# Independent Verification Report - Transpower's RCP3 Expenditure Proposal (2020-25)

A report prepared in accordance with the Tripartite Deed between Synergies, Transpower and the Commerce Commission

12 October 2018

Synergies Economic Consulting Pty Ltd
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# Executive Summary

Synergies and GHD Advisory (GHDA) have been engaged to provide an independent verification opinion on Transpower's RCP3 Base Capex and opex forecasts relating to the 2020-25 period for Transpower and the Commerce Commission (the Commission).

Our verification review has been guided by Terms of Reference (TOR) prepared by the Commission, including prescriptive Evaluation Criteria (refer Appendix A of our report).

In accordance with the TOR, we have engaged with Transpower in an independent manner in accordance with the tripartite deed between Synergies, Transpower and the Commerce Commission.

The guiding principle in our verification review and in forming our verification opinions have been whether Transpower's RCP3 expenditure forecasts and associated grid output measures are consistent with an expenditure outcome that represents the efficient costs of a prudent supplier having regard to Good Electricity Industry Practice (GEIP). This term is defined as follows:[1]

> 'Good electricity industry practice' is defined in Part 1 of the Electricity Industry Participation Code 2010 as: good electricity industry practice in relation to transmission, means the exercise of that degree of skill, diligence, prudence, foresight and economic management, as determined by reference to good international practice, which would reasonably be expected from a skilled and experienced asset owner engaged in the management of a transmission network under conditions comparable to those applicable to the grid consistent with applicable law, safety and environmental protection.

We consider the above definition is consistent with the use of regulatory prudency and efficiency tests generally applied by the Commission and Australian economic regulators. In simple terms, prudency relates to expenditure directed to maintaining the safety, quality, reliability and security of supply of regulated services, Efficiency relates to the provision of regulated services in a least cost manner having regard to conditions in relevant markets for labour, capital and materials inputs.

In forming our verification opinions, we have assessed Transpower's development of its RCP3 expenditure forecasts at an aggregate and individual programme level. Our

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1 Terms of reference for verification of Transpower's RCP3 proposal, p 1

review of individual expenditure programmes has been guided by criteria agreed between Transpower and the Commission and is discussed in the next section.

## Identified and Non-Identified programmes

The TOR requires us to review Transpower's proposed Base Capex and opex allowances for RCP3 with emphasis on Identified Programmes.[2] The purpose of the Identified Programmes is to require more in-depth qualitative and quantitative analysis of the formation of a large subset of Transpower's Base Capex and opex programmes.[3]

Table 1 shows the RCP3 Base Capex Identified Programmes by asset category, forecast expenditure size and verification status.

**Table 1 Identified programmes – Base Capex ($2017/18)[4]**

| Identified programme | Asset category | Sep 2018 RCP3 forecast | Verification status |
|---|---|---|---|
| **Renewal** | | | |
| Power transformers | Substations | $60.1 million | Verified and satisfies GEIP |
| Outdoor 33 kV switchyards; Outdoor to indoor conversions | Substations | $42.1 million | Verified and satisfies GEIP |
| Transmission Line structures & insulators | Lines | $308.7 million | Verified and satisfies GEIP |
| Transmission Line conductor & hardware | Lines | $90.2 million | Verified and satisfies GEIP |
| HVDC | HVDC | $64.6 million | Verified and satisfies GEIP.<br>However, given the size of expenditure and potentially large (but unavoidable) uncertainty of forecast costs, this project satisfies the criteria for Listed Projects.<br>Transpower sought feedback on the appropriate regulatory treatment of this project in its August 2018 stakeholder engagement. |
| Reactive Assets | HVDC | $39.5 million | Verified and satisfies GEIP |

2 Independent Verification TOR, paragraph 17

3 The Capex IM requires Transpower to agree with the Commission on a set of criteria for determining the list of Identified Programmes to include in a Base Capex proposal.

4 Forecasts as at 27 September 2018

| Identified programme | Asset category | Sep 2018 RCP3 forecast | Verification status |
|---|---|---|---|
| Secondary Assets - protection, battery systems and revenue meters | Secondary assets | $141.6 million | Verified and satisfies GEIP |
| Secondary Assets - substation management systems | Secondary assets | $58.6 million | Verified and satisfies GEIP |
| **Enhancement & development** | | | |
| Grid E&D | Enhancement and Development | $76.4 million | Verified and accept new RCP3 forecasting methodology and business rules.<br>We recommend Commerce Commission review methodology and business rules. |
| **Non-network capex** | | | |
| IT telecoms, network & security systems | ICT capex | $48.8 million | Verified and satisfies GEIP |
| Transmission systems | ICT capex | $47.0 million | Verified and satisfies GEIP |
| Total RCP3 Identified Programme expenditure | N/A | $977.5 million | Total RCP3 Identified Programme expenditure verified and satisfies GEIP |
| Total RCP3 Base Capex | N/A | $1,202.4 million | |
| **Identified Programme percentage of RCP3 Base Capex** | **N/A** | **N/A** | **81% of Base Capex verified** |

**Source:** Synergies' forecasts

Table 2 shows the Identified Programmes for RCP3 opex by size.

**Table 2 Identified Programmes – Opex ($2017/18)**

| Identified programme | Sep 2018 RCP3 forecast | Verification status |
|---|---|---|
| **Network opex** | | |
| Preventive maintenance | $198.8 million | Verified and satisfies GEIP |
| Predictive maintenance | $335.9 million | Base year and some step changes verified.<br>Three step changes totalling $26.0 million not verified as consistent with GEIP. |
| **Non-network opex** | | |
| Asset management and operations | $309.5 million | Verified and satisfies GEIP |
| Business support | $226.5 million | Verified and satisfies GEIP |
| Total RCP3 Identified Programme expenditure | $1,070.6 million | 97.6% of RCP3 Identified Programme expenditure verified and satisfies GEIP |
| Total RCP3 Opex | $1,342.9 million | |

| Identified programme | Sep 2018 RCP3 forecast | Verification status |
|---|---|---|
| **Identified Programme percentage of RCP3 Opex** | | **80% of Opex verified** |

**Source:** Transpower RCP3 forecast data

In addition to the Identified Programmes, we have also verified several Non-Identified Programmes for RCP3 Base Capex and opex as shown in Table 3.

**Table 3 Non-Identified Programmes – Base Capex & opex**

| Identified programme | Sep 2018 RCP3 forecast | Verification status |
|---|---|---|
| **Base Capex** | | |
| Buildings and grounds | $39.5 million | Verified and satisfies GEIP |
| Asset management systems | $18.6 million | Verified and satisfies GEIP |
| **Verified Non-Identified Programme Base Capex** | **$58.1 million** | **100% verified and satisfies GEIP** |
| **Opex** | | |
| Insurance | $88.0 million | Verified but does not satisfy GEIP given the information we have relied upon.<br>An actuarial opinion is required to assess the efficiency of the proposed large step change in RCP3 expenditure. |
| ICT opex | $195.9 million | Verified and satisfied GEIP |
| Corrective maintenance | $15.0 million | Verified and satisfies GEIP |
| Proactive maintenance | $2.5 million | Verified and satisfies GEIP |
| **Verified Non-Identified Programme Opex** | **$301.4 million** | **71% verified and satisfies GEIP** |

**Source:** Transpower RCP3 forecast data

Table 4 presents a summary of the outcome of our assessment of verified programmes.

**Table 4 Summary of status of Verified programmes (Identified and Non-Identified)**

| | Verification status |
|---|---|
| **Base Capex** | |
| Total verified Base Capex | $1,132.4 million |
| Verified & GEIP satisfied | $1,132.4 million |
| Verified and GEIP not satisfied | N/A |
| **Verified & GEIP satisfied (%)** | **100%** |
| **Opex** | |
| Total verified Opex | $1,342.9 million |
| Verified & GEIP satisfied | $1,228.9 million |
| Verified and GEIP not satisfied | $114.0 million |

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| | Verification status |
|---|---|
| **Verified & GEIP satisfied (%)** | **92%** |
| Total non-verified Opex | **N/A** |

**Source:** Transpower RCP3 forecast data

We consider the 8% of RCP3 opex that we have not been able to verify as being consistent with GEIP (relating to predictive maintenance and insurance step changes) can be resolved by Transpower prior to submittal of its RCP3 proposal to the Commerce Commission.

## High level assessment against the TOR

A summary of our verification opinions made in accordance with Clause 4 of the TOR is presented in Table 5.

**Table 5 Verification summary**

| TOR requirement | Verification key findings |
|---|---|
| Section 4.1: Consistency with expenditure outcome | **Total RCP3 capex**<br>In its Identified Programmes, Transpower has identified step changes in tower painting, re-conductoring and secondary systems expenditure. We consider these step changes are prudent and efficient satisfying GEIP, because they are underpinned by Transpower's robust asset management framework and cost estimation methodology (see TOR requirement Clause: 4.2 below).<br>We consider the proposed HVDC upgrade in RCP2 is prudent and satisfies GEIP. There is the potential for this project to satisfy the Capex Input Methodology's Listed Project criteria and Transpower consulted on the appropriate regulatory treatment of this expenditure as part of its August 2018 stakeholder engagement.<br>We believe Transpower's RCP3 Enhancement and Development (E&D) forecasting methodology is an improvement on the RCP2 methodology, providing a far better window on forecast expenditure through likelihood classifications. At our recommendation, Transpower has also developed business rules supporting the development of the RCP3 forecast, which we consider will provide a sound approach to forecasting with good consideration of the inherent uncertainties in E&D projects.<br>For ICT Capex, Transpower has provided good high-level preliminary estimates of benefits to support assessment of efficiency and cost effectiveness of the initiatives, such that we can verify that RCP3 forecast expenditure is consistent with GEIP. |

| TOR requirement | Verification key findings |
|---|---|
| | **Total RCP3 opex**<br>Transpower's RCP3 forecast is broadly consistent with RCP2, notwithstanding proposed step changes in several individual expenditure programmes.<br>The most significant step change is in the insurance category, a Non-Identified programme, which we cannot determine satisfies GEIP because this requires an actuarial opinion. We understand that Transpower procured this opinion during our engagement on this project.<br>A relatively large step change of $62.2 million is proposed for the Identified Programme predictive maintenance. We have not been able to verify $26.0 million of this step change, although we accept the proposed changes as being prudent. Consequently, based on the information provided, we cannot determine that GEIP is satisfied for $26.0 million of the RCP3 predictive maintenance expenditure.<br>Of the remaining Identified Programmes, Transpower's RCP3 Asset Management and Operations expenditure is the largest. Whilst there is evidence of the shift from a major capital works to an enhanced maintenance planning focus for RCP3 and Transpower's supporting Asset Management and Maintenance Overview outlines qualitatively the activities and benefits of the current resource levels, we have not been able to verify the effectiveness of the increased number of FTEs planning the maintenance expenditure, particularly as the overall maintenance expenditure for RCP3 is only 4% higher than RCP2. On balance, we verify the proposed expenditure for RCP3 of $309.5 million as being in accordance with GEIP, but identify this as an area for further investigation by the Commerce Commission.<br>Business support opex is consistent with RCP2 expenditure levels and underpinned by efficiency initiatives undertaken during RCP2. We consider that this programme satisfies GEIP.<br>Our economic benchmarking indicates that Transpower's opex is relatively high compared to Australian transmission networks. This appears to be due to Transpower's relatively high indirect rather than direct opex. It may also reflect the outcome of Transpower's capex planning decision-making framework, where opex is considered a viable option through service extensions rather than capital investment – this capex opex trade-off flows through to higher preventive and predictive maintenance expenditure. |
| | **Price-quality testing**<br>Transpower's price-quality testing as part of its August 2018 stakeholder engagement is a well-intentioned initiative in reviewing at a relatively high level, the scope for expenditure and service performance trade-offs in RCP3, as well as in the longer term. However, the current approach only identifies any risk impacts qualitatively. Transpower has acknowledged that more work may be required to quantify the additional risk arising from price-quality trade-offs using techniques like what has been completed for the bottom-up expenditure build.<br>Notwithstanding the relatively cautious nature of the proposed August 2018 price-quality testing presented to Transpower's stakeholders, we believe such testing is likely to be better utilised as an input to Options Assessment Analysis (OAA) rather than as a final expenditure gateway. This is because it can potentially shift the risk profile for an asset class due to options being preferred primarily on quantitative cost and deliverability considerations without quantifying the change in risk – if applied as a final gateway over the long term, this could create an unwanted risk profile for an asset class. |

| TOR requirement | Verification key findings |
|---|---|
| Section 4.2: Consistency with good asset management practice | Transpower's asset management systems are robust, comprehensive and in line with GEIP.<br>It is evident that Transpower has made several enhancements to its asset management framework during RCP2, including the development of asset health models.<br>**Asset health modelling**<br>Transpower's asset health modelling is in its early stages, based on the Ofgem approach and now common across all distribution network operators in the UK. It currently provides a good qualitative guide but requires improved asset condition data for five nominated measures - power transformers, OD circuit breakers, insulators, conductors, tower painting - to better inform the OAA stage of Transpower's Decision Framework, and to eventually quantify the impact of changes to risk for changes in works delivery scheduling and completion.<br>**Capex/opex trade-offs**<br>Capex-opex trade-offs are an inherent part of Transpower's investment governance processes. The Capex Decision Framework is identifying preferred solutions based on consideration of whole-of-life costs and often considers life extension expenditure in lieu of capital investment. Transpower's good capex economic benchmarking performance provides indicative evidence of the practical impact of its capex-opex trade-offs.<br>Asset management systems have been followed in developing the RCP3 expenditure forecasts and it is evident that Transpower is adjusting/deferring work where necessary to ensure deliverability of the proposed capital programme.<br>However, we can see a potential adverse impact of this approach in tower painting and conductor replacement where current systems are implying a big uplift in RCP4 and beyond. The solution in part may lie with increased data gathering to ensure any investment decisions are based on current Condition Assessment/asset health modelling and risk assessments, not legacy data. |

| TOR requirement | Verification key findings |
|---|---|
| Section 4.3:<br>Key policies and governance processes are effective | Transpower's key policies and governance processes are effective and consistent with GEIP.<br>**RCP3 programme governance**<br>Transpower's RCP3 programme governance is based on high level oversight provided by the Board, Chief Executive and the RCP3 General Management Sub-Committee. The latter Sub-Committee comprises four General Managers and the CFO, with Grid Level 3 managers also attending meetings with the RCP3 leadership team.<br>Challenges for RCP3 expenditure forecasts occur at the General Manager and RCP3 General Management Sub-Committee levels, prior to presentation to the Chief Executive and Board for endorsement. There has also been evidence of top down challenges being applied by the Board in the development of the RCP3 expenditure forecasts.<br>**Cost estimation systems and processes**<br>We consider Transpower's cost estimation systems and processes have improved since RCP2 in line with the Commission's recommendations.<br>Transpower's focus is on developing accuracy and confidence levels in volumetric standard job costs and associated building blocks, introducing a reporting facility that will highlight the estimating accuracy for volumetric work vs actual costs with a (in our consideration soft) target of 80% for estimated volumetric works to be within ±20% variance of actual costs. We recommend that this target be increased to 90% as data quality improves and the focus on overall accuracy improvement should also extend to non-volumetric projects.<br>We are satisfied with the processes in place for feedback on reported costs and project reviews feeding into the cost estimation process. However, we recommend full implementation of feedback loops to drive process improvements.<br>Overall, we consider Transpower satisfies GEIP in its cost estimation systems and processes, while recognising that further improvements can be made to enhance the robustness and reliability of its cost estimates.<br>**Demand forecasting methodology**<br>Transpower's demand forecasting methodology incorporates top down and bottom up approaches. There is evidence of improvements in the methodology being made over time.<br>We consider Transpower's demand forecasting methodologies satisfy GEIP. |
| Section 4.4:<br>Deliverability of proposed base expenditure programmes | Transpower's governance framework regarding deliverability of its proposed RCP3 total expenditure programme represents GEIP.<br>It considers external service provider capability and capacity in programming works and facilitates development of mitigation strategies when delivery constraints are found. Transpower also applies procedures to maximise the utilisation of external service providers.<br>There are good examples of RCP2 mitigation strategies for known problems and pre-planning for RCP3 projects.<br>However, significant tower painting & re-conductoring programmes foreshadowed during RCP4 will require early resource planning at the beginning of RCP3. Transpower has flagged its intention to widen the current deliverability review to bridge RCPs to address issues, such as sharp forecast increases in portfolio work. |

| TOR requirement | Verification key findings |
|---|---|
| Section 4.5:<br>Extent and effectiveness of Transpower's consultation | **Proposed RCP3 grid output measures**<br>Transpower has consulted extensively on its existing and potential new grid output measures, which has informed several changes it is proposing to make to the measures for RCP3, including a new 'return to service' measure.<br>We consider the proposed RCP3 grid output measures reflect the effectiveness of Transpower's stakeholder consultation on service performance issues.<br>Based on the information we have been provided and assuming no material changes arising from the August 2018 stakeholder engagement, we consider that Transpower's proposed grid output measures for RCP3 satisfy the expenditure outcome having regard to GEIP. This is because the proposed measures address the areas of service performance that we consider are likely to be of most concern to energy consumers including, most importantly, those consumers directly connected to the Grid.<br>The incorporation of the Value of Loss Load into the service performance incentive arrangements to proxy the value that customers place on a reliable electricity supply improves upon the RCP2 incentive arrangements.<br>The only caveat regarding our verification opinion relates to the details of Transpower's proposed new asset health measures, which will replace the works-based asset health measures and targets applying in RCP2. While we consider that the introduction of these new measures represents GEIP, there appears to be work still required to finalise the details of the associated incentive arrangements for RCP3. We are aware the Commission and Transpower are having ongoing engagement regarding these new measures, including a pilot trail currently underway. Consequently, we do not consider we have enough information to form a verification opinion on these measures.<br>**Proposed RCP3 grid output targets**<br>We consider that Transpower's intent to base the RCP3 targets primarily on historical service performance data is appropriate, in preference to the setting of 'aspirational' targets. Our view is that the primary objective in setting service performance targets should be to satisfy all relevant legislative and regulatory requirements, as well as provide incentive to maintain historic performance levels at a minimum. Any divergences from these requirements should only be considered upon request of individual directly connected customers.<br>Transpower has advised that its proposed RCP3 grid output targets are largely consistent with comparable targets for RCP2, although some Point of Service for the GP1, GP2 and AP2 measures have moved categories and some customers have higher or lower targets for reliability or restoration performance.<br>Based on the information we have been provided and recognising that the targets are still potentially subject to change, we cannot satisfy ourselves that Transpower's proposed targets for its RCP3 grid output measures, including the new asset health measures, satisfy GEIP.<br>We have also not verified the adjustments that have been made to the historical service performance data to set the RCP grid output targets. |

<table>
<tr><th>TOR requirement</th><th>Verification key findings</th></tr>
<tr><td>Section 4.6:<br>Extent to which Transpower's proposal is consistent with stakeholder feedback</td><td>Transpower's proposed grid output measures for RCP3 are consistent with stakeholder feedback.<br>Transpower frequently undertakes business-as-usual engagement activity with its customers affected by the E&D portfolio.<br>Transpower engaged with its customers in August 2018 regarding its full RCP3 proposal, including on price-quality testing and the proposed grid output targets. This engagement may have some impact on RCP3 expenditure, so we are not able to fully satisfy ourselves at this point that GEIP regarding stakeholder feedback is met.<br>However, we believe Transpower has been genuine in its engagement with stakeholders over the RCP3 proposal development process and note that stakeholder feedback can be conflicting such that full consistency is not achievable.</td></tr>
<tr><td>Section 4.7:<br>List of key issues and areas the Commission should focus on</td><td>Our list of key issues that we consider the Commission should focus on are:<ul><li>Asset health models and new asset health grid output measures and associated targets.</li><li>Changes in Grid performance (reliability) (GP1 and GP2) and asset performance (AP2) targets for RCP3, including adjustments made to the historical data used to set RCP3 targets and individual customer impacts.</li><li>Review RCP3 forecasting methodology and business rules for the E&D capex programme.</li><li>Insurance step change.</li><li>Review the 2018/19 base level of expenditure for the Asset Management & Operations opex programme.</li><li>Assess whether the HVDC upgrade project should be treated as a Listed Project in RCP3.</li><li>Assess the longer-term preliminary deliverability plans for tower painting and re-conductoring in RCP4 and RCP5.</li></ul>Chapter 13 of our report summarises the reasons for the identification of these issues.</td></tr>
<tr><td>Section 4.8:<br>Whether Transpower provided us with the type and depth of information we needed for our report</td><td>Transpower provided us with the type and depth of information required to form our verification opinion on its RCP3 expenditure forecasts. It has been open and highly co-operative throughout the project.<br>We do not consider there to be any material omissions in the information we have been provided to undertake our verification review.</td></tr>
<tr><td>Section 4.9:<br>Identify any other information not included in Transpower's RCP3 proposal that we believe it has available and that would assist the Commission in evaluating the RCP3 proposal.</td><td>Given the tight time constraints within this verification report has been prepared, there is information that Transpower has available that we have not been able to fully assess or verify. This includes Transpower's newly developed asset health models and the models used to develop its grid output targets.<br>In addition, Transpower advised us and we have seen evidence of significantly more granular operational data that it was willing to make available. However, such granular data is either beyond the scope of our verification review given the tight project timeline and/or we have had insufficient time to review it.<br>It is open to the Commission to more closely scrutinise this information.</td></tr>
</table>

**Source:** Synergies/GHDA

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# Figures

## Tables

# 1 Introduction

Synergies Economic Consulting (Synergies), in partnership with GHD Advisory (GHDA), has been engaged to perform the role of independent verifier to scrutinise the base capital expenditure (Base Capex) and operating expenditure (opex) components of Transpower's third regulatory control period (RCP3) proposal for its price-quality path for the 5 years from 1 July 2020 to 30 June 2025.

## 1.1 Price-quality regulation of Transpower

Since April 2011, Transpower has been subject to individual price-quality path (IPP) regulation under Part 4 of the New Zealand *Commerce Act 1986* (the Act). Transpower's second regulatory price control period (RCP2) under this form of regulation runs until 30 June 2020.

A key part of the Part 4 regulatory regime is the Transpower Capital Expenditure Input Methodology (Capex IM) determined by the Commission. This sets out the upfront rules, requirements and processes that apply under the IPP. On 25 May 2018, the Commission published its final Capex IM amendments determination, showing the changes due to the Capex IM review.[5]

For Transpower's RCP3 proposal, the Commission also released an information notice specifying the information it requires from Transpower to assess its expenditure forecasts for RCP3.[6]

In addition to IPP regulation, Transpower is also subject to information disclosure regulation under subpart 9 of Part 4 of the Commerce Act, the purpose of which is to ensure that sufficient information is readily available to interested persons to assess whether the purpose of Part 4 of the Act is being met.[7] This is given effect through annual disclosure statements of key performance measures.

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5 Commerce Commission (2018), Transpower Capital Expenditure Input Methodology Amendments Determination 2018, [2018] NZCC 8, May

6 Commerce Commission (2018), Notice to supply information to the Commerce Commission under section 53ZD of the Commerce Act 1986

7 The purpose of Part 4 is to promote the long-term benefit of consumers in markets where there is little or no competition and little or no likelihood of a substantial increase in competition.

## 1.2 Our responsibilities as Transpower's independent verifier

In preparation for its RCP3 proposal and as part of the review of the Capex IM noted above, Transpower agreed to pilot the use of an independent verifier of its propsed expenditure ahead of submitting its proposal.

The Commission intends the independent verifier will be able to frontload work, testing the assumptions underpinning Transpower's Base Capex, opex and demand forecasts. This should assist Transpower to submit a better quality and more robust proposal, as well as direct the Commission to areas of the expenditure proposal that require greater scrutiny.[8]

Transpower and the Commission agreed the verifier should be an independent party that reviews or 'verifies' – within an upfront agreed scope of work – Transpower's RCP3 expenditure proposal and processes used to create the proposal, before the formal submission of the RCP3 proposal (in December 2018) to the Commission.

Reflecting this intent, Synergies/GHDA has been engaged by Transpower as the independent verifier, but also has a duty of care to the Commission to act as an independent expert and with reasonable care in accordance with a signed tripartite deed.

## 1.3 Our Terms of Reference (TOR)

Transpower worked with the Commission to develop TOR to guide our verification review. The TOR closely reflect the amended Capex IM for Transpower noted above. Amongst other things, the TOR establishes the overarching basis of our verification review, which is:[9]

> 3.2. Evaluating whether Transpower's proposed Base Ccapex allowance, proposed opex allowance, proposed grid output measures, and key assumptions are consistent with an expenditure outcome, which represents the efficient costs of a prudent supplier, having regard to:
>
> 3.2.1. Good Electricity Industry Practice (GEIP) as reflecting the appropriate planning and performance standards for a prudent supplier; and
>
> 3.2.2. the evaluation criteria.

[8] http://www.comcom.govt.nz/regulated-industries/regulated-industries-media-releases/detail/2018/additional-scrutiny-ahead-of-transpowers-price-quality-path-application

[9] Independent Verification TOR, paragraph 3

The evaluation criteria are an attachment to the TOR and provide further details on the matters that we must address in our verification review.

The evaluation criteria for the Base Capex proposal largely reflect the evaluation criteria in Schedule A of the Capex IM, which the Commission must apply when assessing Transpower's Base Capex proposal.

The evaluation criteria for the opex proposal are consistent with those for the Base Capex proposal, where appropriate, and include further criteria that are specific to assessing opex proposals.

A copy of the evaluation criteria is presented at Attachment A of our report.

### 1.3.1 Scope of our expenditure verification review

Our verification review is confined to Transpower's Base Capex and opex proposals for RCP3.

The Commission has described Base Capex, which is a sub-component of Transpower's total RCP3 capex proposal, as follows:[10]

> 53. Base Capex includes asset replacement and refurbishment (R&R) (all project sizes) and asset enhancements (under a $20 million threshold), while major capex is limited to asset enhancements (over the $20 million threshold).
>
> 54. Base Capex (including listed projects) is intended to cover all capital expenditure, except those large individual enhancement projects that, given their nature and magnitude (over the threshold), warrant individual scrutiny and public consultation.

This means that we have not been asked to verify Transpower's major capex projects with a value greater than $20 million.

In contrast, the opex component of Transpower's RCP3 expenditure proposal reflects the total operating and maintenance requirement for its business.

We have also not been asked to review issues relating to the form of control, application of the Listed Projects mechanism and processes for annual forecast Maximum Allowable Revenue updates).[11]

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[10] Commerce Commission (2018), Transpower capex input methodology review, Decisions and reasons, p 24 http://www.comcom.govt.nz/regulated-industries/input-methodologies-2/transpower-input-methodologies/capex-input-methodology-review/

[11] Independent Verification TOR, paragraph 18

### 1.3.2 Identified and Non-Identified Programmes

The TOR requires us to review Transpower's proposed Base Capex and opex allowances for RCP3 with emphasis on Identified Programmes agreed between the Commission and Transpower.[12] The purpose of the Identified Programmes is to provide more in-depth qualitative and quantitative information about the formation of a large subset of Base Capex and opex programmes for our verification review.

*Identified Programmes*

The Capex IM requires Transpower to agree with the Commission on a set of criteria for determining the list of Identified Programmes to include in a Base Capex proposal.

Table 6 shows the Base Capex identified programmes by asset category and expenditure size.

**Table 6 Identified base capex programmes ($2017/18)[13]**

| Identified programme | Asset category | Sep 2018 RCP3 forecast |
|---|---|---|
| **Renewal** | | |
| Power transformers | Substations | $60.1 million |
| Outdoor 33 kV switchyards; Outdoor to indoor conversions | Substations | $42.1 million |
| Transmission Line structures & insulators | Lines | $308.7 million |
| Transmission Line conductor & hardware | Lines | $90.2 million |
| HVDC | HVDC | $64.6 million |
| Reactive Assets | HVDC | $39.5 million |
| Secondary Assets - protection, battery systems and revenue meters | Secondary assets | $141.6 million |
| Secondary Assets - substation management systems | Secondary assets | $58.6 million |
| **Enhancement & development** | | |
| Grid E&D | Enhancement and Development | $76.4 million |
| **Non-network capex** | | |
| IT telecoms, network & security systems | ICT capex | $48.8 million |
| Transmission systems | ICT capex | $47.0 million |
| Total RCP3 Identified Programme expenditure | N/A | $977.5 million |
| Total RCP3 Base Capex | N/A | $1,202.4 million |

[12] Independent Verification TOR, paragraph 17

[13] Forecasts as at 24 May 2018

| Identified programme | Asset category | Sep 2018 RCP3 forecast |
|---|---|---|
| **Identified Programme percentage of RCP3 Base Capex** | **N/A** | **81%** |

**Source:** Synergies' forecasts

Table 7 show the identified opex programmes by expenditure size.

**Table 7 Identified opex programmes**

| Identified programme | Sep 2018 RCP3 forecast |
|---|---|
| **Network opex** | |
| Preventive maintenance | $198.8 million |
| Predictive maintenance | $335.9 million |
| **Non-network opex** | |
| Asset management and operations | $309.5 million |
| Business support | $226.5 million |
| Total RCP3 Identified Programme expenditure | $1,070.6 million |
| Total RCP3 Opex | $1,342.9 million |
| **Identified Programme percentage of RCP3 Opex** | **80%** |

**Source:** Synergies' forecasts

To better understand the drivers of RCP3 forecast expenditure across Identified Programme and asset categories, Synergies/GHDA requested from Transpower a more granular breakdown of data, which was provided.

Our detailed review of the Identified Programmes is presented in Chapter 7 (Capex forecast verification) and Chapter 8 (Opex forecast verification).

### *Non-Identified Programmes*

While the TOR directs us to place emphasis on the Identified Programmes in verifying Transpower's RCP3 expenditure proposal, Synergies/GHDA has also reviewed Non-Identified Programmes applying the proportionate scrutiny principle identified in the TOR.[14] This principle provides that the level of scrutiny applied to the specific programme or project should generally be commensurate with its price and quality impact on energy consumers.

The extent to which we have verified Non-Identified Base Capex and opex programmes is explained in Chapter 7 (Capex forecast verification) and Chapter 8 (Opex forecast verification) of our report.

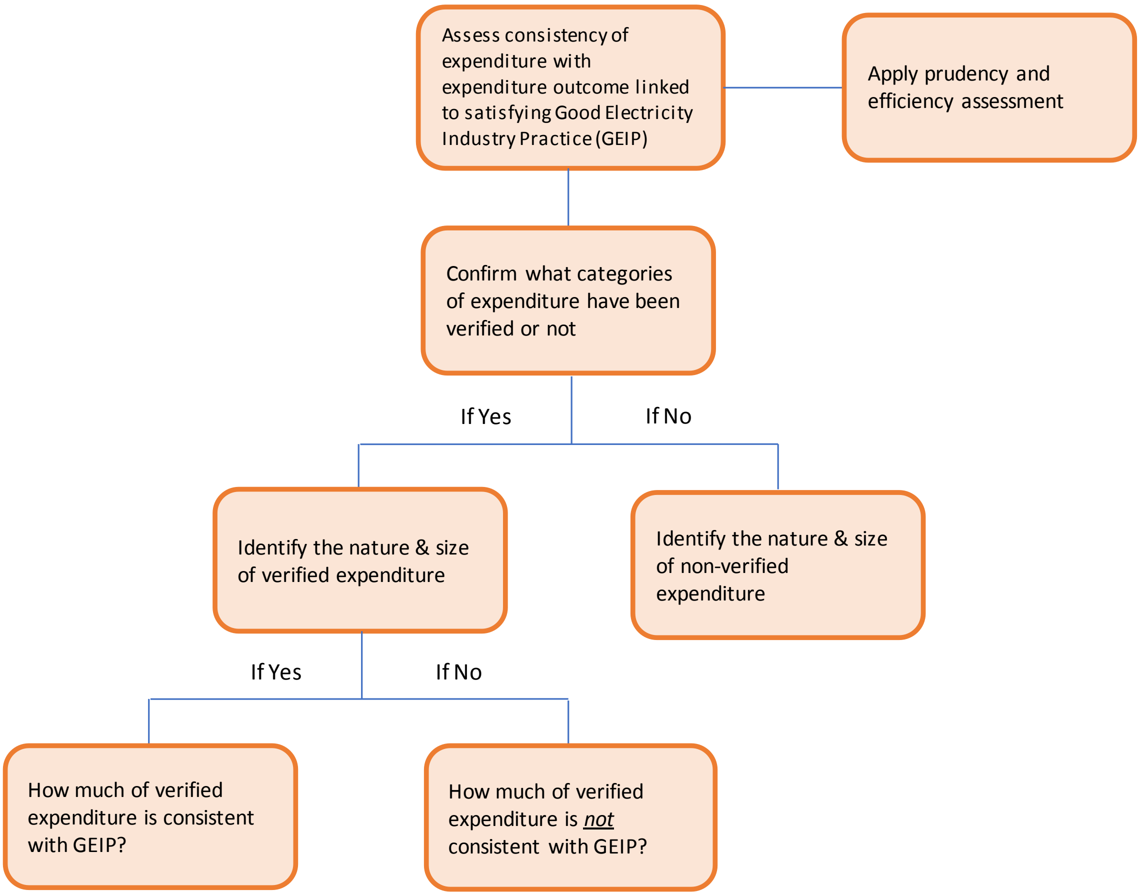
14 Independent Verification TOR, paragraph 19

## 1.4 Our verification assessment approach

Our approach to this expenditure verification review has been guided by input from the Commission and Transpower, having regard to the defined role of the independent verifier and our TOR.

The graphic below sets out the process by which we have identified how much of Transpower's verified expenditure is consistent with GEIP.

**Figure 1 Our verification approach**




In assessing whether Transpower's RCP3 expenditure forecasts satisfy GEIP, we have applied prudency and efficiency tests identified by the Commission in the TOR and also having regard to Australian economic regulators.

The Commission has previously commented on its interpretation of GEIP as follows: [15]

[15] Commerce Commission (2014), Invitation to have your say on Transpower's individual price-quality path and proposal for the next regulatory control period, February, p. 22

4.12 GEIP provides a useful reference for the sound grid strategies, asset management principles and methodologies that a prudent transmission operator could be expected to have in place.

4.13 We consider this approach is appropriate as the extent to which Transpower's expenditure forecasts are efficient and prudent will depend upon the quality of its asset management framework and the appropriateness of the input assumptions.

Australia's national electricity regulatory framework defines GEIP as follows:[16]

The exercise of that degree of skill, diligence, prudence and foresight that reasonably would be expected from a significant proportion of operators of facilities forming part of the power system for the generation, transmission or supply of electricity under conditions comparable to those applicable to the relevant facility consistent with applicable regulatory instruments, reliability, safety and environmental protection. The determination of comparable conditions is to take into account factors such as the relative size, duty, age and technological status of the relevant facility and the applicable regulatory instruments.

Similarly, the AER has noted the key components of GEIP to include effective:

Governance—internal arrangements encompassing reporting lines and supporting systems, including the level of involvement and commitment of senior management and committees, as well as the overall compliance culture of the business.

Expertise—the human resources dedicated to technical compliance, including the allocation of responsibilities, the underlying knowledge systems and the nature and extent of the technical understanding of applicable obligations.

Implementation—the means by which, at a practical level, participants drive and promote compliance through internal procedures and processes, encompassing staff training, technical testing and reporting of compliance matters.

Performance—the overall compliance status of each participant with reference to how effectively compliance programs and arrangements operate, including the ongoing evaluation and updating of such programs and arrangements to reflect lessons learnt.

Having regard to these interpretations of GEIP, we have assessed Transpower's RCP3 Base Capex and opex forecasts to be prudent if they are required to meet Transpower's ongoing legal and regulatory obligations, or its contracts with customers. This includes service (quality) standards approved by the Commission. Further, Base Capex is prudent

[16] National Electricity Rules, Version 113, Chapter 10, Glossary

if it is required to meet forecast demand growth, renewal of existing infrastructure in a timely manner, or it achieves an increase in the reliability or the quality of supply that is explicitly desired by customers or required by the NZ Electricity Authority.[17]

Transpower's RCP3 Base Capex and opex forecasts have been assessed to be efficient if they are underpinned by robust cost estimation and forecasting methodologies, including incorporating reported actual costs into the development of RCP3 forecasts and having regard to the efficiency incentives applying under the Part 4 regulatory framework. The fact that Transpower procures the provision of all its field services from a panel of external service providers has been a pertinent consideration in our prudency and efficiency assessment, including its ongoing management and co-ordination of these external resources.

Further, we have assessed Base Capex to be efficient if Transpower's asset management and capex planning processes are likely to reliably provide for the best means of achieving identified needs (legal, regulatory or contractual) having regard to available options, including the substitution possibilities between Base Capex and opex, such as non-network alternatives.

## 1.5 Summary of our verification review process

Our verification review has been underpinned by close engagement with Transpower from project inception, including ensuring that a robust process for the timely sourcing and interrogation of information from Transpower was established.

We have also liaised periodically with the Commission to seek clarification on several matters of interpretation regarding our TOR and the Transpower Capex IM.

In carrying out our verification work, we note the high degree of assistance and co-operation both Transpower and the Commission have provided to us. We consider this has enhanced the information upon which we have relied for our verification review and consequently the robustness of our analysis.

### 1.5.1 Information gathering and on-site meetings

In undertaking our verification review, we have relied on:

- a significant volume of information and documentation that Transpower has made available;

17 Amongst other things, Transpower is subject to security of supply obligations under the Electricity Industry Participation Code 2010 made under the Electricity Industry Act 2010.

- readily available public-domain information, including previous Commission determinations, Transpower's information disclosure statements and previous independent verification reviews performed under the Part 4 regulatory framework;
- our-in house data and information drawn from cost databases and or previous electricity-network-related projects; and
- information requested directly from and provided to us by Transpower.

Our general approach to information gathering was to review the initial information provided by Transpower and identify any information gaps or questions arising from this information. The information provision process commenced followed an on-site inception meeting we held with Transpower on 23 April 2018. We then requested and obtained responses to our queries through formal requests for information (RFIs).

All information provided by Transpower in support of its RCP3 expenditure proposal, as well as our RFIs and Transpower's responses to the RFIs, have been housed in a dedicated cloud-based data room set up specifically for this verification project.

Further to these on-going desk-top based information provision and RFIs processes, from 14-18 May 2018, we undertook an on-site visit to Transpower's Wellington head office. This on-site visit enabled us to meet and closely question key Transpower staff involved in developing the RCP3 expenditure forecasts. In so doing, we gained a better understanding of Transpower's asset management framework and forecasting methodologies that underpin the RCP3 forecasts, as well as how these internal processes have evolved compared to the RCP2 proposal.

Between 18 and 20 July, we made a further visit to Transpower's Wellington offices to discuss our preliminary draft report findings. This visit enabled us to address any misunderstandings and/or errors in that report and gather additional information to firm up our verification opinions.

We also confirmed during this visit that there were certain expenditure and grid output issues that, at that time, were yet to be settled, primarily because they were subject to Transpower's RCP3 stakeholder consultation process to be run in August 2018. These outstanding issues have been resolved for this Final Verification Report.

### 1.5.2 Evaluation techniques

Clause A4 of the Evaluation Criteria identifies several evaluation techniques that we may employ in undertaking our verification review. We have applied the following techniques:

- trending and time-series analysis;
- high level governance and process reviews;
- economic benchmarking of Transpower's total, capital and operating productivity and partial productivity indicator analysis;
- project, programme and model sampling;
- reviews of Transpower's (i) demand forecasting methodology and (ii) cost estimation methodology.

### 1.5.3 Preparation of our draft and final verification reports

Transpower is preparing its RCP3 proposal in the following three stages:

- preparation of a baseline plan for expenditure and grid output measures, which is the focus of our verification review;
- performance of price-quality testing on that plan, including through stakeholder engagement;
- finalisation of the RCP3 proposal accounting for Transpower's stakeholder engagement on the full proposal in August 2018.

This Final Verification Report takes into consideration feedback received from Transpower and the Commission on our Draft Verification Report provided on 27 July 2018. It also reflects Transpower's responses to its final stakeholder engagement on its RCP3 proposal. Our Final Verification Report will be a supporting submission for Transpower's RCP3 proposal.

Following preparation of this Final Verification Report, it is anticipated that Synergies/GHDA will hold workshops with the Commission over a two-day period in early-November 2018, to enable the Commission to gain a better understanding of our verification findings and to discuss more broadly our verification process.

Table 8 shows the timeline for the full independent verification process. Most work on the project has been undertaken in the three month period from late April to late July 2018.

Table 8 Verification timeline

| Task | Timing |
|---|---|
| Tripartite Deed and Independent Verifier contract documentation finalised | 17 April 2018 |
| Project inception meeting held at Transpower's Head Office, Wellington, NZ | 23 April 208 |
| Transpower Board-approved April 2018 version of RCP3 expenditure forecasts provided | May 2018 |
| 5 days on-site visit to Transpower's Head Office, Wellington, NZ | 14-18 May 2018 |
| May 2018 version of RCP3 expenditure forecasts provided | June 2018 |
| Preliminary Draft Verification Report delivered to Transpower | 6 July 2018 |
| 2 days on-site visit to explain and discuss Draft Verification Report findings at Transpower's Head Office, Wellington, NZ | 19-20 July 2018 |
| Draft Verification Report delivered to Transpower and Commerce Commission | 27 July 2018 |
| Feedback on Draft Verification Report received from Transpower and Commerce Commission | Late August 2018 |
| Transpower undertakes stakeholder consultation on its full RCP3 proposal | August 2018 |
| Transpower provides final updated RCP3 expenditure forecasts for this Final Verification Report | 28 September 2018 |
| Final Verification Report delivered to Transpower | 12 October 2018 |
| Workshop with Commerce Commission | 1-2 November 2018 |
| Commerce Commission releases assessment process paper for Transpower's RCP3 proposal | November 2018 |

## 1.6 Structure of our report

The reminder of our report is structured as follows:

- Chapter 2 provides relevant contextual information for Transpower's RCP3 proposal and our verification review;
- Chapter 3 presents the results of our economic benchmarking of Transpower's productivity performance compared to Australian electricity transmission networks;
- Chapter 4 assesses Transpower's process for determining the grid output measures it will incorporate in its RCP3 proposal;
- Chapter 5 assesses Transpower's asset management decision-making framework used to plan its expenditure programmes, including enhancements made to this framework during RCP2;
- Chapter 6 reviews the cost estimation systems used by Transpower to support both volumetric and non-volumetric work;

- Chapter 7 provides our capex verification review and opinion;
- Chapter 8 provides our opex verification review and opinion;
- Chapter 9 assesses and provides our verification opinion on the deliverability of Transpower's proposed RCP3 expenditure;
- Chapter 10 discusses the preparations Transpower is making for the anticipated significant increase in re-conductoring and tower painting during RCP4 and RCP5;
- Chapter 11 assesses other key forecasting input assumptions used in Transpower's RCP3 proposal;
- Chapter 12 assesses the price-quality testing that Transpower has applied to its RCP3 expenditure proposal, recognising that this price-quality testing, which was subject to stakeholder engagement in August 2018;
- Chapter 13 identifies key issues for the Commerce Commission's consideration in assessing Transpower's RCP3 proposal, including a summary of the verified/not verified status of specific expenditure programmes;
- Appendix A provides the Evaluation Criteria from our terms of reference (TOR) for verification of Transpower's RCP3 proposal;
- Appendix B provides a listing of the information we have relied upon in undertaking our verification review;
- Appendix C provides our verification certificate

# 2 Context for Transpower's RCP3 expenditure proposal

The purpose of this chapter is to provide relevant context for Transpower's RCP3 expenditure proposal.

It includes a summary of Transpower's operating environment and longer term strategic considerations, recognising the long-term nature of investments in its transmission network. This is against the backdrop of a New Zealand and international energy market subject to major change driven by emerging technologies and associated new services, changing consumer behaviour and government climate and energy policies.

The chapter also identifies several recommended management initiatives that the Commerce Commission proposed in its RCP2 Final Decision for Transpower to consider pursuing.[18]

## 2.1 Transpower's key network characteristics

Transpower owns and operates the only electricity transmission network (the Grid) in New Zealand.[19] The Grid has 230 points of service linking supply from six generating companies to 28 distribution network companies and 11 directly connected industrial consumers.

### 2.1.1 Ownership

Transpower is a 100% government-owned entity, Transpower New Zealand Limited, subject to the State-Owned Enterprises Act 1986 (the SOE Act). Transpower also controls several subsidiary companies. Of these subsidiaries, Risk Reinsurance Limited, a captive insurance subsidiary, is the most important in the context of the RCP3 expenditure proposal and our verification review.

Under Section 14 of the SOE Act, Transpower prepares a Statement of Corporate Intent (SCI) annually. The most recent SCI for 2017-18, sets out Transpower's activities,

[18] Commerce Commission (2014), Setting Transpower's individual price-quality path for 2015-2020, [2014] NZCC 23, Attachment I, August, pp 193-213. http://www.comcom.govt.nz/regulated-industries/electricity/electricity-transmission/transpower-individual-price-quality-regulation/transpowers-price-quality-path-from-2015-to-2020/

[19] Transpower is also the System Operator responsible for managing the real-time operation of the electricity system and the wholesale electricity market. However, the costs of the System Operator are not included under the IPP regime and are beyond the scope of our expenditure assessment.

objectives and performance targets (operational and financial) for the three years from 1 July 2017.[20]

### 2.1.2 Key operating environment factors

New Zealand is a long, narrow country with much of its electricity generation geographically distant from the main demand centres. In particular, much of the generation is hydro-based and located in the South Island, while most of the demand is in the North Island, particularly in the Auckland region.

