to that faced by the NZ Battery project. This report provides an overview of insurance and reinsurance, describes how insurers and reinsurers assess and manage risks including outlining the tools and techniques they utilise, and provides an overview of how insurers and reinsurers approach specific risks such as low frequency, high severity risks and emerging risks. We also provide an indication of the expected activities that an insurer would perform if faced with a problem similar in nature to that faced by the NZ Battery project.

The operations of insurers and reinsurers are similar in nature, with both insurers and reinsurers being faced with similar types of risks and employing similar approaches for understanding and managing them. For this reason, unless explicitly stated, throughout the document we refer to "*insurance*" in general, including both direct insurance (i.e., a contract between an individual or entity and the insurer) and reinsurance (i.e., a contract between an insurer and reinsurer).

2. Risk management overview

Risk arises whenever there is uncertainty in the future. Uncertain future events are hard to measure, plan and quantify outcomes for, and can negatively impact an entity's ability to achieve its objectives. The risk management process aims to identify, prioritise, mitigate, and reduce future uncertainty in order to minimise the negative impacts of risk and capitalise on potential opportunities arising from risk.

There are five main strategies to deal with risk. The following table provides an overview of each strategy as well as insurance and non-insurance applications of each strategy.

Table 1: Overview of risk management methods

	Strategy	Description	Examples of insurance application
1	Avoidance	Identifying overly risky elements and removing exposure to them. For instance, airlines delaying flights during turbulent weather.	Identifying overly risky clients through underwriting processes and refusing cover.
2	Acceptance	Identifying and documenting the risk. Consequences are dealt with if the risk materialises. For instance, individuals accept the risk of an accident when skydiving.	Identifying and documenting how the risk of death for smokers may be higher than non-smokers but still providing group life insurance at the same cost for all employees of a business.
3	Reduction	Identifying and understanding the risk in order to implement strategies and processes to limit the impact of the risk if it materialises. For instance, checking vaccinations are up to date prior to overseas travel to reduce the risk of getting sick.	Implementation of standardised reporting, documentation, training, and system processes to reduce the frequency and severity of non-compliance and human error, thus reducing an insurer's own operational risks. An insurer may require similar processes if providing cyber insurance to a business.
4	Spreading	Identifying and spreading risk such that if an event occurs, not everything will be impacted. For instance, keeping multiple copies of documents in various locations to prevent accidental loss of work.	Diversifying policy characteristics and offering cover across a large and varied group of people (e.g. providing flood cover for all of New Zealand, rather than just in one region).
5	Transferring	Identifying and offloading a portion of risky elements to a third party. For example, third party manufacturing can reduce the risk of insufficient supply for small businesses, or homeowners may take out insurance to transfer the financial risk of a natural catastrophe occurring.	Reinsuring policies and transferring a portion of claim costs to a reinsurer. Note that reinsurers also take out reinsurance, called retrocession.

We note that insurers and the NZ Government have different constraints under which they must manage their risks. Insurers must work within the existing regulation and legislation which may limit their ability to manage some of their risks (such as through policy wording, pricing, underwriting etc.) Conversely, the NZ Government does have greater scope to set legislation and policies that enable them to directly manage their risk, but (in the context of the NZ Battery project) are unable to transfer or avoid the risk of an energy shortage event.

3. Insurance

3.1. Overview of insurance and reinsurance

For purchasers of insurance, insurance sits under the *"transferring risk"* strategy outlined above. The insurance industry exists to provide financial protection to individuals and businesses against uncertain and unfavourable outcomes. When purchasing insurance, individuals and entities seek financial protection from adverse events. They purchase the right to transfer a portion of the financial loss relating to an insured event to an insurer. On the other hand, the insurance company, after accepting these risks, employs all five risk mitigation strategies as outlined above to protect itself from adverse events.

By pooling appropriate risks, insurance companies reduce the overall volatility of losses arising from uncertain adverse events, thereby allowing insureds to incur relatively small regular losses in the form of premiums rather than irregular and potentially large losses. However, when purchasing insurance, individuals and entities are willing to pay the insurer more than the expected cost of claims in order to reduce the volatility and potentially extreme consequences of losses to themselves. This is evident in the insurer gross claims ratios (the ratio of claims to premiums before reinsurance), with the NZ market average claims ratio for general insurance averaging 61% from January 2019 to December 2022 (RBNZ, 2023).

From the perspective of the insurer, it can be profitable to charge individuals and businesses to take on their risks as long as the risk exposures are managed properly, and the range of outcomes are able to be considered comprehensively.

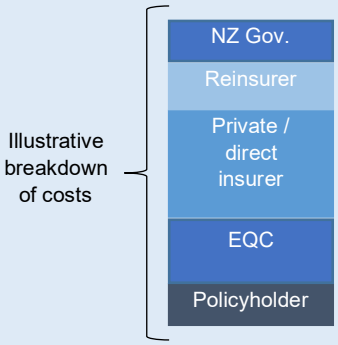
Reinsurance is insurance for insurance companies. Reinsurance serves to stabilise the insurance market by limiting an insurer's risk exposure through funding a portion of the claims when certain conditions are met. Reinsurers charge insurers a premium to take on this risk.

