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1. INTRODUCTION

Welcome to our 2016 Asset Management Plan (AMP). This AMP represents an evolution from our 2015 AMP and is a transition towards the 2018 AMP, which will form part of our RCP3 submission. The focus of our asset management activities is to deliver valued, cost-effective services that meet our customers’ changing needs and ensure that the grid continues to support economic growth by delivering electricity around the country when and where it is needed.

This introductory chapter covers:

- Purpose
- Asset management objectives and initiatives plan
- AMP structure.

1.1. PURPOSE

This AMP explains how we manage our assets. It describes our overall asset management strategy and objectives, our asset risk framework, and our forecast capital expenditure (capex) for the RCP2 period (2015 - 2020) required to ensure the ongoing delivery of services to our customers. The AMP covers our Enhancement and Development (E&D), Asset Class Replacement and Refurbishment (R&R), Information and Communications Technology (ICT) and Business Support expenditure categories.

This AMP is one of three supporting documents for our Integrated Transmission Plan (ITP), which collectively describes our investment and operational plans for managing the grid. The other two supporting documents are the Services Report and the Transmission Planning Report (TPR). The structure of the ITP and supporting documents is illustrated in Figure 1 below. In addition, Transmission Tomorrow plays an important part of forming our long term view on the future requirements for transmission services.

Figure 1: Structure of the Integrated Transmission Plan 2016
1.2. OUR ASSET MANAGEMENT OBJECTIVES, TRANSFORMATION AND INITIATIVES PLAN

Our asset management strategy establishes our asset management objectives. These objectives are targeted at a number of levels. For example, the objectives range from meeting our service performance targets to making sure we are making timely, cost-effective decisions about replacement at an asset class level. As well as describing our objectives, the strategy describes the approach we will employ to achieve our objectives.

Our high-level asset management objectives and strategies:

- Reflect progress since we first published our Asset Management Strategy in 2013
- Include the priorities that have emerged since 2013. Strategic priorities have driven a number of business improvement initiatives.

A key strategic priority is to improve the effectiveness and efficiency of our business to meet our targets for reduced expenditure and improved service over the RCP2 period. To achieve this, we are continuing to progress the implementation of our redesigned Grid Operating Model (GOM). The implementation of our GOM will result in ongoing improvements to our asset management approach.

Our GOM is a process-based model intended to achieve a more systematic, cohesive and risk-informed way of developing a clear, well-prioritised, balanced and deliverable plan. The GOM is illustrated below.

In this regard we are actively transforming our business to ensure that our National Grid and our organisation is running as effectively as possible. The prioritised transformation work streams are aligned to our strategic priorities and are helping us produce a value driven AMP are:

- **RCP3 Service Levels**: Reviewing our existing Service Level measures; we are about to engage with our customers and set new measures and incentives for RCP3
- **Asset Management Strategies**: Updating Transpower’s Asset Strategies as we prepare for RCP3. Updates will describe our approach to achieving our objectives, and will better align our Asset Management Plan to these strategies
• **Decision Framework:** Implementing a framework to support more effective decisions relating to our assets

• **Asset Management Capability Training:** Building better organisational understanding and capability relating to Asset Management

• **Grid Risk:** Delivering greater clarity on risks relating to the asset-based services we provide to our customers and using this information to inform our decision-making

• **Asset Data and feedback:** Determining what data and information is required to make good decisions about asset renewals and maintenance and delivering a framework for its collection and use

• **Cost Estimation Improvement:** Delivering business improvement initiatives relating to our Cost Estimation processes both in planning and delivery

• **Maintenance Optimisation using Reliability Centred Maintenance:** Ensuring we carry out the right maintenance at the right time

These work streams are on target, with the outputs being used to produce our 2017 AMP. Other core Transformation Initiatives that we have introduced to drive efficiency and enhance value are:

• **Service Provider Reset:** Ensuring we are getting value and efficiency from our Service Providers

• **National Works Planning:** Improving our works planning and delivery processes resulting in costs savings

• **Portfolio Savings Programme:** Identifying innovative ideas, prioritising and delivering savings along with exploring existing standards to extract savings and value

• **System-wide planning process:** Reviewing the current system-wide planning process, with a focus on the Enhancement and Development portfolio

• **Maintenance Practices:** Reviewing our maintenance expenditure across vegetation and Preventative maintenance, and the savings from our Service Provider Reset

• **Asset Procurement:** looking for savings enabled by a stable works plan, in areas such as spares holding and reduced unit costs of equipment

To ensure these initiatives are sustainable we are growing supportive behaviours in Transpower people:

• **Develop People:** Embedding behaviours and The Way We’re Wired – Clarity, Collaboration, Accountability, Delivery. Developing our people leaders through training and mentorship

1.2.1. **INITIATIVES PLAN**

The Initiatives Plan published in June 2015 sets out our plans for improving our asset management and forecasting capability and for developing service measures and targets for the RCP3 period. The plan focuses on the period leading up to our 2018 ITP.
The Initiatives Plan identifies our transformation programme as our key business improvement initiative, and identifies the following components:

- Re-designed GOM
- New services framework
- Works planning and delivery improvements
- Service provider contract changes
- Engineering design consultant changes
- Asset feedback improvements
- Data automation
- Other initiatives to improve maintenance work practices and reduce operational costs
- Update of Transmission Tomorrow
- Development of our ITP.

We published an update to the Initiatives Plan in March 2016 providing more information on our plan for further developing:

- Asset health modelling
- Cost estimation.

Consequently, there are a number of areas identified, such as the asset health models, where development is being undertaken but is not sufficiently advanced to be included in this AMP. However, updated information and commentary has been included where available. Our aim is to have the processes and tools developed by mid-2017 so they can be used in preparation of the 2018 AMP and ITP.

We are preparing for engagement with our customers and wider stakeholders over the coming year on refinements to our service measures and targets for RCP3 and beyond. Together, the evolution of our AMPs and the service measures and targets form a key component of our asset management journey.

1.3. AMP STRUCTURE

The structure of this AMP is as follows.
# 1. Introduction

## Part 1: Frameworks, Objectives and Overview

### 2. Asset Management Approach
Our Asset Management framework and priorities

### 3. Lifecycle Activities
How we plan, deliver, operate, maintain and dispose of assets

### 4. Asset Information Systems and Standards
Key systems and capability that support our Asset Management

## 5. RCP2 Asset Expenditure Overview
Summary of our capital expenditure and divestment plans

## Part 2: Enhancement and Development

### 6. Enhancement and Development
Our Enhancement and Development plans and associated expenditure

## Part 3: Asset Class Plans

### 7. Introduction to Asset Class Plans
An overview of our asset classes and the plans

### 8. to 21. Our Asset Class Plans
The population, characteristics, lifecycle activities and the capital expenditure for each asset class

## Part 4: ICT Management Plan

### 22. Introduction to ICT Plans
An overview of our approach to the ICT plan

### 23. ICT Asset Class Plan
Our ICT framework, management plan and associated expenditure

## Part 5: Business Support Management Plan

### 24. Business Support Management Plan
Our Business Support management plan and associated expenditure
PART 1: FRAMEWORKS, OBJECTIVES AND OVERVIEW
2. ASSET MANAGEMENT APPROACH

This chapter introduces our asset management framework and objectives. In July 2014, we became one of the first companies in the New Zealand electricity industry to achieve certification against the international asset management specification PAS 55. In 2015 PAS 55 was withdrawn as a formal BSI specification and replaced with the ISO 55000 international standard for Asset Management. We are currently moving towards certification against the ISO 55 000 standard. This chapter outlines our asset management:

- Documentation
- Policy
- Objectives and strategies
- Asset risk management.

2.1. DOCUMENTATION

We have developed a set of documents to support and communicate our asset management strategies and plans. The document suite is initiated from our corporate objectives, Transmission Tomorrow and corporate strategy as described in the ITP Narrative. These documents set the context and foundation for our asset management strategy documentation, including lifecycle strategies and asset class plans.

A full set of asset management documents is available on our website. Since our 2015 AMP we have also completed an update of Transmission Tomorrow, which is a key component of our company-wide strategic framework. We are currently in the process of integrating the outcomes from Transmission Tomorrow into our corporate objectives and strategy. This will flow through into an updated asset management policy and strategy over the coming year.

2.2. ASSET MANAGEMENT POLICY

Our approach to asset management ensures there is alignment between our external business drivers, our corporate policies, and through to our asset management activities. Our asset management vision is to:

- Provide a grid that safely delivers transmission services at a quality and cost that meets our customers’ expectations.

Our asset management policy states that when managing our assets to ensure we meet consumer long-term grid performance expectations we will demonstrate our commitment by:

- Embedding a strong safety culture and capability to deliver a safe, zero-harm work place
- Delivering excellent customer service by providing an enduring grid that delivers smart solutions, cost-effectively
- Delivering the performance expected of the grid by consumers, taking into account the trade-off required between cost and risk
• Seeking continuous business improvement in our asset management activities
• Making asset management decisions based on complete, accurate and timely information
• Investing in the right mix of talented, competent and motivated people to improve our asset management capability
• Building effective relationships with all New Zealanders affected by our asset-related activities
• Complying with all applicable statutory and regulatory requirements.

2.3. ASSET MANAGEMENT OBJECTIVES AND STRATEGIES

To give effect to our asset management policy we identified five priority areas:

1. Safety
2. Service performance
3. Cost performance
4. New Zealand’s communities
5. Asset management capability

This section provides our updated objectives and strategies for these five areas, along with our approach to innovation.

2.3.1. SAFETY

We are committed to keeping the public, our employees and contractors safe. We do everything we can to ensure people are not put at risk.

Objectives

In relation to public safety and to our workforce, our safety objectives are to ensure:

1. Zero fatalities
2. Zero injuries causing permanent disability or serious harm
3. A workforce that is well and healthy
4. All reasonably practicable steps are taken to ensure grid assets do not present a risk of serious harm to any member of the public.

Safety strategies

To support these objectives, we have the following strategies:

• **Identify and manage our high-consequence risks.** We focus on critical risks which can result in serious injury or fatality. We have introduced ‘bow-tie’ and semi-quantitative risk assessment (SQRA) approaches. We have developed an incident investigation framework which focuses on high consequence incidents.

• **Work collaboratively with our workers and partner service providers.** For example, we are producing our works plan earlier. This will enable our staff and service providers to plan their work further ahead, which will facilitate better and more collaborative safety management by service providers and Transpower.
• **Using the asset management framework to drive safe outcomes.** We use Safety by Design principles and apply these from concept to design, construction contracting and management, and disposal of assets.

• **Investing in a team of engaged, productive workers.** We support health and safety committees to work on meaningful projects, allocate resources to regularly communicate to workers, and setting up reward programmes to recognise individuals’ behaviour. We recognise positive safety initiatives via Service Provider Relationships and “Safety Starts”.

• **Run a health and safety system that delivers safe outcomes.** We ensure information on how to do work on the Grid is understandable and relevant. We check our systems via internal and external audits e.g. TELARC, ACC.

### 2.3.2. Service performance for customers and consumers

In our 2013 ITP we developed a set of customer-facing service performance measures and targets to reflect the long-term performance expectations of consumers. These measures have been developed with input from and the support of our customers and other stakeholders. The targets are differentiated based on the criticality of the point of service to our connected customers, and signal the service that they and end consumers can expect.

We are preparing for engagement with our customers and wider stakeholders on refinement of our RCP3 and longer-term service measures and targets. This work includes finding ways to create a stronger alignment between service targets, individual asset management decisions and the aggregate price path for regulated transmission services.

**Objectives**

Our service performance objectives are summarised in our ITP Narrative, with more detail provided in our Services Report.

**Service performance strategies**

To deliver on these service performance targets we have developed the following strategies:

• **Risk management:** we are continuing to develop asset health modelling and our criticality framework to systematically model asset risk profiles. We are rolling out bow-tie risk management methodology and semi-quantitative risk analysis (SQRA) across the business for integration into the asset management framework.

• **Targeting interventions:** we will be integrating a bow-tie risk management methodology into our asset planning decision-making process, to assist in targeting interventions to address specific asset related risks through our plan. This is additional to the operations and maintenance risk management activities.

• **Corrective action:** we are developing an integrated incident investigations framework for classifying event severity and applying investigation and root-cause analysis methods commensurate to an incident’s severity (or potential severity). This will enable us to better identify and prioritise corrective and preventive actions which will reduce the risk of forced and fault outages to consumers. The results from this process will be recorded and tracked systematically, and then fed back into our asset management framework to minimise the chance of repeat failures.

• **Outage planning:** we have undertaken a comprehensive review of our outage planning processes and systems, and are implementing improvement initiatives.
2.3.3. **Cost Performance**

In delivering the transmission service it is essential that we provide the service expected at an efficient cost to consumers. To achieve this, we need to maintain downward pressure on our cost base, including asset-related operating expenditure (opex) and capital expenditure (capex).

### Objectives

Our cost performance targets are described in our ITP. We have set high level targets of holding RCP2 capital programme costs in line with regulatory benchmarks, holding operating cost increases below inflation, and bringing the cost of our RCP3 replenishment capex programme down. Our targets can be adjusted for cost-neutral re-balancing of capex and opex and are subject to adjustment as we develop our understanding of longer-term cost and risk/service trade-offs.

### Cost performance strategies

Reflecting the above objectives, we are pursuing the following five strategies to improve overall cost performance to consumers.

- **Maintenance improvements**: we are continuing to put in frameworks to optimise our grid opex. Work streams such as the maintenance practice review will deliver additional efficiencies.
- **Improved cost estimation**: we use feedback from completed projects to improve the cost estimation systems used to evaluate options and manage delivery costs. The March 2016 update of our Initiatives Plan provides more detail on improvement actions including the introduction of Building Blocks.
- **Targeted investments**: we continue to use our asset health analysis and risk matrix to prioritise our spending.
- **Improved procurement**: we are running an initiative to optimise our supply chain for the purchasing and warehousing of primary and lines assets.
- **Divestment programme**: we have undertaken a number of divestments of non-core assets to distribution businesses who are better placed to manage low-voltage assets. We continue to explore divestment opportunities where they bring mutual benefits to Transpower, our distribution customers and electricity consumers.

2.3.4. **New Zealand’s Communities**

Maintaining our relationships with communities, iwi and landowners, to ensure we can continue to access and maintain our assets is essential for us to effectively manage our network. We call this our social licence to operate. Communities, iwi and landowners can be significantly impacted by transmission projects and our asset management activities, so it is important for us to carefully manage our relationships with them.

We need to be able to gain access to our assets for routine inspections, maintenance, resolve incidents, and respond quickly in emergency situations. We also need our present and future network to be protected from development that might impact on safety or constrain our operations.

Within this context we continue to secure corridors through implementing the National Policy Statement Electricity Transmission into regional and district planning documents. This programme of work will ultimately result in Council plans which will provide controls on what can and can’t be developed in transmission corridors, and adjacent subdivisions, in order to control inappropriate under-build. Likewise, appropriate buffers are sought around substations to protect against reverse sensitivity issues and to provide future protection on cable routes where appropriate. Currently we
have effective corridor provisions in 41% of operative Council plans, with a further 34% of Councils underway with the process. We anticipate it will take until 2020 for all Councils to incorporate appropriate corridor provisions.

Objectives

Our NZ Community objectives are:

1. **Access Arrangements**: secure appropriate corridor provisions in District Plans that give effect to the National Policy Statement on Electricity Transmission.

2. **Environment**: improve Transpower’s environmental performance and ensure compliance with environmental authorisations. Control annual sulphur hexafluoride (SF₆) gas emissions to no more than 0.8% of total stock.

3. **Landowners**: maintain fair and respectful long-term relationships with landowners, measured though surveys and feedback from them.

4. **Community Engagement**: continue to deliver our community partnership programme.

5. **Iwi Engagement**: move from transactions with iwi (through projects or maintenance) to enduring relationships where appropriate.

Community strategies

To support these objectives, we have the following strategies.

- **Participation reviews**: we have initiated a significant project to coordinate our participation in relevant plan changes. This is included in our Enhancement and Development programme, in Part 2 of this AMP. We are also expecting to input into the Resource Management Act 1991 (RMA) reform to enable our works and protect our assets.

- **Community Care Fund**: during 2015/16 we funded 40 community-based projects, in communities near our assets and will continue this programme.

- **Greenhouse gas emissions**: we are continuing to identify and remove leak prone SF₆ circuit breakers.

- **Relationships with landowners**: maintain one-to-one relationships with landowners where we require critical access to our assets, and act on feedback from our regular landowner surveys.

- **Relationships with iwi**: continue to build relationships with iwi and reflect this in relationship agreements with them where appropriate.

- **Monitoring and reporting**: we continue to improve our environmental reporting and environmental processes to reduce the risk of adverse environmental impact.

### 2.3.5. ASSET MANAGEMENT CAPABILITY

A key to delivering our corporate and asset management objectives is in improving our asset management capability. Since our 2013 ITP we have started a business transformation process. Much of this is targeted at improving our asset management processes and capability.
Objectives

Our asset management capability objectives are:

1. **Risk Management**: we will implement an integrated asset risk management framework that will include qualitative and quantitative risk assessment techniques by 2017. We will continue to set service-based targets to balance the risk of asset failure and the associated reliability impacts with cost.

2. **Asset Knowledge**: we can demonstrate that the quality of our information is improving year on year and enabling more effective risk-based asset management decisions.

3. **Continuous Improvement**: we will demonstrate sustained improvement in delivering the transmission service as a result of incorporating learnings into our asset management practices and approach.

Asset capability strategies

To support these objectives, we have the following strategies.

- **Risk management**: we are enhancing our asset planning decision framework by developing a systematic and transparent risk-based decision-making process. When completed, we will use this to justify our plans and appropriately balance capital and operational expenditure across all grid assets and portfolios.

- **Asset knowledge**: we have established a new asset information management team in our GOM. This team is focused on implementing our asset information strategies.

- **Asset management competence**: we have implemented an asset management competence framework for some specific roles. We are reviewing and expanding this across the business.

- **Continuous improvement**: we have implemented a process and governance for formal, structured, investigative and problem resolution of high-severity events or systemic issues associated with grid asset failures. The design of the GOM is focused on improving our asset management practices and capability to ensure we are delivering the performance customers expect at an efficient cost. As we transition to this new way of working and embed the model, we expect to see significant improvements across a range of activities such as strategy, planning service delivery and integrated feedback loops.

Our transformation programme, which includes other improvements, will help us deliver our service and cost objectives and build our asset capabilities.

2.3.6. INNOVATION

Our long-term strategy for the grid includes monitoring the development and application of new technologies for opportunities to invest and deliver on our service performance measures to customers. This may include emerging technologies such as grid scale batteries which may enable the deferment of investment as well as innovative ways of managing variable load demands.

Where the expected benefits for customers are large (such as the use of power electronics devices to defer capacity investments) we may choose to be an early adopter. However, in cases where the potential benefits are only modest, and the risks appear high, we take a more cautious approach, and defer developing and deploying new technology until our international peers and / or where our EDB customers have explored the benefits within their networks.
2.4. ASSET RISK MANAGEMENT

Effective risk management is critical to our business. By understanding the nature of our risks and applying the controls that have the most effect against these risks, we are more able to meet our objectives. We can make better asset management decisions by including our risk information in our asset planning process.

The overall purpose of our asset risk management is to:

- Understand the causes, likelihoods and consequences of adverse events occurring
- Manage the level of risk to within our corporate risk appetite through established controls
- Actively monitor controls for adequacy and effectiveness
- Provide assurance that asset risks are being well managed
- Inform our asset planning process, to enable reduction in operational risks.

Our risk management processes and practices must be effective, consistently applied and comprehensively communicated to staff, subsidiaries, contractors, and stakeholders.

2.4.1. ESTABLISHING EFFECTIVE ASSET RISK MANAGEMENT

Our asset risk management process is aligned to the corporate risk management framework, which has recently been refreshed.

We use a corporate-wide risk assessment matrix which facilitates analysis of risk across a broad set of consequence categories in combination with an event likelihood scale. This forms the basis of a consistent approach to our risk analysis and enables us to better use our risk inventory to manage grid assets.

The process is also consistent with AS/NZS ISO 31000:2009 Risk management — Principles and Guidelines, which consists of six stages as illustrated below.

---

**Figure 3 Asset risk management process**

1. Establish the context
   - Understand what the business intends to achieve, and internal/external environments in which it operates, including risk appetite

2. Risk identification
   - Identify the end-to-end asset risks associated with the activity or process

3. Risk analysis
   - Analyse the risks to determine the likelihood and consequence along with the effectiveness of controls

4. Risk evaluation
   - Evaluate if residual risk levels are acceptable within the risk appetite. If acceptable, obtain approval.

5. Risk treatment
   - If risks are outside tolerance, develop controls to reduce to an acceptable level as low as reasonably practical, while considering cost

6. Monitoring and review
   - Actively assess adequacy and effectiveness of controls. Determine whether changes in effectiveness of controls have affected risk profile.
2.4.2. EMBEDDING THE PROCESS

To improve our risk management, we have established two integrated risk management methodologies company-wide with supporting software:

- Bowtie analysis
- Semi-quantitative risk assessment (SQRA).

**Bowtie analysis**

We are in the process of organising our wealth of risk information, formerly held in risk registers, into risk bowties. Bowtie is a well-established method used to visually represent how the control environment of a risk event acts against specific causal factors and also mitigates the levels of consequential impact, should an event occur. A bowtie brings a wide range of information together in one risk diagram, in a format which better enables decision-making and analysis, when compared to traditional risk registers.

**Figure 4:** Example of a bowtie risk management diagram

Asset management scenarios can be modelled to determine an optimal approach, taking into account the condition and life expectancy of assets and the effectiveness of the more critical controls.

**SQRA**

Bowtie analysis is most effective when it is paired with the SQRA approach that can compare risks and estimate the value of preventive and mitigative risk controls. SQRA evaluates and scores risks using an approach that integrates traditional qualitative risk evaluation and quantitative risk assessment.

The addition of SQRA is crucial to enable our asset risk management processes to become integrated with our asset planning processes, by creating a common basis upon which to compare risks across different kinds of assets.

**Our review process**

We are moving our focus towards identifying and assessing the effectiveness of key controls in their ability to drive down risk. This has involved asset bowtie workshops utilising technical expertise from
across the grid business to develop the diagrams. Validation reviews will then be carried out to confirm the soundness of the bowties.

Key controls will then be assessed in terms of performance against design effectiveness. The outputs of this assurance process will trigger activities to improve under-performing controls. Our Assurance function ensures the associated controls are embedded and effective, and identify required additional preventive, corrective actions and continual improvement.

Risk information in the bowties will also be reviewed following significant asset event investigations to clarify effectiveness of controls, probability of causes leading to failures, and levels of impact.

2.4.3. ASSET CRITICALITY AND HEALTH

The application of our risk management framework to asset management results in the application of risk management principles to managing our assets. Understanding the consequences of failures of our assets allows us to understand which assets are most important.

Asset Criticality Framework

We use an asset criticality framework to estimate the consequences of failure for each asset. This framework approach has been applied since the RCP2 submission, and is still being enhanced. We are developing this framework to cover a range of dimensions of consequence. It currently includes service performance and public safety. We expect to add further dimensions to this framework during RCP2. These new dimensions could include environmental, safety, market, or financial criticality. The coverage of assets will also expand during RCP2, as we improve our ability to model our network and the necessary data sources. The way we model consequence will also need to improve, to better inform our decision making processes.

Asset criticality forms the linkage between our Service Performance targets, and the decisions we make on a day to day basis. The way this linkage is established is described in a separate document detailing the Asset Criticality Framework.

Asset health

We use estimates of asset health to inform and guide asset lifecycle decisions, including asset replacement and refurbishment. Asset health is expressed using an asset health index (AHI).

AHI is a modelling method that estimates the remaining useful life for assets, and builds up assumptions about the probability of an asset failing. It takes into account a range of factors such as asset condition, failure rate, and environmental factors, depending on the asset class.

Integrated asset risk management

Asset criticality represents the consequences of failure, while asset health is an indicator of the probability of failure. By assessing both criticality and asset health we are able to estimate asset risk in a systematic way. We are developing increasingly systematic ways to utilise and then prioritise our work plan based on this approach.
3. LIFECYCLE ACTIVITIES

This chapter provides an overview of how we manage the five stages of the asset lifecycle:

- Planning
- Delivery
- Operations
- Maintenance
- Disposal and divestment.

Our Lifecycle Strategies provide more detail for each of these stages and are available on our website.

We are currently updating and improving on the structure and definition of our lifecycle stages. As such, while the information presented in this chapter is up to date, it is likely to change in future AMPs.

3.1. PLANNING

Our planning activities cover how we make capex decisions to develop the grid and to replace or refurbish assets.

We categorise capex as follows:

- **E&D.** These investments lead to new grid build to provide additional capability. Our current E&D projects are described Part 2 of this AMP. They can be either:
  - Base E&D projects that are less than $20 million or fall within the Listed Project definition or
  - Major capex projects above $20 million which require separate regulatory approval

- **Asset Class R&R.** These investments consist of like-for-like replacements, or refurbishments that extend the life of existing assets. These are covered in our asset class plans described in Part 3 of this AMP.

- **Customer Investments.** We make these investments to meet requirements specified by a customer. The customer funds these investments directly and must meet safety, environment and network integrity requirements.

3.1.1. APPROACH

Our GOM-centric approach to the planning process includes the following steps:

- Gathering data and information about assets, risks, grid enhancements, and customer projects
- Needs identification based on feedback, modelling of assets, and modelling our network
- Options analysis including cost estimation, commercial, and risk analysis
- Prioritisation, project and portfolio integration
- Producing an asset class plans
• Governance and approvals.

The following diagram shows a high level view of the process, and key related processes.

Figure 5: Planning process

### 3.1.2. Gathering Data and Information

Our decision-making process relies on data about our assets. For example, a range of information is received from the field, analysis from our engineering teams, and insights from our customer team. By assembling this information, we systematically gain insight into the future needs for the grid, and the details of the problems or opportunities we are planning to address.

### 3.1.3. Needs Identification

We identify problems and opportunities (needs) which could be addressed by our asset class plans. The needs are prioritised based on the risk they pose. Needs may be identified through asset health modelling and criticality analysis, network studies and technology assessments, asset risk and safety reviews, or customer requests. We are implementing a formal asset feedback process to systematically capture and manage feedback which impacts the planning process.

### 3.1.4. Options Analysis

Each need passing the prioritisation test then enters the options analysis phase. The number and type of options varies depending on such factors as the type of asset, nature of the problem or opportunity, and the cost or complexity of the investment. Our options analysis also varies depending on whether the expenditure is related to E&D, R&R or customer investments. In some cases, the need may be addressed by either capex or with opex solutions. We select the lowest lifecycle cost option that reduces the risk to an acceptable level. The degree of detail in the options
analysis phase is commensurate with the immediacy and scale of the need. By way of example, immediate needs require a higher level of analysis compared with a need that may be at the edge of our planning horizon where there are large number of uncertain factors which influence the timing and definition of the need.

Enhancement and Development

Our Transmission Planning Report identifies potential transmission investment needs based on the capabilities of the existing grid and the requirements of the Grid Reliability Standards (GRS). Typical options to address the needs include:

- Non-transmission solutions such as demand response
- Enhancements to existing assets
- Creation of new assets
- Operational solutions such as special protection schemes.