The high-voltage direct current (HVDC) link between the two islands is a vital feature of Transpower's network that does not exist in many overseas networks. The Grid is also long and 'stringy' without the level of interconnection more typically found in transmission systems.

Transpower's transmission network is also subject to extreme environmental factors, including seismic activity and significant ocean-related corrosion exposure. Parts of the network are in deeply forested and mountainous topography.

Given New Zealand's geography and low population density, Transpower's network has a relatively low energy density. Low energy density, together with its ownership of several sub-transmission voltage assets, means that Transpower operates a large number (178) of substations.

Transpower's network connections with distribution companies vary considerably in scale. This, together with historic investment decisions, has resulted in Transpower owning and operating connection equipment at multiple voltages – 11 kV, 22 kV, 33 kV, 50 kV, 66 kV and 110 kV. In addition, it operates the main backbone links on the Grid at 220 kV and 350 kV (HVDC).

Such a wide range of voltages is atypical for international transmission network companies, particularly the low-end voltages more usually associated with distribution networks. We understand from Transpower that it is involved in an ongoing process with distribution networks to effect the transfer of its lower voltage network assets to them.

These operating environment factors are relevant to our economic benchmarking analysis and results presented in Chapter 3 of our report.

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20 Transpower (2017), Statement of Corporate Intent 2017-18, https://www.transpower.co.nz/sites/default/files/publications/resources/SCI%202017%2018.pdf

### 2.1.3 Demand trends

Changes in electricity demand and generation are altering the geographic balance between load and generation across the Grid, including due to changes in the location of generation resources connected to Transpower's network. Older uneconomic generation is being retired as new generation is developed closer to renewable resources, such as geothermal, wind, gas or hydro. This has been reflected in a shift towards geothermal generation in the central North Island.

The network remains exposed to the risk of one of its largest directly connected energy consumers, Tiwai Point aluminium smelter, closing or significantly reducing its consumption.

Demand growth on the Grid has flattened in recent years, with dependence on energy intensive activities reducing and energy efficiency improving. Further, growth in small-scale embedded generation, such as solar panels, is offsetting demand growth.

However, the growing population in Auckland is increasing demand in the upper North Island relative to the rest of the country. This has been reflected in the development of a long-term Auckland Strategy to identify the drivers for change on the Grid in Auckland and how Transpower intends to support and plan for those changes. The two key publicly available documents are the Auckland Strategy Direction and Powering Auckland's Future.[21]

Possible longer-term demand trends and associated strategic issues identified by Transpower are discussed in section 2.5 below.

### 2.1.4 Long-term historical expenditure context

Figure 2 presents Transpower's expenditure profile from the 1990s up to the end of RCP2, with the last three years of data based on forecast not actual expenditure.

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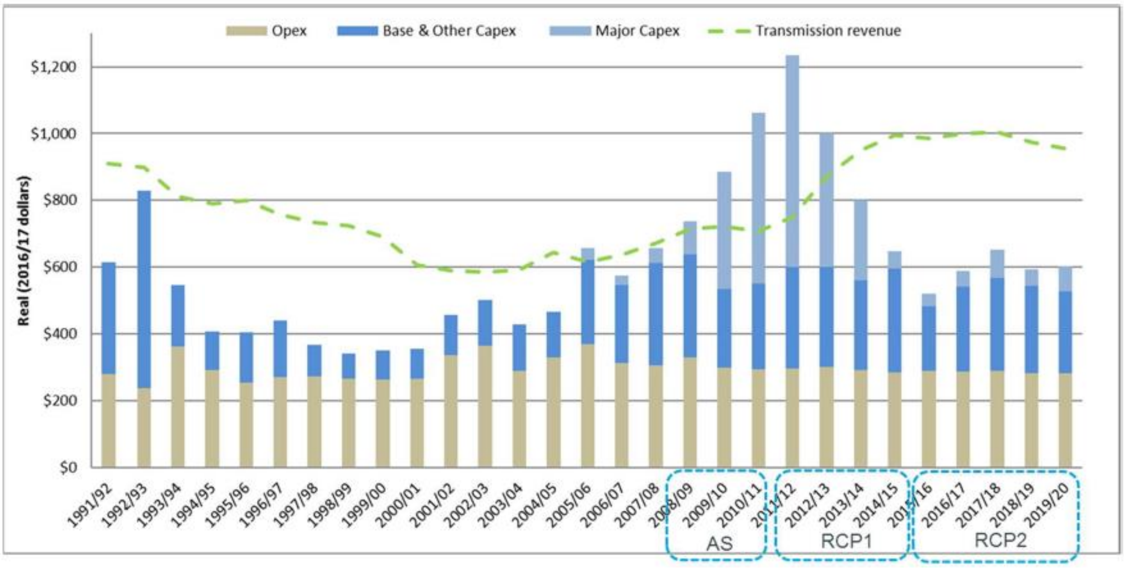
21 Transpower, *Powering Auckland's Future*, Document [3] Our strategy to support the growth of our largest city and our blueprint for future work, (Transpower Auckland Final Strategy Report); and Transpower, Powering Auckland's Future, Our strategy to support the future growth of our largest city (Auckland Strategy Foundation document). https://www.transpower.co.nz/keeping-you-connected/auckland-strategy/our-auckland-strategy

**Figure 2 Transpower's historical expenditure profile (as at May 2017, real 2016/17 dollars)**




It reveals that:

- opex has been very stable over RCP1 and RCP2 at around $280-$290 million per annum (in real terms);
- Base Capex and Other Capex has been more variable annually throughout RCP1 and RCP2 due to a range of factors including deliverability issues; and
- Major Capex was very high in the period from 2009/10 to 2013/14, reflecting several large projects into and through Auckland, improved network diversity in Auckland, to support increased geothermal generation and enhance the inter-Island link, but has reduced significantly in RCP2;
  - it is important to emphasise that the focus of our verification task is Base Capex – hence, Major Capex (including Enhancement and Development projects greater than $20 million) is outside the scope of our review.

The operating environment and demand factors identified in the above sections of this chapter are not expected to have expenditure implications for RCP3 that differ materially from those presenting in RCP2.

The importance of Auckland network-related expenditure in Transpower's RCP3 proposal is discussed in Chapter 7 (Capex forecast verification) and Chapter 8 (Opex forecast verification) of our report.

## 2.2 Commerce Commission's RCP2 final decision

RCP2 was the first regulatory period where all rules and processes set out in the Capex IM applied including:[22]

- the Base Capex expenditure adjustment, which incentivises efficiency for Base Capex;
- the Base Capex policies and processes adjustment incentive mechanism, which encourages Transpower to follow its internal processes and policies in planning and undertaking its approved expenditure;
- the grid output adjustment mechanism, which links grid output (service performance) measures to revenue as part of establishing these measures as the quality standard under Transpower's individual price-quality path; and
- increasing the Major Capex threshold from $5 million to $20 million.

In addition, the incremental rolling incentive scheme (IRIS) input methodology was to be applied to Transpower's controllable opex. The effective rate of sharing rewards and penalties under the Base Capex and controllable opex incentive mechanisms was at the same 33% level. This compares to the incentive rate of 36% for the grid output adjustment mechanism.[23]

For the first time in RCP2, the Commission also applied revenue-linked grid output measures for Transpower to balance the potential for its expenditure-related expenditure efficiency incentives to result in lower service quality, including network reliability and availability.

The Commission also noted that this represented a comprehensive package of revenue-linked incentive mechanisms for Transpower covering grid outputs, capex and opex, compared to RCP1 where the incentive mechanisms were in many cases still under development or were only partially implemented.

Other key design features of the Commission's regulatory framework as it is applied to Transpower's expenditure during RCP2 and that are pertinent to our RCP3 verification review are that:

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[22] Commerce Commission, *Setting Transpower's individual price-quality path for 2015-20*, 29 August 2014, Document [120], pp. 28-29

[23] Ibid., p. 30

- the Commission approves a fungible Base Capex and opex expenditure pool for each regulatory period, such that once this funding pool is approved, Transpower is free to incur spending as it judges to be appropriate given its prevailing network circumstances, including the occurrence of unexpected network-related events;
- the capex incentive scheme has been changed to recognise capex on an 'as incurred' (spend) basis under the capex incentive scheme, rather than on an 'as commissioned' basis as applied in RCP2; and
- the effects of variations between forecast and actual Consumer Price Index (CPI) and foreign exchange outcomes on Transpower's expenditure are treated as cost pass-throughs subject to Commission approval within-period.

The operation of the expenditure incentive schemes, supplemented by the revenue-linked grid output measures means that, in principle, Transpower's reported expenditure and service performance outcomes in RCP2 can be relied upon as establishing an efficient base level of expenditure for RCP3. This was the starting point for our review of the RCP3 expenditure forecasts, particularly those developed using what is known as the base step trend forecasting methodology.[24] However, our review also assessed whether Transpower's expenditure approach and reported outcomes during RCP2 are likely to indicate that it is responding to the Part 4 regulatory expenditure incentives.

The ongoing effect of the incentives applying under the regulatory framework is a separate issue to the asset management processes and forecasting methodologies that Transpower has used to develop its RCP3 forecasts and which have been closely scrutinised in this verification report.

### 2.2.1 Commerce Commission's RCP2 recommended initiatives[25]

The Commission highlighted the following three categories of initiatives it recommended Transpower should implement during RCP2:[26]

- initiatives that it has already been developing to improve the link between expenditure and service performance;

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24 This forecasting methodology is discussed in more detail in Chapter 7 (Opex Forecast Verification) of our report.

25 Commerce Commission Final Decision, pp 193-213

26 Commerce Commission Final Decision, p 193

- initiatives that Transpower has committed to undertake, i.e. the performance measure development (PMD) initiatives; and
- several business improvement initiatives.[27]

Our assessment of Transpower's progress against these recommended initiatives is discussed in Chapter 4 (Transpower's grid output performance measures), Chapter 6 (Cost estimation), Chapter 7 (Capex forecast verification) and Chapter 8 (Opex forecast verification) of our report.

## 2.3 Key Transpower reform initiatives during RCP2

Transpower has undertaken the following major internal reform initiatives during RCP2:

- business-wide efficiency-focussed Transformation Programmes 1 and 2 (TP1 and TP2) , with flow-on effects to the RCP3 expenditure proposal;
- a major change to Transpower's Grid Operating Model in 2015;
- a new Grid Business Strategic Plan, including development of a Strategic Asset Management Plan and associated asset class strategies, improved gathering of asset health information and implementation of monetised risk-based approach to planning; and
- improved delivery of the year-ahead capex programme of work.

### 2.3.1 TP1 efficiency programme

Transpower has advised that TP1 evolved from a previous efficiency programme (Project Atlas), which started in December 2014. It operated during the first two years of RCP2.

The programme included:

- transforming the grid operating model;
- incorporation of a 'portfolio savings programme' aimed at progressing specific cost-reduction initiatives; and

[27] New Zealand Commerce Commission (NZCC) (2014). *Setting Transpower's individual price-quality path for 2015-2020.* ISSN 1178-2560, Project no. 14.11/14120.

- closing the 7.5% gap between its RCP2 forecast capital programme costs and approved RCP2 allowance.

### 2.3.2 TP2 efficiency programme

The TP2 programme:

- incorporates efficiency initiatives and strategic initiatives across expenditure categories; and
- commenced with an intensive benchmarking (including economic and practice benchmarking) and business case development project.

Transpower has advised that the TP2 programme is designed to be self-funding within its first year and to accumulate benefits into the future. Its key features are that it:

- removes $5.2 million of efficiency initiative costs from the 2017/18 base year;
- captures the impact of any opex benefits accruing in 2017/18 (the base year for the RCP3 opex forecasts); and
- excludes any projected future efficiency benefits ie benefits that have yet to be achieved.

Transpower also advised that it intends to review and update (if necessary) the base year outturn and adjustment for one-off factors after the close of 2017/18. Given the timing of our verification review, the expenditure data that we have been provided does not include any such adjustments.

### 2.3.3 Ongoing efficiency initiatives

Transpower has indicated that there are several other efficiency initiatives that have complemented the TP1 and TP2 programmes including:

- an increasingly top-down approach to budget setting;
- centralisation of discretionary consulting budgets;
- the proposed re-negotiation of its grid service provider contracts (to be completed by 2021) and introduction of improved contractual efficiency incentives;
- ongoing improvements to its capital programme performance management;
- publicly setting overall RCP3 capital programme cost targets within its Integrated Transmission Planning updates;

- including cost reduction into its strategic decision-making framework as a key component of longer term strategic priorities (discussed in section 2.5 below);
- complementing operating model changes and efficiency initiatives with a behavioural transformation programme focussed on delivery, clarity, accountability and collaboration.

The effects of these reforms are analysed in more depth in Chapter 6 (Cost estimation), Chapter 7 (Capex forecast verification), Chapter 8 (Opex forecast verification) and Chapter 9 (Deliverability of RCP3 forecast programme of work) of our report.

## 2.4 Transpower's governance structure for RCP3 expenditure forecasts

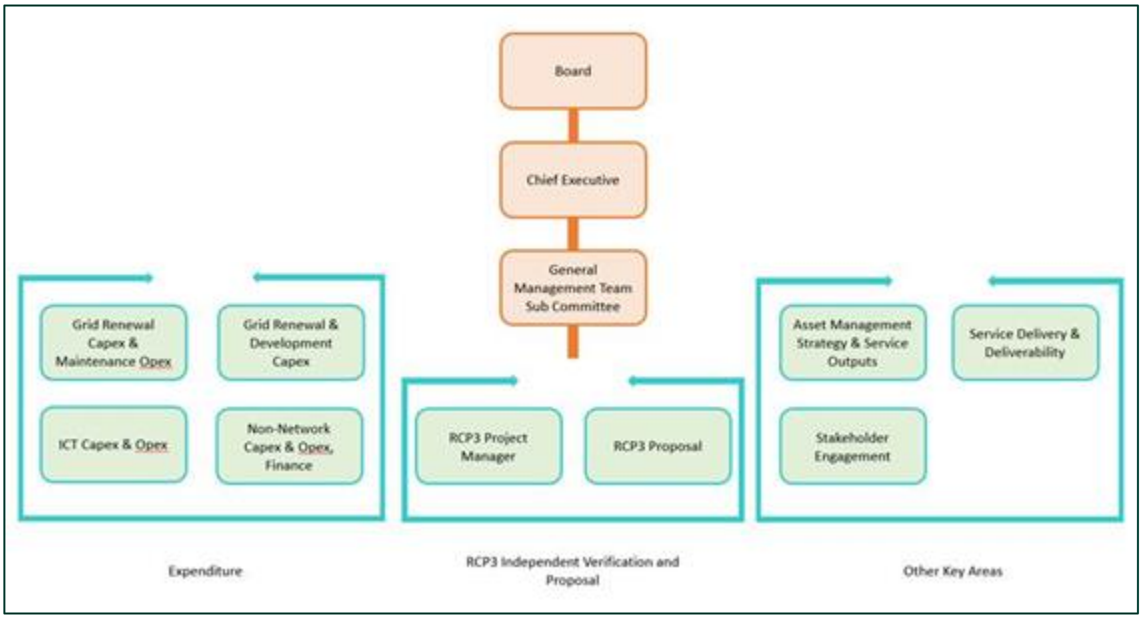
Transpower's overarching corporate governance structure for the development and approval of its RCP3 expenditure forecasts can be characterised as a decentralised model.

Decentralised models rely more heavily on whole–of-business involvement in the development of the regulatory proposal as part of business-as-usual practice, compared to centralised models where the regulatory team maintain close control over preparation of regulatory proposal inputs, including performing tasks that could be delegated to the wider business.

Under a decentralised model, the regulatory team assumes a coordination and quality assurance role for the inputs generated by the operational business units. We consider that our verification review process has contributed to this quality assurance role.

Figure 3 shows Transpower's governance structure for preparation of its RCP3 proposal, including expenditure forecasts.

**Figure 3 Transpower's RCP3 preparation governance structure**

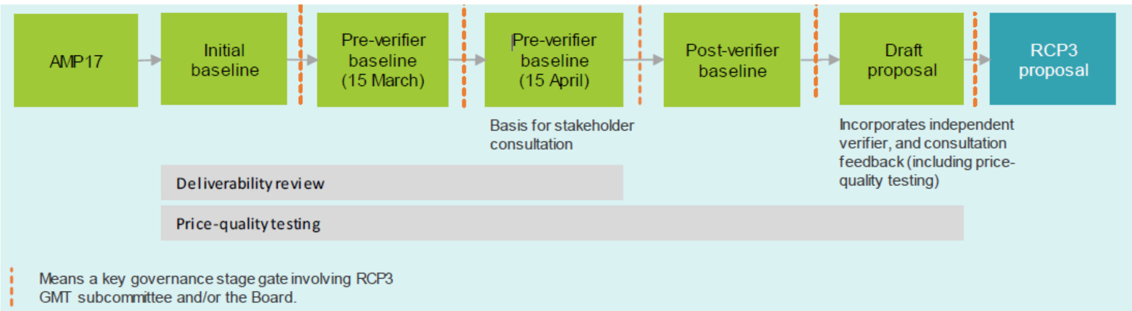



Under this governance model, the GM Team Sub-Committee provides a key role in assessing and approving RCP3 Base Capex and opex baseline forecasts developed by the wider business prior to their submittal to the Chief Executive and Board for approval. This Sub-Committee, as well as the Chief Executive and Board, should provide the top-down challenge to the RCP3 forecasts developed by the wider business.

We are aware that top down challenges from the Board have been applied in the development of the baseline RCP3 forecasts, including an $81 million deliverability adjustment.

Figure 4 presents Transpower's RCP3 development process, incorporating our independent verification role.

**Figure 4 Transpower's RCP3 forecast development process**




Transpower's RCP3 expenditure forecasts have been refined over this forecast development process, with the forecasts presented in this Final Verification Report being the 28 September 2018 Board-approved numbers to be incorporated in the RCP3 Proposal.

## 2.5 Transpower's long term strategic outlook

The TOR require us to have regard to Transpower's strategic documents in assessing its RCP3 expenditure proposal. Of most significance in this regard are the following long-term strategic vision documents:

- Transmission Tomorrow, released in May 2016;[28] and
- Energy Futures, released in May 2018.[29]

### 2.5.1 Transpower's 'Transmission Tomorrow' paper

Transpower's long-term strategic document 'Transmission Tomorrow' sets out a vision of how its transmission network could evolve based on reasonable scenarios of potential technological and energy market developments over the next 5 to 40 years.

Using modelling intended to test the extremes of demand changes and technological impacts, the document finds that even assuming a very high uptake of solar PV (nearly 400 times current levels), and no underlying demand growth, the Grid will continue to remain essential for meeting New Zealand's future energy needs.

While uncertainties in demand, government climate policy and emerging technology uptake are creating new challenges for Transpower, this is also creating new opportunities. Specifically, the report identifies the following six strategic priorities, with relevance for Transpower's RCP3 proposal:

- Reduce costs and evolve services to remain competitive.
- Play an active role in shaping the industry's future.
- Sustain social licence to operate.
- Match infrastructure builds to need over time.
- Improve asset management.
- Develop organisational effectiveness.

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28 Transpower, Transmission Tomorrow, https://www.transpower.co.nz/resources/transmission-tomorrow-2016-0

29 Transpower, Te Mauri Hiko – Energy Futures, https://www.transpower.co.nz/resources/te-mauri-hiko-energy-futures

Table 9 summarises how Transpower envisages implementing its strategic priorities.

**Table 9 Transpower's long-term strategic priorities**

| Strategy | Explanation |
|---|---|
| 1. Reduce costs & evolve services to remain competitive | Economic growth and increasing electrification should support the need for grid-supplied electricity.<br>However, Transpower needs to reduce costs and improve business processes to evolve its services to remain as competitive as possible, while managing asset risk profiles<br>Anticipate changes in the way New Zealanders use electricity and adapt their grid and system operator services accordingly. |
| 2. Play an active role in shaping the industry's future | There is tremendous & increasing opportunity for the sector to deliver more value at lower cost by leveraging information, automation and storage technologies across the entire energy supply chain.<br>Transpower will play an increasingly active role working with the industry on the evolution of market and security-of-supply arrangements, as well as to support successful integration of new consumer and industry technologies into the power system. |
| 3. Sustain social licence to operate | As a large business with a long-term future providing critical services to New Zealanders, it is essential that Transpower continues to focus on ensuring confidence in its operations, including planning ahead for transmission corridor challenges & working to integrate sustainability practices more strongly into the business.<br>Sector transformation & increasing consumer self-reliance may strain some existing goodwill & Transpower will need to adapt to these changes. |
| 4. Match infrastructure builds to need over time. | Transpower's planning trajectory indicates a need to anticipate & rapidly respond to new challenges.<br>To this end, Transpower will revise its processes to accelerate new generation connection & plan for the generation development challenges of the future, increase its forecasting & technology anticipation abilities, evolve its tools for managing demand growth pressures and develop a more flexible approach to grid asset lifecycle planning. |
| 5. Improve asset management | As an asset intensive business, asset management must be a core competence, and there are many opportunities to improve Transpower's systems to be more effective, lift performance & reduce costs.<br>To make better decisions around asset risk & thereby investment, Transpower is improving its works scheduling, grid outage planning, supplier procurement & relationships, as well as re-revising its asset management processes for the information systems that support system operation service. |
| 6. Develop organisation effectiveness | The potential for an increase followed by a decrease in demand for grid capacity over coming decades & for changes in system operations means Transpower must be a forward-thinking but careful & strategic asset investor.<br>These drivers, together with the need for improved cost-effectiveness, motivate Transpower's transformation & organisational development efforts, including redesigned business operating models, revised organisational structure & commencement of work to embed and improve updated internal processes. |

**Source:** Transmission Tomorrow

In considering Transpower's long-term strategic priorities, we note the high degree of uncertainty regarding future industry trends, including the level and profile of demand,

and the type and location of generation sources. Transpower summarises the following factors that are likely to present in the post-2020 period:[30]

- Uncertain net change to demand, but peak demand still drives need for the Grid.
- Increase in off-grid consumers at distribution level.
- Low physical grid asset stranding risk, but increasing financial stranding risk.
- Distributors evolve, rationalise and drive regulatory and market changes.
- Commercial stress on some generators, distributors and retailers.

However, none of the most significant potential future industry changes, including economic saturation of solar PV and/or extensive storage penetration, are expected to present in a material way in RCP3. The risks of closure of thermal plant and/or the Tiwai smelter in RCP3 are fundamentally beyond Transpower's control.

Overall, our view is that Transpower's long-term strategic response to energy industry uncertainty is prudent, particularly its focus on cost competitiveness, improved asset management processes/management and active engagement with other industry stakeholders, which will build on work that it has begun during RCP2. These priorities also clearly have relevance for the development of its RCP3 expenditure forecasts.

### 2.5.2 Transpower's 'Energy Futures' paper[31]

Transpower states the Energy Futures report provides an important and material update to the thinking presented in Transmission Tomorrow and highlights why constant review and inquiry is critical during periods of industry change as is apparent now.[32]

Transpower notes the period between now and 2025 is relatively well understood by the New Zealand energy industry and should be relatively predictable without significant unexpected changes. In contrast, the period from 2025 to 2035 and beyond is much less certain and most relevant to the Energy Futures document.

[30] Transpower, *Transmission Tomorrow*, p 28

[31] Transpower, Te Mauri Hiko, Energy Futures, https://www.transpower.co.nz/resources/te-mauri-hiko-energy-futures

[32] Transpower notes that a diverse range of individuals and organisations, from inside and outside of Transpower, provided feedback and input to the Energy Futures work, including policymakers, business leaders, energy consultants, scientists, future scenario planners and academics.

The core of Energy Futures is the presentation of scenario-based analysis in the pre-2030 and 2030-2050 periods, which provide a basis for assessing future states of the NZ electricity system and context for Transpower's contemporary investment decision-making when there is a materially higher level of uncertainty about New Zealand's energy future than in the past.

The Energy Futures project reveals the following five factors that Transpower expects to strongly influence the future of electricity supply in New Zealand:[33]

- the risk of disruptive climate change, which is growing;
- the possibility of increasing economic, political and security uncertainty;
- new technologies that are disrupting the energy industry;
- evolving domestic policy; and
- New Zealand's unique combination of energy circumstances.

Energy Futures presents three alternative demand and supply scenarios to examine a wide range of possible electricity futures. The scenarios differ mainly in the magnitude and speed of demand growth and in the mix of generation types used to supply future expected growth in demand. Key difference in underlying assumptions relate to

- the policy response to climate change;
- electrification of transport and industrial heat;
- economic and population growth; and
- the extent of technology-driven disruption in the NZ energy system.

We agree with Transpower that the demand scenarios appear reasonably plausible in establishing high and low growth bounds, while recognising the current high degree of difficulty forecasting electricity demand given higher than normal uncertainties in international energy and climate policy, as well as energy market developments. Most significantly from an RCP3 perspective, which is the primary focus of our report, the forecast demand in the 2020-25 period under three of the four scenarios is moderate and aligned.[34]

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[33] Transpower, Te Mauri Hiko, Energy Futures, p 12

[34] Transpower, *Te Mauri Hiko*, Energy Futures, p 43. The high growth scenario, 'Vibrant Haven', is the only exception.

More generally, and consistent with Transmission Tomorrow, we consider the Energy Future project to be a prudent long-term strategic response to energy industry uncertainty.

## 2.6 Chapter key findings

Overall, we consider that the regulatory and market context for RCP3 is relatively stable, notwithstanding potentially larger external energy market changes increasingly influencing the generation and consumption of electricity. In broad terms, this supports a total expenditure programme for RCP3 which is broadly in line with that undertaken in RCP2, rather than one requiring substantive step changes up or down.

The internal reforms that Transpower has undertaken during RCP2, including enhanced asset management systems and its efficiency-driven transformation programmes, should place it well for RCP3 and beyond.

We consider Transpower's long-term view that its transmission network will remain a critical component of New Zealand's energy supply system, is supported by the available evidence and reasonable expectations of the future.

# 3 Economic benchmarking performance

The purpose of this chapter is to present economic benchmarking results drawing out Transpower's own performance and performance relative to Australian transmission network peers over the RCP 1 and RCP2 periods based on:

- partial productivity indicators
- multilateral total factor productivity (MTFP) and
- capex and opex partial TFP results (TBC).

## 3.1 Benchmarking small heterogeneous group of transmission networks

### 3.1.1 Challenge of ensuring like-for-like benchmarks

*Unique and exogenous costs*

In this analysis, we have compared Transpower's expenditure with the five Australian transmission networks that comprise the National Electricity Market (NEM). These Australian networks are Powerlink (QLD), TransGrid (NSW/ACT), AusNet Services (VIC), ElectraNet (SA) and TasNetworks (TAS) and are collectively referred to as the Australian networks.

Economic benchmarking is an exercise that compares businesses based on the differences between the units of output produced for each unit of input used (or the amount of input required for each unit of output). A key obstacle that needs to be overcome before productivity estimates can be inferred is that the comparisons being made are genuinely like for like. If there are costs that a network incurs because of a unique operating environment then this will bias productivity estimates as that network will require more inputs (expenditure) to produce its outputs relative to its peers. Uniqueness of an operating environment can be characterised by differences in the physical environment, weather, socio and demographic factors or regulatory differences, including scope of activities, between networks. The Australian Energy Regulator (AER) has referred to these differences as operating environment factors (OEFs) and has commissioned research into the impact of these OEFs on the benchmarking results of Australian distribution networks[35]. Whilst this work has not

[35] SapereMerz review of operating environment factors – December 2017. This work has not extended to transmission networks – eg 2016 transmission benchmarking report section 1.6 *Transmission networks have undertaken cost benchmarking for a number of years, but whole of business benchmarking of electricity transmission networks is in its relative*

extended to transmission networks due to the less mature and more simplified application of benchmarking results for transmission networks[36], OEFs would be equally applicable to comparisons of any benchmarking metrics for transmission networks. The criteria used by the AER to identify operating environment factors is that they should be material, exogenous and non-duplicative.

Where there are specific costs, driven by factors beyond the control of management (exogenous) and quantifiable, we have removed them from the benchmarking analysis to ensure more accurate estimates are obtained.

Transpower's high-voltage submarine cable connecting the North and South Islands of New Zealand is a good example of a unique and exogenous cost that should be removed before benchmarking is undertaken. The table below outlines costs that have been removed from the analysis to ensure benchmarks that are more comparable.

**Table 10 Cost normalisations applied**

| Cost description | Value in 2016/17 | Reason for removing |
|---|---|---|
| Transpower: High Voltage Direct Current assets | $9.5 M NZD | No other network has an undersea cable at the same scale as Transpower's high voltage cable connecting the North and the South Island. The Basslink connection between Tasmania and the mainland is not owned or operated by TasNetworks and therefore does not provide a suitable comparison. The $9.5 M includes maintenance for the submarine cable together with the substations that support it. |
| AusNet Services: Easement tax | $113 M AUD | The easement tax is a value paid to the Victorian government under the licensing conditions within which AusNet Services operate. This is a cost unique to AusNet and therefore should be removed. |
| AusNet Services: Insurance and self-insurance | $6.1 M AUD | Transpower incurs insurance costs specific to the operation of the submarine cable. In addition, insurance costs can be considered to be largely market tested as they are provided by a third-party through a competitive process. Insurance costs will be influenced by factors such as network value and the risk of environmental / weather events that are |
| ElectraNet: Insurance and self-insurance | $4.3 M AUD | |
| Powerlink: Insurance and self-insurance | $8.2 M AUD | |
| TasNetworks: Insurance and self-insurance | $1.2 M AUD | |

*infancy. Compared to electricity distribution networks there have not been many whole of business benchmarking studies of transmission networks.*

36 As of August 2018, the AER has not used economic benchmarking to adjust the base year opex of any Australian transmission network despite significant difference in benchmarking results

| Cost description | Value in 2016/17 | Reason for removing |
|---|---|---|
| TransGrid: Insurance and self-insurance | $8.6 M AUD | exogenous to the management of a transmission network.<br>For this reason, insurance costs have been removed from the benchmarking analysis. |
| Transpower Insurance and self-insurance | $13 M NZD | |

### *Finding comparative networks*

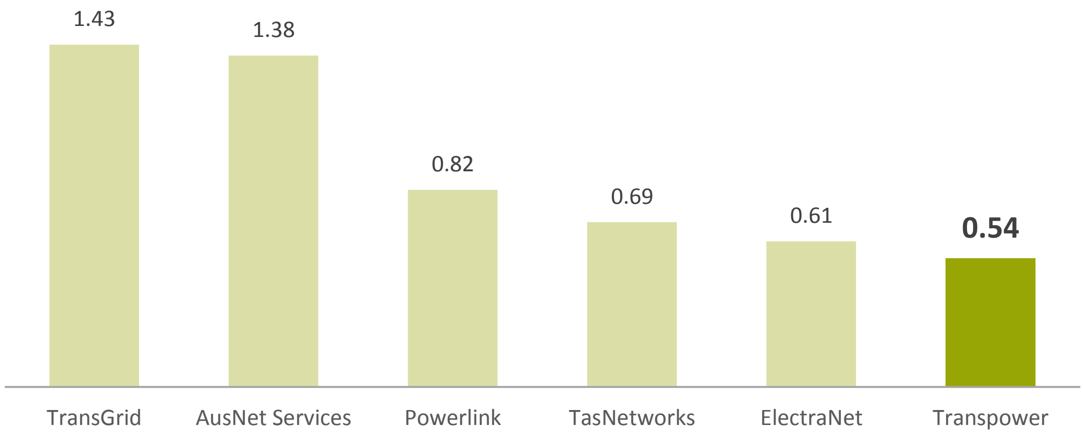
Whilst the AER is undertaking research to quantify the impact of different operating environments on benchmarking results we believe a more pragmatic approach is to identify a sub-group of network peers that can be used based on different network characteristics. This approach seeks to ameliorate the challenges of identifying and quantifying an exhaustive list of environmental factors by focusing on networks that could be considered broadly similar based on network characteristics. After finding a comparable sub-group, a reduced set of environmental factors can be considered to help explain differences in cost outcomes between networks. It should be noted that with a benchmarking group of six networks (Transpower plus the five Australian networks) there will be no one network that mirrors the operating conditions faced by Transpower.

In the following paragraphs we outline the different metrics we have relied upon to identify a comparator group for Transpower.

**Load density**

Load density is the ratio of peak demand and circuit length and is measured in MW per km. Load density (Figure 5) provides a useful proxy for load dispersion on a network. Networks with low load density will generally require longer networks to meet peak demand requirements on the network. High load density by contrast can indicate a more concentrated load base that may require higher rated assets but a shorter line length.

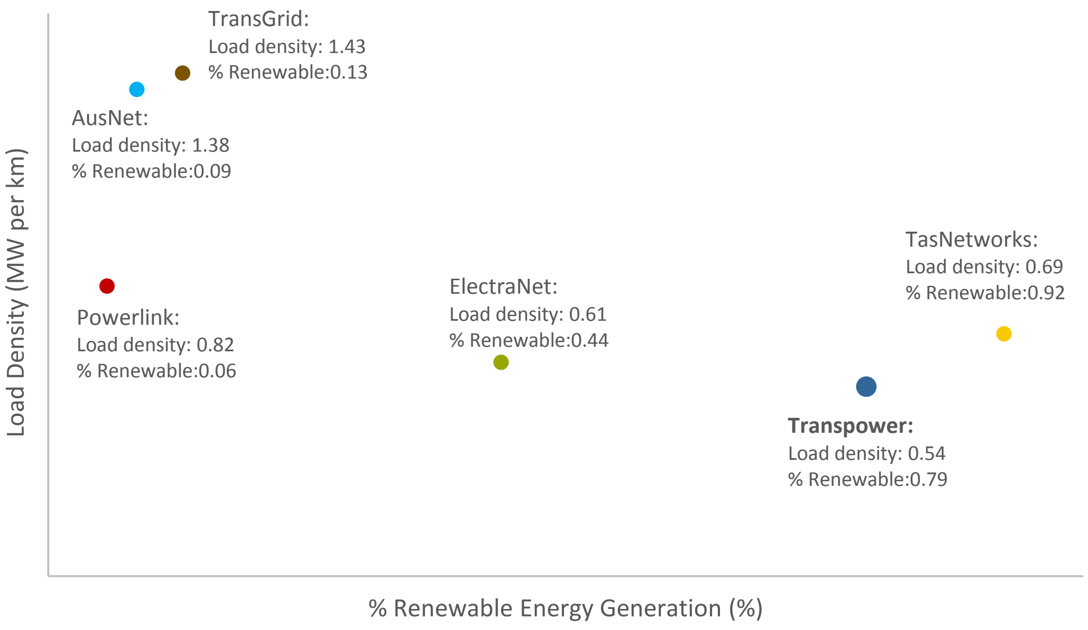
**Figure 5 Load Density – Peak MW per km in 2017**




Transpower has the lowest load density of the sample networks in 2017 followed by ElectraNet and TasNetworks. In the context of electricity transmission, this lower load density is a consequence of having to connect the transmission network to generation sources that are geographically dispersed. In addition, Transpower, ElectraNet and TasNetworks connect to generation sources that are renewable to a much larger extent than TransGrid, AusNet and Powerlink whose networks rely to a much larger extent on thermal generation sources. In the context of cost premiums associated with load density and renewable generation, it is important to consider the system within which the electricity transmission network operates and its design. Coal and gas fired generation plants are generally designed and built to maximise economic viability of connecting to load centres to facilitate cheaper transition to market. By contrast, renewable generation offers less optionality of location and scale and is often in areas that can be difficult to access such as hydro generation in mountainous areas. Figure 6 below illustrates the relationship between renewable generation and load density for the six networks in this report[37]. Transpower and TasNetworks have the highest proportion of energy throughput generated from renewable sources.

37 For AusNet Services the proportion of energy dispatch from non-thermal generation value from 2013 has been used as this information has been made unavailable in the period since.

**Figure 6 Load Density and % Renewable Generation**

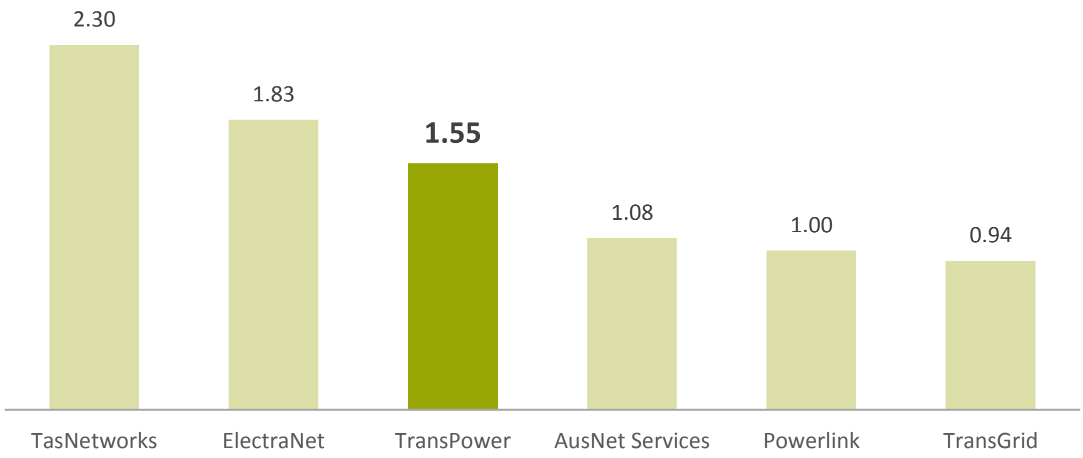



**Connection density**

Number of connections per kilometre is an important characteristic to consider because it identifies differences in network design. Networks with higher numbers of connections per km will generally require more network assets to facilitate the connection between the network and the generator or end user and balancing loads among a higher number of connection points. Figure 7 below shows that TasNetworks has the highest number of connections per km followed by ElectraNet and Transpower.[38] The higher number of connections for these three networks is partly driven by the greater number of small, renewable generation sources connecting to the transmission network. TasNetworks and Transpower also have transmission/distribution network boundaries at lower voltage levels than other networks.

[38] TasNetworks (transmission) is similar to Transpower, in that it generally has a transmission/distribution boundary set at a lower voltage than other Australian electricity transmission utilities.

**Figure 7 Number of network connections per 100km**



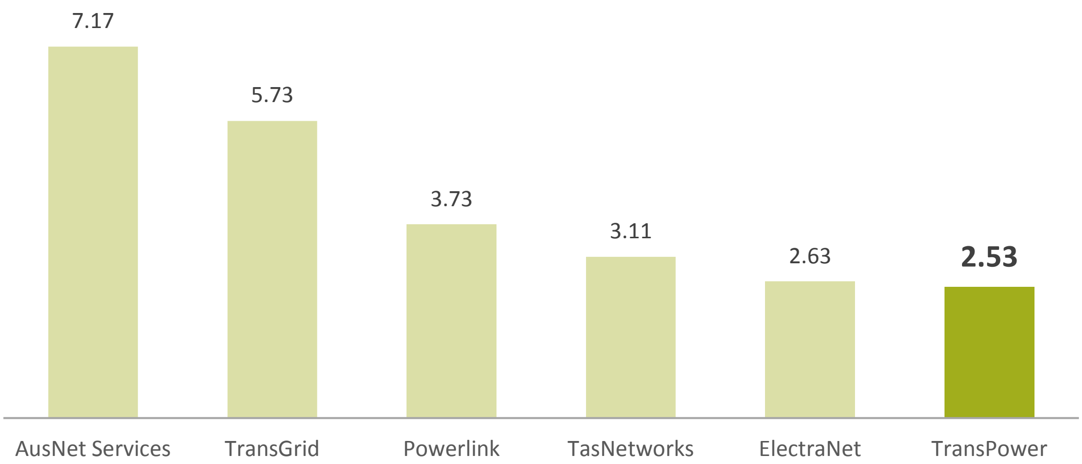

**Energy throughput**

Whilst energy throughput has little influence on the marginal costs of a transmission network, it is an important consideration in the context of economic benchmarking. This is because if energy throughput is included as an output in a benchmarking model (as it is in the AER transmission productivity models), networks that have high levels of throughput per km will benefit relative to networks with lower energy densities.

The experience of TasNetworks illustrates the changes in productivity performance that can occur because of changes in energy throughput. In 2015/16, Basslink experienced an outage that lasted for six months reducing the energy throughput of TasNetworks transmission network. TasNetworks productivity score declined in 2016 as a consequence despite the decline in energy throughput being beyond their control.

Figure 8 shows that of the six networks in the sample, Transpower has the lowest energy density followed by ElectraNet and TasNetworks.

**Figure 8 Energy Throughput per km**




**Network design**

Network design is an OEF that is likely to influence the relative costs of providing electricity transmission services. Generally, networks with higher voltage assets are expected to incur greater costs in building, replacing and maintaining the network. The graphs below show two proxies that can be used with publicly available data to illustrate network design differences between transmission networks - these are the average RAB value per km and the average MVA rating per km.

Of the networks in the sample, Transpower has the lowest average network value per km and the second lowest average MVA rating per km of line (although very close to ElectraNet). See Figure 9 and Figure 10 respectively.

**Figure 9 Average RAB ($000) per km**

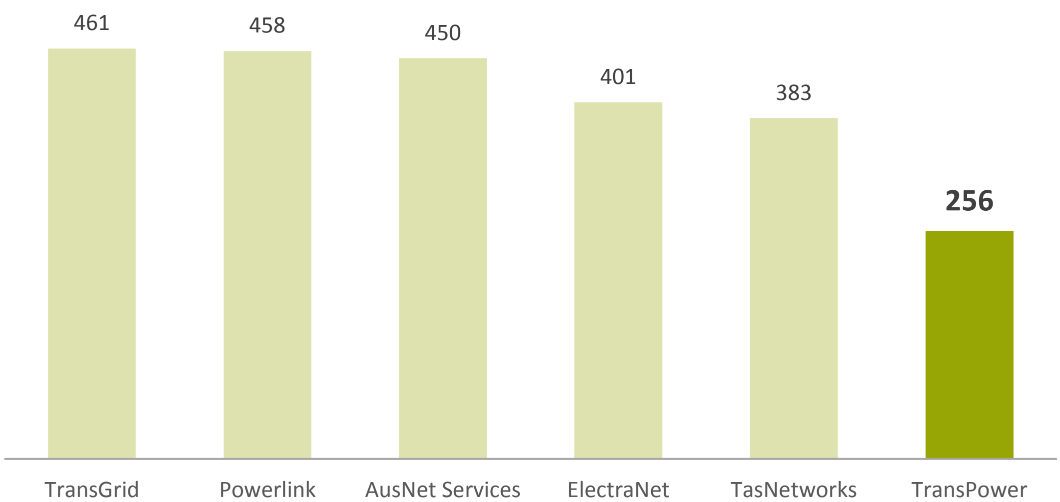
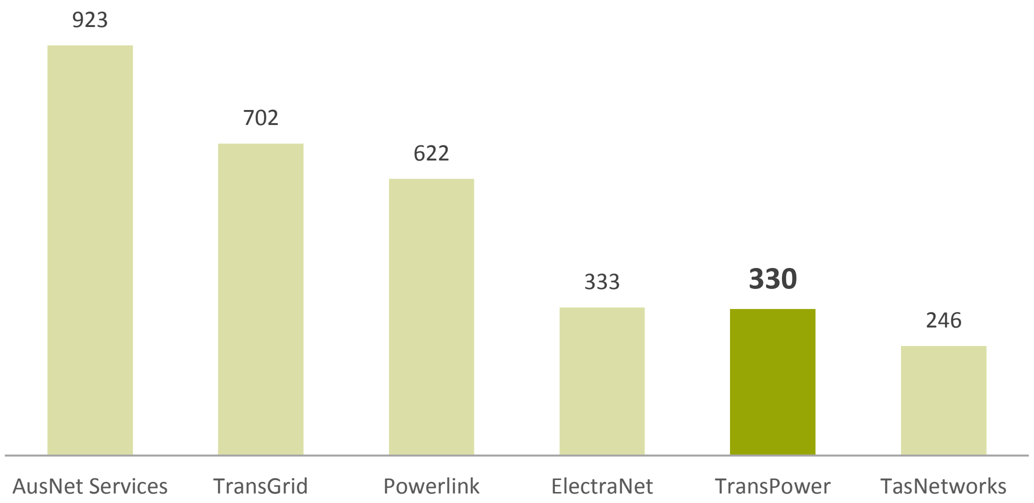


**Figure 10 Average MVA rating per km**




**Summary of OEF's**

Table 11 below compares each of the network characteristics with respect to Transpower, ranked in order of proximity to Transpower's results. On the measures used, ElectraNet and TasNetworks are the two networks in the sample that should be considered most like Transpower.

