A SUPPORTING DOCUMENT TO OUR 2015 INTEGRATED TRANSMISSION PLAN

ASSET MANAGEMENT PLAN 2015

Keeping the energy flowing

TRANSPower

Transpower New Zealand Ltd The National Grid
# TABLE OF CONTENTS

**PART 1 : STRATEGIES AND FRAMEWORK**

1. **INTRODUCTION**
   1.1. Purpose
   1.2. 2015 context
   1.3. AMP structure

2. **FRAMEWORK**
   2.1. Overview
   2.2. Documentation

3. **STRATEGY AND OBJECTIVES**
   3.1. Context for 2015 strategy
   3.2. Asset management policy
   3.3. Asset management objectives and strategies

4. **IMPROVEMENT PLANS**
   4.1. Overview
   4.2. Grid operating model

5. **ASSET MANAGEMENT ACTIVITIES**
   5.1. Planning
   5.2. Delivery
   5.3. Operations
   5.4. Maintenance
   5.5. Disposal and divestments

6. **ICT FRAMEWORK**
   6.1. Overview
   6.2. ICT framework
   6.3. ICT drivers
   6.4. Service delivery lifecycle

7. **SYSTEMS AND CAPABILITY**
   7.1. Asset management information systems
   7.2. Standards and practices
   7.3. Asset risk management
   7.4. Asset management competence
   7.5. Continuous improvement

8. **ASSET WORKS AND DIVESTMENT OVERVIEW**
   8.1. Replacement and refurbishment (R&R)
   8.2. Enhancement and development (E&D)
   8.3. Asset divestments
PART 1 : STRATEGIES AND FRAMEWORK
1. INTRODUCTION

This chapter explains:
- the **purpose** of the Asset Management Plan (AMP)
- the **context** for this 2015 AMP
- the **structure** of this AMP.

### 1.1. PURPOSE

The AMP explains how we undertake asset management and describes our plans for 16 different asset classes.

It is one of three supporting documents for our 2015 Integrated Transmission Plan (ITP). The ITP provides an overview of our 10-year plans for our regulated transmission business.

![Figure 1: Structure of the Integrated Transmission Plan 2015](image)

This AMP documents our best view of our asset management plans today. The plans will adapt to changing requirements; in response to new information, detailed investigation, technology or other environmental factors; or as our asset management matures.

We will provide an update to the ITP in 2016.

### 1.2. 2015 CONTEXT

This AMP builds on and updates the 2013 asset management plans included in our regulatory proposal for the five-year control period beginning 1 July 2015 (RCP2).

#### 1.2.1. ASSET MANAGEMENT DEVELOPMENT

One of our current strategic priorities is to improve the effectiveness and efficiency of our business sufficiently to meet our targets for reduced expenditure and improved service over the RCP2 period.

We have begun a transformation programme that will mean changes to our asset management approach. For example, we are introducing improvements in:
- strategic and tactical asset management
INTRODUCTION

- how we make asset management decisions
- technology initiatives that streamline our asset management information processes
- the production of our asset management plan.

Chapter 4 describes this programme.

1.3. AMP STRUCTURE

The structure of this AMP is as follows.

<table>
<thead>
<tr>
<th>Part 1: Framework</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Introduction</td>
<td>•Purpose, context and structure</td>
</tr>
<tr>
<td>2: Framework</td>
<td>•How we structure our asset management framework</td>
</tr>
<tr>
<td>3: Strategies and objectives</td>
<td>•Our asset management direction and priorities</td>
</tr>
<tr>
<td>4: Improvement plans</td>
<td>•Our new business improvement plans</td>
</tr>
<tr>
<td>5. Asset management activities</td>
<td>•How we plan, deliver, operate, maintain, and dispose of assets</td>
</tr>
<tr>
<td>6: ICT framework</td>
<td>•How we manage information and communication technology</td>
</tr>
<tr>
<td>7: Systems and capability</td>
<td>•Key systems and capabilities that support our asset management</td>
</tr>
<tr>
<td>8. Asset works overview</td>
<td>•Summaries of capital expenditure and divestment plans</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part 2: Asset Class AMPs</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1: Introduction to AMPs</td>
<td>•Overview and approach to asset class AMPs</td>
</tr>
<tr>
<td>2: Asset class AMPs</td>
<td>•AMPs for grid, ICT and business support assets by asset class</td>
</tr>
</tbody>
</table>
2. FRAMEWORK

This chapter:

- provides an overview of our asset management framework
- explains the relationships between our asset management documents.

2.1. OVERVIEW

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. This followed a significant programme of work to assess and improve our asset management practices.

Our asset management framework includes:

- an asset management policy
- our asset management strategy and objectives
- asset management plans, processes, procedures and activities.

2.2. DOCUMENTATION

We have developed a set of documents to support and communicate our asset management strategies and plans. Figure 2 shows the relationships between these and our corporate strategies.

![Figure 2: Asset management documents](image)

A full set of asset management documents is available on our [website](http://www.transpower.co.nz).
3. STRATEGY AND OBJECTIVES

This chapter provides:

- **context** for our 2015 asset management strategy
- our **asset management policy**
- our high-level asset management **strategy and objectives** in five priority areas.

### 3.1. CONTEXT FOR 2015 STRATEGY

Our asset management strategy documents describe our objectives at multiple levels. For example, the objectives range from meeting our service performance targets at a high level down to making sure we are making timely, cost-effective decisions about replacement at an asset class level. As well as describing our objectives, the documents also describe the strategies we will employ to meet those objectives to set the direction and focus for our grid business.

For the 2015 AMP we have updated our high-level asset management objectives and strategies to:

- reflect progress since we first published our Asset Management Strategy in 2013
- include new priorities that have emerged since 2013. In particular, in the last year we have set new strategic priorities which have driven a number of business improvement initiatives and the redesign of our grid operating model. These improvement plans are described in Chapter 4.

### 3.2. ASSET MANAGEMENT POLICY

To align our asset management activities to our corporate objectives, we defined an asset management vision statement and asset management policy. 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.
3.3. **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

The rest of this section provides our updated objectives and strategies for these five areas.

### 3.3.1. SAFETY

We are committed to achieving an injury-free workplace for our employees and service providers, and to minimising public safety risks.

**Objectives**

In relation to our workforce, our objective is to ensure:

1. zero fatalities
2. zero injuries causing permanent disability
3. a sustained, declining trend in medical treatment injuries.

In relation to public safety, our objective is to:

4. take all reasonably practicable steps 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 have an increased focus on critical risks which can result in serious injury or fatality. We are introducing ‘bow-tie’ and semi-quantitative risk assessment (SQRA) approaches (these are described in section 7.3.3.)

- **Work collaboratively with our workers and partner service providers.** For example, we are making a step change in works planning to produce our plans earlier and improve their stability to create an environment where our staff and service providers can operate more safely and working with service providers to get better policies, work practices and reporting disciplines.

- **Using the asset management framework to drive safe outcomes.** We are implementing Safety by Design principles and applying these from concept to design, construction contracting and management and disposal of assets. We are training workers in these practices.

- **Investing in a team of engaged, productive workers.** We are supporting health and safety committees to work on meaningful projects, allocating resources to regularly communicate to workers, and setting up reward programmes to recognise individuals’ behaviour.

- **Run a health and safety system that delivers safe outcomes.** For example, we are providing service specifications and policies to service providers to ensure best practice, reviewing work management policies and providing an improved and transparent public safety management system.
3.3.2. **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.

**Objectives**

Our service performance objectives are summarised in the ITP Chapter 4, with more detail provided in our Services Report.

**Service performance strategies**

To support these objectives we have the following strategies.

- **Risk management**: we are continuing to develop asset health and criticality measures and are starting to roll out bow-tie risk management methodology across the business.
- **Targeting interventions**: we will be using a ‘bow-tie’ risk management methodology to assist in targeting interventions to help us meet our service objectives.
- **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.
- **Outage planning**: we have undertaken a comprehensive review of our outage planning processes and are implementing improvement initiatives.

3.3.3. **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 the ITP Chapter 7.

**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 optimising our grid opex through targeted reductions in maintenance expenditure. We have implemented a maintenance practice workstream to identify and deliver efficiencies.
- **Divestment programme**: we are reducing overall costs to end consumers by divesting non-core assets to distribution businesses who are better placed to manage low-voltage assets. We have completed several divestments and have more under discussion.
- **Improved cost estimation**: we use feedback from completed projects to improve the cost estimation systems used to evaluate options and manage delivery costs.
• **Improved procurement**: we are running an initiative to optimise long-term supply contracts for our primary assets among other procurement initiatives to drive efficiencies.

• **Targeted investments**: We continue to use our new performance targets and asset health analysis to prioritise our spending.

### 3.3.4. NEW ZEALAND’S COMMUNITIES

Maintaining our relationships with communities and landowners, and ensuring we can access and protect our assets, is essential for us to effectively manage our network.

Communities 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 landowners and communities to mitigate these impacts.

We need to be able to gain access to our assets for maintenance, to resolve incidents and in emergency situations, and we need our investments to be protected from development that might impact on safety or constrain our operations.

**Objectives**

Our objectives are in terms of:

1. **access arrangements**: secure appropriate corridor provisions in district plans
2. **environment**: improve environmental performance and ensure 90% 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.

**Community strategies**

To support these objectives, we have the following strategies.

• **Participation in all district plan reviews**: we have initiated a significant project to coordinate our participation in all district plans and the Auckland Supercity Plan. This is included in our enhancement and development programme (section 8.2.1).

• **Community Care Fund**: during 2014/15 we undertook 45 community-based projects, and will continue this programme.

• **Greenhouse gas emissions**: we are continuing to identify and remove leak prone SF₆ circuit breakers. We have reduced emissions since 2005 and last year we achieved the lowest ever rating of 0.35 per cent.

• **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.

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

### 3.3.5. 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 objectives are in terms of:

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. **Asset management competence:** we will establish a framework for asset management competence by 2016.

4. **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 decision function by developing a systematic and transparent risk-based decision-making process to justify and appropriately balance capital and operational expenditure across all grid assets. This involves a company-wide programme to implement ‘bow-tie’ and semi-quantitative risk assessment (SQRA). (Section 7.3 explains our risk management approach in more detail.)

- **Asset knowledge:** we are establishing a new asset information management team in our new grid operating model. This team will focus on implementing our asset information strategies. We are also beginning a data automation work programme focussing on eliminating the duplication of data entry into our asset information systems by Transpower and service provider staff, automating data flows and improving data quality.

- **Asset management competence:** we have implemented an asset management competence framework for some specific roles and we will review and expand this across the business as we transition to our new grid operating model.

- **Continuous improvement:** we have implemented a process and governance for formal, structured, investigative and problem resolution for high-severity events or systemic issues associated with grid asset failures. The design of the new grid operating model is focussed 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 (see Chapter 4).
4. IMPROVEMENT PLANS

This chapter explains:

- our improvement plans
- our new grid operating model

4.1. OVERVIEW

We published our Initiatives Plan in June 2015 that sets out our plans for developing service measures and targets for the RCP3 period, and for improving our asset management and forecasting capability. The plan focusses on the period leading up to our 2018 ITP, which will form the basis of our RCP3 proposal. Our aim is to have any material new processes and tools developed by mid-2017 so they can be used in preparation of the 2018 ITP.

The Initiatives Plan identifies our transformation programme as our key business improvement initiative, and identifies the following components of the programme:

- re-engineered grid operating model
- 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
- redevelopment of Transmission Tomorrow
- development of our ITP.

In addition, the Initiatives Plan identifies two further areas where we will provide more detailed improvement plans in March 2016:

- asset health modelling
- cost estimation.

We are also developing an engagement paper that we will use to support development of our RCP3 service measures and targets. We are planning to publish this in September 2016, and intend to cover:

- how we use economic estimates of the value of reliability (termed the value of lost load, or VoLL) within our framework for setting reliability targets
- using new costing and feasibility information to re-test our restoration targets
- considering the results of a pilot study of metrics for our event communications service, and comparing these with a survey-based approach
- reviewing how we construct metrics for grid availability that capture the essence of this service
- examining how ‘fitness for service’ fits with our service targets and the broader regulatory framework.
4.2. **GRID OPERATING MODEL**

Re-engineering of our grid operating model is central to our transformation programme, and to our plans for improving our asset management. We have designed 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 high-level operating model is illustrated below.

We are in the process of implementing the new model, including putting in place a new structure to support it and developing supporting processes and tools. This work includes putting in place new strategic and tactical asset management teams, who will assume accountability for our asset management plan.
5. ASSET MANAGEMENT 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 and are available on our website.

The asset class AMPs in Part 2 present our plans for lifecycle activities for each asset class.

5.1. 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:

- **Replacement and refurbishment (R&R):** These investments consist of like-for-like replacements, or refurbishments that extend the life of existing assets.

- **Enhancement and development (E&D):** These investments lead to new grid build to provide additional capability. They can be either:
  - major capex projects above $20 million which require separate regulatory approval or
  - base E&D projects less than $20 million.

- **Customer investments:** We make these investments to meet requirements specified by a customer, where we would not undertake them as part of our normal programme of work. The customer funds these investments directly and the work is contestable, but must meet safety, environment and network integrity requirements.

5.1.1. APPROACH

Our planning approach includes the following steps:

- needs identification
- options analysis
- cost estimation
- approvals
- integration and optimisation
- governance
5.1.2. NEEDS IDENTIFICATION
We investigate where investments may be needed through: asset condition monitoring, network studies, technology assessments and safety reviews.

5.1.3. OPTIONS ANALYSIS
Once we have identified grid capex needs, we can consider potential solutions. The number and type of options varies depending on the type, value and complexity of the investment. Our options analysis is based on whether the capex is related to E&D, R&D or customer investments.

Replacement and refurbishment
We address most condition-related issues through two intervention options: to replace or refurbish the asset, or continue maintaining the asset.
We compare the whole-of life costs and benefits (such as reduced failure risk) of replacing or refurbishing the asset, with the costs of maintaining the asset, or running the asset to failure. We also determine the optimum timing for the intervention.

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)\(^1\). Typical options to address the needs include:

- non-transmission solutions such as demand response

\(^1\) The GRS are set out in the Electricity Industry Participation Code.
ASSET MANAGEMENT ACTIVITIES

• 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.

Customer investments
The need for 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.

5.1.4. 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 for large single projects (>1m) that 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.

5.1.5. INTEGRATION AND OPTIMISATION

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

The main processes are as follows.