For major capital projects we apply the Regulated Investment Test (RIT) as prescribed in the Capex Input Methodology (Capex IM). For Base capex E&D projects we apply the RIT principles, but modify the level of analysis commensurate with the size of the investment.

Replacement and Refurbishment

We address condition-related issues through a range of intervention options including completely replacing an asset, refurbishing asset, or continuing to maintain.

We compare the lifecycle costs and benefits of replacing or refurbishing the asset, with the costs of maintaining the asset, or repairing the asset when it breaks. A “do nothing” option is also considered in many cases. We also determine the optimum timing for the intervention.

Customer Investments

The need for a Customer Investment generally comes from a customer request to investigate grid investment options to meet their specific current and/or future needs. Where there is a requirement to build a connection asset the customer funds the investment through a bilateral investment contract. New connection work is contestable. The customer can contract with another supplier or build the connection assets themselves but they must meet the technical and safety requirements for connection to our assets.

3.1.5 Cost Estimation

We use a cost estimation tool known as the Transpower Enterprise Estimating System (TEES). TEES provides consistent and traceable pricing, automated rate updates and centralised management of foreign exchange risk.

For grid capex forecasts, we develop two forms of cost estimate:

- **Customised estimates**: Large single projects (>1m) require individual, tailored investigation. To provide these estimates we develop project-specific scopes of work.

- **Volumetric estimates**: For smaller, high-volume projects that are routine and uniform.

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1 The GRS are set out in the Electricity Industry Participation Code.
3.1.6. PRIORITISATION, PROJECT AND PORTFOLIO INTEGRATION

We prioritise and integrate base capex and opex projects (by timing and location) with other work programmes, including maintenance programmes and major capex projects.

The main processes are as follows:

- **Integration:** During detailed investigations we identify opportunities for work integration (for example, to include transmission protection work alongside power transformer work). In future, we will systematically review work across portfolios during the planning stage, using a data-driven approach to identifying potential integration points.

- **Asset Planning meetings:** We undertake a range of planning meetings involving our internal stakeholders and external service providers to challenge and reaffirm planned grid capex and opex for the upcoming years. We split the meetings into two aspects, a specific focus on short term (0-2 years) and then on long term (2-10 years).

- **Customer integration:** We discuss our work plans with our customers on an annual basis to ensure our plans remain aligned with those of our customers.

3.1.7. GOVERNANCE AND APPROVALS

Throughout the planning process we use a challenge and review process to ensure that proposed projects are consistent with our strategic objectives. This process includes stakeholder consultation.

The process follows a number of steps and requires business case approvals at each stage. Our business case documents are as follows:

- **Need registration:** This authorises the entry of works into the approvals system. Portfolio owners approve these documents, which include confirmation that the project is aligned to overall asset management objectives and strategy.

- **Investigation approval:** Gives approval for a detailed investigation to begin. This is generally only necessary for large, complex projects that require detailed design to finalise the solution.

- **Delivery business case:** Finalises the budget and, subject to management sign-off, gives authority for the work to proceed.

3.2. DELIVERY

Delivery covers all capital and operational build projects: E&D, R&R, opex projects, and Customer Investment.

3.2.1. APPROACH

Delivery involves three main stages:

- Project establishment and design
- Execution and construction
- Commissioning and close-out.

We outsource most of our delivery work, relying on specialist design consultancies for our engineering design work and on long-term relationships with our service providers for construction.

Delivery relies on activities such as procurement, skills and competency development, costs management, environmental assessment and property rights, access and landowner relationships.
3.2.2. PLANNING AND DESIGN

This stage converts early work completed in the planning phase (which focusses on defining scope, timelines and budget) into sufficient detail to tender and control the delivery works. We prepare the Project Management Plan and Procurement Plan, and undertake detailed design.

3.2.3. EXECUTION AND CONSTRUCTION

This is the stage where we award tenders, procure materials, mobilise work teams and oversee construction. In some cases these activities start during the planning stage, especially where we need to place orders for long lead items such as transformers.

3.2.4. COMMISSIONING AND CLOSE-OUT

This is the process of planning safe connection, testing, livening and handing over the asset to our operation and maintenance teams.

3.2.5. GOVERNANCE

The three stages above are subject to our asset management governance processes. We use a series of challenge and review processes in planning which we continue through delivery to ensure the project delivers the approved objectives. We have a business case change process for adjusting budget, scope or timing.

3.3. OPERATIONS

We operate our assets to meet network, operational and asset performance requirements taking account of asset reliability, cost, safety and environment. These requirements are drawn from customers, service providers, regulators and other stakeholders.
Grid operations activities are divided into three key areas.

- **Operational control**: provides real-time network control, monitoring and event response. The security and reliability of the transmission network and public and worker safety are critical outcomes of this activity.

- **Operational planning**: supports real-time control and plans for assets to be safely taken out of service to enable works on grid.

- **Operational event and performance review**: provides for the continuous improvement of grid operations, aims to avoid repeat events and provides feedback into other stages of the asset lifecycle.

### 3.4. MAINTENANCE

We maintain the grid to meet our service targets, taking into account safety, statutory compliance, sustainable operations and overall cost. We manage grid maintenance under two main categories of work: routine maintenance and maintenance projects. This section only covers how we manage our grid assets. How we maintain our ICT assets is discussed separately in Chapters 22 and 23 of this AMP.

#### Routine maintenance

We categorise routine maintenance into three main work types. The work types distinguish how the work is initiated and are fundamental to our approach to maintenance improvement. The main work types are summarised in Table 1 below.

<table>
<thead>
<tr>
<th>Work type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preventive</td>
<td>Routine servicing or inspections to prevent failure or understand asset condition in line with an established schedule$^2$</td>
</tr>
<tr>
<td>Corrective</td>
<td>Unforeseen maintenance to respond to a fault, or correct failed equipment and defects</td>
</tr>
<tr>
<td>Predictive</td>
<td>Maintenance performed prior to equipment failure based on known equipment condition, identified by remote monitoring or preventive maintenance inspections</td>
</tr>
</tbody>
</table>

These categorisations of work enable more granular tracking of maintenance interventions, their costs and their drivers. The analysis of work history is an important tool within reliability improvement and cost control.

#### Maintenance projects

Maintenance projects typically involve condition-based replacement of assets or components, and repairs of a scale beyond the scope of routine maintenance. For example, lines projects typically bundle identical work (such as attachment point replacement) throughout a line route. All maintenance project work is approved through our Integrated Works Planning (IWP) process.

#### 3.4.1. APPROACH

We group our maintenance activities as:

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$^2$ The Preventive Maintenance Schedule is a live matrix in Maximo that assigns Standard Maintenance Procedures and a service frequency to individual assets and calculates the dates for the corresponding maintenance activity.
• **Maintenance specification**: Specifies how and when maintenance should be done, and the analysis and interpretation of asset information to improve reliability and performance.

• **Maintenance delivery**: This is how we plan and manage our maintenance work and parts and materials inventory.

### 3.4.2. MAINTENANCE SPECIFICATION

Maintenance specification involves:

- Specification of maintenance requirements
- Asset information assessments to improve reliability
- Risk management to improve performance.

Each of these are described below.

#### Maintenance requirements specification

To plan our preventive maintenance, we need to understand what asset maintenance is needed and how and when it is to be undertaken. We must also ensure that maintenance is undertaken as specified. Our maintenance requirements include the following.

- **Maintenance practices**: We have an extensive suite of service specifications that provide the technical reference specifying what maintenance is required and when. We have a set of standard maintenance procedures (SMPs) that define preventive maintenance on all asset types. We use these SMPs and the maintenance frequencies from the service specifications to support our preventive maintenance schedule. This baseline plan sets out our maintenance programmes across our whole network.

- **Supply practices**: Our maintenance requirements include supply management procedures that aim to improve the delivery of parts and material on time and at best purchase price and manage obsolescence and critical spares requirements.

- **Service Management practices**: Our Service Management practices ensure service delivery aligns with the required level of service. Real time daily, weekly, and monthly operational regimes ensure effective event and incident management regimes operate in order to return service and keep our customers connected to their power systems. This provides visibility of asset and service level performance and reporting. Problem management regimes also operate to ensure that unplanned events are investigated in order to drive continual improvement.

- **Quality assurance**: Our assurance approach is an integrated part of our Corporate Risk & Assurance framework. The Quality Assurance Advisory Group (QAAG) centralizes assurance across the company and assists with the development of fit for purpose assurance programmes. Assurance activities cover safety, asset, services, environment, quality, and competency considerations across procurement, project delivery, service delivery, operations, information, data, ICT and key enterprise functions.

#### Asset information assessments to improve reliability

We generate extensive information on the condition and status of assets every day in the form of condition indicators, failure sequences, corrective work requests and operating parameters. Reliability improvement involves the interpretation of this information to forecast and manage the future condition and capability of the assets and to refine our maintenance practices.

Reliability improvement involves:
• **Operations support**: Using information to address emerging operational risks, and to limit the impact of events.

• **Reliability analyses**: Assessing work history and other data to identify poor reliability equipment and systems, and support maintenance delivery with benchmarking.

• **Fault and event analysis**: Ongoing systematic recording and analysis of faults and events to recognise trends, short-term reviews through daily operational meetings, regional events review meetings and investigations of major incidents.

• **Defect management**: Root cause analyses and other investigations of significant failures to ensure these problems do not re-occur.

• **Preventive maintenance optimisation**: Recommended improvements to our service specifications and SMPs.

• **Condition assessments**: Assessments of condition data and test results to inform predictive maintenance, maintenance projects, capital replacement and refurbishment requirements, and our asset health measures.

### 3.4.3. Maintenance delivery

We deliver our maintenance activities through the efforts of a large number of people in wide-ranging and interdependent roles. Some are direct employees but the majority are external service providers. We have several different long-term service provider arrangements. These outsourced contracts are divided broadly into:

- **Lines**: Covering transmission lines, access ways, and fibre optics on transmission lines
- **Stations**: Covering our substations, including control and protection, revenue metering and communications equipment, and underground cables
- **Others**: Includes submarine cables, high-voltage (HV) cables and facilities (buildings and grounds).

We manage the service provider work teams and retain day-to-day budget control and we are accountable for the approval of all work.

Maintenance delivery involves:

- Works planning
- Work management
- Inventory management.

**Works planning**

Works planning involves collating and scheduling upcoming maintenance work and expenditure.

We build our routine maintenance plan from baseline preventive maintenance and forecasts for corrective work. This takes account of year-by-year variations in preventive maintenance schedules, changes to the asset base, and changes to our maintenance approach and projected efficiencies.

We manage the progressive approval and prioritisation of maintenance project work within the IWP process, which culminates in the issuing of a schedule of projects for the coming year within annual planning cycle.
Work management

Work management involves delivering the maintenance works plan. The challenge is to effectively manage the different work types with their inherently different lead times and the changes in the schedule due to weather or system considerations.

Inventory management

Inventory management involves procurement, stock management and materials supply for maintenance. Stock holdings should represent the minimum required to ensure reliable operations and enable planned work to proceed on time.

Our stock includes a significant holding of strategic spares of major equipment, which require controls ensuring their availability. These strategic spares are assets such as transformers that we hold in reserve to use when we need to take assets out of service for refurbishment or for unexpected events.

3.5. DISPOSAL AND DIVESTMENTS

Disposal includes reusing, selling, or recycling redundant assets. Divestment involves transferring non-core grid assets to our distribution customers. We do this where the customer is willing and where we think assets can be more efficiently maintained, operated and developed by the customer.

Disposal

We make asset disposal decisions when we are replacing assets or removing redundant assets from service. We also dispose of equipment and materials as a result of servicing and repairs.

Disposal options include: dismantling, reuse as a spare and sale of redundant assets. Disposal activities also include disposal of waste materials.

We take the interests of the local community (including iwi) and landowners into account when disposing of certain assets (such as poles, towers and buildings). This includes consulting with customers, affected landowners, occupiers and communities at an early stage of planning projects that involve disposal or removal of assets.

Divestment

Asset divestments relate to assets that are still required on the network but can be more efficiently owned and managed by an electricity distribution business (EDB). The primary reasons for divestment are as follows.

- **Focus on the core grid**: We can release engineering resources supporting connection asset replacement to focus on higher value work to improve core grid performance.
- **Asset rationalisation**: Divestment can lead to more efficient investments in the New Zealand electricity system as a whole. Distribution companies can sometimes make integrated decisions to enhance their networks for overall lower cost by including our current connection assets when planning network enhancement.
- **Operational efficiency**: We can simplify the operational boundary with EDBs by eliminating the coordination required to manage equipment outages on low-voltage assets and faults in distribution networks.
- **Cost-effectiveness**: We can reduce operating and capital costs by divesting assets.
- **Reducing diversity**: We can reduce spares holdings and procedural requirements by divesting assets that differ from the majority of our asset class.
• **Customer requests**: Some customers proactively seek to purchase and manage their connection assets.

We are currently reviewing our strategy for divestments.
4. ASSET INFORMATION SYSTEMS AND STANDARDS

This chapter summarises our information systems and capabilities that support our asset management, along with our document control and standards structure. It covers:

- Asset management information systems
- Standards and practices

Our wider ICT environment, framework and approach are discussed further in Part 4 of this AMP.

4.1. ASSET MANAGEMENT INFORMATION SYSTEMS

To meet the long-term expectations of our customers we must manage our assets effectively. To do this we require information that is meaningful, timely and of appropriate quality to support decisions across the full asset lifecycle.

The scope of this information is broad and includes both master data and transactional data. For example, information relating to the timing and type of asset interventions to deliver services required, and data such as asset characteristics, performance, condition, incident reports, work and expenditure histories is all necessary for effective asset management decision making. We utilise a number of applications and tools to gather, manage and store the information required.

Asset management information system

Maximo is our core asset management information system for all grid assets. We use Maximo as our asset register, to manage our maintenance programme, to manage incidents (operations, safety, environmental) and manage inventory. Maximo is an integral part of our finance processes and has tight integration with our PeopleSoft Financial Management System. Maximo is a standard enterprise asset management product from IBM. Maximo replaced the legacy Pacer (MMS) system that we used from 1997 to 2013.

Supplementary asset management systems

We have a number of bespoke or specialist applications to manage the following functions:

- Grid transmission capability
- Outage management
- Cost estimation
- Drawings management
- Spatial
- Programme / project management
- Commissioning process
- Firmware management.

These tools and applications are specifically designed to meet our specific requirements.
Asset performance, reporting and analytics

We utilise a data warehouse and Oracle business intelligence tools for reporting and analytics. The times series historian platform (OSISoft PI) provides historic and real time operational view of asset performance.

4.2 Standards and practices

We maintain a set of controlled documents that are an important part of our asset management process. They cover design standards, service specifications and operating instructions. They refer to codes of practice or industry standards where relevant.

Standards tend to be of a technical or compliance nature and they are required to go through a managed review and approval process. Table 2 describes the types of policies and standards that we utilise in our asset management processes.

Table 2: Controlled document types

<table>
<thead>
<tr>
<th>Document type</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corporate policy</td>
<td>Represent the core requirement of good governance (such as the Code of Ethics and Conduct Policy) and/or are applicable across the company</td>
</tr>
<tr>
<td>Corporate procedure</td>
<td>Specify procedures applicable across the organisation</td>
</tr>
<tr>
<td>Technical policy</td>
<td>Specify our policy on general commercial and technical issues (eg, asset maintenance or replacement.) They are split into:</td>
</tr>
<tr>
<td></td>
<td>• general policies</td>
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<tr>
<td></td>
<td>• lines policies</td>
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<tr>
<td></td>
<td>• stations policies</td>
</tr>
<tr>
<td></td>
<td>• communications and computing policies</td>
</tr>
<tr>
<td></td>
<td>• protection policies</td>
</tr>
<tr>
<td></td>
<td>• outage coordination</td>
</tr>
<tr>
<td>General and technical</td>
<td>Specify approved systems, guidelines and processes and define a minimum level of compliance. They are split into:</td>
</tr>
<tr>
<td></td>
<td>• administration and management standards</td>
</tr>
<tr>
<td></td>
<td>• design standards</td>
</tr>
<tr>
<td></td>
<td>• maintenance standards</td>
</tr>
<tr>
<td></td>
<td>• construction standards</td>
</tr>
<tr>
<td></td>
<td>• operations standards</td>
</tr>
<tr>
<td></td>
<td>• procurement standards</td>
</tr>
<tr>
<td>Service specifications</td>
<td>Are published as schedules to contracts, incorporating the requirements of appropriate standards. They are split into:</td>
</tr>
<tr>
<td></td>
<td>• 01 Administration</td>
</tr>
<tr>
<td></td>
<td>• 02/03 Equipment maintenance</td>
</tr>
<tr>
<td></td>
<td>• 04 Design, construction and testing</td>
</tr>
<tr>
<td></td>
<td>• 05 Environment and landowners</td>
</tr>
<tr>
<td></td>
<td>• 06 Safety and worker competence</td>
</tr>
<tr>
<td></td>
<td>• 07 Operating and emergency management</td>
</tr>
<tr>
<td>Service advisory</td>
<td>Interpret, extend or provide supporting information for a standard or service specification</td>
</tr>
<tr>
<td>Standard maintenance</td>
<td>Set out step-by-step procedures for scheduled services on each asset type</td>
</tr>
<tr>
<td>Asset operations instructions</td>
<td>Set out business processes, procedures and policies involving regional operating centres</td>
</tr>
<tr>
<td>Table cell</td>
<td>Table cell</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
</tr>
<tr>
<td>Purchase specification</td>
<td>Specify the performance and technical requirements for equipment and materials to be purchased for Transpower use</td>
</tr>
<tr>
<td>Business continuity plan</td>
<td>Plans to ensure Transpower’s preparedness to be able to sustain business critical functions</td>
</tr>
</tbody>
</table>

**Continuous improvement**

We have commenced an extensive review of our technical controlled documents with a view to aligning them to our asset management document suite. This will improve their accessibility and use-ability, reducing duplication and ensuring new revisions to the documents are underpinned by risk based justification. We have defined a future state and a number of actions to get there which were derived through consultation with internal and external stakeholders. A plan resulting from this consultation has now been shared with our internal and external stakeholders.
5. RCP2 ASSET EXPENDITURE OVERVIEW

This chapter provides a summary of our forecast capex expenditure for RCP2 in the following areas:

- Enhancement and development
- Expenditure by Asset Class
- Information Systems and Communication Technologies (ICT)
- Business Support.

A more detailed description of each area is provided in the subsequent Parts of this AMP. This chapter also describes:

- Asset divestment.

5.1. ENHANCEMENT AND DEVELOPMENT

E&D covers our forecast expenditure for developing the grid to meet a forecasted increase in demand for grid services. It primarily addresses either capacity or other constraints on the network. The E&D expenditure is split into two categories:

- **Base capex**: Expenditure for projects that either fall below the $20m threshold or within the Listed Projects category as defined in the Commission’s Capex Input Methodology
- **Major capex**: Expenditure for projects which are approved by the Commission under the RIT.

A summary of the forecast expenditure for each category is presented below.

**Base Capex**

Overall the forecast E&D expenditure for RCP2 period has reduced from $102m to $54m. This reprioritisation of E&D expenditure has arisen from a review of the timing and forecast requirements for increased capacity and voltage management. The low to flat forecast demand on the network has also contributed to delaying expenditure into RCP3. In summary, the primary causes of the overall reduction in RCP2 expenditure are:

- Review of the timing of several projects has resulted in deferring $40m into the RCP3 period.
- A more detailed investigation of a number of projects (totalling $14m) has revealed the projects do not pass the economic test.
- An $8m project investigating reactive support for the upper North Island has been incorporated into the wider major capex investigation of thermal decommissioning.
- Revised costs have increased the costs of four projects by a total of $3.6m
- Identification of needs not previously observed has resulted in the addition of an estimated $16.5m.

Figure 7 summarises the Base E&D capex for the RCP2 period.
The variation in the 2018/19 is due to the deferment of the Otahuhu – Wiri and the North Taranaki projects which together account for $35m of the $40m deferment of projects into RCP3.

**Listed Projects**

Ongoing review of the need for the Listed Projects for RCP2 has resulted in moving the timing of some projects into the RCP3 period, resulting in reduced expenditure need within the RCP2 period from $112m in 2015 to $72m. The explanation for the change in individual projects is explained in Chapter 6 below.

**Major Capex**

Major projects are over the $20m threshold and are individually approved by the Commission under the RIT. The total major project expenditure reported in the 2015 ITP equated to $208m. For the same projects the revised expenditure total is now $185m. The primary contributor to the reduction is the lower contract costs associated with the Bunnythorpe to Haywards reconductoring project.

The only major project currently under investigation that may result in expenditure within the RCP2 period is associated with the impact of the Huntly Power Station decommissioning. Two potential major projects reported on in the 2015 ITP have been deferred as the timing of the need has been reassessed.

**Under Investigation**

Currently we have one project investigating the need for dynamic and static voltage support in the upper North Island as a result of the planned decommissioning of Huntly Power Station. Expenditure is currently expected to be in the order of $36m.

### 5.2. Expenditure by Asset Class

Our grid Asset Class Plans sets out our forecast R&R expenditure for RCP2. The asset class programmes include some of our largest expenditure by value, and include such activities as transformer replacements, outdoor to indoor conversions and tower painting.

When assets approach the end of their lives we also take the opportunity to review whether they are at appropriate capacities or capabilities, or whether they are still required.
In summary, the material changes in the RCP2 capex expenditure are:

- A detailed review of the replacement requirement of Power Transformers has resulted in a reduction of $38m.
- A review of the grillage programme has revealed the need to increase the number of replacements required. In addition, the costs for grillages have increased and as such the total programme costs have increased by $14.2m.
- A review of outdoor-indoor conversions has resulted in a re-prioritisation of some sites between RCP2 and RCP3. For example, one site an alternative was utilised and another site was divested. The overall change in the asset class is a decrease of $7m.
- We have reduced the volume of insulator replacements needed based on updated condition information. The overall change in expenditure is a reduction of $5.9m.
- A review of the capacitor and reactor program has resulted in cancelling two projects that could not be economically justified. The change in the overall programme is a reduction of $5.7m.

The overall reduction in capex expenditure across all grid asset classes is $42m.

Figure 8 provides a summary of the forecast phasing of grid asset class expenditure over the RCP2 period and Table 11 provides a breakdown by asset class showing changes arising from the reviews we have undertaken since our 2015 AMP.

The differences in each portfolio are summarised in Table 3 below.
### Table 3: R&R plans (totals for five-year RCP2 period)

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Asset class / programme</th>
<th>Total units replaced or refurbished in RCP2</th>
<th>Forecast RCP2 Capex Expenditure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2015 AMP</td>
<td>2016 AMP</td>
</tr>
<tr>
<td>8. TL Towers and Poles</td>
<td>TL Paint</td>
<td>2569</td>
<td>2556</td>
</tr>
<tr>
<td></td>
<td>TL Pole</td>
<td>913</td>
<td>910</td>
</tr>
<tr>
<td></td>
<td>TL Tower (replacement)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>9. TL Foundations</td>
<td>TL Access</td>
<td>6</td>
<td>6</td>
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<td></td>
<td>TL Foundation</td>
<td>97</td>
<td>105</td>
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<td></td>
<td>TL Grillage</td>
<td>1685</td>
<td>1881</td>
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<tr>
<td>10. TL Conductors and insulators</td>
<td>TL Conductor</td>
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<td></td>
<td>TL Insulators</td>
<td>6398</td>
<td>6025</td>
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<tr>
<td>11. AC Stations outdoor 33 kV switchyards</td>
<td>ACS outdoor 33 kV switchyards</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>12. AC Stations outdoor circuit breakers</td>
<td>ACS Outdoor circuit breakers</td>
<td>128</td>
<td>109</td>
</tr>
<tr>
<td>13. AC Stations indoor switchgear</td>
<td>ACS Indoor switchgear</td>
<td>37</td>
<td>41</td>
</tr>
<tr>
<td>14. AC Stations power transformers</td>
<td>ACS Power transformers</td>
<td>30</td>
<td>18</td>
</tr>
<tr>
<td>15. AC Stations buildings and Grounds</td>
<td>ACS Buildings and grounds</td>
<td>33</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>ACS Buildings and seismic</td>
<td>7</td>
<td>3</td>
</tr>
<tr>
<td>16. AC stations reactive power</td>
<td>ACS Capacitors and reactors</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ACS Dynamic reactive power</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>17. AC Station power cables</td>
<td>ACS Power cables</td>
<td>11</td>
<td>8</td>
</tr>
<tr>
<td>18. AC Stations other primary equipment</td>
<td>ACS Disconnectors and earth switches</td>
<td>151</td>
<td>102</td>
</tr>
<tr>
<td></td>
<td>ACS Instrument transformers</td>
<td>170</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>ACS Other station equipment</td>
<td>6</td>
<td>7</td>
</tr>
<tr>
<td></td>
<td>LVAC Switchboards</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>ACS Structures and buswork</td>
<td>25</td>
<td>21</td>
</tr>
</tbody>
</table>
5.3. ICT

Our ICT delivers and supports the infrastructure, server hardware and applications that interface with the grid and connect the system operator and the market. The expenditure for ICT covers the five areas of service (excluding System Operator support systems):

- Transmission systems
- Asset management systems
- Corporate systems
- ICT shared services
- Telecommunications, network and security services

Figure 9 and Table 4 below provides a summary of the capex expenditure for the RCP2 period.
The variance in RCP2 capex expenditure between the 2015 ITP and the 2016 is primarily due to the decrease in ICT expenditure over the 2015/16 financial year driven by the implementation of business change and the GOM over the past year.

For more information on the ICT asset class plans refer to Part 4 of the AMP.

### 5.4. Business Support

Our business support assets enable us to operate as a business and provide essential capability to deliver our service objectives. Business support expenditure falls into five categories:

- **Strategic Properties**
- **Non-critical substation buildings**
- **Office buildings and facilities**
- **Vehicles**
- **Office equipment**

The diversity of our business support assets means that each portfolio is specifically managed through different mechanisms and processes. Figure 10 and Table 5 summarises out the total business support expenditure for RCP2.
Figure 10: Business Support capex for RCP2

![Diagram of Business Support capex for RCP2]

Table 5: Business support expenditure plan (for the five year RCP2 period)

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>2015 ITP RCP2 Total</th>
<th>2016 ITP RCP2 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Support Capex expenditure</td>
<td>39.1</td>
<td>30.2</td>
</tr>
</tbody>
</table>

The largest variance in the forecast expenditure from the 2015 AMP occurs in the 2017/18 financial year and is driven by savings in office and facilities. The savings have been driven by the reassessment of the need to relocate the Addington warehouse to Islington (which was included in the 2015 AMP), and lower vehicle funding costs.

For more information on the Business Support capex for RCP2 refer to Part 5 of this AMP.

5.5. **Asset Divestment**

The underlying tenet of undertaking an asset transfer is that any transfer must provide a long term benefit to New Zealand electricity consumers. A set of criteria have been developed to ensure that this occurs and that any asset transfer is undertaken in a structured and transparent manner.

Table 6 below lists the assets considered for possible divestment.