**Table 11 Network attributes compared to Transpower (in order of highest similarity)**

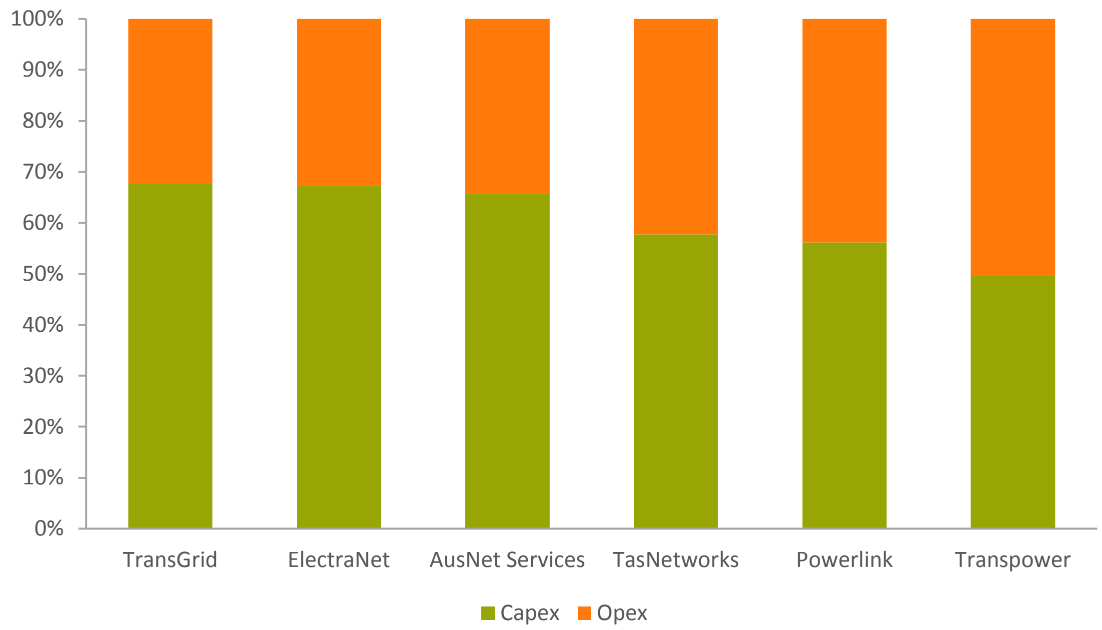
| Load density | % Renewable | Energy density | Connection density | Average MVA per km |
|---|---|---|---|---|
| ElectraNet | TasNetworks | ElectraNet | ElectraNet | ElectraNet |
| TasNetworks | ElectraNet | TasNetworks | AusNet | TasNetworks |
| Powerlink | TransGrid | Powerlink | Powerlink | Powerlink |
| AusNet | AusNet | TransGrid | TasNetworks | TransGrid |
| TransGrid | Powerlink | AusNet | TransGrid | AusNet |

### *Differences in accounting and cost allocation*

Even with a consistent reporting framework the Australian transmission networks can have significantly different interpretations of how costs should be allocated across different categories. This is exacerbated with the inclusion of Transpower into the sample which will have its own reporting rules and accounting treatments that make consistent benchmarks at a disaggregated level difficult to obtain.

The graph below shows differences in the composition of total expenditure between capex and opex over the last five years (FY13-FY17). Transpower has the lowest ratio of capex / totex over the period with a capex proportion of around 50%, significantly lower than its Australian counterparts. Whilst totex[39] benchmarking will alleviate these differences, when opex or capex is considered individually these differences in capitalisation should be considered.

**Figure 11 Totex Composition (FY13-FY17)**




### *Differences in purchasing power*

OECD purchasing power parity rates have been used to convert Australian dollars into a New Zealand equivalent. The table below shows the respective PPP values for Australia and New Zealand relative to USD for the past five years. The analysis in this report has used a five year average of the relative PPP values (2013-2017) to convert Australian dollars into New Zealand dollars.

**Table 12 Purchasing Power Parity Rates**

| Year | AUD/USD | NZD/USD | AUD/NZD |
|---|---|---|---|
| 2013 | 1.447 | 1.446 | 1.001 |
| 2014 | 1.452 | 1.441 | 1.008 |
| 2015 | 1.471 | 1.464 | 1.005 |
| 2016 | 1.486 | 1.468 | 1.012 |

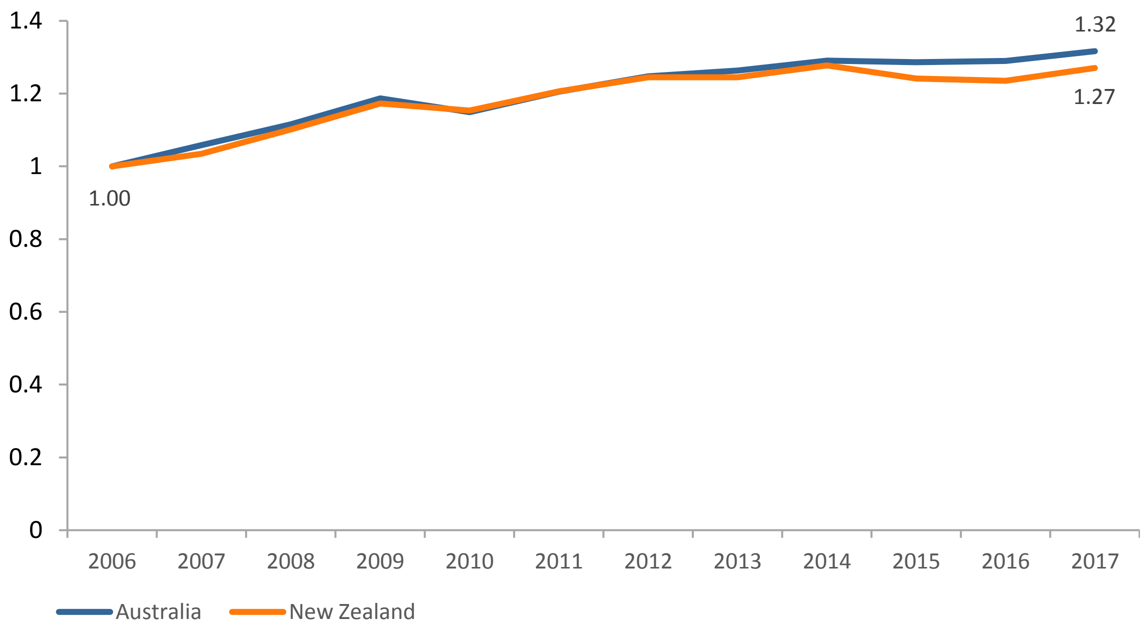
39 In this report we have used totex in the benchmarking of transmission networks. This is different to the AER's total factor benchmarking that uses capital inputs such as MVA-kms to measure inputs – the reasons for this difference is explained below.

| Year | AUD/USD | NZD/USD | AUD/NZD |
|---|---|---|---|
| 2017 | 1.516 | 1.477 | 1.026 |
| **Average** | **1.474** | **1.459** | **1.010** |

*Changes in opex prices over time*

Respective Producer Price Indexes have been used to convert Australian historic expenditure into $17/18. The changes in Australian and New Zealand indexes over time are illustrated below (Figure 12). The graph shows that the two indices grow at a very similar rate until 2014 where the Australian PPI continues to grow whilst New Zealand's PPI declines slightly ending 27% above 2006 levels.

**Figure 12 Producer Price Index Growth, 2006-2017**




### 3.1.2 Defining the outputs of a transmission network

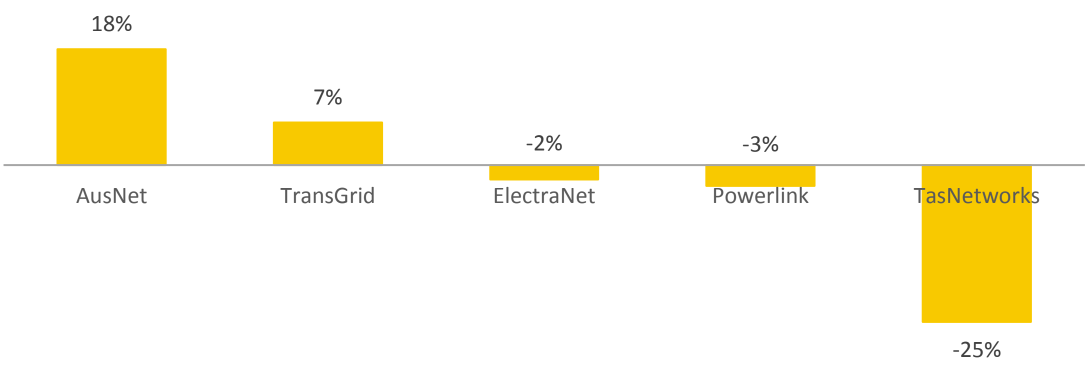
*Australian NEM view*

Whilst in both a literary and regulatory context there are many examples of economic benchmarking in the electricity supply industry, there remains little consensus as to what constitutes the outputs and inputs of an electricity network. Broadly speaking, output specifications have tended to include variables that capture the demand side of an electricity network such as customer numbers and energy throughput or the supply side such as system capacity and circuit length. In an industry with a small number of heterogeneous networks such as electricity transmission these differences in output specification can have significant impacts on the benchmarking results with large, rural networks being favoured by supply side outputs and urban networks benefitting from demand side outputs.

The experiences of the Australian transmission networks subject to AER benchmarking highlight the significant changes in results that can result from a change in model specification. The graph below shows the change in productivity scores for each of the NEM transmission networks in 2016 after a change to the output specification by the AER in which the number of transmission connection points (weighted by voltage) was replaced by the number of downstream customer connections.

As the graph shows, the change in output specification to include customer connections had a significant impact on the benchmarking scores reported in the Annual Benchmarking Report. Transmission networks connecting thermal generators to high-density cities such as Melbourne and Sydney benefitted at the expense of networks with a higher number of exit and entry connections to maintain (particularly TasNetworks, which as noted above has the highest number of connections per km in the sample).

**Figure 13 Change in productivity performance with change in AER Output Specification**




### *Adopted benchmarking outputs*

Given the sensitivity of benchmarking results to the selection of network outputs, our preferred approach is to first group networks into broadly similar groups and then measure benchmarking results relative to these comparison points. The comparison points used in this benchmarking reports are those of ElectraNet and TasNetworks. The choice of these two networks as comparators has been informed by the similarities in network characteristics described in the previous section. The selection of a network peer group is designed to minimise the impact of output specification and environmental factors on the benchmarked network.

The output specification used is the latest relied upon by the AER in its 2017 Annual Benchmarking Report.

These outputs, and their respective weights, are outlined below:

- Energy throughput (0.231),
- Ratcheted maximum demand (0.194),
- Downstream customer connections (0.199), and
- Circuit length (0.376).

## 3.2 Top down benchmarking

### 3.2.1 Advantages of top down benchmarking

Top down benchmarking can help to mitigate some of the issues associated with benchmarking networks with different cost accounting methods. For example, at a totex level opex, impacts of the different capex and opex allocation practices – and the bias this introducing to benchmarking results of either opex or capex – are less material.

### 3.2.2 Approach

This analysis has used a total factor productivity approach that is similar to the one used by the AER in its Annual Benchmarking Report and its most recent Regulatory Determinations. One significant difference we have made is to include capex as an input rather than the capital inputs used by the AER (sub-transmission MVA-kms, distribution MVA-kms and Transformer capacity are used as inputs in the AER's TFP model). The reasons we have used capex as an input rather than capital inputs are:

- Using capex will normalise for the different capitalisation policies of the different networks whereas in the capital input approach a network that chooses to capitalise higher levels of expenditure, or buy rather than lease support assets, will appear more productive[40].
- The use of capital inputs requires accurate reporting of RAB values at different voltage and asset categories (e.g. overhead sub-transmission RAB, transformers RAB etc.). Given Transpower and the NEM networks operate under different

40 For example moving a dollar from opex to capex will decrease opex by a dollar but have no impact on transformer capacity or MVA-kms which are used as capital inputs in the AER's model.

regulatory reporting requirements using different estimates of RAB are likely to introduce further bias into any benchmarks produced.

The output weights used to create an aggregated output index are consistent with the current AER model. These are circuit length (0.376), downstream customer connections (0.199), ratcheted peak demand (0.194) and energy throughput (0.231).

Total factor productivity uses a single index of outputs for each network over time by aggregating a network's outputs with the respective weights displayed in the brackets above. The ratio of this output index and a network's input index (constructed from opex and capex over time) results in a productivity index that is displayed below.

### 3.2.3 Results

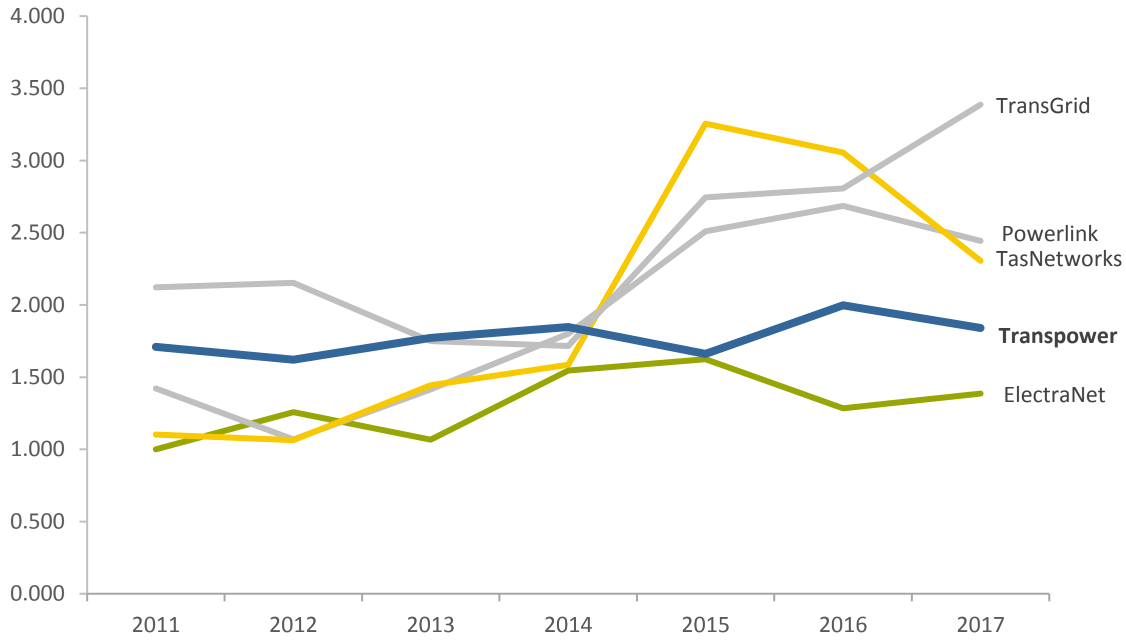
Figure 14 below shows the total factor productivity scores since 2011 for each of the networks in the NEM and Transpower.

A higher score indicates increasing productivity; however, it must be noted that comparisons between networks (rather than over time) are problematic due to the model variables not capturing all differences in operating environments. Transpower in 2017 has a score that placed it in between its two closest comparators ElectraNet and TasNetworks.

Different capex profiles over the past seven years has resulted in significant fluctuations in performance over time – illustrated in the capital partial factor productivity results.

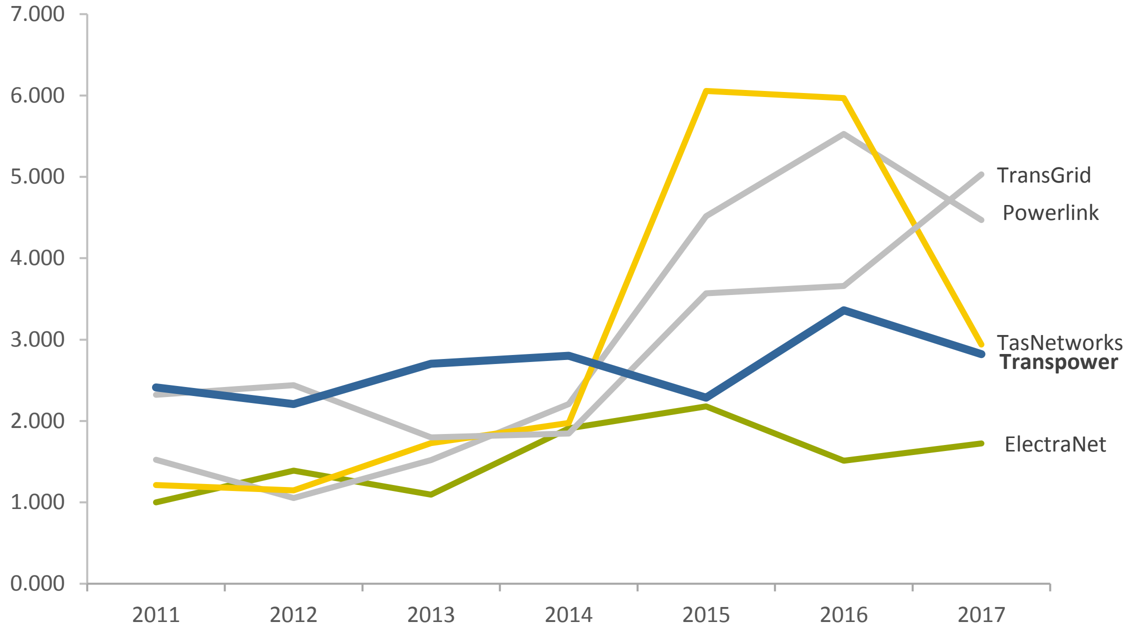
Note that AusNet has been removed from both the total factor (refer Figure 14) and capital productivity (refer Figure 15) results. This is because in Victoria the responsibility for planning and procuring network augmentation rests with the Australian Energy Market Operator (AEMO) and not AusNet Services.

**Figure 14 Total Factor Productivity, FY11-FY17**



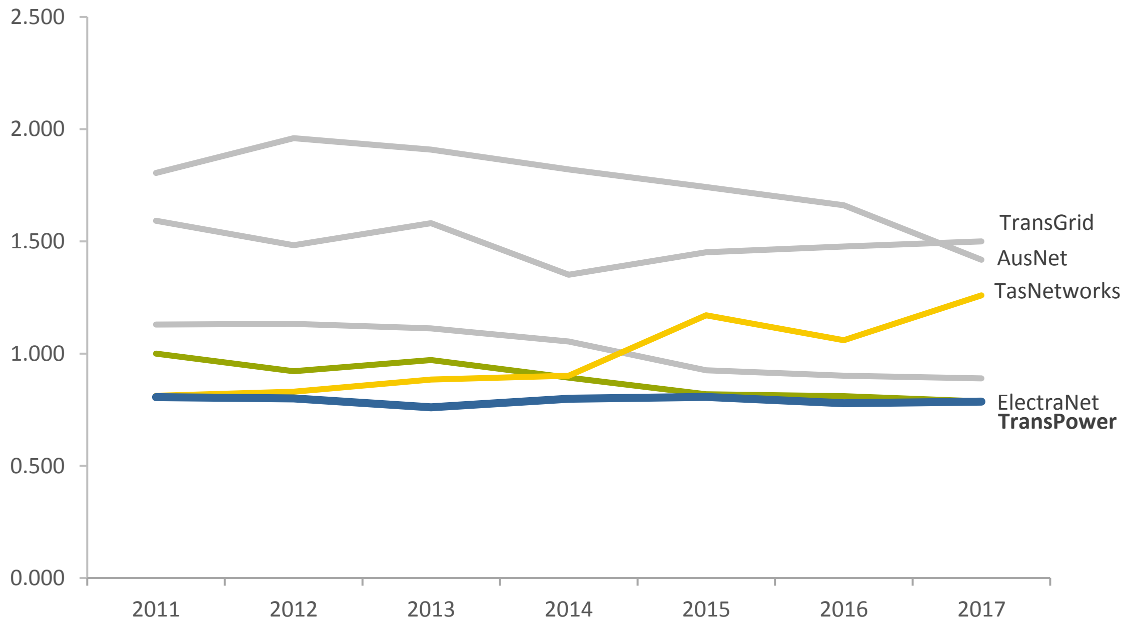

Transpower's capex PFP score has remained consistent (refer Figure 15) over the benchmark period in contrast to the Australian networks that have had significant increases in their productivity scores because of declines in their augmentation expenditure. In 2017, Transpower's capex PFP score was similar to TasNetworks. For both the Australian networks and Transpower, capex is added to the RAB and recovered over time from consumers. This means when addressing network performance consideration should be given to historic performance levels as well as single point-in-time estimates.

**Figure 15 Partial Factor Productivity (capex), FY11-FY17**




When relying on opex as the sole input (refer Figure 16) Transpower benchmarks below TasNetworks and similarly to ElectraNet. TransGrid and AusNet perform well with this model specification due to the benefit of having the highest number of downstream customer connections.

**Figure 16 Partial Factor Productivity (opex), FY11-FY17**



## 3.3 Category (bottom-up) benchmarks

The top down economic benchmarking of aggregate capex and opex presented in section 3.2 can be supplemented by benchmarking of the more significant expenditure programmes and/or by introducing operating environment factors into the analysis to better understand the drivers of the overall productivity results.

### 3.3.1 Advantages of category benchmarking

Category benchmarking can be useful in identifying specific expenditure areas where a network performs differently to other networks. Whilst top down benchmarking may provide a useful overall productivity score, it is limited in its ability to provide information to the networks on which expenditure areas they perform poorly.

### 3.3.2 Benchmarking operating expenditure

Transpower's share of opex as a proportion of total expenditure over the benchmark period is the highest of the networks in the sample. This is likely to be influenced by the significant capex programmes for each of the Australian networks since 2011. It may also be reflective of a preference for maintenance over replacement in New Zealand relative to the Australian networks.

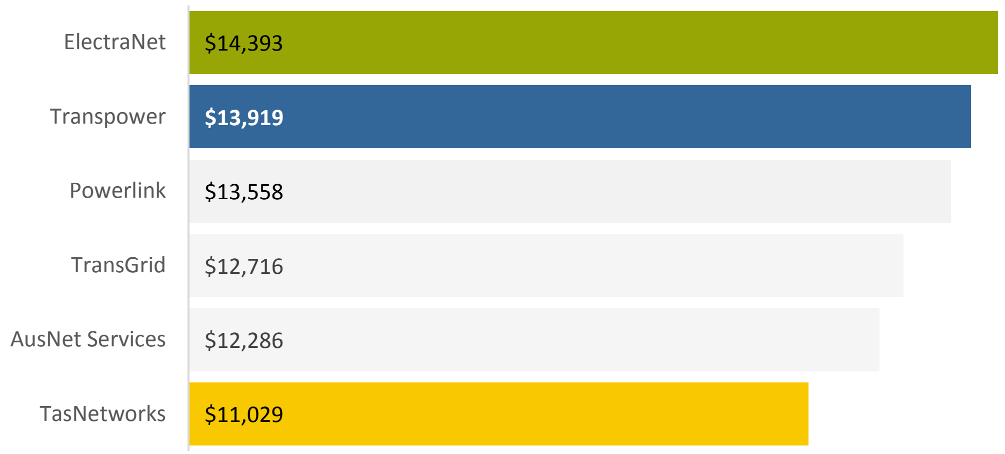
Table 13 below shows the proportion of opex as a percentage of total expenditure for each of the networks in the sample between 2011-2017 (seven-year average) and 2013-2017 (five-year average).

**Table 13 Opex as percentage of Totex**

| Network | 2011-2017 opex / totex | 2013-2017 opex / totex |
|---|---|---|
| ElectraNet | 30% | 33% |
| TransGrid | 31% | 32% |
| AusNet Services | 35% | 34% |
| Powerlink | 35% | 44% |
| TasNetworks | 35% | 42% |
| **Transpower** | **46%** | **47%** |

This high proportion of opex translates to poorer benchmark results when using opex only. Figure 17 shows Transpower had the second highest opex per km between 2013 and 2017. Relative to the comparator networks, ElectraNet and TasNetworks, Transpower's average opex per km was $474 below ElectraNet and around $2,900 higher than TasNetworks. TasNetworks has the advantage over the other two businesses of sharing costs across its transmission and distribution networks. This is also the case for AusNet Services, a network that also benchmarks well on an opex per km basis.

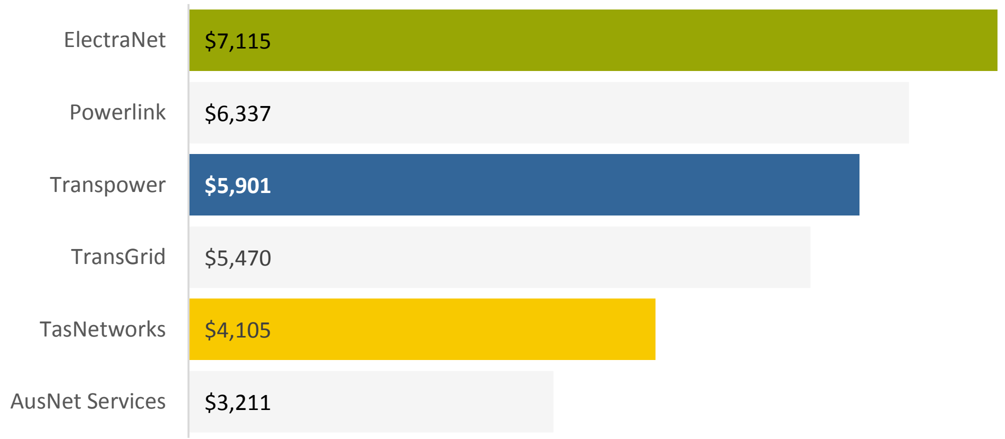
**Figure 17 Total opex per km (2013-17 average)**




To identify differences in average expenditure at a greater level of granularity, aggregate opex costs have been allocated as either direct expenditure (includes maintenance and vegetation management), or indirect expenditure (all other expenditure – includes corporate, network and non-network opex).

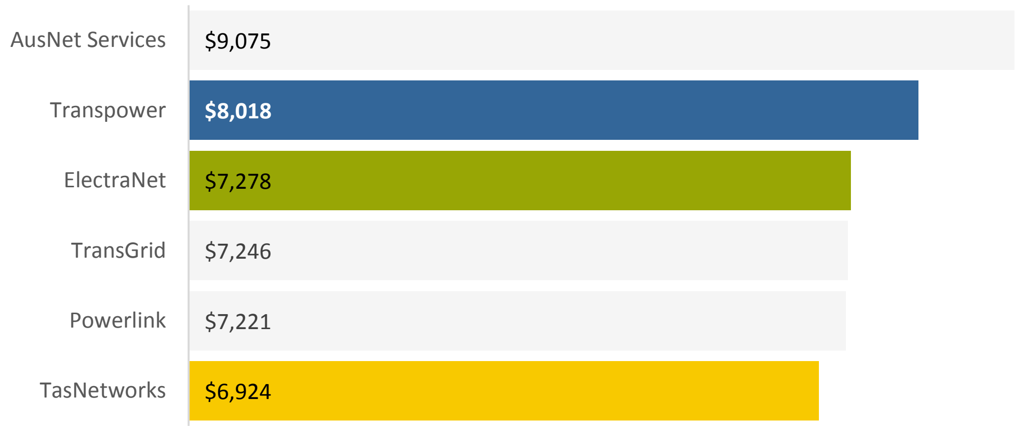
Figure 18 shows that relative to the selected comparison networks, Transpower's direct opex is in between ElectraNet and TasNetworks ($1,214 per km below ElectraNet and $1,796 above TasNetworks).

**Figure 18 Direct opex (maintenance and veg management) per km (2013-17 average)**




In contrast, Figure 20 shows that Transpower's costs are higher than both comparators on the indirect opex per km measure used ($740 higher than ElectraNet and $1,094 higher than TasNetworks).

**Figure 19 Indirect opex per km (2013-17 average)**

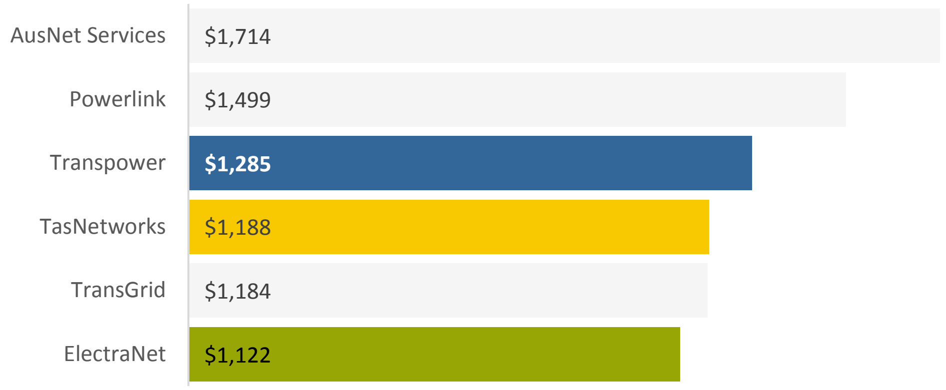



TasNetworks as a distribution and transmission network will benefit from being able to allocate many of its shared costs (for example corporate functions and information services) across two networks. Nevertheless, the direct/indirect breakdown of the opex data provides indicative evidence to suggest it is Transpower's indirect opex that is the more important contributor to its relatively poor opex benchmarking results. This is worthy of closer scrutiny in assessing Transpower's RCP3 opex forecasts.

Different reporting categories between the Australian networks and Transpower makes it difficult to explore this opex benchmarking outcome with further granularity. However, one expenditure category in which all the sampled networks report is ICT opex. In the context of the benchmarks shown above, this category would be a component of the indirect opex per km benchmark.

Figure 20 shows that relative to the selected comparison networks, Transpower's ICT opex is only marginally higher than ElectraNet and TasNetworks ($97 per km above TasNetworks and $163 per km above ElectraNet), which indicates that ICT opex is making only a small contribution to Transpower's higher opex per km compared to ElectraNet and TasNetworks.

**Figure 20 ICT Opex per km (2013-17 average)**

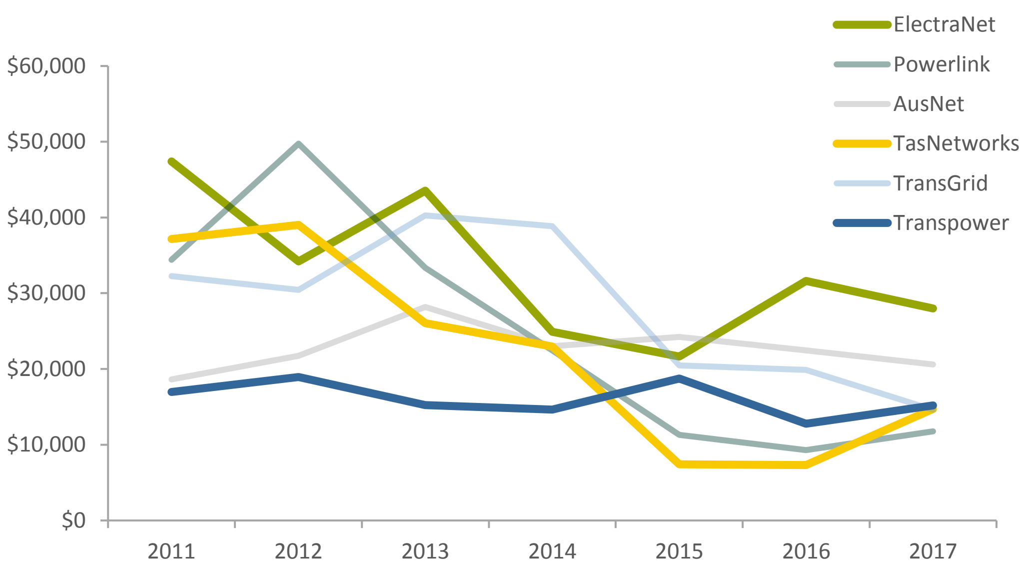



ICT benchmarking is discussed further in our capex benchmarking results in section 3.3.3 below.

### 3.3.3 Benchmarking capital expenditure

Transpower's capex over time has remained relatively consistent. By comparison, the NEM networks (other than AusNet Services which does not have responsibility for network augmentation) invested heavily in the early part of the period and have recently reduced capital expenditure programmes significantly, as shown in Figure 21 below.

**Figure 21 Capex per km**



Similarly, to the opex category, capital expenditure has been disaggregated to identify cost differences within comparable categories. The capex information below has been allocated to either replacement (repex), augmentation (augex) or connections as one category and other capex as a second category. This 'other' category will include capitalised overheads and non-network capex.

Over the last five years, Transpower has had the lowest capex per km of networks benchmarked (refer Figure 22), particularly in the repex, augex and connections benchmark (refer Figure 23).

**Figure 22 Average capex per km (2013-17)**

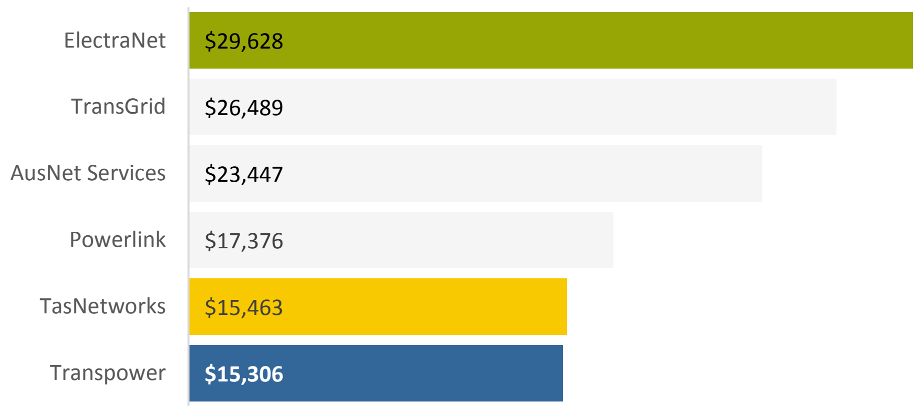
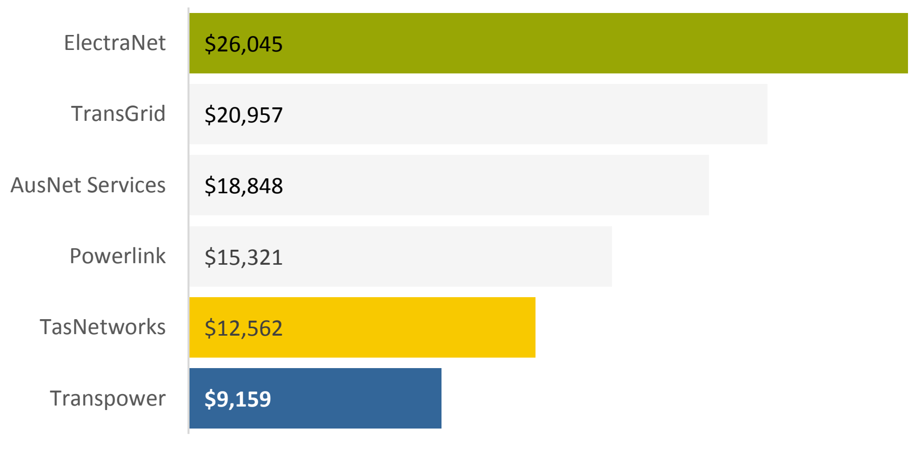
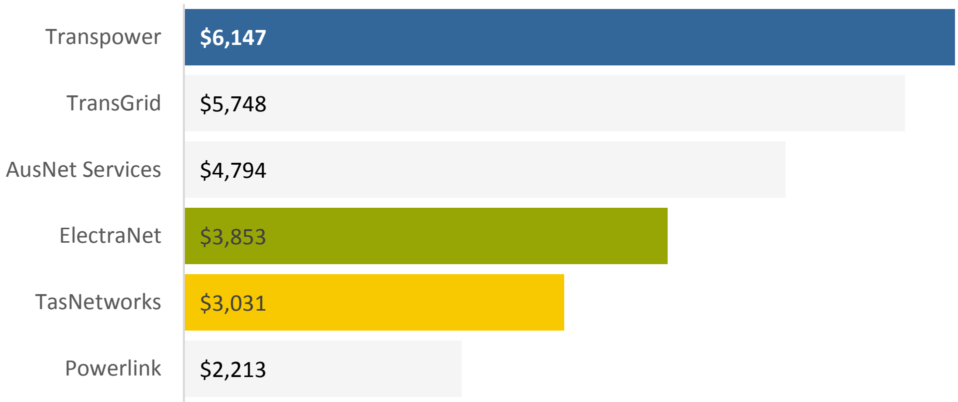



**Figure 23 Average replacement, augmentation and connections capex per km (2013-17)**




However, this relatively good direct capex performance is offset by the relatively high non-network capex benchmark result (refer Figure 24).

**Figure 24 Average overheads and non-network capex per km (2013-17)**




Looking at how Transpower has allocated capex within the ICT category it is likely that accounting differences are driving the perceived poor performance in the overheads and non-network capex category. Transpower's ICT capex includes capex for the following categories:

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

IT telecoms, network and security services, and transmission systems are likely to be categorised differently by the Australian networks. For example, in the Regulatory Information Notices (RINs) used by the Australian networks to report expenditure Telecommunications Network / Systems, Communications Network Assets, Station SCADA and control systems capex are included with the replacement expenditure category.

This difference in reporting is most likely driven by the different network characteristics between the Australian networks that have built their own communications networks and Transpower, a network that leases much of this capability. Removing IT telecoms, network and security services, and transmission systems capex from the overheads and non-network capex benchmarks and including them within repex, results in Transpower's benchmarking performance improving significantly (refer Figure 25 and Figure 26).

**Figure 25 Average replacement, augmentation and connections capex per km (2013-17)**

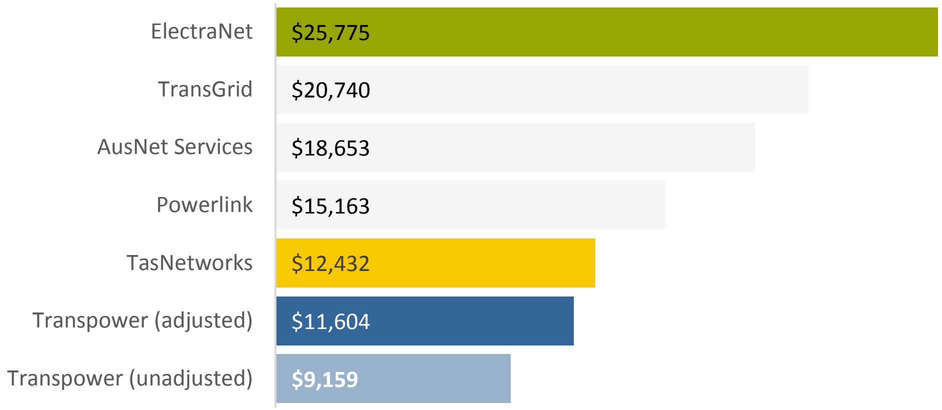
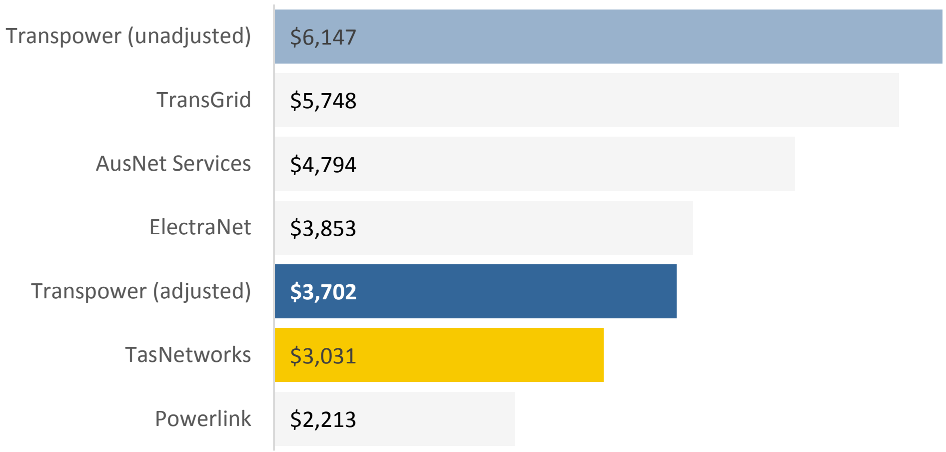



**Figure 26 Average overheads and non-network capex per km (2013-17)**




### 3.3.4 Transpower's productivity performance trend

One of the inherent difficulties with comparing networks operating within a diverse range of environments is how to ensure that benchmarks are truly reflective of controllable differences that a network's management can influence.

Trending Transpower's historic performance together with a projection into the future without comparison to other networks is one way to mitigate the cross-sectional heterogeneity that is present in the transmission network sample.

In this respect we acknowledge that whilst it may be difficult to measure how networks compare at a single point in time it is possible to identify how networks are performing over time on a trend basis. Table 14 below indicates how Transpower has performed over time using the total and partial factor productivity indexes produced earlier in section 3.2 of this chapter. In addition, Transpower's RCP3 forecast expenditure has been included to provide a perspective on the productivity implications of its proposed expenditure.[41]

**Table 14 Transpower expenditure productivity indexes from 2011-22**

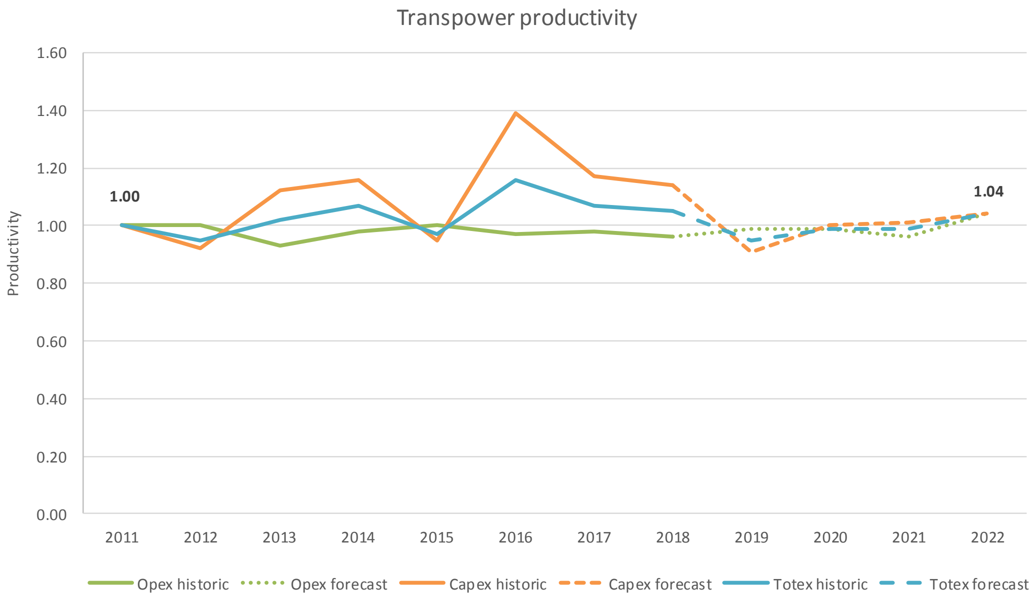
| Expenditure | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Opex historic | 1.00 | 1.00 | 0.93 | 0.98 | 1.00 | 0.97 | 0.98 | 0.96 | | | | |
| Opex forecast | | | | | | | | 0.96 | 0.99 | 0.99 | 0.96 | 1.04 |
| Capex historic | 1.00 | 0.92 | 1.12 | 1.16 | 0.95 | 1.39 | 1.17 | 1.14 | | | | |
| Capex forecast | | | | | | | | 1.14 | 0.91 | 1.00 | 1.01 | 1.04 |
| Totex historic | 1.00 | 0.95 | 1.02 | 1.07 | 0.97 | 1.16 | 1.07 | 1.05 | | | | |
| Totex forecast | | | | | | | | 1.05 | 0.95 | 0.99 | 0.99 | 1.04 |

Transpower's forecast total productivity in 2022, measured by forecast outputs relative to forecast totex is around 4% higher than in 2011. Specifically, Transpower's forecast expenditure suggests its opex productivity score will be 3.8% higher in 2022 than in 2011 and its capex productivity score will be 4.3% higher in 2022 relative to 2011.

Transpower's highest productivity score over the period occurred in 2016 as result of reported capex declining significantly between 2015 ($289 million) and 2016 ($197 million) and has fallen over RCP2 as capex has increased from the 2016 low with outputs relatively stable over this period (stable output and increasing capex inputs push down measured productivity).

[41] Transpower's outputs have been forecast using the following assumptions: Energy throughput growth: 1.01%, peak demand growth: 1.39%, circuit length: 0%, customer connections: 0.75%

**Figure 27 Transpower productivity trend 2011-22**




## 3.4 Conclusion

We have applied partial productivity and MTFP economic benchmarking techniques to assess Transpower's productivity performance relative to Australian electricity transmission networks over the past 5 years.

Based on our analysis of key network characteristics, we find that two Australian electricity transmission networks, ElectraNet and TasNetworks, are most comparable to Transpower.

Given this very small sample size, care must be taken in drawing firm conclusions from our benchmarking results. However, we consider the results could reveal important information about the way Transpower is investing in and operating its network.

Our benchmarking results indicate that Transpower's capex productivity performance is one of the best in sample, particularly when a five or seven year average is considered. Transpower's opex productivity performance compares less favourably.

This result could indicate that capex-opex trade-offs are an important component of Transpower's investment governance process, with whole-of-life cost considerations often resulting in opex being used to extend life as the preferred and most economic option in lieu of capital investment. This is a reflection of different management strategies and plans, rather than an indication that Transpower is particularly efficient in capital expenditure and inefficient in operating expenditure. These inherent difficulties in benchmarking electricity networks across jurisdictions and accounting methods is one of the reasons that moving to a totex benchmarking approach is currently under consideration in Australia.