• During investigation: during detailed investigations we identify opportunities for work integration (for example, to include transmission protection work alongside power transformer work).
• Service provider meetings: we undertake an annual process with our service providers to challenge and reaffirm planned grid capex and opex for the upcoming 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.
• Delivery integration: we integrate and optimise our grid capex plans after formal approval to proceed. This ensures that we reflect changing priorities, including any changes in investment drivers, and resource availability. It also takes account of changes to the asset base, including asset failures and unforeseen events (such as damage by storms or earthquakes).

5.1.6. GOVERNANCE AND APPROVALS

Throughout the planning process we use a challenge and review process to ensure that proposed projects are consistent with relevant 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**: this 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**: this finalises the budget and, subject to management sign-off, gives authority for the work to proceed.

Our ITP contains projects at different business case stages. Those planned for earlier years are further ahead than those planned for later years.

### 5.2. DELIVERY

Delivery covers all capital build: E&D, R&R or customer investment.

#### 5.2.1. APPROACH

Delivery involves three main stages:

- planning 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.

Figure 5 illustrates our delivery approach.

![Figure 5: Delivery process and main activities](diagram.png)
5.2.2. PLANNING AND DESIGN
This stage converts early work completed in the planning phase (which focuses 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.

5.2.3. 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.

5.2.4. 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.

5.2.5. 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.

5.3. OPERATIONS
Transpower operates its 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.

5.3.1. APPROACH
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.

5.4. 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.
Routine maintenance

We categorise routine maintenance into four work types. The work types distinguish how the work is initiated and are fundamental to our approach to maintenance improvement. 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.</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 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.

5.4.1. APPROACH

We group our maintenance activities as:

- maintenance specification—specifying 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.

5.4.2. MAINTENANCE SPECIFICATION

Maintenance specification involves:

- specification of maintenance requirements
- asset information assessments to improve reliability
- risk management to improve performance

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 assure 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. We have a set of standard...
maintenance procedures (SMPs) that define preventive maintenance on all asset types. We use these SMPs 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.
- **Quality management**: We have field assessors who communicate standards and monitor compliance with our maintenance practices. The quality management covers skills and competency as well as work practices, and compliance with maintenance and supply requirements.

### 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 requirements and our asset health measures.

### Risk management to improve performance

Performance improvement activities weigh maintenance costs against risks to our performance. These activities include using asset health indices to inform our planning, and using an asset criticality model to look at the impact on customer continuity of supply of parts of our network. These are described in section 7.2 on risk management.

### 5.4.3. 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 lines, towers and fibre optics on towers
- **stations**: covering our substations and underground cables
- **others**: such as 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, 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.

### 5.5. 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.

#### 5.5.1. APPROACH

**Disposal**
We make asset disposal decisions as part of our planning process set out in section 5.1 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 fleet.
- **Customer requests**: some customers proactively seek to purchase and manage their connection assets.
6. ICT FRAMEWORK

This chapter provides overviews of:

- the Information Systems and Communication Technologies (ICT) we use and manage
- our ICT governance framework
- our ICT drivers
- our ICT lifecycle activities.

An overview of our ICT plans is provided in the ICT asset management plan in Part 2.

6.1. OVERVIEW

ICT delivers and supports the infrastructure, server hardware and applications that interface Grid technology and connect the system operator and the market.

Figure 6: Overview of our ICT systems, infrastructure and services

We divide our grid-based ICT into five business service categories, as shown in the table 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 provides better alignment with our reporting and governance processes.
Table 2: 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 and planning 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>

6.2. ICT FRAMEWORK

6.2.1. RELATIONSHIP BETWEEN OUR PLANNING AND STRATEGIC DOCUMENTS

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.

6.2.2. ICT GOVERNANCE

Our ICT programmes are guided by a set of enterprise architecture principles.

- 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, acting as the ICT Governance Board (ICTGB), is the primary authority for all ICT governance. 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.

6.3. 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.

6.4. SERVICE DELIVERY LIFECYCLE

ICT planning and governance processes rely on the service delivery lifecycle (SDLC)—our overarching project delivery framework which broadly corresponds to the asset management lifecycle for our grid assets of planning, delivery, operations, maintenance and disposal.

The SDLC has five stages, as follows.

• **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.
7. SYSTEMS AND CAPABILITY

This chapter covers key systems and capabilities that support our asset management:

- asset management information systems
- standards and practices
- asset risk management processes
- asset management competence
- continuous improvement.

7.1. ASSET MANAGEMENT INFORMATION SYSTEMS

To meet the long-term expectations of our customers we must manage our assets effectively, and 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, or data such as asset characteristics, performance, condition, incident reports, work and expenditure histories.

Asset management information system

Maximo is our asset management information system for all grid assets. We use Maximo as our asset register, and to manage our maintenance programme. Maximo is also an integral part of Transpower’s finance 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.

We have recently enabled the Health, Safety and Environmental add-on within Maximo. This system is being used to deploy additional business processes, which will enable us to work on:

- integrated management of hazards and risk
- improved data quality with more accurate reporting
- reduced data replication
- improved planning for safety, resulting in a safer working environment
- full transparency of corrective actions
- integration with work order management.

This will enable us to manage hazards in Maximo and gives us better visibility of site hazards when planning work. Corrective actions are also managed in Maximo and mitigate the risk of repeat incidents.

7.2. STANDARDS AND PRACTICES

We maintain a set of controlled documents that are an important part of our asset management process. They cover things like 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.

The asset class AMPs in Part 2 refer to asset-specific standards, specifications or operating instructions.

<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>
</tr>
<tr>
<td></td>
<td>• lines policies</td>
</tr>
<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 standard</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 procedures</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>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>

7.3. **Asset Risk Management**

Effective risk management is a critical component of our business. By understanding the risks that need to be managed to meet our objectives, we can make better asset management decisions.
The overall purpose of our asset risk management is to:

- understand the causes, consequences and likelihoods of adverse events occurring
- manage the risks within our corporate risk appetite through established controls
- actively monitor controls for adequacy and effectiveness
- provide assurance that asset management risks are being well managed.

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

7.3.1. ESTABLISHING EFFECTIVE ASSET RISK MANAGEMENT

Our asset risk management process is supported by our Asset Risk Management Policy which is aligned with the Transpower Risk Management Policy.

The policy includes reference to our corporate risk appetite and details of the broad categories under which we classify and assess risks. Our risk appetite is encompassed in a risk assessment matrix so we can apply a consistent approach to our risk analysis.

We have an asset risk management process that involves six key stages that are consistent with AS/NZS ISO 31000:2009 Risk management—Principles and Guidelines. These stages are illustrated below.

7.3.2. EMBEDDING THE PROCESS

We have established a risk register for each grid team and have held facilitated risk workshops to capture and analyse team-specific risks. We regularly review risks at a team, general management and board level, as follows.

- We hold monthly risk review meetings at a team level.
- The Management Risk Committee meets monthly and reviews risks for each group on a rotating basis.
- We report the most significant risks to the board on a monthly basis.
The Board Risk Committee reviews risks on a quarterly basis.

By regularly analysing the aggregated risk register we can effectively monitor and manage our overall risk profile. The register also highlights key risk trends, which are useful to inform decision-making.

7.3.3. RISK MANAGEMENT DEVELOPMENT PLANS

To improve our risk management we are establishing two integrated risk management methodologies company-wide with supporting software:

- bowtie analysis
- semi-quantitative risk assessment (SQRA).

**Bowtie analysis**

Bowtie analysis is a well-established method used to visually analyse and communicate the control environment related to a given risk (or hazard).

**Figure 9: Example of a bowtie risk management diagram**

The power of a bowtie diagram is that it provides an overview of multiple plausible scenarios, in a single picture. It provides a simple, visual representation of a risk that would be more difficult to explain effectively in a traditional approach using a risk register.

The bowtie diagram illustrates the root cause, threats or triggers of credible events, and the consequences or outcomes. The control environment is then mapped to the relevant threat paths.

**SQRA**

Bowtie analysis is most effective when it is paired with a SQRA approach that can compare risks and can estimate the value of preventive and recovery risk controls.

SQRA evaluates and scores risks using an approach that integrates traditional qualitative risk evaluation and quantitative risk assessment.

**Our progress**

We are using bowtie analysis and SQRA methodologies within the corporate services and legal and compliance functions. We are rolling out the techniques to other areas of the business, and will include the grid assets and asset management activities in 2016.
7.3.4. **ASSET CRITICALITY AND HEALTH**

**Asset criticality**

Understanding the consequences of outages or failures of our assets allows us to understand which assets are most important. We use an asset criticality framework to estimate the consequences of failure for each asset. This framework approach is new to Transpower, and is still under development. 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.

**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. It takes into account a range of factors such as asset condition, failure rate, and environmental factors, depending on the asset class.

We have AHI models for nine asset classes, including the most expensive and most numerous stations and lines assets.

**Informing asset management**

Asset criticality represents the impact of failure, and asset health is a proxy for the probability of failure. By assessing both criticality and asset health we are able to estimate asset risk, and this helps us to prioritise our asset plans.

The asset class AMPS in Part 2 provide a summary of criticality and asset health where this is available. We continue to extend our criticality and asset health models to other asset classes.

---

7.4. **ASSET MANAGEMENT COMPETENCE**

As a business providing an essential service with high safety hazards, we must have ready and continued access to a sufficient pool of competent people who can undertake key activities. These people include a diverse workforce of highly skilled employees and service providers. We are also the only large employer in New Zealand for many specialist skills required for the management, construction and maintenance of the grid.

In our People and Capability Strategy, we recognise the importance of asset management competence. To further develop this competence, we have developed an asset management competence framework and we are in the process of embedding it across our business.

---

7.5. **CONTINUOUS IMPROVEMENT**

Our main continuous improvement focus for the next two years is our transformation programme.

We also have initiatives to drive continuous improvement through our corrective and preventive action processes, and the use of innovation to meet and improve the delivery of our services to our customers and end consumers, where it is economic to do so.
7.5.1. Transformation Programme

As explained in Chapter 4, our improvement plans and the implementation of the new grid operating model is focused on improving our asset management. As we move to this new way of working, we expect to see improvements across a range of activities such as strategy, planning, service delivery and integrated feedback loops.

7.5.2. Corrective and Preventive Action

The purpose of corrective action is to address the root cause of identified non-conformances, problems or incidents, to prevent or reduce the likelihood of recurrence. Preventive actions are proactive steps taken to address the root cause of potential problems before they occur.

Our approach to corrective and preventive action is not currently well integrated across all asset management activities. Opportunities exist to improve this integration, for example by using a more systematic approach to learning from incidents, identifying root causes, and following through with initiatives to prevent recurrence. We have plans to improve our incident analysis and asset feedback through implementation of our new grid operating model and improvement initiatives.

7.5.3. Innovation

Our long-term strategy for the grid includes lifting performance by adopting approaches that are innovative or use new technology.

Adopting innovations and new technology can lead to significant benefits, but may also bring risks. We may choose to be either a leader or a follower of innovations, based on the benefit/risk trade-off of these innovations to consumers when applied to the grid.

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 have evidence that its use is a success.
8. ASSET WORKS AND DIVESTMENT OVERVIEW

This chapter summarises our plans for:

- replacement and refurbishment of assets
- enhancement and development projects
- asset divestment.

8.1. REPLACEMENT AND REFURBISHMENT (R&R)

R&R activities are generally managed as a series of programmes within a portfolio, focussed on a particular asset fleet (such as power transformers.) These programmes include some of our largest by value, such as transformer replacements, outdoor to indoor conversions and tower painting.

When assets approach the end of their lives we take the opportunity to review whether they are at appropriate capacities or capabilities, or whether they are still required.

The asset class AMPs in Part 2 explain our R&R planning for each asset class.

We have made some changes to our R&R plans since our 2013 ITP, as we gain updated information on assets and service requirements and reprioritise to meet our RCP2 allowances set by the Commerce Commission. The changes reflect:

- updated asset condition information
- reprioritisation based on safety or service criticality
- updated cost estimates
- our integrated works plan.

We continue to reassess our plans throughout RCP2.

Table 4 provides a summary of our planned R&R for the five-year RCP2 period, showing changes since our 2013 ITP. The table presents the number of units and the value of assets to be commissioned. The number of units is given for those asset classes where R&R has relatively standard unit costs. For those asset classes where the cost of individual replacements or refurbishments can vary significantly, we have provided only the total value of the programmes.

We treat some large-scale reconductoring projects in the same way as major capex projects with separate approval from the Commerce Commission. These ‘listed projects’ are included in the next section.

Our asset classes are grouped as towers and lines (TL), alternating current stations (ACS) and secondary assets (SA), HVDC and other R&R.
Table 4: R&R plans (totals for five-year RCP2 period)

<table>
<thead>
<tr>
<th>Assets</th>
<th>Total units replaced or refurbished</th>
<th>Commissioned value ($m)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ITP 2013</td>
<td>ITP 2015</td>
</tr>
<tr>
<td>TL Tower (replacement)</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>TL Pole</td>
<td>982</td>
<td>913</td>
</tr>
<tr>
<td>TL Paint (painted or repainted)</td>
<td>2,580</td>
<td>2,569</td>
</tr>
<tr>
<td>TL Foundation</td>
<td>89</td>
<td>97</td>
</tr>
<tr>
<td>TL Grillage</td>
<td>1,910</td>
<td>1,685</td>
</tr>
<tr>
<td>TL Conductor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TL Insulators</td>
<td>7,090</td>
<td>6,398</td>
</tr>
<tr>
<td>TL Access</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Outdoor to indoor conversions</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>ACS Outdoor circuit breakers</td>
<td>136</td>
<td>128</td>
</tr>
<tr>
<td>ACS Indoor switchgear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Power transformers</td>
<td>26</td>
<td>30</td>
</tr>
<tr>
<td>ACS Buildings and grounds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Buildings and seismic</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Dynamic reactive power</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Capacitors and reactors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Power cables</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Structures and buswork</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ACS Instrument transformers</td>
<td>189</td>
<td>170</td>
</tr>
<tr>
<td>ACS Disconnectors and earthswitches</td>
<td>170</td>
<td>151</td>
</tr>
<tr>
<td>ACS Other station equipment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SA Substation management systems</td>
<td>168</td>
<td>130</td>
</tr>
<tr>
<td>SA Metering</td>
<td>35</td>
<td>34</td>
</tr>
<tr>
<td>SA Buszone protection</td>
<td>47</td>
<td>40</td>
</tr>
<tr>
<td>SA Line protection</td>
<td>137</td>
<td>136</td>
</tr>
<tr>
<td>SA Transformer protection</td>
<td>75</td>
<td>71</td>
</tr>
<tr>
<td>SA Batteries and DC systems</td>
<td>179</td>
<td>171</td>
</tr>
<tr>
<td>SA Feeder protection</td>
<td>52</td>
<td>45</td>
</tr>
<tr>
<td>HVDC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RR Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>876.8</strong></td>
<td><strong>850.4</strong></td>
</tr>
</tbody>
</table>

3 Total units are provided only for those assets where R&R has relatively standard unit costs.
8.2. ENHANCEMENT AND DEVELOPMENT (E&D)

Our development programme is built from projects to resolve issues identified in our Transmission Planning Report. It includes:

- base capex projects (< $20 million)
- major capex projects (> $20 million).