Not all risks will be covered by the insurance market. Some risks, for example war, are considered uninsurable[2] by the market and avoided completely through product exclusions. Conversely, some risks are deliberately accepted by an individual or entity, such as those under a product excess, when the costs of insurance are extremely high (for example, flood cover in a flood zone) or where there is sufficient scale to manage the costs within their own organisation (for example the Accident Compensation Corporation (*"ACC")* Accredited Employers Programme (*"AEP"),* see case study in Section 3.4). Other risks are unintentionally accepted by an individual / entity, such as when individuals are underinsured. Within NZ, there are often other support systems available to help manage remaining risks, such as the public hospital system (rather than private health insurance), social housing (if there is a loss of a house) and welfare (if there is a loss of income). The NZ Government may also play a role in the insurance market, both as a direct insurer, reinsurer, or insurer of last resort. These relationships are outlined in the case study below.

[2] For a loss to be insurable the following conditions must apply: The loss must be fortuitous; the frequency and magnitude of the expected loss must be assessable; the circumstances of a loss must be capable of definitions; the premium must be affordable; there must not be excessive exposure to loss (such as a wide geographical event or exposure to very large losses); and, the insurance must not be against the public interest, such as encouraging criminal activity.

Case Study: Toka Tū Ake EQC Earthquake Commission *("EQC")*, Building cover

Toka Tū Ake EQC is a NZ Government organisation that provides insurance to homeowners for specific natural disasters (including earthquakes). After an excess, EQC will cover the first $300,000 (plus GST) of losses relating to a residential building (with conditions applying). Further losses (up to the sum insured) are covered by the homeowner's building insurance. The private insurance companies may also cover losses which are not covered by EQC. The private insurer will likely have reinsurance treaties in place through which a portion of the losses are then spread to other reinsurers. EQC itself has a range of reinsurance treaties in place. In extreme events, such as the 2011 Christchurch Earthquake, the NZ Government may step-in to provide additional financial support to guarantee that claims will be paid (Stowell, 2011).



Premiums are paid by the policyholder to the direct insurer, which includes a levy that is passed to the EQC. The direct insurer then pays a premium to the reinsurer. The NZ taxpayer will also contribute to costs should the NZ Government be required to provide additional supports.

3.2. Insurance risks and management

Due to the nature of their work, insurance companies are exposed to a variety of risks. It is essential for these risks to be responsibly managed by the insurer to fulfill their contracted obligation to the policyholder, maintain financial stability and solvency, efficiently resolve claims, meet regulatory compliance, and sustain operations.

Risks often arise from the information asymmetry that exists between insurers and their customers. While an insurer may have a better understanding of the full distribution of risk, those seeking insurance will often have a better understanding of their specific circumstances. This can lead to "*adverse selection*" (when only high-risk customers take out insurance) and / or "*moral hazard*". The impacts of information asymmetry and moral hazard must be managed by the insurer.

The following table outlines a selection of key risks faced by insurers and how they are managed. We note that other types of risk also exist for insurers (such as strategic risk, reputational risk, economic risk, regulatory risk, liquidity risk etc.) but are not explicitly addressed as they are less relevant to this discussion.

Table 2: Insurance company risks and management techniques

Risk	Example management techniques
Insurance, Pricing & Underwriting Risks, including catastrophe risks Incorrectly pricing a policy, underestimation of potential claim costs, adverse policy selection, and the impact of natural	• **Underwriting** – Taking an analytical approach to pricing, which values premiums based on a policy's inherent risk including identifying policy holders that exceed the insurer's risk appetite and rejecting cover for those policies. • **Product development** – Considering the range of potential risks and issues a new product may have and changing product features/ creating adjustments accordingly. Setting policy excess[3] and limits (i.e., sum insured) to reduce moral hazard and limit exposure. • **Reducing underlying risk** – putting in place promotions, advertising or undertaking advocacy activities that aims to reduce the underlying level of risk of their policyholders.

[3] An excess works to reduce moral hazard by ensuring the insured party still has an interest in the outcome and will therefore act in ways to reduce their risk.

Risk	Example management techniques
hazards that can cause a large number of claims at once.	• **Diversification** – Where possible, ensuring that policies have different risk characteristics. This reduces the concentration of risk and decreases the likelihood of adverse claims experience impacting the whole portfolio at once. Some insurers also diversify across the types of insurance offered (e.g., travel, home, professional liability) and the geographical location (including being multinational) to further reduce the overall volatility of the portfolio. • **Monitoring** – Analysing and monitoring emerging experience to determine the suitability of premiums and claim assumptions over time. Understanding trends of key indicators such as lapse rates, uptake rates, claims ratios and policy numbers. Making changes if appropriate. • **Modelling** – Using historical data (internal and external), perils models, and expectations of the future to inform decision-making. • **Sensitivity testing** – Varying individual assumptions (e.g., claims ratios and investment returns) to determine how results may change due to a change in a factor. • **Reinsurance** – Taking out reinsurance to reduce claim volatility and the risk arising from natural catastrophes. Arrangements can also limit capital requirements and enable a competitive return on capital to be achieved.
Operational Risk Failure of internal controls or technology and fraud.	• **Standardised procedures to reduce / mitigate risk** – Establishing internal guidelines and processes for claims management, underwriting, assessment, and management. • **Information system outsourcing** – Smaller insurance companies may choose to outsource management systems to specialised companies.
Market and Credit Risk Losses arising from investments or counterparty default.	• **Quality asset selection** – Managing the volatility of assets by limiting certain types of assets and / or counterparties within the portfolio along with their proportions. • **Diversification** – Investing in assets across a range of geographies, industries, asset classes and counterparties. Utilising multiple reinsurers to reduce impact if a single reinsurer defaults.
Solvency Risk Having insufficient capital to meet obligations when they arise.	• **Asset / liability matching (Immunisation) –** Matching the timing of asset and liability cashflows to help ensure that portfolio values are protected against interest rate movements. • **Risk margin**[4] – Holding claim and premium liabilities above the 50th percentile of sufficiency so that capital is available to meet unexpected increases in claims costs. • **Holding capital** – Holding above the regulated minimum capital standards, as prescribed by the Reserve Bank of New Zealand *("RBNZ")*. Excess capital can be used to absorb unexpected obligations. • **Reinsurance –** Reducing the severity of unexpected claim outcomes by transferring extreme claim amounts.