Nevertheless, given these benchmarking results, Transpower's decision-making around capex-opex trade-offs in its expenditure planning has been subject to close scrutiny in our review.

Further, our benchmarking of Transpower's long term productivity performance trend, including forecasts for RCP3, indicates improving opex productivity in RCP3 offset by more sharply declining capex productivity. We have had regard to these findings in our assessment of Transpower's RCP3 expenditure forecasts in Chapter 7 (Capex forecast verification) and Chapter 8 (Opex forecast verification) of our report.

# 4 Transpower's grid output performance measures

The purpose of this chapter is to assess Transpower's performance against the Commission's approved grid output measures for RCP2 and the measures that Transpower proposes to implement for RCP3, including its stakeholder engagement on these measures.

## 4.1 Transpower's service performance framework

Transpower's services framework identifies eight services, including its system operator activity and other activities not regulated under the IPP.

The following three services are the most significant drivers of cost and quality for end consumers and for our verification report:[42]

- reliable grid – keep interruptions to a very low level, and restore supply quickly when there is an interruption;
- grid availability – keep sufficient grid capacity and resilience available to allow NZ's lowest cost sources of supply to be used to meet demand; and
- event communications – communicate with customers when supply is interrupted to achieve the best outcomes for them.

## 4.2 Commerce Commission's RCP2 final decision

In its Final Decision for RCP2, the Commission approved 23 revenue-linked grid output measures for Transpower grouped as follows:[43]

- Asset performance (AP) measures, for which there are two measures: AP1 and AP2.
- Grid performance (GP) measures, for which there are three measures: GP1 to GP3 that each have five categories representing different points of service (15 grid reliability measures in all).
- Asset health (AH) measures, for which there are six measures for six fleets of assets: AH1 to AH6. Three of the measures have yearly targets and the other three have targets for the full regulatory period.

[42] Transpower (2017), Services Report, September 2017, p. 1

[43] Commerce Commission, Final Decision, p. 43

A target, cap, collar, and incentive rate is defined for each of the measures. The cap and collar set the range of performance within which Transpower is penalised or rewarded. The caps and collars are symmetric, meaning that the incentive rate is the same for rewards and penalties, and the maximum possible reward and penalty are equal.

The Commission indicated it would monitor the effectiveness of these incentives over the course of RCP2. It also approved several non-revenue performance measure development (PMD) initiatives to be reported on by Transpower over the RCP2 period.

Table 15 summarises the PMDs.

**Table 15 Transpower's PMD initiatives for RCP2**

| PDM initiative | Recommendation |
|---|---|
| Nine performance measure development initiatives (PMD1 to PMD9) | • The Commission recommend that Transpower considers developing nine performance measures in RCP2, i.e. these consist of six that Transpower proposed and three that the NZCC included (PMD7 to PMD9).<br>• While Transpower only accepted developing PMD8 (objecting to the others), the NZCC's reasons for retaining the other two measures were as follow:<br>– PMD7 measure links interruptions and the cost of interruptions. The Commission recommended that, via PMD7, Transpower:<br>o reports the estimated unserved energy due to unplanned interruptions until Transpower develops an appropriate measure that provides the financial impact of interruptions to customers and consumers;<br>o explores the feasibility of estimating VoLL for each category of points of service so that, for the grid output measures in RCP3, it can set incentive rates that are linked with VoLL; and<br>o reports the estimated unserved energy along with its GP1 reporting.<br>• PMD9 monitors an element of customer satisfaction. The Commission considered such a measure will complement Transpower's move towards being a more customer focused business and may help Transpower identify aspects of customer service it needs to focus on. |
| Reporting on nine performance measure development initiatives | • The Commission recommends that Transpower reports on the information noted below.<br>– Time to provide initial information following an unplanned interruption (PMD1):<br>o the percentage of unplanned interruptions where Transpower contacted affected customers within 15 minutes; and<br>o the maximum time taken by Transpower to contact an affected customer.<br>– Time to provide updated information following an unplanned interruption that was not restored within 30 minutes (PMD2):<br>o the percentage of interruptions where Transpower updated affected customer within 30 minutes;<br>o the maximum time taken by Transpower to update an affected customer; and<br>o the number of affected customers that were not updated. |

| PDM initiative | Recommendation |
|---|---|
| | – Accuracy of notified restoration times following unplanned interruptions (PMD3), i.e. the percentage of unplanned interruptions that were restored:<br>o within 10 minutes of the advised estimated restoration time;<br>o within 30 minutes of the advised estimated restoration time; and<br>o more than 30 minutes after the advised estimated restoration time.<br>– Extent that Transpower meets planned outage restoration times (PMD4), i.e. the percentage of planned outages where<br>o the end time was after the planned end time;<br>o the end time was more than 30 minutes after the planned end time; and<br>o actual end time was over 30 minutes earlier than planned end time.<br>– Extent that Transpower places customers on 'N' security (PMD5):<br>o the percentage of time that each point of service was reduced to N-security; and<br>o the number of hours a point of service was on N-security.<br>– Number of unplanned momentary (of less than one minute) interruptions (PMD6), i.e. the number of momentary interruptions:<br>o at each point of connection; and<br>o by category.<br>– Energy not supplied for each point of service for each unplanned interruption (PMD7), i.e. for each unplanned interruption including interruptions caused by AUFLS:<br>o the estimated unserved energy (MWh) by point of service for the interruption;<br>o the date, time and duration of the interruption; and<br>o where unserved energy for the interruption is greater than 0.5 system minutes, the reasons for the interruption; Transpower's response to the interruption; and any changes to Transpower's policies or standards because of the interruption.<br>– Extent that Transpower meets planned outage start times for critical circuits and equipment (PMD8), i.e. for all planned outages of selected HVDC circuits and components of the HVDC links:<br>o the percentage of outages that the start time was within 30 minutes of the planned start time; and<br>o the percentage of outages that the start time was more than 60 minutes after the planned start time.<br>– Extent that Transpower provides its reports to affected parties on unplanned interruptions within 15 workings days of the interruption (PMD9). Transpower will report any exceptions on the number of times it did not meet the timeframe. Specifically:<br>o the number of unplanned interruptions where Transpower did not provide a report within 42 working days to affected customers; and<br>o the percentage of unplanned interruptions where Transpower did not provide a report within 42 working days to affected customers. |

### 4.2.1 Transpower's RCP2 revenue-linked grid output performance

Transpower's performance against its 23 revenue-linked grid output measures in RCP2 is presented below.

### *Grid Reliability measures*

Grid Reliability measures how often a customer experiences an unplanned interruption and the duration of the interruption.

Transpower is required to report the following three Grid Reliability measures:

- the number of unplanned interruptions each year
- the average duration of unplanned interruptions each year (in minutes)
- the 90th percentile duration of unplanned interruptions each year (in minutes).

Each of these measures is required to be reported across five service categories - high-priority, important, standard, generator and 'N-security'.

Transpower's performance against each of these measures is provided in Table 16 below.

**Table 16 Transpower's RCP2 grid reliability performance – 2015/16 to 2017/18**

| Measure | Number of sites | RCP2 Targets | | | Actuals | | |
|---|---|---|---|---|---|---|---|
| | | Target | Cap | Collar | 2015/16 | 2016/17 | 2017/18 to March 2018 |
| **Grid Interruptions** | | | | | | | |
| **GP1: Number of interruptions (p.a.)** | | | | | | | |
| High Priority | 21 | 2 | 0 | 4 | 0 | 3 | 0 |
| Important | 39 | 9 | 4 | 14 | 2 | 6 | 6 |
| Standard | 79 | 26 | 21 | 31 | 14 | 23 | 31 |
| Generator | 39 | 11 | 6 | 16 | 4 | 20 | 3 |
| N-security | 44 | 56 | 38 | 74 | 22 | 26 | 41 |
| **Restoration** | | | | | | | |
| **GP2: Average duration of interruptions (min)** | | | | | | | |
| High Priority | 21 | 70 | 30 | 110 | 0 | 47 | 0 |
| Important | 39 | 100 | 30 | 170 | 14 | 201 | 40 |
| Standard | 79 | 65 | 0 | 130 | 42 | 75 | 179 |
| Generator | 39 | 130 | 50 | 210 | 162 | 105 | 487 |
| N-security | 44 | 80 | 45 | 115 | 167 | 616 | 170 |
| **GP3: P90 Longest durations (min)** | | | | | | | |
| High Priority | 21 | 120 | 80 | 160 | 0 | 72 | 0 |
| Important | 39 | 240 | 170 | 310 | 17 | 482 | 61 |
| Standard | 79 | 130 | 60 | 200 | 116 | 131 | 164 |
| Generator | 39 | 350 | 260 | 440 | 234 | 173 | 1087 |
| N-security | 44 | 215 | 170 | 260 | 341 | 1056 | 302 |

means worse than the collar

means better than the cap

The table indicates that Transpower performed well in terms of the number of interruptions so far over RCP2. However, the duration of the interruptions (time taken to restore the service) has exceeded the collars on several occasions, particularly in the most recent reporting period. Further, the duration of several interruptions has significantly exceeded target levels.

*Grid Availability measures*

Grid Availability measures are concerned with the impact that grid asset availability can have on access to the lowest-cost mix of generation. The two grid availability measures approved for RCP2 are:

- the availability of Transpower's inter-island high-voltage direct current (HVDC) system; and
- the availability of 27 high-voltage alternating current circuits (HVAC) selected based on based on the potential effect on the electricity market of an outage of that circuit.

Transpower's performance in relation to grid availability is presented in Table 17 below.

**Table 17 Transpower's RCP2 grid availability performance – 2015/16 to 2017/18**

| Measure | Number of sites | RCP2 Targets | | | Actuals | | |
|---|---|---|---|---|---|---|---|
| | | Target | Cap | Collar | 2015/16 | 2016/17 | 2017/18 to March 2018 |
| Grid Availability | | | | | | | |
| Availability (%) | | | | | | | |
| AP1: HVDC | - | 98.5 | 99.5 | 97.5 | 98.9 | 98.6 | 98.6 |
| AP2: HVAC | - | 99.6 | 100.0 | 99.2 | 99.0 | 99.0 | 99.0 |

means worse than the collar
means better than the cap

Transpower has met availability targets in relation to its HVDC link so far in RCP2. However, Transpower notes that its performance has been affected by its decision to not undertake live-line work to ensure it complies with new guidelines that have been published by the Electricity Engineers' Association. This stance may have some effect on Transpower's ability in future to achieve its Grid Availability targets.[44]

The availability of the HVAC has been below target and collar levels so far during RCP2. Transpower has indicated that its HVAC targets were not well-calibrated and may be further impacted by its most recent decisions regarding changes to live-line work. In response, Transpower has worked to an internal target of 98.7% that, in its view, better balances need for HVAC availability, with the need for lines to be de-energised for

[44] Transpower (2017), Services Report, September 2017, p. 16

planned maintenance. Transpower is refining this target for RCP3 by also considering factors such as historical performance and the current planned work programme for RCP3 so that it better reflects this balance.[45]

### *Asset Health (works delivery) measures*

The asset health reporting measures in RCP2 require Transpower to publicly report on:

- the number of towers painted
- grillages commissioned
- insulators commissioned
- outdoor circuit breakers commissioned
- transformers commissioned
- outdoor to indoor conversions commissioned

The first three of the above asset classes were given annual output targets, while the remaining three asset classes had targets to be met by the end of RCP2.

It is important to note that these measures are more in the nature of input-focussed works delivery targets, as opposed to output-focussed service performance measures as is normally the case. These targets appear to have reflected Commerce Commission concerns regarding Transpower's deliverability of its RCP2 expenditure programmes.

Transpower's performance against these works delivery targets is provided in Table 18 below.

[45] Ibid., p. 16

**Table 18 Transpower's RCP2 asset health performance**

| Measure | | RCP2 Targets 2015/16 | RCP2 Targets 2016/17 | RCP2 Targets 2017/18 | RCP2 Targets 2018/19 | RCP2 Targets 2019/20 | Actual 2015/16 | Actual 2016/17 | Forecast 2017/18 | Forecast 2018/19 | Forecast 2019/20 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Number of transmission towers refurbished or replaced** | | | | | | | | | | | |
| | Cap | 467 | 563 | 557 | 598 | 595 | | | | | |
| | Target | 427 | 523 | 517 | 558 | 555 | 461 | 542 | 494 | 583 | 603 |
| | Collar | 387 | 483 | 477 | 518 | 515 | | | | | |
| **Number of grillages [sets] commissioned** | | | | | | | | | | | |
| | Cap | 370 | 427 | 439 | 421 | 408 | | | | | |
| | Target | 339 | 396 | 408 | 390 | 377 | 276 | 320 | 409 | 288 | 267 |
| | Collar | 308 | 365 | 377 | 359 | 346 | | | | | |
| **Number of insulators [sets] commissioned** | | | | | | | | | | | |
| | Cap | 1647 | 1581 | 1517 | 1430 | 1490 | | | | | |
| | Target | 1532 | 1466 | 1402 | 1315 | 1375 | 755 | 887 | 998 | 990 | 1325 |
| | Collar | 1417 | 1351 | 1287 | 1200 | 1260 | | | | | |
| **Number of outdoor circuit breakers commissioned** | | assessed after 2019/20 for the full RCP2 period | | | | | | | | | |
| | Cap | | | | | 153 | | | | | |
| | Target | | | | | 141 | 26 | 15 | 19 | 19 | 31 |
| | Collar | | | | | 129 | | | | | |
| **Number of power transformers commissioned** | | assessed after 2019/20 for the full RCP2 period | | | | | | | | | |
| | Cap | | | | | 28 | | | | | |
| | Target | | | | | 26 | 1 | 1 | 4 | 7 | 9 |
| | Collar | | | | | 24 | | | | | |
| **Number of outdoor to indoor conversions commissioned** | | assessed after 2019/20 for the full RCP2 period | | | | | | | | | |
| | Cap | | | | | 16 | | | | | |
| | Target | | | | | 15 | 2 | 2 | 4 | 3 | 3 |
| | Collar | | | | | 14 | | | | | |

(red) means worse than the collar
(green) means better than the cap

Transpower failed to meet most of the asset health targets over the first three years of RCP2.

Transpower has explained that the grillage encasement strategy has been through a significant review and update since the 2016 Asset Management Plan and the result of this has been a reduction in the volume of work forecast to be completed in RCP2. The structures and insulators replacement programme is constantly reviewed given new condition assessment data and refinements to health modelling, which has resulted in the forecast for insulator replacement in RCP2 to be reduced.[46]

46 Transpower (2017), Services Report, September 2017, p. 18

According to Transpower, the reduction in the number of transformers commissioned also reflects the use of new planning frameworks and tools that have seen it defer some of this work to deliver cost savings.[47]

### 4.2.2 Non-revenue linked grid output measures

In addition to the revenue-linked asset health output measures summarised above, Transpower has also been required in RCP2 to report against three additional grid output measures but that are not linked to revenue.

These grid output measures have targets relating to the average remaining life (in years) of Transpower's transmission tower coating, transformers, and outdoor circuit breakers and have associated reporting requirements.

These measures form part of a pilot reporting on asset health measures to ensure the revenue-linked asset health measures are providing appropriate incentives and with a view to linking these measures to revenue in RCP3.

Transpower was exempted from reporting on these measures in 2016 so that it could develop improved asset health measures aligned to its evolving asset health models and provide more meaningful information for stakeholders. Transpower advised that it agreed with the Commission the new reporting measures and started reporting against these in 2017/2018. Consequently, there is no meaningful data to assess Transpower's performance against these measures in RCP2.

### 4.2.3 Trial PMD measures

For RCP2, the Commission also approved a set of 'performance measure development' (PMD) initiatives seen as potentially important to stakeholders.[48]

The approved measures are as follows:

- PMD1 – Time to provide initial information following an unplanned interruption
- PMD2 – Time to provide updated information following an unplanned interruption (greater than 30 minutes)
- PMD3 – Accuracy of notified restoration times following unplanned interruptions

[47] Ibid., p. 18

[48] We understand some of the measures arose from Transpower's consultation on its RCP2 service performance measures and some arose from the RCP2 reset process.

- PMD4 – Extent that Transpower meets planned outage restoration times
- PMD5 – Extent that Transpower places customers on 'N' security
- PMD6 – Number of unplanned momentary (of less than one minute) interruptions
- PMD7 – Energy not supplied for each point of service for each unplanned interruption
- PMD8 – Extent that Transpower meets planned outage start times for critical circuits and equipment
- PMD9 – Extent that Transpower provides its reports to affected parties on unplanned interruptions within 15 working days of the interruption

Transpower has indicated that it internally trialled these development measures for one year and has subsequently engaged with customers and stakeholders on whether to adopt them as future measures for RCP3. The outcomes of this engagement and implications for RCP3 are discussed in the next section of this chapter.

### 4.2.4 Transpower proposed grid output measures for RCP3

During RCP2, Transpower has undertaken an initiative to develop its asset health models, data and processes, which allows it to improve its asset health reporting for the remainder of RCP2.

It also has developed revenue-linked asset health output measures for RCP3 using this updated reporting methodology (replacing the current works-based asset health targets).[49]

Consistent with the RCP2 grid output measures, Transpower will continue to report against the following two revenue-linked grid output measures' (as defined in the Capex IM):

- Reliable Grid (measure of grid performance)
- Grid Availability (measure of asset performance)

[49] Transpower (2017), Services Report, September, p 1

## 4.3 Stakeholder engagement on proposed RCP3 grid output measures

This section outlines our approach to assessing the extent and effectiveness of Transpower's consultation with its stakeholders.

### 4.3.1 Our assessment approach

We define the extent of Transpower's consultation as meaning the scope, form and size of its consultation process. We defined the effectiveness of Transpower's consultation as meaning how effective Transpower's consultation process was in achieving stakeholder engagement in the development of RCP3 service performance measures.

Our assessment methods included:

- reviewing documents provided by Transpower;
- reviewing relevant Transpower website content, including that published on its dedicated 'Transpower Service Measures Refresh for RCP3' web page (https://www.transpower.co.nz/transpower-service-level-refresh-rcp3);
- meeting with Transpower to discuss their consultation methodology;
- considering their response to our request for additional information relating to its consultation methodology; and
- considering all information gathered and assessing it collectively against best practice principles and practice.

To support our review, Transpower provided us with the following documents:

- SHE001 Stakeholder Engagement
- 2017 ITP Services Report
- Engagement Paper 3 (provided 15 June 2018)
- Asset Health Pilot report.

In addition, we reviewed the following documents available on the 'Transpower Service Measures Refresh for RCP3' web page:

- Transpower Services Engagement Paper
- Service Performance Measures - Customer Feedback Summary (Transpower's summary of feedback on each question asked in the consultation paper)

- Summary Customer Feedback (full submission papers)
- Service Performance Measure Refresh RCP3 (focus group session presentation)
- Engagement Paper 2
- Service Engagement Submissions
- Service Performance Measures Feedback Summary – May 2017
- Service Performance Measure Refresh (workshop presentation).

We also reviewed Transpower's response to our request for additional information, comprising:

- RFI No 7 Transpower Response
- RFI No 7 Accompanying Document Next steps and Timeframes
- RFI No 7 Accompanying Document RCP3 Communications Engagement Plan.

In reviewing the extent and effectiveness of Transpower's consultation, we have used Public Relations Institute of New Zealand (PRINZ) best practice as a benchmark. Best practice consultation makes a positive contribution to the end policy, project or work programme.

Key principles of PRINZ best practice consultation include:

- The consultation process is meaningful (feedback influences decisions)
- The process is transparent and has integrity
- The process is timely and provides sufficient time to enable quality feedback
- Key stakeholders have been identified and engaged
- Participants in the process are kept informed.

### 4.3.2 Extent of Transpower's stakeholder consultation

Our opinion is that to-date the extent of Transpower's consultation with its stakeholders has been adequate. Although Transpower did not prepare an engagement plan for RCP3 measures, their content and methodology are sound. We also note that Transpower's engagement for RCP3 forms part on an ongoing stakeholder engagement programme that it runs.

We have based our opinion on the following factors:

*Transpower is implementing an open and transparent consultation process*

This has included publishing (on its website) an outline of its consultation process, consultation papers with clear information and questions for submitters, and both submission summaries and the submissions themselves.

*Transpower sought to involve stakeholders in the engagement process design*

Transpower proactively published an outline of its proposed engagement approach early in the process, through the October 2016 Service Engagement Paper. This paper also actively sought stakeholder feedback on the proposed engagement process.

*Transpower has sought to engage stakeholders through several channels*

In addition to publishing consultation documents and supporting information on its website, Transpower has also leveraged email, phone calls, focus group sessions and workshops with its key stakeholders.

*Transpower has identified its key stakeholders and actively sought to engage them in their service measure refresh process*

Transpower identified 52 key stakeholders and proactively issued an engagement paper to them seeking written feedback on the engagement process as well as the service measures.

Transpower also identified several consumer advocacy groups representative of electricity consumers and sought meetings with chief executives of these groups prior to consultation.

*Transpower has kept their stakeholders informed throughout the process*

A dedicated page on Transpower's website enables stakeholders to keep up-to-date with the service measures refresh for RCP3.[50] Transpower has also used targeted emails to keep stakeholders informed and engaged in the RCP3 process.

*Transpower has set, communicated and worked to a clear timeline for engagement*

Early in the process, Transpower published its intended timeline for engagement alongside its proposed methodology. Transpower has also communicated engagement

[50] https://www.transpower.co.nz/transpower-service-level-refresh-rcp3

next steps and timeframes at each stage of the service measure refresh process. This will have provided stakeholders with enough advance visibility of timeframes to support their preparation of feedback.

However, we note that the June 2018 Service and Asset Health Engagement Paper 3 provides just two weeks for submitters to respond. Because many of its stakeholders are engaged in several other regulatory processes, a short submissions period may have been a barrier to stakeholders wishing to respond.

*Transpower has closed the 'feedback loop' by letting stakeholders know how their feedback has influenced the service measure refresh*

As it finalises each stage of the consultation process, Transpower has clearly documented its response to submitter feedback and how feedback has influenced their decisions. Transpower has also updated the relevant page on its website at key points in the planning and consultation process.

### 4.3.3 Effectiveness of Transpower's consultation

Our opinion is that Transpower's consultation with its stakeholders has been moderately effective to-date.

We have found assessing the effectiveness of Transpower's consultation challenging, as it has no documented consultation objectives or success measures. As previously noted, Transpower integrates stakeholder engagement into its 'business as usual' activities, rather than managing it as a distinct work stream with its own objectives, strategy, tactics and success measures. While this is effective for day-to-day operations, it is our opinion that major engagement projects (such as consultation for the RCP3 service measures refresh) benefit from a more structured approach.

It is our opinion that had Transpower identified engagement as a key work stream supporting the multiple RCP3-related projects and planned and managed this work stream independently of those projects, consultation would have been more effective and success easy to measure.

Transpower has provided us with a draft RCP3 communication and stakeholder engagement plan, which outlines the way forward (from May 2018) for engagement on the RCP3 proposal document. This plan clearly articulates very broad target audiences, how they prioritise these audiences, key messages and communications and engagement activities. It is best practice to avoid identifying 'the general public' as a target audience, as this is too broad. For example, 'New Zealanders interested in energy sustainability' would be a more targeted audience.

The draft RCP3 communication and stakeholder engagement plan is currently very output-focussed. It could be improved by re-focussing on outcomes, in the form of the relevant business objectives, engagement objectives and success measures. An outcome-focussed plan is more likely to drive high performance and more effectively support achievement of business objectives.

A planned approach to Transpower's engagement efforts would also provide greater consistency in its messaging. For example, introductory text on the dedicated Transpower Service Measures Refresh for RCP3 web page states that "*… A major part of the refresh is consultation with our customers, interested consumer groups and the general public.*" However, it is clear from the industry-focused location of this page within the Transpower website, and the draft RCP3 communication and stakeholder engagement plan, that consumer groups and the general public are of low priority for engagement. Setting, communicating and delivering to clear expectations for engagement with each target audience is critical to success. Messages that set expectations that are unlikely to be met can be counter-productive.

### *Verification opinion*

In the absence of documented objectives and success measures, we have based our verification opinion on the following:

- Transpower's November 2016 consultation on service performance measures achieved a 23% response rate (12 submissions), and the subsequent consultation on the proposed set of service measures for RCP3 achieved a 9.6% response rate (5 submissions).
- While these response rates are low, they are an improvement on response rates achieved in the Commerce Commission's consultation on key issues in Transpower's RCP2 proposal (5 submissions).
  - Transpower has noted that that although the quantity of responses is considered low, it considers the quality of feedback received has been high/very valuable.
- Consultation documents have been generally well written and relatively easy to understand, given the technical nature of the content. Transpower's use of info-graphics was effective and they could further improve readability by using visual content more extensively in future documents. Transpower could also make consultation documents more accessible by more rigorously applying plain English principles to content and including a glossary for acronyms and technical terms.

- Transpower has demonstrated a genuine intent to engage, and committed a high level of effort to the engagement process.
- Transpower has acknowledged the extensive involvement many of its customers and stakeholders have in current regulatory processes and consultations. We believe 'consultation fatigue' will have likely impacted the effectiveness of Transpower's consultation. Transpower could offset this by providing longer submissions periods for its consultation papers.
- Transpower has put significant effort into engaging with both a broad group of industry stakeholders and consumer groups. Transpower achieved a much lower level of participation from consumer groups and the wider public than industry groups and customers, but this is to be expected and reasonable in our opinion given the relatively small number of directly connected transmission network customers. Small business and residential energy consumers are likely to have a lower understanding of, and interest in, Transpower's decisions.

On balance, we consider the extent of Transpower's stakeholder consultation for its RCP3 grid output measures satisfies the expenditure outcome having regard to GEIP.

### 4.3.4 Proposal consistency with feedback

As it finalises each stage of its consultation, Transpower has published submissions, and its response to submitter feedback. They have also clearly communicated how stakeholder feedback has influenced their service measure design process. This has supported our assessment process.

Our assessment method was to review stakeholder submissions and related documents. Transpower has made these publicly available via the Transpower Service Measures Refresh for RCP3 web page.

We reviewed Transpower's engagement paper content outlining how stakeholder feedback has influenced service measure design. We then reviewed stakeholder submissions documents and assessed their consistency with Transpower's engagement paper content.

Our opinion is that Transpower's proposal is mostly consistent with the feedback Transpower received from its stakeholders. It is clear that Transpower has considered stakeholder feedback and incorporated it into their proposal, as far as practicable given the diverse views held about some proposed service performance measures.

Where Transpower has chosen not to implement a stakeholder's preferred approach, they have outlined their reasons for this. Where feedback from several stakeholders has been consistent, Transpower has adjusted its proposal to reflect this, or left the issue open for further engagement. Where a stakeholder or stakeholders have expressed outlying views, Transpower has acknowledged this in its submissions summaries and engagement papers.

Table 19 summarises the extent to which each proposed service performance measure reflects stakeholder feedback.

**Table 19 Stakeholder feedback**

| Proposal | | Consistency with feedback |
|---|---|---|
| To not adopt RCP2 measures PMD1, PMD2, PMD3, PMD5, PMD6, PMD7, PMD9 | | Most feedback supported Transpower's proposal to not adopt these measures for RCP3.<br>However, one submitter believes PMD6 and PMD9 should be developed into full, incentivised performance measures for RCP3. |
| To not adopt RCP2 measure GP3 | | Most feedback supported this proposal, but one submitter does not. |
| Reliability | GP1: Number of unplanned interruptions each year across all POS in a sub-category | In developing these proposed measures, Transpower has considered stakeholder feedback and proposed refinements for further consultation.<br>Stakeholders support Transpower's proposed change in POS categorisation methodology, but requested additional consultation.<br>Not all stakeholders expressed views on N site classification. The views of stakeholders who did provide feedback were mixed.<br>Transpower has explained how it has addressed this feedback in its Service and Asset Health Engagement Paper 3.<br>Three of four submitters support greater stratification of generation sites. Transpower has explained how it has addressed this feedback. |
| | GP2: Average duration of unplanned interruptions greater than 1 minute across all POS in a sub-category (min/year) | |
| Availability | AP1: % energy availability of HVDC | Stakeholder feedback supports Transpower's proposal to retain this measure. |
| | AP2: % availability of selected HVAC assets | Stakeholder feedback supports Transpower's proposal to review HVAC circuits. Transpower is further consulting on their proposed list of assets for RCP3.<br>Most feedback supports Transpower's proposal to consider alternative ways of setting availability targets. Transpower is further consulting on their proposed alternatives. |

| Proposal | | Consistency with feedback |
|---|---|---|
| | AP3: Return to Service Time. Extent that Transpower keeps to unplanned outage times | Stakeholder feedback supports replacing PMD4 and PMD8 with this proposed new measure. |

## 4.4 Verification review of proposed RCP3 grid output measures

Reflecting the evolution of Transpower's grid output performance reporting under its individual price path regulation, it is proposing several changes for RCP3 based on RCP2 outcomes and trials, and associated stakeholder consultation for RCP3.

It is important to note that our review has been undertaken prior to the finalisation of the grid output measures and targets, which will be subject to further stakeholder consultation in August 2018. Specifically, our review relates to information provided prior to Transpower's June 2018 stakeholder engagement, with some information we have been provided now outdated.

It appears that the grid output targets are continuing to evolve through the engagement processes of June and August 2018 and will be finalised for the RCP3 proposal to be submitted in December 2018. Less change appears likely in regards to the proposed grid output measures.

### 4.4.1 RCP3 grid output measures

Transpower is proposing a smaller set of revenue-linked grid output measures for RCP3, including some refinements to existing grid reliability and grid availability measures.

*Transpower's proposed changes to its GP1, GP2, AP1 and AP2 grid output measures*

Transpower has advised that it is proposing to change the way it categorises POS for its GP1 and GP2 measures RCP3. In RCP2, it used qualitative factors (eg if POS served key load or a major city) to sub-categorise load N-1 into three sub-categories based on priority.

For RCP3, it is proposing to use the following sub-categories:

- High economic consequence
- Material economic consequence
- Generator.

Economic consequence will be measured using the amount of load being served at a POS multiplied by the value of loss load (VoLL) at that POS. This calculation reflects the expected economic cost of an unplanned interruption at that POS. Transpower notes that it is using economic consequence in its asset criticality framework for prioritising expenditure at load POS. Also, by applying this concept in the GP1 and GP2 measures, it will better align Transpower's forward work plan and understanding of the relationship between its costs and service performance.

Transpower has also advised us that the economic consequence concept is more difficult to apply for Generator POS, so it has simply separated these POS into sites with N-1 and N security.

Table 20 presents the changes in service categories between RCP2 and those proposed for RCP3, and which will be used for the GP1, GP2, AP1 and AP2 grid output measures.

**Table 20 Transpower's proposed changes in its service categories compared to RCP2**

| RCP2 | | | RCP3 proposed | | |
|---|---|---|---|---|---|
| Category | Sub-category | POS | Category | Sub-category | POS |
| **N-1 security** | High priority | 21 | **N-1 security** | High economic consequence | 47 |
| | Important | 39 | | Material economic consequence | 97 |
| | Standard | 79 | | Generator | 44 |
| | | **139** | | | **188** |
| **N security** | N security | 44 | **N security** | High economic consequence | 14 |
| | | **44** | | Material economic consequence | 23 |
| **Generator** | | 39 | | Generator | **9** |
| | | **39** | | | **46** |
| **Total** | | **222** | **Total** | | **234** |

*New grid output measures*

Transpower also proposes the following new grid output measures:

- Return to service – adherence to the outage plan/extent that Transpower keeps to planned outage times, which will be revenue-linked.[51]
- Customer service/event communications measure following on from its stakeholder engagement regarding the PMDs, which will not be revenue-linked.

As previously noted, Transpower will also propose new asset health measures, which will more accurately reflect how it utilises asset health information in the business. Transpower is piloting an asset health report in the remainder of RCP2, which will form the basis of the proposed RCP3 asset health measures.

For RCP3 Transpower is intended to submit new asset health output measures based on its asset health framework used in its asset planning processes. The changes in its proposed asset heath measures for RCP3 compared to the RCP2 measures are presented in the Table 21 below.

**Table 21 Changes in Transpower's asset health grid output measures**

| Design | RCP2 measures | Proposed RCP3 AHI measures |
|---|---|---|
| Asset classes covered | • Transmission towers<br>• Grillages<br>• Insulators<br>• Outdoor circuit breakers<br>• Power transformers<br>• Outdoor to indoor conversions | • Tower foundations<br>• Tower protective coating (paint)<br>• Insulators<br>• Outdoor circuit breakers<br>• Power transformers |
| Description of measure | • Total number of asset replacements or refurbishments during the RCP<br>• There is a mix of annual and 5-year targets | The proportion of assets with an asset health score of poor to very poor health (Asset Health Index of 8 or above) at the end of RCP3 |
| Revenue amount | • Around $14 million | Currently being developed and trailed |

Transpower has explained to us that the proposed new measures build on the way it manages assets in the business, which involves creating an asset heath index for each

[51] This was the position proposed in Transpower's June 2018 report. Following feedback, we understand it is now proposing this be a non-revenue linked measure and have it defined as the extent that Transpower keeps to planned outage times. Transpower argue the measure aims to improve certainty around the return of assets back into service after a planned outage.

asset class using asset health modelling and condition data to reflect the current state of the grid asset fleet.

As indicated in Table 21 there will be five asset classes covering $390 million of planned investment (around 42% of its proposed grid renewal programme of work), which have been selected on the following grounds:

- span a diverse range of asset types (lines, tower, substation);
- includes large and small asset classes by expenditure and population (volumetric and non-volumetric asset classes are included);
- have asset health models that are suitable for supporting output measures;
- have a manageable potential for volatility between planned and actual outcomes (eg conductors are excluded); and
- are being tested during RCP2 through the asset health reporting pilot.

Transpower has advised the basis for RCP3 targets for the asset health measures will be:

- current asset health scores for selected asset classes;
- future health scores based on deterioration models;
- the impact of Transpower's intended investment plans, which are not always solely driven by asset health and can be driven by efficiencies, constraints and other objectives.

The asset health measures will be revenue-linked.

### *Summary of proposed RCP3 grid output measures*

Table 22 presents Transpower's proposed service performance-related grid output measures for RCP3. The proposed new asset health output measures are discussed in detail in a section below.

**Table 22 Transpower's proposed RCP3 grid output measures**

| Category | Performance measure | RCP3 code | Proposed refinement |
|---|---|---|---|
| Reliability | Number of unplanned interruptions each year by customer category | GP1 | Categorisation to be aligned with economic consequence (VoLL* energy consumption) |

| Category | Performance measure | RCP3 code | Proposed refinement |
|---|---|---|---|
| | Average duration of unplanned interruptions by customer category (min/yr) | GP2 | Categorisation to be aligned with economic consequence (VoLL* energy consumption) |
| Availability | % availability of HVDC | AP1 | None proposed (however, a refinement to the target is proposed for RCP3 and is discussed further in section 4.4.2). |
| | % availability of selected HVAC circuits | AP2 | Circuits included to be reviewed |
| | Return to service<br>Extent that Transpower keeps to planned outage times | AP3? | Measure and target to be developed |
| **Customer Service/Event Communications**<br>Existing post event survey. Focuses on timely information provision and communications | | CS1 | Incorporates PMDs1, 2 and 3, including qualitative information on the quality of the communications |
| Other reporting: finalisation of post event reports, online updates for energy not supplied for each POS, voltage disturbance working group | | | |

### 4.4.2 RCP3 grid output targets

We understand that Transpower is part-way through developing RCP3 targets for the above grid output measures. This will include two rounds of stakeholder engagement, in June and August 2018.

Transpower has advised its proposed RCP3 baseline targets involved consideration of:

- historical data and performance;
- for the AP2 and AP3 measures, which assets cause the most impact on the market from an outage;
- for GP1 and GP2 measures, how to group Points of Service (POS);
- the results of its recently completed Value of Loss Load (VoLL) study;
- planned work programme for RCP3; and
- likely impact of future trends, including extreme weather events, suspension of live-line work, ageing transmission and secondary asset base and transformation business improvements.

Transpower has provided us with its preliminary baseline targets (for the June 2018 stakeholder engagement) and the proposed targets (for the August 2018 engagement). It has indicated that the proposed targets will then be finalised for the RCP3 Submission in December 2018.

### *Transpower's proposed GP1 and GP2 targets for RCP3*

Transpower has advised us that its intention is to incorporate realistic rather than aspirational targets for RCP3, particularly given emerging technologies and their potential impact on the economic consequences of unplanned interruptions.

Hence, the preliminary baseline GP1 and GP2 targets are a consolidation of long-term average interruptions due to weather, human-error, animals, birds, and miscellaneous causes and short-term (3 year) average interruptions due to equipment failure.

Table 23 presents Transpower's preliminary GP1 targets for RCP3.

**Table 23 Transpower's GP1 RCP3 targets compared to RCP2**

| RCP2 | | | | RCP3 proposed | | | |
|---|---|---|---|---|---|---|---|
| Category | Sub-category | POS | Target per year per POS | Category | Sub-category | POS | Target per year per POS |
| N-1 security | High priority | 21 | 0.10 | **N-1 security** | High economic consequence | 47 | 0.16 |
| | Important | 39 | 0.23 | | Material economic consequence | 97 | 0.25 |
| | Standard | 79 | 0.33 | | Generator | 44 | 0.21 |
| | | 139 | **0.27** | | | **188** | **0.22** |
| N security | N security | 44 | 1.27 | **N security** | High economic consequence | 14 | 0.39 |
| | | 44 | **1.27** | | Material economic consequence | 23 | 1.30 |
| Generator | | 39 | 0.28 | | Generator | **9** | 1.28 |
| | | 39 | **0.28** | | | **46** | **1.02** |
| Total | | 222 | **0.47** | **Total** | | **234** | **0.43** |

Transpower has indicated that its preliminary GP2 targets for RCP3 are based on long term reported averages.

Table 24 presents Transpower's proposed GP2 targets for RCP3 compared to the RCP2 targets.

**Table 24 Transpower's GP2 RCP3 targets compared to RCP2**

| RCP2 | | | | RCP3 proposed | | | |
|---|---|---|---|---|---|---|---|
| Category | Sub-category | POS | Target minutes per year | Category | Sub-category | POS | Target minutes per year |
| N-1 security | High priority | 21 | 70 | **N-1 security** | High economic consequence | 47 | 93 |
| | Important | 39 | 100 | | Material economic consequence | 97 | 62 |
| | Standard | 79 | 65 | | Generator | 44 | 174 |
| | | 139 | **76** | | | **188** | **96** |
| N security | N security | 44 | 80 | **N security** | High economic consequence | 14 | 103 |
| | | 44 | **80** | | Material economic consequence | 23 | 138 |
| Generator | | 39 | 130 | | Generator | **9** | 93 |
| | | 39 | **130** | | | **46** | **118** |
| Total | | 222 | **86** | **Total** | | **234** | **109** |

Transpower has stated that re-classification of Huiranga may result in a slightly lower target for the N-1 High Economic Consequence sub-category and a very slightly higher target for the N-1 Material Economic Consequence sub-category. However, this is yet to be determined.[52]

### *Transpower's proposed AP1 and AP2 targets for RCP3*

Transpower is proposing to retain the RCP2 target for grid output measures AP1, relating to availability of the HVDC link and lower the target for grid output measure AP2, which measures availability of HVAC assets.

The proposed base line target of 98.5% for AP1 continues to allow for a 1% loss for scheduled outages and 0.5% for forced outages. Given there is planned to be a major Pole 2 life-extension during RCP3, Transpower intends to propose two alternative ways of removing the effect of the unavailability of the HVDC link when the planned work is undertaken. Either to retain the 98.5% target but remove the effect of the planned Pole 2 work in the relevant three years of RCP3 or set a lower target (of 97.8%) for the three affected years.

[52] Transpower (2018), Securing Our Energy Future 2020-2025, Regulatory Control Period 3,  p 36

In terms of the AP2 grid output measure, based on its stakeholder engagement, Transpower reviewed its selected HVAC circuits used to measure grid availability and removed those circuits that would not cause a market constraint. It also retained and/or added assets that could have the most impact on the wholesale electricity market.

This review process results in 67 selected assets being used in the revised AP2 measure, which now includes transformer and bus section assets (as well as circuits). Transpower advises that these assets comprise around 20% of the circuit kilometres in its HVAC network and 22% of interconnecting transformers. As part of its August 2018 customer consultation, Transpower indicated that it was investigating the possibility of four additional circuits which, if included in the measure, would likely result in a very slightly lower proposed availability target. However, this is yet to be determined.[53]

Transpower has advised that its AP2 baseline target of 98.9% is based on combined unavailability of all 67 assets in a year. This is a lower target than the 99.6% in RCP2 (for 27 circuits) and is based on a detailed review of historical data and consideration of planned maintenance and project work during RCP2 so far. Transpower has also advised that the proposed RCP3 target has considered historical performance, the current planned work programme for RCP3 and the likely impact of future trends (e.g. considering uncertainties around extreme weather events, changes to live-line work, its replacement programme and its impact on future asset health).

We note that Transpower has reported relatively poor performance compared to the targets and collars set for the AP2 measure so far in RCP2. Transpower has argued that the RCP2 AP2 target was 'aspirational'.

Table 25 summarises Transpower's proposed AP1 and AP2 targets for RCP3 (assuming the effect of Pole 2 life extension is removed from the grid availability data).

**Table 25 Transpower's GP2 RCP3 targets compared to RCP2**

| Output measure | RCP2 target | Proposed RCP3 target | Explanation |
|---|---|---|---|
| AP1 | 98.5% | 98.5% for all RCP3; or 98.5% for two years & 97.8% for three years of RCP3 when HVDC work is undertaken | The RCP3 target is based on the RCP2 target except that it will be adjusted to reflect the outage effects of the proposed HVDC work, either through removal of these effects if the RCP2 target is retained, or through applying a lower target in the three affected years of RCP3. |
| AP2 | 99.6% | 98.9% | Updated to 67 selected assets compared to 27 circuits in RCP2. |

[53] Transpower (2018), Securing Our Energy Future 2020-2025, Regulatory Control Period, p 37

| Output measure | RCP2 target | Proposed RCP3 target | Explanation |
|---|---|---|---|
| | | | Proposed a slightly lower availability target based on a bottom-up approach. |

*New return to service measure – AP3*

Based on its stakeholder engagement, Transpower is proposing a new grid output measure for RCP3. This new measure, AP3, is currently defined as '*less than 5% of removed-from-service outages to be returned to service 8 trading periods (4 hours) after the scheduled return time*'.

Transpower has advised that the new measure only relates to late return to service time. The measure is intended to create the incentive for Transpower to return assets to service in a timely manner following an outage and to provide greater certainty to customers in terms of supply restoration timing.

The target for the measure is intended to ensure that 95% of the time, assets that are removed from service for an outage are returned to service within four hours of the scheduled time. It applies to the same 67 assets proposed to be used in the AP2 grid output measure.

Transpower argues that the four-hour buffer built into the measure is intended to discourage perverse behaviour in returning assets back to service, including to ensure safety for the public and its staff is not compromised.

*New asset health measure targets*

Table 26 shows the current asset health measures that Transpower proposes to report performance for during RCP3. The asset health targets will represent the proportion of assets in each asset class that have been assessed as having an asset health score of poor to very poor health at the end of RCP3. This corresponds to a health score greater than AHI 8.

**Table 26 Current RCP3 asset health measures and targets**

| Asset class | Effectiveness ratio[54] AHI > 8 | Pop'n (000s) | Asset not scored (%) | Percentage of assets with AHI > 8 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Actual Jun 2017 (%) | 2020/21 (%) | 2021/22 (%) | 2022/23 (%) | 2023/24 (%) | 2024/25 (%) | 2024/25 No RCP3 investment (%) |
| Power transformers | N/A | 439 | 1.14 | 4.10 | 2.96 | 3.19 | 4.33 | 8.20 | 10.02 | 13.44 |
| OD Circuit Breakers | N/A | 1,505 | 0.13 | 0.80 | 1.06 | 1.06 | 2.19 | 3.06 | 2.99 | 4.85 |
| Insulators | 70% | 53,320 | 4.73 | 1.91 | 0.85 | 1.42 | 2.64 | 3.57 | 4.41 | 13.58 |
| Tower Grillage Foundations | 60% | 10,529 | 0.00 | 7.40 | 4.61 | 4.45 | 3.35 | 1.49 | 2.08 | 10.41 |
| Tower Protective Coating | 60% | 23,703 | 1.35 | 1.80 | 4.32 | 4.22 | 4.27 | 3.83 | 3.49 | 11.45 |

Transpower has chosen the above asset classes as a good representative group of high capex needs and where the asset health models for the assets are sufficiently advanced to robustly support the measure and set the targets.

In setting the targets for each measure, Transpower will identify the target based on an acceptable level of risk associated with the percentage (or volume) of assets with Asset Health Index (AHI) scores greater than 8.

For volumetric asset classes (insulates, tower grillage foundations and tower protective coating), Transpower is proposing an effectiveness ratio defined as the portion of replacement and refurbishment interventions that target poor health (AHI scores greater than 8). It argues these ratios are required to ensure the asset health targets are achievable having regard to current asset planning and delivery approaches. Transpower's use of the AHIs in its capex planning is discussed in section 5.4 of our report.