8.2.1. BASE CAPEX

Since our 2013 ITP we have made changes to a number of our base capex E&D projects. The changes reflect a mixture of:

- updated cost information from TEES
- scope or timing changes through further investigation.

We have also identified new projects that we expect will be needed during the RCP2 period.

Table 5 provides updates on the projects we included in our 2013 ITP, and an overview and estimates for the new projects.

Table 5: Update on base E&D projects

<table>
<thead>
<tr>
<th>RCP2 projects</th>
<th>2013 ITP $m</th>
<th>2015 ITP $m</th>
<th>2015 ITP update</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projects included in 2013 ITP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Otahuhu–Wiri Transmission Capacity</td>
<td>19.7</td>
<td>17.6</td>
<td>We have made changes in costs as a result of further investigation and revisions to scope of the work. This is a potential major capex project.</td>
</tr>
<tr>
<td>Relieve Generation Constraints</td>
<td>17.9</td>
<td>5.8</td>
<td>This programme is for grid upgrades to facilitate new or increased generation connection. At the time of ITP 2013 the largest project included was upgrading T13 at Kawerau. Following further analysis we have decided not to progress the T13 upgrade.</td>
</tr>
<tr>
<td>Upper North Island Reactive Support</td>
<td>8.7</td>
<td>8.0</td>
<td>We have updated cost estimates, but with no change in scope.</td>
</tr>
<tr>
<td>Bus Section Fault Reliability</td>
<td>15.2</td>
<td>7.7</td>
<td>In 2013 ITP this project included work to increase the bus security at Bunnythorpe, Mt Roskill and Haywards. Following further analysis we have:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- reduced the scope for the Mt Roskill work</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- removed Bunnythorpe from this portfolio. It is included as a new project (see Bunnythorpe 220kV Structure and Buswork Section Security below.)</td>
</tr>
<tr>
<td>Wellington Supply Security</td>
<td>12.3</td>
<td>-</td>
<td>We have investigated options in more detail considering condition, capability and work to enable reconductoring and have decided this work is no longer needed.</td>
</tr>
<tr>
<td>Otahuhu and Penrose Interconnection Capacity</td>
<td>17.6</td>
<td>5.3</td>
<td>We have revised the scope from three transformers to one following further investigation:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Otahuhu T4 withdrawn</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Otahuhu T2 replacement deferred to RCP3.</td>
</tr>
<tr>
<td>RCP2 projects</td>
<td>2013 ITP $m</td>
<td>2015 ITP $m</td>
<td>2015 ITP update</td>
</tr>
<tr>
<td>---------------------------------------------------</td>
<td>-------------</td>
<td>-------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Bunnythorpe Interconnection Capacity</td>
<td>9.5</td>
<td>8.4</td>
<td>We have revised cost estimates and brought the project forward one year based on a revised need assessment.</td>
</tr>
<tr>
<td>New Plymouth Early Exit (previously North Taranaki</td>
<td>0.2</td>
<td>17.3</td>
<td>We have revised the scope of the work and cost estimates and brought the project forward based on an updated need assessment. This project is a potential major capex project.</td>
</tr>
<tr>
<td>Transmission Capacity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Timaru Interconnecting Transformers Capacity</td>
<td>0.2</td>
<td></td>
<td>This is part of a larger project ($8 million) expected to be commissioned in RCP3. We are currently investigating need, scope and timing.</td>
</tr>
<tr>
<td>Southland Reactive Power Support</td>
<td>6.4</td>
<td>6.2</td>
<td>We have updated cost estimates, but with no change in scope.</td>
</tr>
<tr>
<td>High-Impact Low Probability Event Mitigation</td>
<td>11.3</td>
<td>8.0</td>
<td>This includes a number of projects. We commissioned two of them earlier in RCP1 and have identified three new projects which are undergoing detailed investigation to confirm scope and timing.</td>
</tr>
<tr>
<td>Hororata and Kimberley Voltage Quality</td>
<td>3.6</td>
<td>3.4</td>
<td>We have revised costs and deferred the project by two years based on a revised assessment of the need.</td>
</tr>
<tr>
<td>Islington Spare Transformer Switchgear</td>
<td>2.5</td>
<td></td>
<td>The economic benefits do not justify progressing with this project at this time.</td>
</tr>
<tr>
<td>Haywards Local Service Third Incomer</td>
<td>1.9</td>
<td></td>
<td>The economic benefits do not justify progressing with this project at this time.</td>
</tr>
<tr>
<td>E&amp;D Other</td>
<td>3.7</td>
<td>4.5</td>
<td>This portfolio consists of a number of smaller projects. The changes reflect both revised cost estimates and scope for the projects included in the portfolio.</td>
</tr>
</tbody>
</table>

**New projects (not included in 2013 ITP)**

| Corridor Management Programme                      | -           | 2.1         | Strategic programme of works to seek and advocate for appropriate provisions in statutory planning documents under the Resource Management Act.          |
| Auckland Supercity Programme                       | -           | 3.0         | Strategic programme of works to seek and advocate for appropriate provisions in statutory planning documents under the Resource Management Act within the Auckland Supercity region. |
| Masterton Bus 110 kV Bus Security                   | -           | 1.5         | New work identified to improve bus security at Masterton. Currently undergoing detailed investigation to confirm need, scope and timing.             |
| Bunnythorpe 220 kV Structure and Buswork Section   | -           | 3.1         | This includes Bunnythorpe work previously included in the Bus Section Fault Reliability portfolio. (No change to scope of the work.)                  |
| Security                                           |             |             |                                                                                                                                                |
| Total                                              | 130.7       | 101.9       |                                                                                                                                                |
8.2.2. MAJOR CAPEX

Our 2015 ITP forecasts include the following major capex items:

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

These are shown in the tables below. We have other major capex and listed reconductoring projects under development for RCP3 and beyond. These are included in ITP Schedule 7.

Approved projects

Table 6: RCP2 Commerce Commission-approved major capex projects

<table>
<thead>
<tr>
<th>Approved projects</th>
<th>Commissioned value ($m)</th>
<th>2015 ITP update</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bunnythorpe–Haywards A and B line reconductoring</td>
<td>127.3</td>
<td>136.9</td>
</tr>
<tr>
<td>Clutha–Upper Waitaki Lines Project (previously Lower South Island Renewables)</td>
<td>104.8</td>
<td>24.4</td>
</tr>
<tr>
<td>HVDC</td>
<td>-</td>
<td>9.5</td>
</tr>
<tr>
<td>North Island Grid Upgrade Project (NIGUP)</td>
<td>-</td>
<td>4.5</td>
</tr>
<tr>
<td>North Auckland and Northland Grid Upgrade Project (NAaN)</td>
<td>-</td>
<td>3.2</td>
</tr>
<tr>
<td>Upper North Island Dynamic Reactive Support (UNIDRS)</td>
<td>25.7</td>
<td>6.5</td>
</tr>
<tr>
<td>Lower South Island Reliability</td>
<td>18.1</td>
<td>19.2</td>
</tr>
</tbody>
</table>
Other Approved  -  4.6

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

Listed projects

Table 7: RCP2 listed projects

<table>
<thead>
<tr>
<th>Line</th>
<th>Affected circuits</th>
<th>Commissioned value ($m)</th>
<th>2015 ITP update</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>2013 ITP</td>
<td>2015 ITP</td>
</tr>
<tr>
<td>Bunnythorpe–Wilton A</td>
<td>Bunnythorpe–Linton–Wilton 1</td>
<td>4.4</td>
<td></td>
</tr>
<tr>
<td>(Bunnythorpe–Judgeford section)</td>
<td>Bunnythorpe–Tararu Wind Central–Linton 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Haywards–Linton 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deferral of the conductor replacement date into RCP3 and beyond based on present condition assessment information.</td>
<td></td>
</tr>
<tr>
<td>Bunnythorpe–Wilton A</td>
<td>Bunnythorpe–Linton–Wilton 1</td>
<td>49.7</td>
<td>53.5</td>
</tr>
<tr>
<td>(Judgeford–Wilton section)</td>
<td>Haywards–Wilton 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated cost estimates.</td>
<td></td>
</tr>
<tr>
<td>Brunswick–Stratford B</td>
<td>Brunswick–Stratford 3</td>
<td>11.3</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Deferral of the conductor replacement date into RCP3 and beyond based on present condition assessment information.</td>
<td></td>
</tr>
<tr>
<td>Central Park–Wilton B</td>
<td>Central Park–Wilton 2 and 3</td>
<td>26.1</td>
<td>27.4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated cost estimates.</td>
<td></td>
</tr>
<tr>
<td>Oteranga Bay–Haywards A</td>
<td>HVDC Pole 2 and 3</td>
<td>28.2</td>
<td>29.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Updated cost estimates.</td>
<td></td>
</tr>
</tbody>
</table>

Under development

Table 8: RCP2 major capex projects under development

<table>
<thead>
<tr>
<th>Projects</th>
<th>Description</th>
<th>Commissioned value ($m)</th>
<th>2015 ITP update</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>51.2</td>
<td>57.1</td>
</tr>
<tr>
<td>Lower North Island Transmission Build Provision</td>
<td>The work is a provision to relieve constraints on the 220 kV Tokaanu–Whakamaru circuits to facilitate generation in the Lower North Island when there were quite a few proposals for wind generation in the area.</td>
<td>20.3</td>
<td>-</td>
</tr>
<tr>
<td>Waitaki Valley</td>
<td>This project is to reduce constraints in the lower Waitaki 110 kV network.</td>
<td>20.2</td>
<td>21.6</td>
</tr>
</tbody>
</table>
8.3. Asset Divestments

We have an on-going programme of asset divestments. In the last two years we have divested seven sets of line or substation assets to connected customers. We are exploring other potential asset transfers with customers to rationalise our asset base to focus on the development, operation and maintenance of the backbone grid.

Table 9 lists the assets we considered possible for divestment at the time of our 2013 ITP, with an update for 2015. Any asset transfers will affect our forecast capital and operating expenditure.

<table>
<thead>
<tr>
<th>Station assets</th>
<th>Line assets</th>
<th>Target date</th>
<th>2015 ITP update</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waitaki T28 transformer</td>
<td>-</td>
<td></td>
<td>Deferred</td>
</tr>
<tr>
<td>Waipawa 33kV and 11kV switchyards</td>
<td>-</td>
<td></td>
<td>Deferred</td>
</tr>
<tr>
<td>-</td>
<td>Sections of Mangahao–Paekakariki–A and B line</td>
<td>2016</td>
<td>Under discussion</td>
</tr>
<tr>
<td>Hinuera substation</td>
<td>Hinuera–Karapiro–A line</td>
<td>2017</td>
<td>Under discussion</td>
</tr>
<tr>
<td>Hamilton 11 kV switchboard</td>
<td>-</td>
<td></td>
<td>Withdrawn</td>
</tr>
<tr>
<td>Hamilton 33 kV switchboard</td>
<td>-</td>
<td></td>
<td>Withdrawn</td>
</tr>
<tr>
<td>Hororata 33 kV switchyard</td>
<td>-</td>
<td></td>
<td>Deferred</td>
</tr>
<tr>
<td>Islington 33 kV switchyard</td>
<td>-</td>
<td></td>
<td>Deferred</td>
</tr>
<tr>
<td>Arthurs’ Pass substation</td>
<td>-</td>
<td></td>
<td>Under discussion</td>
</tr>
<tr>
<td>Castle Hill substation</td>
<td>-</td>
<td></td>
<td>Under discussion</td>
</tr>
</tbody>
</table>
INTRODUCTION TO ASSET CLASS AMPS

This chapter provides:

- an overview of our asset base
- our approach to the asset class AMPs.

1.1. OVERVIEW OF OUR ASSET BASE

Our asset base includes an extensive network of assets located throughout New Zealand. It includes 169 substations, 11,238 km (route length) of transmission lines, three submarine HVDC cables and extensive communications fibre.

The Transmission Planning Report includes an overview of our network, and of each network region.

<table>
<thead>
<tr>
<th>Table 10: Overview of our asset base</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AC stations</strong></td>
</tr>
<tr>
<td>Substations</td>
</tr>
<tr>
<td>169</td>
</tr>
<tr>
<td>Power transformers (total banks)</td>
</tr>
<tr>
<td>323</td>
</tr>
<tr>
<td>- Supply</td>
</tr>
<tr>
<td>266</td>
</tr>
<tr>
<td>- Interconnecting</td>
</tr>
<tr>
<td>57</td>
</tr>
<tr>
<td>HV power cable</td>
</tr>
<tr>
<td>68.4 km</td>
</tr>
<tr>
<td>Outdoor circuit breakers (all voltages)</td>
</tr>
<tr>
<td>Indoor switchgear (total circuit breakers)</td>
</tr>
<tr>
<td>Reactive power</td>
</tr>
<tr>
<td>- STATCOMS and SVCs</td>
</tr>
<tr>
<td>10</td>
</tr>
<tr>
<td>- Synchronous condensers</td>
</tr>
<tr>
<td>8</td>
</tr>
<tr>
<td>- Capacitors</td>
</tr>
<tr>
<td>96</td>
</tr>
<tr>
<td>- Reactors</td>
</tr>
<tr>
<td>145</td>
</tr>
<tr>
<td>23,663</td>
</tr>
<tr>
<td>14,364</td>
</tr>
<tr>
<td>Instrument transformers (standalone)</td>
</tr>
<tr>
<td>Disconnectors and earth switches</td>
</tr>
<tr>
<td>5,452</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>ICT</strong></td>
</tr>
<tr>
<td>Fibre cable (OPGW)</td>
</tr>
<tr>
<td>440 km</td>
</tr>
<tr>
<td>Fibre cable (ADSS)</td>
</tr>
<tr>
<td>5 km</td>
</tr>
<tr>
<td>Fibre cable (buried)</td>
</tr>
<tr>
<td>775 km</td>
</tr>
<tr>
<td>Fibre cable (submarine)</td>
</tr>
<tr>
<td>135 km</td>
</tr>
<tr>
<td>SDH multiplex equipment</td>
</tr>
<tr>
<td>264 Devices</td>
</tr>
<tr>
<td>PDH multiplex equipment</td>
</tr>
<tr>
<td>407 Devices</td>
</tr>
<tr>
<td>CORE MPLS routers</td>
</tr>
<tr>
<td>36 Devices</td>
</tr>
</tbody>
</table>

1.2. APPROACH TO ASSET CLASS AMPS

The asset class AMPs build on and update the work completed for our 2013 ITP. They are based on our fleet strategies, but updated to reflect changes since ITP 2013.