Table 6: Assets targeted for divestment programme

<table>
<thead>
<tr>
<th>Station assets</th>
<th>Line assets</th>
<th>Target date</th>
<th>2016 ITP update</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hinuera substation</td>
<td>Hinuera–Karapiro–A line</td>
<td>1 Apr 2017</td>
<td>On hold</td>
</tr>
<tr>
<td>Hororata 33 kV switchyard</td>
<td>-</td>
<td></td>
<td>Under consideration</td>
</tr>
<tr>
<td>Islington 33 kV switchyard</td>
<td>-</td>
<td></td>
<td>Under consideration</td>
</tr>
</tbody>
</table>
PART 2: ENHANCEMENT AND DEVELOPMENT
6. ENHANCEMENT AND DEVELOPMENT

This chapter describes our forecast E&D expenditure in more detail. The projects described here are based upon the applicable planning set out in our Transmission Planning Report for the RCP2 period. The chapter also provides a summary and update on the progress we have made on our major projects. It is divided into three sections:

• Overview of our approach to E&D
• Base capex
• Major capex.

6.1. OVERVIEW OF OUR APPROACH TO E&D

Our Transmission Planning Report identifies potential transmission investment needs based on the capabilities of the existing grid and the requirements of the Grid Reliability Standards (GRS)\(^3\). It sets out a list of potential options to address those needs and the broad cost range of each option. Typical options to address the needs include:

• Non-transmission solutions such as demand response
• Enhancements to existing assets
• Creation of new assets
• Operational solutions such as special protection schemes.

This basic approach applies to all our E&D projects whether they are considered Base or Major capital expenditure. For major projects we apply the RIT as prescribed in the Capex IM. For base capex E&D projects we apply the RIT principles, but modify the level of analysis commensurate with the size of the investment.

6.2. BASE CAPEX

Since our 2015 AMP we have reviewed a number of projects. Table 7 provides an update on the projects we included in our 2015 ITP, and an overview and estimate for the new projects that have been identified.

Table 7: Update on base E&D projects

<table>
<thead>
<tr>
<th>RCP2 projects</th>
<th>2015 ITP</th>
<th>2016 ITP</th>
<th>2016 ITP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Otahuhu-Wiri</td>
<td>17.5</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Transmission Capacity</td>
<td></td>
<td></td>
<td>We have deferred the project as the use of variable line ratings is likely to defer the capacity constraints until RCP3.</td>
</tr>
</tbody>
</table>

\(^3\) The GRS are set out in the Electricity Industry Participation Code.
## RCP2 projects

<table>
<thead>
<tr>
<th>Project Description</th>
<th>2015 ITP</th>
<th>2016 ITP</th>
<th>2016 ITP</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$m</td>
<td>$m</td>
<td></td>
</tr>
<tr>
<td>Relieve Generation Constraints</td>
<td>5.8</td>
<td>-</td>
<td>The need has not been confirmed, and therefore the project has been placed on hold.</td>
</tr>
<tr>
<td>Upper North Island Reactive Support 2012 - 2020</td>
<td>8.0</td>
<td>-</td>
<td>Project has been set aside and will be considered within the context of the thermal decommissioning.</td>
</tr>
<tr>
<td>Bus Section Fault Reliability</td>
<td>7.7</td>
<td>8.0</td>
<td>The project now includes the Bunnythorpe bus security.</td>
</tr>
<tr>
<td>Otahuhu and Penrose Interconnection Capacity</td>
<td>5.3</td>
<td>0.2</td>
<td>We have deferred the project to RCP3 as it is dependent on the outcome of the OTA-WIR transmission project.</td>
</tr>
<tr>
<td>Bunnythorpe Interconnection Capacity</td>
<td>8.4</td>
<td>8.3</td>
<td>The project is proceeding as planned.</td>
</tr>
<tr>
<td>North Taranaki Transmission Capacity</td>
<td>17.3</td>
<td>0.5</td>
<td>The timing of the project is under review, and at this stage has been deferred until RCP3.</td>
</tr>
<tr>
<td>Southland Reactive Power Support</td>
<td>6.2</td>
<td>-</td>
<td>Following a review of the need date, the project will unlikely proceed in RCP2.</td>
</tr>
<tr>
<td>High Impact Low Probability Event Mitigation</td>
<td>8.0</td>
<td>8.2</td>
<td>This includes three projects that are undergoing detailed investigation to confirm scope and timing.</td>
</tr>
<tr>
<td>Hororata and Kimberley Voltage Quality</td>
<td>3.4</td>
<td>-</td>
<td>The $3.4m in expenditure on capacitors cannot be justified as the load is expected to drop. We are considering how this might be managed through Demand Response.</td>
</tr>
<tr>
<td>Auckland Supercity Programme</td>
<td>3.0</td>
<td>5.0</td>
<td>Strategic programme of works to seek and advocate for appropriate provisions in statutory planning documents under the Resource Management Act and within Auckland Supercity region.</td>
</tr>
<tr>
<td>Corridor Management Programme</td>
<td>2.1</td>
<td>3.3</td>
<td>Strategic programme of works to seek and advocate for appropriate provisions in statutory planning documents under the Resource Management Act.</td>
</tr>
<tr>
<td>Masterton Bus Security</td>
<td>1.5</td>
<td>-</td>
<td>We have cancelled the work as the project does not pass the necessary economic tests.</td>
</tr>
<tr>
<td>Bunnythorpe Structure &amp; Buswork Section Security</td>
<td>3.1</td>
<td>-</td>
<td>We have cancelled the work as the project does not pass the necessary economic tests.</td>
</tr>
<tr>
<td>Fire Prevention Systems Upgrade</td>
<td>0.5</td>
<td>0.2</td>
<td>Some expenditure has now been incorporated into other expenditure programmes.</td>
</tr>
<tr>
<td>E&amp;D Other</td>
<td>4.0</td>
<td>3.4</td>
<td>This consists of a number of smaller projects. Some of these have been deferred, cancelled or merged with other current projects.</td>
</tr>
</tbody>
</table>

**New projects (not included in 2015 ITP)**
Timaru Region Capacity Upgrade Power Transformer - 7.0 Voltage stability issue in the area indicates investment will be needed in RCP2.

SWN Generator Exit - 1.0 An identified need arising due to SWN generation decommissioning

E&D Other - 8.5 A number of smaller projects identified across the grid.

Total 102.0 53.6

6.3. MAJOR CAPEX

Our 2016 ITP forecasts include the following major capex items:

- Commerce Commission-approved major capex projects
- Other projects that are likely to involve at least partial commissioning during RCP2 include:
  - ‘listed’ reconductoring projects
  - major capex projects under development.

These are detailed in the tables below. We have other major capex and listed reconductoring projects under development for RCP3 and beyond. These are included in the ITP.

Approved projects

Table 8: Approved Major Projects

<table>
<thead>
<tr>
<th>RCP2 projects</th>
<th>2015 ITP</th>
<th>2016 ITP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunnythorpe–Haywards A and B line reconductoring</td>
<td>136.9</td>
<td>119.7</td>
</tr>
<tr>
<td>Clutha–Upper Waitaki Lines Project (previously Lower South Island Renewables)</td>
<td>24.4</td>
<td>16.2</td>
</tr>
</tbody>
</table>

In 2015-16 the reconductoring of Section 1 has been completed. This also included the installation of the HTLS (experimental) conductor sections and the trialling of the Catenary Support system. Enabling works on that section were completed along with the commencing of the enabling for Sections 2 & 3.

In 2016-17 the reconductoring of sections 2 and 3 is planned - including over Waikanae. The RCP2 period project costs have reduced mainly due to lower tender and contract costs for the reconductoring works, along with savings from more refined designs.

This programme involves five line upgrade projects; three of which are on-hold pending potential changes in system demands in Lower South Island; e.g. Tiwai leaving.

The CYD-ROX Ccts 1 & 2 was commissioned last year (i.e. in RCP1); along with the AVI-WTK circuit of AVI-LIV A Line. In 2015-16 we will commission the LIV-WTK cct of AVI-LIV A.

Costs for the RCP 2 period are lower due to sections being commissioned earlier (in RCP1); lower costs in tendering for
the wiring; and reduced tower strengthening. No cost are now forecast in RCP3

<table>
<thead>
<tr>
<th>Commissioned value ($m)</th>
<th>2015 ITP</th>
<th>2016 ITP</th>
<th>2016 ITP</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVDC</td>
<td>9.5</td>
<td>8.7</td>
<td></td>
</tr>
<tr>
<td>North Island Grid Upgrade Project (NIGUP)</td>
<td>4.5</td>
<td>6.4</td>
<td></td>
</tr>
<tr>
<td>North Auckland and Northland Grid Upgrade Project (NAaN)</td>
<td>3.2</td>
<td>2.9</td>
<td></td>
</tr>
<tr>
<td>Upper North Island Dynamic Reactive Support (UNIDRS)</td>
<td>6.5</td>
<td>5.5</td>
<td></td>
</tr>
<tr>
<td>Lower South Island Reliability</td>
<td>19.2</td>
<td>19.5</td>
<td></td>
</tr>
<tr>
<td>Other Approved</td>
<td>4.6</td>
<td>5.9</td>
<td></td>
</tr>
</tbody>
</table>

The HVDC, NIGUP and NAaN projects are all in close out phase. The costs refer to residual works and contractual milestones.

The static synchronous compensators (STATCOMs) at Marsden and Penrose have been commissioned. The Auckland reactive power controller is part of the UNIDRS grid upgrade project that is still to be completed. Alternate solutions have been identified to deliver the project benefits at a lower cost.

Cost variation is for refining the implementation of the project.

This cost refers to residual works of the completed projects, such as Hawera substation gantry works (part of Wanganui–Stratford A line reconductor), Penrose and Marsden STATCOMs (part of Upper North Island Dynamic Reactive Support), Wairakei–Whakamaru C line.

### Listed projects

#### Table 9: RCP2 Listed E&D Projects

<table>
<thead>
<tr>
<th>Line</th>
<th>Affected circuits</th>
<th>Commissioned value ($m)</th>
<th>2016 update</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunnythorpe–Wilton A</td>
<td>Bunnythorpe–Linton–Wilton 1</td>
<td>53.5</td>
<td>28.3</td>
</tr>
<tr>
<td>(Judgeford–Wilton section)</td>
<td>Haywards–Wilton 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Brunswick–Stratford B</td>
<td>Brunswick–Stratford 3</td>
<td>1.3</td>
<td>-</td>
</tr>
<tr>
<td>Central Park–Wilton B</td>
<td>Central Park–Wilton 2 and 3</td>
<td>27.4</td>
<td>15.4</td>
</tr>
<tr>
<td>Oteranga Bay–Haywards A</td>
<td>HVDC Pole 2 and 3</td>
<td>29.3</td>
<td>28.2</td>
</tr>
</tbody>
</table>

No material change to the overall project. The phasing between RCP2 and RCP3 has been reviewed resulting in a reduction in the expenditure within RCP2.

Deferral of the conductor replacement date into RCP3 and beyond based on present condition assessment information.

Reduced scope as condition assessment has identified that the replacement of some sections of the conductor can be deferred by approximately 10 years.

Project costs have been reviewed resulting in a slight reduction.
### Under investigation

Table 10: Major Projects under investigation

<table>
<thead>
<tr>
<th>Projects</th>
<th>Description</th>
<th>Commissioned value ($m)</th>
<th>2015 ITP</th>
<th>2016 ITP</th>
<th>2016 ITP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pakuranga–Whakamaru Series Compensation</td>
<td>The project is to reduce transmission constraints and system losses on the 220 kV network supplying Auckland.</td>
<td>57.1</td>
<td>-</td>
<td></td>
<td>Deferred to RCP4. Likely to be looked at as part of Waikato UNI Voltage Management project.</td>
</tr>
<tr>
<td>Waitaki Valley</td>
<td>This project is to reduce constraints in the lower Waitaki 110 kV network.</td>
<td>21.6</td>
<td>-</td>
<td></td>
<td>Moved to RCP3 as need and timing is dependent on scope and timing of potential customer work in the area.</td>
</tr>
<tr>
<td>Waikato UNI Voltage Management (thermal decommissioning)</td>
<td>This project is to resolve the upper North Island load limits due to both dynamic and static voltage issues</td>
<td>unknown</td>
<td>35.5</td>
<td></td>
<td>Currently under investigation.</td>
</tr>
</tbody>
</table>
PART 3: ASSET CLASS PLANS
7. INTRODUCTION TO ASSET CLASS PLANS

This chapter provides an overview of our Asset Class approach to managing our assets. It covers:

- Our approach to Asset Class Plans
- Overview of our asset population.

The remaining chapters in Part 3 provide the detail for each asset class.

7.1. OUR APPROACH TO ASSET CLASS PLANS

Our asset class plans build on and update the work completed for the 2015 ITP. They are based on our existing class strategies, but updated to reflect any approved changes.

Each asset class plan describes the:

- Population of assets in each asset class
- Characteristics of the asset class, including the applicable asset health indices and criticality (where these exist)
- Asset performance information
- Lifecycle activities for each asset class (planning and delivery, operations and maintenance, and disposal and divestment)
- Works programme expenditure (Capex expenditure for the RCP2 period).

The asset data, asset health and criticality information presented in this AMP are all as at 30 June 2016 unless otherwise stated.

7.2. OVERVIEW OF OUR ASSET POPULATION

Our asset base includes an extensive network of assets located throughout New Zealand. It includes substations, transmission lines, submarine HVDC cables and extensive communications fibre. Table 11 sets out the chapter in which the management activities for each asset class are described.

<table>
<thead>
<tr>
<th>Table 11: Summary of the asset class</th>
<th>Asset Class Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>8. TL Towers and Poles</td>
<td>TL Tower (replacement)</td>
</tr>
<tr>
<td></td>
<td>TL Pole</td>
</tr>
<tr>
<td></td>
<td>TL Paint</td>
</tr>
<tr>
<td>9. TL Foundations</td>
<td>TL Foundation</td>
</tr>
<tr>
<td></td>
<td>TL Grillage</td>
</tr>
<tr>
<td></td>
<td>TL Access</td>
</tr>
<tr>
<td>10. TL Conductors and insulators</td>
<td>TL Conductor</td>
</tr>
<tr>
<td></td>
<td>TL Insulators</td>
</tr>
<tr>
<td>Chapter</td>
<td>Asset Class Activity</td>
</tr>
<tr>
<td>---------</td>
<td>----------------------</td>
</tr>
<tr>
<td>11. AC Stations outdoor 33 kV switchyards</td>
<td>ACS outdoor to indoor conversions</td>
</tr>
<tr>
<td>12. AC Stations outdoor circuit breakers</td>
<td>ACS Outdoor circuit breakers</td>
</tr>
<tr>
<td>13. AC Stations indoor switchgear</td>
<td>ACS Indoor switchgear</td>
</tr>
<tr>
<td>14. AC Stations power transformers</td>
<td>ACS Power transformers</td>
</tr>
<tr>
<td>15. AC Stations buildings and Grounds</td>
<td>ACS Buildings and grounds</td>
</tr>
<tr>
<td>16. AC stations reactive power</td>
<td>ACS Buildings and seismic</td>
</tr>
<tr>
<td>17. AC Station power cables</td>
<td>ACS Dynamic reactive power</td>
</tr>
<tr>
<td>18. AC Stations other primary equipment</td>
<td>ACS Capacitors and reactors</td>
</tr>
<tr>
<td>19. SA substation management systems</td>
<td>ACS Power cables</td>
</tr>
<tr>
<td>20. SA secondary systems</td>
<td>ACS Structures and buswork</td>
</tr>
<tr>
<td></td>
<td>ACS Instrument transformers</td>
</tr>
<tr>
<td></td>
<td>ACS Disconnectors and earthswitches</td>
</tr>
<tr>
<td></td>
<td>LVAC Switchboards</td>
</tr>
<tr>
<td></td>
<td>ACS Other station equipment</td>
</tr>
<tr>
<td>21. HVDC</td>
<td>SA Substation management systems</td>
</tr>
<tr>
<td></td>
<td>SA Metering</td>
</tr>
<tr>
<td></td>
<td>SA Buszone protection</td>
</tr>
<tr>
<td></td>
<td>SA Line protection</td>
</tr>
<tr>
<td></td>
<td>SA Transformer protection</td>
</tr>
<tr>
<td></td>
<td>SA Batteries and DC systems</td>
</tr>
<tr>
<td></td>
<td>SA Feeder protection</td>
</tr>
<tr>
<td></td>
<td>HVDC</td>
</tr>
</tbody>
</table>
8. TL TOWERS AND POLES

This chapter describes the lifecycle management of our galvanised steel lattice tower (towers) and pole assets. Table 12 provides a breakdown of the tower and pole population by voltage level.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>≤ 66 kV</th>
<th>110 kV</th>
<th>220 kV</th>
<th>350 kV</th>
<th>400 kV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of towers</td>
<td>351</td>
<td>6,216</td>
<td>15,031</td>
<td>1,667</td>
<td>418</td>
<td>23,683</td>
</tr>
<tr>
<td>No. of poles</td>
<td>1,687</td>
<td>12,581</td>
<td>83</td>
<td>33</td>
<td>10</td>
<td>14,394</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

8.1. ASSET CHARACTERISTICS

Towers

The condition of steel towers depends primarily on the corrosiveness of the local atmosphere and the quality and thickness of the galvanising. We have allocated each tower to one of six corrosion zones, this is reviewed and updated as required to ensure the right corrosion zone is allocated to each structure. Table 13 gives life expectancies for unpainted towers in the six corrosion zones.

<table>
<thead>
<tr>
<th>Corrosion zone</th>
<th>Typical environment</th>
<th>Life expectancy (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>Geothermal/exposed</td>
<td>18</td>
</tr>
<tr>
<td>Very severe</td>
<td>Sea-shore (surf)</td>
<td>25</td>
</tr>
<tr>
<td>Severe</td>
<td>Sea-shore (calm)</td>
<td>44</td>
</tr>
<tr>
<td>Moderate</td>
<td>Sheltered/coastal with low salinity</td>
<td>62</td>
</tr>
<tr>
<td>Low</td>
<td>Arid/rural/inland</td>
<td>86</td>
</tr>
<tr>
<td>Benign</td>
<td>Dry, rural/remote from coast</td>
<td>120</td>
</tr>
</tbody>
</table>

We use paint to protect the underlying steel from the corrosive environment. The lifespan of paint is significantly influenced by the corrosiveness of the atmosphere. We are currently developing asset health models to incorporate both the degradation rates for towers at each corrosion zone, and the expected life of the paint.

A tower is deemed to have reached the end of its life, and pose unacceptable risks, when steel members are no longer capable of meeting specific load requirements.

We have no towers which are at imminent risk of failure due to poor condition. However, there are a significant number which need painting and steel members replaced, so as to avoid full replacement.

Poles

Our asset health model for poles takes into account:

- Pole type and quality
- Site-specific influences.
Figure 11 shows the asset health of our poles.

The health of our poles is generally good, although some older-type concrete poles have cracks, spalling and rusting reinforcement. Most of our poor-condition poles are old non-treated hardwood poles that tend to rot just below ground level, reducing section area to a point where the structure cannot reliably carry design loads. Significant above-ground defects also occur, such as major splitting or pole top rot.

**Tower and pole criticality**

Figure 12 sets out the proportion of towers and poles in each service performance criticality category. We assign service performance criticality in terms of the effect on customers if they are taken out of service.

**8.2. Asset Performance**

Structural failures of towers and poles are rare and are usually associated with extreme weather events or ground subsidence. We typically replace two structures annually where the structure is at risk of collapse due to third party actions or causes as noted above.

**8.3. Planning and delivery**

Planning and Delivery activities consist of:

- Enhancement and development
• Replacement and refurbishment
• Design
• Procurement.

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

We plan tower or pole investments where new structures or strengthened structures are required to support higher capacity conductors.

**Replacement and refurbishment**

We identify and prioritise R&R investments using asset health and criticality data.

The R&R work developed for RCP2 involves:

• Tower painting, which is generally more cost-effective than piece-wise replacement of steel members or tower replacement
• Replacing older poles when they approach a point where they can no longer support their design loads, or where it is prudent to do so.

**Design**

We standardise structure designs as far as practicable, and ensure the structures are appropriately resilient to high loading events.

**Procurement**

Materials and services for towers and pole activities are procured as required by the relevant work package. Our procurement approach involves:

• A first preference for sole source, second preference for selected tender to minimise the number of suppliers of structures
• Awarding work by geographic location utilising local service provider knowledge and experience i.e. experience in rugged terrain
• Following our procurement strategy for tower painting. This was introduced in 2014 to help increase the pool of painting contractors available so we can paint towers when and where we need.

---

**8.4. OPERATIONS AND MAINTENANCE**

Operations and Maintenance activities consist of:

• Outage planning
• Contingency planning
• Corridor management
• Preventive maintenance
• Predictive maintenance
• Corrective maintenance
• Maintenance projects.

Our approach to each of these lifecycle activities is described below.

**Outage planning**
Outages are planned and coordinated when maintaining and replacing towers and poles to minimise impact on customers. Works able to be completed using live line techniques are also coordinated where appropriate.

**Contingency planning**
Towers and poles will occasionally fail during extreme events such as high winds, snow storms, earthquakes, volcanic eruptions and landslides. Our objective is to restore security of supply at a site within one calendar week of a major failure of a tower.

Our contingency planning for towers and poles involves:
• Preparing sufficient plans, skilled manpower and emergency spares to enable rapid restoration of transmission service
• Keeping one emergency tower for every 800 towers in service
• Keeping an additional 30 spare poles located strategically throughout the country.

**Corridor management**
Our corridor management plans are to:
• Maintain or improve our relationships with landowners or occupiers impacted by line corridors
• Seek provisions in council plans to ensure appropriate buffer distances are provided from existing transmission assets for third-party activities.

**Preventive maintenance**
For our tower and pole assets, the largest component of preventive maintenance is condition assessment, as little servicing is required.

Our condition assessment programme involves:
• Eight-year inspections for tower-line assets
• Six-year inspections for pole-line assets
• More frequent inspections where condition is worsening, the environment is harsh or safety or service is critical
• Annual ground-based line patrols.
• Corrective maintenance.

We will make repairs to towers, poles and associated hardware where a defect has been identified that could potentially result in a failure, or when a failure has occurred.
Predictive maintenance
We will complete minor repairs to towers and poles that have sustained minor damage, require some remedial work, or require low-value components to be replaced.

Maintenance projects
We plan to:

- Replace corroded components, such as insulator attachment points, steel bolts and isolated individual steel members, for sections which are deteriorating
- Identify, assess and mitigate the risk of transferred hazardous voltages and earth potential rise, specifically the risk due to people touching transmission line structures.

8.5. DISPOSAL AND DIVESTMENT

Disposal
We will redeploy or scrap towers or poles as part of replacement or enhancement work.

Divestment
We are continuing to transfer a number of assets to our distribution business customers. This affects mainly lower voltage line towers and poles.

8.6. TOWERS AND POLES WORKS

Table 14 provides a summary of the towers and poles R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL Tower (replacement)</td>
<td>8</td>
</tr>
<tr>
<td>TL Pole</td>
<td>910</td>
</tr>
<tr>
<td>TL Paint</td>
<td>2,556</td>
</tr>
</tbody>
</table>
9. TL FOUNDATIONS

This chapter describes the life cycle management of the foundations for our tower and pole assets. Tower and pole foundations vary depending on the design loads, soil type and the preferred construction practices of the time which they were installed. The quantities of each type are shown in Table 15.

Table 15: Foundation types and population

<table>
<thead>
<tr>
<th>Foundation type</th>
<th>Description</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Towers</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel grillage</td>
<td>Grillages that have not yet been refurbished</td>
<td>10,898</td>
</tr>
<tr>
<td>Concrete over steel grillage</td>
<td>Refurbished grillage foundations (by encasement in concrete)</td>
<td>2,627</td>
</tr>
<tr>
<td>Concrete plug (bored/dug)</td>
<td>Currently preferred foundation type</td>
<td>9,465</td>
</tr>
<tr>
<td><strong>Other</strong></td>
<td>Includes as:</td>
<td>737</td>
</tr>
<tr>
<td></td>
<td>• Driven pile with pile cap—generally only used at river crossings or sites with very poor soils</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Pad and chimney—occasionally used at sites with poor soils</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Raft and screw pile type foundations</td>
<td></td>
</tr>
<tr>
<td><strong>Poles</strong></td>
<td>Driven pile and wailings For mounting poles in riverbeds</td>
<td>314*</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>24,041</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

9.1. ASSET CHARACTERISTICS

Figure 13 shows the asset health for foundations.

The foundations with the shortest remaining life include ageing foundations and towers with buried steel grillage foundations which are showing corrosion on tower legs and bracing near the ground.
This results in a loss of steel section that leads to an increased risk of foundation failure and subsequent tower failure with potential safety, environment and network performance impacts.

**Criticality**

Figure 14 shows the proportion of foundations in each service performance criticality category.

![Figure 14: Foundations—service performance criticality](image)

**9.2. Asset Performance**

Our foundations are designed, monitored, and maintained to withstand severe loading conditions in extreme weather. Structural failures of foundations are rare and are usually a direct result of erosion or flooding.

**9.3. Planning and Delivery**

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement.

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

The most important driver for new foundation investments is the need for new or strengthened towers. As part of uprating projects, we strengthen foundations that do not comply with current design standards, to increase reliability.

**Replacement and refurbishment**

We identify and prioritise R&R investment based on condition and criticality data. The work planned for RCP2 includes:

- Continuing our long-term programme of grillage concrete encasement, avoiding the need to replace steelwork. We target foundations to ensure minimal cross section loss on main steel members.
• Continuing to investigate the capacity of existing foundations constructed between 1967 and 1983 (known to have design and construction deficiencies) at critical sites and strengthening those found to have undersized bored concrete foundations

• Replacing pile foundations at sites susceptible to erosion, and those in rivers that have degraded to a point where replacement is warranted

• Replacing a number of bridges on access corridors.

Design

There are economies of scale in increasing foundation capacity when undertaking foundation encasement/replacement. We design replacement foundations to carry the design loads of likely future upgrades. We standardise designs as far as practicable, and ensure structures are appropriately resilient to high loading events.

Our preferred method for new foundations is concrete plugs with cast-in tower leg stubs. Where concrete is not easily transportable to a remote location, other foundation types are considered.

We standardise designs as far as practicable, and ensure structures are appropriately resilient to high loading events.

Procurement

Grillage encasement work is mostly of a volumetric nature. Our preferred procurement method is sole source, and our second preference is selected tender.

9.4. OPERATIONS AND MAINTENANCE

Operations and Maintenance activities consist of:

• Outage planning
• Contingency planning
• Corridor management
• Preventive maintenance
• Corrective maintenance
• Predictive maintenance
• Maintenance projects.

Our approach to each of these lifecycle activities is described below.

Outage planning

Very few foundation works require outages. When works do require an outage, these are planned to minimise disruption to customers.

Contingency planning

We will have sufficient plans, skilled manpower, and emergency spares in place to enable rapid restoration of transmission service following single or multiple structure failures or conductor drops.
Corridor management
Our corridor management plans are to:

- Maintain or improve our relationships with landowners or occupiers impacted by line corridors
- Seek provisions in council plans to ensure appropriate buffer distances are provided from existing transmission assets for third-party activities.