Transpower is proposing its asset health measures drawing on the experience of developments in Ofgem's RIIO (Revenue + Incentives + Innovation + Outputs) non-mechanistic approach. The assessment of whether targets are met considers whether deviations from the asset health scores are justified or unjustified. Transpower provided information on the proposed measures in document RFR046 Asset Health Pilot Report July 2017. This report outlined the features of the proposed measures compared with

[54] Effectiveness Ratio is a measure of the assets with an AHI > 8 that were replaced for asset health reasons, with the remainder replaced for other reasons

the past volumetric measures and a likely approach to assessing performance against the targets.

AHIs are based on a model of the actual condition of assets projected into the future based on specific factors which affect an assets life, for example, corrosion codes (predicted deterioration rates). The model can and is expected to be updated with actual field-recorded condition data and additional deterioration factors to improve the model predictions.

The updated data and modelled deterioration rates may result in a variation to the AHI score for the assets in a portfolio. In this case, no capital expenditure has occurred, but the index may improve and worsen based on the actual field condition of assets. Provide the change is validated this is an appropriate outcome. Transpower calls this a "change to model inputs".

A change to asset health can also occur through significant network enhancement, developments or divestment projects. Introducing new assets or removing old assets can affect the proportion of assets with AHI >8. A "change in network" could therefore change the percentage score whereas no actual change in the volume of aged assets has occurred. Such changes need to be tracked to enable a justified reason for diverging from a forecast AHI score.

Transpower has indicated in the Asset Health Pilot Report that changes in its work programme that provides benefits to consumers should not result in a penalty. Examples quoted are:

- where the work is found unnecessary;
- better solutions are found to achieve the same risk exposure; and
- where it is optimal, in terms of risk and long-term costs, to defer or cancel replacement.

We consider these above types of work program changes should not incur a penalty; however, any change of work program that increases the risk exposure should incur a penalty. The obvious example is where the required work is not performed because resources were diverted onto other projects.

The following points should be noted;

- If the modelling was a perfect representation of actual asset deterioration, the index would be equivalent to the old volume-based measure. Given this is not the case, any activity which improves the knowledge of the asset conditions should be incentivised. The outcome can be a positive or negative adjustment to the score.

- We consider that the target and measure should be the volume of assets with an AHI>8 rather than the percentage of assets. This means any change to the volume of new assets would not impact the score. Volume is also more closely related to the risk exposure.
- Any adjustments due to changes in model inputs, change to network or change in work program should be validated and able to be audited.

Transpower has also considered the incentive value to be assigned to each asset portfolio. One method is a proportional allocation to each asset portfolio based on asset value or programme expenditure. Another approach, which we favour, is to base the allocation on agreed relative criticality. Relative criticality and a volume measure (with and without investment AHI>8) would be easier to understand. This volume measure is different to the RCP2 measures as the score is the volume of assets with AHI>8, not the volume replaced, and the target can be adjusted due to a change in asset health and assessed risk discovered during the period. We also support a deadband for each measure, as proposed by Transpower, to save on unnecessary administration costs associated with small differences between the target and actual outcomes.

## 4.5 Transpower's August 2018 customer consultation

In August 2018, Transpower undertook its final customer consultation regarding the RCP3 proposal. Transpower's proposed RCP3 grid output measures and associated targets were an important component of this consultation.

The service performance and asset health grid output measures, with associated targets that were presented to customers were the same as those set out in the preceding section of this chapter.

Transpower has sought feedback on whether the proposed service performance and asset health targets are appropriate for RCP3.

## 4.6 Verification opinion

Transpower is proposing to make several reasonably significant refinements to its grid output measures for RCP3, including due to outcomes arising from its extensive stakeholder engagement on the measures.

In response to Transpower's August 2018 consultation paper, stakeholders have raised some issues regarding the details of the grid output measures and/or targets, including asset health measures. However, we consider these to be in the nature of proposed refinements rather than reflecting any fundamental concerns with what Transpower is proposing. We expect Transpwer to consider these issues prior to submittal of its RCP3 proposal to the Commerce Commission.

#### 4.6.1 Grid output measures for RCP3

Our preliminary verification opinion is that Transpower's proposed grid output measures for RCP3 satisfy the expenditure outcome having regard to GEIP. This is because the proposed measures address the areas of service performance that are likely to be of most concern to energy consumers including, most importantly, those consumers directly connected to the Grid. Further, the introduction of the concept of economic consequence linked to VoLL estimates for the GP1 and GP2 grid output measures enhances the robustness of the measures because it incorporates the value that customers place on supply reliability into the service performance incentive mechanism.

In terms of Transpower's four-hour buffer built into the proposed new return to service measure (AP3), we have some concerns that it is too large, primarily because Transpower sets the scheduled return to service time and in so doing should be able to reasonably factor in the safety considerations it suggests are the primary reason for the four-hour buffer. In practice, the four-hour buffer may not provide an especially strong incentive on Transpower. Given this measure is proposed not to be revenue-linked in RCP3, it would be appear reasonable for a shorter buffer to be applied.

We also consider the proposed RCP3 grid output measures reflect the effectiveness of Transpower's stakeholder consultation on service performance issues.

We consider the development of the proposed new asset health measures and incorporating them in the RCP3 service performance incentive regime, in principle, represents good electricity industry practice. The proposed new asset health measures will increase Transpower's accountability in terms of the integrity of major asset classes arising from its ongoing investment in and operation of the Grid.

However, reporting on these measures will be significantly more challenging than reporting on typical grid reliability and availability measures, including due to the need for judgement to be applied in the administration of the incentive arrangements. In this context and given the work still required to design the operational details of the incentive arrangements, including the views we have expressed in this report, we are not able to determine at this point that the new asset health measures satisfy GEIP.

### 4.6.2 Grid output targets for RCP3

We consider that Transpower's intent to base the RCP3 targets primarily on historical service performance data is appropriate, in preference to the setting of aspirational targets. Our view is that the primary objective in setting service performance targets should be to satisfy all relevant legislative and regulatory requirements. Any divergences from these requirements should only be considered upon request of individual directly connected customers.

Transpower has advised that its proposed RCP3 grid output targets are largely consistent with comparable targets for RCP2, although some POS for the GP1, GP2 and AP2 measures have moved categories and some customers have higher or lower targets for reliability or restoration performance. The detail of the proposed changes were detailed in the Appendices of the June 2018 engagement paper and discussed in the body of that paper.

Following the June 2018 engagement, Transpower has advised that one POS in Taranaki (associated with Methanex's load) has moved from the "Material Economic Consequence" to "High Economic Consequence" category.

Given this evolving situation, we have not been able to fully satisfy ourselves that Transpower's proposed targets for its RCP3 grid output measures satisfy GEIP, primarily because the targets may still be subject to change, albeit not materially. We also have not verified details regarding adjustments made to historical average data in setting the RCP3 targets.

# 5 Asset management decision-making framework for capex and opex

In assessing GEIP, the Commerce Commission has the following view on the asset management framework that should be in place to support the development of expenditure forecasts:

> "5.15 GEIP requires that asset management strategies and forecast expenditure for asset fleets are determined within an integrated planning framework. This framework should systematically analyse the condition of ageing assets and optimise investment while maintaining service performance within targets. Such an approach includes development of robust asset health models for asset fleets and considers asset criticality within a wider risk management framework.[55]
>
> 5.16 Where Transpower has based its fleet expenditure forecasts on mature health assessment models, supported by high quality condition assessment and criticality data and tested by rigorous sensitivity analysis, we would expect to be able to develop confidence that the forecast expenditures would meet the evaluation criteria"[56]

## 5.1 Asset management framework

Figure 28 illustrates the Transpower grid asset management system framework, highlighting the hierarchy from the overall corporate strategies, such as Transmission Tomorrow (refer section 2.5.1), to the Grid Business Strategic and Strategic Asset Management Plans, through to Asset Class Strategies and Portfolio Management Plans. It also demonstrates the inherent feedback loops to support continuous improvement and improved asset condition knowledge.

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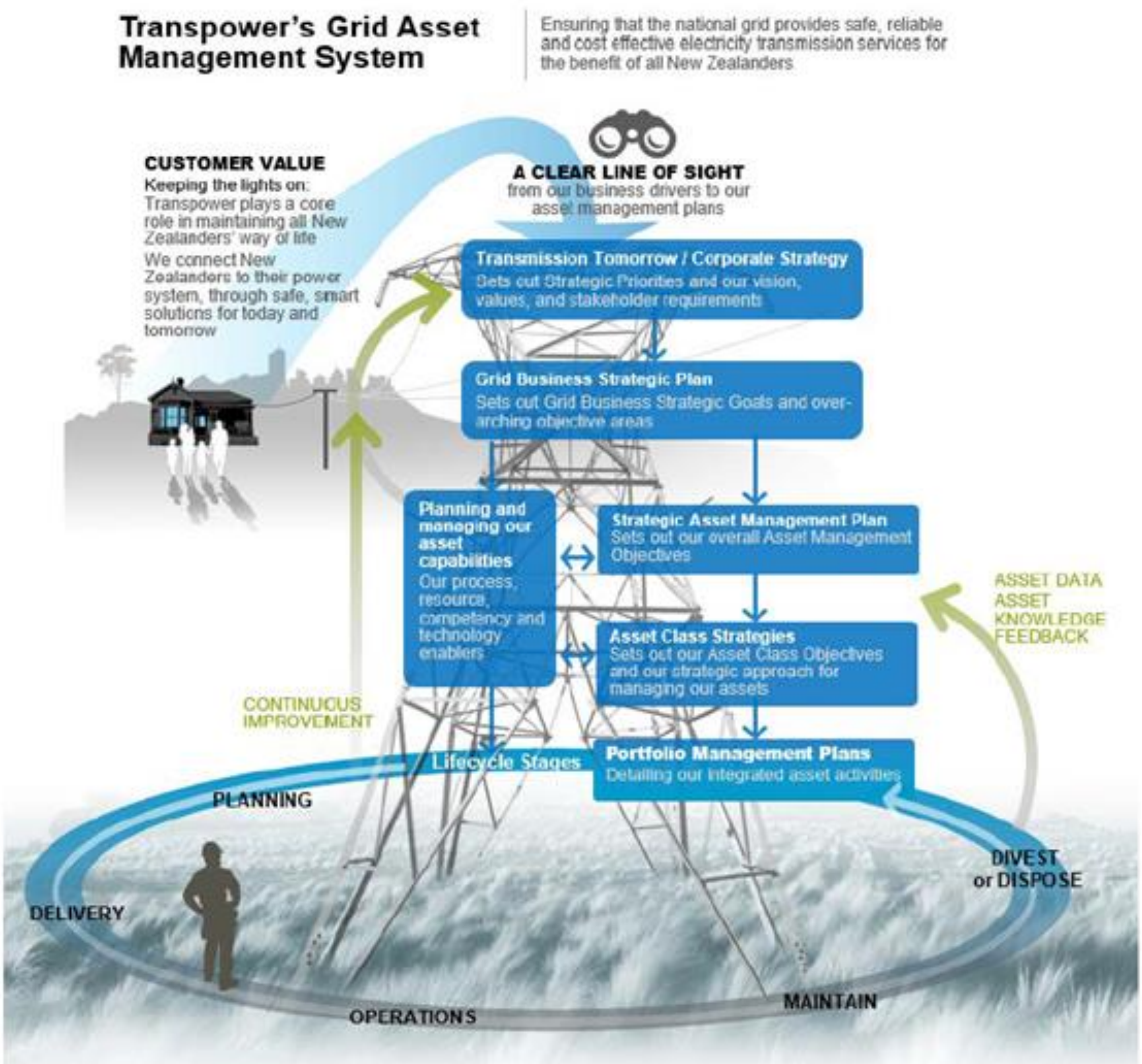
[55] One commercialised example of such a framework is the Condition Based Risk Management software platform, developed by EA Technology, known as CBRM 2.0

[56] Commerce Commission, *Invitation to have your say on Transpower's individual price-quality path and proposal for the next regulatory control period*, February 2014, clauses 5.15 and 5.16, p. 29

**Figure 28 Transpower grid asset management framework[57]**




Transpower is required to prepare and publish an Asset Management Plan that brings together all aspects of Transpower's asset planning and strategies. In the Asset Management Plan 2017, Transpower states that:

> "… in July 2014, we became one of the first companies in the New Zealand electricity industry to achieve certification against the international asset management specification PAS 55. In 2015, PAS 55 was withdrawn as a formal BSI specification and replaced with the ISO 55000 international standard for Asset Management. We are currently building into our business the fundamental components of ISO 55000.

[57] Transpower, *Asset Management Plan 2017,* Document [8], section 4, Figure 6, p. 9

> Our approach to asset management reflects the standard of care and focus required by these international standards."[58]

Transpower has made changes to its Asset Management Framework during RCP2 to align with the current international ISO55000 standard. The framework deploys grid service levels targets, through a line of sight to specific asset class performance objectives. This is primarily done within the Strategic Asset Management Plan and in turn each Asset Class Strategy, which provide the strategic approach to managing each similar set of assets. The Asset Class Strategy outlines all the specific documents and processes involved in the planning and decisions for the relevant class of assets, including the Asset Health Model applied to the class of assets.

The integrated asset activities, including planning and estimating with capital and operating expenditure forecasts, are documented in Portfolio Management Plans, which often cover more than one asset class.

GHD has assessed that Transpower's Asset Management Framework and its implementation are at a very high level of competence compared to peers across Australia and internationally. A key measure of this is leadership from the Board and Executive Management, role clarity throughout the organisation and consistent employee understanding of the Asset Management Framework and systems.

## 5.2 Commerce Commission's recommended initiatives in RCP2

In its RCP2 Final Decision, the Commerce Commission recommended several asset health-related performance management development (PMD) initiatives that Transpower should pursue in RCP2. In making these recommendations, it was the Commission's intention to improve the link between Transpower's expenditure and service performance. The PMD initiatives are summarised in Table 27.

[58] Transpower, *Asset Management Plan 2017*, Document [8], section 4, p. 8

**Table 27 Commerce Commission's asset health recommendations**

| PMD initiative | Recommendation |
|---|---|
| Continuing Transpower's development of its asset health modelling | • Transpower should develop a programme for asset health modelling for each asset portfolio. The development programme for each asset portfolio should include milestones with clear deliverables. Where Transpower is not going to develop models for any asset fleets, it should be clearly explained.<br>• The target for completion is before the submission of Transpower's quality and expenditure proposal for RCP3. That is, all the models should be completed, populated, and used by Transpower in developing its proposal for RCP3. |
| Improving Transpower's asset criticality framework | • Transpower develop a programme for improving its asset criticality framework, including having asset criticality assigned to all circuits or network branches (the programme should include milestones with clear deliverables).<br>• Transpower should have asset criticality assigned to all circuits or branches (to be fed into its asset management models) before Transpower submits its quality and expenditure proposal for RCP3. That is, the revised asset criticality framework should be used by Transpower in developing its quality and expenditure proposal for RCP3. |
| Developing a better understanding of the economic impact from interruptions (to inform asset criticality framework) | • Transpower report on the viability and benefits of developing measures that better account for the economic impact of interruptions.<br>• Subject to the outcome of the report on viability and benefits, Transpower provide a development programme for economic impact measures, including milestones with clear deliverables.<br>• Including the economic impact of interruptions at a connection point level would help create a more granular view of level of service performance requirements. |

We have assessed Transpower's progress against these PMD initiatives during RCP2 and the implications for development of its RCP3 expenditure forecasts.

## 5.3 Asset Management documentation

### 5.3.1 Grid Business Strategic Plan 2017-2027

This Plan is informed by the broad corporate direction defined in Transmission Tomorrow and Transpower's Corporate Strategy, which provides directional guidance for the Grid business by defining a set of 'givens' and 'choices'.

The Plan defines the Grid business strategic goals across five main areas:

- health and safety;
- service performance;
- cost performance;
- customers and stakeholders; and
- asset management capability.

### 5.3.2 Grid Asset Management System Framework

The Grid Asset Management System (AMS) describes:

- requirements for an asset management system;
- key stakeholders of the AMS;
- asset management strategies, plans, approaches and methodologies, including the AMS;
- scope of asset management at Transpower; and
- AMS authorities and responsibilities.

### 5.3.3 Asset Management Plan

The Asset Management Plan (AMP) describes how the grid assets are managed, outlining the approach to asset management, asset classes and details the forecast replacement and refurbishment capital and operational expenditure for the period to 30 June 2035. It is a single document required to be published annually and brings together the plans developed across each Asset Class Strategy and Portfolio Management Plans.

The AMP is one of three supporting documents to the Integrated Transmission Plan; the others being the Transmission Planning Report and the Services Report. The 2017 version of the AMP was available to us for our independent verification review.

The 2017 version had been:[59]

> "… updated to reflect the substantial amount of work that has gone into refreshing and renewing our strategy, planning, and delivery functions. It incorporates our updated approach to grid asset management, reflects our continuous improvements in Information and Communications Technology (ICT) strategy, and changes in managing our business support assets. It was approved by the Board for publication in August 2017."

The AMP is structured in four parts - the first is an overview of the Transpower approach to asset management of the Grid, ICT and Business Support asset portfolios, including the management of risk; the other three parts detail the portfolio plans for each of the categories.

59 Transpower, *Asset Management Plan 2017*, Document [8], section 1, p. 1

## 5.4 Asset Health Modelling

Transpower has moved from a 'remaining life' measure of an asset's health to an AHI approach common across the network assets, except for substation buildings and grounds.[60] This is like approaches adopted by some utilities in Australia and the UK.

### 5.4.1 Australian regulatory experience

The AER's current practice in Australia for assessing network renewal capex uses a model based on network asset age profiles provided by the electricity utilities, standard asset lives for asset classes and consideration of historic replacement volumes. The AER model 'calibrates' the nominal asset life for each asset class based on the replacement volumes for the previous regulatory period and calculates the renewal/replacement capex forecast for the next 5 years.

This AER modelling approach standardises the approach in assessing renewal/replacement capex forecasts and looks to consider that electricity network assets can remain in-service beyond their nominal asset life with appropriate maintenance and operation during service life. The model assumes that the age profile for asset populations is accurate and complete - which is often not the case, as utilities in many instances have applied conservative business rules due to incomplete legacy data. The net effect of these assumptions is that the renewal/replacement capex forecast generated by the model, can be significantly distorted.

In recent AER decisions, the robustness and reasonableness of its renewal/replacement capex modelling has been heavily debated, largely in part due to the assumptions used in age profiles, past replacement volumes and implied asset lives.

We concur with the key findings of one review of the AER's modelling approach made by an electricity distribution network that highlighted several inherent faults.[61] In conclusion, the review recommended "*… the AER should consider extending its review into assessing the engineering considerations of the business rather than restricting the assessment to a desktop analysis of selected health indicators as a proxy for network and asset performance.*"[62]

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60 Renewal capex forecasts for substation buildings and grounds uses a standard SPM Assets method of condition scoring (ranked C1-5) based on field inspections

61 Jacobs, *Review of AER REPEX forecasting modelling*, Energex revised regulatory proposal for 2015-20, 15 June 2015 (as published on AER website), Document [131], Executive Summary, pp. 3-4

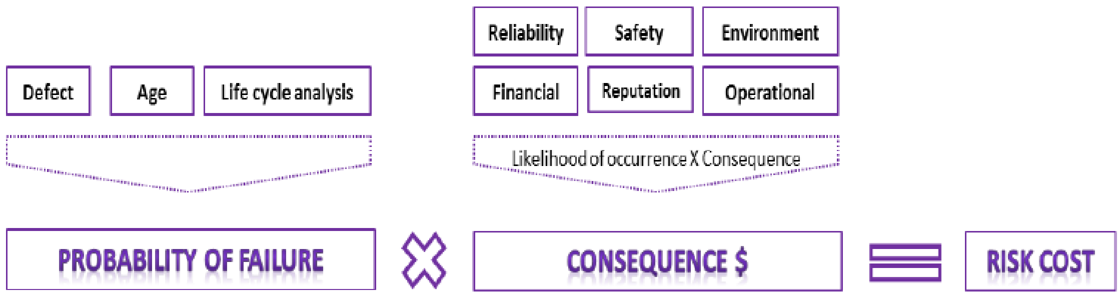
62 Ibid.

Of specific relevance in a Transpower context for RCP3, is TransGrid's regulatory proposal for 2018-23, which highlighted a change in the forecasting of network replacement, through an improved evaluation of asset condition, and the development of asset health indices for major asset classes to "*… enable consistent and accurate assessment of condition.*"[63] TransGrid's new investment risk tool uses asset condition, probabilities of failure for different failure modes and consequences and likelihood of failure.

Asset condition assessments include factors such as historical defect rate, age, lifecycle analysis, planned maintenance, test reports, and condition assessment from physical inspection. The standard corporate risk matrix is used for assessing consequences in reliability, safety, environment, financial, reputation and operational areas. Reliability calculations consider estimates of the Value of Customer Reliability set by the Australian Energy Market Operator (AEMO).[64]

Figure 29 presents a schematic of TransGrid's investment risk tool.

**Figure 29 TransGrid investment risk tool[65]**




TransGrid noted that all capital investments are compared against a 'do-nothing' and enhanced maintenance options. This approach determines the risk-based cost for each asset class. In adopting this approach, TransGrid has developed a Network Asset Health Framework for all its primary network assets and protection relays.

In assessing this new approach, the AER noted in its Final Decision for capital expenditure that:

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63 TransGrid, *Approach to Forecasting Expenditure 2018/19 to 2022/23*, section 5.2.2, p. 8

64 In dollar terms, the VCR represents a customer's willingness to pay for the reliable supply of electricity. The values produced are used as a proxy and can be applied for use in revenue regulation, planning, and operational purposes.

65 Ibid., Figure 4, p. 8

> "TransGrid recently enhanced its asset and risk management processes in order to better understand the condition and performance of its assets and to more effectively target expenditure to address asset risks.
>
> **We consider that the methodology adopted by TransGrid in regard to its asset risk management framework is consistent with good industry practice.** [emphasis added] However, the evidence indicates that in the application of its methodology TransGrid overstates asset risk costs, therefore prudent and efficient costs are overstated. In particular, we consider that:
>
> - There is insufficient evidence of capex portfolio optimisation.
> - TransGrid's application of its risk assessment methodology overstates project risk costs and therefore the expected benefits of proposed capex.
> - There is insufficient consideration of the optimal timing of capex.
>
> TransGrid has developed its forecast predominately through a bottom-up aggregation of individual projects and programs. We have previously expressed our view that bottom-up forecasts have a tendency to overstate efficient capex as they do not adequately account for overlap and synergies between projects. This is particularly relevant here as TransGrid does not appear to have developed an overall network risk profile that would provide an overall assessment of the value of network risk reductions which could be compared with its proposed investment cost."[66]

and

> "In its application of its risk cost methodology TransGrid's uses a 'worst case' consequence of asset failure to value risk. The evidence suggests that TransGrid has not sufficiently moderated this 'worst case' consequence to reflect the likelihood of the consequence occurring."[67]

We believe the AER decision reinforces the need for the asset health framework to be supported by robust datasets for asset population and condition assessment and a refined assessment of risk.

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66 Australian Energy Regulator, *Final Decision - TransGrid transmission determination 2018 to 2023: Attachment 6 - Capital expenditure*, May 2018, Document [125], p. 6-4

67 Ibid.

### 5.4.2 Ofgem framework

On 2 May 2017, Ofgem published a decision mandating the Common Network Asset Indices Methodology (CNAIM) approach for asset health, asset criticality and monetised risk for distribution network operators (DNOs) in the GB electricity distribution network sector.[68]

The CNAIM methodology details the inputs, calculations and calibration parameters to be used in the calculation of asset health and criticality. Based on extracts from the CNAIM Methodology document[69], the network asset indices have the following three components:

- Health Index
- Criticality Index
- Risk Index.

*Health index*

Asset Health and probability of failure (PoF) are determined using five bands with assets allocated a health index band based on the health score determined for the asset and which relates directly to its PoF. Asset Health is a measure of the condition of an asset and the proximity to the end of its useful life. The methodology includes a common approach for the calculation of Asset Health for individual assets. This includes:

- current Asset Health based on observed and measured condition factors; and
- future Asset Health, using assumptions regarding the likely future deterioration in Asset Health.

To take account of future deterioration, it is necessary for the methodology to:

- include some age-based elements within the calculation of Asset Health; and
- use a continuous Health Score scale for the evaluation of Asset Health

As the health of an asset deteriorates (i.e. its condition worsens), the likelihood that it will fail due to condition increases. The methodology relates Asset Health to the associated probability of condition-based failure. For each asset type, the methodology

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68 Refer Document [129]. The common framework sets the definitions, principles and calculation methodologies for the assessment, forecasting and regulatory reporting of asset risk.

69 Document [129], pp. 13-14

specifies the exact relationship between Health Score and PoF. Therefore, Asset Health can be expressed in terms of PoF.

*Criticality index - consequence of failure*

This index consists of four bands with assets allocated a criticality index band according to relative value of the consequence of failure (CoF) of the individual asset compared to the average CoF for the relevant asset category. When an asset fails, there will be an associated impact resulting from that failure. For example, there could be a loss of supply to customers, or an injury resulting from a failure. Such impacts are referred to as Consequences of Failure (CoF).

The methodology includes a common approach to the evaluation of the likely CoF associated with the condition-based failure of individual assets. Monetised values are determined for all CoF. The criticality of an asset is a relative measure of its CoF compared with the average for its asset type.

*Risk index*

This index measures monetised risk based on the health and criticality indexes.

**Equation 1 Monetised risk for asset class**

[Probability of Failure] x [Asset Criticality (Consequence of Failure)] = [Monetised Risk]

A monetised value of risk is calculated by assigning typical PoF to each health index band and typical CoF to each criticality index band, with the risk index score for an asset based on its position in the risk matrix.

### 5.4.3 Transpower framework

For RCP3, Transpower has moved towards an AHI approach that is like the CNAIM approach published by OFGEM. The methodology details the inputs, calculations and calibration parameters to be used in the calculation of asset health. The AHI approach is currently used for only seven of the 17 asset classes, and these seven asset classes use the CNAIM equations.

The primary systems within the Transpower asset management system (AMS) are:

- Maximo – an asset management information system holding the operational asset register and used as the maintenance management tool, as well as an integral component of the finance system.

- Condition Based Risk Management toolset (CBRM) – a risk-based asset health modelling system that provides asset health and criticality that defines the risk profile of an asset class and improves the visibility and usability of asset condition and risk information.
- Asset Management Planning System (AMPS) – an asset management planning system that provides strategic, long-range asset, risk, and budget planning capability. A new AMPS (PowerPlan - refer section 5.6.1) is currently being introduced into the Transpower AMS.

To support asset health modelling, Transpower has developed two specific documents:

- Asset Health framework
- Asset Criticality framework.

This framework reflects the approach used in the UK by Ofgem in the DNO CNAIM. Transpower is looking to enhance some aspects of the Ofgem scheme by adding failure modes and health indices for sub-components on selected assets, such as bushings on transformers. The Transpower AHI model uses failure rates curves modelled against the health index for each asset and a criticality score is assigned and determined for each asset. These are used in risk analysis models to determine a more accurate forecast of optimum intervention points for replacement of the asset in the future.

Currently, Transpower has focused on substation outdoor primary assets, with application to be extended to transmission line assets in the future.

*Asset Health framework*

Through the Asset Health framework, Transpower generates an AHI for assets to indicate how close they are to the end of their nominal useful life.

An AHI is derived for each asset type using five variables:

- base life
- location
- duty
- condition
- reliability.

As the in-service age of an asset approaches its nominal asset life, typically it will require either replacement or a major refurbishment to extend its service life. However, general electricity industry experience is that assets can remain serviceable beyond their nominal asset life depending upon operating conditions, service requirements and regular maintenance. Considering these variables, and with other information, engineering knowledge and decision approaches, an AHI can be used to inform a decision for optimal replacement timing. Transpower uses AHI for medium to long range planning by considering the current asset health and predicting how this asset health will change over time. AHI for the asset categories currently modelled are assessed periodically (6-12 month intervals) to update investment decisions.

The health modelling creates an AHIfor each asset using various factors, including condition data. Transpower proposes to report five asset health measures based on the following asset classes:

- Tower grillage foundation
- Tower protective coating
- Insulators
- Power transformers
- Outdoor circuit breakers

As discussed in Chapter 4 of our report, the asset health measures and related targets will be revenue-linked grid output measures for the RCP3 submission. Transpower has advised the asset health targets will represent the proportion of assets in each asset class assessed as having an asset health score of poor to very poor health (health score greater than AHI 8) at the end of RCP3.

Preliminary targets have been based on:

- current asset health scores across each population of assets (based on June 2017 modelling);
- future health scores in the absence of investment; and
- impact of intended investment plans on future health (draft targets based on April baseline plan).

The asset health targets are dependent on many variables influencing the works plan, such as potential price-quality trade-offs, updated condition information affecting asset health scores and consultation feedback.

### *Asset Criticality framework*

The Asset Criticality framework enables a systematic approach towards setting performance targets and adopting strategies that are differentiated based on the consequences of asset failure to generate an Asset Criticality value based (as appropriate to the asset type) on:

- service performance - includes double contingency N-2 permutations for another outage during the current loss of supply event and consideration of unitised historic cost of restoration time
- workplace safety
- public safety
- environment
- direct cost.

These are combined to derive the total consequence of failure of an asset. This is expressed in dollar terms enabling monetised consequence (of risk) to be derived, and prioritisation of works programmes based on an initial ranking of the monetised risks.

### *Risk assessment*

In deciding on an appropriate risk matrix, Transpower initially used the standard corporate 5 x 5 matrix but found that it was not precise enough to adequately identify likelihood and consequence. We understand other electricity utilities who have introduced asset health modelling have had similar issues. For example, in their network asset risk assessment methodology, TransGrid has nominated six broad areas of consequence.[70]

In consultation with the Transpower Risk Manager, an 8 x 8 risk matrix was developed (refer Figure 30). The likelihood component of the matrix measures consequence on a scale from very low to extreme and consequence on a scale from insignificant to catastrophic.

[70] In their Network Asset Criticality Framework, TransGrid nominated six areas of criticality that are applied to each asset type - safety, environmental, reliability, market impact, service incentive and commercial/customer

**Figure 30 Transpower Corporate Risk Assessment Matrix**

To calculate the monetised risk, monetary values are assigned to:

| Return | Frequency | LIKELIHOOD | Insignificant | Negligible | Minor | Moderate | Major | Severe | Critical | Catastrophic |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.3 yr | 3 | Almost Certain | HIGH | HIGH | VERY HIGH | VERY HIGH | EXTREME | EXTREME | EXTREME | EXTREME |
| 1 yr | 1 | Very Likely | MEDIUM | HIGH | HIGH | VERY HIGH | VERY HIGH | EXTREME | EXTREME | EXTREME |
| 3 yrs | 0.3 | Likely | MEDIUM | MEDIUM | HIGH | HIGH | VERY HIGH | VERY HIGH | EXTREME | EXTREME |
| 10 yrs | 0.1 | Possible | LOW | MEDIUM | MEDIUM | HIGH | HIGH | VERY HIGH | VERY HIGH | EXTREME |
| 30 yrs | 0.03 | Unlikely | LOW | LOW | MEDIUM | MEDIUM | HIGH | HIGH | VERY HIGH | VERY HIGH |
| 100 yrs | 0.01 | Very Unlikely | VERY LOW | LOW | LOW | MEDIUM | MEDIUM | HIGH | HIGH | VERY HIGH |
| 300 yrs | 0.003 | Rare | VERY LOW | VERY LOW | LOW | LOW | MEDIUM | MEDIUM | HIGH | HIGH |
| 1000 yrs | 0.001 | Very Rare | VERY LOW | VERY LOW | VERY LOW | LOW | LOW | MEDIUM | MEDIUM | HIGH |

CONSEQUENCE

| Insignificant | Negligible | Minor | Moderate | Major | Severe | Critical | Catastrophic | |
|---|---|---|---|---|---|---|---|---|
| $100,000 | $300,000 | $1,000,000 | $3,000,000 | $10,000,000 | $30,000,000 | $100,000,000 | $300,000,000 | Direct Cost |
| 0.03 min | 0.1 min | 0.3 min | 1 min | 3 min | 10 min | 30 min | 100 min | Security |
| First Aid injury or pain and discomfort | Medical Treatment Injury (MTI) | Lost Time Injury (LTI) | Serious harm or serious injury or illness | Fatality or permanent disabling injury or illness | Multiple fatalities or permanent disabling injuries or illness | Multiple fatalities at numerous sites | | Workplace Safety |
| First Aid injury or pain and discomfort | Medical Treatment Injury (MTI) | Lost Time Injury (LTI) | Serious harm or serious injury or illness | Fatality or permanent disabling injury or illness | Multiple fatalities or permanent disabling injuries or illness | Widespread fatalities or multiple fatalities at numerous sites | | Public safety |
| Short term damage to small area of limited significance | Pollution beyond Transpower property but contained | Pollution beyond Transpower property impacting area of significant environmental value | Medium to long term major but recoverable environmental damge | Long term serious environmental damage and/or degradation, difficult restoration | Major widespread environmental release or major environment effects | Long term serious environmental damage and/or degradation, difficult restoration | Irreversible widespread environmental damage and/or degradation | Environment |
| Non-compliance or minor breach of regulation or other contract/obligation | Breach of regulation or other contract/obligation with penalty | Major breach of regulation or other contract/obligation with penalty | Breach of regulation with penalty or financial implications | Investigation by Office Holder or Agency | Investigation by Crown / Shareholder / Minister | Public inquiry or lost of core function such as System Operator | Loss of licence to operate | Compliance |
| Sustained adverse local media coverage | Adverse national media coverage | Sustained adverse national media coverage | Short term international adverse media coverage | Sustained international adverse media coverage | Minister consistently upholds major complaints from stakeholders | | | Reputation |

- service performance/compliance
- workplace safety
- public safety
- environment
- direct cost.

*Asset knowledge*

The general methods used to determine the condition of assets are:

- Age and expected life - the approach uses an asset's age and expected life to approximate when an asset will require capital investment for replacement. It is useful for long-term forecasting purposes and requires a basic set of data to be collected. It is suitable for less complex asset categories. Often it is used as a trigger for condition inspections to determine whether an asset replacement should be brought forward or could be deferred.

- Condition inspections and monitoring - this approach typically requires inspections and testing of the assets. In many cases, the costs of testing are expensive and cannot be justified. Condition testing is typically conducted to prevent failure or to identify more accurately the optimum time for asset replacement.

One of the key inputs to the analysis relates to the geographical location of the proposed augmentation - there are six corrosion codes in descending order from most to least corrosive environment as described in Table 28.

**Table 28 Corrosion codes[71]**

| Corrosion code | Typical exterior environment |
|---|---|
| Extreme | Geothermal/exposed |
| Very Severe | Sea shore (surf) |
| Severe | Sea shore (calm) |
| Moderate | Sheltered/coastal with low salinity |
| Low | Arid/rural/inland |
| Benign | Dry, rural/remote from coast |

Asset knowledge includes both structured and unstructured asset information and asset feedback provided by staff and service providers. The framework includes a formal documented feedback loop and an Asset Feedback register.

*Options assessment*

The AHI modelling is a key input to the Options Assessment Analysis (OAA) (refer section 5.6), by examining the different type of interventions that may be required. For example, some solutions driven by AHI are self-evident, such as replacing insulators, whilst other solutions may have multiple options that require integration of works, such as integrating circuit breaker refurbishment/replacement work with renewal work on instrument transformers.

In assessing options, consideration is given to the monetary value of the work and the proposed timeline, together with any possibility for combining it with other work in the same geographic area to support efficient delivery.

*Planning*

The Asset Management Planning System (AMPS) is an information system being configured with the AHI model and criticality models so that optimum assets strategies

71 Document [43], section 2.2.2, Table 3, p. 9

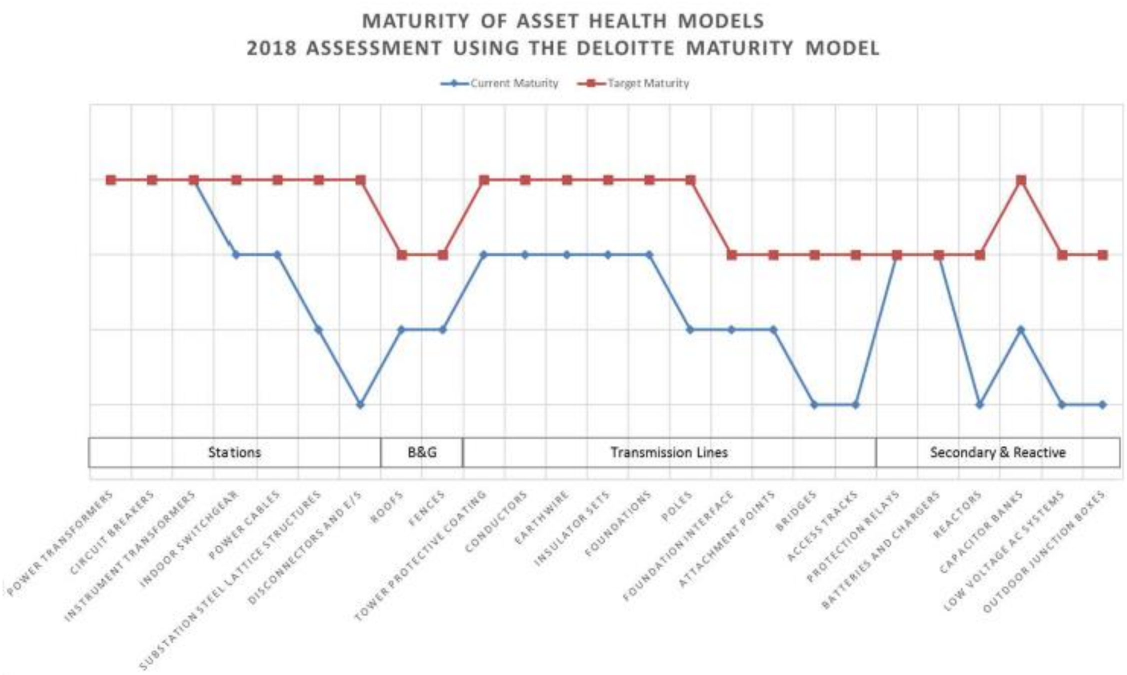
and asset management plans are automatically produced. The system also allows for price-quality trade-offs options to be tested.

Furthermore, the models allow maintenance strategy optimisation and will assist in determining the asset performance targets and an alignment with Grid performance.

*Current relative AHI maturity assessment*

Figure 31 shows an assessment of the current relative maturity of the Transpower asset health modelling, with the blue line showing the current level, and the red line the target level.

**Figure 31 Relative maturity of asset health modelling[72]**




This maturity assessment highlights that whilst substation outdoor primary assets are well understood, there remains areas to be developed, particularly for transmission lines and reactive plant. The lack of maturity in asset health modelling for AC substation buildings and grounds is of no consequence as SPM Assets is used for modelling condition for assets in this class (refer section 7.4.1).

SPM includes asset health models for Transpower's buildings and grounds assets. Although the types of models used for the building and grounds assets are different to

72 Document [42]

the types of model for the AC Substation electrical assets and transmission lines, they are mature. SPM health models are widely used by councils and facility managers.

We have independently reviewed the current maturity and confidence of the asset health modelling for the portfolio of assets under the scope of this review with the results illustrated in Table 29.

**Table 29 Asset health modelling maturity and confidence**

| Asset Class | Data Confidence | Asset Health Model | Criticality Model | Investment/Risk Forecasting |
|---|---|---|---|---|
| Tower Protective Coating | 3 | 4 | N/A | 4 |
| Insulators | 3 | 4 | 4 | 4 |
| Poles | 2 | 3 | 4 | 4 |
| Transmission Line Conductors | 3 | 4 | 4 | 4 |
| HVDC | 4 | 3[1] | 4 | 3[1] |
| Reactive Assets – Capacitors | 2 | 3 | 2 | 3 |
| Reactive Assets - Other | 2 | 3[1] | 3[1] | 3[1] |
| Power Transformers | 5 | 5 | 5 | 4 |
| Secondary Assets – protection & battery systems | 3 | 3 | 2 | 3 |
| Secondary Assets - substation management systems | 3 | 2 | 2 | 2 |
| Building (Roofing and Fences) | 3 | 4 | 3 | 3 |

**Legend**

| | |
|---|---|
| 2 | Low level of confidence or maturity |
| 3 | Improvements needed to provide benefits |
| 4 | Mature state with improvements planned |
| 5 | Mature state ongoing improvements |
| 2 | State of Confidence or Maturity is of some concern |
| 2 & 3 | Level of Confidence or Maturity is not of concern |
| 3[1] | Assets Classes not suitable for fleet based asset health modelling |
| 4 | Level of Confidence or Maturity - well developed |
| 5 | Level of Confidence or Maturity - high |

In our assessment there is concern regarding the level of data confidence for the asset classes indicated. Similarly there are several opportunities for improvement in the maturity of the asset management health and criticality modelling. There is considerable benefits to improving the life expentency of secondary assets and hence benefits from improved data and modelling for these assets. We also consider that an Asset Health Model can and should be refined for HVDC and the majority of individual Reactive Plant Assets, the difference being is that these models are based on a facility approach as distinct from the standard fleet based asset health models.

*Improvement opportunities*

Transpower has identified several functional and control improvements in asset health modelling for RCP3 and future control periods as follows:

- develop asset health models for transmission lines (existing models in Excel to be transferred to CBRM models);
- continue to develop PoF curves for each asset class - PoF curves have been developed for major outdoor substation equipment and will be refined;
- improving probability of failure from well-researched historical failure modes and include an understanding of return periods of loading;
- continued development of the criticality model through reviewing assumptions, such as restoration times;
- increasing the coverage of asset classes for criticality (refer Table 30); and
- developing the measurement and reporting framework.

Table 30 shows the current HVAC asset coverage for criticality.

**Table 30 Current asset class criticality coverage**

| Coverage of Criticality | | Asset Population March 2017 | Criticality Coverage |
|---|---|---|---|
| Asset Group | Asset Class | | |
| Lines | Conductors (km) | 16,526 | 99.2% |
| | Tower foundations - other | 12,783 | 98.7% |
| | Tower foundations - grillage | 10,697 | 99.6% |
| | Tower Protective Coating | 23,729 | 98.9% |
| | Insulators | 54,873 | 96.3% |
| | Pole structures | 14,627 | 90.1% |
| Stations | Instrument transformers | 5,871 | 84.9% |
| | Outdoor Circuit Breakers | 1,514 | 94.1% |
| | Power transformers | 439 | 87.2% |
| | Disconnector & earth switch | 5,282 | 63.1% |

Transpower anticipates that during RCP3, the coverage will be extended to a minimum of 3 other asset classes.

*Deliverability*

Whilst Asset Health is a major driver for replacement and refurbishment, this does not imply that those assets with the worst AHI score are always given priority for replacement. In practice, to assist with deliverability, the programme optimisation will bundle and blend work packages with assets with a range of AHI scores.

This approach should lead to efficient delivery, managing landowner or system impacts, or leveraging off larger projects (e.g. replacing insulators slightly earlier while re-conductoring). Transpower advise the resulting work packages need to be considered when setting AHI targets for tower grillage foundations, insulators, and tower protective coating.

For volumetric asset classes, an effectiveness ratio is used to define the portion of replacement and refurbishment interventions that target poor health (AHI >8) assets. The optimal effectiveness ratio depends on the type of assets presenting with poor health and the economic analysis for field work programme bundling and blending. Improving effectiveness ratios should be possible as the benefits of the improved asset management systems are achieved.

*Verification findings*

Notwithstanding its significant data and analysis requirements, in principle, we are satisfied with the approach Transpower has adopted for asset health modelling and consider it is consistent with GEIP. This view is supported by both the AER assessment of a similar approach recently adopted by TransGrid and given Transpower has chosen to model its approach on a mature and accepted asset health index modelling used by Ofgem in regulating DNOs in the UK.

Transpower has developed Asset Health Framework and Asset Criticality Frameworks that inform a systematic approach to identifying prudent investment plans for asset portfolios and setting performance targets and strategies differentiated on the consequences of asset failure. However, the long-term use of asset health modelling relies upon the level of completeness and robustness of asset population and condition assessment data, as well as a mature and informed assessment of likelihood and consequence to assign appropriate risk levels and monetised risk values to each asset class.

We note that unlike TransGrid in the Australian market, Transpower expanded its standard 5 x 5 corporate risk matrices to provide additional likelihood classifications and consequences across cost, security, workplace safety, public safety, environment, compliance and corporate reputation. We consider this is an improvement on the TransGrid approach and is in line with the mature UK asset health modelling approach that requires risk evaluation that is not necessarily limited to a corporate risk matrix.

At present, Transpower is currently applying asset health modelling to substation primary assets (excluding buildings and grounds) and transmission lines.[73]

Therefore, we consider that Transpower has shown good progress in RCP2 in moving to asset health modelling for renewal/replacement capex forecasting, but needs to continue its planned data-gathering to update asset information in Maximo and AMPS to move to a more quantitative approach, as highlighted by the Deloitte maturity modelling (refer Figure 31.

We believe that AHI is an improved asset management approach in assessing efficient investment in replacement and renewal to extend in-service life, in that it considers whole-of-life costs together with the cost of risk associated with each asset. However, we expect that Transpower will need to continue to improve both its supporting asset datasets and condition assessments, as well as its optimal programme of field work scheduling to fully realise the benefits of the AHI approach. Transpower has identified several improvement opportunities, which are consistent with the ongoing development that TransGrid has foreshadowed for its AHI implementation.