---

4 These include small populations of unique assets, including thyristor valves, cooling systems, controls, and valve base electronics.
Each AMP includes:

- asset class description
  - the role of the assets
  - asset population and age statistics for in-service assets
- asset characteristics—this covers asset criticality and asset health indices
- asset performance information
- a summary of the lifecycle activities for each asset class (planning, delivery, operations, maintenance and disposal and divestment). These activities are summarised from our fleet strategies and updated to reflect changes since our RCP2 proposal.

Our asset management information system, Maximo, holds all asset data. The asset data included here is based on extracts from Maximo, as at June 2015.
2. TL TOWERS AND POLES

2.1. ASSET DESCRIPTION

Table 11 provides a breakdown of the galvanised steel lattice tower and pole structure population by voltage level.

Table 11: Tower and pole asset population and average age (June 2015)

<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>
<th>Average age</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of towers</td>
<td>353</td>
<td>6,489</td>
<td>14,755</td>
<td>1,648</td>
<td>418</td>
<td>23,663</td>
<td>52 years</td>
</tr>
<tr>
<td>No. of poles</td>
<td>2,012</td>
<td>12,262</td>
<td>90</td>
<td>0</td>
<td>0</td>
<td>14,364</td>
<td>31 years</td>
</tr>
</tbody>
</table>

2.2. 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. Table 12 gives life expectancies for unpainted towers in the six corrosion zones.

Table 12: Life expectancy of unpainted towers

<table>
<thead>
<tr>
<th>Corrosion zone</th>
<th>Typical environment</th>
<th>Life expectancy (years)</th>
<th>No. of towers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme</td>
<td>Geothermal/exposed</td>
<td>18</td>
<td>281</td>
</tr>
<tr>
<td>Very severe</td>
<td>Sea-shore (surf)</td>
<td>25</td>
<td>1,808</td>
</tr>
<tr>
<td>Severe</td>
<td>Sea-shore (calm)</td>
<td>44</td>
<td>3,733</td>
</tr>
<tr>
<td>Moderate</td>
<td>Sheltered/coastal with low salinity</td>
<td>62</td>
<td>12,462</td>
</tr>
<tr>
<td>Low</td>
<td>Arid/rural/inland</td>
<td>86</td>
<td>3,611</td>
</tr>
<tr>
<td>Benign</td>
<td>Dry, rural/remote from coast</td>
<td>120</td>
<td>1,659</td>
</tr>
</tbody>
</table>

We use paint to protect the underlying steel from the corrosive environment. The lifespan of paint depends on the corrosion zone.

We are 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 major members have lost 10 per cent of their strength and minor members 20 per cent.

No towers are at imminent risk of failure due to poor condition, but a significant number are degrading to the point where we need to replace steel members and paint to avoid the towers degrading to a point necessitating full replacement.

Poles

Our asset health model for poles takes into account:

- pole type and quality
- Site-specific weather exposure
• structure loadings.

Figure 10 shows the asset health of the pole fleet. As a minimum, we replace all poles identified as ‘now due’ within 12 months of their identification.

Figure 10: Poles— asset health (estimated remaining life at June 2015)

The health of the pole fleet is generally good, although some older-type concrete poles have cracks, spalling and rusting reinforcement. Most 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 11 sets out the proportion of towers and poles in each criticality category. We assign criticality in terms of the effect on customers if they are taken out of service.

Figure 11: Tower and pole— criticality (June 2015)

2.3. ASSET PERFORMANCE

Structural failures of towers and poles are rare, typically less than one each year, and are usually associated with extreme weather events.

2.4. PLANNING AND DELIVERY

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&D 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 due to ground instability.

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

Design and construction standards
- TP.CL 01.01 Construction and modification of transmission lines, towers and poles
- TP.DL 12.01 Transmission line loadings code
- TP.DL 12.02 Transmission line structures spacing and distances
- TP.DL 14.01 Design of transmission line crossing over roads, rail, waterways and overhead lines
- TP.SS 02.11 Maintenance and construction of steel towers and tower foundations
- TP.SS 02.13 Maintenance and construction of pole structures, guys and foundations
- TP.SS 04.10 Tower structures, and foundation design
- TP.SS 04.11 Pole structures, guys and foundation design

Procurement
Tower and pole work is mostly volumetric—we purchase multiple towers or poles, or paint groups of towers. Our 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 because contractors often have local knowledge and experience (for example, experience in rugged terrain)
- following our procurement strategy for tower painting (TP.TL 01.02). This was introduced in 2014 to help increase the pool of paint contractors available so we can paint towers when and where we need.

Procurement standards
- TP.TL 01.02 Tower painting procurement strategy
- TP.PL 01.11 Hardwood poles for overhead powerlines
- TP.PL 01.14 Tower fasteners
- TP.PL 01.15 Prestressed hollow concrete poles
- TP.PL 01.16 Structure fittings
- TP.PL 02.02 Forged and cast fittings
- TP.PL 01.20 Steel pole transmission structures

2.5. OPERATIONS AND MAINTENANCE

Outage planning
We need to take lines out of service for maintenance and replacements of towers and poles, as a number of procedures cannot be carried out as live line work.
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 fleets, 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 aggressive 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.
- install fall arrest systems on frequently visited or climbed transmission towers.
- identify, assess and mitigate the risk of transferred hazardous voltages and earth potential rise, specifically the risk due to people touching transmission line structures.

Standards and specifications for working on towers and poles
TP.ML 03.01 Transmission line pole structures
We have two service specifications that define the competency requirements for working with our towers and poles:

- **TP.SS 06.20** Minimum competencies for lines maintenance
- **TP.SS 06.25** Minimum requirements for Transpower field work

### 2.6. 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.

### 2.7. TOWERS AND POLES WORKS

Table 13 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>913</td>
</tr>
<tr>
<td>TL Paint (painted or repainted)</td>
<td>2,569</td>
</tr>
</tbody>
</table>
3. TL FOUNDATIONS

3.1. ASSET DESCRIPTION

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 14. The average age of our steel grillage foundations is 57 years, while the average age of the entire fleet is 44 years.

Table 14: Foundation types and populations (June 2015)

<table>
<thead>
<tr>
<th>Foundation type</th>
<th>Description</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Towers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel grillage</td>
<td>Grillages that have not yet been refurbished</td>
<td>11,177</td>
</tr>
<tr>
<td>Concrete over steel grillage</td>
<td>Refurbished grillage foundations (by encasement in concrete)</td>
<td>2,310</td>
</tr>
<tr>
<td>Concrete plug (bored/dug)</td>
<td>Currently preferred foundation type</td>
<td>9,456</td>
</tr>
<tr>
<td>Other</td>
<td>Includes as:</td>
<td></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>451</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>Poles</td>
<td>Driven pile and wailings</td>
<td>314</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>23,708</td>
</tr>
</tbody>
</table>

3.2. ASSET CHARACTERISTICS

Figure 12 shows the asset health of the foundation fleet.

Figure 12: Foundations—asset health (estimated remaining life at June 2015)

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 line. This results in a loss of steel section that leads to an increased risk of foundation and subsequent tower failure with potential safety, environment and network performance impacts.
3.3. ASSET PERFORMANCE

Our foundations are designed to withstand severe loading conditions in extreme weather, and we monitor and maintain them to ensure satisfactory performance. Structural failures of foundations are rare; only 12 have been recorded since 1963.

3.4. PLANNING AND DELIVERY

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 make decisions to replace or refurbish foundations based on condition and informed by their relative criticality. The work planned for RCP2 includes:

- continuing our long-term programme of grillage concrete encasement, avoiding the need to replace steelwork. We target foundations with an estimated remaining life of 5–10 years
- 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.

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, we will consider other foundation types.

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

TP.CL 01.01 Construction and modification of transmission Lines, towers and poles
TP.DL 01.01 Transmission line foundation design
TP.DL 01.05 Grillage foundations—concrete encasement
TP.SS 02.11 Maintenance and construction of steel towers and tower foundations
TP.SS 02.13 Maintenance and construction of pole structures, guys and foundations
TP.SS 04.10 Tower structures, and foundation design
TP.SS 04.11 Pole structures, guys and foundation design
TP.SS 04.15 Transmission line drawing requirements
TP.SS 04.16 Transmission line standard drawings

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

Delivery planning
We ensure planned projects are deliverable within available financial, labour and material constraints. Specifically, we try to package works into blocks of consecutive structures and ensure multiple works are carried out at one site simultaneously where possible.

3.5. OPERATIONS AND MAINTENANCE

Outage planning
Very few foundation works require outages. When works do require an outage, we will plan 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.

In many instances, condition assessments and line patrols identify issues before towers fail. We keep a register of problematic areas and monitor at-risk structures after major weather events.

Corrective maintenance
We will ensure that foundation repairs are carried out promptly, as required, 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
- replacing or refurbishing tower foundations in marine environments that are subject to degradation from tidal activity and chloride ingress attacking the reinforced steel
- completing river protection work on pole foundations.

Relevant standards and specifications
TP.SS 02.10 Transmission line patrols and assessments
TP.SS 02.12 Protective coating of transmission line structures and foundations
TP.SS 02.17A Transmission line condition assessment—Part A: General requirements
TP.SS 02.11 Maintenance and construction of steel towers and tower foundations
TP.SS 02.13 Maintenance and construction of pole structures, guys and foundations
TP.SS 02.17B Structures

3.6. 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.

3.7. FOUNDATIONS WORKS

Table 15 provides a summary of the foundations R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL Foundation</td>
<td>97</td>
</tr>
<tr>
<td>TL Grillage</td>
<td>1,685</td>
</tr>
<tr>
<td>TL Access</td>
<td>-</td>
</tr>
</tbody>
</table>

| 5 Unit numbers are provided for foundations and grillages only, as these projects have standard unit costs. |
4. TL CONDUCTORS AND INSULATORS

4.1. ASSET DESCRIPTION

The fleet covered in this section includes conductors, insulators and hardware associated with conductors.

Conductors

Transmission line conductors are core components of our transmission network that enable electricity flow from generators to consumers.

<table>
<thead>
<tr>
<th>Table 16: Conductor length by voltage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conductor type</strong></td>
</tr>
<tr>
<td>ACSR-GZ</td>
</tr>
<tr>
<td>ACSR-AC</td>
</tr>
<tr>
<td>AAAC</td>
</tr>
<tr>
<td>Copper</td>
</tr>
<tr>
<td>SC/AC</td>
</tr>
<tr>
<td>SC/GZ</td>
</tr>
</tbody>
</table>

We have ACSR-type conductors on more than 60 per cent of our transmission lines. Our preference for new conductors is AAAC-type conductors.

Hardware

There are a number of hardware types associated with the conductor population. Table 18 sets these out, with their approximate population numbers.

<table>
<thead>
<tr>
<th>Table 18: Conductor hardware population</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hardware type</strong></td>
</tr>
<tr>
<td>Mid-span joints</td>
</tr>
<tr>
<td>Dead end and other joints</td>
</tr>
<tr>
<td>Spacers(^6)</td>
</tr>
<tr>
<td>Vibration dampers</td>
</tr>
</tbody>
</table>

Insulators

Insulators attach energised conductors to supporting structures such as towers and poles.

---

\(^6\) Spacers maintain the distance between twin and triple conductor configurations.
We have approximately 210,000 insulator strings in service on the transmission network, comprising 58,000 insulator circuit sets (approximately 51,000 suspension sets and 7,000 strain sets). Glass and porcelain insulators together make up around 80 per cent of the fleet. The remaining 20 per cent of insulators use composite technology.  

4.2. ASSET CHARACTERISTICS

Conductors

We are developing an asset health model to assist the prediction of end of life for each span of conductor.

The observed life expectancy of conductors varies significantly depending on the location of the circuit and the type of conductor. Table 19 gives typical life expectancies in years for the main conductor types in six corrosion zones.

<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 14 shows the current asset health profile of the insulator fleet as at June 2015.

---

7 Composite insulator assemblies use a fibreglass rod with silicone rubber sheath and sheds.

8 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 little or no grease. We refer to these as ‘grease holidays’.
4.3. ASSET PERFORMANCE

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

Figure 16 shows the annual number of failure events which caused conductor drops and the general reason for each between 20015 and 2015. ‘Veg’ refers to an event where a tree has fallen into a line causing conductor drop.
The physical reliability of our hard-drawn copper conductors is poor by comparison with ACSR and other modern conductors. A relatively small copper conductor is more likely to fail under snow load, or when hit by lightning or other faults.

4.4. PLANNING AND DELIVERY

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 primary plan 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 earthwires, insulators, and hardware to maintain the asset health of the insulator fleet and avoid major failures
- planning aerial laser surveys every second 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 plans include:
- 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.

Relevant design and procurement standards
TP.DL 12.01 Transmission line loadings code
TP.DL 01.06 Earthwire and insulator set attachment design and drawings
4.5. **OPERATION AND MAINTENANCE**

**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**

For the conductor and insulator fleets, the largest component of preventive maintenance is condition assessments involving:

- annual line patrols on every transmission line asset to identify defects that pose risk to each line’s integrity
- 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 annual maintenance to conductor joints on towers that are showing rising resistance
• minor repairs to conductors due to lightning damage, wire strikes caused by third-party cranes, fires under conductors, vandalism and vibration dampers working loose
• 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.

Relevant operations and maintenance specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP.SS 01.32</td>
<td>Management criteria for transmission line emergency kits</td>
</tr>
<tr>
<td>TP.SS 02.15</td>
<td>Maintenance of insulators and insulator fittings</td>
</tr>
<tr>
<td>TP.SS 02.16</td>
<td>Installation and maintenance of conductor, conductor accessories and aerial communications cables</td>
</tr>
<tr>
<td>TP.SS 02.17C</td>
<td>Transmission line condition assessment-Part C: Insulators and conductors</td>
</tr>
<tr>
<td>TP.SS 02.17A</td>
<td>General requirements</td>
</tr>
</tbody>
</table>

4.6. 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.