3.3. Determination of risk management and reinsurance arrangements

The decision on which risks to reinsure, retain, mitigate, and accept is made based on a variety of factors, including the insurer's risk appetite, alignment to the insurer's long term strategy, the features (and associated risk) of the insurance product, availability and costs of reinsurance, and the capital requirements to support the risks. These are discussed further below.

[4] A risk margin is an addition amount in the claims and premium liabilities held on insurer's balance sheets. The risk margin increases the central estimate (i.e., 50th percentile of sufficiency) to at least the 75th percentile. Insurers may choose what probability of sufficiency they wish to hold based on their risk appetite (RBNZ, 2022).

The ultimate decision on risk retention and acceptance will be made by the board of directors *("BoD").*

To help with the identification and analyses of risks, insurance companies visualise the threat landscape using a risk matrix which grades the risk based on likelihood and impact. An example of a risk matrix is given below:

Figure 2: Insurance example risk matrix

Risk Assessment Matrix				
Severity\ Probability	**Catastrophic (1)**	**Critical (2)**	**Marginal (3)**	**Negligible (4)**
Frequent (A)	**High**	**High**	**Serious**	**Medium**
Probable (B)	**High**	**High**	**Serious**	**Medium**
Occasional (C)	**High**	**Serious**	**Medium**	**Low**
Remote (D)	**Serious**	**Medium**	**Medium**	**Low**
Improbable (E)	**Medium**	**Medium**	**Medium**	**Low**
Eliminated (F)	**Eliminated**			

Note: Adapted from "Risk assessment" by Actuaries Institute Australia - Life Insurance and Retirement Product Development – Module 12: Risk Management Frameworks (p. 34), 2023, Actuaries Institute Australia, Australia

Importantly, risk management is not a *"set and forget"* activity. An insurer will be regularly monitoring their exposure to risk and making adjustment to their risk management activities where emerging experience or changes to the insurer's operations or environment requires.

Risk appetite and long-term objectives

A risk appetite statement is a written definition of the amount and type of risk an insurer is willing to take to meet its long-term objectives. The risk appetite statement is defined by the BoD, with input from experts from legal, reinsurance, marketing, pricing, underwriting and claims management, and will consider the expectations of stakeholders. The risk appetite statement will define what level of risk is / is not acceptable to retain, and under what circumstances.

There may be greater appetite to accept risks where they support the long-term objectives of the insurer. For example, the insurer is exposed to additional risk when they enter a new market, some of which may need to be accepted. Conversely there may be limited appetite for risks which could have broader social and non-financial consequences for the insurer's policyholders.

The risk appetite is typically established using a series of steps:

1. Identify the key stakeholders in the risk management process such as management, BoD, regulators etc.
2. Establish what the priorities are for the insurer by considering the company's goals and objectives.
3. Identify and assess risks faced by the insurer such as insurance, catastrophic, market and operational risks.
4. Set risk tolerance ranges and limits for each risk identified through quantitative measures such as financial ratios, operational metrics, and probability of insolvency.
5. Define the risk appetite statement in relation to these priorities.
6. Consider qualitative measures that can affect the set tolerance ranges such as regulatory requirements, competitor pricing etc.
7. Engage key stakeholders and discuss tolerance levels.
8. Define specific tolerance levels for each risk type.
9. Review and document final risk appetite statement.
10. Continuously monitor and review the statement according to actual risk exposure and performance.

The above process is iterative and will require extensive and thorough discussion with key stakeholders and subject matter experts. Different insurers will have different tolerances to each risk type, so this

process is not about determining the *"right"* tolerance level but rather about articulating the boundaries to risk in a common and agreed manner.