We also accept the anecdotal evidence from Transpower there will still be a need for the programming and scheduling phase of asset planning process to refine the works programme for any delivery constraints or programme efficiency through bundling and blending. We have discussed the progress of implementation for asset health modelling in each of the identified base capex programme reviews in section 7.

## 5.5 Asset planning process

Transpower's asset planning process covers three main phases:[74]

- Tactical Phase - applying asset management strategies to maintain and develop the transmission network assets to meet long-term development strategies and service requirements. This phase includes asset health and risk assessment, and the

[73] AHI models are currently available for foundations and towers only in Excel spreadsheets, not CBRM

[74] Refer to Figure 1 in our separate Attachment A.

optimisation of solutions for addressing network voltage and capacity constraints. Delivery constraints are considered in optimising an integrated maintenance, renewal and enhancement programme of works.

- Programming and Scheduling - tests the integrated capital and operational programme of works for known constraints such as scheduled outages, circuit availability, resourcing and capability constraints and reschedules work by either deferring or promoting individual projects or programmes to level out workloads prior to contracts being awarded to service providers. At this stage, top-down adjustments in monetary terms are made to the expenditure programme where any service provider deliverability constraints are identified.
- Delivery Phase - safe and efficient delivery of the integrated capital and operational programme of works as refined in the Programming and Scheduling Phase, including liaising and monitoring of external service providers.

Transpower has designated responsibilities[75] for all the functions within each phase, such as asset strategy and planning, and scheduling and delivery. Integral to this process is contingency planning for identifying and responding to incidents and emergencies to mitigate the risk of network outages.

## 5.6 Decision Framework

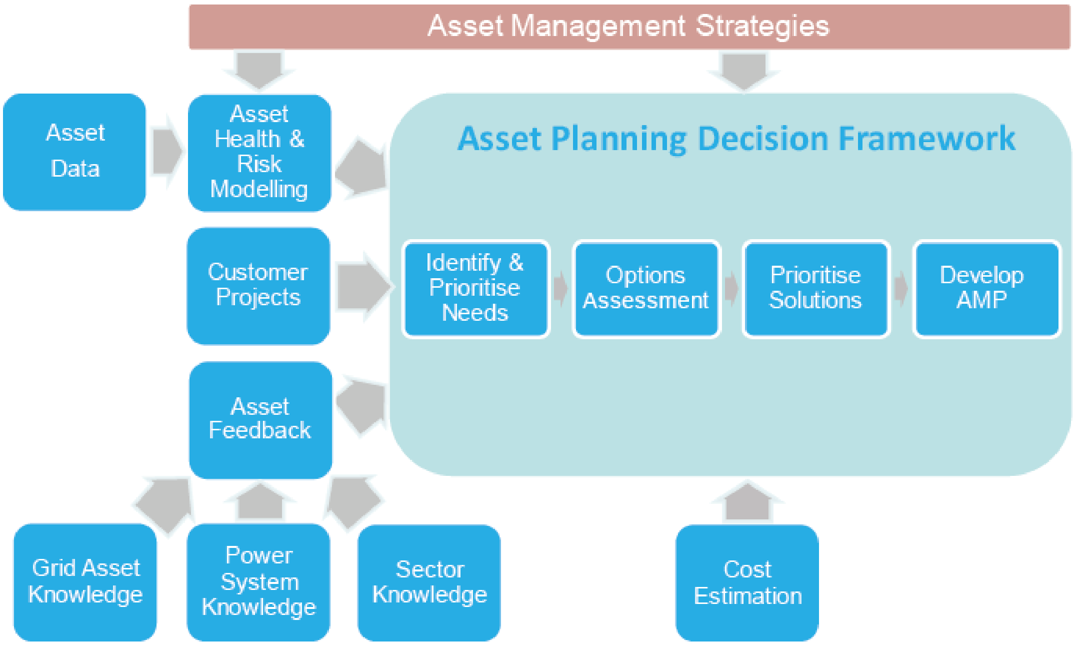
In justifying and prioritising all network expenditure (capex and opex) in the Tactical Phase of the asset planning process, Transpower employs a Decision Framework for the following work categories:

- asset replacement and refurbishments;
- grid enhancement and development;
- maintenance activities;
- customer-initiated projects; and
- network investigations.

Figure 32 illustrates the Decision Framework process.

[75] Document [6], Appendices A & B, pp. 14-22

**Figure 32 Asset Planning Decision Framework**[76]




The Decision Framework has four steps to determine work programmes and support the development of expenditure forecasts:

- identifying needs - modelling of asset health, probability of failure and risk to identify the need for intervention and the likely timeline for the work. Factors affecting this assessment include any safety considerations, condition assessment, in-service age, performance and maintenance history and corrosion code (refer Table 28);
- options assessment - identifying and assessing options and identifying a preferred solution. A do-nothing solution is always considered together with potential solutions that are based on:
  - life-cycle costs to acquire, construct, operate, maintain and dispose of assets;
  - maximum net benefit provided by each option, including risk mitigation or opportunity cost value;
  - any changes in the option's benefit if augmentation is either deferred or brought forward;

76 Document [5], Figure 10, p. 18

  - any residual risk costs;
- prioritising solutions, which is typically based on the needs date. For solutions that are based on a risk assessment, those with the highest net benefit are prioritised; and
- developing a programme management plan - this may be brought forward or deferred to integrate into the capital and operational works expenditure programme to support deliverability, with an assessment of the associated risks and costs for any additional maintenance of any deferment.

### 5.6.1 PowerPlan

Transpower is currently introducing PowerPlan to support the Decision Framework. This system-based capability supports:

- Asset-related problems and opportunities:
  - received and stored in a single location
  - easily identified and grouped or blended together
  - benefits along with costs and impacts for do-nothing option are recorded
  - assessed for overall risk based on Transpower Corporate Risk Assessment Matrix (refer Figure 30 above);
- include and align any forward planned scheduled asset works and maintenance;
- decisions and plans to be recorded to address problems and opportunities;
- scenarios being modelled to show:
  - impact changes will have to overall plan
  - how different scenarios impact the risk level for Transpower
  - cost impact of the different scenarios;
- reporting and analysis;
- integration with various systems:
  - financial management information system
  - enterprise asset management system
  - asset risk tools
  - business intelligence system
  - email/messaging system.

### 5.6.2 Deliverability

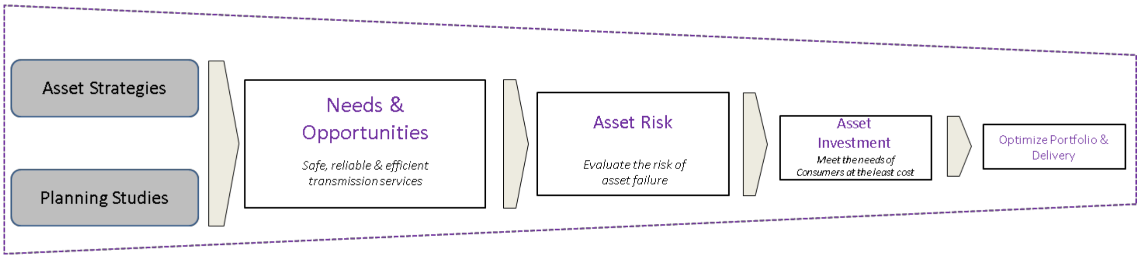
We note that the Commerce Commission expressed some concerns in the RCP2 individual price-quality path decision regarding resource availability risks. These are detailed in section 9 of our report, with the key points being:

- deferment of work during RCP1 due to a lack of available resources, particularly for tower painting; and
- ongoing concerns that there may be resourcing constraints that hinder an optimal risk profile for towers due to a backlog in the painting programme.

The Decision Framework is a key part in the approach now adopted by Transpower in assessing the best solution to identified problems, including consideration of the delivery of the preferred solution, and the risks and costs associated with deferring the work.

We have observed that electricity transmission utilities in Australia have similar governance and delivery processes, albeit that some retain an internal workforce for asset maintenance and smaller capital works. For example, the TransGrid 2018-23 regulatory proposal to the AER included a description of its capital investment framework as shown in Figure 33.

**Figure 33 TransGrid prescribed capital investment framework[77]**




The main components are:

- identification of needs and opportunities from condition assessments and network planning processes, to reduce unacceptable risks to acceptable levels. Opportunities include potential market benefits; as well as other NPV positive saving opportunities;

77 Document [15], section 5.1.1, Figure 3, p. 6

- an investment risk tool which quantifies the risk before and after the proposed investment, including appraisal of multiple options and identification of the option with greatest value;
- justification and prioritising asset investments, and ranking of portfolio of projects based on NPV analysis and compliance criteria (such as reliability and safety); and
- optimising the portfolio by considering changes in cost due to bundling and modifying timing to level resource requirements.

TransGrid stated that "… *the new investment framework is a robust and transparent system, developed for consistent economic justification of required investment in the network. Its development has supported TransGrid's continued accreditation to the ISO 55001 standard and follows from TransGrid's aspiration to continuously push towards industry best practice.*"[78]

In the draft decision, the AER concluded "… *TransGrid's forecasting methodology and adoption of risk based economic planning approach reflects good industry practice.*"[79]

We consider the Decision Framework adopted by Transpower to be in line with GEIP, as supported by the AER's appraisal of a similar approach used by TransGrid. We are of the opinion this framework addresses the concerns identified by the Commerce Commission with regards to the planning of works having regard to the mitigation of any resource constraints, and identifying the costs and risks associated with deferring required work.

## 5.7 Verification opinion

We have compared the asset management framework strategies, plans and processes and the Decision Framework against asset management systems used by Australian electricity transmission utilities that have been recently reviewed by the AER. The findings from the reviewing consultants for the AER concluded in each case that the asset management systems reflected GEIP.

From our experience in reviewing asset management systems for electricity distribution and transmission utilities in Australia, we consider the systems, frameworks and processes used by Transpower are comparable, and reflect robust asset management principles and GEIP.

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78 Document [15], p. 7

79 Document [124], section 6.5.3, p. 6-26

We note that Transpower is continuing to enhance its asset management framework through the implementation of AMPS (PowerPlan) for enhanced asset planning, revision of asset class strategies as the condition and performance of the asset base is better understood, with strategies optimised for maintenance requirements and service intervals. This is being supported by ongoing retrieval and collation of asset condition information to support asset health modelling.

We have discussed the progress of implementation of asset health modelling in our reviews of each identified base capex programme in section 7.

# 6 Cost estimation

This chapter reviews Transpower's cost estimation methodology used to develop its RCP3 expenditure forecasts, including improvements made to the methodology over RCP2.

## 6.1 Overview

Transpower uses a centralised Estimating Team and enterprise system (Transpower Enterprise Estimation System (TEES)) to support asset planning decisions and develop its capex and opex forecasts. TEES is based on the US Cost Success Enterprise cost estimation system, which is also used by ElectraNet in Australia.

TEES has capability to support both volumetric (using standard building blocks) and non-volumetric (based on an aggregate of [quantity] x [rate]) capital estimates (refer section 6.4), and has become an integral part of the capex forecasting process since the beginning of RCP2. TEES is not used in the development of forecasts/estimates for opex programmes, ICT or the HVDC link (which relies upon HVDC asset costs from specialist service providers).

Unit rates for developing opex forecasts based on standard maintenance jobs are stored in Maximo and are informed by actual costs reported by external service providers.

## 6.2 RCP2 decision

The independent review[80] of the Transpower RCP2 noted that TEES was introduced "around" 2009/10 and that as RCP2 was an early use of the system, there was little project cost information that was available for the review.

The review concluded *"… the TEEs (sic) system, with associated scope risk analysis capabilities that Transpower has adopted, provides a reasonable basis for estimating expenditure requirements for grid capex and grid opex projects"*[81] and *"… while no specific weaknesses are evident to us, Transpower's information on specification of input unit costs, and its governance of the process for updating these costs (with a feedback loop from actual purchases and actual completed projects), was not compelling … we consider that it would now be timely for Transpower to review its TEEs cost estimation tool and associated cost estimation processes and documentation in order to provide greater confidence"*[82]

80 Document [118], section 5.3.1, clause 192, p. 47

81 Ibid., section 5.4.1, clause 210, p. 52

82 Document [118], section 5.4.1, clause 211, p. 52

In the RCP2 final decision, the Commerce Commission echoed these concerns regarding the level of confidence in the implementation of the cost estimation process and the related accuracy of project/programme cost estimates. Table 31 shows the recommended performance development management initiatives.

**Table 31 Recommended cost estimation development initiatives**[83]

| PDM initiative | Recommendation |
|---|---|
| Improve the cost estimating processes | • Transpower develops a programme for updating and reviewing its cost estimation system, TEEs, with the development programme for TEEs to include milestones with clear deliverables;<br>• Transpower carries out regular audits to ensure the programme is being met and the processes are being complied with;<br>• Transpower provides annual reports on the progress against the development programme, including the reasons for any significant changes in the programme; and<br>• Transpower provides annual reports on the variance between BC1+ and BC3 estimates and between BC3 estimates and the actual cost. The variances are expected to narrow over time as the estimation process improves. |

The Commission supported these recommendations as follows:

I61 We consider that these suggested initiatives will address areas of concern that were identified with the RCP2 documentation.

I61.1 We have identified a number of issues with the cost estimation system and are not very confident in the outputs from the estimating model in a number of areas. There is insufficient evidence to show that Transpower is using the system for the majority of its projects. Also, there does not appear to be a consistent approach to reviewing actual costs and recalibrating the models.

I61.2 The majority of expenditure in the current proposal is based on first level business cases. There needs to be confidence that these are reasonable estimates of the actual costs.

## 6.3 Developments since RCP2

Table 32 shows the developments that Transpower has made to TEES since the beginning of RCP2.

83 Document [120], Attachment I, p. 211

**Table 32 TEES developments**

| Period | Developments/improvements |
|---|---|
| 2013 | Building Blocks (BBs) created and used for volumetric project estimates - initially 220<br>BBs linked to estimating library of rates at average quantities to generate overall average rate per unit<br>Non-volumetric projects estimated in full on actual quantities x unit rate basis |
| 2013-16 | TEES interfaced with project cost accounting tool (FMIS)<br>Linked volumetric BBs with Transpower-measured deliverables in FMIS<br>Improved reporting options, using data from multiple sources e.g. service provider resourcing, material purchases<br>Unit rates updated<br>Process to document all changes that is readily auditable |
| 2016-18 | Commercial (financial) support for Delivery Project Managers<br>Work Breakdown Structure introduced as standardised project cost collection tool<br>Cost escalation factors used to update rates linked to NZIER indices<br>Measure actual productivity levels as check against tendered rates & improve estimation accuracy measure<br>Extend link to estimate beyond approval gate, so revised budget estimate can be adjusted as scope changes |

As part of the governance processes in place, only members of Transpower's Estimating Team can change a building block.

## 6.4 Volumetric and non-volumetric estimates

Table 33 shows a summary of the characteristics and estimating approach used for volumetric and non-volumetric estimates for project/programme expenditures.

**Table 33 Estimating approaches**

| Classification | Characteristics | Estimating method |
|---|---|---|
| Volumetric | Low value<br>Consistent scope & delivery method<br>Does not require an individual investigation<br>Needs Registration (NR) business case | **Building Block**<br>Average rate based on standard scope of work<br>1:1 relationship with FMIS deliverable |
| Non-volumetric | High value<br>One-off<br>Require an investigation<br>Needs Registration Plus (NR+) business case | **High-Level Building Block**<br>Average rate based on assumed scope of work<br>Initial estimate only (before project has defined scope of work) |
| | | **Detailed Estimate**<br>Defined scope of work<br>Bill of Materials quantity and unit rate |

TEES is used in forecasting the majority of Grid capex, and complemented by maintenance schedules from Maximo, generates the preventive maintenance forecast based on standard job costs.

## 6.5 Unit rates

In ensuring that unit rates are kept current, volumetric projects are periodically tracked and analysed throughout their lifecycle, as shown in the following table.

**Table 34 Volumetric project cost analysis**[84]

| Analysis | Description | Frequency |
|---|---|---|
| Building Block | Analysis of all volumetric projects. Analyses at a transactional, project and building block level to understand spend breakdown, trends and current actual costs | 3-monthly |
| Tower Painting | Analysis of all volumetric projects which fall in the tower painting portfolio. Analyses based on $m^2$ items, any additional breakdowns and trends | 2-monthly |
| Service Provider Reset | Analysis of Service Provider agreed pricing for any 'SP Reset Building Blocks' (each Service Provider undertakes an annual SP Reset where they agree to rates for several building blocks | Annually |

The four levels of analysis - transactional, project, building block and SP Reset - ensures that any changes in unit rates are auditable and well understood.

In developing high-level building blocks and more detailed estimates, Transpower relies upon actual tender prices to inform their unit rates for primary components, including primary electrical plant, SCADA and protection devices, site works and miscellaneous and minor works (including demolition).

To improve the feedback of actual costs incurred by Transpower, a Work Breakdown Structure was introduced as a standardised project cost collection tool, with external service providers on capital work requested to use it to feedback actual costs into TEES. During our discussions with Transpower, we received anecdotal evidence that Transpower is receiving 80-85% acceptance from the service providers on the breakdown structure.

Foreign exchange and CPI future adjustments are calculated in TEES and forwarded to the FMIS. Cost escalation applied to the unit rates is based on a set of indices sourced from the New Zealand Institute of Economic Research (NZIER) (refer section 6.11).

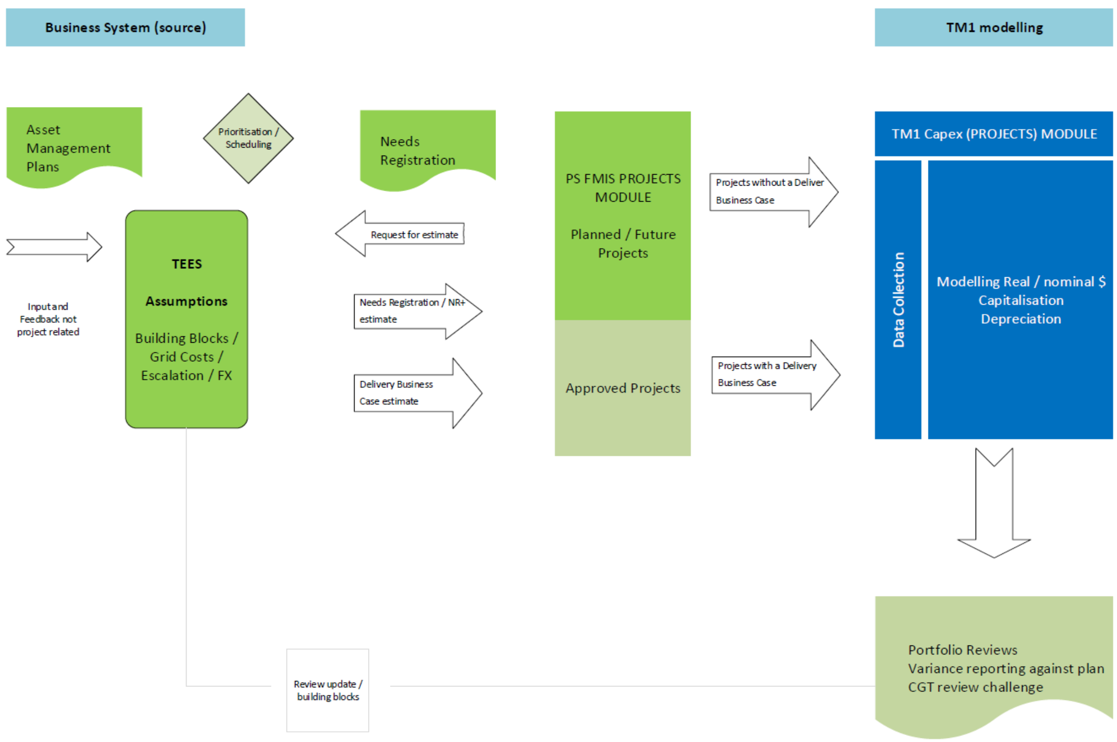
84 Transpower response to RFI22 dated 3 July 2018

As previously noted, only authorised members of the Estimating Team can update unit rates, with all reviews and rate adjustments documented to support any external audit that maybe required. The Estimating Team will inform the Project Managers of any cost changes and discuss any changes (e.g. statutory) with Portfolio Managers before amending any unit rates. Unit rates are updated in batch on a quarterly basis.

## 6.6 Capex forecasting

Figure 34 shows the approach used in generating its Base Capex forecasts and major project estimates for RCP3, which use TEES and rely upon high-level building blocks for volumetric renewal works and individual unit rates for major project components, together with cost escalation factors provided by NZIER.

**Figure 34 Capex cost estimation[85]**




By way of example, Transpower provided four examples of non-volumetric estimates:

85 Process diagram provided by Transpower 14 May 2018

- Two were based on high-level building blocks for ACS power transformer replacements - a 110/33 kV unit in the South Island and a 220/33 kV unit in the North Island. These estimates were broken down into the following broad areas:
  - primary plant
  - associated substation work
  - civil works
  - cabling
  - protection
  - SCADA.

  For each area, costs are split across major plant/equipment/external labour/internal labour/design/land/finance.

  These standard building blocks use standard assumptions for labour requirements without consideration of any regional factors.
- Two were detailed non-volumetric estimates for transformer replacement (a 110/33 kV unit and a 220/33 kV unit) and associated switchyard civil works, itemised for the primary components for all tasks involved in the work, including temporary work and removal of redundant material.

### 6.6.1 Verification opinion

The level of detail that Transpower includes in the non-volumetric estimates based on high-level building blocks is like that we have noted used by other electricity utilities, including transmission companies in Australia, for developing budget or feasibility estimates. Consequently, we are satisfied that the high-level building block approach used by Transpower is consistent with GEIP. We acknowledge that these building block costs have been developed using actual costs incurred and, by inference, on costs that have been market tested.

This approach of building an estimating database is consistent with general industry practice, with unit rates regularly updated and building blocks added as project/tender/procurement costs are captured. Transpower has advised that all cost reviews and unit rate adjustments, and the source of the data, are documented and auditable. We are satisfied that the continual updating process used by the Estimating Team should ensure unit rates for primary electrical equipment and the associated labour content that Transpower are using for generating capital estimates reflect market costs and are fit-for-purpose.

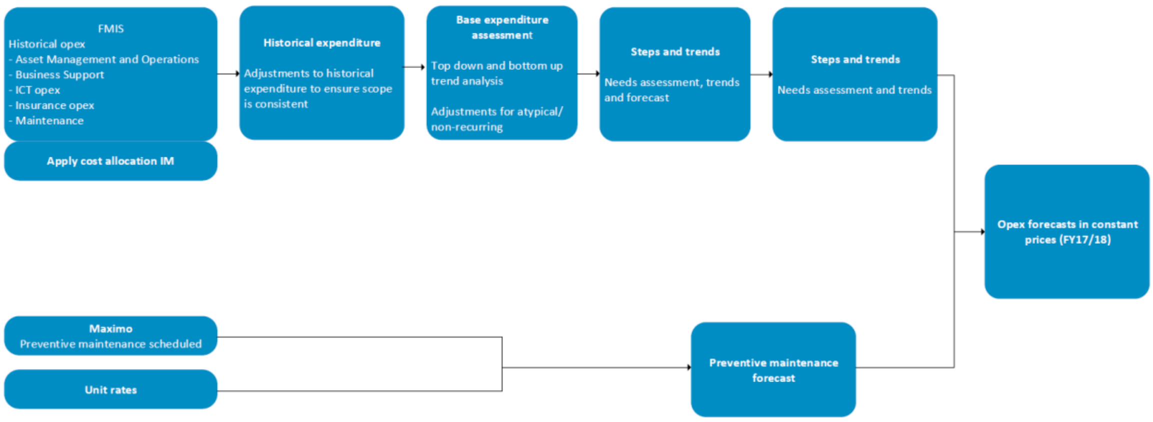
We accept that the TEES system has been developed since the start of RCP2 in line with the Commission's suggested initiatives and that the system cost database is regularly updated with actual cost data. We are satisfied that the TEES system is consistent with GEIP for estimating systems used by utilities for developing capital expenditure and major project estimates.

## 6.7 Opex forecast

Figure 35 shows the hybrid approach used in developing the opex forecast for RCP3:

- base-step-trend for most of the opex categories, based on a base level of reported aggregate costs, which is increased to reflect step changes (if any) and escalated in real dollar terms; and
- a 'ground-up' cost build for the second largest maintenance programme, Preventive Maintenance, which is aggregated and escalated in real dollar terms.

**Figure 35 Opex cost estimation**[86]




For Preventive Maintenance, the standard job costs are stored and work volumes are scheduled in Maximo, with the forecast for Preventive Maintenance based on an aggregation of [quantity] x [standard job unit rate], plus real cost escalation.

### 6.7.1 Service provider price book

To support our review, Transpower provided an extract from an external service provider's price book to illustrate the range of standard jobs used in preventive maintenance work.

86 Process diagram provided by Transpower 14 May 2018

This price book example listed 186 standard job building blocks covering 3,663 maintenance activities in:

- Diagnostic, inspection and service
- General/annual inspection
- Transformer DGA sampling
- Minor maintenance activities
- Protection check
- Calibration check
- Thermographic survey.

In this price book, each standard job building block assumes a set scope of work adjusted for different asset types within a common class, and includes cost allocations for:

- Services (adjusted for broad asset type)
  - Labour based on an estimate of work hours and average hourly rate
  - Plant and tools
  - Materials
  - Subcontractor
  - Miscellaneous materials.
- Travel allowance (area specific).

We note that within the price book, the standard building blocks have been customised depending upon asset location. That is, these building blocks generally have standard job labour allocations but with differing travel allowances.

### 6.7.2 Transpower standard job costs

These standard job costs are based on actual costs incurred by external service providers. All completed work is typically tightly coded by the service providers to region, activity and sub-activity and therefore allows for accurate identification of actual costs for maintenance work.

For each standard job, Transpower has generated the total cost using data sourced from the external service providers, therefore relying on historical costs for developing labour hours, material costs, construction costs and equipment. Transpower advised that service providers provide a breakdown of costs in a standard way that supports the process used for developing building block rates. We believe this estimating process provides a reliable base for generating bottom-up preventive maintenance forecasts as part of the overall RCP3 opex forecast.

The optimised works programme generated by Maximo is separately adjusted for any deliverability constraints that are identified as part of the Programming and Scheduling Phase of the asset planning process (refer section 5.5).

In monitoring the volumetric standard job costs used by external service providers for preventive activities, Transpower advised the following:

> "We have developed price book (rate card) and a methodology that allows us to compare prices across our services providers and effectively benchmark across the group.
>
> In 2014, we split out the management services fees (MSF) from the overall fees, which are the administrative support costs for delivering the underlying work. We had found different service providers applied different methodologies on where these costs were allocated so comparison between service providers was difficult. At the same time as splitting out this MSF, we introduced a price book, with scopes of work. The work for each region is matched to the relevant items in the price book and service providers are asked to submit their price for each of the line items. We are then able to compare the same scoped job across the service providers and review and challenge the outliers to ensure the rates are appropriate and justifiable.
>
> As part of the negotiation strategy with the service providers, we utilise the traffic light report to highlight types of jobs that are outliers in comparison to the rest of the groups. This process has allowed us to identify which of our service providers are uncompetitive and resulted in one termination in 2015. Their work was split amongst the other more competitive service providers. This price book (rate card) methodology has been used to set the yearly contract prices for the last 4 years. The RCP3 proposal has used this as the basis of the bottom up costing for RCP3."[87]

[87] Transpower, *Response to RFI No. 21*, 27 June 2018, Document [114]

### 6.7.3 Cost efficiency assessment

We have reviewed the Traffic Light Report[88] used by Transpower to identify outliers, and note that variances in the external service provider rates from the "comparative market price"[89] for each standard job are graded as follows:

- Green - variance is less than 10%
- Yellow - variance is between 10% and 20%
- Red - variance exceeds 20%

We believe this method relies upon there being a competitive market for the relevant services and that the costs proposed by the service providers are reflective of rates for standard jobs that an end user could reasonably expect to incur for work subject to a typical competitive tender process. In reviewing the Traffic Light Report, we noted the following:

- The price book concept was introduced by Transpower to provide transparency on its standard volumetric costs - an approach that was accepted by the external service providers. The underlying driver for this approach was to provide confidence that the costs being used by the service providers were efficient and representative of market costs.
- The analysis was based on a sample of 60 standard jobs from first-pass submission of four external service providers' costs.
- We believe the variance test used by Transpower is useful in identifying an outlier, particularly where one external service provider's rate is significantly different to the other three. In doing so, it identifies areas where Transpower can invite a service provider to refine their cost to be comparable to the other service providers.
- In reviewing the proposed CY7 costs for four external service providers, we included calculating the minimum and maximum proposed costs for each standard job, and the average cost across all four service providers. For the example Transpower has provided us, we noted that there was little consistency in the price ranges for each standard job, with some tasks having a relatively tight range, whilst others having order of magnitude differences between the minimum and maximum values. Of the 60 standard job costs in the Traffic Light Report, there were 19 where the variance between the minimum and maximum costs was less than 100% and a

[88] Document [74]

[89] Calculated as the average cost across the other service providers

further 20 where the variance was between 100% and 200%. However, approximately ⅓ of the sample has variance that was several orders of magnitude. Some examples are:

- Standard Maintenance Procedure: SMP-02.44.016 for inspection and service of disconnectors and earth switches has an 18% variance between the minimum and maximum values, which reflects a well-defined task that each service provider is familiar and experienced in doing.
- Standard Maintenance Procedure: SMP-02.30.005 for DGA sampling of power transformers has a variance of 41%, which we would expect given the regular nature of the task.
- Standard Maintenance Procedure: SMP-02.33.001 for diagnostic inspection and servicing of instrument transformers varied 147% between the minimum and maximum costs.
- Standard Maintenance Procedure SMP-02.41.001 for the inspection of fall arrest systems, fixed ladders and guardrails has a range of 378%, with a minimum cost of $123 compared to a maximum of $589. We cannot accept there could be such a variance for a task that we would anticipate is a standard check for compliance with standards and statutory requirements. For this standard job, there is no grouping apparent, with the external service provider estimates spread evenly across the range. We believe this is not reflective of each service provider basing their estimates on common tasks.
- Standard Maintenance Procedure: SMP-02.73.003 for functional checks on a standby generator varied 1200% - a minimum cost of $108 to a maximum of $1,403. For a small sample of costs for this job, we consider it unusual in a competitive market for there to be such significant variances. The wide range of costs suggests there is a significant difference in the scope of work each external service provider has relied upon due to regional influences in generating their estimated costs.

- Transpower has clarified these differences reflect different work requirements for SMP based on the nature of assets in different geographic locations. Work is allocated on a geographic basis, with a given external service provider being responsible for all work in a certain area of the transmission network. As such, by way of an example, whilst an SMP may relate to the inspection and servicing of a specific asset type, it may be that some areas have single-phase units whilst other areas may have three-phase units. Consequently, the comparison highlighted above illustrates the wide variance in costs for a SMP with the same scope but different actual work requirements.

Another key driver in ensuring costs are reflective of efficient market costs is the standard contractual arrangements for the external service providers. Contracts given to service providers are location-based contracts that include 24 x 7 fault response with pre-agreed response times and, depending upon the remoteness of the location, includes unproductive time to cover occasions when staff are required for fault response but with insufficient maintenance work to fully occupy them.

### 6.7.4 External service provider contracts

Service contracts run for a 6-year period, with 3 x 1-year extensions available. Costs are indexed by CPI for the first 2 years, reset mid-term, escalated by CPI for a further 2 years and then re-negotiated at the time of contract renewal.

Transpower is aware of service providers needing continuity of work to retain staff and to be sustainable and have sought to improve the process for the next contract renewal stage due on 30 June 2021. Contracts will be more standardised, with fewer customised clauses for easier contract management. Specialised work will be separated from the routine maintenance work, and either undertaken internally or allocated to one or two providers. Contracts will continue to be awarded on a geographic basis, with the locations to be bigger than those currently in place.

Transpower considers the current performance management framework has driven ongoing cost savings throughout RCP2 and estimate savings of approximately $50 million to date.

### 6.7.5 Verification opinion

We believe that basing standard jobs costs on actual costs incurred from approved external service providers is an auditable and robust approach, although it does rely on sufficient market forces to drive competitive maintenance activities.

We accept the Traffic Light Report approach is sound in identifying outliers for each standard job and the visual green/yellow/red grades can quickly identify where a particular service provider is competitively priced for similar work against other service providers (as a proxy for the market). We acknowledge that comparing costs for the current SMPs is not straightforward, as there are some differences between service providers for SMPs with the same scope but differing amounts of work and region-specific costs. As the SMPs in Maximo are optimised, we believe that this Traffic Light approach will support further competitiveness across the service providers as costs for individual SMPs become more comparable.

We are satisfied that Transpower has a sound approach in negotiating and managing the standard job costs as part of external service provider contracts, and that the performance management framework in place should continue to put pressure on the service providers to find efficiencies in their costs.

## 6.8 Accuracy and confidence levels

During discussions with Transpower, we were advised that the target accuracy for estimates generated by TEES is based on unit rates for components being +10/-15%.

Separate Attachment C shows the typical level of accuracy for estimates for different stages of a project and an explanation of the different classes of estimates as defined in an international recommended practice. We believe that whilst Transpower has an aspirational target for the accuracy of TEES estimates, the accuracy quoted at different stages of the project/programme should reflect the level of project definition available.

## 6.9 Contingencies

Transpower has explicitly stated that there are no contingency allowances in their expenditure forecasts.

Separate Attachment C reviews the inclusion of contingencies in capital and operational expenditure forecasts and the view of both the Commerce Commission and Australian regulators regarding the inclusion of contingency allowances.

## 6.10 Project/programme cost review

Transpower advised that there are several feedback paths to check and update costs:

- Increasingly, external service providers are requested to split out costs for standard jobs to match Transpower's unit rate breakdown, with a reported 80-85% compliance rate.
- Costs for non-volumetric work are requested from external service providers using a breakdown provided by Transpower, which highlights both inclusions and exclusions. Transpower advises that this is helpful with understanding maintenance costs, particularly in highlighting any significant outliers.
- Transpower has introduced risk workshops to review risk allocations for non-volumetric project estimates.

The Estimating Team reviews all works estimated using TEES, comparing the actual programme/project costs with the estimate included in the Delivery Business Case. This practice is in response to the initiative I60.4 proposed by the Commerce Commission in Attachment I to the RCP2 decision:

> I60.4 Transpower provides annual reports on the variance between BC1+ and BC3 estimates and between BC3 estimates and the actual cost. The variances are expected to narrow over time as the estimation process improves.

For volumetric projects, Transpower maintains a database comparing actual and estimated expenditure by deliverable. This allows a project level Accuracy Measure to be calculated for the projects. To determine the overall Accuracy Measure requires some additional steps.

The Accuracy Measure covers the work defined by the building block scopes for each building block/standard job and any site-specific costs (including regional considerations). To provide for a like-for-like comparison with actual project costs incurred, the estimated costs include cost escalation (refer section 6.11). This comparison then identifies any under-spend or over-spend in actual costs, and the degree of variance.

Transpower has adopted a preliminary test of reasonableness as an acceptable variance being within the range ±20%. This test directly matches a similar test for reasonableness we apply in generating comparative estimates (refer separate Attachment C). We believe this nominated variance is appropriate given the typical level of project definition available when preparing the initial project/programme estimate and without detailed knowledge of any site or regional factors that may impact the actual costs incurred during the execution of the works.

The current goal for Transpower is for 80% of all deliverables to fall within the nominal ±20% variance range for reasonableness. Until recently, this analysis has been collated using a Microsoft Excel® model and focused on individual projects, but Transpower are transitioning to using the Power BI[90] package for analysing and reporting estimating accuracy. The transition to Power BI is not yet complete (Transpower advises it is "*approximately 80% complete*").

Figure 36 shows an example of the report that Power BI will generate.

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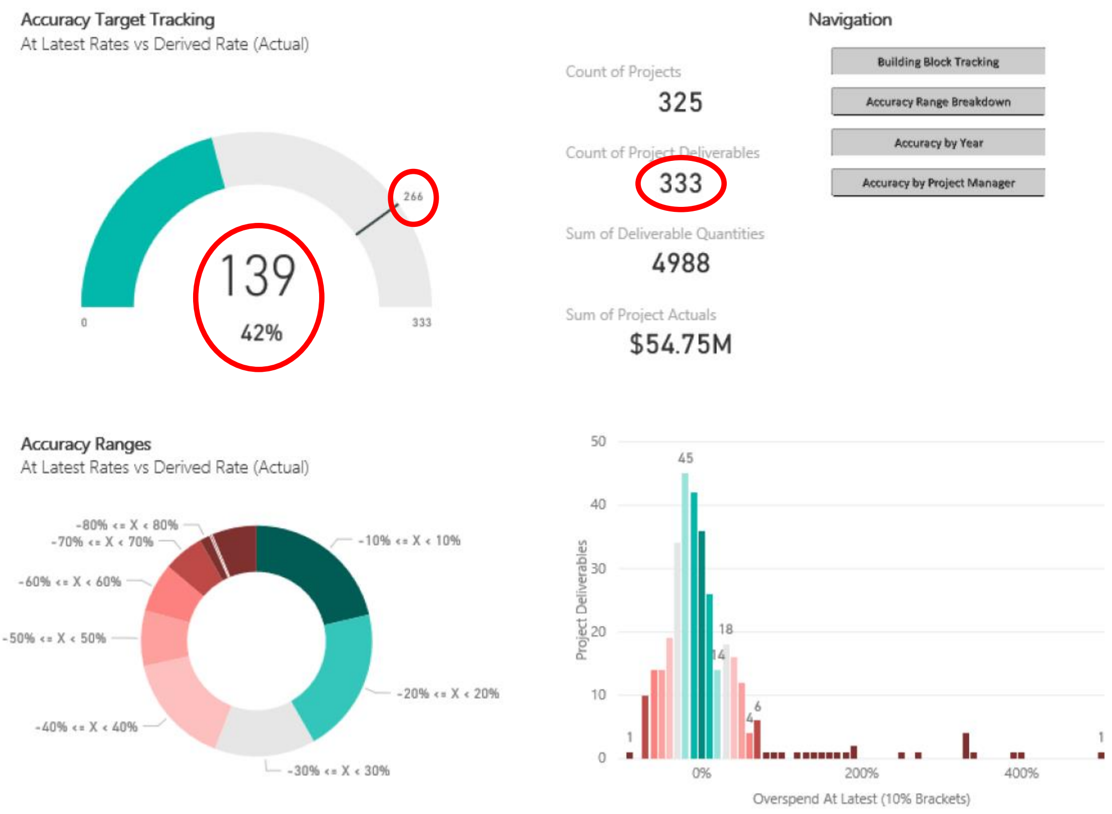
[90] Power BI is a Microsoft product that interfaces with the Office 360 suite of applications, and is a uniform reporting platform

**Figure 36 Power BI dashboard report for estimate review**




In summary, the dashboard report we reviewed shows:

- 333 project deliverables have been reviewed, totalling $54.8 million.
- Target of 80% for the sample reviewed being within the nominal ±20% variance for reasonableness is 266 deliverables.
- By project count, 139 or 42% of the sample satisfied the nominal ±20% variance test.

As the business implementation of Power BI progresses, the tool will allow further interrogation to building block level, which analyses the Accuracy Measure for individual building block unit rates compared to actual costs incurred. From Figure 36, there are 20 projects with overspends in excess of 100%. Transpower advised that in these instances, the actual costs are examined to highlight the primary causes.

Transpower reviews non-volumetric estimates for variance between estimated and actual costs overall but believes that "*… because the number of projects is limited and usually unique, in our view an overall analysis provides limited insight. Each project has little bearing to* *the next and each utilises very different unit rates / scope cost items"*[91] Transpower does not apply a similar ±20% variance test of reasonableness; instead, calculating an overall Accuracy Range and individual project ranges.

### 6.10.1 Verification opinion

We acknowledge that the Commerce Commission and their independent reviewer questioned the confidence level in Transpower's cost estimation approach based on TEES used during RCP1 and RCP2 (refer section 6.2) and suggested future improvements.

We have experience with electricity utilities in Australia with governance arrangements requiring a post-project review that analyses the actual costs incurred, a comparison against the original business case budget, and an analysis of any variances to identify specific contributing factors. For a NSW utility, we noted its estimating system is mature enough to allow for review requirements such that any project with a variance of ±10% in actual vs estimated is fully investigated and the findings reported. Its similar Accuracy Measure is approximately 2% overall. Whilst we have not independently verified the 2% variance claim, we recognise that a robust and mandatory review of project costs at the completion of the works will drive improvements in estimating accuracies.

Transpower has introduced a reasonableness test of ±20% variance for volumetric projects. We adopt a similar test as that proposed by Transpower for evaluating the reasonableness of a comparative estimate by using a nominal ±20% variance test. We believe this is appropriate given the limited project definition often available for a comparative estimate and the lack of information available regarding any site or regional factors that may materially impact the costs incurred.

We believe the introduction of a dedicated tool, Power BI, to analyse and report estimating performance is a very good initiative and represents GEIP. As the tool is fully implemented, we recommend that reporting the Accuracy Measure should be included in the Transpower performance reporting to demonstrate internally and externally to stakeholders the reliability and accuracy of its cost estimating process.

We do not agree with Transpower that a similar ±20% variance test should not be applied to the non-volumetric projects. Whilst TEES may rely on unit costs for individual cost items rather than building blocks, our experience is that these costs should be monitored and updated in a cost estimating database in a similar way to standard job costs. There

91 Response to RFI22 received 3 July 2018

are sufficient non-volumetric programmes/projects in the Transpower works programme to warrant targeting similar estimating accuracy as the volumetric maintenance work.

As an initial target and given the progressive implementation of the new Power BI tool, we accept the Transpower target of 80% for estimates within the nominal ±20% variance range. However, as the tool becomes fully implemented, and the associated level of understanding of the accuracy of TEES estimates and the primary contributory factors to any variance in actual costs, we would expect that this target should be increased to a minimum 90% for volumetric work. We are satisfied that Transpower has and is establishing a framework for cost estimation that will support an enhanced performance in cost estimating and has demonstrated improvements since RCP1 and RCP2. We believe that the concerns expressed by the Commerce Commission at the time of its RCP2 Final Decision, including proposed improvement initiatives, have been addressed in the development of the RCP3 expenditure forecasts.

## 6.11 Cost escalation

### 6.11.1 Commerce Commission's critique of Transpower's RCP2 forecasting methodology

The Commission stated in its RCP2 decision paper (para H5) that:

> In the future we will expect a rigorous retrospective review of the accuracy of competing forecast methodologies to be a central part of justifying proposed set of cost escalation factors.[92]

In its RCP2 decision paper, the Commission also identified a concern that Transpower's commodity weighting factors were appropriate but lacked transparency in their calculation (paragraph H40-41).

### 6.11.2 Transpower's forecasting methodology enhancements

Transpower has advised that its approach to cost escalation for the RCP3 expenditure forecasts is an evolution of its approach for RCP2. The unchanged elements are:

- a two-step process (from constant $2017/18 prices to real prices and from real to nominal prices);

[92] Commerce Commission, *Setting Transpower's individual price-quality path for 2015-20*, 29 August 2014, Document [120], Attachment H, paragraph H5, p. 183

- the use of independent forecasts prepared by NZIER regarding forecast input price movements; and
- for capex forecasts, the use of commodity weighting factors based on the composition of the aggregate capex forecast and assumed commodity breakdown across programmes.

Transpower has identified the following improvements in in its cost estimation methodology applied in the development of its RCP3 expenditure forecasts:

- commodity weighting factors are more robust and transparent – derived in TEES to resource level costs (which is a level below building blocks);
- foreign exchange rate forecasts are also derived at a building-block level in TEES;
- foreign exchange rate forecasts are now based on forward curves [taken from Bloomberg] for input materials not sourced in NZ;
- opex cost escalation is applied at a more aggregate level, consistent with Transpower's updated forecasting methods; and
- more granular refinements have been made to cost escalation techniques for some inputs (e.g. distinguishing between capex labour and design consultant costs).

Transpower has advised that for its May 2018 RCP3 baseline expenditure forecasts, real price effects sum to around $40 million across RCP3, which compares to around $130 million for CPI and foreign exchange rate effects.[93]

## 6.12 Verification review

Transpower has made refinements to its cost estimation and escalation methodologies in preparing its RCP3 capital programme expenditure forecasts compared to its RCP2 forecasts.

### 6.12.1 Transpower's RCP3 cost estimation methodology

We have noted similar approaches with Australian electricity utilities in developing cost estimates and expenditure forecasts through their asset management systems. In each instance, they relied upon standard building blocks based on a nominated configuration

93 Over the course of RCP3, Transpower will update its CPI and foreign exchange components of its allowances for actual rates.

for capital estimates, and standard maintenance jobs for routine or preventive maintenance activities.

As an example, the main features of the approach used by an Australian electricity distribution utility for developing project estimates are:

- based on asset management system covering all aspects of recording, planning, maintaining and constructing network assets;
- interfaced with financial module with latest purchase prices for materials and services provided by external service providers, and planning module used in management of maintenance program, parts and inventory;
- building block estimates based on standard unit assemblies built up from components available in database of costs;
- costs include material procurement including corporate and stores overheads, labour rate including on-costs and overheads, plant and vehicle costs, and other construction costs incurred; and
- unit rates are regularly scrutinised, and cost variance report generated for every project, with a detailed investigation triggered if the variance is outside a nominal ±10% range.