4.7. Conductors and Insulators Works

Table 20 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished$^9$</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>TL Conductor</td>
<td>28.7</td>
</tr>
<tr>
<td>TL Insulators</td>
<td>6,398</td>
</tr>
</tbody>
</table>

$^9$ Total units are provided only for insulators, as these relatively standard unit costs.
5. ACS OUTDOOR 33 KV SWITCHYARDS

5.1. ASSET DESCRIPTION

We have 54 outdoor 33 kV switchyards, which were constructed before 1984. These provide a large proportion of the interfaces between our high-voltage transmission network and medium-voltage distribution customers.

Outdoor 33 kV switchyard structures and buswork

The outdoor 33 kV switchyards involve four main types of structure.

- **Large lattice**: large galvanised steel or aluminium lattice-type structures. The design of these typically allow for very little tolerance for movement during maintenance activities.

- **Lattice**: galvanised steel or aluminium lattice structures, less congested than large lattice.

- **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 they may also have small maintenance clearances.

- **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.

The 33 kV outdoor switchyards involve four types of buswork.

- **Vertically stacked double bus**: double rigid buswork, stacked on top of each other.

- **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.

Outdoor 33 kV circuit breakers

Table 21 shows the population, age and life expectancy by interrupter type.

<table>
<thead>
<tr>
<th>Type</th>
<th>Population</th>
<th>Average age (years)</th>
<th>Life expectancy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk oil</td>
<td>212</td>
<td>44</td>
<td>45</td>
</tr>
<tr>
<td>Minimum oil</td>
<td>4</td>
<td>40</td>
<td>40</td>
</tr>
<tr>
<td>Sulphur hexafluoride (SF₆)</td>
<td>104</td>
<td>13</td>
<td>35</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>320</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Other 33 kV outdoor equipment

Table 22 shows the population of other 33 kV outdoor equipment.

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disconnectors</td>
<td>816</td>
</tr>
<tr>
<td>Free-standing instrument transformers</td>
<td>411</td>
</tr>
<tr>
<td>Earth switches</td>
<td>206</td>
</tr>
<tr>
<td>Surge arrestors</td>
<td>131</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1564</strong></td>
</tr>
</tbody>
</table>

5.2. **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 SF$_6$ 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 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 17, almost 75 per cent of the fleet 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.

---

Figure 17: Outdoor 33 kV circuit breakers—asset health (estimated remaining life at June 2015)
Criticality

Figure 18 shows the breakdown of 33 kV outdoor switchyards in terms of criticality.

Figure 18: Outdoor 33 kV switchyards— criticality

5.3. 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 insulation failure
- the majority of the existing circuit breakers being bulk oil or minimum oil, with higher rates of forced and fault outages than modern circuit breakers
- most of the 33 kV switchyards being without 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. Over the last 10 years there have been approximately 99 forced outages of indoor and outdoor 33 kV circuit breakers\(^\text{10}\). The number of forced and fault outages associated with outdoor circuit breakers (60) is substantially greater than for indoor switchgear (39).

Safety performance

The prime asset management driver for this fleet 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.

---

\(^{10}\) Circuit breakers are used here to provide a ‘fair’ comparison between 33 kV indoor switchgear and 33 kV outdoor equipment. Indoor circuit breakers are mentioned here for comparison purposes only.
5.4. PLANNING AND DELIVERY

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 outdoor 33 kV switchyards and replacing them with indoor switchgear by 2025 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 and 11 kV assets (such as bulk oil and minimum oil circuit breakers) on condition and age grounds before the switchyard is due for replacement.

5.5. OPERATIONS AND MAINTENANCE

Outage planning
The majority of these sites operate with N-1 security, and this normally allows for 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.

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.

Operations standards and specifications
TP.AOI 07.127 Circuit breaker in hazardous condition
TP.SS 07.25 Locking of HV switchgear and lockout requirements
TP.OG 42.02 Operation of circuit breakers and disconnectors

Maintenance specifications
TP.SS 02.20 Outdoor bulk-oil circuit breaker maintenance
5.6. 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.

5.7. OUTDOOR 33 kV SWITCHYARD WORKS

Table 23 provides a summary of the R&R plans for RCP2.

Table 23: 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>15</td>
</tr>
</tbody>
</table>
6. ACS OUTDOOR CIRCUIT BREAKERS

6.1. ASSET DESCRIPTION

Circuit breakers rapidly disconnect faulty equipment during faults and limit any impacts to a small section of the grid. In addition, they are used for operational purposes 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 24 shows our outdoor circuit breakers by type, population and average age.

Table 24: 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>
<th>Average age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk oil</td>
<td>0</td>
<td>42</td>
<td>25</td>
<td>67</td>
<td>46 years</td>
</tr>
<tr>
<td>Minimum oil</td>
<td>0</td>
<td>9</td>
<td>3</td>
<td>12</td>
<td>39 years</td>
</tr>
<tr>
<td>Sulphur hexafluoride (SF₆)</td>
<td>514</td>
<td>473</td>
<td>83</td>
<td>1070</td>
<td>15 years</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>514</strong></td>
<td><strong>524</strong></td>
<td><strong>111</strong></td>
<td><strong>1149</strong></td>
<td><strong>17 years</strong></td>
</tr>
</tbody>
</table>

6.2. 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 have developed an asset health model for circuit breakers. 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 breakers. 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 19 summarises the asset health of the outdoor circuit breaker fleet.

Figure 19: High-voltage outdoor circuit breakers—asset health (estimated remaining life at June 2015)

Criticality

Figure 20 shows the criticality breakdown of the fleet.
6.3. ASSET PERFORMANCE

Most transmission system circuit breakers operate infrequently, with less than 2,000 operations in their lifetime. Some circuit breakers, such as those used for switching shunt capacitor banks and HVDC harmonic filter banks, operate up to several times a day.

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 21 shows that annual SF6 emissions are at an all-time low.

Figure 22 shows the forced and fault outages of outdoor circuit breakers by cause. We have replaced many older circuit breakers that had serious generic defects. The most common failure modes are now related to normal ageing and deterioration.
6.4. PLANNING AND DELIVERY

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 SF$_6$ circuit breakers
- continuing to replace legacy interrupter types
- replacing older SF$_6$ 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 (SF$_6$) by 2025.

Procurement
Our procurement plans involve:

- ensuring interchangeability of entire circuit breakers and components
- purchasing live tank SF$_6$ 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.

Relevant procurement standards or policies

TP.PS 13.01  36 kV, 72.5 kV, 123 kV and 245 kV outdoor circuit breaker purchase specification
6.5. OPERATIONS AND MAINTENANCE

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 SF\textsubscript{6} circuit breakers
- undertaking operation-based maintenance on frequently operated circuit breakers such as time travel tests, SF\textsubscript{6} 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 SF\textsubscript{6} level alarms
- repairing or replacing leaking SF\textsubscript{6} 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.

Relevant operations and maintenance standards and specifications

| TP.AOI 07.127 | Circuit breaker in hazardous condition |
| TP.OG 42.02  | Operation of circuit breakers and disconnectors |
| TP.SS 02.20  | Outdoor bulk-oil circuit breaker maintenance |
| TP.SS 02.21  | Outdoor minimum oil circuit breaker maintenance |
| TP.SS 02.22  | Outdoor SF\textsubscript{6} circuit breaker maintenance |
| TP.SS 02.28  | Station compressed air system maintenance |
| TP.SS 02.29  | Sulphur hexafluoride (SF\textsubscript{6}) gas and handling equipment maintenance and management |

6.6. 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 fleet and allow some rationalisation of spares and maintenance procedures.

6.7. Outdoor Circuit Breaker Works

Table 25 provides a summary of the R&R plans for RCP2.

Table 25: Outdoor circuit breaker R&D plans

<table>
<thead>
<tr>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Outdoor circuit breakers</td>
<td>128</td>
</tr>
</tbody>
</table>
7. ACS INDOOR SWITCHGEAR

7.1. ASSET DESCRIPTION

Switchgear refers to the combination of circuit breakers, disconnectors and earth switches used to control, protect and isolate electrical equipment on electric power systems.

Medium voltage (MV) indoor switchgear

The three main switchboard busbar systems are:

- compound insulated—used in older installations (up to the 1970s)
- air insulated busbar— used for most metal-clad switchgear purchased since the early 1980s and still being purchased for 11 kV switchboards
- SF$_6$ insulated busbar— used since 2000 and current technology for 33 kV switchboards.

Table 26 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>240</td>
<td>0</td>
<td>319</td>
<td>559</td>
</tr>
<tr>
<td>SF$_6$</td>
<td>5</td>
<td>40</td>
<td>117</td>
<td>162</td>
</tr>
<tr>
<td>Bulk oil</td>
<td>73</td>
<td>0</td>
<td>0</td>
<td>73</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>12</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>339</strong></td>
<td><strong>40</strong></td>
<td><strong>448</strong></td>
<td><strong>827</strong></td>
</tr>
</tbody>
</table>

The age profile of MV circuit breakers is shown by interrupter type in Figure 23.

High voltage (HV) indoor switchgear

The main busbar systems for indoor HV circuit breakers are SF$_6$ insulated.
Table 27 lists HV gas-insulated switchgear (GIS) installations, showing year of manufacture and volume of associated switchgear.

Table 27: Indoor HV switchgear asset fleet population

<table>
<thead>
<tr>
<th>Site</th>
<th>Voltage (kV)</th>
<th>Year of manufacture</th>
<th>Manufacturer</th>
<th>Age</th>
<th>Circuit breakers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rangipo</td>
<td>220</td>
<td>1979</td>
<td>Merlin Gerin</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>Bream Bay</td>
<td>220</td>
<td>1981</td>
<td>Mitsubishi</td>
<td>34</td>
<td>8</td>
</tr>
<tr>
<td>Wilton</td>
<td>220</td>
<td>1981</td>
<td>Mitsubishi</td>
<td>34</td>
<td>7</td>
</tr>
<tr>
<td>Tiwai</td>
<td>220</td>
<td>1982</td>
<td>Mitsubishi</td>
<td>33</td>
<td>14</td>
</tr>
<tr>
<td>Motunui</td>
<td>110</td>
<td>1983</td>
<td>Mitsubishi</td>
<td>32</td>
<td>9</td>
</tr>
<tr>
<td>Clyde</td>
<td>220</td>
<td>1986</td>
<td>BBC</td>
<td>29</td>
<td>9</td>
</tr>
<tr>
<td>Otahuhu</td>
<td>220</td>
<td>2008</td>
<td>Areva</td>
<td>7</td>
<td>12</td>
</tr>
<tr>
<td>Wairau Road</td>
<td>220</td>
<td>2012</td>
<td>Alstom</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>Hobson Street</td>
<td>220</td>
<td>2012</td>
<td>Alstom</td>
<td>3</td>
<td>6</td>
</tr>
</tbody>
</table>

7.2. 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.

Figure 24: MV indoor circuit breakers—asset health (estimated remaining life at June 2015)

All HV indoor circuit breakers have asset health in excess of 15 years.

Criticality

Figure 25 sets out the proportion of MV and HV indoor circuit breakers in each criticality category.

---

11 Age as at 2015.
12 The Rangipo GIS installation is shared with Genesis.
13 The Clyde GIS installation is shared with Contact Energy.
7.3. 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 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.

7.4. PLANNING AND DELIVERY

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.

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 fleet of 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.

Relevant design and procurement standards and policies
TP.PS 17.01 11 kV and 33 kV indoor switchgear purchase specification
TP.PS 03.01 12 kV, 36 kV, 72.5 kV, 123 kV and 245 kV disconnectors and earthing switches purchase specification

7.5. OPERATIONS AND MAINTENANCE

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 testing and servicing 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
• 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 a cost-effective alternative to a full overhaul which, would involve lengthy outages

• 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.

Relevant operations and maintenance standards and specifications

TP.AOI 07.127   Circuit breaker in hazardous condition
TP.AOI 07.210   Mitsubishi GIS Restoration Procedure
TP.SS 07.25    Locking of HV switchgear and lockout requirements
TP.OG 42.02    Operation of circuit breakers and disconnectors
TP.OG 42.04    Operation of metalclad switchgear
TP.SS 02.23    Gas insulated switchgear (GIS) maintenance
TP.SS 02.26    Metalclad switchgear maintenance
TP.SS 02.29    Sulphur hexafluoride ($SF_6$) gas and handling equipment maintenance and management
TP.SS 02.25    Air blast circuit breaker maintenance

7.6. 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.

7.7. INDOOR SWITCHGEAR WORKS

Table 28 provides a summary of the R&R plans for RCP2.

Table 28: Indoor switchgear R&R plans

<table>
<thead>
<tr>
<th>Units replaced or refurbished(^{14})</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Indoor switchgear</td>
<td>19.5</td>
</tr>
</tbody>
</table>

\(^{14}\) Total units are not provided for this asset class, as R&R has highly variable unit costs.
8. **ACS POWER TRANSFORMERS**

8.1. **ASSET DESCRIPTION**

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 (where we use a single transformer). Most transformers installed since the early 1970s are three-phase.

<table>
<thead>
<tr>
<th>Table 29: Main power transformer fleet population (June 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Supply (three-phase)</td>
</tr>
<tr>
<td>Supply (single-phase)</td>
</tr>
<tr>
<td>Interconnecting (three-phase)</td>
</tr>
<tr>
<td>Interconnecting (single-phase)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 30: ‘Other’ transformer fleet population (June 2015)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Local service</td>
</tr>
<tr>
<td>Earthing</td>
</tr>
<tr>
<td>Regulators</td>
</tr>
<tr>
<td><strong>Total</strong></td>
</tr>
</tbody>
</table>
8.2. Asset Characteristics

Asset health for supply and interconnecting transformers is summarised below.

Our transformer asset health model uses 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).

Health is expressed in terms of estimated remaining life. We are currently developing an improved model that brings in a wider range of factors.

Criticality

We developed a service criticality framework as part of our preparations for RCP2. We have nearly completed a process of assigning an asset criticality to each transformer based on service criticality.
8.3. 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 31: Key transformer performance characteristics

<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. Key performance issues at present are:

- 220 kV windings in pre-1990 transformers—failure rate is high compared to peers, and high compared to 110 kV transformers
- single-phase transformer banks—failure rate is high compared to three-phase transformers.

### 8.4. PLANNING AND DELIVERY

#### 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 identify and prioritise R&R investments using asset health and asset criticality tools.

The programme of transformer R&R work developed for RCP2 aims to:

- reduce the proportion of transformers with ‘now due’ asset health ratings to 5 per cent by 2020. This target is based on economic analysis that tests expected consequences of failure against expected cost of replacement
- replace all single-phase transformers with three-phase units over the next 20 years.