Preventive maintenance
We generally patrol lines annually to identify any defects that could pose a risk to the structural integrity. We keep a register of problematic areas and monitor at-risk structures after major weather events.

Corrective maintenance
Foundation repairs are carried out promptly, to maintain network reliability and performance.

Predictive maintenance
The most common minor repairs required for foundations are due to land subsidence or rapid soil erosion. Each year a number of sites require stabilising work and repairs to avoid failure. In extreme cases we may relocate a structure.

Maintenance projects
Our maintenance projects include:

- Refurbishing corroding tower baseplates, anchor bolts and cast-in stubs before the onset of significant rusting in the interface zone
- Replacing or refurbishing tower foundations in marine environments that are subject to degradation from tidal activity and chloride ingress attacking the reinforced steel
- Installing and maintaining river protection work on both tower and pole foundations.

9.5. Disposal and divestment

Disposal
We reinstate decommissioned site foundations to their former natural forms to allow the land to recover. We monitor rehabilitated areas for a period of time after reinstatement.

Divestment
We will continue to transfer a number of transmission line assets as part of asset transfers to our distribution business customers.

9.6. Foundations works

Table 16 provides a summary of the foundations R&R plans for RCP2.
Table 16: Foundations R&R plans

<table>
<thead>
<tr>
<th></th>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL Foundation</td>
<td>105</td>
<td>9.4</td>
</tr>
<tr>
<td>TL Grillage</td>
<td>1,881</td>
<td>60.4</td>
</tr>
<tr>
<td>TL Access</td>
<td>-</td>
<td>5.9</td>
</tr>
</tbody>
</table>

4 Unit numbers are provided for foundations and grillages only, as these projects have standard unit costs.
10. TL CONDUCTORS AND INSULATORS

This chapter describes the lifecycle management of our conductors, conductor hardware and insulators. These are described below.

Conductors

Transmission line conductors are core components of our transmission network that enable electricity to flow from generators to consumers. Table 17 sets out the conductor length by voltage.

<table>
<thead>
<tr>
<th>Voltage</th>
<th>Route (km)</th>
<th>Circuit (km)</th>
<th>Total (km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 66 kV</td>
<td>351</td>
<td>633</td>
<td>11,066</td>
</tr>
<tr>
<td>110 kV</td>
<td>4,097</td>
<td>6,090</td>
<td>17,445</td>
</tr>
<tr>
<td>220 kV</td>
<td>5,848</td>
<td>9,184</td>
<td></td>
</tr>
<tr>
<td>350/HVDC</td>
<td>586</td>
<td>1,167</td>
<td></td>
</tr>
<tr>
<td>400 kV</td>
<td>184</td>
<td>371</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11,066</td>
<td>17,445</td>
<td></td>
</tr>
</tbody>
</table>

We have ACSR-type conductors on more than 60 per cent of our transmission lines. Our preference is for AAAC-type conductors to be used for new lines and reconductoring where existing corridors allow.

Hardware

There is a number of hardware types associated with the conductor population. Table 18 sets out the conductor hardware population.

<table>
<thead>
<tr>
<th>Hardware type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-span joints</td>
<td>37,560</td>
</tr>
<tr>
<td>Dead end and other joints</td>
<td>38,169</td>
</tr>
<tr>
<td>Spacers</td>
<td>242,831</td>
</tr>
<tr>
<td>Vibration dampers</td>
<td>316,429</td>
</tr>
</tbody>
</table>

Insulators

Insulators attach energised conductors to supporting structures such as towers and poles. Composite insulators are made from a fibreglass rod with silicone rubber sheath and sheds. Table 19 sets out the insulator population.

<table>
<thead>
<tr>
<th>Hardware type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Composite</td>
<td>10,805</td>
</tr>
<tr>
<td>Glass and Porcelain</td>
<td>42,653</td>
</tr>
<tr>
<td>Other</td>
<td>757</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

5 Spacers maintain the distance between twin and triple conductor configurations.
10.1. **Asset Characteristics**

**Conductors**

We are developing an asset health model to assist the prediction of end of life for each span of conductor. Currently we use condition as a replacement driver.

The observed life expectancy of conductors varies significantly depending on the location of the circuit and the type of conductor. Table 20 gives typical life expectancies in years for the main conductor types in six corrosion zones based on our observed experience.

<table>
<thead>
<tr>
<th>Type</th>
<th>Benign</th>
<th>Low</th>
<th>Moderate</th>
<th>Severe</th>
<th>Very Severe</th>
<th>Extreme</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACSR-GZ greased</td>
<td>157</td>
<td>126</td>
<td>99</td>
<td>73</td>
<td>54</td>
<td>38</td>
</tr>
<tr>
<td>ACSR-GZ grease holiday</td>
<td>121</td>
<td>96</td>
<td>74</td>
<td>53</td>
<td>38</td>
<td>26</td>
</tr>
<tr>
<td>ACSR-GZ ungreased</td>
<td>114</td>
<td>90</td>
<td>70</td>
<td>50</td>
<td>35</td>
<td>24</td>
</tr>
<tr>
<td>ACSR-AC greased</td>
<td>180</td>
<td>143</td>
<td>113</td>
<td>91</td>
<td>70</td>
<td>47</td>
</tr>
<tr>
<td>ACSR-AC grease holiday</td>
<td>126</td>
<td>113</td>
<td>88</td>
<td>71</td>
<td>54</td>
<td>35</td>
</tr>
<tr>
<td>AAAC greased</td>
<td>160</td>
<td>139</td>
<td>120</td>
<td>103</td>
<td>87</td>
<td>70</td>
</tr>
<tr>
<td>Copper</td>
<td>117</td>
<td>104</td>
<td>90</td>
<td>77</td>
<td>65</td>
<td>54</td>
</tr>
<tr>
<td>SC/GZ</td>
<td>80</td>
<td>63</td>
<td>49</td>
<td>35</td>
<td>25</td>
<td>17</td>
</tr>
<tr>
<td>SC/AC and SC/CC</td>
<td>96</td>
<td>75</td>
<td>59</td>
<td>48</td>
<td>36</td>
<td>23</td>
</tr>
</tbody>
</table>

Condition, rather than age, is the primary driver for conductor replacement.

**Insulators**

Glass and porcelain insulators invariably reach the end of their lives due to corrosion of the steel cap and pin. We monitor this corrosion by visual condition assessment. Figure 15 shows the asset health profile of our insulators.

**Criticality**

Figure 16 shows the proportion of conductors in each service performance criticality category.

---

6 Values for greased ACSR assume well-greased conductor throughout the entire length. Conductors purchased prior to the mid-2000s had poor grease application quality controls; many have patches of little or no grease. We refer to these as ‘grease holidays’.
10.2. Asset Performance

Despite the large numbers of components in service, the reliability of conductors and insulators is high and failures are rare.

Figure 17 shows the annual number of conductor drops and the cause for each between 2006 and 2016.

The physical reliability of our hard-drawn copper conductors is poor by comparison with ACSR and other modern conductors.

10.3. Planning and Delivery

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement.

Our approach to each of these lifecycle activities is described below.
Enhancement and development

We plan E&D projects principally for new build transmission projects and the uprating of existing lines.

Replacement and refurbishment

We identify and prioritise R&R investments of conductor and insulator assets using asset health and criticality data.

Our approach is to replace conductors when a significant proportion of spans have sections nearing the end of their life due to loss of strength or cross-sectional area, and when the cost of maintaining such defects and the risk of failure have become unacceptably high.

The conductor replacement and refurbishment work planned for RCP2 involves:

- Replacing degraded earth wires, insulators, and hardware to maintain the asset health of our conductors and insulators to avoid major failures
- Planning aerial laser surveys typically every third year to survey un-surveyed lines or to re-survey lines that have been modified or underbuilt
- Carrying out under-clearance mitigation works on low conductors. This work will continue into RCP3
- Preventing conductor clashing in severe climatic conditions by providing inter-phase spacers on vulnerable spans.

Design

We have design standards which specify transmission line loading and line clearances. Our approach to conductor and insulator design is:

- Where possible to install AAAC conductors which we expect to last longer than the ACSR conductors
- To use glass discs for all new insulator installations except in highly corrosive environments or where audible noise is an issue, where we will install composite insulators
- To minimise the diversity of conductor and insulator types in new and replacement construction by maintaining a list of pre-approved equipment.

Procurement

Our procurement approach includes:

- Performing a rigorous conductor selection process that balances project-specific cost optimisation with lifetime performance for any new build or re-conductoring work
- Ensuring the quality control of conductor grease application for all conductor types.
- Engagement of specialist services for specific projects such as ALS flights and conductor testing.

10.4. Operations and Maintenance

Operations and Maintenance activities consist of:

- Outage planning
Contingency planning
Corridor management
Preventive maintenance
Corrective maintenance
Predictive maintenance
Maintenance projects.

Our approach to each of these lifecycle activities is described below.

Outage planning
We coordinate with key stakeholders to ensure that any unavoidable system disruptions and outages are notified well in advance so that affected parties can prepare.

Contingency planning
Our contingency planning for conductors and insulators involves ensuring there are sufficient plans, skilled manpower, and emergency spares to enable restoration of transmission service following single or multiple structure failures or conductor drops.

Corridor management
Our corridor management plans involve:
• Maintaining or improving our relationships with landowners or occupiers impacted by line corridors
• Seeking provisions in council plans to ensure appropriate buffer distances are provided from existing transmission assets for third-party activities.

Preventive maintenance
The largest component of preventive maintenance for conductors and insulators is assessments involving:
• Annual line patrols on every transmission line asset to identify defects that pose risk to each line’s integrity
• Condition assessments to provide relevant meters for use in asset health measures and modelling
• More detailed inspections as end of life approaches, such as close aerial inspections, conductor condition testing (Cormon testing) and laboratory inspections of samples.

Corrective maintenance
The most common fault response is patrolling lines to try to establish the cause and rectify the problem.

Predictive maintenance
We will complete minor condition-based repairs on insulators and hardware that have sustained minor damage, require some remedial work, or require low-value components to be replaced.

The types of repairs include:
• Replacing damaged insulators, vibration dampers, spacers and insulator hardware
• Planned maintenance to conductor joints that are showing rising resistance
• Minor repairs to conductors due to lightning damage, wire strikes caused by third-party activities, fires under conductors, and vandalism
• Managing vegetation to avoid breaching statutory minimum clearances from live conductors.

**Maintenance projects**

We plan maintenance projects including:

• Continuing to assess conductor health and criticality to prioritise conductor sections for replacement and manage the risks of conductor drops
• Performing regular visual condition assessments of conductors (by targeted close aerial surveys and Cormon corrosion detector and conductor sampling)
• Making localised repairs on ACSR lines that are known to be corroding due to minimal or no remaining protective coating, or from spacer damage.

### 10.5. DISPOSAL AND DIVESTMENT

**Disposal**

We will use safe work and site management processes when recovering, recycling or disposing conductors and insulators. This includes the appropriate probity and environmental responsibility of scrap disposal processes.

**Divestment**

We will continue to transfer a number of transmission line assets as part of asset transfers to our distribution business customers.

### 10.6. CONDUCTORS AND INSULATORS WORKS

Table 21 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL Conductor</td>
<td>33.0</td>
</tr>
<tr>
<td>TL Insulators</td>
<td>6,025</td>
</tr>
</tbody>
</table>

7 Total units are provided only for insulators, as these relatively standard unit costs.
11.  **AC STATION OUTDOOR 33 KV SWITCHYARDS**

This chapter describes the lifecycle management of our 33kV outdoor switchyards. Our 33kV outdoor switchyards provide a large proportion of the interconnection between our high voltage transmission network and medium voltage distribution customers. We have 54 remaining 33 kV outdoor switchyards, all of which were constructed before 1984 and are currently implementing a programme of converting these to indoor installations. This is known as our “outdoor to indoor conversion” programme.

Outdoor switchyards consist of the following assets:

- Structures and buswork
- Circuit breakers
- Other outdoor equipment.

Outdoor 33 kV switchyard structures and buswork

The outdoor 33 kV switchyards consist of four main types of structure:

- **Large lattice**: large galvanised steel or aluminium lattice-type structures. The design of these typically allows for very little tolerance for worker movements during any maintenance activities.
- **Lattice**: galvanised steel or aluminium lattice structures which tend to be less congested than large lattice structures.
- **Tall poles**: concrete pole structures that consist of strung bus instead of rigid bus types. Generally, these structures are less congested compared to large lattice/lattice structures, but still have poor clearances due to back-to-back disconnectors.
- **Ground mounted equipment**: 33 kV equipment and rigid bus are ground mounted on concrete support posts with no surrounding structures. Some do not have an overhead bus. These structures tend to have safer maintenance clearances.

The 33 kV outdoor switchyards involve three types of buswork.

- **Single rigid bus**: single rigid buswork such as copper tubes or busbars.
- **Strung bus**: generally consists of conductor strung between concrete pole or lattice gantries.
- **No bus**: downstream 33 kV assets (such as feeder breakers and associated disconnectors) generally feed into a customer’s switchboard.

All of our 33 kV vertically stacked double bus outdoor switchyards have now been replaced with indoor switchboards due to safety reasons.
Outdoor 33 kV circuit breakers

Table 22 shows the population, age and life expectancy by interrupter type.

### Table 22: Outdoor 33 kV circuit breakers

<table>
<thead>
<tr>
<th>Type</th>
<th>Population</th>
<th>Life expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk oil</td>
<td>183</td>
<td>45</td>
</tr>
<tr>
<td>Minimum oil</td>
<td>3</td>
<td>40</td>
</tr>
<tr>
<td>Sulphur hexafluoride (SF₆)</td>
<td>77</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>263</strong></td>
<td></td>
</tr>
</tbody>
</table>

Other 33 kV outdoor equipment

Table 23 shows the population of other 33 kV outdoor equipment.

### Table 23: Other 33 kV outdoor equipment

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disconnectors</td>
<td>729</td>
</tr>
<tr>
<td>Free-standing instrument transformers</td>
<td>201</td>
</tr>
<tr>
<td>Earth switches</td>
<td>253</td>
</tr>
<tr>
<td>Surge arrestors</td>
<td>134</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1317</strong></td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

### 11.1. Asset characteristics

Bulk oil circuit breakers are nearing the end of their expected life and minimum oil circuit breakers are considerably beyond their expected life. This contributes to poor reliability performance and increased maintenance costs. The newer SF₆ circuit breakers are in good overall condition.

The asset health model for circuit breakers is calculated using the condition of the asset, its age, observed degradation of the circuit breaker family, and environmental factors that affect the rate of degradation, such as proximity to the coast affecting the rate of corrosion.

Based on the asset health percentages shown in Figure 18, almost 75 per cent of the asset class are candidates for individual replacements during RCP2. We are decommissioning many of these as part of outdoor-to-indoor conversion projects. Some isolated in-situ replacements will also be required.
11.2. **Asset Performance**

**Reliability performance**

Outdoor 33 kV switchyards have a much higher rate of forced and fault outages than equivalent indoor switchboard, owing to:

- Small insulation clearances leading to electrical failure
- The majority of the existing circuit breakers are bulk oil type, with higher rates of forced and fault outages than modern SF6 circuit breakers
- Most of the 33 kV switchyards do not have bus zone protection or bus section circuit breakers. In the last 10 years we have had, on average, two bus faults each year in outdoor 33 kV structures.
The majority of outages are caused by circuit breakers. Disconnectors are the second most common cause.

**Safety performance**

The prime asset management driver for this asset class is the safety of the working environment. We have had four fatalities of maintenance workers in our outdoor 33 kV switchyards in the past 25 years. In addition to the four deaths, there have been serious harm injuries, medical treatment injuries and near miss incidents in these structures.

The particular safety hazards associated with the outdoor 33 kV switchyards include the small safety clearances to adjacent live equipment, and the need to work at heights and climb into structures to undertake work.

### 11.3. Planning and delivery

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment.

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

We will not plan any new outdoor switchyards, and will use only indoor switchgear for all new installations.

**Replacement and refurbishment**

Our planned R&R work includes:

- Decommissioning the majority of our outdoor 33 kV switchyards and replacing them with indoor switchgear by following a prioritised work plan, to meet safety obligations, improve reliability and decrease maintenance requirements
- Prioritising the order of replacement of outdoor 33 kV switchyards, taking into account the safety of the structure type, switchyard criticality and asset health of circuit breakers
- Replacing some individual 33 kV assets (such as certain bulk oil and minimum oil circuit breakers) on condition grounds before the switchyard is due for replacement or if the switchyard will remain outdoors indefinitely.

### 11.4. Operations and maintenance

Operations and Maintenance activities consist of:

- Outage planning
- Contingency planning
- Preventive maintenance
Corrective maintenance.

Our approach to each of these lifecycle activities is described below.

Outage planning

The majority of these sites operate with N-1 security and this normally allows outages for installation works to be arranged without undue difficulty. However, we also have a number of N-security sites where we can use our mobile substation to maintain supply during maintenance outages.

Contingency planning

We hold spares for 33 kV equipment in our three warehouses to cover possible failure of in-service equipment. The spares are condition-monitored and maintained and are ready for immediate installation/service.

We will retain one spare emergency mobile 33/22/11 kV switchroom that we can deploy anywhere in the country at short notice to enable prompt restoration of supply in the event of a major failure.

Preventive maintenance

We will carry out regular condition assessments on all remaining 33 kV outdoor switchyard installations, at a frequency determined by the condition and model of each equipment type. Bulk oil or minimum oil circuit breakers require major invasive servicing at least every four years, or after clearing a set number of heavy faults.

Corrective maintenance

We will make repairs of all existing 33 kV outdoor switchgear promptly, as required, to maintain network reliability and performance.

11.5. DISPOSAL AND DIVESTMENT

Disposal

We will perform disposal activities such as:

- Reusing modern switchyard assets from the outdoor 33 kV switchyards we are decommissioning
- Reusing circuit breakers to replace older circuit breakers at other sites or as spares
- Disposing of the assets in a safe and environmentally sustainable manner, where reuse is not appropriate
- Performing soil sampling on all decommissioned outdoor switchyards before we undertake earthworks to identify contaminated ground and select an appropriate treatment or disposal options.

Divestment

We have an active programme for transfer of ownership of some sub-transmission assets which will have an effect on the total population of outdoor switchyards.

11.6. OUTDOOR 33 kV SWITCHYARD WORKS

Table 24 provides a summary of the R&R plans for RCP2.
### Table 24: Outdoor 33 kV switchyard R&R plans

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Outdoor to indoor conversions</td>
<td>14</td>
</tr>
</tbody>
</table>
12. AC STATION OUTDOOR CIRCUIT BREAKERS

This chapter describes the lifecycle management of our outdoor circuit breakers. Circuit breakers rapidly disconnect faulty equipment during faults and limit any impacts to a small section of the grid. In addition, they are used to control the flow of power around the system.

Circuit breakers are generally classified by the medium they use to extinguish the arc that occurs when current is interrupted. Table 25 shows our outdoor circuit breakers by type, and population.

Table 25: Number of high voltage outdoor circuit breakers—by type and voltage

<table>
<thead>
<tr>
<th>Type</th>
<th>220 kV</th>
<th>110 kV</th>
<th>50 kV-66 kV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum</td>
<td></td>
<td>1</td>
<td></td>
<td>1</td>
</tr>
<tr>
<td>Bulk oil</td>
<td>0</td>
<td>36</td>
<td>25</td>
<td>61</td>
</tr>
<tr>
<td>Minimum oil</td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>12</td>
</tr>
<tr>
<td>Sulphur hexafluoride (SF₆)</td>
<td>517</td>
<td>489</td>
<td>97</td>
<td>1103</td>
</tr>
<tr>
<td>Total</td>
<td>517</td>
<td>534</td>
<td>126</td>
<td>1177</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

12.1. ASSET CHARACTERISTICS

Our outdoor circuit breakers are generally in good condition, but are vulnerable to corrosion in the New Zealand environment. Corrosion of SF₆ circuit breaker models can cause gas leaks to develop.

We are improving the accuracy of the asset health model for circuit breakers to enable it to be used more effectively in the asset management process. This assumes an initial life expectancy of 35 years for SF₆ circuit breakers, 45 years for bulk oil circuit breakers, and 40 years for others. We adjust this for factors such as the time to reach the operation count limit in the case of frequently operated circuit breaker. Many of the older (1970–1995) SF₆ circuit breakers were designed and built with an expected life of 2,000 operations. Our recent circuit breaker purchases specify 10,000 operations.

Figure 20 summarises the asset health of our outdoor circuit breakers.

Figure 20: High-voltage outdoor circuit breakers—asset health
Criticality

Figure 21 shows the service performance criticality breakdown of our outdoor circuit breakers. Many of our circuit breakers operate in functional roles which have proved challenging to model, in terms of their failure consequences. We are developing our criticality models to close this knowledge gap.

12.2. ASSET PERFORMANCE

The major cause of circuit breaker forced outages is SF₆ leaks. Sulphur hexafluoride gas is a potent greenhouse gas. Leaks from circuit breakers and emissions from handling SF₆ gas associated with outdoor circuit breakers make up around one third of our total carbon footprint. We are committed to minimising SF₆ emissions and keeping annual emissions to less than 0.8% of our total SF₆ inventory. Figure 22 shows that annual SF₆ emissions are at an all-time low.
12.3. PLANNING AND DELIVERY

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Procurement.

Our approach to each of these lifecycle activities is described below.

Enhancement and development

We plan E&D projects of outdoor circuit breakers primarily in conjunction with other projects such as:

- Development of new customer grid exit points (GXP)s
- Greenfield transmission line projects
- The uprating of existing lines, which may also require additional substations and other supporting equipment.
Replacement and refurbishment

We have an ongoing programme to replace aged, deteriorated and unreliable circuit breakers. Our main activities for outdoor circuit breakers for RCP2 and RCP3 are:

- Replacing and repairing leak-prone SF6 circuit breakers
- Continuing to replace legacy interrupter types
- Replacing older SF6 circuit breakers that would exceed their forecast life expectancy
- Replacing circuit breakers that have reached maximum operation limits
- Replacing legacy types of circuit breaker that use bulk oil and minimum oil interrupters with our preferred circuit breaker type (SF6) by 2025.
- When circuit breaker replacements are required, using where practicable live tank disconnecting circuit breakers, to reduce the number of disconnector and earth switches
- Using Compact Switchgear Assemblies (CSA) at space constrained sites.

Procurement

Our procurement plans involve:

- Ensuring interchangeability of entire circuit breakers and components
- Purchasing live tank SF6 circuit breakers where practical, as it is proven technology that has been used successfully on the grid
- Seeking to obtain extended warranty periods for outdoor circuit breakers.

12.4. Operations and Maintenance

Operations and Maintenance activities consist of:

- Outage planning
- Contingency planning
- Preventive maintenance
- Corrective maintenance
- Predictive maintenance.

Our approach to each of these lifecycle activities is described below.

Outage planning

We plan outages to provide a safe environment for employees and service providers to undertake the work, while minimising the disruption for customers.

Contingency planning

Our contingency planning for outdoor circuit breakers involves:

- Maintaining spares
- Ensuring an adequate level of emergency preparedness to enable rapid restoration of transmission service following circuit breaker failure.
Preventive maintenance
We perform preventative maintenance such as:

- Taking monthly pressure gauge readings for leak-prone SF6 circuit breakers
- Performing diagnostic inspections and servicing on a frequency appropriate to the technology type, typically 4, 8 or 12 yearly
- Undertaking operation-based maintenance on frequently operated circuit breakers such as time travel tests, SF6 gas sampling, and internal inspection of interrupter units.

Corrective maintenance
We perform corrective maintenance activities such as:

- Responding promptly to asset alarms, such as low SF6 level alarms
- Repairing or replacing leaking SF6 circuit breakers wherever it is practical and economic.

Predictive maintenance
We will perform predictive maintenance activities such as repairing defects identified in condition assessments. These type of repairs include operating mechanism repairs and adjustments, contact repairs, oil filtration and corrosion control.

12.5. DISPOSAL AND DIVESTMENT

Disposal
We will maintain and follow an appropriate decommissioning process that includes safe work site management and responsible scrap disposal. The disposal stage of the lifecycle involves replacing and decommissioning outdoor circuit breakers and the associated air compressors, where applicable.

Divestment
We will continue to transfer a number of substations and transmission lines to distribution businesses. In addition to some direct savings in circuit breaker maintenance costs, the asset transfer programme will remove some makes and models of equipment from the asset class and allow some rationalisation of spares and maintenance procedures.

12.6. OUTDOOR CIRCUIT BREAKER WORKS

Table 26 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Outdoor circuit breakers</td>
<td>109</td>
</tr>
</tbody>
</table>
This chapter describes the lifecycle management of our indoor switchgear. Switchgear refers to the combination of circuit breakers, disconnectors and earth switches used to control, protect and isolate electrical equipment on electric power systems. There are two types of indoor switchgear; medium voltage and high voltage. Each is addressed below.

Medium voltage (MV) indoor switchgear

The two main switchboard busbar systems are:

- Air insulated busbar: Used for most metal-clad switchgear purchased since the early 1980s and still being purchased for 11 kV switchboards
- SF6 insulated busbar: Used since 2000 and current technology for 33 kV switchboards.

Table 27 shows our MV indoor circuit breakers (by interrupter type and voltage) as at June 2015.

<table>
<thead>
<tr>
<th>Type</th>
<th>11 kV</th>
<th>22 kV</th>
<th>33 kV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vacuum</td>
<td>249</td>
<td>14</td>
<td>357</td>
<td>620</td>
</tr>
<tr>
<td>SF6</td>
<td>4</td>
<td>26</td>
<td>111</td>
<td>141</td>
</tr>
<tr>
<td>Bulk oil</td>
<td>72</td>
<td>0</td>
<td>12</td>
<td>84</td>
</tr>
<tr>
<td>Air blast</td>
<td>12</td>
<td>0</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Minimum oil</td>
<td>9</td>
<td>0</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>346</strong></td>
<td><strong>40</strong></td>
<td><strong>480</strong></td>
<td><strong>866</strong></td>
</tr>
</tbody>
</table>

High voltage (HV) indoor switchgear

The main busbar systems for indoor HV circuit breakers are SF6 insulated.

Table 28 lists HV gas-insulated switchgear (GIS) installations, showing year of manufacture and volume of associated switchgear.

<table>
<thead>
<tr>
<th>Site</th>
<th>Voltage (kV)</th>
<th>Year of manufacture</th>
<th>Manufacturer</th>
<th>Age 8</th>
<th>Circuit breakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rangipo 9</td>
<td>220</td>
<td>1979</td>
<td>Merlin Gerin</td>
<td>37</td>
<td>2</td>
</tr>
<tr>
<td>Bream Bay</td>
<td>220</td>
<td>1981</td>
<td>Mitsubishi</td>
<td>35</td>
<td>8</td>
</tr>
<tr>
<td>Wilton</td>
<td>220</td>
<td>1981</td>
<td>Mitsubishi</td>
<td>35</td>
<td>7</td>
</tr>
</tbody>
</table>

8 Age as at 2016.
9 The Rangipo GIS installation is shared with Genesis.
13.1. Asset Characteristics

The asset health model for MV indoor circuit breakers uses the asset condition, age, number of operations, make and model-specific information, performance history and typical degradation of the category of asset.

Figure 24 shows the asset health of indoor circuit breakers.