Similarly, another Australian electricity distribution utility has created approximately 400 standard jobs for maintenance activities for their substation and line assets, covering general maintenance, inspection, operational and calibration checks and thermographic scans. These standard jobs have standard work scopes that are considered the work that is typically required for these activities, with specific allowances added for work in remote areas. Costs are based on actual costs captured in their general ledger, making the standard job costs reliable and auditable.

We are satisfied that the TEES approach that Transpower has adopted is consistent with what is considered GEIP in the Australian electricity network sector. It provides a reliable platform for generating both project and capital programme estimates and standard maintenance jobs in Maximo for opex forecasts.

We note that since the introduction of TEES in 2009/10, Transpower has progressively improved the system through a series of initiatives during RCP2 to increase its use across the business, integration with other Transpower business functions and improved data sourcing and feedback processes. These improvements are consistent with our experience with Australian electricity and water utilities who have been through similar processes in improving their estimating capabilities.

We also note that Transpower has accepted the critical need for TEES to be the purview of a specific Estimating Team within the business and that maintenance of the cost database for both material and labour rates must be done on a regular basis. In Transpower's case, we understand that costs are updated quarterly including any efficiency changes/savings that may impact building block costs or related cost items. It is also crucial that strict governance is applied in the regular updates of cost databases and the managing of the standard building blocks and standard jobs, and that any changes are agreed with Portfolio Managers, and only affected and documented by the Estimating Team.

We are satisfied that the cost review processes that Transpower has introduced will lead to improved accuracy in capital project and programme estimates and are consistent with practices in the Australian electricity industry. As noted previously, we accept the initial target of 80% of volumetric estimates being within the nominal ±20% variance range for reasonableness, but in time we believe this target should be increased to a minimum of 90% to increase confidence in TEES and accuracy of the expenditure forecasts it generates.

We accept Transpower is confident that costs within non-volumetric projects are being scrutinised as closely as those used for volumetric projects, but in a different way as the scope varies for each separate project. However, we consider that there are sufficient non-volumetric programmes/projects in the Transpower works programme to warrant targeting similar estimating accuracy as for volumetric work in RCP3.

Whilst we recognise that the TEES system is aiming for a high level of accuracy and confidence level in the estimates it generates, we would caution Transpower to ensure that project/programme estimates and expenditure forecasts are only quoted to an accuracy that reflects the level of project definition available. We noted that an E&D project listed as Likely, and therefore only with 0-2% project definition was quoted to a dollar level, which we consider is well beyond the level of accuracy that would be reasonable or possible (refer to separate Attachment C). We recommend that Transpower states the level of accuracy for its project forecasts to reflect the level of project definition, and confidence level in the estimate.

In summary, we consider TEES is a good platform for developing capital expenditure forecasts, and with proper governance and upkeep will provide reliable estimating for both volumetric and non-volumetric project/programme works at a good confidence level. We are satisfied that Transpower has and is adopting GEIP to improve the accuracy of its cost estimating system.

# 7 Capex forecast verification

In this chapter, we assess Transpower's RCP3 Base Capex forecast against the TOR. This required us to:

- assess Transpower's policies and planning approaches, assumptions, drivers and forecasting methodologies, focussing on Identified Programmes; and
- provide our verification opinion on Transpower's RCP3 Base Capex forecasts, including whether these forecasts satisfy the expenditure outcome regarding GEIP.

## 7.1 Background

Transpower has forecast total capex for RCP3 of $1,202.4 million in real 2017/18 dollars. Table 35 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex with major expenditure category variances.

**Table 35 Comparison of RCP2 and RCP3 capex ($2017/18 million)**

| Expenditure category | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Renewal | 846.1 | 976.8 | 15% |
| Enhancement & Development | 97.5 | 76.4 | -22% |
| ICT | 169.5 | 146.1 | -14% |
| Business Support | 30.4 | 17.1 | -44% |
| PQ & grid related ICT benefits | - | (14.0) | |
| **Total** | **1,143.6** | **1,202.4** | **5%** |

The RCP2 forecast included a 7.5% 'productivity' adjustment applied to grid replacement and refurbishment, whilst ICT capex included an additional reduction of 2.5% applied by the Commerce Commission.[94] No similar adjustment was applied to the Enhancement & Development capex. The value shown for RCP2 in Table 35 includes actual expenditures during 2015/16 and 2016/17, and forecast spend during the balance of RCP2.

To date, actual expenditure is $13 million less than the RCP2 allowance, with reduced E&D expenditure ($20 million) and structures programme ($9 million) offset primarily by a cost overrun due to tower painting ($11 million). All other asset class expenditures are within $5 million of their RCP2 allowance.[95]

[94] Document [120], section 5, clauses 5.13 to 5.17, p. 66. A top-down 'productivity' adjustment of 7.5% to grid and 10% to ICT base capex were applied in the RCP2 decision. This adjustment reflected gains in productivity and was applied at an aggregate level and not at a project level.

[95] Document [27]

Table 36 shows the annual forecast capex for RCP3 by high-level expenditure category in real 2017/18 dollars.

**Table 36 Annual forecast capex for RCP3 ($2017/18 million)**

| Expenditure category | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Renewal (incl. phasing adjustment) | 218.2 | 225.0 | 187.3 | 175.9 | 170.4 | 976.8 |
| Enhancement & Development | 15.3 | 15.3 | 15.3 | 15.3 | 15.3 | 76.4 |
| ICT | 31.7 | 28.7 | 27.2 | 28.3 | 30.2 | 146.1 |
| Business Support | 2.8 | 3.6 | 3.9 | 3.6 | 3.3 | 17.1 |
| Phasing of Renewal capex | (57.5) | (18.9) | 12.9 | 23.4 | 40.2 | 0.0 |
| PQ & grid related ICT benefits | (2.8) | (2.8) | (2.8) | (2.8) | (2.8) | (14.0) |
| **Total** | **207.7** | **250.8** | **243.7** | **243.7** | **256.5** | **1,202.4** |

Figure 37 shows the annual capex for the regulatory periods RCP1 to RCP3, and Figure 38 shows the total capex for the regulatory periods RCP1 to RCP5.

**Figure 37 Annual capex for RCP1 to RCP3**

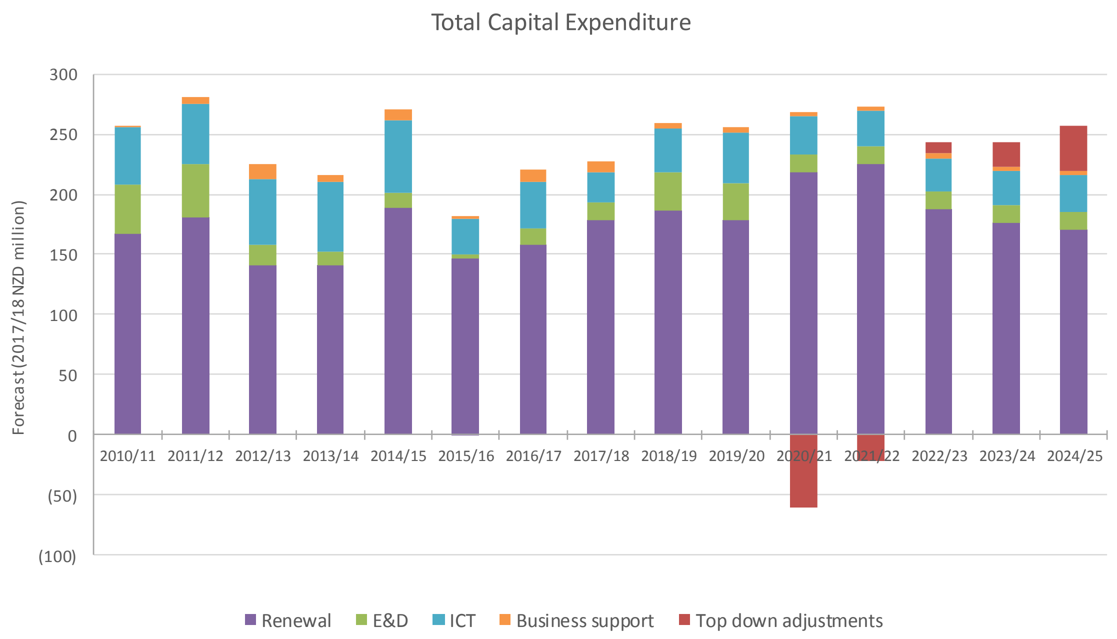
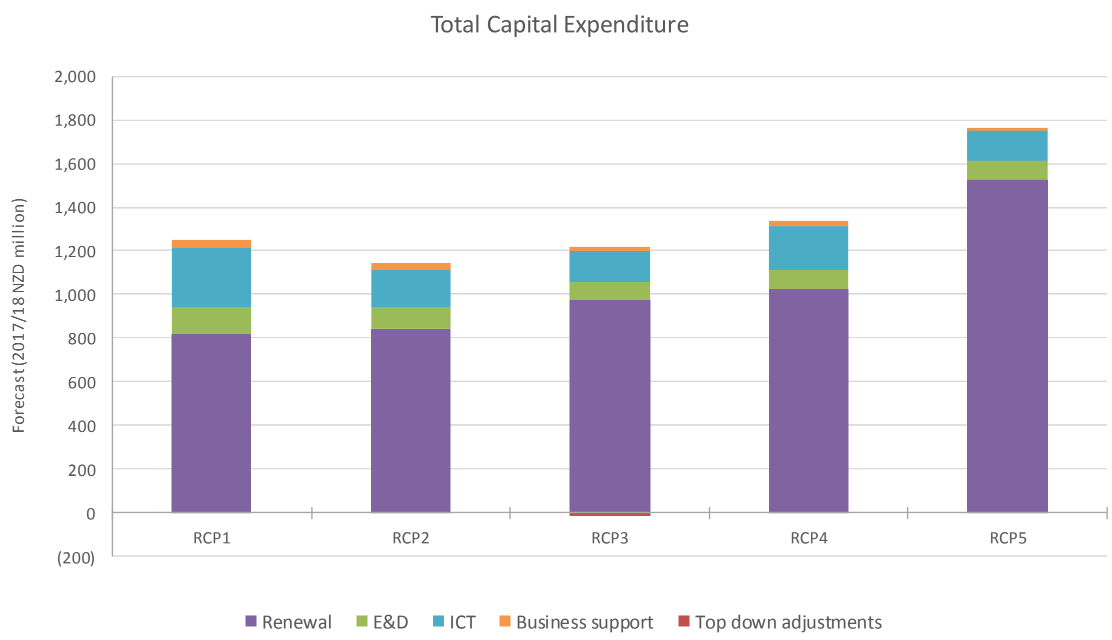


**Figure 38 Total capex for RCP1 to RCP5**




For the RCP3 regulatory period, Transpower has proposed capex of $1,202.4 million ($2017/18) which represents an increase of $58.8 million or 5% on the approved total capex allowance during RCP2.

The key forecast expenditure driver for RCP3 is grid renewal capex, which represents 88% of the total forecast. There are eleven identified capex programmes for RCP3 (refer section 7.3), eight of which relate to asset renewal.

## 7.2 Assessment approach

In accordance with the TOR, the following factors have been considered in assessing Transpower's Base Capex programme:

- reasonableness of the key assumptions relevant to Base Capex relied upon, including:
  - method and information used to develop them
  - how they were applied
  - their effect on the proposed Base Capex allowances across programmes;
- whether policies regarding the need for, and prioritisation of, projects and programmes demonstrate a risk-based approach consistent with good asset management practice and are directed towards achieving cost-effective and efficient solutions;

- reasonableness and adequacy of asset replacement models used to prepare the proposed Base Capex allowances across programmes;
- appropriateness of demand forecasts and other key assumptions applied in determining the proposed Base Capex; and
- extent to which Transpower has demonstrated the type of efficiency improvements obtained in the current and previous regulatory periods.

## 7.3 Identified Programmes

The list of Identified Programmes for the RCP3 proposal was based on criteria developed and agreed by Transpower and the Commerce Commission between November 2017 and February 2018. The selection of Identified Programmes covers a range of expenditure and asset categories as follows:

- expenditure categories for a range of different asset classes
- asset classes with the larger expenditure forecasts
- asset classes with RCP3 expenditure forecasts that vary significantly from RCP2.

The Capex IM requires Transpower to agree a set of criteria for deciding a list of Identified Programmes with the Commerce Commission for inclusion in the Base Capex proposal, as the Capex IM does not mandate any specific selection criteria such as expenditure thresholds or asset categories. Transpower is required to provide in-depth qualitative and quantitative information supporting the capex forecast for assessment of these Identified Programmes.

The agreed selection criteria for RCP3 capex Identified Programmes is:

(a) Top two asset classes by expenditure for the following asset categories:

   (i) Network capex - Substations[96]

   (ii) Network capex - Lines

   (iii) Network capex - HVDC & Reactive Assets

   (iv) Network capex - Secondary Assets

   (v) Non-network capex - ICT

(b) Enhancement & Development capex

[96] Transpower and the Commerce Commission agreed ACS Buildings & Grounds to be a Non-identified Programme

(c) Should the capex programmes identified by (a) and (b) not represent a minimum of 70% of the total RCP3 capex forecast, additional capex programmes ranked from largest to smallest until the 70% minimum threshold is satisfied

There are 11 agreed Identified Programmes, representing 81% of the total RCP3 capex forecast of $1,202.4 million (refer Table 36) as shown in Table 37.

**Table 37 RCP3 Identified Programmes ($2017/18 million)**

| Capex | Expenditure category | Asset category | Asset class | RCP3 forecast |
|---|---|---|---|---|
| Network | Renewal | AC Substations | Power Transformers | 60.1 |
| | | | OD 33 kV switchyards: OD to ID conversion | 42.1 |
| | | Transmission Lines | TL Structures & Insulators | 308.7 |
| | | | TL Conductor & Hardware | 90.2 |
| | | HVDC & Reactive Assets | HVDC | 64.6 |
| | | | Reactive Assets | 39.5 |
| | | Secondary Assets | SA Protection | 141.6 |
| | | | SA Substation Management Systems | 58.6 |
| | Enhancement & Development | Enhancement & Development | Enhancement & Development | 76.4 |
| Non-network | ICT | IT Telecoms, Network Services | IT Telecoms, Network Services | 48.8 |
| | | Transmission Systems | Transmission Systems | 47.0 |
| **Total** | | | | **977.5** |

For our RCP3 assessment, ICT Transmission Systems replaces ICT Asset Management Systems as an Identified Programme compared to the Commission's RCP2 review.

### 7.3.1 Grid capex - Transmission Lines

The Transmission Line asset category consists of four asset classes:

- Structures and Insulators
- Conductors and Hardware
- Grillage Foundations
- Other foundations and access bridges

The forecast expenditure for unlisted projects for transmission lines in RCP3 is a total of $452.7 million, with a large percentage of the expenditure allocated to Structures and

Insulators $308.7 million (68.2%) and Conductors and Hardware $90.2 million (19.9%) in real 2017/18 dollars.

*TL Structures and Insulators*

The asset strategy and expenditure forecasts for Structures and Insulators are detailed in three Portfolio Management Plans and corresponding Asset Class Strategies:

- TL Paint Portfolio Management Plan
- TL Structures Portfolio Management Plan
- TL Insulators Portfolio Management Plan
- TL Insulators and Fittings Asset Class Strategy
- TL Towers and Poles Asset Class Strategy.

Transpower has forecast a total capex for TL Structures & Insulators in RCP3 of $308.7 million in real 2017/18 dollars. Table 38 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 38 Comparison of TL Structures & Insulators RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| TL Structures & Insulators | 254.1 | 308.7 | 21% |

Table 39 shows the annual forecast capex for TL Structures & Insulators in RCP3 in real 2017/18 dollars.

**Table 39 Annual forecast capex for TL Structures & Insulators in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| TL Structures & Insulators | 57.3 | 57.7 | 62.6 | 64.6 | 66.5 | 308.7 |

Figure 39 shows the annual TL Structures & Insulators capex for the regulatory periods RCP1 to RCP3, and Figure 40 shows the total TL Structures & Insulators capex for the regulatory periods RCP1 to RCP5.

**Figure 39 Annual capex for TL Structures & Insulators for RCP1 to RCP3**

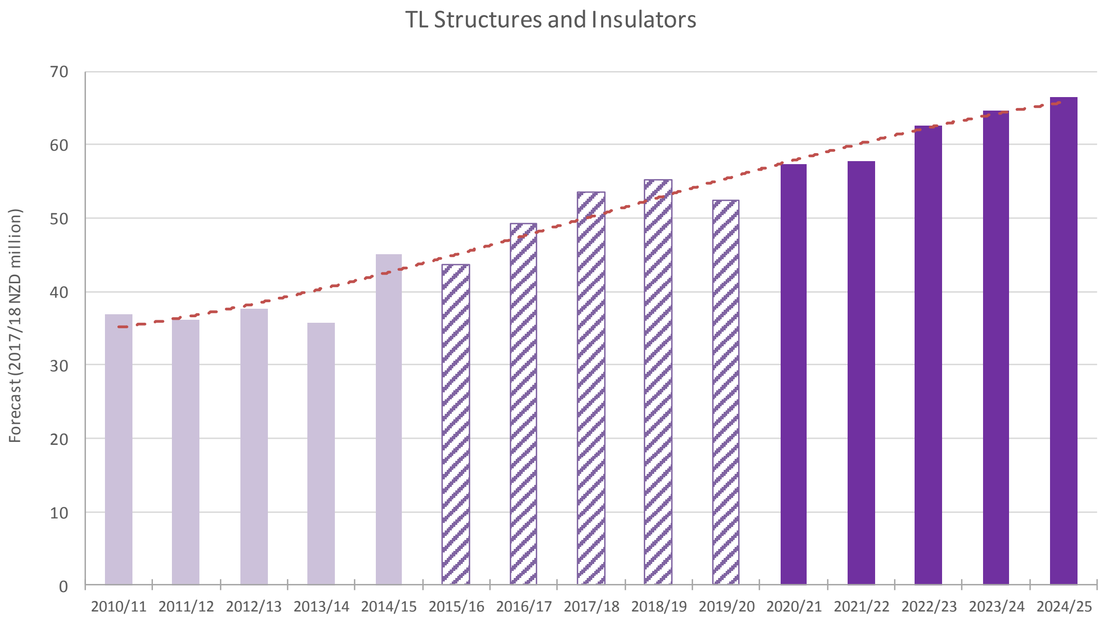
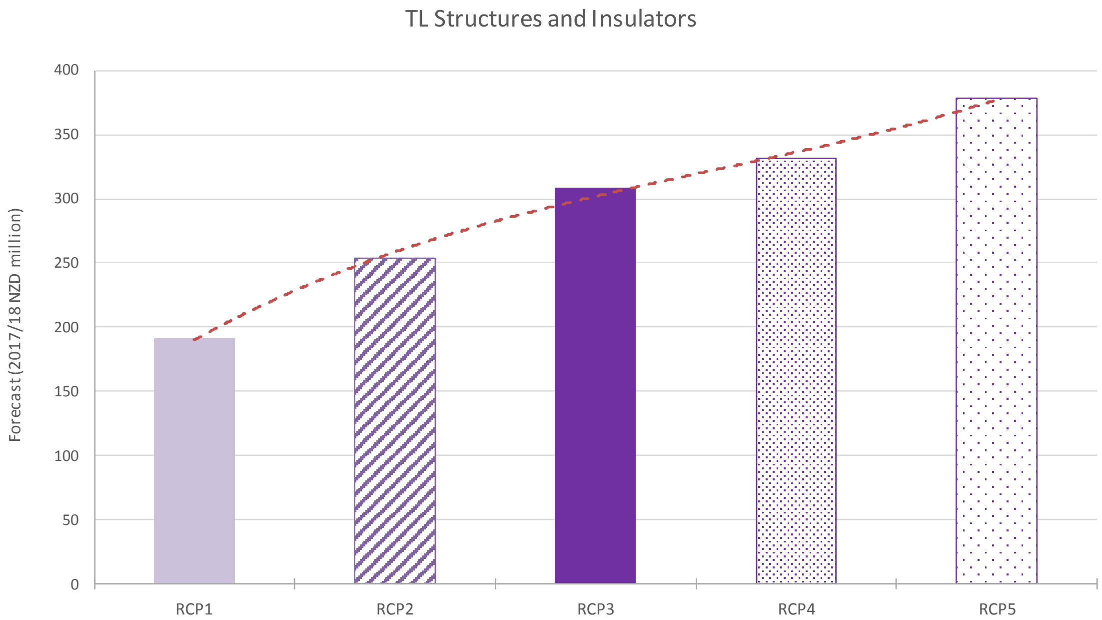



**Figure 40 Total TL Structures & Insulators capex for RCP1 to RCP5**




For RCP3, Transpower's capex of $308.7 million ($2017/18) represents an increase of $54.6 million or 21.5% on capex during RCP2. Transpower has advised that the predominant driver behind this increase is the growing volume of towers reaching the end of their expected life with intervention required to extend tower life through 15-18 yearly recoats of paint.

A relatively small capex amount for structure replacement (poles and towers) of around $37 million is driven predominately by an increasing volume of hardwood poles reaching end of life and $4 million for tower section replacements.

The RCP2 expenditure forecast for the insulator portfolio was originally $35 million. The volume of work envisaged prior to the RCP2 submission did not materialise and modelling over-estimated the amount of assets reaching end of life. The RCP2 forecast has been adjusted to a forecast of $18 million. In RCP3, this is forecast to increase to $31 million, which is relatively small compared to other programmes, such as tower painting and conductor replacement. The much higher quantities of insulators in AHI bands between 3 and 8 means the forecast expenditure is expected to increase and peak around $36 million in RCP4 and RCP5.

**Asset Health Modelling for TL Structures and Insulators**

In the past, Transpower used a remaining life approach to predict forward workload for tower painting. The previous asset health model assumed a linear degradation rate of steel from the original installation date to the most recent condition assessment score, with replacement to occur at CA=20.

Transpower has developed an Asset Health Index model for tower painting during RCP2 but the criticality framework is not applicable as intervention is based on optimising long run costs to maintain towers in a condition well before they reach a critical failure condition (CA=20). For tower painting the interventions levels are higher as follows than this potential critical failure point:

- Extreme: CA 50
- Very Severe: CA 40
- Severe: CA 40
- Moderate: CA 30
- Low: CA 30
- Benign: CA 30

For the future, Transpower has recognised that alongside the condition of the asset, the probability of failure is dependent on the structural duty of particular components. Consequently, the capacity (which could factor in a member cross-section and steel grade), as well as site-specific weather loading conditions expected at the structure, can be considered.

Generally segmenting an asset class by more granular risk categories and degradation categories creates more complex modelling requirements with diminishing returns. Determining the right level of segmentation is expected to be determined through finer refinement of the model in RCP3.

The previous tower painting condition degradation model for RCP2 was developed in 2012. In this model, Transpower condition assessed structural items on the worst face of the tower, and averaged these to reach a CA score. In 2017, Transpower moved to an Overview CA (OVCA) approach which takes weighted average of CA scores across the whole tower.

Some issues have been found with the new single parameter OVCA model as the asset may be more degraded in locations before the intervention takes place. This has implications both for safety and cost, for example more preparation work being required due to the steel being in more degraded condition than expected. Transpower plans to review the CA regime, to ensure the OVCA reflects what it was intended to, and confirm the intervention CA points.

A risk management framework and tools were developed during RCP2 for use across the towers and poles to evaluate investment options. A key part of this framework are the tools for making quantitative estimates (on a structure-by-structure basis) of the likely impacts (consequences) of tower or pole failures on service performance, safety, environment and property. This model has been used to derive the forecasts volumes for RCP3.

Since 2013, further development of the corrosion zones, intervention points, and enhanced condition assessment data (OVCA) have contributed to the revised asset health model to forecast both the backlog and forecast workload ahead. Transpower is currently 5 years into an 8-yearly cycle and have 74% of structures where OVCA data is utilised in the model. Ongoing review and refinement of the model is required to ensure the correlation between OVCA data and specified intervention points to achieve the strategic objective of maintaining structures prior to the onset of significant rusting.

With the fundamental asset health model in place for tower painting, analysis of field data on observed degradation rates will provide refinement of more accurate degradation profiles in the model in RCP3. The quality of data reported on tower structures by Transpower is very high hence the above planned improvements during RCP3 should be achievable.

There were no issues found with the current asset management model developed during RCP2 to model the condition of towers that would have an impact on the accuracy of the input volumes forecasted for RCP3. The asset health model is spreadsheet based and has the capability to predict future health with or without investment intervention. It does not use or need to use a monetised criticality assessment tool.

Transpower state that they intend to continually review the linear degradation profiles used for painted structures with observed degradation rates to provide more accurate degradation profiles. Identified changes will be considered for implementation in the asset health model and potentially intervention periods can be extended. This will become more important as the number of painted towers increases, along with improving the life of recoats and the costs of recoating. We agree with these initiatives and improvements.

Future initiatives proposed for tower painting include;

- Testing new painting technologies, and reviewing new technologies and international experience, within and outside of the electricity industry
- Data analytics to improve evidence and calibration of degradation within Tower Paint AHI model (first paint and recoat paint)
- Data review of costs and condition of tower paint economic optimisation model for first paint and recoat paint

The asset health model for insulators has been developed by modelling the degradation rate of insulator type when exposed to different levels of corrosion (corrosion zones). Transpower continues to learn about the degradation rates and replacement requirements based on the asset exposure.

The asset health model provides a view as to the expected condition for a segment of the asset population and risk assessments based on criticality provides a reasonable prediction of forecast funding over the next and future periods. Criticality for insulators is based on the standard criticality framework across the five service performance dimensions.

It is difficult to precisely predict which specific assets will reach replacement criteria as the actual degradation may not match modelled degradation, and it is necessary to prepare a specific project list two years ahead of the replacements, as planned work relies heavily on the latest forecast condition.

Over the first 2½ years of RCP2, Transpower replaced a lower number of insulators than forecasted, approximately 850 per year compared to the forecast 1,420 insulator sets. This has largely been due to insulators being in a better condition than was forecast, thereby not requiring replacement. The replacement need for future RCPs is now taking this into consideration through revision of the asset health models that projects the insulators reaching replacement criteria, resulting in a reduction of forecasts volumes into the future.

There were no issues found with the current asset management model developed for insulators during RCP2 to model the condition of towers that would have a significant impact on the accuracy of the input volumes forecasted for RCP3. The asset health model is mature and spreadsheet based. It has the capability to predict future health with or without investment intervention and uses a monetised criticality assessment approach which provides for assessment of future risk with and without intervention.

Transpower has recently tested their strategy and plan by considering changes to the intervention point for insulators. The current strategy is to identify all replacements candidates based on a condition at or worse than AHI8. Initial analysis has shown that running low risk insulators to a declining level of health may be appropriate and further work is underway to ensure other risk levels are not exceeded.

Transpower has identified several areas of development for the model in RCP3:

- Currently Transpower uses six corrosion zones to differentiate and predict degradation rates, but have identified that this approach may be too coarse. This would apply to all asset classes subject to corrosion impacts.
- More work is required to verify the base life of all insulator types in all corrosion codes, especially composites and degradation processes.
- Consideration of the use of structural duty which may allow some insulator applications to adopt a lower condition intervention point.

The forecasted delivery units for tower and pole structures over RCP 3 have been based on historical replacements as the asset health models are in their infancy. Of some concern is the level of confidence in the data for transmission pole structures. This is more with respect to forecasting replacement input values then a concern with risk as the poles are routinely inspected for condition and replacements are based on these more accurate field inspections.

There may be an opportunity for targeting structures more prone to degradation and to reduce inspection costs, and for the models to be developed to provide more robust forecasts of future costs and risks with or without investment. However, the relatively small opex costs for pole inspections is unlikely to warrant a segmented approach. The current model has the ability to forecast pole replacement volumes based on future expected condition. The expenditure over RCP3 for pole replacements is around $33 million, hence improvements in the asset health model for this asset type should be a lower priority compared to other capital expenditure programs. Future opportunities, as indicated by Transpower, include standardising pole engineering assessments across all service providers, which is related to condition assessments rather than the asset health model itself.

For tower and pole attachment points (steel members and bolt condition) an Asset Health Model has been developed to predict the volume of work over future revenue periods but not the actual locations. Transpower has indicated that the current model requires more work in RCP3 to ensure that the right data inputs are being modelled.

Criticality for structures is site specific and based on the standard criticality framework across the five service performance dimensions. Criticality for attachment points is the same as for the corresponding insulators.

**Asset strategy and planning - TL Structures and Insulators**

The key strategy of the TL Paint Portfolio is to undertake a tower painting programme to ensure that the structural integrity of transmission towers is maintained in perpetuity at least lifecycle cost. The strategy is to paint towers prior to significant rusting and to re-paint prior to paint failure. This approach can extend the life of towers indefinitely and will have a lower lifecycle cost than full tower replacement.

Painting is preventative and is undertaken well before any potential failure event, which we acknowledge is a prudent least cost strategy. As such, Transpower does not currently use criticality assessments for tower painting prioritisation. Delays in painting towers beyond the optimal window impacts the cost to complete the works rather than increasing failure likelihood.

We requested Transpower to respond to the value of providing long run renewal cost forecasts beyond RCP5 with a view to informing their *Transmission Tomorrow* and *Te Mauri Hiko* (Energy Futures) strategy outlooks. In response,[97] Transpower confirmed that long-range forecasts of tower painting investment have been developed; however, we have a concern with their forecasts of expenditure, post 2040, estimated to plateau at just over $350 million over 5-year reset periods.

Our analysis confirms Transpower methodology and agree that $350 million is the level of expenditure that can be expected for the regulatory period around 2040. By then, new painted towers will be overlapping with towers painted 15 years prior. The level of

[97] Document [106]

expenditure though in theory will increase again in later years when new painted towers overlap with both towers painting 15 years prior, and 30 years prior. Our calculations suggest expenditure for the periods would reach $420 million in today's dollars. Projecting costs even further, after all towers are painted, expenditures would in theory reach $550 million in today's dollars (current repainting costs at around $70 million per tower, 23,580 towers repainted at 15 year intervals).[98]

Predicting further then 20 years is somewhat academic, as the whole network topology could change by then. Nevertheless, the point is that the expenditure will have increased significantly by 2040 and that the technologies applied now and up to 15 years prior to this period will be defining that level of expenditure. Investment in researching new techniques and technology to extend the life of painting protection in RCP3 is warranted and very important.

Transpower has indicated in discussions that due to improved controls on preparation and application standards implemented in RCP2, coating systems are now expected to last 20 years. While tower painting is a lower cost strategy than complete tower replacement, the benefits to extend the life of tower painting cycles from 15 years to even further to 25 years is significant (long term average RCP expenditure would reduce by 40% of current projected expenditure).

Transpower is continuing to investigate and trial new painting technologies and applications. This focus and investment is prudent in RCP3 as the volume of painting begins to increase. Transpower has pointed out that while it has looked at more stringent specification of the preparation and application standards, it needs to be mindful that the ability to prepare towers using historical abrasive blast techniques could be restricted in future. Any consideration of changes needs to understand all the applications and ongoing maintainability of whatever system is chosen, and the compatibility with presently installed systems.

Transpower also stated that information on long-term investment needs and impacts on price path can provide useful context for customers and stakeholders, including the Commerce Commission. This is one of the improvement areas Transpower has been working on as part of its overall approach to RCP3.

The key challenges for Transpower is to identify new products and techniques, or improved application of the products that can extend the life of repainting for the different levels of corrosion environments. During 2015, Transpower went to the paint manufacturer market to assess and review available products and any new innovations

[98] Document [57], Tables 3, 4 and 6, pp. 13-18

in coating technologies. The outcomes of this review were no new products were identified that provided increased performance or reduced cost.

Additionally, Transpower is seeking products to provide quick application solutions for inside MAD areas. Quick application is required to maximise the opportunity during limited duration circuit outages without significantly reducing the forecast performance.

The forecasted and increasing cost of tower painting into the future, due to the volume of repainting as towers structures age, justifies a significant level of resources to be applied during RCP3 and RCP4 to identifying life extension strategies.

Due to the significant increasing forecast costs for tower painting in future periods, we consider that Transpower should identify a target for future cost reductions from life extension options for tower painting which in turn justifies a budget for proactive investigations as outlines above. A business case should justify increasing current opex expenditure on these investigations and Transpower can take a greater lead internationally in this area.

During the past 18 months an independent report has been completed by CEATI International titled "Evaluation of Transmission Line Steel Structure Coatings", published January 2018. Information in the report has been sourced from participating utilities and publicly available documentation. Information contained in the report is to be reviewed and considered for improvement opportunities in the painting programme.

Transpower's key asset strategies for structures are:

- Paint towers based on optimal condition assessment (CA) scores for each corrosion code;
- Repair or replace structures that have degraded to a point where they can no longer support their design loads; and
- Replace insulator attachment points at the onset of section loss (CA 20) or before the fastener threads seize up (CA 30). Attachment points are replaced at a level that will ensure continuing acceptable levels of safety and reliability performance, and before it is too difficult to remove them from the structure.

Transpower's asset management approach for insulators is to maintain them in perpetuity and to replace them based on a CA score of 20. To achieve an overall least lifecycle cost, the current strategy is to replace the insulators in blocks or bundles of work. To improve efficiency, re-insulation work is also bundled with any works where conductor lifting is done (e.g. re-conductoring, pole/cross arm replacement or attachment point replacement), whenever this is deemed cost-effective to do so.

There are over fifty thousand insulator sets in service across the Grid. The health of these assets is primarily influenced by the corrosiveness of the environment they are in, and as such, their life expectancy can vary greatly depending on their environment.

The insulators may be glass, porcelain, or composite, and are situated in corrosion zones varying from benign to extreme.

**Key Drivers for Tower Painting in RCP3**

Over the period since 2010, a significant growth in painting resources has occurred to address the increase within the painting portfolio. Transpower is now painting some 550 towers per year in 2017-18, forecasting 2,627 towers in total in RCP2. This is estimated to grow further to around 700 towers per year by late RCP3, with 2,845 towers planned for painting across RCP3 in total. Transpower advises issues with tower painting delivery and quality have been addressed in RCP1 and now tower painting delivery is functioning well and quality challenges in RCP2 have been resolved.

The key points that impact on the painting work forecasts are:

- 3,474 of the 5,741 towers with extreme, very severe, and severe corrosion codes are already painted. The majority of the remaining 2,267 towers in these codes will require painting in the next 12 years.
- The aging population of towers with other corrosion codes, average 53 years, and is reflected in the number of structures now due or approaching the optimum initial intervention point.
- Life of structures to first paint and subsequent recoat painting vary across the corrosion codes, with most painted towers requiring recoats between 12 to 20 years depending on the corrosion code.

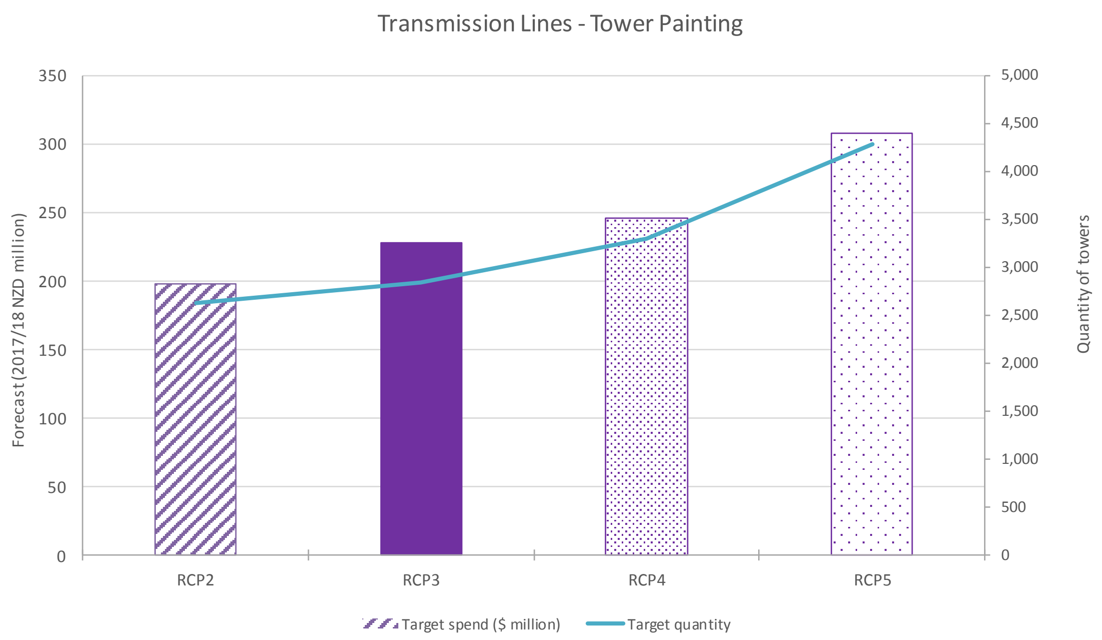
During RCP3, Transpower is planning continued growth of painting as the now due structures are addressed while maintaining the coating of the already painted structures in serviceable condition. As the quantity of painted structures increases, the quantity of recoat painting increases aligned with the recoat cycles for each corrosion code. Painting volumes around 2010 were increasing from 200 up to 300 per year, and with some 1000 now due recoat structures, the plan is to recoat an average of 380 structures per year through RCP3. New paint quantities are forecast at an average of 250 structures per year during RCP3 to reduce the quantity of now-due towers, and manage the towers reaching AH8. These quantities reflect the asset health model data and the delivery alignment of works.

The following table summarises the increased work volumes and capex planned for RCP2 to RCP5 for tower painting.

**Table 40 Tower painting volumes and capex for RCP2 to RCP5 ($2017/18 million)[99]**

| | RCP2 | RCP3 | RCP4 | RCP5 |
|---|---|---|---|---|
| Tower painting target quantities | 2,627 | 2,845 | 3,292 | 4,286 |
| Tower painting target spend | 197.4 | 227.6 | 245.5 | 307.7 |

**Figure 41 Tower painting expenditure and quantities for RCP2 to RCP5**




**Key drivers for Insulators in RCP3**

The purpose of insulators on overhead lines is to support the overhead conductors whilst insulating the support structure, tower, or pole from the live conductor. Insulators perform an electrical and mechanical function, and thus the performance of insulators is critical to ensuring public safety as well as maintaining a reliable power supply to customers.

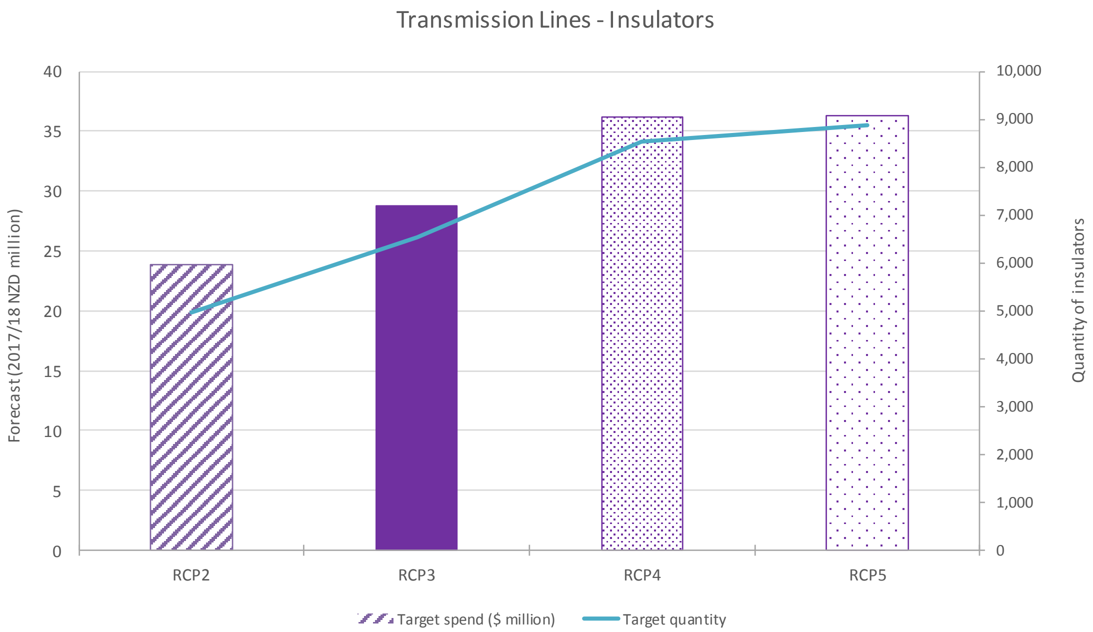
The key drivers for the volume of insulator replacements in RCP3 are to replace glass and porcelain insulators and fittings when condition assessment shows that they have reached their replacement criteria. Glass and porcelain insulators are managed based on condition, which varies with age and corrosion code.

99 Document [57], section 7.2, tables 12-16, pp. 41-2

Composite insulators and fittings are replaced based on age, prior to their normal expected life, or sooner where condition dictates. Transpower are continuing to obtain relevant data on composite insulators with the view to moving to a replacement on condition strategy.

Our analysis of the age of insulator types and expected life in different corrosion zones indicate the long run average cost of insulator replacements will plateau at around $36 million which is reached in RCP4 and RCP5.

**Figure 42 Insulator expenditure and replacement quantities for RCP2 to RCP5**




**Key Drivers for Towers and Pole Structures in RCP3**

Transpower's pole structures strategy is to replace them based on a condition assessment score of 20, to ensure that the requirements of Transpower's Safety Management System (SMS) under the Electricity Act is met.

Table 41 shows the replacement volumes for towers and poles from RCP2 to RCP5, whilst Figure 43 illustrates the increased capex planned for the same regulatory periods.[100] Transpower expects the expenditure on pole replacement to increase over RCP 3 and RCP 4 due to an increasing volume of hardwood poles reaching end of life. This trend is expected to reduce by RCP5.

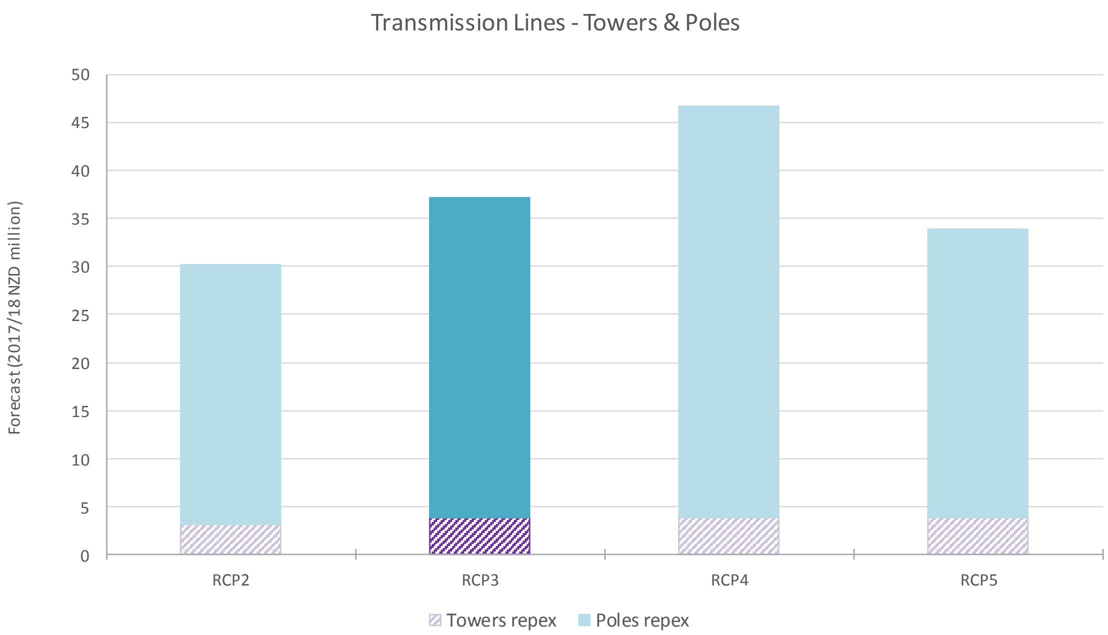
100 Document [58], p. 41

**Table 41 Replacement volumes for TL structures for RCP2 to RCP5**

| | RCP2 | RCP3 | RCP4 | RCP5 |
|---|---|---|---|---|
| Tower replacement volumes | 10 | 10 | 10 | 10 |
| Pole replacement volumes | 1,000 | 1,250 | 1,570 | 1,330 |

A scope of work within the TL structures portfolio relates to the replacement of steel and bolts, including the repair of attachment points and replacement of the occasional tower that fails, or is accidentally damaged by landowners.

**Figure 43 Tower and pole replacement expenditure for RCP2 to RCP5**




**Verification assessment of TL Structure and Insulators**

We consider there has been a high level of rigor and detail applied by Transpower to the management of its transmission line structures and insulators, evident in the quality of the data on towers and poles in particular, and in the development and methodology for assessing asset health index (AHI) scores and the condition-monitoring programme that updates the assessed AHI for each tower.

The intervention year for the initial painting and subsequent repainting is initially based on decay curves modelled for each corrosion code, which is then refined through actual field-based condition assessments made on an 8 year cycle.