#### Design

Each transformer is bespoke, but where practical we use standardised specifications to limit fleet 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, construction and commissioning

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 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.

**Design, procurement and construction standards**

- TP.PS 20.05 Procurement strategy: power transformers
- TP.PS 54.01 Specification for unused and regenerated mineral insulating oil
- TP.SS 04.55 Removal, transport, storage and installation of power transformers, voltage regulators, reactors and resistors
- TP.SS 04.60 Testing of power transformers, voltage regulators and reactors
- TP.DS 20.01 Transformer oil and winding temperature indicators and monitors
- TP.DS 20.03 Design specification for power transformer foundations

**8.5. OPERATIONS AND MAINTENANCE**

**Outage planning**

For transformers in an N-1 configuration, we can take individual transformers out of service without interrupting supply. This affords 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 and ensuring we test emergency preparedness. 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.
### Preventive maintenance

#### Table 32: 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>Two-yearly</td>
<td>Tests of inhibitor levels in 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 winding insulation resistance and polarisation index, and tests of bushing insulation</td>
</tr>
<tr>
<td></td>
<td>Tests of levels of furans in oil sample.</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- or six-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 (eg, porcelain bushings and control instrumentation) and oil treatment. We use online dissolved gas analysis monitors to help identify when we should remove a transformer from service prior to failure.

### Operations standards

- **TP.AOI 07.114**: Off load tap position change management
- **TP.AOI 07.130**: STK T6 & T10 transformer livening and 33 kV bus load management
- **TP.AOI 07.510**: Transformer asset offer (supply transformers)
- **TP.AOI 07.514**: Transformer overvoltage management (of off load tap supply transformers)
- **TP.AOI 07.523**: RDF T3 & T4 interconnecting bank load management
- **TP.OG 41.07**: Operation of power transformers

### Maintenance specifications

Detailed maintenance tasks and schedules for power transformers are set out in the following Service Specifications:

- **TP.SS 02.30**: Oil-immersed power transformers, voltage regulators, reactors, resistors and resistor/reactor maintenance
- **TP.SS 02.31**: Major repairs of power transformers, voltage regulators, reactors and resistors
- **TP.SS 02.35**: Insulating oil - acceptance criteria, monitoring and treatment
- **TP.SS 02.36**: Treatment of oil in energised transformers, voltage regulators and reactors
- **TP.SS 07.32**: Management of power transformers: site services
8.6. 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.

8.7. TRANSFORMER WORKS

Table 33 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Transformer</th>
<th>Units replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Power transformers</td>
<td>30</td>
<td>148.8</td>
</tr>
</tbody>
</table>
9. ACS BUILDINGS AND GROUNDS

9.1. ASSET DESCRIPTION

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.

Our categories are:

- buildings
- building services
- site infrastructure
- fencing.

Table 34: Buildings population (June 2015)

<table>
<thead>
<tr>
<th>Buildings</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Station buildings</td>
<td>584</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><strong>Total</strong></td>
<td><strong>628</strong></td>
</tr>
</tbody>
</table>

The oldest substation buildings still in service were built in the 1930s; most of our substation buildings were built in the 1950s to 1970s. Since the 1980s there have been a few new substation sites constructed; these generally have only a single building.

As part of our on-going programme to replace outdoor 33 kV switchyards with indoor switchgear some new buildings have been required at existing sites. We have reduced building numbers through the demolition of redundant buildings and the divestment of sites.

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.

---

16 These figures exclude: our offices, which are included in the business support AMP 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.
### Table 35: 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>466</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>182</td>
</tr>
<tr>
<td>Standby generators</td>
<td>4</td>
</tr>
<tr>
<td>Uninterrupted power systems</td>
<td>4 sites</td>
</tr>
</tbody>
</table>

### Table 36: 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 37: Fencing population

<table>
<thead>
<tr>
<th>Fencing</th>
<th>Metres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Switchyard and equipment fencing</td>
<td>70,000</td>
</tr>
<tr>
<td>Boundary and non-security fencing</td>
<td>420,000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>490,000</strong></td>
</tr>
</tbody>
</table>

### 9.2. Asset characteristics

Our National Grid Operating Centre (NGOC) Auckland accommodates one of Transpower’s two regional NGOCs, which are considered critical sites.

Much of the infrastructure and building fabric is original and over 25 years old. 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, and will require replacement when maintenance is no longer economic.

Investigative work at Haywards substation concluded that the water mains and sewerage systems have reached the end of their serviceable life, and should be replaced. 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.
9.3. 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.

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.

We have identified a potential health and safety and environmental risk from asbestos in older substation buildings and subsurface infrastructure. We have set up an asbestos register and we are working on a new asbestos management policy. About one third of our fleet contains asbestos in building elements. Approximately 10 per cent of the identified asbestos requires urgent response to eliminate potential hazards to personnel or operations. This work is included in our plans.

Related document

TP.GG 61.02 Seismic policy

9.4. Planning and Delivery

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

We will continue to upgrade all buildings to comply with current New Zealand standards for seismic loading by the end of 2015/16. The majority of our forecast RCP2 expenditure is for seismic strengthening of the condenser hall building at Haywards.

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 NGOCs at Otahuhu and Islington.

Our switchyard infrastructure programmes involve end-of-life replacement, including:
• fences
• aggregate surfacing
• 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 plans include:
• installing hypoxic air fire suppression systems in high-criticality indoor facilities
• trial deployment of intelligent video surveillance systems
• installing emergency showers at all substations.

**Delivery**

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

**Design**

We use standard design, specifications and service levels or industry standards 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 Resource Management Act 1991 (RMA) and Building Act 2004.

**Relevant design standards**

TP.DS 40.01 SA1  Design working life of buildings
TP.DS 40.03  Switchyard and grounds lighting
TP.DS 40.04  Installation of 230/400 V socket-outlets and residual current devices
TP.DS 53.02  Design of substation security fencing
TP.DS 61.06  Substation fire mitigation
TP.DS 52.01  Design of substation earthing

**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 Resource Management Act, regional and district plans.

Construction and commissioning
Our approach to construction involves facilities managers tendering and overseeing the construction works and commissioning on our behalf. Commissioning includes the final calibration and configuration of systems such as air conditioning and security systems.

9.5. OPERATIONS AND MAINTENANCE

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.

Facilities manager post-earthquake response plan
Our Facilities Manager Contract covers a standard contract deliverable whereby Opus carry out post-earthquake checks in the upper North Island region and Downer carry out post-earthquake checks in the lower North Island and South Island. Opus and Downer’s Emergency Preparedness Continuity and Succession Plan sets out their Post-Earthquake Response Plans. These provide a process in which Opus and Downer regional coordinators provide a structural engineer (to check the building structure and assess environmental hazards) to be accompanied on site with a restricted area entry qualified stations contractor (to check electrical equipment and systems). The purpose of this plan is to ensure:

- a clear outline of evaluation procedures for accessing Transpower 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 quarterly quality inspections and annual 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.

Maintenance specifications for buildings and grounds

- **TP.SS 02.40B**: Condition assessment for stations equipment and facilities—Part B: Asset management of buildings, grounds and facilities services
- **TP.SS 02.41**: Stations inspections
- **TP.SS 02.72**: Uninterruptible power supplies and inverter maintenance
- **TP.SS 02.73**: Standby generator maintenance
- **TP.SS 02.80**: Buildings, grounds and facilities routine maintenance
- **TP.SS 02.81**: Heating, ventilating and air conditioning equipment and cooling tower maintenance
- **TP.SS 02.82**: Cranes, lifting gear and service platform maintenance
- **TP.SS 02.86**: Fire protection system maintenance
- **TP.SS 02.87**: Security systems equipment maintenance
- **TP.SS 06.40 AS1**: Asbestos management on Transpower worksites
- **TP.SS 07.40**: Station security—procedures

9.6. 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.

9.7. BUILDINGS AND GROUNDS WORKS

Table 38 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 Buildings and grounds</td>
<td>32.3</td>
</tr>
<tr>
<td>ACS Buildings and seismic</td>
<td>6.9</td>
</tr>
</tbody>
</table>

17 Total units are provided only for assets where R&R has relatively standard unit costs.
10. ACS REACTIVE POWER

10.1. ASSET DESCRIPTION

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 combine 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 sections.

Capacitors and reactors 18

As shown in Table 39, we have standalone AC capacitor banks, and capacitor banks associated with STATCOMs and SVCs.

Table 39: AC capacitor banks and filter banks by voltage (June 2015)

<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>32</td>
<td>58</td>
</tr>
<tr>
<td>SVC capacitors</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>STATCOM capacitors</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>13</strong></td>
<td><strong>13</strong></td>
<td><strong>70</strong></td>
<td><strong>96</strong></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 40 shows the number of reactors in the fleet by voltage. While most of the fleet is relatively young, a number of reactors are beyond their expected service life of 30 years.

18 For the purposes of this statistics section, capacitor installations include capacitor banks and individual capacitors associated with SVCs and STATCOMs.
Table 40: Reactors by voltage (June 2015)

<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>Part of Capacitor Bank</td>
<td>13</td>
<td>13</td>
<td>45</td>
<td>71</td>
</tr>
<tr>
<td>Standalone</td>
<td>2</td>
<td>1</td>
<td>18</td>
<td>21</td>
</tr>
<tr>
<td>Part of SVC</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>28</td>
</tr>
<tr>
<td>Part of STATCOM</td>
<td>0</td>
<td>0</td>
<td>21</td>
<td>21</td>
</tr>
<tr>
<td>Part of synchronous condenser</td>
<td>0</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Total</td>
<td>15</td>
<td>14</td>
<td>116</td>
<td>145</td>
</tr>
</tbody>
</table>

Dynamic reactive support assets

Table 41 provides an overview of our dynamic reactive support assets.

Table 41: Dynamic reactive support assets

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
<th>Number</th>
<th>Age</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>8 at Haywards</td>
<td>50 years</td>
</tr>
<tr>
<td>SVCs</td>
<td>Provides fast-acting reactive power</td>
<td>SVC3 (Islington)</td>
<td>19 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SVC7 (Albany)</td>
<td>7 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SVC9 (Islington)</td>
<td>6 years</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</td>
<td>5 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 at Penrose</td>
<td>2 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 at Marsden</td>
<td>2 years</td>
</tr>
<tr>
<td></td>
<td></td>
<td>1 at Haywards</td>
<td>2 years</td>
</tr>
</tbody>
</table>

10.2. Asset Characteristics

There are a number of capacitor banks and reactors at the end of their economic life. We will retain them in service and monitor their performance regularly. Most capacitor banks are less than 30 years old which is the typical life expectancy of a capacitor bank.

The Haywards synchronous condensers have undergone major overhauls; we refurbished them all during RCP1. We expect these condensers to operate reliably until 2035. However, the evaporative cooling towers of the Haywards synchronous condensers are deteriorating; we will replace four in RCP2 and the remaining two 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.

Criticality

Reactive power assets do not fit in standard network asset criticality frameworks. While they are primary equipment, their function serves regions rather than individual substations, circuits or branches. During RCP2 we will develop a criticality model for our reactive power assets.
10.3. 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.

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. 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.

10.4. Planning and Delivery

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 in the Auckland 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, and technological change. Over RCP2 we plan to:

- replace four deteriorating synchronous condenser cooling towers at Haywards
- replace a small number of capacitor banks and reactors to reduce maintenance costs and outages
- replace capacitors, reactors and instrument transformers in SVC installations that have experienced high levels of component failure
- purchase a spare 220 kV capacitor bank for the North Island region, as the current capacitor banks are operating in a harsh environment
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 SVC3.

**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.

**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.

**Design, procurement and construction standards**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP.DG 01.01</td>
<td>Design of insulation co-ordination</td>
</tr>
<tr>
<td>TP.DG 25.01</td>
<td>Transmission code of practice</td>
</tr>
<tr>
<td>TP.DG 30.01</td>
<td>Electric and magnetic field design parameters for AC 50 Hz transmission lines, substations and underground cables</td>
</tr>
<tr>
<td>TP.DS 01.02</td>
<td>Guidelines and information for switchyard structure design</td>
</tr>
<tr>
<td>TP.DS 61.01</td>
<td>Guidelines and information for substation design</td>
</tr>
<tr>
<td>TP.SS 04.55</td>
<td>Removal, transport, storage and installation of power transformers, voltage regulators, reactors and resistors</td>
</tr>
<tr>
<td>TP.SS 04.60</td>
<td>Testing of power transformers, voltage regulators and reactors</td>
</tr>
<tr>
<td>TP.TS 14.01</td>
<td>Procurement strategy: substation primary assets</td>
</tr>
<tr>
<td>TP.PS 30.01</td>
<td>Shunt reactors</td>
</tr>
<tr>
<td>TP.PS 31.01</td>
<td>Capacitor banks</td>
</tr>
</tbody>
</table>

**10.5. OPERATIONS AND MAINTENANCE**

**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.

- 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 yearly 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.

**Predictive maintenance**

Typical condition-based repairs include condenser brush-gear renewals, capacitor bank re-balancing, capacitor can replacement, CO₂ gas replacement, rotor balancing, and cooling system repairs.

**Operations standards**

TP.AOI 01.113  Siemens remote access to ISL and KIK SVC

**Maintenance specifications**

- TP.SS 02.30  Oil-immersed power transformers, voltage regulators, reactors, resistors and resistor/reactor maintenance
- TP.SS 02.31  Major repairs of power transformers, voltage regulators, reactors and resistors
- TP.SS 02.35  Insulating oil—acceptance criteria, monitoring and treatment
- TP.SS 02.36  Treatment of oil in energised transformers, voltage regulators and reactors
- TP.SS 02.40  Condition assessment for stations equipment and facilities
- TP.SS 02.41  Station inspections
- TP.SS 02.51  Thyristor valve maintenance
- TP.SS 02.52  Mercury arc and thyristor valve cooling system maintenance
- TP.SS 02.60  Capacitor bank maintenance
- TP.SS 02.61  Synchronous condensers maintenance
- TP.SS 02.62  Air-cored reactors and line trap maintenance
- TP.SS 02.83  Protective coatings: paint systems for outdoor substation equipment
- TP.GS 01.02  Stations equipment maintenance and replacement policy: control of insulator contamination
- TP.GS 01.08  Condition assessment policy for AC stations and HVDC equipment and facilities
10.6. 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 (part of the Upper South Island major capital project).
- 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 in RCP2.