All HV indoor circuit breakers have asset health in excess of 12 years.

Criticality

Figure 25 sets out the proportion of MV and HV indoor circuit breakers in each service performance criticality category. Many of our circuit breakers operate in functional roles which have proved challenging to model, in terms of their failure consequences. We are developing our criticality models to close this knowledge gap.

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10 The Clyde GIS installation is shared with Contact Energy.
13.2. **Asset Performance**

A high level of reliability is required for indoor switchgear given the critical safety functions of circuit breakers and the potential for major failure to result in widespread damage to other equipment and significant interruptions to supply.

We have had 10 major failures of MV indoor switchgear over the past 25 years. In most of these failures, there was extensive damage caused by arc-flash incidents. In several cases, the lack of segregation in these installations compromised the reliability of supply from the complete switchboard. We have already retrofitted Arc-flash protection at eight sites to minimise the risk of harm and limit damage to equipment.

Our HV indoor switchgear has a proven record of reliability and performance, and failures are extremely rare.

13.3. **Planning and Delivery**

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement.

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

We will use indoor MV switchgear over outdoor MV switchyards for new projects, to deliver superior safety performance, reduce maintenance requirements, reduce substation footprint and protect from vandalism, pests and corrosion.

**Replacement and refurbishment**

The switchgear R&R work planned for RCP2 involves:

- Replacing old and poor condition MV switchgear with modern indoor switchgear
- Replacing a large installation at Kinleith, where there are forty-two 11 kV bulk oil circuit breakers and five 33 kV circuit breakers in one switchgear room
• Installing arc-flash protections on existing indoor switchgear where technically feasible
• Retrofitting safety improvements to improve arc fault containment
• Penrose 22 kV switchboard building requires replacement due to asbestos contamination of the switchroom.

Design
We use a set of design standards for all new indoor switchgear. Specifically for all new switchgear projects, we deploy switchgear designs that include:
• arc fault detection
• arc fault containment and venting
• physical segregation between bus sections serving significant loads.

Procurement
Our procurement plans involve:
• Developing relationships with a limited group of manufacturers
• Limiting suppliers to an approved list of vendors, to reduce the diversity within the switchboards, resulting in lower costs and risks and increased reliability
• Seeking to obtain extended warranty periods for indoor switchgear supply contracts
• Staying in regular contact with the original equipment manufacturer (OEM) so that we receive adequate notice of declining availability of spare parts. This will provide us with an opportunity to purchase additional spares before these are no longer available.

13.4. Operations and Maintenance
Operations and Maintenance activities consist of:
• Outage planning
• Contingency planning
• Preventive maintenance
• Corrective maintenance
• Predictive maintenance
• Maintenance projects.

Our approach to each of these lifecycle activities is described below.

Outage planning
We plan outages to provide a safe environment for employees and service providers to undertake the work, while minimising the disruption for customers.

Contingency planning
Our contingency planning for indoor switchgear involves:
• Reviewing and maintaining spares holdings
• Ensuring an adequate level of emergency preparedness
• Retaining provision of a mobile 33/22/11 kV switchroom that can be deployed at short notice in the event of a major failure of a MV switchboard.

Preventive maintenance
We will perform preventative maintenance activities such as:
• Carrying out regular condition assessments on all MV and HV switchgear installations
• Scheduling the necessary maintenance and repairs
• Performing diagnostic inspections and servicing typically every eight years.

Corrective maintenance
We will perform corrective maintenance activities such as returning switchgear faults back to service within a fault response timeframe depending on the criticality of the asset.

Predictive maintenance
We will perform predictive maintenance activities such as repairing defects identified in the condition assessments.

Maintenance projects
We plan the following maintenance projects:
• A mid-life refurbishment of the Clyde 220 kV GIS, due to deteriorated condition and risk of failure
• Replacing or refurbishing the hydraulic drives, pressure relief devices, moisture filters and other components of the Clyde 220 kV GIS indoor switchgear that are in poor condition
• Continuing to manage leaks and replace seals on GIS at Rangipo Power Station. We have completed 85% of the seals and following the next set of repairs we will review the remainder; this is a cost-effective alternative to a full overhaul which would involve lengthy outages.

13.5. DISPOSAL AND DIVESTMENT

Disposal
We will maintain and follow an appropriate decommissioning process that includes safe work site management and responsible scrap disposal as part of projects.

Divestment
We are continuing with the transfer of a number of assets to EDBs. We will transfer indoor MV switchgear to customers as part of substation and transmission line divestments.

13.6. INDOOR SWITCHGEAR WORKS

Table 29 provides a summary of the R&R plans for RCP2.
Table 29: Indoor switchgear R&R plans

<table>
<thead>
<tr>
<th>Units replaced or refurbished¹¹</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Indoor switchgear</td>
<td>40.8</td>
</tr>
</tbody>
</table>

¹¹ Total units are not provided for this asset class, as R&R has highly variable unit costs.
14. AC STATION POWER TRANSFORMERS

This chapter describes the lifecycle management of our power transformers. Power transformers enable energy transfer between voltage levels. We have the following types:

- Supply transformers: connect generators, distribution networks and major users to our transmission network.
- Interconnecting transformers: interconnect between our backbone transmission network (220 kV) and our regional transmission and sub-transmission networks (110 kV or 66 kV).
- Other transformers: includes traction transformers (supplying KiwiRail), local service transformers (supplying our own substations) and earthing transformers.

We have a mix of single phase transformers (where we use a bank of three single phase transformers) and three phase transformers. Most transformers installed since the early 1970s are three phase.

Table 30: Main power transformer population

<table>
<thead>
<tr>
<th>Type</th>
<th>220 kV</th>
<th>110 kV</th>
<th>66 kV &amp; below</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supply (three-phase)</td>
<td>68</td>
<td>93</td>
<td>26</td>
<td>187</td>
</tr>
<tr>
<td>Supply (single-phase)</td>
<td>14</td>
<td>62</td>
<td>2</td>
<td>78</td>
</tr>
<tr>
<td>Interconnecting (three-phase)</td>
<td>34</td>
<td>1</td>
<td>35</td>
<td></td>
</tr>
<tr>
<td>Interconnecting (single-phase)</td>
<td>21</td>
<td>1</td>
<td>22</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>137</td>
<td>157</td>
<td>28</td>
<td>322</td>
</tr>
</tbody>
</table>

Table 31: ‘Other’ transformer population

<table>
<thead>
<tr>
<th>Type</th>
<th>220 kV</th>
<th>110 kV</th>
<th>66 kV &amp; below</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local service</td>
<td>6</td>
<td>1</td>
<td>172</td>
<td>179</td>
</tr>
<tr>
<td>Earthing</td>
<td>2</td>
<td>0</td>
<td>107</td>
<td>109</td>
</tr>
<tr>
<td>Regulators</td>
<td>0</td>
<td>0</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>8</td>
<td>1</td>
<td>281</td>
<td>290</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

14.1. ASSET CHARACTERISTICS

Asset health for supply and interconnecting transformers is summarised below.

Figure 26: Power transformers—asset health
Our transformer asset health model uses a standardised assessment of:

- Base life—post-1992 transformers benefitted from higher quality design and manufacture
- Major overhaul—most pre-1992 transformers have been overhauled to address common maintenance concerns
- Winding design or manufacturer defects
- Components (such as tap changers and bushings)
- External condition
- Internal condition (such as moisture content, dissolved gases and furans).

We are currently developing an improved model that brings in a wider range of factors, and will consider the individual remaining life the major components of each transformer including active part, bushings, tank, oil and tap changer.

**Criticality**

The criticality of our power transformers is shown in Figure 27 below.

---

**Figure 27: Power transformers—service performance criticality**

- 5-LOW (41%)
- 4-MED LOW (28%)
- 3-MED (20%)
- 2-MED HIGH (5%)
- 1-HIGH (0%)
- TO BE ALLOCATED (5%)
14.2. **Asset Performance**

Transformers are designed to operate continuously up to their rated capacity, or at a higher rating for short periods of time. Key performance characteristics are described below.

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated capacity</td>
<td>Can limit ability of power system to meet demand, or to provide access to least-cost mix of generation sources.</td>
</tr>
<tr>
<td>Availability (N-1 configuration)</td>
<td>Outage of one transformer transfers load to other transformers so that supply is not interrupted. Resilience is reduced, and can cause increased losses.</td>
</tr>
<tr>
<td>Availability (N configuration)</td>
<td>Outage immediately interrupts supply. Interruption can be prolonged.</td>
</tr>
<tr>
<td>Overload capacity</td>
<td>Ability to operate a transformer in the short term above continuous steady state rating to avoid load management following the outage of a parallel transformer</td>
</tr>
<tr>
<td>Integrity</td>
<td>Transformers are oil-filled and can leak (environmental harm) or explode (safety and environmental harm).</td>
</tr>
<tr>
<td>Power quality (Voltage)</td>
<td>Many older single-phase transformers only have off-load tap selectors which can create voltage constraints and require short outages for temporary changes to off-load tap settings.</td>
</tr>
</tbody>
</table>

The number and cause of transformer faults between 2005 and 2015 is set out below.

Approximately 60 per cent of outages are attributed to minor equipment malfunction/failure which does not cause damage or prolonged outages. The majority of the ‘other’ outage causes in 2010/11 and 2011/12 were caused by Buchholz trips due to the Christchurch earthquakes.

---

12 This data includes outages affecting all ‘power’ and ‘other’ transformers. Note this data is not normalised.
14.3. Planning and Delivery

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement.

Our approach to each of these lifecycle activities is described below.

Enhancement and development
We plan E&D investments when there is a need to install new transformers to enable system growth.

Replacement and refurbishment
We are developing a sophisticated model to economically optimise major expenditure on the power transformers. AHI is a key input to this model, quantifying the probability of failure for any transformer depending on a set of monitored asset health variables. Asset criticality is another major input to the model and accounts for value ($/MWh) and size (MW) of lost load and also monetarised costs of failure in terms of safety, environment and reputation.

A number of changes from the RCP2 submission have been made so far to the plan bringing the overall replacement total from 26 down to an expected number of 18 transformer units. The details are as follows:

- New asset condition information: Central Park (2 units) deferred to RCP3 and contingency plan created, Waitaki (2 units) bushings replaced in 2015/16 so replacement deferred until RCP3/RCP4
- External considerations: STU (2 units) replacement not required due to potential new GXP, NSY (2 units) will use ex Ashburton three phase units when these are redundant (determined by the customer but expected to be in RCP3), ASY (2 units) replacements performed in RCP1 as 1x CIC and 1x R&R due to synergies
- Currently uneconomic: Penrose (1 unit) to be reconsidered with Otahuhu (1 unit) interconnector transformer as at least one replacement or temporary connection to a strategic spare transformer is likely to be required at least
- HWB (2 to 1)(1 unit) and BPE (3 to 2)(1 unit), BRY (2 to 1)(1 unit)

Further changes to the plan are possible as more information becomes available later in RCP2 and our modelling improves.

Design
Each transformer is bespoke, but where practical we use standardised specifications to limit diversity and reduce the likelihood of design errors. Other key design considerations are seismic resilience of foundations, corrosion resistance, fire protection and substation configuration.
Procurement

The root cause of almost all transformer major failures in service is defects in design and manufacturing. Transformer failures have a high cost, put the network at significant risk, and have long recovery times.

To mitigate risks of latent design or manufacturing errors, we:

- Sustain significant in-house technical and commercial expertise
- Maintain a panel of pre-qualified suppliers
- Witness key points in the manufacturing and assembly process
- Oversee factory testing
- Use standardised specifications for transformer bushings and tap changers.

In total we have eight compulsory factory inspections at various stages of manufacture. These are attended by Transpower staff and/or independent transformer experts. This is resource-intensive but necessary to limit the risk of system issues during commissioning and initial operation.

It is also a requirement of our transformer panel contracts that we visit the factories for commercial/relationship meetings. This helps us to determine significant changes within the factory management structure, which can be a major cause in the decline of a factory’s performance.

We use pre-commissioning testing to reduce the duration of commissioning outages.

14.4. OPERATIONS AND MAINTENANCE

Operations and Maintenance activities consist of:

- Outage planning
- Contingency planning
- Preventive maintenance
- Corrective maintenance
- Predictive maintenance
- Maintenance projects.

Our approach to each of these lifecycle activities is described below.

Outage planning

For transformers in an N-1 configuration, we can take individual transformers out of service without interrupting supply. This provides flexibility but we do have to take into account the impact of outages on grid capacity and resilience. For transformers in an N configuration we are sometimes able to use a mobile substation to achieve outages without interrupting customer supply.

Contingency planning

We use contingency planning to mitigate the consequences of transformer failure. This includes holding spare transformers. We aim to be able to restore full security of supply within one calendar month of a major transformer failure.
On-site spares are provided at most sites where single-phase transformers are installed. Sixteen strategic spares now provide coverage for 98% of our entire present and expected future three-phase fleet. A number of spare standard bushings have been purchased and are in store at Otahuhu, Bunnythorpe and Addington.

Further work will continue to be performed at individual substations to assess their ability to have a strategic spare transformer fitted in the event of a failure in less than a month.

Preventive maintenance

Table 33: Condition-monitoring tests and inspections

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly</td>
<td>An in-service visual and audible noise level 1 inspection during routine station inspection</td>
</tr>
<tr>
<td>Yearly</td>
<td>An in-service level 2 inspection, which is more comprehensive than the level 1 inspection and includes operational checks</td>
</tr>
<tr>
<td></td>
<td>A thermo-graphic survey during a survey of the station.</td>
</tr>
<tr>
<td></td>
<td>Oil screen tests</td>
</tr>
<tr>
<td></td>
<td>Dissolved gas analysis of oil samples</td>
</tr>
<tr>
<td>Four-yearly:</td>
<td>An out-of-service diagnostic inspection of the transformer and all of its components.</td>
</tr>
<tr>
<td></td>
<td>Out-of-service diagnostic tests, including bushing, core and frame insulation resistance and bushing power factor tests</td>
</tr>
<tr>
<td></td>
<td>Tests of levels of furans in oil sample on transformers over 20 years of age.</td>
</tr>
<tr>
<td></td>
<td>Tests of inhibitor levels in oil samples on transformer purchased after 1975.</td>
</tr>
<tr>
<td></td>
<td>A high-level condition assessment on which to base major work such as refurbishment, repair or replacement</td>
</tr>
<tr>
<td>Two-, four-, six-, or eight-yearly:</td>
<td>Major service of on-load tap changer (interval depends on make, type and operating duty)</td>
</tr>
</tbody>
</table>

Corrective maintenance

The most common repairs include oil leak repairs, overhaul and reconditioning of tap changer drive mechanisms, radiator repairs, bushing replacements, and treatment of corrosion on metalwork.

Predictive maintenance

Key activities include corrosion control, component replacement (e.g., porcelain bushings and control instrumentation) and oil treatment.

We have multiple types of online dissolved gas analysis monitors installed but are yet to economically analyse the merits of on line monitoring to be sure it we should invest further.

Maintenance Projects

We manage our bushing replacements as maintenance projects due to their complexity and size.
14.5. **Disposal and Divestment**

**Disposal**
We retain transformers as spares if we have concerns about condition of an existing unit and sell oil (for regeneration) and metals from scrapped transformers.

**Divestment:**
Our divestment programme is reducing the population of lower voltage transformers.

14.6. **Transformer Works**

Table 34 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Power transformers</td>
<td>19</td>
</tr>
</tbody>
</table>
15. **AC STATION BUILDINGS AND GROUNDS**

This chapter describes the lifecycle management of our AC station buildings and grounds. The buildings and grounds included in this asset class provide the accommodation, services and physical security for critical grid equipment and systems. We categorise these assets by their main function. The categories we use are:

- Buildings
- Building services
- Site infrastructure
- Fencing.

The following tables describe each category by type.

<table>
<thead>
<tr>
<th>Buildings¹³</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station buildings</td>
<td>693</td>
</tr>
<tr>
<td>Remote communications</td>
<td>40</td>
</tr>
<tr>
<td>National grid operating centres</td>
<td>2</td>
</tr>
<tr>
<td>Unmanned emergency operating centres</td>
<td>2</td>
</tr>
<tr>
<td>Warehouses</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>740</strong></td>
</tr>
</tbody>
</table>

Our oldest substation buildings which are still in service were constructed in the 1930s. Most of our substation buildings were built in the 1950s to 1970s, with only a few new substations constructed since the 1980s. Many of our remote communications buildings were built during the 1950s to 1970s with some pre-1950.

We have built approximately 20 remote communications buildings since 1987 and as part of our ongoing programme to replace outdoor 33 kV outdoor switchyards with indoor switchgear some new buildings have been required at existing sites. However, overall we have reduced building numbers through the demolition of redundant buildings and the divestment of sites.

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¹³ These figures exclude: our offices, which are included in the Business Support assets described in chapter 24 and the system operator National Coordination Centre in Hamilton, which is maintained by our facilities managers but is not part of our regulated transmission business.
Part 3: Asset Class Plans – AC Station Buildings and Grounds

Table 36: Building services population

<table>
<thead>
<tr>
<th>Building Services</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating and air conditioning systems</td>
<td>675</td>
</tr>
<tr>
<td>Fire alarm systems (not part of integrated security alarm systems)</td>
<td>150</td>
</tr>
<tr>
<td>Sprinkler systems</td>
<td>12</td>
</tr>
<tr>
<td>Electronic access control and security systems</td>
<td>190</td>
</tr>
<tr>
<td>Standby generators</td>
<td>4</td>
</tr>
<tr>
<td>Uninterrupted power systems</td>
<td>3 sites</td>
</tr>
</tbody>
</table>

Table 37: Site infrastructure population

<table>
<thead>
<tr>
<th>Site infrastructure</th>
<th>Sites</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roads</td>
<td>170</td>
</tr>
<tr>
<td>Water supplies</td>
<td>170</td>
</tr>
<tr>
<td>Stormwater and foul drainage systems</td>
<td>170</td>
</tr>
<tr>
<td>Switchyard metalling</td>
<td>190</td>
</tr>
<tr>
<td>Planting and trees</td>
<td>92</td>
</tr>
</tbody>
</table>

Table 38: Fencing population

<table>
<thead>
<tr>
<th>Fencing</th>
<th>Metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchyard and equipment fencing</td>
<td>87,340</td>
</tr>
<tr>
<td>Boundary and non-security fencing</td>
<td>95,246</td>
</tr>
<tr>
<td>Total</td>
<td>182,586</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

15.1. Asset characteristics

We have identified a number of building infrastructure items that need to be upgraded due to age, capacity, condition, integrity, level of resilience and fire protection currently provided.

Building and site infrastructure, such as switchyard fencing, air conditioning, roofing and cladding, subsurface infrastructure water supplies and drainage, roading and switchyard aggregate surfacing are deteriorating. This infrastructure will require replacement when maintenance is no longer economic. For example, investigative work at Haywards substation concluded that the water mains and sewerage systems have reached the end of their serviceable life, requiring replacement. We expect several substations of a similar age are likely to experience similar issues. We are recording significant potable water losses on sites such as Bunnythorpe substation and warehouse facilities.

Access roads on our sites often reach only five to 10 years before significant maintenance or replacement is required. One challenge we face is the impact of heavy, slow-moving, multi-wheel vehicles (such as transformer transporters) making sharp turns on narrow access roads. These can displace existing asphalting surfaces, leading to accelerated deterioration.
15.2. **Asset Performance**

The buildings and grounds asset class contributes to system reliability through the physical protection of transmission system equipment and the provision of essential support infrastructure.

The buildings asset class has performed extremely well. This can be attributed to sound construction methods, proactive inspections and planned preventive maintenance. The probability of severe building failure is low. However, there are a number of age-related issues that have the potential to affect service performance. Of specific note is the seismic and weather tightness performance of the buildings.

As of 2011, only 45 per cent of our critically important buildings complied with our Seismic Policy, with about 150 buildings requiring some remedial work. The National Seismic Upgrade programme has strengthened the majority of our level one buildings. Seismic building standards have developed considerably over the years. A number of our buildings were strengthened as part of our 1990 seismic strengthening programme. These buildings were excluded from our 2011 assessment and construction works under our National Seismic Upgrade programme that was completed in June 2016. These buildings may now require further upgrade work to comply with seismic loading. This is an ongoing process, taking into account planning for the extra costs involved.

In recent years, we have had a number of leaks or damage to substation buildings due to extreme weather conditions and high-risk design elements. There have been no reported transmission outages as the result of a weather tightness event. However, given the prevalence of these weather-tightness issues, there is a reasonably high likelihood of future consequences.

Switchyard infrastructure provides an essential physical protection for the transmission system. Generally, this infrastructure performs well. However, when pests gain access to buildings or switchyards they can cause damage to our communications and control cabling. In some cases this has caused high-voltage flashovers, resulting in some major interruptions to transmission service.

Urbanisation of populated growth areas such as Auckland is impacting the use of land around our substations. As rural areas change to residential zones and housing is built next to substations, risks associated with site security, and public health and safety increases. These changes have driven the need for further investment in our substation security and public safety management.

One of our key strategies and initiatives designed to improve our asset performance during RCP2 is to ensure fencing at our substations ensures that staff, contractor, and public safety is maintained. Our fencing strategy takes into account all of our legislative requirements. Security fences are maintained and refurbished until it becomes uneconomic to do so, in which case they will be replaced. The enhancement of security measures is a priority during RCP2 and we are conducting a trial of CCTV cameras to determine their effectiveness in reducing unauthorised access.

A health and safety and environmental risk from asbestos in older substation buildings and subsurface infrastructure has been identified. We manage our asbestos risk in accordance with the Health and Safety at Work (Asbestos) Regulations 2016 and have clear protocols in place to ensure a safe working environment. We also have:

- Undertaken inspections on buildings and grounds at substations, remote radio repeater sites, regional offices, operating centres and warehouses including any leased depots associated with these sites.
- We are currently undertaking an in-depth review of our substation assets that are known or likely to contain asbestos.
- Put in place a national asbestos register and management plan to evaluate and manage asbestos risk.
• Developed asbestos work procedures that set out protocols for addressing the common questions and scenarios relating to asbestos management

• Completed an additional investigation to understand what the extent of the hazard is at Wilton, Henderson, Otahuhu, Penrose (Control Building and Workshop) and Central Park.

The visual investigation carried out in 2014/15 identified a third of our sites contains asbestos in building elements. While the majority of asbestos is contained or encapsulated, if a site is identified as a potential high risk to personnel or operations, these risks are mitigated immediately. This has involved considerable expenditure. The long term costs associated with future mitigation and removal of this hazard will be determined through the development of site strategies for RCP3 and beyond.

We have three Warehouses nationally in Addington, Bunnythorpe and Otahuhu that house our strategic spares for transmission assets. These buildings have been identified for immediate upgrade due to age, condition and provision of a healthy and safe work environment for personnel. A programme of improvement projects has been phased into the 2016/17 year that will bring these facilitates up to an acceptable standard.

15.3. **PLANNING AND DELIVERY**

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Delivery
- Design
- Procurement
- Environmental consent process and procedures
- Construction and commissioning

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

We plan new buildings and grounds as part of larger grid development projects, or for specific customer-funded developments.

**Replacement and refurbishment**

The majority of our forecast RCP2 expenditure is for seismic strengthening of the condenser hall building at Haywards. Penrose has been excluded from the seismic project due to asbestos contamination. Removal of this building will be scheduled once outcomes from the Penrose Control Room Replacement Investigation are delivered.

Other buildings expenditure includes:

- Replacing critical substation roofs that have a high risk of weather tightness failure
- Removing asbestos
- Controlling step and touch potentials to safe levels using switchyard metalling.
Our programmes for building services include:

- Routine replacement of fire systems and security systems
- Lifecycle replacement of air conditioning and humidity control systems in control and relay rooms
- Upgrade of critical building services infrastructure supporting the National Grid Operating Centres at Otahuhu and Islington.

Our switchyard infrastructure programmes involve end-of-life replacement, including:

- Fence replacements when they are no longer fit for purpose
- Aggregate surfacing ensuring staff, contractor and public safety is maintained with appropriate step and touch potential
- Cable trench covers.

We will also replace roads, parking areas and other hard surfaces at end-of-life or provide newly constructed surfaces to provide reliable access to facilities and site services. We have planned a national subsurface infrastructure mapping programme during RCP2 to map underground services requiring end-of-life replacement.

Other general infrastructure and safety related plans include:

- Installing hypoxic air fire suppression systems in high-criticality indoor facilities
- Trial deployment of intelligent video surveillance systems
- Replacement of tin sheds from switchyards with concrete delineator sheds
- Road safety improvements for entry and exit from Haywards.

Delivery

We manage the delivery of major projects through our normal project management mechanisms. For routine maintenance and minor enhancements of our buildings and grounds facilities we engage Opus and Downer to direct and manage condition and performance work.

Design

We use standard design, specifications, and service levels for the design of buildings and grounds assets. Our environmental team is involved in the design of new and refurbished buildings and grounds to ensure we take into account the requirements of the RMA and Building Act 2004.

Procurement

The Facilities Managers manage the purchase of materials for buildings and grounds facilities.

Environmental consent process and procedures

The Facilities Managers engage planners to work with local councils to obtain consents and waivers for buildings and grounds facilities. Facilities managers use our evaluation and project assessment processes when investigating or determining which consents are required under the RMA, Regional and District Plans.
Construction and commissioning

The Facilities Managers tender and oversee construction and commissioning. Commissioning includes the final calibration and configuration of systems such as air conditioning and security systems.

15.4. OPERATIONS AND MAINTENANCE

Operations and Maintenance activities consist of:

- Real-time asset management
- Contingency planning
- Facilities manager post-earthquake response plan
- Preventive maintenance
- Corrective maintenance
- Predictive maintenance
- Maintenance projects.

Our approach to each of these lifecycle activities is described below.

Real-time asset management

We monitor electronic access control and security systems, fire alarm systems, temperature and humidity monitoring systems and emergency power supplies in real-time.

Contingency planning

We have a mobile substation (15 MVA, 110/33–11 kV) and a mobile switchroom (33/22/11 kV) that can be used as part of our response to major failures or incidents.

Post-earthquake response plan

Post-earthquake checks are carried out on our buildings and grounds in accordance with the Post-Earthquake Response Plan. A structural engineer checks the building structure and assesses any environmental hazards. Electrical equipment and systems are checked by qualified personnel. The purpose of the Post-Earthquake Response Plan is to ensure:

- A clear outline of evaluation procedures for accessing our sites and entering damaged buildings
- Plan activation by either Opus or a Transpower station team leader
- Key buildings are inspected and evaluated following a major earthquake
- We confirm whether it is safe to enter the building.

Preventive maintenance

We undertake monthly inspections, quarterly quality inspections and three yearly condition assessments of every substation site, following the International Infrastructure Management Manual condition assessment process. We gather building and service data at an increased granularity, looking at buildings in terms of elements and components.
Corrective maintenance

Our facilities manager service provider contracts specify response times for each site following a fault condition. We repair buildings and ground assets with damage from adverse events as required. We use historical spending trends to inform forecasts.

Predictive maintenance

Appropriately timed servicing and minor repairs will also take place governed by our standards and service specifications.

Maintenance projects

We have planned for expenditure on remedial roofing projects, switchyard aggregate surfacing, exterior repainting and interior refurbishment.