A risk appetite might consist of statements such as:

- Target capital is set such that the probability of meeting regulatory requirements (in absence of management actions) over one year is at least 97.5% (Koob, D. *et al.*, 2016)
- The company targets an S&P AA range credit rating (implied minimum of AA-) (Koob, D. *et al.*, 2016)
- The company will accept a maximum exposure of 10% per counterparty (Koob, D. *et al.*, 2016).
- "*We have zero tolerance for any of our people knowingly engaging in any business, activity or association where foreseeable reputational risk or damage has not been considered and / or mitigated*. (HSBC, 2021)"

Insurance features

Certain features of an insurance product and market may expose the insurer to additional risk. Some of these risks may be able to be reinsured or mitigated while others cannot. Examples include:

- **Premium flexibility** – in some products (such as Private Health Insurance in Australia) legislation prevents insurers from varying the premium to account for the risk of the policyholder (i.e. age, gender, and current health status). In this case, insurers accept the risk of additional claims cost and look to mitigate this risk through other (non-price) means (such as marketing). Premiums may also be inflexible if premiums are paid as a lump sum or are guaranteed at the outset of a long-term policy or if there may be high social pressure relating to charging the full premium.
- **Automatic acceptance** – some products (such as life insurance offered through superannuation in Australia) are provided to a group of individuals with the insurer being unable to assess the risk of individuals. Legislation for some products may also remove the ability for an insurer to underwrite and select risks. The insurer must manage the risk that the group of individuals may have higher claims experience than expected and of adverse selection. The insurer may do so through reinsurance, incentivising behaviours that reduce the risk profile of the group (for example, the AIA Vitality programme which incentives healthier lifestyle choices) and through close monitoring of the product experience.
- **Product coverage and intent** – insurance products vary in their target market, coverage, and intent. For instance, a basic hospital product with high excess and waiting period will have both a lower frequency and lower cost of claims than a comprehensive hospital product without these additional limiting features. Similarly, a premium home and contents policy can be expected to have a higher average claims cost should an event occur[5]. These risks are retained and managed through comprehensive underwriting, pricing, and reinsurance programmes.

Reinsurance arrangements and capital requirements

Each direct insurer's reinsurance arrangements (or reinsurer's retrocession arrangements) will reflect the level and type of risk being transferred, the aims of the reinsurance programme within the insurer's broader strategic objectives and the current reinsurance market.

An insurer looking to transfer the risk of low frequency high severity claims (such as those arising from a large single policy or event) may take out facultative[6] or non-proportional cover[7], such as *"Excess of Loss"* cover. In addition, they may also take out *"Catastrophe Excess of Loss"* which provides protection from natural catastrophes where a single event may result in many individual claims. Conversely, an

[5] For example, the 2018 Californian wildfires destroyed multiple million-dollar mansions in Malibu (Schleuss and Stiles, 2018).
[6] Facultative reinsurance is a one-off transaction where the amount of risk transferred is defined for a single policy or a group of policies.
[7] Under a non-proportional reinsurance arrangement, cover is provided for claims costs above a predetermined threshold but below a set limit.

insurer that is entering a new market may take out proportional[8] reinsurance to reduce their overall exposure.

The amount of risk transferred (as defined by the retention level, limits, or share) will depend on the insurer's objectives and risk appetite, what is available in the market, the price of the cover, and the amount of capital (both regulatory and working) that would be required to meet these risks. Reinsurance is cost effective if the premium is less than the cost of capital that would otherwise be held to meet the risks being transferred. As such, an insurer's reinsurance arrangements are often influenced by the regulatory capital requirements.

The insurer will also consider the risks and other possible benefits associated with the reinsurer (for example, additional underwriting support). To reduce the risk of reinsurer failure impacting their own financial position, the insurer will consider the credit worthiness of the reinsurer and will diversify across reinsurers.

Similar to the overall risk management strategy, the reinsurance strategy requires BoD approval based on comprehensive analysis of the environment, market conditions, capital requirements and financial position.

3.3.1. Acceptance of failure risk

Solvency risk or failure risk is the risk that the insurance company is unable to meet their obligations to its stakeholders and cannot keep operating at its current capacity. The conscious acceptance of certain solvency risks occurs when the likelihood of an event occurring does not justify the additional capital requirements and costs to mitigate against the risks. For example, RBNZ requires insurers to hold sufficient capital to cover their net (i.e., after reinsurance) exposure to a 1 in 1000 year seismic event[9] (Insurance Council of New Zealand, 2023). The RBNZ is therefore implicitly accepting the risk of failure of any seismic event with a probability of less than 0.1% as the probability of such an event is extremely low.

The acceptance of residual risks means that there will always be some risk of business failure.

RBNZ aims to maintain a sound and efficient monetary and financial system. Its role includes managing inflation, regulating banks, insurers, and finance companies, and otherwise acting as NZ's central bank. Within its role as a regulator and supervisor, RBNZ takes a risk-based approach, meaning entities or issues with the greatest significance are provided the most attention. RBNZ's attention and responses will also increase as the stress of a financial institution increases. However, RBNZ does not run a zero-failure regime. It allows entities to fail where the risks to the financial system are understood and can be managed, and this provides the incentives for self-and-market discipline to operate effectively. Failure may be allowed in cases where the impact on the wider economy, the financial system and on policyholders can be minimised, such as accepting a small risk of contagion, or facilitating the transfer of policies to another insurer. Prior to reaching this point, RBNZ will work to minimise risk of failure, including undertaking heightened supervision and / or assisting with the recovery and resolution of distressed entities (RBNZ, 2022). If an entity does fail and alternate resolution measures are unsuccessful a *"government bailout"* may be undertaken under specific circumstances to limit further economic and social impacts from the failure.