10.7. REACTIVE POWER WORKS

Table 42 provides a summary of the R&R plans for RCP2.

Table 42: Reactive power R&R plans

<table>
<thead>
<tr>
<th>Units replaced or refurbished$^{19}$</th>
<th>$m$</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Dynamic reactive power</td>
<td>-</td>
</tr>
<tr>
<td>ACS Capacitors and reactors</td>
<td>-</td>
</tr>
</tbody>
</table>

$^{19}$ Total units are provided only for those assets where R&R has relatively standard unit costs.
11. ACS POWER CABLES

11.1. ASSET DESCRIPTION

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 for the majority of new and replacement cables.

Table 43 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>3</td>
<td>2</td>
<td></td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>XLPE</td>
<td>60</td>
<td>149</td>
<td>6</td>
<td>200</td>
</tr>
<tr>
<td>Copper</td>
<td>PILC</td>
<td>17</td>
<td>41</td>
<td></td>
<td>58</td>
</tr>
<tr>
<td></td>
<td>XLPE</td>
<td>402</td>
<td>392</td>
<td>9</td>
<td>798</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>482</td>
<td>584</td>
<td>15</td>
<td>1,061</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 within substations (<1km).

Oil-filled (OF) PILC were installed up until the mid-1980s. Since then we have used XPLE insulation for new cables. We have approximately 3.6 km of 110 kV and 220 kV OF PILC dating from 1974 to 1985.

We also have approximately 265 km 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 44 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>5</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>XLPE</td>
<td>29</td>
<td>21</td>
<td>50</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>32</td>
<td>29</td>
<td>61</td>
</tr>
</tbody>
</table>
We are planning to review the way we manage data about our cables, in order to improve the information on our cable assets. The current cables data is known to contain inconsistencies.

### 11.2. 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. 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. We have repaired these cables but we expect them to reach the end of their life by the end of RCP2. Our oil-filled cables at other sites are in good external condition.

**Criticality**

Figure 30 shows criticality for power cables.

![Figure 30: Cables—criticality](image)

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. We plan to increase condition monitoring and to replace or refurbish the cables in RCP2.

### 11.3. Asset Performance

Power cables are usually 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.

### 11.4. Planning and Delivery

**Enhancement and development**

We plan E&D projects primarily during the development of new transmission lines or substations.

In addition, we are receiving an increasing number of applications from property developers for undergrounding sections of overhead transmission line in Auckland and Christchurch regions. Any works of this type will be fully funded by the applicant.

**Replacement and refurbishment**

Power cable R&R 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
• decommissioning the New Plymouth 220 kV and 110 kV oil-filled cables as part of the New Plymouth site rationalisation
• undertaking a programme of condition assessment testing, refurbishment and repair of the remaining 220 kV oil-filled cables
• procuring a cable oil treatment unit for the cables
• gaining experience with the installed distributed temperature sensing (DTS) systems, 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.

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.

Construction
Our construction includes:
• installing cable joints or terminations at a high standard to avoid significant risks of equipment damage (to transformers or indoor switchgear) and interruptions to supply
• improving the quality of workmanship for future installations by implementing a lessons-learnt register and developing a training and competency programme.

Relevant design procurement and construction standards
TP.PS 04.01 66, 110 and 220 kV XLPE cable
TP.PS 04.02 11 kV and 33 kV XLPE cable purchase specification
TP.PS 04.03 11 kV PILC cable purchase specification

11.5. OPERATIONS AND MAINTENANCE

Contingency planning
We will manage contingencies by:
• using a tiered response where local service providers rectify small cable failures, and overseas specialists are available 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 the outer plastic coating (sheath), partial discharge (PD) measurements focusing on joints and terminations and oil sample tests on the oil-filled cables
- monitoring cable temperatures using our four distributed temperature sensing (DTS) systems installed on our critical circuits
- off-line HV pressure tests and PD 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 (high-impedance short circuit, low-impedance short circuit, open circuit, etc) 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:

- repairing 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.

Relevant maintenance specifications and policies

<table>
<thead>
<tr>
<th>Description</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>HV and extra high-voltage (EHV) power cables, sealing ends and tunnel</td>
<td>TP.SS 02.46</td>
</tr>
<tr>
<td>maintenance</td>
<td></td>
</tr>
<tr>
<td>Replacement of outdoor junction boxes and lead-sheathed vulcanised Indian</td>
<td>TP.GP 09.01</td>
</tr>
<tr>
<td>rubber (VIR) cables</td>
<td></td>
</tr>
<tr>
<td>Stations equipment maintenance and replacement policy: replacement of power</td>
<td>TP.GS 04.01</td>
</tr>
<tr>
<td>cables</td>
<td></td>
</tr>
</tbody>
</table>

11.6. Disposal and divestment

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

Our divestment plans include:

- optimising our network boundaries with our connected customers (such as lines and generator companies) by divesting certain MV cables\textsuperscript{20}
- ensuring future power cable route designs take into account future divestments and address any asset boundary issues
- divesting a 118m section of 110 kV cable on the Kensington–Maungatapere circuit together with its respective transmission line during RCP2
- divesting a number of 11 kV and 33 kV power cables along with associated power transformers, indoor switchgear or outdoor 33 kV switchyard equipment.

11.7. POWER CABLES WORKS

Table 45 provides a summary of the R&R plans for RCP2.

<table>
<thead>
<tr>
<th>Units replaced or refurbished\textsuperscript{21}</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Power cables</td>
<td>10.4</td>
</tr>
</tbody>
</table>

\textsuperscript{20} The only MV cables we retain and operate are transformer or bus-tie/tie-line cable circuits.

\textsuperscript{21} Total units are provided only for those assets where R&R has relatively standard unit costs.
12. ACS OTHER PRIMARY EQUIPMENT

12.1. ASSET DESCRIPTION
This fleet includes other primary equipment not covered by other fleets. The table below provides an overview of the fleet.

Table 46: Overview of other primary equipment

<table>
<thead>
<tr>
<th>Description</th>
<th>Population</th>
<th>Average age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Instrument transformers</td>
<td>1944</td>
<td>17</td>
</tr>
<tr>
<td>50 kV and over current transformers, voltage transformers, neutral current transformers, capacitor voltage transformers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disconnectors</td>
<td>2962</td>
<td>-</td>
</tr>
<tr>
<td>50 and 110 kV units mostly manually operated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>220 kV motor-operated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Earth switches</td>
<td>1179</td>
<td>-</td>
</tr>
<tr>
<td>Outdoor bus systems</td>
<td>199</td>
<td>-</td>
</tr>
<tr>
<td>50 kV and over outdoor switchyards containing buswork and support structures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lightning protection systems</td>
<td>Most sites</td>
<td>-</td>
</tr>
<tr>
<td>Lightning masts, rods, overhead earthwires or surge arresters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neutral earthing resistors (NERs)</td>
<td>99</td>
<td>-</td>
</tr>
<tr>
<td>Metal grid, and some older liquid-type NERS which limit fault currents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Surge arresters</td>
<td>494</td>
<td>-</td>
</tr>
<tr>
<td>Gapless metal oxide surge arresters</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local service supply</td>
<td>Most sites</td>
<td>-</td>
</tr>
<tr>
<td>Transformers and associated equipment to distribute local service power to stations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oil containment facilities</td>
<td>Most sites</td>
<td>-</td>
</tr>
<tr>
<td>Earth grids</td>
<td>All sites have one or more.</td>
<td>-</td>
</tr>
<tr>
<td>Underground network of copper conductors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outdoor junction boxes (ODJB)</td>
<td>Most sites</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></td>
<td></td>
</tr>
</tbody>
</table>

12.2. ASSET CHARACTERISTICS
Significant asset condition issues for this fleet 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 unacceptable safety risks. 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.

• Local service systems and associated components are now beyond their expected lives, making them harder to maintain and test.

• A number of junction boxes are in poor condition and are likely to require replacement during RCP2.

**Criticality**

Criticality of the ACS other fleet is generally linked to the criticality of either the primary assets to which they connect or the substation in which they are located. Figure 31 shows the proportion of instrument transformers and disconnector and earth switches in each criticality category.

![Figure 31: Instrument transformer, disconnector and earth switches criticality](image)

12.3. **ASSET PERFORMANCE**

Over the past seven years, we have had an average five instrument transformer forced or fault outages 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 15 forced and fault outages due to the disconnector fleet, 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 disconnector fleet to poor 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.

12.4. **PLANNING AND DELIVERY**

**Enhancement and Development**

We plan E&D 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 substation.

**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
improving the competence of the workforce to achieve satisfactory mechanical alignment of the disconnector fleet
completing major busbar refurbishment projects that began in RCP1 at Timaru, Wilton, and Hawera
undertaking a major structure and buswork project at Kinleith substation
replacing a number of substation low-voltage AC panels and switchboards that are in poor condition.

Design
Our design plans include:
reducing the diversity within fleets
standardising busbar systems and LVAC systems as they become due for replacement.

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.

Design, procurement and construction standards

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP.DG 01.01</td>
<td>Design of insulation co-ordination</td>
</tr>
<tr>
<td>TP.DG 30.01</td>
<td>Electric and magnetic field design parameters for AC 50 Hz transmission lines,</td>
</tr>
<tr>
<td></td>
<td>substations and underground cables</td>
</tr>
<tr>
<td>TP.DS 01.01</td>
<td>Buswork design</td>
</tr>
<tr>
<td>TP.DS 01.02</td>
<td>Guidelines and information for switchyard structure design</td>
</tr>
<tr>
<td>TP.DS 07.01</td>
<td>Shielding against direct lightning strikes to station equipment</td>
</tr>
<tr>
<td>TP.DS 40.02</td>
<td>Station low voltage AC supplies</td>
</tr>
<tr>
<td>TP.DS 52.01</td>
<td>Design of substation earthing</td>
</tr>
<tr>
<td>TP.DS 54.01</td>
<td>Substation oil containment systems</td>
</tr>
<tr>
<td>TP.DS 61.01</td>
<td>Guidelines and information for substation design</td>
</tr>
<tr>
<td>TP.GS 03.03</td>
<td>Interlocking and power operation of disconnectors and earth switches</td>
</tr>
<tr>
<td>TP.GS 54.01</td>
<td>Oil spill management</td>
</tr>
<tr>
<td>TP.CG 10.01</td>
<td>Installation requirements for buried copper earthing connections</td>
</tr>
<tr>
<td>TP.CP 09.04</td>
<td>Panel, junction box and cabling installation</td>
</tr>
<tr>
<td>TP.SS 04.62</td>
<td>Testing and preparing instrument transformers for service</td>
</tr>
<tr>
<td>TP.TS 14.01</td>
<td>Procurement strategy: substation primary assets</td>
</tr>
<tr>
<td>TP.PS 01.01</td>
<td>Prefabricated aluminium tubular busbar purchase specification</td>
</tr>
<tr>
<td>TP.PS 01.02</td>
<td>Switchyards steel structures</td>
</tr>
<tr>
<td></td>
<td>12 kV, 36 kV, 72.5 kV, 123 kV and 245 kV disconnectors and earthing switches</td>
</tr>
<tr>
<td></td>
<td>purchase specification</td>
</tr>
<tr>
<td>TP.PS 03.01</td>
<td>Earthing/local service transformer for low/medium impedance earthing purchase</td>
</tr>
<tr>
<td>TP.PS 17.02</td>
<td>LVAC switchboard purchase specification</td>
</tr>
<tr>
<td>TP.PS 20.03</td>
<td>11/0.415 kV and 33/0.415 kV local service transformer purchase specification</td>
</tr>
<tr>
<td></td>
<td>Earthing/local service transformer for low/medium impedance earthing purchase</td>
</tr>
<tr>
<td>TP.PS 20.04</td>
<td>Current limiting and neutral earthing reactors purchase specification</td>
</tr>
<tr>
<td>TP.PS 22.01</td>
<td>66 kV, 110 kV and 220 kV outdoor current transformer purchase specification</td>
</tr>
<tr>
<td>TP.PS 23.01</td>
<td>50 kV, 66 kV, 110 kV and 220 kV outdoor voltage transformer purchase specification</td>
</tr>
<tr>
<td>TP.PS 30.02</td>
<td>11 kV to 220 kV surge arrester selection guide and purchase specification</td>
</tr>
</tbody>
</table>
12.5. OPERATIONS AND MAINTENANCE

Contingency planning
We will 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 will 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-yearly 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 15 years.

Corrective maintenance
We will investigate concrete bus posts installed in the 1950s and repair or replace them if necessary to avoid failure.

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.

Operations standards

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP.AOI 07.112</td>
<td>Bus livening procedures</td>
</tr>
<tr>
<td>TP.AOI 07.121</td>
<td>HWB 33 kV bus operation</td>
</tr>
<tr>
<td>TP.AOI 07.134</td>
<td>HAY and BEN 220 kV bus switching requirements</td>
</tr>
<tr>
<td>TP.SS 07.25</td>
<td>Locking of HV switchgear and lockout requirements</td>
</tr>
<tr>
<td>TP.OG 41.06</td>
<td>Operation of disconnectors to interrupt current</td>
</tr>
<tr>
<td>TP.OG 42.02</td>
<td>Operation of circuit breakers and disconnectors</td>
</tr>
<tr>
<td>TP.SS 07.25 SA1</td>
<td>Locking and tagging off of existing 220 kV ground-mounted disconnectors in manual operating mode</td>
</tr>
</tbody>
</table>

Maintenance specifications

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TP.SS 02.24</td>
<td>Outdoor reclosers and vacuum circuit breaker maintenance</td>
</tr>
<tr>
<td>TP.SS 02.33</td>
<td>Instrument transformers, coupling capacitors, resistive voltage dividers, HVDC transducers and transductors, and HVDC isolating transformer maintenance</td>
</tr>
<tr>
<td>TP.SS 02.40</td>
<td>Condition assessment for stations equipment and facilities</td>
</tr>
<tr>
<td>TP.SS 02.41</td>
<td>Station inspections</td>
</tr>
</tbody>
</table>
12.6. 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 monitors and remaining rod gaps of transformers that hold a risk of causing fault outages.

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

12.7. OTHER PRIMARY ASSETS WORKS

Table 47 provides a summary of the R&R plans for RCP2.