15.5. DISPOSAL AND DIVESTMENT

Where the use of a building or site changes over time we will review the building or site use. We will dispose of assets that have a significant maintenance cost and no strategic value.

We will continue to divest buildings and grounds as part of substation and transmission line asset transfer to customers at the fringes of the grid.

15.6. BUILDINGS AND GROUNDS WORKS

Table 39 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Table 39: Buildings and grounds R&amp;R plans</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Buildings and grounds</td>
<td>32.5</td>
</tr>
<tr>
<td>ACS Buildings and seismic</td>
<td>2.6</td>
</tr>
</tbody>
</table>
16. AC STATION REACTIVE POWER

This chapter describes the lifecycle management of our AC station reactive power assets. Reactive power is needed in an alternating-current (AC) transmission system to support the transfer of real power over the network, but it needs to be carefully controlled to optimise system capacity, reduce system losses and maintain voltage levels. We use static capacitor banks and reactors to provide the majority of the reactive power support required.

To ensure stability under transient or abnormal conditions, the system also needs fast-acting sources of dynamic reactive power. Dynamic reactive power can be provided by a combination of generators, synchronous condensers, static var Compensators (SVCs), and static synchronous compensators (STATCOMs). Modern power electronic technologies used in SVCs and STATCOMs combines the functions of capacitor banks and shunt reactors to provide fast-acting, variable reactive power.

We have optimised the operation of our reactive power plants and transformer tap changers by commissioning three reactive power controllers (RPCs). More information on these is provided in the secondary systems and HVDC chapters.

Capacitors and reactors

As shown in Table 40, we have standalone AC capacitor banks, and capacitor banks associated with STATCOMs and SVCs.

Table 40: AC capacitor banks and filter banks by voltage

<table>
<thead>
<tr>
<th>Type</th>
<th>220 kV</th>
<th>110 kV</th>
<th>≤66 kV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitor banks</td>
<td>13</td>
<td>13</td>
<td>56</td>
<td>82</td>
</tr>
<tr>
<td>SVC capacitors</td>
<td>5</td>
<td>0</td>
<td>10</td>
<td>15</td>
</tr>
<tr>
<td>STATCOM capacitors</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>18</td>
<td>13</td>
<td>70</td>
<td>101</td>
</tr>
</tbody>
</table>

Reactors are integral to capacitor banks and filter banks, as they limit in-rush currents. They are also used in filter banks in combination with other components to filter potentially damaging harmonic frequencies. For voltage control purposes, reactors are used as standalone units or as part of a capacitor bank, or SVCs. Table 41 shows the number of reactors by voltage. While most of this asset class is relatively young, a number of reactors are beyond their expected service life of 30 years.

14 For the purposes of this statistics section, capacitor installations include capacitor banks and individual capacitors associated with SVCs and STATCOMs.
### Dynamic reactive support assets

Table 42 provides an overview of our dynamic reactive support assets.

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synchronous condensers</td>
<td>Large rotating machines that provide reactive power and improve system inertia which is essential for the operation of the HVDC link</td>
<td>1 at Haywards</td>
</tr>
<tr>
<td>SVCs</td>
<td>Provides fast-acting reactive power</td>
<td>SVC3 (Islington), SVC7 (Albany), SVC9 (Islington)</td>
</tr>
<tr>
<td>STATCOMs</td>
<td>More advanced, smaller forms of SVC using insulated gate bipolar transistors (IGBT) technology. In general have higher losses, but lower harmonics than SVCs</td>
<td>2 at Kikiwa, 2 at Penrose, 2 at Marsden, 1 at Haywards</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

### 16.1. Asset characteristics

There are a number of capacitor banks and reactors at the end of their economic life. Depending on the system need, we will retain them in service and monitor their performance regularly or decommission them. Most capacitor banks are less than 30 years old which is the typical the life expectancy of a capacitor bank.

The Haywards synchronous condensers have undergone major overhauls during RCP1. We expect these condensers to operate reliably until 2035. However, the evaporative cooling towers of the Haywards synchronous condensers are deteriorating which we will replace four in RCP2 and the remaining four in RCP3. A major failure of a cooling tower would make a synchronous condenser unavailable for approximately six months.

With the exception of the SVC3 at Islington, the other SVCs and STATCOMs are relatively new and in good condition. Islington SVC3’s control and protection system is no longer supported by the manufacturer. Its cooling system also requires replacement due to leaks. The Albany SVC7 and Islington SVC9 assets have experienced a few component failures in the past. However, we have replaced most of the failed components with more reliable replacements, and expect the
performance of these assets to improve. Islington SVC9 had a capacitor fire which has forced out the SVC. We are proactively working to reinstate the SVC.

**Criticality**

Reactive power assets do not fit in to standard network asset criticality frameworks. While they are primary equipment, their function serves regions rather than individual substations, circuits or branches. During RCP2 we are planning to develop a criticality model for our reactive power assets.

### 16.2. Asset performance

A failure of reactive power assets is unlikely to cause a power outage. However, some reactive power assets are necessary for the operation of the system, as they are required for managing the system voltage.

The synchronous condensers at Haywards are reliable, often operating continuously for many months without incident or servicing. This is very good performance for large rotating machines. In the past 25 years, we have had only one electrical failure in the switchgear of the SC2 synchronous condenser, causing an extended forced outage of the equipment.

The SVCs have generally achieved annual availabilities of 98 per cent or more. The SVC9 has experienced a number of component failures within the warranty period. We have also experienced a capacitor failure causing a fire in February 2016. This has damaged a significant portion of the SVC.

The Albany SVC7 asset has had a number of equipment failures due to poor design or manufacturing defects in the past, which we have addressed.

Installation issues at the Kikiwa STATCOM caused four forced outages from April to June 2010. Since then, plant availability has improved to over 98 per cent. We have also experienced a number of outages due to poor air conditioning performance. We are resolving this now. Among all the STATCOM installations, power module failures are the most common mode of failure. We also had a number of control system issues which required forced outages to restart the control system. The STATCOM manufacturer is investigating these issues. Kikiwa STATCOM has also experienced a number of spurious operations under transient conditions. We are consulting the manufacturer regarding these issues.

A small number of our capacitor banks have experienced relatively high rates of failure of individual capacitor cans, which have reduced annual availability.

### 16.3. Planning and delivery

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement.

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

Load growth and proposed large generator shutdowns in the upper North Island will require additional reactive power support so we plan to install new shunt capacitor banks or dynamic
reactive plants in the upper North Island area. We will also install new shunt capacitor banks in Southland to address insufficient reactive support during periods of low generation at Manapouri.

More embedded generation and new technologies such as rooftop solar panels and electric cars will affect the future need for reactive support; we will investigate these issues. Operation of the Tiwai aluminium smelter is also a major factor that will influence reactive power investments.

Replacement and refurbishment

The most important drivers for reactive power R&R are condition, cost of maintenance, the system need, and technological changes. Over RCP2 we plan to:

- Replace four deteriorating synchronous condenser cooling towers at Haywards
- Replace capacitors, reactors and instrument transformers in SVC installations that have experienced high levels of component failure
- Purchase spare capacitor bank components to cover minor capacitor bank failures
- Hold a suitable stock of spares for STATCOM power modules, SVC thyristors, and control cards to cover for possible equipment failures
- Install 11 kV disconnectors between the Haywards 220/110 kV interconnecting transformers and the SC1 and SC2 synchronous condensers to reduce maintenance outage requirements
- Undertake planning study for the future of Islington SVC.

Design

Our design plans include:

- Developing a standard capacitor bank design for the upper North Island region that will include a mechanically switched capacitor with damping network design. This is to address the concern that harmonic levels will be amplified in the upper North Island region as more static shunt capacitor banks are added to the network. This design will provide broad spectrum damping of harmonic frequencies
- Standardising the use of cascaded multi-level converter technology that provides reduced losses and maintenance requirements for future STATCOM installations
- Standardising the MVar rating and configuration for future SVCs
- Standardising the some capacitor bank components to improve the management of emergency spares and to gain cost efficiencies.

Procurement

We will stay in regular contact with the original equipment manufacturers so that we receive notice of declining availability of spare parts. This means we can purchase additional spare components for the remaining life of the main equipment, before these parts are no longer available.

16.4. OPERATIONS AND MAINTENANCE

Operations and Maintenance activities consist of:

- Contingency planning
- Preventive maintenance
- Corrective maintenance
- Predictive maintenance.

Our approach to each of these lifecycle activities is described below.

**Contingency planning**
We review and maintain spares holdings, and ensure an adequate level of emergency preparedness. The spares include entire capacitor banks and spare components for capacitor banks, power electronics installations, and synchronous condensers.

**Preventive maintenance**
- Synchronous condenser condition assessments include visual and thermal inspections as well as electrical, mechanical, and gas tests undertaken as minor weekly tasks between two-to four-year equipment services. We have installed a number of smart monitoring systems to continuously monitor the condition of the synchronous condensers. We will carry out internal inspections of the synchronous condensers time to time to ensure reliable operation of the condensers by identifying issues in-advance.
- Capacitors and reactors have four-yearly inspections to monitor signs of corrosion, paint peeling, leaks or physical deformation.
- 220 kV and 110 kV capacitor banks that are of a model known to have problems have capacitance measured regularly on an unscheduled basis to detect problems early.
- We undertake visual inspections and thermo-vision inspections of power electronic assets annually.
- We will undertake thorough assessment of Albany SVC7 and Islington SVC9 in 2018 to inform R&R planning.

**Corrective maintenance**
Reactor failures usually arise when system or environmental conditions occur that are outside the design specifications, such as overvoltage transients, lightning, over current, and pollution. We will undertake minor repairs on failed reactors as required.

We have enough component spares for proactive replacement of failed components at each SVC and STATCOM. Lessons learned from the Islington SVC9 fire will be used for future contingency planning and design of the SVCs.

**Predictive maintenance**
Typical condition-based repairs include condenser brush-gear renewals, capacitor bank re-balancing, capacitor can replacement, CO$_2$ gas replacement, rotor balancing, and cooling system repairs.
16.5. Disposal and Divestment

Disposal

• Due to the Kikiwa STATCOM, we no longer require the 50-year-old Stoke 11 kV capacitor bank. We will test and monitor the capacitor bank, and will decommission and dispose of the capacitor bank and circuit breakers when necessary during RCP2

• We have salvaged control and excitation system spares from the systems that we replaced on Haywards SC1, SC2, SC7, SC8, SC9, and SC10, and will re-use them to extend the life of SC3 and SC4 synchronous condensers

• We plan to decommission Islington SVC3 and replace it with a shunt reactor

• There are two synchronous condensers at Islington which are at the end of their economic life and we no longer need these for system support. They are currently out of service and we will decommission them when the opportunity arises.

16.6. Reactive Power Works

Table 43 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Table 43: Reactive power R&amp;R plans</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Dynamic reactive power</td>
<td>8.8</td>
</tr>
<tr>
<td>ACS Capacitors and reactors</td>
<td>1.8</td>
</tr>
</tbody>
</table>
17. AC STATION POWER CABLES

This chapter describes the lifecycle management of our AC Station power cables. There are two types of cables on our network, medium voltage and high voltage. Each category is described below.

Medium-voltage cables (11 kV–66 kV)

We use medium-voltage (MV) cables extensively for connections within substations. The majority of these operate at 11 kV and 33 kV.

Paper-insulated lead-sheathed cables (PILCs) were installed up until the mid-1970s. Since then we have used cross-linked polyethylene (XLPE) insulation with heat shrink or cold shrink terminations or plug-in cable connectors for the majority of new and replacement cables.

Table 44 gives the population of our MV cable circuits.

<table>
<thead>
<tr>
<th>Conductor type</th>
<th>Insulation type</th>
<th>11 kV</th>
<th>33 kV</th>
<th>50–66 kV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>PILC</td>
<td>0</td>
<td>4</td>
<td></td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>XLPE</td>
<td>110</td>
<td>448</td>
<td>15</td>
<td>573</td>
</tr>
<tr>
<td>Copper</td>
<td>PILC</td>
<td>24</td>
<td>46</td>
<td></td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>XLPE</td>
<td>349</td>
<td>414</td>
<td>13</td>
<td>776</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>483</td>
<td>912</td>
<td>28</td>
<td>1,423</td>
</tr>
</tbody>
</table>

High-voltage cables (110 kV and 220 kV)

Our High Voltage (HV) cables provide transmission services in urban areas where the use of overhead lines is undesirable. We also use HV cables for connections between power transformers and indoor switchgear within substations (<1km).

We have approximately 88 km (route length) of HV cable. A small number of oil-filled (OF) PILC were installed up until the mid-1980s. Since then we have used XPLE insulation for all new cables. We have approximately 1 km (route length) of 110 kV and 220 kV OF PILC dating from 1974 to 1985.

We also have approximately 87 km (route length) of 110 kV and 220 kV XLPE cables dating from 1990 to 2015. We installed a number of 220 kV cables as part of the North Auckland and Northland (NAaN), North Island Grid Upgrade (NIGUP) and Otahuhu Diversity projects to reinforce the network supplying Auckland and Northland. These are among the most critical cable circuits in our network.
Table 45 gives an overview of our HV cable circuits.

<table>
<thead>
<tr>
<th>Conductor type</th>
<th>Insulation type</th>
<th>110 kV</th>
<th>220 kV</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>OF PILC</td>
<td>3</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Copper</td>
<td>OF PILC</td>
<td>0</td>
<td>7</td>
<td>7</td>
</tr>
<tr>
<td>XLPE</td>
<td></td>
<td></td>
<td></td>
<td>125</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td>32</td>
<td>106</td>
<td>138</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

**17.1. Asset characteristics**

We installed most of our MV XLPE cables in the last 10 years and they are in good condition. There are some legacy MV PILC cables that have had issues relating to moisture ingress and poor workmanship, which have led to sheath/termination failures.

All of our HV XLPE cables are in good condition, most having been installed since 2010. We still have 11 (legacy) oil-filled HV cable circuits in service in Bream Bay, Wilton, New Plymouth, and Rangipo. Condition assessments on the Bream Bay cables showed cracks in the oversheaths and a minor leak in the oil tank, all of which was repaired. Our oil-filled cables at other sites are in good external condition. Cable oil testing was carried out during 2015 on the OF cables at Bream Bay, Rangipo and Wilton. The results indicate that the insulation of these cables is in good condition.

**Criticality**

Figure 29 shows criticality for power cables.

Our Bream Bay cables supply the New Zealand Oil Refinery at Marsden Point where a loss of supply lasting more than a few days could lead to a depletion of fuel supplies in the Auckland region. While recent testing indicated the cables are in good condition, we are currently assessing the common mode failure risk that the cables represent, and the options for mitigating the risk. As such the cables may be replaced or upgraded pending the outcomes of the investigation. This has been included in the RCP2 capex budget.
17.2. **Asset Performance**

Power cables are highly reliable. For cables installed outside controlled areas, the main risks arise from damage caused by third parties during excavations.

We have had an average of two to three MV cable failures a year. The main causes have been poor workmanship on cable joints and terminations, faulty cables and terminations. We are undertaking a project to replace heat-shrink terminations at critical locations. We are also taking steps to ensure cable termination installers are adequately trained and qualified.

17.3. **Planning and Delivery**

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement
- Construction.

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

Enhancement and development projects for power cables occur primarily during the development of new transmission circuits or installation of new power transformers at substations.

In addition, we are receiving frequent enquiries from property developers about undergrounding sections of overhead transmission line, mostly in Auckland and Christchurch regions. On average we undertake one of these projects every 2-3 years. Any works of this type will be fully funded by the applicant.

**Replacement and refurbishment**

Power cable replacement and refurbishment is primarily triggered by poor asset condition and prioritised by their relative criticality. We are planning work for RCP2 involving:

- Replacing or refurbishing the Bream Bay HV oil-filled cables, preceded by an assessment of the risk of failure of two or more cables simultaneously leading to a sustained loss of supply to the Marsden Point oil refinery
- Decommissioning the New Plymouth 220 kV and 110 kV oil-filled cables as part of the New Plymouth site rationalisation
- Undertaking a programme of refurbishment and repair of the remaining 220 kV oil-filled cables
- Procuring a cable oil treatment unit for these cables (needed for refurbishment and repairs)
- Gaining experience with the distributed temperature sensing (DTS) systems installed on the new NAaN and NIGU 220 kV cables, to improve our operational capability and undertake lifecycle replacement as they come to the end of their useful life (prior to RCP3).
Design
Our design process aims to ensure safety, optimise the use of materials, standardise cable designs as much as possible and ensure the cables are appropriately resilient to high loading and seismic events. We are aiming to develop a design standard/guideline for power cable systems.

Procurement
Our procurement plans involve:
- Reducing the per-unit cost of power cables
- Combining the procurement of similar cables across different projects, to reduce the overall cost
- Standardising cable conductor sizes to minimise the cost of bespoke cable spares.

Construction
Our construction includes:
- Installing cable joints or terminations to a high standard to avoid significant risks of equipment damage (to transformers or indoor switchgear) and interruptions to supply
- Installing cables in HDPE ducts outside substations to provide greater mechanical protection against third party damage and for seismic event resilience
- Improving the quality of workmanship for future installations by developing a training and competency programme.

17.4. OPERATIONS AND MAINTENANCE
Operations and Maintenance activities consist of:
- Contingency planning
- Preventive maintenance
- Corrective maintenance
- Predictive maintenance
- Maintenance projects.

Our approach to each of these lifecycle activities is described below.

Contingency planning
We manage cable failure by:
- Using a tiered response where local service providers rectify small cable failures, and overseas specialists are hired for major cable failures
- Developing and maintaining a plan for repairs or replacement following failures of major cable circuits within two weeks within our substation boundaries and one month if outside
- Considering bypass arrangements, which involve temporary bays with associated switchgear, national spare transformers, transmission lines and protection.
Preventive maintenance
Key activities include:
- Regular condition assessments
- Carrying out regular cable route patrols on all cable installations to identify external damage (predominately due to unauthorised third-party activity) and ground displacement. The required frequency is determined by criticality, risk exposure, age and cable type
- Regular condition tests that assess joints and terminations and oil sample tests on the oil-filled cables
- Monitoring cable operating temperatures using our four distributed temperature sensing (DTS) systems installed on our critical 220 kV circuits
- Outer sheath insulation resistance testing (to detect damage that allows water to penetrate the cable)
- Partial discharge measurements.

Corrective maintenance
Key activities include:
- Responding to power cable faults using a specialised set of equipment, skills and experience to locate, excavate and make repairs
- Identifying the cable failure condition (usually short circuit) as well as the fault location
- Making sure that any cable repairs are sufficiently planned and resourced.

Predictive maintenance
We will repair defects identified during condition assessments on cables and cable terminations.

Maintenance projects
We plan the following maintenance projects:
- Refurbishing the HV oil-filled cable circuits to mitigate failure risk and potential loss of supply
- Carrying out any repairs on the 220 kV oil-filled cables at Wilton, New Plymouth and Rangipo substations.
17.5. **DISPOSAL AND DIVESTMENT**

**Disposal**
We will maintain and follow decommissioning processes where reuse is not appropriate. Successful disposal projects require effective site restoration.

**Divestment**
The 118m section of 110 kV cable, together with the Kensington–Maungatapere overhead line, was divested to the connected customer on 1 April 2015.

Our divestment plans include:

- Optimising our network boundaries with our connected customers (such as lines and generator companies) by divesting certain MV cables\(^\text{15}\)
- Ensuring future power cable route designs take into account future divestments and address any asset boundary issues
- Divesting a small number of 11 kV and 33 kV power cables associated with power transformers, indoor switchgear or outdoor 33 kV switchyard equipment.

17.6. **POWER CABLES WORKS**

Table 46 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>ACS Power cables</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACS Power cables</strong></td>
<td><strong>7.7</strong></td>
</tr>
</tbody>
</table>

\(^{15}\) The only MV cables we retain and operate are transformer or bus-tie/tie-line cable circuits.
18. AC STATION OTHER PRIMARY EQUIPMENT

This chapter describes the lifecycle management of the other primary equipment in our AC stations. These assets include other primary equipment not covered by other asset classes. The table below provides an overview of our other primary equipment.

<table>
<thead>
<tr>
<th>Description</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Instrument transformers</strong></td>
<td></td>
</tr>
<tr>
<td>50 kV and over (single phase units)</td>
<td>4077</td>
</tr>
<tr>
<td>- current transformers</td>
<td>774</td>
</tr>
<tr>
<td>- voltage transformers</td>
<td>213</td>
</tr>
<tr>
<td>- neutral current transformers</td>
<td>1056</td>
</tr>
<tr>
<td><strong>Disconnectors</strong></td>
<td></td>
</tr>
<tr>
<td>50 and 110 kV units mostly manually operated</td>
<td>2953</td>
</tr>
<tr>
<td>220 kV motor-operated</td>
<td></td>
</tr>
<tr>
<td><strong>Earth switches</strong></td>
<td>1194</td>
</tr>
<tr>
<td><strong>Outdoor bus systems</strong></td>
<td>163</td>
</tr>
<tr>
<td>50 kV and over outdoor switchyards containing buswork and support structures</td>
<td></td>
</tr>
<tr>
<td><strong>Lightning protection systems</strong></td>
<td></td>
</tr>
<tr>
<td>Lightning masts, rods, overhead earthwires or surge arresters</td>
<td>Most sites</td>
</tr>
<tr>
<td><strong>Neutral earthing resistors (NERs)</strong></td>
<td>131</td>
</tr>
<tr>
<td>Metal grid, and some older liquid-type NERS which limit fault currents</td>
<td></td>
</tr>
<tr>
<td><strong>Surge arresters</strong></td>
<td>533</td>
</tr>
<tr>
<td>Gapless metal oxide surge arresters</td>
<td></td>
</tr>
<tr>
<td><strong>LVAC Switchboards</strong></td>
<td></td>
</tr>
<tr>
<td>Main 415V Low Voltage AC (LVAC) switchboard immediately downstream of the local service transformer or primary local service source changeover system.</td>
<td></td>
</tr>
<tr>
<td><strong>Local service supply</strong></td>
<td></td>
</tr>
<tr>
<td>Transformers and associated equipment to distribute local service power to stations. This includes external source changeover equipment, main and submains cabling to distribution or AC supply cables to primary equipment.</td>
<td>Most sites</td>
</tr>
<tr>
<td><strong>Oil containment facilities</strong></td>
<td>Most sites</td>
</tr>
<tr>
<td><strong>Earth grids</strong></td>
<td></td>
</tr>
<tr>
<td>Underground network of copper conductors</td>
<td>All sites have one or more.</td>
</tr>
<tr>
<td><strong>Outdoor junction boxes (ODJB)</strong></td>
<td></td>
</tr>
<tr>
<td>Provide cabling interface point in the switchyard for control and protection functions, and power to support equipment.</td>
<td>Most sites</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

18.1. ASSET CHARACTERISTICS

Significant asset condition issues for this asset class are as follows:

- The instrument transformer population is relatively young and in good condition but we have recognised limitations in the usefulness of the current condition assessment data. We have
initiated a programme of improvements to address this, including the development of asset health models

- There are some vertically stacked double busbar systems in service that present safety hazards during maintenance. Support structures are generally in good condition but steel lattice structures at some sites need work to address corrosion and some concrete bus support posts installed in the 1950s and 1960s have exposed and corroding reinforcing steel

- Many main switchboards, local service systems and associated components are now beyond their expected lives, have inherent electrical safety hazards and lack spare parts, making them harder to maintain and test. Some have insulating panels made of asbestos containing materials (ACM)

- A number of junction boxes are in poor condition and are likely to require replacement during RCP2. Some have insulating panels made of ACM.

**Criticality**

Criticality of the AC Station Other Primary Equipment is generally linked to the criticality of either the primary assets to which they connect or the substation in which they are located, but this isn’t always applicable. Figure 30 shows the proportion of instrument transformers and disconnector and earth switches in each criticality category. Because of the wide diversity of functions in this asset class, modelling all assets is challenging.

![Figure 30: Instrument transformer, disconnector and earth switches service performance criticality](image)

Criticality of main switchboards and local service systems within the ACS asset class is becoming an issue where primary assets have a high dependency on low voltage supplies and cannot tolerate a total loss of local service. Such systems include SVC and STATCOM cooling systems, or sites where communications assets may be compromised by loss of air conditioning systems.

### 18.2. Asset Performance

Over the past ten years (2006-2015), we have had an average of six instrument transformer forced or fault outages per year predominantly due to environmental conditions, faulty connections or deteriorated equipment. We are seeking to improve the reliability of the asset type.
Over the same period, we have had about 30 forced and fault outages per year due to our disconnectors; a rate that is higher than our international peers. The root cause of this poor performance is the vulnerability of a large proportion of our disconnectors to poor contact alignment.

Additionally, a small number of the older type of surge arresters (gap type) are less reliable than the modern gapless types, regardless of condition.

During inspections of the Marsden switchyard oil leaks were observed on the 110kV CTs that were installed in 2009 / 2010. Forensic inspection of the CTs has revealed a serious crevice corrosion issue as the root cause of the leakage. To resolve the issue will require the CTs to be replaced before the expected operational lifetime (35 years) with the replacement now being planned for RCP2.

### 18.3. Planning and delivery

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement.

Our approach to each of these lifecycle activities is described below.

**Enhancement and Development**

We plan enhancement and development investments when there is need to facilitate new or upgraded AC substation assets.

We are currently upgrading the low-voltage supply system at our Islington and Haywards substations.

**Replacement and Refurbishment**

Our approach during RCP2 is to focus on:

- Replacing ageing and underperforming instrument transformers, disconnectors, earth switches, gap-type surge arrestors, and ODJBs
- Reviewing of our disconnector and earth switch asset class has shown that aging is not indicative of replacement. Where it is economic, refurbishment will be used to extend the life of some models
- Improving the competence of the workforce to achieve satisfactory mechanical alignment of the disconnectors
- Completing major busbar refurbishment projects that began in RCP1 at Timaru, Wilton, and Hawera
- Undertaking a major structure and buswork project at Kinleith substation
- Prioritising replacement of a number of substation local service main switchboards that are in poor condition or present unacceptable electrical safety risks.
Design
Our design plans include:
- Reducing the diversity within the asset classes
- Standardising busbar systems and LVAC systems as they become due for replacement.
- Aligning low voltage design requirements as far as practicable with national standards.

Procurement
We will procure disconnectors, earth switches and instrument transformers from the minimum possible number of vendors commensurate with the need to manage supplier risk.
We have engaged a preferred supplier of replacement LVAC switchboards to help manage costs, minimise spares holdings and standardise installations where practicable.
We have standardised on a preferred rating of new local service transformers to manage costs of new main switchboards.

18.4. OPERATIONS AND MAINTENANCE
Operations and Maintenance activities consist of:
- Contingency planning
- Preventive maintenance
- Corrective maintenance
- Predictive maintenance.

Our approach to each of these lifecycle activities is described below.

Contingency planning
We perform contingency planning activities for our instrument transformers, disconnectors and earth switches and surge arrestors, such as reviewing and maintaining the holdings of spares and ensuring an adequate level of emergency preparedness.