3.4. Reinsurance specific risk management

To manage the risks received by insurers, reinsurers employ similar techniques to those stated in Section 3.2. However, given the more volatile experience covered by reinsurers and their separation from the underlying risk being insured, there are some differences:

- **Underwriting**: With the exception of large facultative treaties, it is not practical for a reinsurer to individually assess each policy underwritten by the insurer. Rather, underwriting for a

[8] Under a proportional reinsurance arrangement, the amount of risk transferred can be expressed as a proportion of sum insured.
[9] RBNZ generally calibrates the solvency standard to a 1 in 200 year event for incidents other earthquakes.

reinsurer relates to assessing and monitoring the underwriting standards and quality of the insurer.

- **Tailoring agreement:** For large policies (such as very large buildings or infrastructure), the reinsurer may choose to provide a facultative treaty and perform individual underwriting for each policy to be reinsured.
- **Setting retention[10] and cession[11] limits**: Setting a retention and cession limit reduces the volatility of claims for reinsurers, reduces an reinsurer's exposure to a single insurer, and incentivises insurers to properly manage claims. It is common for insurers to have multiple layers of reinsurance, with each layer provided by a different reinsurer.
- **Other limits and exclusions:** Reinsurers may set other limits such as an aggregate deductible[12] or occurrence limit[13] to reduce their exposure to risk. Risks that are typically excluded by direct insurers (such as war) will also be excluded by the reinsurer.
- **Diversification:** Reinsurance companies operate across different geographies (i.e., globally), industries and types of insurance which allows them to accept risks with limited or no correlation and therefore reduce the overall volatility of their portfolio.
- **Profit distribution:** Profit will be released dependent on the current economic environment and business cycle. High performing years will have some of the profits retained to offset poor performing years.
- **Retrocession:** Buying further reinsurance to prevent high volatility impacting its business.

Moral hazard is a key risk that must be managed by a reinsurer. For a reinsurer, moral hazard arises through the insurer's approach to underwriting and claims management. The potential for moral hazard varies depending on the product:

- For proportional reinsurance (where the insurer and reinsurer share the results), there is limited risk of moral hazard unless the portfolio is heavily reinsured.
- For non-proportional reinsurance (where the reinsurer takes on the costs of one or more related claims after a certain limit), the insurer may have limited incentives to control the small number of large claims. Reinsurers may have some control in cases (such as excess of loss or facultative reinsurance) where the reinsurer approves or may even manage payments above the limit.
- For stop-loss reinsurance (where the reinsurer takes on the remaining costs of a portfolio once a limit is reached) the insurer has no incentive to limit claims once the stop-loss limit is reached. In fact, the insurer has incentives to manipulate claims so that more claims fall within the scope of that treaty.

Reinsurers manage the risk of moral hazard through their underwriting and monitoring processes, including not providing cover if there is evidence of poor behaviours in past treaties.

Reinsurers are also faced with information asymmetries. Given their highly diversified operations, reinsurers may not be experts in a given region and product. They may also only have limited information on the more frequent low-cost events, however, have the benefit of global data. This information asymmetry means that insurers and reinsurers may have different views on the underlying risk of a portfolio.

[10] The amount of risk to be retained by the insurer before reinsurance coverage may commence.
[11] The maximum amount that the reinsurer will cover. This limit may be set on an individual policy level, event, or time basis.
[12] The total maximum amount of risk the direct insurer will retain before the insurance/reinsurance coverage may commence.
[13] The maximum amount that the reinsurer will cover. This limit may be set on an individual policy level, event, or time basis.

Case Study: ACC AEP programme

The ACC operates a no-fault scheme providing cover for injuries that occur from an accident in NZ. NZ companies are required to pay a levy to ACC to cover accidents that occur in the workplace. For most NZ companies, ACC acts as the direct insurer which manages and incurs the cost of the claim. However, for a small number of large employers who participate in the AEP, ACC acts as the reinsurer with the employer managing the claim (either directly or via a third party) and incurring the cost of the claim for a specified period. The work levy for these employers may be reduced by up to 90%.

Similar to a reinsurer, ACC will take on the management and / or costs of the long-term or high-cost claims under the AEP. ACC also offers stop-loss cover to employers to limit their annual exposure to claims costs.

To join the AEP, employers must demonstrate that they have appropriate workplace health and safety standards, are committed to injury prevention and rehabilitation, have the appropriate policies, procedures, and resources for injury prevention, claims management and rehabilitation, and have the financial strength and stability to meet the costs of cover and rehabilitation. Employers are required to undertake an annual audit demonstrating the above. In this way ACC is effectively underwriting which employers it will accept into the programme.

ACC is also able to contribute its expert injury rehabilitation knowledge by taking on the management of large or long-term claims from the employer. This also provides ACC with greater control over the outcomes of these claims.

When acting as the direct insurer, the ACC reduces moral hazard by requiring employers to pay the first week of wages and incorporating an experience rating component in the premium for larger employers. In doing so, the premiums incurred may be higher or lower than the industry average depending on the employer's experience. This provides an incentive for employers to both prevent injuries and facilitate the rehabilitation of employers (ACC, 2023).