Table 47: Other primary assets R&R plans

<table>
<thead>
<tr>
<th></th>
<th>ITP 2015 replaced or refurbished</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACS Structures and buswork</td>
<td>-</td>
<td>23.7</td>
</tr>
<tr>
<td>ACS Instrument transformers</td>
<td>170</td>
<td>14.4</td>
</tr>
<tr>
<td>ACS Disconnectors and earthswitches</td>
<td>151</td>
<td>10.5</td>
</tr>
<tr>
<td>ACS Other station equipment</td>
<td>-</td>
<td>6.7</td>
</tr>
</tbody>
</table>

22 Total units are provided only for assets where R&R has relatively standard unit costs.
13. SA SUBSTATION MANAGEMENT SYSTEMS

13.1. ASSET DESCRIPTION

Substation telemetry systems enable the remote control and monitoring of our substations. Our existing substation telemetry systems are based on remote terminal units (RTUs).

Table 48: 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>259</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>49</td>
</tr>
<tr>
<td>Time synchronisation clocks</td>
<td>Provide time tagging of events as they occur at substations. The average age is about six years</td>
<td>197</td>
</tr>
</tbody>
</table>

13.2. 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 fleet at this stage.

13.3. 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.
13.4. PLANNING AND DELIVERY

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.

Design, procurement and construction standards
TP.DC 29.01 Design for RTU and station control system (SCS) installations and related serial data communications
TP.DC 29.03 Design for station server, human machine interface (HMI) and related communications
TP.DC 29.05 Supervisory control and data acquisition (SCADA) protocols and performance standard
TP.DC 29.07 Design for station management systems, including remote engineering access, HMI and related ethernet communications
TP.PC 02.03 Application guide for approved RTU, SMS, SCS, HMI, station server and associated equipment and software
TP.SS 04.66 Commissioning and decommissioning requirements for RTU/IED and National SCADA
TP.GC 29.03 Station management system interconnection policy
13.5. OPERATIONS AND MAINTENANCE

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 five-yearly diagnostic testing 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.

Operations standards
TP.AOI 07.610 Managing the loss of RTUs or national SCADA
TP.AOI 07.612 SCADA NIS, TAG and notes management

Maintenance specifications
TP.SS 03.06 SCADA and SCS maintenance
TP.GC 29.02 RTU replacement and upgrade policy

13.6. 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-useful or unnecessary components to a specialist electronics disposal company for breaking down and recycling.

13.7. SUBSTATION MANAGEMENT SYSTEMS WORKS

Table 49 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>130</td>
</tr>
</tbody>
</table>
14. **SA SECONDARY SYSTEMS**

### 14.1. Asset Description

**Protection equipment**

Secondary systems protection equipment 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.

**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\(^{23}\) bus sections (ranging from 11 kV to 220 kV) in the network, which leaves about 100 bus sections with no dedicated bus protection. Table 50 shows the percentage breakdown and average age of bus protection relays by relay type.

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
<th>Average age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>80</td>
<td>15</td>
</tr>
<tr>
<td>Static</td>
<td>10</td>
<td>14</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td>Numerical</td>
<td>5</td>
<td>6</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 51 shows the percentage breakdown and average age of feeder protection relays by relay type.

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
<th>Average age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>8</td>
<td>45</td>
</tr>
<tr>
<td>Static</td>
<td>2</td>
<td>31</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>13</td>
<td>12</td>
</tr>
<tr>
<td>Numerical</td>
<td>77</td>
<td>11</td>
</tr>
</tbody>
</table>

\(^{23}\) This includes bus sections with the fast bus blocking scheme.
SA SECONDARY SYSTEMS

**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 52 shows the percentage breakdown and average age of line protection relays by relay type.

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
<th>Average age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>2</td>
<td>17</td>
</tr>
<tr>
<td>Static</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>23</td>
<td>12</td>
</tr>
<tr>
<td>Numerical</td>
<td>73</td>
<td>9</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 53 shows the percentage breakdown and average age of line protection relays by relay type.

<table>
<thead>
<tr>
<th>Relay type</th>
<th>% of total relays</th>
<th>Average age (years)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electromechanical</td>
<td>9</td>
<td>33</td>
</tr>
<tr>
<td>Static</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Microprocessor</td>
<td>14</td>
<td>18</td>
</tr>
<tr>
<td>Numerical</td>
<td>62</td>
<td>10</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 fleet 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 4 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.

**14.2. 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 eight years of service, when we then replace them.
All revenue meters are in good condition. They have a life expectancy of 15 years.

**Criticality**

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

### 14.3. 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 cleared by line protection equipment satisfactorily. 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.

### 14.4. Planning and Delivery

**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
• expand the Christchurch RPC to capacitors and new transformer tap changers at Bromley
• upgrade the RPC simulator so it is available for troubleshooting and planning work
• install an RPC scheme in Auckland based on the Christchurch RPC to optimise the dynamic and static reactive plants in the Auckland area

Replacement and refurbishment
The secondary systems fleet 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.

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.

Design, procurement and construction standards
TP.DG 25.01 Transmission code of practice
TP.AP 01.02 Relay setting process
TP.DP 01.01 Test facilities
TP.DP 02.03 Protection of interconnecting transformers
TP.DP 02.04 Protection of star-delta supply transformers
TP.DP 02.07 Protection of delta-star supply transformers
TP.DP 03.01 Feeder protection design standards
TP.DP 03.05 Auto reclose for line circuits
TP.DP 04.01 Design of circuit breaker failure protection
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.

### 14.5. OPERATIONS AND MAINTENANCE

**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.

**Operations standards**

- TP.AO1 07.518: Circuit tripping response management
- TP.OP 02.03: Transformer and feeder protection setting guide
- TP.OP 03.04: Distance and directional earth fault protection setting guide
- TP.OP 04.03: High-impedance differential busbar protection: setting guide

**Maintenance specifications**

- TP.MP 03.09: Removal from service of protection on in-service transmission circuits
- TP.SS 02.71: Lead-acid batteries and DC systems maintenance
- TP.SS 03.00: HV power system protection maintenance
- TP.SS 03.11: Condition assessment for secondary equipment

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

### 14.6. 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.

### 14.7. SECONDARY SYSTEMS WORKS

Table 54 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>40</td>
</tr>
<tr>
<td>SA Line protection</td>
<td>136</td>
</tr>
<tr>
<td>SA Transformer protection</td>
<td>71</td>
</tr>
<tr>
<td>SA Batteries and DC systems</td>
<td>171</td>
</tr>
<tr>
<td>SA Feeder protection</td>
<td>45</td>
</tr>
</tbody>
</table>
15. HVDC

15.1. Asset Description

All around the world HVDC is the preferred option for bulk power transmission over longer distances due to its high-voltage and DC configuration. 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>
15.2. **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)
- 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 fleet 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, the HVDC availability will be critical for the operation of the power system. We do consider these impacts in planning maintenance on the HVDC system, and our future criticality framework may take account of this additional criticality dimension.

15.3. **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 fleet 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.

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 (a 1 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.

15.4. PLANNING AND DELIVERY

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
- 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
- refurbishing all the Pole 2 converter transformers by the end of RCP3.

Design

We have no major design work planned until the future Pole 4 project. 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 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.

15.5. OPERATIONS AND MAINTENANCE

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 developing 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. 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.

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.

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 due to 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
• 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.

Operations standards
TP.OG 48.02 HVDC: Bipole operating policy

Maintenance specifications
TP.SS 02.43 Outdoor buswork and supporting structure maintenance at AC and HVDC stations
TP.SS 02.51 Thyristor valve maintenance
TP.SS 02.53 Miscellaneous HVDC maintenance requirements
TP.SS 02.54 HVDC shore electrode maintenance
TP.SS 02.55 HVDC land electrode maintenance
TP.SS 03.10 HVDC controls and protection maintenance
TP.GS 01.08 Condition assessment policy for AC stations and HVDC equipment and facilities

15.6. 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.
15.7. HVDC WORKS

Table 56 provides a summary of the R&R plans for RCP2.

Table 56: HVDC R&R plans

<table>
<thead>
<tr>
<th>Units replaced or refurbished(^{24})</th>
<th>$m</th>
</tr>
</thead>
<tbody>
<tr>
<td>HVDC</td>
<td>-</td>
</tr>
</tbody>
</table>

\(^{24}\) Total units are provided only for assets where R&R has relatively standard unit costs.
16. ICT

16.1. Asset Description

ICT delivers and supports the infrastructure, server hardware, and applications that interface with grid technology and connect the system operator and the market.

ICT solutions change frequently as an increasingly large number of devices and processes depend on digital technologies and communication. 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 systems and 250 supporting ICT components. The population of our physical assets is shown in Table 57.

<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>440km</td>
<td>Voice routers</td>
<td>145 devices</td>
</tr>
<tr>
<td>Fibre cable—all di-electric self-supporting (ADSS)</td>
<td>5km</td>
<td>New radios</td>
<td>23 devices</td>
</tr>
<tr>
<td>Fibre cable—buried</td>
<td>775km</td>
<td>Power line carriers</td>
<td>24 devices</td>
</tr>
<tr>
<td>Fibre cable—submarine</td>
<td>135km</td>
<td>Physical computers</td>
<td>649 servers</td>
</tr>
<tr>
<td>Synchronous digital hierarchy (SDH) multiplex equipment</td>
<td>264 devices</td>
<td>Network routing</td>
<td>1400 switches</td>
</tr>
<tr>
<td>Plesiochronous digital hierarchy (PDH) multiplex equipment</td>
<td>407 devices</td>
<td>Firewalls</td>
<td>68 devices</td>
</tr>
<tr>
<td>Core multiprotocol label switching routers</td>
<td>36 devices</td>
<td>Datacentres</td>
<td>5</td>
</tr>
</tbody>
</table>

We group our ICT assets into the five business service categories shown in Table 58. There is also a market systems category which is omitted from this overview.

<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>• SCADA (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>
<tr>
<td></td>
<td>• PI System (process information)—enables the storage of time series data and analytical tools to report on that data. The data is fed in real time from key assets on the grid through the SCADA system or direct to the PI database.</td>
</tr>
<tr>
<td></td>
<td>• GMMS (grid meter management system)—provides a metering data repository and data management system that is the master source of metering data within Transpower.</td>
</tr>
<tr>
<td>Asset management systems</td>
<td>Support the forecasting and planning of grid asset maintenance and our management systems. Includes:</td>
</tr>
<tr>
<td></td>
<td>• Maximo—our core asset management information system for all grid assets which</td>
</tr>
</tbody>
</table>
ICT 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.
- **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.

### 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/stakeholders.
- **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.

### Telecommunications, network and security services
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).

- **TransGO**—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.
- **Security systems**—Security enforcement points and architecture that support our security of supply and system availability.
- **Voice-video conferencing**—provide the corporate voice and video services using a number of platforms through the network.
16.2. 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 59: 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>
</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.

16.3. Asset Performance

We monitor all ICT systems continuously for performance and capacity, and report our critical asset performance monthly. The key performance measurements for our major systems are shown in Table 60.

Table 60: ICT performance measurements for major systems

<table>
<thead>
<tr>
<th>Key performance indicators</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>99.99%</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>99.7%</td>
<td>Measure is against agreed support hours</td>
</tr>
</tbody>
</table>

There are currently no major performance concerns with our asset fleet.

16.4. Planning and Delivery

During the RCP2 period, our investment focus will change from building new capability to ensuring continued support and maintenance of our existing systems.

We have enterprise architecture principles that enforce our strategy and guide ICT investment through a number of key concepts (included in Chapter 1 of Part 1 of the AMP.)

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 will be investigating efficiency opportunities provided by cloud and all AoG providers for our enterprise systems. This may see a decrease in capex and a move to increased opex during RCP3. Investigations are at a very early stage, and we cannot at this time forecast this potential shift in expenditure.

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**
- Delivering a version upgrade of Alstom Grid software for our SCADA and energy management systems (EMS) systems from v2.3 to v2.6 by the end of 2015, and further upgrades 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 condition-based risk management and near real time asset health indices in 2015–2018. 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.
- Replacing ageing lightning sensors in 2020 and undertaking a major software/hardware refresh of the LDS system in 2023.
- Refreshing the SDTF system in 2019 and 2024.

**Corporate systems**
- Upgrading our FMIS system to Peoplesoft 9.2 in 2015, 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 will also replace our desktop software in 2019 and consider the use of Desktop as a Service.
- Separating our critical systems access from our enterprise access as part of IAM. We may extend the enterprise 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.

16.5. 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 Transpower 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.

16.6. DISPOSAL AND DIVESTMENT ACTIVITIES

While we do not have an explicit disposal policy for ICT assets, we look at achieving efficiencies when decommissioning older assets being replaced or refreshed as part of our annual programme.
17. BUSINESS SUPPORT ASSETS

17.1. ASSET DESCRIPTION

Business support assets include assets not otherwise included in other asset fleets:

Table 61 provides an overview of the business support assets.

Table 61: Business support assets (June 2015)

<table>
<thead>
<tr>
<th>Asset category</th>
<th>Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategic properties</td>
<td>5 properties at Islington, Geraldine, Timaru, 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>4 leased offices, 2 owned offices, 3 owned warehouses and 3 owned training facilities</td>
</tr>
<tr>
<td>Vehicles</td>
<td>92 passenger vehicles</td>
</tr>
<tr>
<td>Office equipment</td>
<td>Office desks, chairs and meeting room furniture</td>
</tr>
</tbody>
</table>

Because these assets are different in nature, this AMP considers each separately.

17.2. STRATEGIC PROPERTIES

Asset characteristics and performance

Strategic property is not included in our regulated asset base. We have five of these properties located at Islington, Geraldine, Timaru (ex-Turner), 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. Surrounded 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).
17.3. 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. The disposal programme covers 43 properties which could yield over $10 million net proceeds.

17.4. 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, Bunnthorpe and Addington substations, plus linesman training facilities at Western Road substation, Omaka (Blenheim) and Bunnthorpe 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
BUSINESS SUPPORT ASSETS

- Refurbishment or relocation of our Palmerston North office in 2016/17
- Minor refurbishments of our Auckland and Christchurch offices in 2019/20
- Relocation of our Addington warehouse to Islington substation in 2016/17
- Upgrade of the Bunnythorpe and Omaka training facilities in 2015/16.

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 sell the Addington warehouse and land if the business case to relocate this site to Islington is justified.

17.5. VEHICLES

Asset characteristics and performance
Our vehicles are predominantly located at the Auckland, Palmerston North and Christchurch offices and are used as pool vehicles or allocated to staff who regularly visit our sites, landowners and customers. 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 (AoG) contract for the supply of motor vehicles, which is regarded as able to achieve 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.

Disposal and divestment
We replace petrol vehicles every three years or 100,000 km and diesel vehicles every five years or 150,000 km. We usually sell vehicles through established auction houses.

17.6. OFFICE EQUIPMENT

Asset characteristics and performance
Transpower’s 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.