Preventive maintenance
We perform preventive maintenance activities such as:
- Performing maintenance on a group of equipment such as instrument transformers, disconnectors, and surge arrestors around a major item such as a power transformer or capacitor bank at the same time
- Four or eight-yearly (depending on performance issues) external inspections of instrument transformers and piloting internal condition assessments of older instrument transformers
- Disconnector condition assessments to reduce forced outages caused by poor alignment
- Carrying out current injection tests on all earth grids once every 10 years.

Corrective maintenance
We are investigating concrete bus posts installed in the 1950s for sign of damage or concrete spalling. We will repair or replace them if necessary to avoid failure.
We are identifying bus support lattice structures that exhibit significant rusting or corrosion with the intention of undertaking planning repairs, including painting in future.

**Predictive maintenance**

Minor repairs to disconnectors and earth switches associated with condition-based defects typically include contact re-alignment and hotspot repairs, corrosion control, and disconnector mechanism repairs.

We will avoid invasive repairs of freestanding instrument transformers, as it is more cost-effective and entails lower risk to replace the equipment.

### 18.5. Disposal and divestment

**Disposal**

We plan disposal of assets that are non-essential to our existing substations or are in poor condition. Specifically, we will remove disconnectors and earth switches that are not required, aging capacitor voltage transformer (CVT) monitors and remaining rod gaps of transformers that hold a risk of causing fault outages.

Oil from decommissioned instrument transformers is removed and taken to an authorised reclaimer or refuse disposal site.

Suspected ACM such as low voltage distribution equipment gearplates will be removed and disposed of in accordance with statutory requirements.

### 18.6. Other primary assets works

Table 48 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th></th>
<th>ITP 2015 replaced or refurbished(^{16})</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Structures and buswork</td>
<td>-</td>
<td>21.4</td>
</tr>
<tr>
<td>ACS Instrument transformers</td>
<td>164</td>
<td>15.9</td>
</tr>
<tr>
<td>ACS Disconnectors and earthswitches</td>
<td>102</td>
<td>7.5</td>
</tr>
<tr>
<td>LVAC Switchboards</td>
<td>35</td>
<td>1.9</td>
</tr>
<tr>
<td>ACS Other station equipment</td>
<td>-</td>
<td>6.9</td>
</tr>
</tbody>
</table>

\(^{16}\) Total units are provided only for assets where R&R has relatively standard unit costs.
19. SA SUBSTATION MANAGEMENT SYSTEMS

This chapter describes the lifecycle management of substation management systems. Substation management systems (also referred to as telemetry systems) enable the remote control and monitoring of our substations. Our existing substation telemetry systems are based on remote terminal units (RTUs).

Table 49: Substation management systems assets

<table>
<thead>
<tr>
<th>Asset</th>
<th>Description</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>RTU</td>
<td>Used to monitor signals from substation equipment and to transmit indications to a control centre. Also directs controls from a remote control centre to substation equipment.</td>
<td>239</td>
</tr>
<tr>
<td>Substation management systems (SMSs)</td>
<td>New telemetry systems that will eventually replace existing RTUs. The SMS communicates with intelligent electronic devices (IEDs) in the substation and with the remote control centre, typically by fibre networks. They include the capability for remote engineering access to relays and other IEDs.</td>
<td>57</td>
</tr>
<tr>
<td>Time synchronisation clocks</td>
<td>Provide time tagging of events as they occur at substations.</td>
<td>192</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.

19.1. Asset characteristics

For telemetry assets, condition is difficult to assess because the assets are static and are either functioning correctly or have failed. More than half of our RTUs are more than 10 years old and referred to as legacy units. For older models of RTU, it is no longer possible to procure new spare components and existing spares are depleted.

The time synchronisation clocks have 10-year warranties and life expectancies of about 15 years.

We have not applied our criticality framework to the SMS asset class at this stage.

19.2. Asset performance

The existing RTUs are reaching the limits of their capacity, creating a constraint on our ability to monitor power system equipment. The loading of RTUs has increased significantly over the past 10 years, as we have replaced electromechanical protection relays with modern numerical relays. Additionally, increasing demands for high-speed data communications and management from these new solutions have significant implications for our existing RTU-based substation telemetry systems.

RTU failures are occurring at an average rate of approximately one every six weeks. These failures are of concern because of the potential impacts of the loss of real-time monitoring and control capability on grid reliability, safety, and the system operator’s role in the electricity market. Reliability performance of existing RTUs is forecast to decline over time.
We do not have sufficient reliability data for the SMS installations to be meaningful because we are at a very early stage of the SMS deployment programme.

### 19.3. PLANNING AND DELIVERY

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement
- Commissioning.

Our approach to each of these lifecycle activities is described below.

**Enhancement and development**

We plan to install new SMS technology telemetry assets whenever we upgrade or build substations to meet increased customer demand.

**Replacement and refurbishment**

We plan to continue our staged replacement of RTU-based telemetry systems with SMS telemetry systems, and expect to replace the RTUs by 2025. We are prioritising the implementation of SMSs based on the condition and technical obsolescence of the existing RTUs and the site-level benefits.

Other R&R plans include:

- Introducing remote engineering access at the same time as SMS replacements to allow remote management of electronic devices
- Replacing time synchronous GPS clocks when firmware is unsupported, maintenance costs are no longer acceptable, or spares cannot be purchased
- Migrating all third-party RTU connections at substations to a centralised solution based on the secure Inter-Control Centre Communications Protocol by 2025.

**Design**

Our design plans include:

- Standardising the design of SMS telemetry to reduce the risks and costs of bespoke designs and facilitates deployment of SMSs for new and replacement projects
- Deploying smaller models of the SMS system in some of our smaller substations that do not require the range of benefits provided by a full SMS.

**Procurement**

Our procurement plans involve:

- Delaying equipment obsolescence by having good vendor relationships and support in place
- Managing vendor relationships to ensure ongoing support.
Commissioning
We plan extensive testing when we install SMSs to identify problems early.

19.4. OPERATIONS AND MAINTENANCE
Operations and Maintenance activities consist of:

• Real-time asset management
• Preventive maintenance
• Corrective maintenance.

Our approach to each of these lifecycle activities is described below.

Real-time asset management
The system operator national control centres, the national grid operating centres and grid performance remote systems manage the monitoring of real-time telemetry equipment.

We will be introducing a ‘hardened’ intra-substation communications network that meets international standards (IEC 61850). Additionally, we will integrate data gathered from substations into other systems (such as PI Historian) to provide relevant data to input into decision-making processes and generate automatic reports.

Preventive maintenance
We perform annual visual inspections and ten-yearly internal battery replacements on RTUs.

Corrective maintenance
We replace RTUs that fail while in service no later than 24 hours after the failure. In this case we investigate the RTU and have it repaired if feasible and economic. The repaired RTU will then be added to the stock of spares to replace the spare RTU that was used in the fault response phase.

19.5. DISPOSAL AND DIVESTMENT
Disposal
Our disposal plans include:

• Reusing any usable spare parts such as power supplies and chassis from RTUs that are made redundant following replacement with SMS telemetry
• Sending all non-usable or unnecessary components to a specialist electronics disposal company for breaking down and recycling.

19.6. SUBSTATION MANAGEMENT SYSTEMS WORKS
Table 50 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA Substation management systems</td>
<td>160</td>
</tr>
</tbody>
</table>
20. **SA SECONDARY SYSTEMS**

This chapter describes the lifecycle management of our secondary systems assets. Secondary systems refer to our protection equipment that operates to rapidly detect and initiate isolation of electrical faults to protect primary equipment and ensure the safety of employees, service providers and the public.

Our protection equipment consists of the following:

- Bus protection
- Feeder protection
- Line protection
- Transformer protection.

**Bus protection**

We have bus protection schemes at most of our high-voltage (66 kV and above) substations to ensure that faults occurring on the interconnections between different kinds of primary equipment (such as transmission circuits, transformers, capacitors and feeders) are isolated promptly (rather than tripping remote devices).

We have bus protection on around 400\(^{17}\) bus sections (ranging from 11 kV to 220 kV) in the network, which leaves about 100 bus sections with no dedicated bus protection. Table 51 shows the percentage breakdown of bus protection relays by relay type.

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>49</td>
</tr>
<tr>
<td>Static</td>
<td>30</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>3</td>
</tr>
<tr>
<td>Numerical</td>
<td>3</td>
</tr>
<tr>
<td>Currently unclassified</td>
<td>15</td>
</tr>
</tbody>
</table>

**Feeder protection**

Feeders are the point of connection between the network and our supply customers. Feeder protection usually consists of an IED, which provides protection, control, automation and telemetering. We have approximately 900 feeder protection relays, most of which are associated with 33 kV and 11 kV feeders. Table 52 shows the percentage breakdown of feeder protection relays by relay type.

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>49</td>
</tr>
<tr>
<td>Static</td>
<td>30</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>3</td>
</tr>
<tr>
<td>Numerical</td>
<td>3</td>
</tr>
<tr>
<td>Currently unclassified</td>
<td>15</td>
</tr>
</tbody>
</table>

\(^{17}\) This includes bus sections with the fast bus blocking scheme.
Line protection

Transmission line protection systems are designed to identify the location of faults and isolate only the faulted section. There are approximately 1,200 line protection relays in service, mostly providing distance protection, with a significant and increasing number of current differential schemes. Table 53 shows the percentage breakdown of line protection relays by relay type.

Table 53: Line protection by type

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>24</td>
</tr>
<tr>
<td>Static</td>
<td>6</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>9</td>
</tr>
<tr>
<td>Numerical</td>
<td>49</td>
</tr>
<tr>
<td>Currently unclassified</td>
<td>12</td>
</tr>
</tbody>
</table>

Transformer protection

There are approximately 1,130 transformer protection relays in service, the majority of which relate to supply transformers. Table 54 shows the percentage breakdown of line protection relays by relay type.

Table 54: Transformer protection by type

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>27</td>
</tr>
<tr>
<td>Static</td>
<td>23</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>8</td>
</tr>
<tr>
<td>Numerical</td>
<td>33</td>
</tr>
<tr>
<td>Currently unclassified</td>
<td>9</td>
</tr>
</tbody>
</table>

Station DC battery supply systems

Station 125 V (and occasionally 240 V) DC battery supply systems are installed at substations to supply power to protection schemes and other items such as circuit breaker close coils, control, and metering. The asset class includes 337 protection battery banks and 343 protection battery chargers.
Metering

The metering portfolio includes revenue meters that supply electricity volume information and transient recorders that can provide fault records of events that occur on the network. We have about 400 revenue meters installed at 145 different sites that are between 0 and 5 years old.

Christchurch RPC system

We have an RPC at Christchurch, developed as a pilot project, to ensure that dynamic and static reactive devices are optimally coordinated.

20.1. Asset characteristics

Condition assessments of relays are generally pass/fail assessments, with failure resulting in correction or replacement. This means protection relays are generally in a good condition. Their life expectancy is 40 years for electromechanical types and 20 years for all other types.

Batteries typically remain in reasonable condition throughout their first twelve years of service, when we then replace them.

All revenue meters are in good condition and they have a life expectancy of 15 years. We will therefore replace the current revenue meeting between 2022 and 2025.

Criticality

During RCP2 we will refine our use of the criticality framework to improve our prioritisation of capital works in the secondary systems asset class.

20.2. Asset performance

Over the past 10 years protection performance reliability during system events has improved to over 98%. Protection equipment may fail to operate (provide a tripping signal to a circuit breaker) during a fault event, in which case the primary asset may be damaged. This is rare. Self-monitoring provides an alarm when the relay fails and is included in modern numerical relays. Protection schemes can also fail to discriminate appropriately and react to an event outside their zone. Again, this is rare.

Feeder protection

The majority of feeder protection faults are the result of devices failing to operate as expected. Largely as a result of moving to numerical relays, feeder protection failure is improving from a historical average of three or four times a year.

Line protection

There is an average of 300 line faults a year, most of which are single phase to earth faults and are satisfactorily cleared by line protection equipment. Line protection equipment has failed to operate an average of 10 times a year. In most cases this is owing to equipment failure, although relays have inherent limitations for some types of faults.

The performance is improving from a combination of numerical relays, relay duplication, and increased standardisation.

Bus protection

There have been no known events within the past 10 years where bus protection or circuit breaker fail protection has failed to operate for a genuine fault condition.
Transformer protection
There have been no known cases where transformer protection failed to operate for an in-zone transformer fault.

Christchurch RPC
The Christchurch RPC has performed according to expectations by maintaining voltages to the specified set-points and dead-bands without causing an excessive number of capacitor switching or tap-change operations.

20.3. Planning and Delivery
Planning and Delivery activities consist of:

• Enhancement and development
• Replacement and refurbishment
• Design
• Procurement
• Commissioning.

Our approach to each of these lifecycle activities is described below.

Enhancement and development
The most significant driver for secondary assets E&D investment is new or upgraded primary assets that require protection. Additionally, we will:

• Implement special protection schemes to maintain security in areas experiencing network growth
• Investigate installing bus section circuit breakers with bus zone protection for each bus section to avoid losses of supply during bus faults
• Install an RPC scheme in Auckland to optimise the dynamic and static reactive plants in the Auckland area

Where economic and technically feasible, we will be enabling auto-reclose when replacing or installing line protection at circuits which do not have auto-reclose. The auto-reclose functionality enables fast restoration of transmission circuits during transient faults.

Replacement and refurbishment
The secondary systems asset class expenditure for RCP2 mainly involves:

• Transitioning from electromechanical relays to numerical protection relays for the majority of the protection schemes
• Replacing high-impedance bus protection schemes with modern electromechanical relays given their criticality, the importance of correct operation, and the limited requirement for advanced functionality.
• Replacing DC batteries every eight years and replacing DC supply system equipment when performance deteriorates.
• Installing bus protection schemes at substations where there are none. We are aiming for all high-voltage (66 kV+) buses to have dedicated protection with clearance times of less than 150 milliseconds, by 2025

• Replacing all fast bus blocking schemes by 2025 due to their poor reliability.

Design

To help reduce cost and time during the review of protection settings, logic block diagrams will be included in designs. We will select protection equipment that provides the required functionality, is reliable, is cost-effective and has technical support from manufacturers.

Additionally, we will continue transitioning to modern secondary systems by implementing Smart Grid and IEC 61850 policies, standards and standard designs.

The current Situational Distance to Fault functionality provides benefits in allowing for fault location to be viewed in near real time. In addition to this, the replacement and installation of line protection using the latest modern numerical relays provide a high degree of accuracy for locating faults i.e. a fault can be located to within 2 to 4 towers. This allows for faults to be fixed more quickly, directly improving service performance. This also reduces the cost of fault responses as less service provider time will be required. The technology may also help pinpoint the root cause of persistent line faults, and enable prompt corrective work.

Procurement

We foster close relationships with suppliers and reduce the number of vendors to a manageable level. This delays equipment obsolescence and maintains long-term technical support.

Commissioning

More extensive testing will be done at the time of installation because new IEDs require less (or no) testing during their service.

We also have a number of design, procurement and construction standards which include:

• Protection drawings and diagrams

• Protection cabling and wiring

• Transformer protection

• Line, feeder and busbar protection

• Current transformers and voltage transformers

• Revenue metering

• DC supplies

• Testing and commissioning

• Interconnection with customers.

20.4. OPERATIONS AND MAINTENANCE

Operations and Maintenance activities consist of:

• Outage planning

• Contingency planning
PART 3: ASSET CLASS PLANS - SA SECONDARY SYSTEMS

- Preventive maintenance
- Corrective maintenance
- Predictive maintenance.

Our approach to each of these lifecycle activities is described below.

Outage planning

We plan outages of secondary system assets to minimise outage length and risk of primary fault occurring. Generally, protection outages are allowed only if there is duplicate protection on the primary asset. If not, an outage on the primary asset may be required to get an outage on secondary system assets.

Contingency planning

We will maintain sufficient plans, skilled manpower and emergency spares to enable rapid restoration of transmission services following secondary system failure.

Preventive maintenance

We have requirements under the Electricity Industry Participation Code for regular testing of relays of all types; ten-yearly testing for numerical relays and four-yearly for electromechanical, static, and microprocessor relays. We test our relays at these intervals or more frequently.

The post-2000 numerical relays have advanced levels of self-monitoring so generally require less frequent testing than older relays.

Other condition assessments include:
- Annual monitoring of batteries.
- Five-yearly monitoring of RPC hardware
- Three-yearly revenue meter calibration required by the Electricity Industry Participation Code.

Corrective maintenance

Protection relays are complex IEDs and we cannot easily repair them when they malfunction. The manufacturer may provide repairs or replacements, or we will replace them.

We do not normally repair batteries due to their low cost. Occasionally, one cell within a battery bank may fail, but it is more efficient to replace the cell rather than repair it.

Predictive maintenance

Minor works on protection relays typically include fault downloads, settings changes and firmware changes.

We also have a number of operations and maintenance specifications that are for specific protection schemes or special protection schemes.
20.5. **Disposal and Divestment**

**Disposal**

For secondary system assets, we are particularly concerned that all lead-acid batteries are disposed of appropriately once they reach the end of their life.

20.6. **Secondary Systems Works**

Table 55 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>SA Metering</td>
<td>34</td>
</tr>
<tr>
<td>SA Buszone protection</td>
<td>44</td>
</tr>
<tr>
<td>SA Line protection</td>
<td>113</td>
</tr>
<tr>
<td>SA Transformer protection</td>
<td>65</td>
</tr>
<tr>
<td>SA Batteries and DC systems</td>
<td>180</td>
</tr>
<tr>
<td>SA Feeder protection</td>
<td>39</td>
</tr>
</tbody>
</table>
21. HVDC

This chapter describes the lifecycle management of our HVDC assets. The New Zealand HVDC system runs from the Benmore converter station in the South Island to the Haywards converter station in the North Island. The original 600 MW mercury arc valve Pole 1 was commissioned in 1965. In 1991, the Hybrid HVDC project commissioned the 700 MW Pole 2. In 2012, Pole 1 was fully decommissioned and the new 700 MW Pole 3 was commissioned in 2013. The Pole 2 control and protection system was also upgraded as part of the Pole 3 project. Currently Pole 2 and Pole 3 are operating in parallel and the total system capacity is 1200 MW.

HVDC system components

Converter Station equipment — Both Haywards and Benmore converter stations are connected to the 220 kV AC system at each island. HVDC converter transformers, thyristor valves, control and protection systems, HVDC switchyards, and AC harmonic filters are located at each converter station. There are eight synchronous condensers and a STATCOM at Haywards to support the HVDC system. To coordinate the operation of all the harmonic filters, synchronous condensers, interconnecting transformer tap changers, and the STATCOM, an RPC is implemented at Haywards. Similarly an RPC is installed at Benmore to coordinate the six Benmore generators, generator transformer tap changers, and the harmonic filters. Both RPCs are fully integrated into the HVDC control system.

HVDC cables and lines — HVDC transmission line carries two transmission circuits which are connected to each pole. Each transmission circuit connects the converter stations to the cable stations where the overhead HVDC line is connected to undersea HVDC Cook Strait cables.

Electrode line — Electrode line carries HVDC neutral current to each electrode station where the neutral current is transferred to the remote earth. The South Island ground electrode station is located at Bog Roy and the North Island sea electrode station is located at Te Hikowhenua.

Simulator and replica control and protection system — A real time digital simulator (RTDS) and a replica HVDC control and protection system has been received as part of the HVDC Pole 3 project. The simulator is used for HVDC enhancements, maintenance, and testing purposes. This system allows HVDC modifications and testing to be carried out with minimal system impact.

<table>
<thead>
<tr>
<th>Asset</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Submarine cables</td>
<td>3 x 38 km</td>
</tr>
<tr>
<td>Converter transformers single-phase</td>
<td>16</td>
</tr>
<tr>
<td>Circuit breakers</td>
<td>39</td>
</tr>
<tr>
<td>Converter station</td>
<td>4</td>
</tr>
<tr>
<td>Cable stations</td>
<td>2</td>
</tr>
<tr>
<td>Electrode stations</td>
<td>2</td>
</tr>
</tbody>
</table>

The asset characteristics, lifecycle activities and forecast RCP2 expenditure is described below.
21.1. Asset Characteristics

The Pole 3 converter stations were constructed between 2011 and 2013 and are in excellent condition.

Due to its historical loading conditions, the main circuit equipment in Pole 2 is generally in good condition and has considerable remaining life (total life of 35 years). Some Pole 2 subsystems have reached the end of their expected lives, requiring replacements or other interventions. Examples of these are:

- The valve base electronics (VBE) systems
- Thyristor control units (TCUs)
- Snubber circuitry
- Filter bank circuit breakers
- Couplings in the thyristor valve water cooling systems
- Converter transformer components.

There is rapid deterioration of the earth and sea electrodes if the HVDC link is in unbalanced or monopole operation. The Bog Roy electrode arms had an increased deterioration rate when Pole 1 was decommissioned and prior to the Pole 3 commissioning (monopole operations of Pole 2). The electrodes at the Te Hikowhenua station also deteriorated during this time through a build-up of magnesium and calcium deposits. Due to round power operation the HVDC link still operates in monopole or unbalanced operation regularly.

Despite the harsh environment in the Cook Strait, underwater surveys indicate that the HVDC cables are still in good condition and likely to remain usable for their original design life.

The Oteranga Bay cable station is located in an extremely harsh coastal environment. The roof and wall claddings of the building are significantly corroded.

Criticality

Our current criticality framework considers the dimensions of service performance and public safety. We have assigned all assets within the HVDC asset class as low service criticality, because a failure of the HVDC system will not usually result in interruptions to customers. The performance of the HVDC system can heavily influence electricity prices, and frequency keeping activities. If a number of North Island thermal power stations are decommissioned as announced, or Tiwai closes, the HVDC availability will be increasingly critical for the operation of the power system. We do consider these impacts in planning maintenance on the HVDC system.

21.2. Asset Performance

The HVDC inter-island link has achieved world-class levels of performance over the years since the original scheme was commissioned in 1965.

Failure of the assets within the HVDC asset class can lead to an outage of the inter-island connection or a portion of the connection’s capacity. In many cases this would lead to a large price discrepancy between the North Island and the South Island. Price discrepancies in the electricity market may result in disruption to economic activities and may raise public concerns. The savings obtained through the frequency keeping services that are enabled by the HVDC link will be lost if both poles are not available to the market.
HVDC submarine cable performance has been very reliable, with only one failure due to an internal electrical fault— in Cable 6 in October 2004. The most significant risk to the submarine cables is damage caused by illegal fishing and anchoring in the Cook Strait Cable Protection Zone (CPZ). We are actively managing this risk by patrolling the CPZ and educating the public.

The new Pole 3 equipment has been designed to withstand higher-intensity earthquakes than Pole 2 (a1 in 2,500-year compared to 1 in 1,000-year event). In the event of a relatively large earthquake, it is expected that Pole 3 could continue to operate while Pole 2 may not. Yet Pole 3 is dependent on several parts of the common AC system (delivered in the 1990s). In particular, the Haywards switchyard B insulators and disconnectors are a seismic risk for Pole 2 and Pole 3.

Our customers for the HVDC transmission service require high levels of annual availability. We aim to limit scheduled outages for routine maintenance and condition assessment to three or four days each year for each pole of the HVDC link.

21.3. Planning and Delivery

Planning and Delivery activities consist of:

- Enhancement and development
- Replacement and refurbishment
- Design
- Procurement
- Construction.

Our approach to each of these lifecycle activities is described below.

Enhancement and development

Our E&D plans include:

- Developing and testing control system enhancements in the RTDS facility to address market and new system requirements
- Designing control system modifications to overcome known system limitations and issues
- Investigating stage 3 of the HVDC Pole 3 project as a major capex proposal to install at least one more submarine cable, a second STATCOM and additional filter banks to increase capacity of the link up to 1400 MW
- Investigating an overload scheme for Pole 2 to obtain a 1000 MW half an hour overload from Pole 2.

Replacement and refurbishment

We plan R&R work that includes:

- Replacing the Pole 2 VBE and associated fibre optic links to improve the reliability of the pole
- Replace Pole 2 snubber circuitry
- Replacing or refurbishing several frequently operated Pole 2 filter bank circuit breakers that are expected to surpass their recommended number of operations
• Refurbishing the roof and wall claddings of the Oteranga Bay cable station building and replacing or refurbishing other HVDC site buildings and grounds infrastructure, and building services

• Replacing deteriorated electrode arms at the Bog Roy electrode station with an improved design to improve the performance of the electrode and to address existing drainage issues

• Replacing the disintegrating buried copper earthwire cables and the knife switches at the Te Hikowhenua electrode station

• Replacing the Haywards switchyard B insulators and Pole 2 pantograph disconnectors to provide seismic improvement

• Pole 2 life extension programme:
  o repairing/upgrading the Pole 2 converter hall and building services
  o replacing oil filled porcelain bushings with SF6 polymer bushings
  o replacing some Pole 2 era primary equipment based on their condition/risk
  o Pole 2 low voltage AC systems replacement
  o Pole 2 converter transformer repair/refurbishment work
  o Pole 2 cooling system repair/replacement.

**Design**

We have no major design work planned.

We will require smaller-scale design work for possible HVDC projects, including a new submarine cable or cables as part of stage 3 of the Pole 3 project Pole 2 VBE replacement project, and the design of Pole 2 1000 MW overload capability. We are also utilising the RTDS system to carry out preliminary design work in-house, which reduces the overall cost and time requirements.

**Procurement**

We plan to carry out competitive tender processes where possible. However, there is limited competition in the international HVDC market, which can impact service offerings and pricing levels.

**Construction**

For the Pole 3 project it was particularly important to have our personnel on-site to identify and formally record defects. Our engineers were involved in the design and delivery process to oversee the entire project and to ensure that all the technical and quality requirements were met by the suppliers. We will practice this approach in future projects as well.

**21.4. Operations and Maintenance**

Operations and Maintenance activities consist of:

• System simulation

• Ratings

• Outage planning

• Contingency planning
• Preventive maintenance
• Corrective maintenance
• Maintenance projects.

Our approach to each of these lifecycle activities is described below.

System simulation
We will continue to use the RTDS to help solve a range of complex dynamic problems. We are also developing in-house control system modifications to satisfy our requirements.

Ratings
We are planning to develop thermal models for Pole 2 transformers and installing necessary equipment to provide data for the dynamic rating controls and asset management purposes.

We plan to install a new submarine cable, a STATCOM and new filter banks at both stations as part of stage 3 of the Pole 3 project. This will increase the capacity of the link up to 1400 MW. With the implementation of more detailed thermal models in the future, the system can be dispatched up to the thermal limits of the AC lines. This will allow us to utilise the link up to its capability limit.

Outage planning
We plan HVDC outages in summer when the HVDC demand is lowest. We try to minimise the number of outages on the HVDC system as the availability of the HVDC system affects the operation of the electricity market and frequency keeping services enabled by the HVDC system. In RCP2 we are aiming to swap out one converter transformer unit on Pole 2. This is a pilot project for Pole 2 converter transformer refurbishment projects planned for RCP3. This will also provide us with valuable condition assessment data.

Contingency planning
Our contingency planning for the HVDC system focuses on:
• Auditing the Pole 2 spares inventory to document the quantity and condition of spares
• Holding at least one spare for major equipment such as the Haywards and Benmore converter transformers smoothing reactors and other primary plant
• Acquiring spare capacitor cans, control system cards and other necessary spares for Pole 3 during RCP2/3.