3.5. Assessing and managing low frequency, high severity risks

Low frequency, high severity risks are risks that have a low probability of occurring but, if eventuated, have severe consequences. Within the NZ Battery project, this is represented by dry-year events. In insurance, this may be natural catastrophic events such as severe earthquakes or floods. These events have the potential to result in extreme financial losses, irreversible reputational damage, prolonged operational disruption and may even result in insolvency for the insurer if not properly managed.

Insurers and reinsurers use the following techniques to qualitatively model the extent of these risks:

- **Stochastic modelling*:*** In stochastic modelling, a forecast of future inflows and outflows is developed, similar to standard projection models. However, within a stochastic model, assumptions are set around the distribution and correlation of key input variables. Rather than providing a single forecast or a limited number of scenarios, a stochastic model provides the full distribution of results which helps to determine the likelihood of specified events occurring. Additional modelling or analysis (e.g., detailed economic modelling) may also be required to quantify the consequence associated with these events.
- **Estimating a probability distribution:** Insurers use statistical techniques to estimate a probability distribution for their claims experience. The distribution may be theoretical (based on the insurer's expert understanding), empirical (where historical data is used to estimate the distribution) or a combination of both where an empirical distribution is used for the frequent small claims where the insurer has sufficient data, and a theoretical distribution is used for the infrequent large claims (i.e., the tail) where there is limited data available. These estimated distributions may be used directly by the insurer to understand their risk or as an input into further stochastic modelling or scenario / stress testing.

- **Peril modelling**: Using in-house or proprietary peril models to understand the distribution of losses relating to natural catastrophes, such as bushfire, floods, earthquakes etc. These models can take a granular approach to estimating the distribution of losses, including accounting for the impact of geographical factors (such as soil composition, distance from rivers etc.), and other factors (such as building materials and height). These models are especially useful for tail events or extreme risks where they are used to simulate the resultant effects on investment portfolios, claim amounts and reinsurance coverage. A peril model may be used as an input into further stochastic modelling or to inform scenario / stress testing.
- **Credibility theory:** Credibility theory is a statistical approach used by insurers to combine different sources of information (for example, the mortality experience of a small group of people with NZ national mortality rates). By combining multiple sources of information, insurers may be able to get a better understanding of the potential distribution of outcomes.

The above techniques enable statistical measures that quantify the extent of the risk to be estimated. Examples include:

- Probability of adequacy / probability of sufficiency: The probability that available capital will be sufficient
- Value at risk (VaR): Severity of a loss which occurs with a given probability.
- Tail value at risk (TVaR): The expected loss given that an event outside the specified VaR has occurred.

Scenario, stress, and reverse stress testing can also be used to establish an understanding of the extent of the risks, as well as how effective management action and risk mitigation solutions may be to manage the risk. To perform stress / scenario testing[14], the impact of one or more cumulative events are tested with the resulting outcome incorporating the expected result of risk mitigation activities and reasonable management actions. Reverse stress testing considers what assumptions / scenarios will cause the entity to fail in meeting its objective and can help the insurer understand the conditions that it could not withstand.

Events included in scenario testing may include a series of likely events to a single highly improbable event. The events to be tested and their outcomes may be informed by historical experience or may be hypothetical, aiming to capture the full extent of adverse events. These events may be documented in an event catalogue, which provides the detail of past events or near misses and their consequences.

The probability of each event or series of events can be estimated based on historical experience or stochastic modelling (using statistical techniques to combine the probabilities) or by judgement (i.e., being allocated ratings such as frequent, occasional, improbable, highly improbable). Scenario testing is informed by input from the insurer's experts, including the Chief Risk Officer, claims and underwriting specialists and is often performed and tested through a series of workshops.

It is not expected that an insurer would remain solvent under all combinations of scenarios tested. Rather, the results of the scenario testing can be compared back to the risk appetite statement to determine whether the insurer is meeting the BoD's expectations to the level and type of risks retained, or if adjustments to the insurer's operations, capital or risk management approach are required.

Having established an understanding of the extent of the risk, insurers will look to manage them using the approaches outlined above, including underwriting and risk-based pricing, policy excesses, limits and exclusions, diversification, reinsurance (or retrocession), capital management and issuing Catastrophe bonds[15]. This will be an iterative process where the residual risk (after risk management activities) is re-assessed to understand the residual exposure and if further management activities are required.

[14] When performing stress testing only one factor is varied at a time while multiple factors are varied under scenario testing.
[15] Catastrophe bonds (or cat bonds) are a financial instrument where the insurance company will receive a fixed payout (the bond principal) if the specific conditions of the bond are met. In return, the insurance company provides a high interest rate on the principal. Cat bonds are similar in principle to reinsurance (i.e. they transfer the risk of a natural disaster to another party for a price), however the risk is transferred to multiple private investors and the trigger for payment can be uniquely defined.

The actual experience is closely monitored by the insurer, with modelling, scenario analysis and risk mitigation activities updated on a regular basis.

It is important to note that the above techniques can help understand and manage, but not fully eliminate, solvency risk. We also note that many of these risk management approaches will not be applicable to the NZ Battery project.