Preventive maintenance
Our preventive maintenance activities include:
• Requiring our service providers to undertake regular condition assessments of the HVDC assets
• Performing maintenance works during scheduled outages
• Cleaning roof bushings at cable stations to remove high pollutant accumulation on the bushings
• Continuing to monitor the Cook Strait submarine cables with a marine patrol of the Cook Strait Cable Protection Zone to deter and detect illegal fishing and anchoring
• Continuing with programmes of surveys of the Cook Strait cables by remote-operated vehicles and by divers
• Repairing the sea and land electrodes as required.

Corrective maintenance
Our corrective maintenance activities include:
• Replacing failed assets, such as capacitor cans, converter transformers and submarine cables
• Carrying out detail analysis of asset failures to identify the route cause to address any common issues proactively
• Responding to all failures in a timely manner, as determined by the criticality of the asset.

Maintenance projects
We plan the following maintenance projects:
• Carrying out regular maintenance on the Te Hikowhenua electrodes to remove build-up of calcium due to unbalanced operation of the HVDC link
• Carrying out minor seismic improvement work to improve the seismic resilience of Pole 2 and the AC switchyard to bring the site up to a higher seismic standard
• Refurbishing the interrupters and operating mechanisms of filter bank circuit breakers
• Carrying out maintenance projects on components of HVDC buildings based on their current condition and the expected degradation rate
• Carrying out maintenance projects on components of Pole 2 HVDC converter transformers to extend their service life.

21.5. DISPOSAL AND DIVESTMENT

Disposal
We will continue the practice of donating retired equipment to education institutions if requested, or recycling as much of the equipment as possible.

We have decommissioned and disposed of Pole 1 equipment, but will demolish the Pole 1 buildings at Benmore and Haywards during RCP2.

21.6. HVDC WORKS

Table 57 summarises the HVDC R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished(^{18})</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVDC</td>
<td>26.2</td>
</tr>
</tbody>
</table>

\(^{18}\) Total units are provided only for assets where R&R has relatively standard unit costs.
PART 4: THE ICT PLAN
22. INTRODUCTION TO THE ICT PLAN

This chapter provides an overview of our approach to managing our ICT assets. Our ICT assets support our asset management decisions and practices. The chapter covers:

- ICT overview
- ICT framework
- ICT drivers
- Service delivery lifecycle.

22.1. ICT OVERVIEW

ICT delivers and supports the infrastructure, server hardware and applications that interface with the grid and, in the wider Transpower context, connect the system operator and the market. Figure 31 provides an overview of the component parts that contribute to ICT.

We divide our grid-based ICT into five business service categories, as shown in the Table 58 below. We have rationalised the categories since the 2013 ITP to combine telecommunications, network and security services, as these three are closely related and this updated categorisation provides better alignment with our reporting and governance processes.
Table 58: Our five business service categories

<table>
<thead>
<tr>
<th>Service Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission systems</td>
<td>Support the core transmission services through provision of real-time and time-series information</td>
</tr>
<tr>
<td>Asset management systems</td>
<td>Support forecasting, planning, and delivery of asset management activities</td>
</tr>
<tr>
<td>Corporate systems</td>
<td>Support our corporate operations and obligations by providing human resource, finance, risk, audit and compliance and project management information systems</td>
</tr>
<tr>
<td>ICT shared services</td>
<td>Support ICT services and infrastructure, which in turn support the operations of our information systems</td>
</tr>
<tr>
<td>Telecommunications, network and security services</td>
<td>Support telecommunications and network collaboration links between Transpower sites and between Transpower and public networks</td>
</tr>
</tbody>
</table>

22.2. ICT FRAMEWORK

There is a close relationship between our corporate strategy and our ICT planning and strategic documents. This is illustrated in Figure 32 below.

Figure 32: ICT planning documents and their link to business requirements

We set out our ICT strategies at a high level in the Information Services Strategic Plan (ISSP), and at a more granular level in our Business Services Strategy.

Under this framework we derive our ICT programmes based on delivering our grid and corporate business requirements. ICT is also maturing its investment value proposition by moving from a traditional “Run, Grow, Transform” model to a “Lifecycle, Benefits Driven, Leading” model. The change in approach will allow ICT to transform by decentralising some functions, and to innovate as we move to deliver long term digital business outcomes. This allows the categorisation of ICT investment to ensure we can classify and prioritise the value delivered to meet the challenges we face as outlined in Transmission Tomorrow. The components of the investment profile are:

- **Lifecycle Based Investments**: These represent the technology investments “Must Do’s” that address the need to meet our regulatory requirements, reduce risks to Transpower and maintain the value of our existing assets
- **Benefits Driven Based Investment**: Investments in this category deliver enhancements and value to Transpower, allowing us to deliver new capabilities that reduce costs or enhance the value of grid and system operations. They support efficient and effective use of our assets.
• **Leading Based Investment:** The business value of investments in this category allow flexibility to invest in new technology that deliver greater future benefits, and will enable the introduction of new digital technologies supporting the move to a smarter more efficient grid.

Adoption of this investment model allows ICT to steadily increase its efficiency gains through better information, remote interrogations and improved automated control, while controlling the cost, quality, security and risk exposure of our current investments in alignment with our ICT strategic direction.

### 22.2.1. ICT GOVERNANCE

Our ICT programmes are guided by a set of enterprise architecture principles. These are:

- IT system solutions must be created to address clear, strategically aligned requirements
- Systems that support critical functions must be segregated from all other systems
- Solutions must strive to maximise benefits at appropriate level of risk and cost
- Cloud services should be used where they deliver value
- Systems must be designed and operated so that business activities can continue despite system interruptions
- Knowledge and information is treated as an asset
- Solutions and services must be fit for purpose rather than best in class
- Solutions and services should not be dependent on specific technologies
- Solutions and services are built using low-coupling, reusable, modular components that have a successful track record
- Enterprise architecture principles apply to external solutions and services
- We will ensure services have viable support
- Newer operational technologies are increasingly incorporating IT modules and require integrated management practices
- Security is required to support and protect the operational integrity of all system solutions and services to agreed standards.

**The ICT Governance Board**

Our general management team, act as the ICT Governance Board (ICTGB), which has the primary authority for all ICT decisions. Full general management team membership of the ICTGB provides a ‘whole-of-business’ mind-set to ICT matters generally.

The role of the ICTGB is to:

- Approve the enterprise architecture principles, security policies, ISSP and information management and security policies
- Review and prioritise ICT programmes and projects
• Understand and manage risks.

Strategic Sourcing
We have a policy of engaging the right outsource partners for scale and depth of expertise to support rapidly changing environments. This includes leveraging experience and knowledge from industry thought leaders to foster innovation. We also outsource non-critical supporting systems with common business functions to leverage investments from the wider ICT industry. Within this context we are developing strategic relationships with our top suppliers to leverage more value from our investments and engage in contestable sourcing for each architecture layer to drive down the whole of life costs.

22.3. ICT DRIVERS
Our ISSP considers our overarching business goals and desired future state, together with the external technology environment and determines ICT strategies. These are grouped into five categories:
• Improve asset management practices
• Improve real-time management of the grid
• Embed greater internal alignment and collaboration
• Ensure people, practices and technology are fit for purpose
• Embed effective and efficient investment planning and execution.

22.4. SERVICE DELIVERY LIFECYCLE
ICT planning and governance processes rely on the service delivery lifecycle (SDLC). The SDLC is our overarching project delivery framework. The SDLC consists of five lifecycle stages:
• **Business problem definition:** A relevant business owner assesses the business need and clarifies whether it can be met through people and process changes alone or requires an ICT systems investment.
• **Concept development:** We investigate alternative ICT solutions and the business owner agrees on a preferred approach. The outcome is an investment brief that provides a high-level justification and initial business case.
• **Solution development:** A project brief is developed to establish the capital project and confirm the approach. At this stage we finalise the business case and design, build (or source), test and implement the solution.
• **Operations and maintenance:** The solution is supported day-to-day to ensure it operates to business expectations as defined by service-level agreements.
• **Disposal:** Unnecessary or retired solutions are decommissioned.
23. ICT ASSET CLASS PLAN

This chapter describes the ICT Asset Class plan. ICT solutions change frequently and the majority of our ICT assets have a depreciation life of less than five years, reflecting the rapid rate of innovation and change in the technology industry.

Overall we have ten major ICT systems and hundreds of supporting components. The population of our physical assets is shown in Table 59 below.

<table>
<thead>
<tr>
<th>Type</th>
<th>Total</th>
<th>Type</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibre cable—optical ground wire (OPGW)</td>
<td>664km</td>
<td>Voice routers</td>
<td>194 devices</td>
</tr>
<tr>
<td>Fibre cable—buried</td>
<td>1179km</td>
<td>TransGO Radios</td>
<td>20 devices</td>
</tr>
<tr>
<td>Fibre cable—submarine</td>
<td>80km</td>
<td>Power line carriers</td>
<td>20 devices</td>
</tr>
<tr>
<td>Synchronous digital hierarchy (SDH)</td>
<td>312 devices</td>
<td>Physical Servers</td>
<td>419 servers</td>
</tr>
<tr>
<td>Plesiochronous digital hierarchy (PDH)</td>
<td>668 devices</td>
<td>Physical Network Switches</td>
<td>810 switches</td>
</tr>
<tr>
<td>Core multiprotocol label switching (MPLS)</td>
<td>38 devices</td>
<td>Physical Firewall Cluster</td>
<td>99 servers</td>
</tr>
<tr>
<td>Datacentres</td>
<td>5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Our physical device count is down from our 2015 ITP due to the implementation of our consolidation strategy. Our network device count continues to fluctuate as we consolidate into the new data centres and finish our building move. This is expected to stabilise during 2016/17. The quantity of submarine fibre has reduced as two cables have now become unserviceable.

As described in chapter 22 above, we group our ICT assets into the five business service categories. A description of the applications and systems that fall within each service category is described in Table 60.

<table>
<thead>
<tr>
<th>Business service category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission systems</td>
<td>Provision of real-time and time-series Grid information systems and the management of the substation information. Includes:</td>
</tr>
<tr>
<td></td>
<td>• <strong>SCADA</strong> (supervisory control and data acquisition)—used to operate the grid with coded signals over communication channels so as to provide control of remote equipment.</td>
</tr>
</tbody>
</table>
### Asset management systems

Support the forecasting and planning of grid asset maintenance and our management systems. Includes:

- **Maximo** — our core asset management information system for all grid assets which holds the core operational asset register and is our maintenance management tool. It is also an integral part of our finance system. Maximo is a standard enterprise asset management product from IBM.

- **IONS** (integrated outage notification system) — provides the capability to schedule, coordinate and track grid outages.

- **Geospatial Systems** — provides location based intelligence for all our asset systems including Maximo, SDTF, Asset Map, and CONNECT.

- **SDTF** (situational distance to fault) — provides grid operators with the ability to view faults in near real time, to assist in determining the root cause and appropriate remedial actions. It takes data feeds from the Lightning Detection System, SCADA event data via PI, and weather data from New Zealand MetService.

- **LDS** (lightning detection system) — detects and tracks thunderstorms across New Zealand. Refreshed in 2014, the LDS is managed by agreement with MetService.

There are a number of other systems which support asset management including, among others. Drawings Management systems, Data Warehouse and Business Intelligence tools, and Asset Capability Information (ACI). Together these support our asset management decisions and practices.

### Corporate systems

Support our corporate operations through human resource, finance, risk, audit and compliance and project management information systems. Includes:

- **FMIS** (financial management information system) — provides functions for financial reporting, project planning, project costing, accounts payable, group account consolidation, purchasing, accounts receivable, billing and time-sheeting.

- **TIPU** (Transpower integrated project utility) — provides an enterprise-wide planning and project/portfolio management platform.

- **CONNECT** — manages interactions with landowners.

- **TPCRM** — manages interactions with customers and stakeholders.

- **ENVI** — manages RMA approval and compliance.

- **Hub** — provides our information management platform, currently on Sharepoint 2010. The Hub is the primary information repository across Transpower.

### ICT shared services

Support ICT services and infrastructure, which in turn support the operations of our information systems (such as gateway applications, authentication services, storage area networks and hardware virtualisation tools like VMware).

- **eMail** — provides our email system, with a document management capability.

- **ESB** (enterprise service bus) — uses JFuse to provide integration across ICT assets, and is segregated for both corporate and critical systems.

- **Server and desktop infrastructure.**

- **IAM** (identity and access management) — provides password synchronisation and
authorisation for our systems.

• **Data centres**—We have five data centres: three on our sites in Christchurch, Hamilton and Wellington and two new data centres, managed by Spark Digital. The data centres support our critical and critical enabling systems and ensure we have the ability to control all aspects of our critical capabilities.

<table>
<thead>
<tr>
<th>Telecommunications, network and security services</th>
<th>Support telecommunications and network collaboration links (such as voice, video) between Transpower sites and between Transpower and public networks. Ensure the availability and integrity of our information systems by applying the correct security classifications and controls to minimise risk (such as firewalls).</th>
</tr>
</thead>
<tbody>
<tr>
<td>• <strong>TransGO</strong>—A high-capacity and highly resilient network comprising a diverse triplicated inner core running between Hamilton, Wellington and Christchurch, with branches looping out into all regional areas. TransGo provides connectivity to 158 sites—Transpower substations, offices, warehouses and other sites.</td>
<td></td>
</tr>
<tr>
<td>• <strong>Security systems</strong>—Security enforcement points and architecture that support our security of supply and system availability.</td>
<td></td>
</tr>
<tr>
<td>• <strong>Voice-video conferencing</strong>—provide the corporate voice and video services using a number of platforms through the network.</td>
<td></td>
</tr>
</tbody>
</table>

### 23.1. **Asset Characteristics**

We maintain our ICT systems through risk-based investment to achieve business outcomes. They are assessed annually against technical quality criteria and business value criteria, which allows a tolerate-invest-migrate-eliminate (TIME) assessment to improve the balance of value to supported cost and risk.

**Table 61: Business value and technical quality criteria for ICT systems**

<table>
<thead>
<tr>
<th>Business value criteria</th>
<th>Technical quality criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security of supply: direct dependency</td>
<td>Business functionality</td>
</tr>
<tr>
<td>High availability: of the services</td>
<td>Availability of the system/services</td>
</tr>
<tr>
<td>High reliability: for critical processes</td>
<td>Reliability of the system/services</td>
</tr>
<tr>
<td>Fast recoverability: from a major event</td>
<td>Recoverability from a major event</td>
</tr>
<tr>
<td>Change adaptability: level of importance</td>
<td>Maintainability of system/services</td>
</tr>
<tr>
<td>Management control: of strategy and decisions</td>
<td>Manageability of system/services</td>
</tr>
<tr>
<td></td>
<td>Affordability of system/services</td>
</tr>
</tbody>
</table>

All ICT systems are in good health. Our enterprise systems are segregated from our critical (‘Keep the lights on’) systems, to further reduce operational risk.

### 23.2. **Asset Performance**

We monitor all ICT systems continuously for performance and capacity, and report our critical asset performance monthly. There are currently no major performance concerns with our ICT asset class. The key performance measurements for our major systems are shown in Table 62.

**Table 62: ICT performance measurements for major systems**
## Key performance indicators

<table>
<thead>
<tr>
<th></th>
<th>Target measure</th>
<th>Current performance</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCADA availability</td>
<td>&gt;99.9%</td>
<td>99.97%</td>
<td>Measure is against unplanned service outages</td>
</tr>
<tr>
<td>Market systems availability</td>
<td>&gt;99.9%</td>
<td>100%</td>
<td>Measure is against unplanned service outages</td>
</tr>
<tr>
<td>Teleprotection availability</td>
<td>&gt;99.999%</td>
<td>100%</td>
<td>Measure is against duplicated circuits only</td>
</tr>
<tr>
<td>Corporate systems availability</td>
<td>&gt;99.5%</td>
<td>99.9%</td>
<td>Measure is against agreed support hours</td>
</tr>
</tbody>
</table>

### 23.3. Planning and delivery

During the RCP2 period, our investment focus has changed from building new capability to ensuring continued support and maintenance of our existing systems. The enterprise architecture principles ensure our strategy is delivered and they guide ICT investment through a number of key concepts. From 2021 to 2025, we expect an increase in the quantity and type of data gathered from our grid assets through increased monitoring and new substation management systems. This will require an increase to network bandwidth, and shared services infrastructure.

We are beginning to use Azure cloud services for our enterprise systems, starting with our development & test systems. This will see a gradual phased decrease in capex and a move to increased opex during RCP3. Adoption of cloud services is evaluated on efficiency opportunities as systems are considered for technical refresh or lifecycle replacement.

Our expenditure plans specific to each of our business services categories are outlined below. The upgrades to our software and systems are generally needed to maintain vendor version support.

#### Transmission systems

- Our SCADA and energy management systems (EMS) systems were successfully upgraded to v2.6 in March 2016, and further upgrades are planned in 2019/20 and 2024. The programme also includes upgrade of infrastructure and some small related application projects
- Upgrading the GMMS system in 2018 and carrying out further enhancements in 2023
- Refreshing PI Historian system software from PI Data Archive version 2012 (3.4.390.16) in 2017 and 2021

#### Asset management systems

- Integrating Maximo with core systems such as FMIS, IONS, and third-party service provider systems. We are also refreshing Maximo software in 2017, and planning a further upgrade in 2023
- Introducing new systems to support asset condition-based risk management and near real time asset health indices in 2016–2018. We have not yet specified these systems but they will assist in identifying optimal cost-risk-performance trade-offs when making asset investment decisions
- Refreshing software and hardware of the IONS application in 2016/17 and replacing it in 2021/22
• We have brought forward the replacement of ageing lightning sensors to 2016/17 to mitigate site compromises, and failures. A major software/hardware refresh of the LDS system is planned for 2023
• Refreshing the SDTF system in 2019 and 2024.

Corporate systems
• Upgrading our FMIS system to Peoplesoft 9.2 in 16/17, providing new reporting capability and fully supporting the system to 2021. We will consider an upgrade or replacement in 2021
• Integrating TIPU with our existing FMIS, Maximo and outage management systems. We will also upgrade TIPU in 2019 with a subsequent refresh in 2025
• Upgrading the Hub in 2016, with a further minor refresh in 2018.

ICT shared services
• Considering email as a candidate system for moving to cloud service in 2022
• Refreshing ESB in 2019 and 2023 in accordance with the vendor lifecycle
• Replacing physical server and desktop assets based on age, performance and capacity. We have brought forward the replacement of our desktop software to 2016 to take advantage of current market opportunities, and in support of our building move
• Separating our critical systems access from our enterprise access as part of IAM. We have extended our enterprise services out to cloud providers. We are also planning a refresh for 2018 that will provide for mobility and consolidated single sign-on. A further refresh will be done in 2024
• Refreshing new data centres managed by Spark Digital in 2019 and 2024.

Telecommunications, network and security services
• Investing in our core TransGO network systems in RCP3 as they will be approaching 10 years old. This will ensure they continue supporting grid operations and are capable of increased communications with substation monitoring and remote engineering access. Our submarine fibre cables will need lifecycle replacement in 2022/23.

23.4. Operations and Maintenance
Our market systems and transmission applications team supports all mission-critical 24/7 systems, with vendor agreements for third-tier support where appropriate.

The information systems and business applications team support our enterprise systems, with vendor agreements where appropriate for third-party or subject matter expertise.

A dedicated shared services team manages our license and capacity costs. Upgrades of our system usually require a significant investment provided through our capital planning.

Spark Digital is responsible for managing data centre facilities and will resolve incidents that affect our facilities. Our data centres are subject to an independent annual compliance audit and review, with any defects identified and managed through a rectification plan.
Our service management ensures that proper procedures and controls are in place for the delivery, distribution and tracking of IT services. It also has monthly service level monitoring and reporting against agreed service levels.

We record and track all ICT incidents and fix minor or high-priority incidents within agreed service levels. Incidents that require significant analysis or investment are prioritised into the annual capital programme.

23.5. **Disposal and Divestment Activities**

We look at achieving efficiencies when decommissioning older assets being replaced or refreshed as part of our annual programme.

23.6. **ICT Works Plan**

By moving from a traditional “Run, Grow, Transform” model to a “Lifecycle, Benefits Driven, Leading” model, the resultant expenditure profile is shown in Figure 33 below.

![Figure 33: ICT expenditure profile](image)

Table 63 provides a summary of the ICT capex plans for RCP2.

<table>
<thead>
<tr>
<th>Table 63: ICT RCP2 asset class capex plans</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT Plans</td>
<td>166.1</td>
</tr>
</tbody>
</table>
PART 5: BUSINESS SUPPORT PLAN
24. BUSINESS SUPPORT PLAN

This chapter describes the management of our Business Support Assets and expenditure for the RCP2 period. It covers:

- Overview of our business support assets
- Strategic properties
- Non-critical substation buildings and land
- Office buildings and facilities
- Vehicles
- Office Equipment
- Forecast RCP2 expenditure

24.1. OVERVIEW OF OUR BUSINESS SUPPORT ASSETS

Business support assets include assets not otherwise included in other asset fleets. Table 64 provides a summary of the assets included.

Table 64: Business support assets

<table>
<thead>
<tr>
<th>Asset category</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic properties</td>
<td>3 properties at Islington, Otahuhu and Morrinsville</td>
</tr>
<tr>
<td>Non-critical substation buildings</td>
<td>Transpower owns and operates 137 GXPs and 32 grid injection points (GIPs). The majority of GXPs have an area of non-critical substation land and many have non-critical buildings</td>
</tr>
<tr>
<td>Office buildings and facilities</td>
<td>5 leased offices, 2 owned offices, 3 owned warehouses and 3 owned training facilities</td>
</tr>
<tr>
<td>Vehicles</td>
<td>99 passenger vehicles</td>
</tr>
<tr>
<td>Office equipment</td>
<td>Office desks, chairs and meeting room furniture</td>
</tr>
</tbody>
</table>

These assets are diverse in nature, consequently each is considered separately below.

24.2. STRATEGIC PROPERTIES

Asset characteristics and performance

Strategic property is not included in our regulated asset base. We have three of these properties located at Islington, Otahuhu and Morrinsville (ex-Aitcheson series capacitor site). Typically these properties are where we have identified a significant advantage to hold this land to enable future expansion or development. Surrounding land use ranges from rural pastoral farming to residential and industrial land use.
Planning
The identification, acquisition and disposal of strategic property is set out in the RCP2 strategic document Strategic Property Purchase and Sale Strategy. We have made a provision in RCP2 to cover possible purchase of strategic property to support grid E&D plans.

Operations and maintenance
Where possible we licence properties to cover holding costs and where practicable provide a return. Tenants are generally responsible for maintenance of land and improvements. In the absence of a tenancy or where we need to carry out maintenance over and above the tenant’s obligations, these costs are met under the regional facilities maintenance contracts.

Disposal and divestment
Where there is no further strategic need, we sell properties at current market value (subject to all necessary internal and external approvals).

24.3. Non-critical Substation Buildings and Land

Asset characteristics and performance
- Non-critical substation buildings—generally these consist of storage buildings and a number of current and former depots. These buildings were built at our older substations and remain at a significant number. Typically these buildings are in a fair to good condition. There are also a small number of non-critical buildings and land that are not directly associated with a substation (for example, the Evans Bay cable store, the Bog Roy earthing station and the Molesworth depot).
- Non-critical substation land—land surrounding or abutting substation switchyards. The purpose of this land is to enable future development and to ensure the operational integrity (the safety, security and ability to operate) of the station by providing a visual, sound and security buffer and to contain earth potential rise effects.

Planning
Non-critical buildings and land are managed by our regional service managers and may be used by connected customers for feeder access or associated connections equipment.

Operations and maintenance
Where possible and appropriate, we license non-critical buildings and lands to cover holding costs and where practicable provide a return. Generally tenants are responsible for maintenance of land and improvements. In the absence of a tenancy or where we need to carry out maintenance over and above the tenants’ obligations, these costs are met under the regional facilities Maintenance contracts.

Disposal and divestment
In 2014/15 we reviewed all our land holdings to identify any that were not directly necessary for the safe and secure operation of the grid. As a result we identified a number of properties for disposal and approved a three-year disposal programme starting in 2015/16 to sell surplus land subject to all necessary internal & regulatory approvals. For the year 2015/16 22 properties have been sold with gross proceeds of $6.5m. The disposal programme for 2016/17 covers a further 14 properties which could yield over $6million in gross proceeds.
24.4. **OFFICE BUILDINGS AND FACILITIES**

Asset characteristics and performance

We have corporate offices in Auckland, Hamilton, Wellington (two), Palmerston North and Christchurch. We also have warehouses at Otahuhu, Bunnythorpe and Addington substations, plus linesman training facilities at Western Road substation, Omaka (Blenheim) and Bunnythorpe substation. The Auckland office, Christchurch office, all the warehouses and training facilities are on sites owned by Transpower, so the maintenance of these sites is included as part of ACS buildings and grounds asset management. The Wellington, Palmerston North and Hamilton offices are leased. All the offices, warehouses and training facilities are in good condition and regularly maintained.

Planning

The following office projects are planned for RCP2.

- Consolidation of our two Wellington offices to a redeveloped site at 22 Boulcott Street, due to be completed in October 2017
- Minor refurbishments of our Auckland and Christchurch offices in 2019/20
- Upgrade of our warehouse facilities (various works planned from 2015/16 to 2017/18) Upgrade of the Western Road training facility in 2016/17.

Operations and maintenance

We have agreements with suppliers to maintain the office buildings and facilities. These are regularly reviewed.

Disposal and divestment

We plan to terminate the lease of our Horsham Downs office in Hamilton on 31/8/16 and relocate staff to the refurbished North Island Control Centre in Ruakura, Hamilton.

24.5. **VEHICLES**

Asset characteristics and performance

Our vehicles are predominantly located at the Auckland, Palmerston North and Christchurch offices. They are either allocated to staff that regularly visit our sites, landowners and customers or used as pool vehicles. We replaced the majority of vehicles in 2014 to meet higher safety standards and to ensure the fleet was fit for purpose.

Planning

We are planning to replace vehicles during RCP2 when they meet our replacement criteria. We participate in the All of Government contract for the supply of motor vehicles, which is regarded as the best available price offered in the market.

Operations and maintenance

The vehicle fleet is managed by an external provider who takes a consistent and cost-effective approach to maintenance based on manufacturer’s guidelines. GPS is fitted to vehicles to ensure they are operated efficiently and safely. We also participate in the Ministry of Defence syndicated fuel contract with BP, which has reduced our annual fuel bill by 15 per cent.
Part 5: Business Support Plan

Disposal and divestment
We use a condition based assessment to determine when vehicles should be replaced. We usually sell vehicles through established auction houses.

24.6. Office Equipment

Asset characteristics and performance
Our office equipment is modern and ergonomic.

Planning
We have budgeted to replace all Wellington office furniture when we relocate in 2017.

Operations and maintenance
Office equipment is repaired or replaced as required.

Disposal and divestment
We sell redundant office equipment or donate it to charities.

24.7. Business Support Works Plan

Table 65 below summarises our forecast RCP2 capex expenditure for business support.

<table>
<thead>
<tr>
<th>Table 65: Business Support RCP2 asset class capex plans</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Support</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

Asset Management Plan – August 2016