3.6. Managing emerging risks

Emerging risks are new risks that are known to some degree but are not likely to materialise or have an impact for several years (i.e. beyond an entity's immediate strategic horizon). Emerging risks often arise from developments in technology, changes in societal behaviour and environmental factors. These risks are often unprecedented and have the potential to severely undermine an insurer's financial stability, operations and reputation if not dealt with. As such, a major concern when managing risks is ensuring that these risks are accounted for and appropriately examined in scenario testing (as outlined above).

Cyber insurance is a sector especially exposed to emerging risks. It covers financial losses incurred from a cyberattack or data breach. These types of risks are challenging to insure due to factors such as:

- The rapid development of technology.
- Limited amount of data available.
- Volatile claims experience.
- Limited number of subject matter experts.
- Limited understanding of cyber risks by the BoD.

Cyber insurance was first established in the 1990s. While uptake rates remain low compared to other insurances, the uptake for cyber insurance is growing rapidly, with a 23% increase in the number of organisations purchasing cyber insurance in Australia in the first half of 2021, and high growth rates projected in the near future (Insurance Council of Australia, 2022).

The following table reviews the insurance approaches for emerging risks in the context of cyber insurance.

Table 3: Insurance approaches for emerging risks with respect to cyber insurance

Approach	Description	Application in cyber insurance
Policy exclusions	Adding conditions which will waive coverage for the event being insured.	If the event was the result of human error or negligence, no payout will be made. Specifically, if the attack occurred as a result of poor security processes, prior breaches, human error, insider action or pre-existing vulnerabilities then no payout will be made (Fortinet, 2023). When first launching products, there are often many policy exclusions. This enables insurers to collect more data and better understand the emerging risk whilst limiting their exposure.
Underwriting	Using insights gained during the underwriting process to calculate a premium which reflects the level of risk posed by the entity.	Entities with better cyber resilience and practices have lower premiums. Some insurers used third-party suppliers to proactively assess the risk posed by a potential client (Actuaries Institute Australia, 2022). To assist with the underwriting process, brokers have developed a cyber security self-assessment tool which enables comparison of security standards against best practice standards. Insurers entering a new market will work closely with market experts to form an understanding of the drivers of risk.

Approach	Description	Application in cyber insurance
Continuous policy development	Changing policy features according to changes in the business environment, experience analysis and client needs.	The cover provided by cyber policies have been continuously improved upon and developed to focus on different concerns such as business interruption, compensation cover or brand restoration. Some insurers have also updated non-cyber product wording to explicitly exclude cyber coverage (Actuaries Institute Australia, 2022).
Reinsurance	Transferring a portion of the risk.	Cyber insurance is typically reinsured through proportional arrangements. When launching new products, insurers may reinsure large proportions of their portfolio. This enables them to gain market share and a better understanding of the market whilst limiting their exposure. Reinsurers may also be able to provide insurers with expert advice.
Limiting and reducing cover and / or increasing premiums	Increasing the cost for cover and / or reducing the amount payable under a policy to respond to emerging experience.	Insurers were stated to have increased cyber premiums by up to 300% at renewal and lowering coverage limits (ACA, 2022). In the early 2000s, some insurers first entered the market with low levels of cover in order to reduce risk exposure. All insurers will closely monitor their portfolio and adjust the policy premiums or level of cover to respond to emerging experience.

3.7. Pricing for insurers

Insurers set their premiums by considering the *"technical premium"* and how that fits within the competitive market that they operate and with their strategic objectives.

The technical premium reflects the cost of claims (after risk mitigation activities, including reinsurance), costs associated with the policy (such as reinsurance and commissions), a share of corporate overheads, the cost of capital required to support the policy, and the planned profit margin. Higher risk products will require more capital to support them and therefore have a higher technical premium. Insurers will also *"risk rate"*, meaning that customers are charged a different premium based on their underlying risk characteristics. This enables the technical premium to reflect the expected costs more closely for the policy.

However, insurers may choose to charge higher or lower than the technical premium to support their market strategy and long-term objectives. An uncompetitive market may enable an insurer to charge higher than their technical premium and therefore gain greater profits. Conversely, a highly competitive market will constrain the premium and profits.

In some instances, insurers may accept a lower or even negative profit margin where it aligns to the insurer's purpose and vision. One such example is home builder's warranty insurance[16] which is often underwritten by the government rather than private insurers. In some instances, a government may choose to have a very low or even negative expected profit margin on this product to support the ongoing stability of the housing construction market.

Most products have an annual premium which covers the individual / entity for events over the following year. However, some products may have a single one-off premium with the risks covered over multiple years. Other products, typically those that are compulsory, may instead be charged as a levy to the user.

[16] Home builder's warranty provides insurance to homeowners undertaking building works if the works are not completed and / or there is a fault in the works, and the costs cannot be recouped from the builder.

When setting the premiums, insurers will test the impact of the selected premium on their business. This may include market testing, utilise profit testing[17] models, utilising stochastic models and other quantitative methods to understand the financial implications, and assessing the alignment to the risk appetite statement.

4. An insurer's approach to the NZ Battery

The NZ Battery project aims to mitigate against the risk of having insufficient energy production whilst transitioning NZ away from fossil fuels.

The issues being explored by the NZ Battery project are analogous to the reinsurance market. Reinsurers (or in this case, the NZ Government) must manage the risk of having insufficient resources (capital or energy supply) within the context of uncontrollable and unpredictable events (e.g., earthquakes or dry-year events), where these events are firstly being managed by another party (the direct insurers or electricity market participants).

Given the similarities, we consider the activities an insurance business may undertake to understand and manage a risk similar in nature to that faced by the NZ Battery project, and what processes or tools may be useful in this context[18]. These have been developed to help MBIE understand how an insurer would view the issues being examined by the NZ Battery project. This is not intended to provide a critique of the Indicative Business Case *("IBC")* or the delivery plan for a Detailed Business Case but could be useful in setting this.

The activities are outlined below.

Activity 1: Understand risk exposure (consequence and likelihood across the full distribution of risk).

Utilise stochastic modelling and other analysis to understand and quantify the likelihood and consequence of an event occurring in the future given a current realistic forecast of their business. Stochastic models in combination with additional modelling and analysis (e.g. detailed economic modelling), can be used to better understand the probability of a specified event occurring and the potential consequences of an event of that severity.

Activity 2: Compare the risk exposure to the risk appetite statement.

An insurer would compare the existing risk exposure to their risk appetite statement to determine if the level and type of risk is acceptable (including the risk of failure to supply sufficient energy to the New Zealand public) or if action must be taken.

If the risk appetite statement does not exist for this risk or is out of date, the outputs from the modelling (Activity 1) may be used to identify, analyse, and select the acceptable risk tolerance whilst considering the costs and other potential consequences of the risk. The tolerances would be developed iteratively with input from the insurer's experts and stakeholders.

A clear risk appetite statement would determine what risks are / are not acceptable, consider the trade-offs between reducing the risks and the costs, and therefore guide the insurer's future decisions and activities.

Activity 3: Identify and model the options to manage the risk.

Having understood how the current risk exposure compares to the risk appetite, identify potential options to manage the risk and consequences of an event to an acceptable level. The effectiveness

[17] Profit testing models are statistical models used to determine the profitability of an insurance contract according to a defined set of parameters. The product's cashflows will be projected and the present value of expected premiums will be derived based on external factors such as stakeholder return and profit margin.

[18] We note that insurance concepts explored in this paper could also be relevant to managing the risk of damage to an asset within the NZ Battery project. However, this discussion focuses on how an insurer would conceptually view the NZ Battery project, not on how an insurer would approach insuring an asset developed as part of the NZ Battery project.

of the risk management options can be modelled via incorporation into the modelling (Activity 1) and by performing stress / scenario testing to understand how robust these solutions are.

Reverse stress testing may also help identify what range of assumptions are / are not reasonable and the potential vulnerability of different solutions to failure.

When considering options, consideration should also be given to the potential for moral hazard.

Activity 4: Identify the appropriate approach to recoup the costs

An insurer's expenses (including those relating to the risk mitigation activities) will need to be recouped from its policyholders via the premium or levy. The insurer will need to determine the appropriate group of customers and the time period over which to recoup the costs, especially for investments with high upfront capital costs. Consideration must be given to the feasibility and equity of each approach (including current market conditions) and how the approach may impact on the insurer's financial position and its stakeholders.

The models developed in Activity 1 will enable the insurer to model the *"technical price"* for each option and the potential implications of pricing away from the *"technical price"*.

Activity 5: Identify the *"optimal"* solution

Determine the final *"optimal"* solution (including risk management activities and pricing approach) by considering how the solution performs against a range of factors, as outlined below. The results of the modelling and scenario analysis may be a key input into this decision making.

1. **Alignment to long-term strategy**
2. **Effectiveness in managing the risk**: The amount and types of residual risk that will be being accepted, and how they compare to the risk appetite statement.
3. **Economic cost**: The relationship between the cost of the risk mitigation activity and its benefits may not be linear, meaning some activities may be more or less cost effective depending on the scale required.
4. **Social cost**: The degree and prevalence of any social costs or benefits (including the avoidance of costs) provided by the risk mitigation activities
5. **Environmental cost**: The degree of any environmental impacts arising from the risk mitigation activity? Is the solution more / less prone to risks resulting from changing environmental factors?
6. **Long-term sustainability:** How will the risk mitigation activity perform over time, including consideration of changes in the business and broader operating environment. Modelling will need to be completed with regards to a realistic time period.
7. **Resilience to emerging risks**: How would the risk mitigation activities perform with respect to emerging risks, for example climate change?

The extent of how much extra cost is reasonable to mitigate a risk and how this is recouped is ultimately an exercise in judgement with no single correct approach. The development of approaches will require extensive examination of the chosen option with respect to consequences and costs. As such, a *"scorecard"* approach may be taken when considering the cost and benefits of the risk mitigation activities, where the scorecard considers both the costs and modelled outcomes against the risk appetite, as well as more qualitative factors as outlined above.

Activity 6: Implement the solution and monitor

The agreed upon solution will be implemented by the insurer, following which the insurer will closely monitor the performance of the risk mitigation solution, and adjust should emerging experience suggest it is required or if there is a change in the insurer's circumstances or environment.

While there is no single correct answer, supplementing future activities on the NZ Battery project with an approach founded in insurance principles would provide a robust framework to understanding, quantifying, and prioritising the trade-off of risks and costs for the NZ Battery project, building upon the work already performed.

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