There is a current programme underway to obtain condition data to develop new composite condition codes for towers. After this programme is completed, we consider that an inspection and condition assessment of towers every 8 years is sub-optimal and that the inspection of paint condition could be done by sampling towers and conducting the assessment a few years earlier than the expected life of the paint coat rather than on a fixed 8 year cycle.

There is practically no risk of failure of towers due to extending the period for recoating, except that costs will increase for preparation and recoating. This would allow Transpower to be less conservative and err on the side of extending the period before recoating.

We reviewed the Asset Health (AH) models and developments for Tower Painting, Structures and Insulators and found;

- The AH Model for the asset classes that are being applied to determine input values and the actual volumes forecasted for the RCP3 were found to conform and be based on the model findings and subsequent field condition assessments.
- Significant developments have been made to the asset health models for transmission line assets during RCP2 resulting in improved short-listing of targeted assets for intervention.
  - This has increased the effectiveness of cost optimisation and the management of risks. Condition assessments then provide actual data to support business cases before final commitment of funds.
  - The modelling has improved the reliability of Capex forecasts for future periods
  - This has in turn informed the need for increased investment in RCP3 for greater investigation, research and new strategies to potentially reduce future costs, particularly with tower painting costs which are forecasted to greatly increase from RCP3 to RCP5 and beyond.
- Improvements to the Asset Criticality and Asset Health Models can be made and are planned for investigation by Transpower during RCP3
  - There were no issues found with the current asset health models that would have significant impact on unit volumes forecasted for RCP3
  - Transpower are reviewing further segmentation of the asset fleet by corrosion zones and other potential factors for opportunities to differentiate strategies and forecasted intervention needs.
  - Segmenting an asset class by more granular risk and degradation categories could create more complex modelling requirements with limited added value. This should be an important consideration in making changes to the model.

- The more important investigative and research strategies for the TL asset class is activities focussed on extending the life of protective coatings and lowering the cost of application. Transpower should identify targets for future cost reductions for the tower painting program in particular and use this information to justify the increased operating costs aimed at these strategic investigations.

Based on our analysis of the asset class strategy, condition assessments and modelling outcomes provided by Transpower, we verify that the investment in transmission line structures and insulators is reasonable and prudent for RCP3. Transpower has demonstrated efficiency improvements over the RCP2 and previous regulatory periods and is continuing to address current issues and identify technology opportunities. Furthermore, deliverability has been built into forecasts for RCP3.

The asset management objectives for each of the portfolios are supported by the asset strategies and are linked to grid output measures with respect to achieving the targeted AHI score. There was also strong evidence that the building block costs are based on feedback from actual project costs.

Transpower is continuing to investigate and trial new painting technologies and applications with a view to optimising future costs. These costs are reflected in increased asset management and maintenance expenditure over RCP3. We view this expenditure as prudent investment in opex trading off against a significant increasing forecast in tower painting capex costs from RCP3 through to RCP5, and not peaking until post 2040.

A focus on investment is prudent in RCP3 to achieve ways to increase repainting life cycles. We are concerned that our estimate of future costs indicates tower painting costs will peak at much higher levels than Transpower is projecting, which more greatly emphasises the need in RCP3 to discover advancements to extending the life of paint coats, reducing the cost of application, and to review resource implications to meet the growing future painting programme demand.

Overall, we believe Transpower's RCP3 TL Structures and Insulators capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - TL Structures and Insulators

Table 42 summarises our verification assessment and opinion.

**Table 42 Verification summary - TL Structures and Insulators**

| Expenditure category | Capex - TL Structures and Insulators | |
|---|---|---|
| **Transpower RCP3 forecast** | $308.7 million | |
| **Recommendation** | **Accept:** $308.7 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* asset class strategy, condition assessments and modelling outcomes demonstrates prudency of proposed expenditure<br>* development and methodology for assessing asset health index (AHI) scores and condition-monitoring programme updates assessed AHI for each tower<br>* supported by asset strategies linked to grid output measures to drive achievement of AHI scores | N/A |
| **Other relevant criteria from ToR** | General evaluation of the Base Capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | Investment focused on extending repainting lifecycles | N/A |
| **Potential scope for improvement** | * New composite condition codes for towers being developed<br>* Improvements to Asset Criticality and Asset Health models through further segmentation of structure population to differentiate strategies and intervention needs | N/A |

### *TL Conductors and Hardware*

The asset strategy and expenditure forecasts for Conductors and Hardware are detailed in the TL Conductors Portfolio Management Plan and the corresponding Asset Class Strategy.

Table 43 and Table 44, with Figure 44 and Figure 45, include capex for the respective identified Base Capex programme (i.e. does not include large listed conductor replacement projects).

Table 43 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 43 Comparison of TL Conductor & Hardware RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| TL Conductor & Hardware | 36.9 | 90.2 | 144% |

Table 44 shows the annual forecast capex for TL Conductor & Hardware in RCP3 in real 2017/18 dollars.

**Table 44 Annual forecast capex for TL Conductor & Hardware in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| TL Conductor & hardware | 33.2 | 37.4 | 11.5 | 2.4 | 5.7 | 90.2 |

Figure 44 shows the annual TL Conductor & Hardware capex for the regulatory periods RCP1 to RCP3, and Figure 45 shows the total TL Conductor & hardware capex for the regulatory periods RCP1 to RCP5.

**Figure 44 Annual TL Conductor & Hardware capex for RCP1 to RCP3**

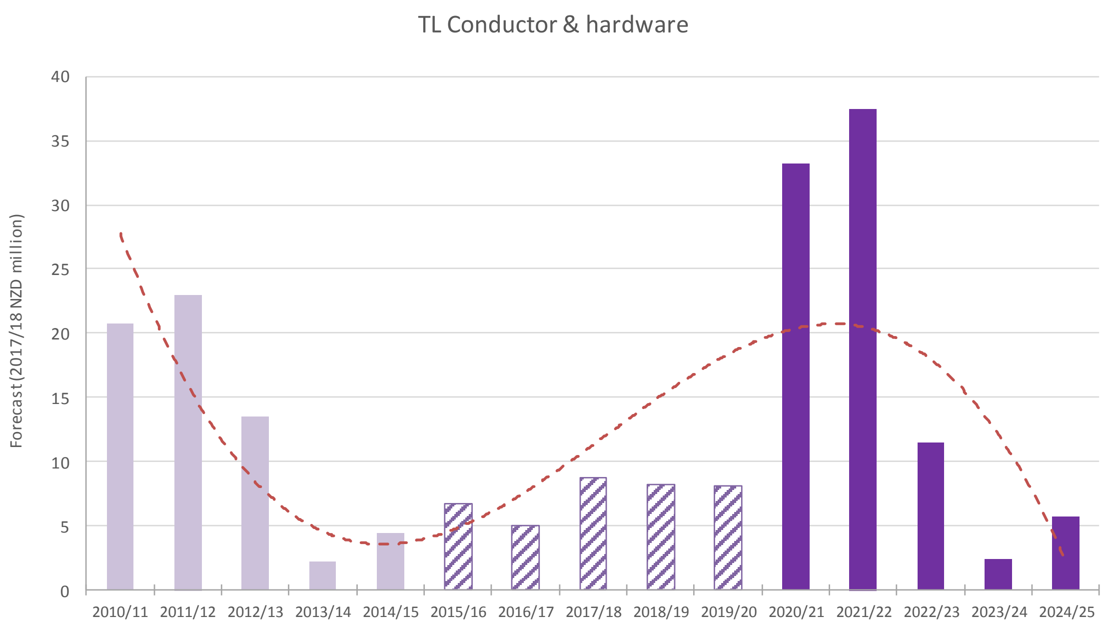
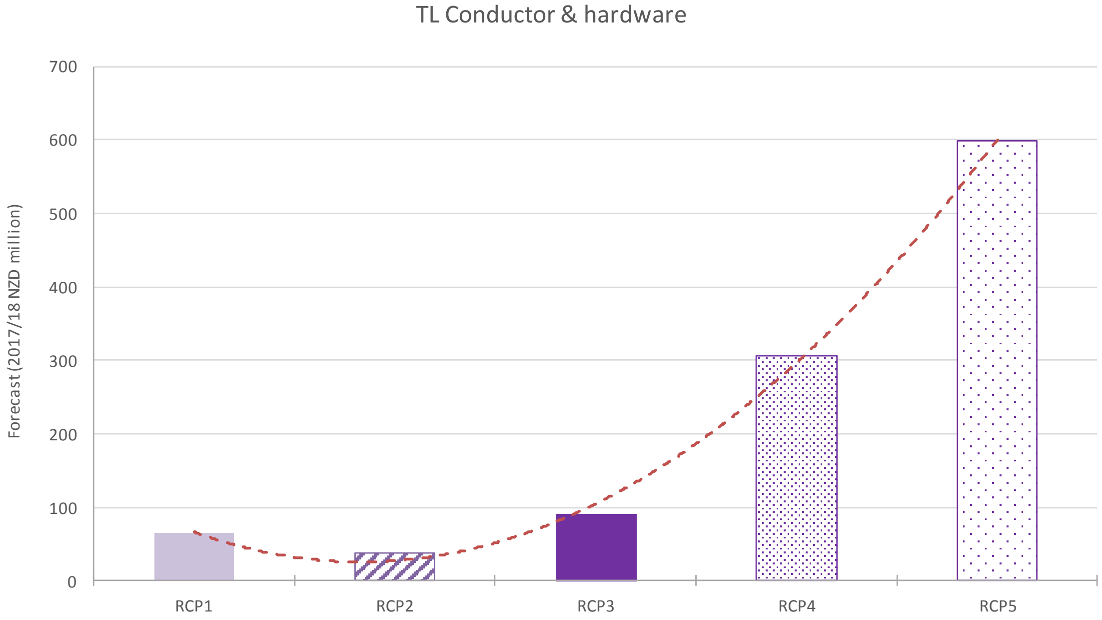


**Figure 45 Total TL Conductor & Hardware capex for RCP1 to RCP5**




Approximately 52,900 circuit spans of conductor (16,500 circuit kilometres), and 10,000 spans of earth wire (4,900 kilometres) are in service on the Grid.

For the RCP3 period, the conductor replacement volumes are assessed on a project-by-project basis and are approximately 40% lower than volumes predicted by the conductor asset health model. The conductor replacements in RCP2 will be lower than was forecast at the time of the RCP2 submission. The reduction in spend in RCP2 was mainly for the RCP2 Listed Projects and the deferral of interventions to RCP3, or further investigations reducing the scope of work.

Transpower has set this baseline forecast lower than the volumes predicted by the asset health model but higher than volumes predicted by some theoretical modelling scenarios considered. This difference is considered acceptable due to the uncertainty associated with the prediction, likely pessimism inherent in the current model, and future opportunities for innovation and the application of alternative strategies. We support this approach for RCP3.

The apparent large amount of work and expenditure shown in Figure 44 for Base Capex in 2020/2021 is being followed by the larger Listed Projects over the remainder of RCP3, which creates a work volume over the whole period that is smoother than may be suggested by Figure 44.

The RCP3 Base Capex quantities are based on the following:

- Conductor replacement quantities based on assessment of the specific assets and reflect likely solutions to replace or remove degraded conductors. Specific projects are included in the working RCP3 plan to address degraded conductor on a defined list of projects. Conductor condition reports are being prepared for each of these lines prior to the RCP3 proposal being submitted, which will assist identification in refining the scope.
- Earth wire replacements are based on a high-level analysis of the developing asset health model and an expectation to replace 350 spans of earthwire in RCP3.
- Under-clearance span management (capex). Transpower expects to complete known capex rectifications for spans on pole lines categorised as 'high risk' during RCP2 and the first year of RCP3. In RCP3, 48 capex rectifications in 2020/21 have been allowed, followed by an average of three additional capex rectifications per year thereafter at an average cost of $30k per rectification.

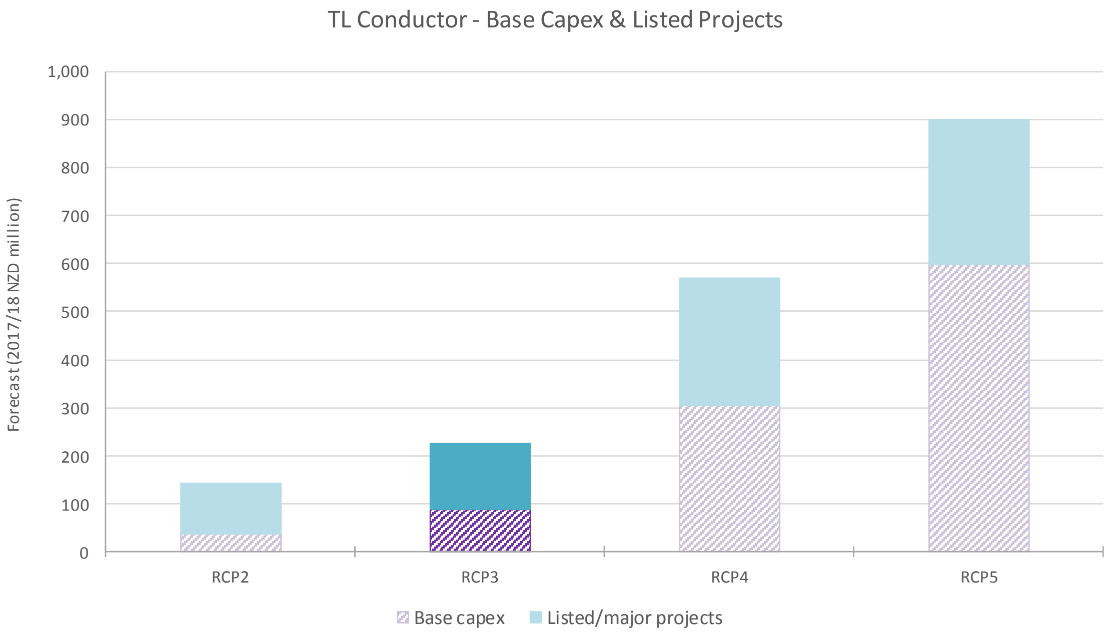
We note in Figure 45 there is a step change in expenditure in Base Capex from RCP4 to RCP5. Table 45 includes Listed Projects for total conductor replacements and the expenditure is $419 million forecast for RCP4 rising to $1,013 million in RCP5.

**Table 45 TL Conductor expenditure (including Listed Projects) for RCP2 to RCP5 ($2017/18 million)**[101]

| | RCP2 | RCP3 | RCP4 | RCP5 |
|---|---|---|---|---|
| Base Capex | 37 | 90 | 306 | 598 |
| Listed/Major Projects | 105 | 135 | 263 | 300 |
| **Total** | **142** | **226** | **569** | **898** |

101 Document [60], Table 14, p. 49

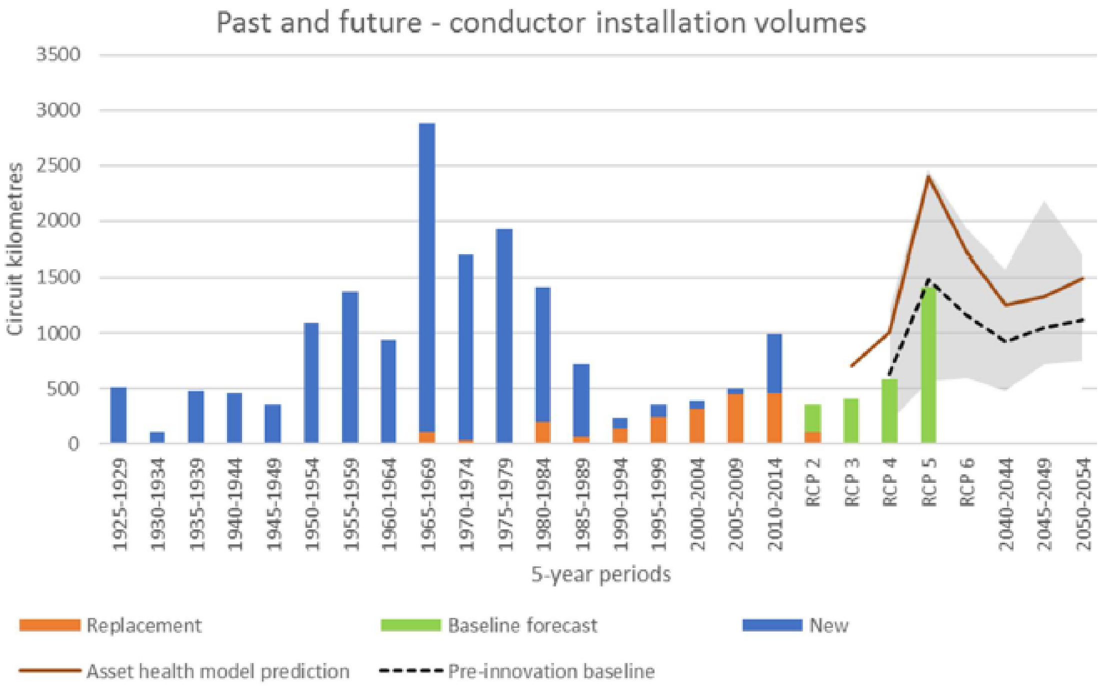
**Figure 46 Total TL Conductor expenditure (including Listed Projects) for RCP2 to RCP5**




Transpower has based these projections on the asset health model, stating that conductor replacement volumes may increase significantly in RCP4 and RCP5 – almost doubling in each of those periods. However, Transpower points out that the uncertainty in the asset health indicators and condition knowledge increases significantly for the future forecasts.

Figure 47 shows that the current AHI modelling is predicting higher volumes then Transpower has allocated in the forecasts for RCP4 and RCP5.

**Figure 47 Re-conductoring volumes (circuit km)[102]**




Transpower's long term forecasting of re-conductoring expenditure[103] noted a presentation in November 2017 to the Board, which indicated that revenue required beyond RCP5 to recover the increasing costs of re-conductoring will increase and peak in 2050 requiring 180% additional revenues compared to the recovery of costs in the RCP2 period.

We have analysed the long run average costs for reconductoring and estimate this to be around $1,100 million per annum, and hence we can confirm the size of Transpower's long-range forecast. The bulk of conductors are coming to the nominal end of life over the next 30 years (Over 60% of conductor assets were installed between 1950 and 1980), and this represents an average of around 1,700 km to be replaced over each period for 35 years from RCP5 onwards, with replacement costs of $650 million per cct km).[104]

However, Figure 47 indicates the volume capping at 1,500 km and reducing after RCP5 and beyond. Initiatives to extend conductor life may defer the expenditure however the peak is still likely to occur with the 35 year period beyond RCP4. Reducing the peak

102 Document [60], Figure 14, p. 45

103 Document [113]

104 Transpower, *Transmission Line - Conductors and Hardware: Asset Class Strategy*, Figure 1

volume would only seem possible if the volume of conductors are no longer required for the network.[105]

This view beyond RCP4 is important to RCP3 expenditure with respect to supporting Transpower's investment in asset strategies to improve the AH forecasting model, condition inspections and knowledge of conductor assets, and the planning, scheduling and deliverability of re-conductoring projects with the aim to minimise costs into the future.

A strategy, for example, may be to bring forward expenditure into RCP4 as being prudent to allow capacity to ramp up for the long-term deliverability of the programme into RCP5, RCP6, and beyond. Lowering re-conductoring costs per km and efficiencies within the whole program should be a focus over RCP3 and RCP4.

We consider that Transpower should identify a target for future cost reductions and other initiatives required to validate future projections for reconductoring volumes and costs:

- An increase in Opex budgets for proactive investigations as outlined above should be justified through a business case evaluation of operating costs versus the long term benefits and risks.
- Reduce overall lifecycle costs and risk by using pre-qualified vendors, detailed specifications and economies of scale approach, and ensuring that Transpower staff, Engineering Consultants and Service Providers work closely throughout the design and build process.

**Asset Health Modelling - TL Conductor and Hardware**

Asset health models for conductors and earthwires are relatively new and still developing. The conductor asset health model calculates an expected asset life for individual conductor spans, and groups of spans into line sections. These line sections share three properties – circuit, conductor type, installation year – and are contiguous.

The model is a theoretical approach to predict end of life based on relatively high-level inputs – corrosion code, installation year, conductor type, grease and grease defect information. The model output can then be modified by manual adjustment to the predicted end of life.

The current Asset Health Model itself does not underpin the input values (volume of conductor to be replaced) determined for RCP3. Transpower uses the asset health model

[105] Document [60], p. 18

to identify sections of line that are likely to require replacement during the planning horizon and then uses non-destructive Cormon testing on a random selection of the identified sections to verify condition. Condition information from the testing, close aerial surveys, and destructive sample testing is then considered by subject matter experts, and factored into the end of life predictions as a manual adjustment. It is expected that these adjustments will also begin to inform the condition assessment methodology and asset health models to provide improvements for further development of the models during RCP3.

Application of this process provides a bottom-up investment plan for conductor replacement in RCP 3. Conductor assets and replacement volumes are assessed on a project-by-project basis for the RCP 3 forecast, rather than being driven solely by the volumes predicted by the conductor asset health model.

Many conductors sections in the portfolio are predicted to reach end of life over the next 15-20 years, although there is significant uncertainty in this prediction as:

- asset health models for conductors and earthwires are relatively new and still developing
- the nature of conductor degradation is relatively complex
- detailed condition assessment data is not available for all of the conductor spans
- degradation modelling for conductors and earthwires is relatively difficult.

The current Asset Health Model developed in RCP2 does not use condition information in the base logic, apart from where this condition information is taken into account by a subject matter expert. This current version of the model makes the condition assessment (CA) information visible to the subject matter expert in a systematic way, but does not have inbuilt logic to build into an end of life adjustment. Condition information for conductors is expensive and time-consuming to obtain, and not always representative of the condition of the wider line or line section and it will take time for feedback information to inform the asset health model for conductors.

While the accuracy of predicting the distribution of life expectancy for selected segments of conductors is currently difficult the Asset Health Model could be developed further with distribution functions for life expectancy by segment which would then lead to high and low forecasts of future expenditure. Based on actual condition assessments undertaken to date, Transpower calculates that the forecasted end of life is currently only only accurate to ±10 years at best. Transpower also has compared the asset-specific view (condition assessments) to the current asset health model predictions for RCP 3 which proved that the current asset health model is conservative when forecasting actual RCP3 conductor replacement needs. We agree with Transpower that this pessimism is considered acceptable as the model is used to trigger detailed condition assessment activities on assets predicted to require intervention.

Transpower recognises the scale of possible reconductoring work in growing in RCP 4 and RCP 5, and beyond, hence over RCP 2 and RCP 3 they are increasing investment of time and resources into innovation, condition assessment activities, and planning to improve the longer-term forecast. This approach mitigates the risk of RCP4 becoming not deliverable, by providing lead time to resource a possible increase if it emerges. It also mitigates the risk of early investment, which may not be economic or required, until more certainty around the future need and management strategies is available.

In terms of the asset criticality component of the model, significant work has been done during RCP2 to assign criticality classes to spans and structures. This requires making quantitative estimates of the likely impacts of conductor failures on service performance and safety on a span-by-span basis. The model is being used to forecasts replacement capital costs into the future and despite the current inaccuracies in the current model it is highlighting the importance of the program of improvements to conductor management aimed at reducing a likely $200 million per annum plus expenditure on conductor replacement in the future.

In the short term there are benefits to be achieved by improving the ability to better identify conductor segments most likely to be approaching end of life so as to limit the high costs of condition monitoring to these more likely segments. Opex expenditure aimed at improving and limiting the cost of conductor condition monitoring is justified. Improving the accuracy of the asset health model will occur as a result of improved condition monitoring but should not be a high priority in itself.

Transpower is predicting a reduction in peak expenditure for conductors due to the current conservativeness in the asset health model. We do not agree that the conservativeness in the model in life expectancy of conductors will reduce the expenditure peak (35 year duration) but rather it will defer the beginning of the peak period some 10+ years and not reduce its duration. This does have benefits in terms of current NPV but will not shield customers from the eventual revenue requirements to recover these costs.

We consider Transpower should identify a target for future reductions in conductor replacement costs to justify a budget for proactive investigations into delivery and scale efficiencies for reconductoring projects. A business case could justify an even higher level of current Opex expenditure in RCP3 for these investigations.

**Asset strategy, planning and estimating - TL Conductors and Hardware**

The main strategies for TL Conductors and Hardware are set out below:

- Build new, and uprate existing lines, to ensure that the required capacity and reliability is achieved whilst minimising lifecycle costs;
- Repair conductors when analysis shows that localised sections have reached end of life, and replace where ongoing management costs and risk are unacceptably high; and
- Invest in technology and research during RCP3 on conductor condition deterioration, failure modes and condition assessment with the longer term aim to minimise future capital expenditure on conductor replacements.

The predominant intervention within the TL Conductor portfolio is re-conductoring. The projects (or alternative solutions) are considered at the specific project level, unlike other replacement and refurbishment work on TL assets (e.g. insulators, poles, tower painting) which are more 'volumetric' (ie many small projects, rather than a few large projects). Work in the conductor portfolio also includes, earthwire replacement, interphase spacer installation, conductor condition assessment, conductor repairs, joint testing and repairs, spacer and damper replacement, aerial laser surveys (ALS) and under-clearance management.

Transpower has experienced particular issues with some ASCR conductors manufactured before the mid-2000's which have inconsistent grease application, with many conductors having patches of little or no grease (referred to as 'grease holidays'). This inferior barrier to corrosion reduces the expected useful life of conductors and this issue is a key driver for conductor replacement projects.

Conductor management is a complex exercise and needs to consider the most cost-effective approach for repair or replacement, including sub-span, span or section replacement approaches. A high-level conductor planning process is used to determine the final conductor programme. Detailed condition assessment is triggered by the predictive modelling (asset health model) or feedback from site. Based on the results of this condition assessment and the operating context for the line, an asset-specific management strategy is selected on a project-by-project basis.

The next steps range from continued monitoring, through to repairs, replacement or removal. Application of this process results in a bottom-up investment plan for conductor replacement for RCP3.

Transpower has recognised the uncertainty about the quantities predicted and the deliverability of the forecast work volumes in RCP4 and RCP5, as well as uncertainties associated with Transpower's future capabilities and strategies for managing the condition and risk across this portfolio. Given the uncertainty in the longer-term forecast, the approach for the RCP3 planning for re-conductoring is to:

- continue to apply a least whole-of-life cost approach to project specific replacement decisions; and
- increase innovation, condition assessment activities, and planning resources over the rest of RCP2 and early RCP3 to position and better understand the likely RCP4 need before the RCP4 submission and improve the longer-term forecast.

This approach mitigates the risk of the RCP4 re-conductoring programme becoming undeliverable, by providing lead-time to resource a possible increase if it emerges. Transpower has stated that this also mitigates the risk of early investment, which may not be economic or required, until more certainty around the future need and management strategies are available. While it is true that extending life provides value in deferred investment, it may in fact cost more due to a shortage of delivery capability and with that cause greater risks.

Transpower has also improved the estimating approach for the RCP3 submission. In RCP2, cost estimates applied a top-down approach based on a review of each line section proposed for re-conductoring.

For the RCP3 preparation, Transpower generates TEES estimates based on scopes produced through high level engineering analysis and risk workshops with the local external service providers. These estimates use specifc re-conductoring, high-level building blocks and build on the methodology used for RCP2.

We consider this approach to estimating re-conductoring projects has improved the forecasting accuracy for RCP3.

Given the degree of uncertainty in the current AHI model for TL Conductors, upon request Transpower provided samples of engineering analysis/reports that provide the justification for conductor replacement projects currently in the Base Capex for RCP3:

- Failure Analysis of ACSR Zebra
- Conductor Condition Report
- Conductor Sample test report example
- NL5 Aerial Conductor Inspection Report Tensile test report example
- Overhead Line Corrosion Detector Report

Transpower also explained further the process to justify the work included in the Base Capex plan. The range of engineering analysis includes:

- Collection of condition data and assessment
- Review of the asset health model and available condition data. This has involved a series of workshops with internal and external subject matter experts, where each line section intervention predicted to be required by 2050 was reviewed. If the apparent condition was in better or worse condition than predicted, and there was sufficient information to draw a reasonable conclusion, then an adjustment was made to the model.
- Based on this review, Transpower generated a list of conductor replacement work (11 projects) that may be required in RCP3, and prepared cost estimates
- Transpower collected additional condition information where required and undertook further planning work to refine the Base Capex projects included in the overall portfolio.

Transpower provided an example a draft conductor condition report for the BPE-WIL-A (JFD-WIL section) project. The forecast value of this Base Capex project is $36.5 million, which represents 68% of the Base Capex re-conductoring work (or 38% of the total portfolio).

A key point is that in this portfolio it is the asset-specific condition information, utilization, and context of the line that drives inclusion in the programme. The asset health model alone does not drive Base Capex re-conductoring projects in RCP3 without this further asset-specific support, so any uncertainty in the AHI model does not have a material impact on these projects in RCP3.

**Key Drivers for TL Conductors and Hardware in RCP3**

The key investment themes associated with the TL Conductors and Hardware portfolio in RCP3 are:

- Replace the increasing number of degraded conductors, earthwires, and hardware as they reach end of useful life, based on actual condition assessments of conductors involving identified projects.
- Increase inspection, testing, and repairs above RCP2 levels to increase the accuracy of the future forecasts, and manage the condition and operational risk associated with the ageing infrastructure.

- Continue to manage and rectify spans with insufficient clearances to conductors.
- Minimise expenditure on re-conductoring by deferring projects that are justified based on actual condition and thereby create the opportunity for alternative approaches to be captured.

**Verification assessment of Conductors and Hardware**

We have reviewed the Asset Health (AH) Model and the development for TL Conductor and Hardware and found:

- The approach to the management of the conductor and hardware asset fleet is at an advanced level of maturity based on our analysis of the asset class strategy, use of the asset health index model for expenditure forecasting and for triggering conductor condition monitoring, and with the approach taken to determine asset strategies at a project level.
- The AH Model for the asset class is being applied to forecasting conductor replacement requirements but it was not used directly to determine input volumes for the RCP3 forecast. The model informs targeted condition assessment programs providing condition data which is the basis for the forecasts.
- The current Asset Health Model developed in RCP2 is relatively new and does not use condition information in the base logic, apart from where this condition information is taken into account by a subject matter expert. The implication to RCP3 is that the model itself does not directly determine the forecasted volumes.
- Asset Criticality and the AH model improvements are still required however this does not a significant impact on the current forecasts for RCP3.
- Predicting the life expectancy for selected segments of conductors is currently difficult. The Asset Health Model could be developed further through the use of distribution functions of life expectancy by segment which would then lead to high and low forecasts of future expenditure.
- We agree with Transpower that the current pessimism in the model is acceptable as the model is used only to trigger detailed condition assessment activities on assets predicted to require intervention.
- Transpower is predicting a reduction in peak expenditure for conductors due to the current conservativeness in the asset health model. We do not agree that the conservativeness in the model in life expectancy of conductors will reduce the expenditure peak (35 year duration) but rather it will defer the beginning of the peak period some 10+ years and not reduce its duration.

- We consider Transpower should identify a target for future reductions in conductor replacement costs to justify the budget for proactive investigations into delivery and scale efficiencies for reconductoring projects.

A business case could justify an even higher level of current opex expenditure in RCP3 for these investigations. Due to cost and complexity, Transpower does not have detailed condition assessment data for all conductor spans on the network. Over the remainder of RCP2 and in RCP3 the intention is to increase this programme of work to help ensure that suitable data can support replacement works and support better long-term planning. At present, Transpower has detailed condition assessment data for less than 30% of conductor assets. As this data becomes available, forecast expenditure within each future RCP will become more accurate as a direct output of the AHI model.

We are satisfied that Transpower's management processes and strategies will identify the conductor sections requiring replacement and that the programme will firm towards the start of the RCP3 period.

However, due to the timeframes and complexity required to develop detailed scopes and delivery methodologies for each larger re-conductoring project in the Base Capex forecast, the estimates that are developed for each project identified for inclusion have a high level of variability.

Transpower has explained that there are cost estimation risks for large conductor replacement or removal works in RCP3 which may be significant. While some cost estimates have an accuracy of ±30%, most of cost estimates have an accuracy of ±50% at this stage in the planning process. Some of the variations in costs can be attributed to access and site conditions and other impacts specific to each re-conductoring project.

The TEES building block rates generate P50 estimates and are based on average completed costs. The P50 estimates mean that some projects are expected to cost more, and others are expected to cost less, but across the portfolio the average unit rate and overall expenditure is expected to balance out. This risk is expected to be managed through scope changes or portfolio substitutions.

The asset management objectives for each of the portfolios are supported by the asset strategies and are linked to grid output measures, through condition codes and service level targets.

Transpower provided strong evidence that the building block costs are based on feedback from actual project costs; however, there was little evidence of a drive to improve efficiency in the delivery of the work. We recommend inclusion of strategy initiatives to include a summary of improvements in delivery efficiency.

As projects are predominately identified within this portfolio, with scopes and high level estimates prepared in each case, there is a low risk of the forecast being high for the work required in RCP3:

- How is the AH Frameworks being applied to determine input values and the degree of conformance to actual input values determined for RCP3
- Improvements made in RCP2 to the AM Strategy and implication to RCP3
- Asset Criticality/AHI Frameworks improvements still required; impact of it not being achieved to date – hence priority of improvement

Based on our analysis of the asset class strategy, condition assessments and modelling outcomes provided by Transpower, we verify that the investment in conductors and hardware is reasonable and adequate. Transpower has demonstrated efficiency improvements over the RCP2 and previous regulatory periods and Transpower is continuing to address current issues and technology opportunities. Furthermore, deliverability has been built into forecasts for RCP3.

We have analysed the long run costs for re-conductoring and estimate this to be around $1,200 million per reset period from 2030 onwards and potentially for the 30 year period to 2060. Transpower has confirmed this outlook of expenditure peaking around 2050. This view beyond RCP4 is important to RCP3 expenditure in terms of supporting Transpower's investment in asset strategies for improving the AH forecasting model, condition inspections and knowledge of conductor assets, and the planning, scheduling and deliverability of re-conductoring projects.

Overall, we believe Transpower's RCP3 TL Conductor and Hardware forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - TL Conductor and Hardware

Table 46 summarises our verification assessment and opinion.

**Table 46 Verification summary - TL Conductor and Hardware**

| Expenditure category | Capex - TL Conductor and Hardware | |
|---|---|---|
| **Transpower RCP3 forecast** | $90.2 million | |
| **Recommendation** | **Accept:** $90.2 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Advanced level of maturity in management of fleet | N/A |

| | | |
|---|---|---|
| | demoinstrates prudency of RCP3 forecast<br>* Demonstrated efficiencies over RCP2 | |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | * More detailed condition assessment data for all conductor spans on the network | N/A |
| **Potential scope for improvement** | * Asset Criticality and Asset Health model improvements<br>* Identify target for future reductions in conductor replacement costs to justify budget for proactive investigations into delivery and scale efficiencies for re-conductoring projects<br>* Strategy initiatives for improvements in delivery efficiency | N/A |

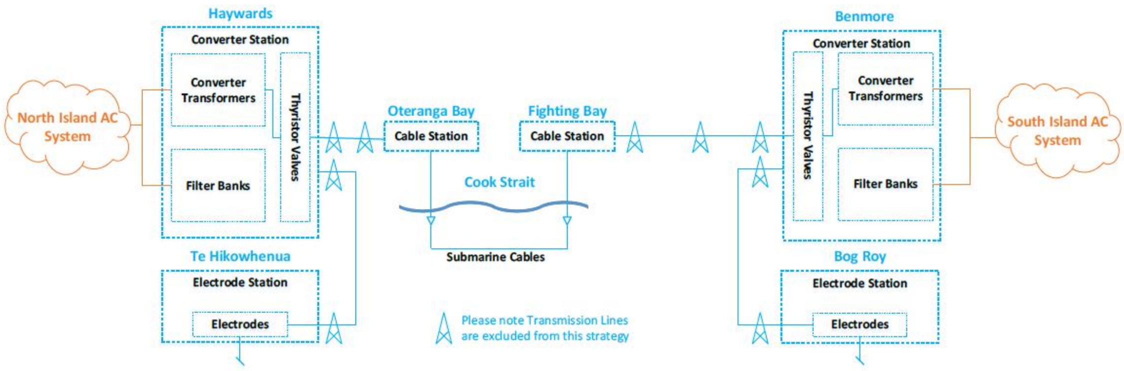
### 7.3.2 Grid capex - HVDC and Reactive Assets

*HVDC Assets*

The asset strategy and expenditure forecasts for the HVDC assets are detailed in the HVDC Assets Portfolio Management Plan and the corresponding HVDC Asset Class Strategy.

The HVDC inter-island link electrically connects the North Island and South Island and enables energy transfer between the islands. The link supports the national electricity market by providing North Island consumers access to South Island hydro generation, and South Island consumers access to North Island thermal generation, which provides increased security of supply in dry years. Figure 48 shows the assets that comprise the HVDC system.

Figure 48 HVDC high-level overview




The HVDC converter stations include a diverse range of equipment, some of which is highly specialised. There are challenges in managing HVDC equipment, because of the small population of largely unique equipment in service. There is only a limited experience base on which to build a detailed understanding of potential failure modes and develop appropriate condition assessment and risk management strategies.

The expenditure for the HVDC assets exclude the HVDC overhead transmission lines, electrode line and supporting structures, and excludes the Haywards synchronous condensers and STATCOM 31 which are part of other expenditure portfolios.

The HVDC assets are managed by Transpower as an "asset facility" similar to power stations and distinct from "asset classes" which are typically the structure for network assets In many regards the function of the HVDC system and how it operates on the grid is like that of a power station.

Transpower has forecast a total capex for HVDC in RCP3 of $64.6 million in real 2017/18 dollars. Table 47 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 47 Comparison of HVDC RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| HVDC | 27.4 | 64.6 | 136% |

Table 48 shows the annual forecast capex for HVDC in RCP3 in real 2017/18 dollars.

**Table 48 Annual forecast capex for HVDC in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| HVDC | 4.6 | 14.1 | 14.9 | 14.9 | 16.1 | 64.6 |

Figure 49 shows the annual HVDC capex for the regulatory periods RCP1 to RCP3, and Figure 50 shows the total HVDC capex for the regulatory periods RCP1 to RCP5.

**Figure 49 Annual HVDC capex for RCP1 to RCP3**

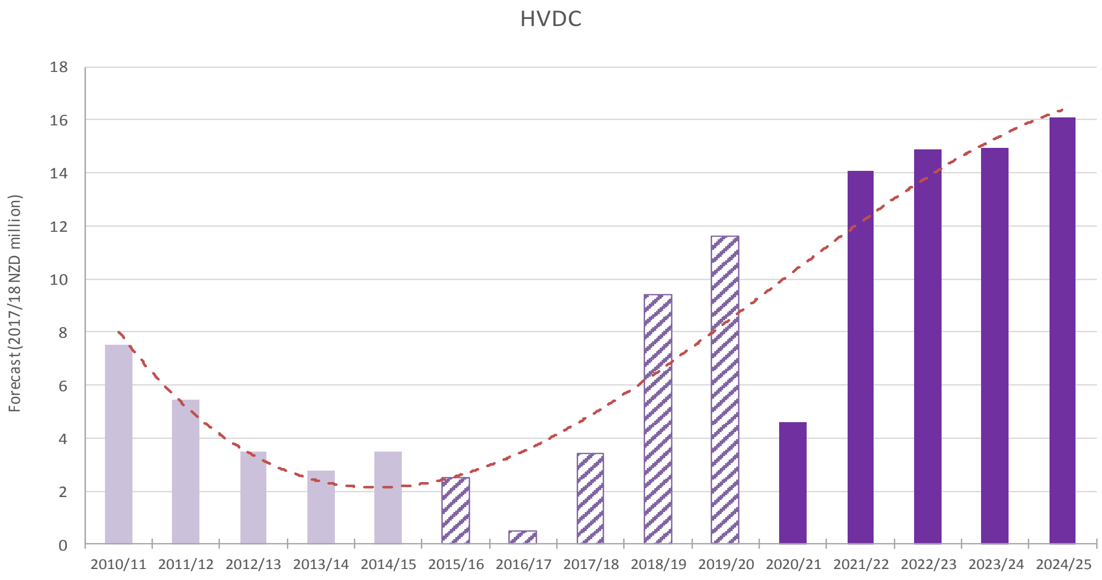
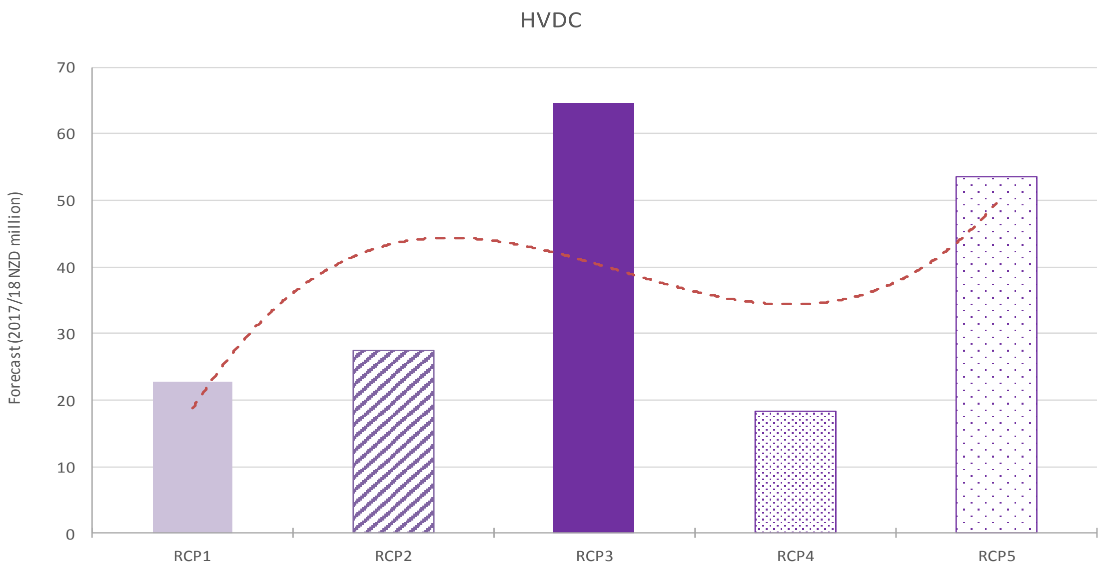



**Figure 50 Total HVDC capex for RCP1 to RCP5**




The HVDC converter stations located at Haywards and Benmore contain HVDC converters, auxiliary and secondary systems, AC and HVDC primary assets, and reactive power assets. The converters comprise many smaller components and subsystems. For example, valve stacks include thyristor valves, fibre optic cables, snubber circuitry, cooling pipes, etc. The HVDC system also includes converter transformers, wall bushings, smoothing reactors, filtering equipment, measuring systems, disconnectors and earth switches, and many other HVDC assets which are necessary for HVDC transmission.

HVDC control and protection systems control the power flowing through the system and protect HVDC assets when fault conditions are detected. Control and protection systems are fully redundant and are vital for the operation of the HVDC system.

Most of these assets can be divided into two categories based on their age. Pole 2 and the associated AC and HVDC assets (commissioned in 1991) and Pole 3 assets (commissioned in 2013).[106]

Pole 3 assets are still in good condition. The Pole 2 control and protection system and some primary assets were also replaced at the same time as the Pole 3 project between 2010 and 2013. The remainder of Pole 2 assets, except the building and the valve stacks, are either being replaced in RCP2, or are planned to be replaced or refurbished during RCP3 to extend the life expectancy of the entire Pole 2 installation to achieve the expected 50-year Pole 2 life expectancy.

Delaying this work will increase the risk of asset failure and result in assets having a remaining life that extends beyond the end of life of the whole Pole 2 installation. Most of the RCP 3 expenditure in this portfolio is related to Pole 2 life extension works covering:

- refurbishing converter transformers including transformer bushings replacement
- replacing wall bushings (both AC and HVDC)
- replacing / refurbishing HVDC primary assets
- refurbishing secondary and auxiliary systems
- improving seismic performance of HVDC buildings
- refurbishing AC filter banks

[106] The HVDC system pole is the part of an HVDC system consisting of all the equipment in the HVDC substation. It also interconnects the transmission lines that during normal operating condition exhibit a common direct polarity with respect to earth. Thus, the term “pole” refers to the electrical path of DC flow that has the same polarity with respect to earth. The total pole includes substations, transmission line and cables.

- enhancements to other HVDC assets, such as upgrading the Windows-based operating system on HVDC computers, improving HVDC local supply security, and fire system upgrades.

The three HVDC submarine cables (Cable 4, 5, and 6) were commissioned in 1991 and have a life expectancy of 40 years. Transpower has undertaken a life expectancy assessment of the submarine cables, based on assessing expected operating and ageing parameters for submarine cables. The results of the life expectancy study indicated that the cables may have different life expectancies due to differences in submarine environment exposure. The assessment indicated that Cable 4 has an expected life of approximately 34-44 years, while other two cables are expected to last over 40 years.

Annual electrical testing and submarine cable surveys of the cables are carried out to detect any cable deterioration in advance.

**Asset Health Modelling - HVDC Assets**

There are no specific Asset Health Modelling and Criticality strategies for this fleet. Knowledge can be established with a relatively high degree of confidence as AC system assets typically have large populations and have well understood electrical, mechanical and environmental stresses.

In contrast to the AC system, Transpower states that the HVDC link consists of assets that:

- have small and diverse populations
- require highly specialised knowledge to operate and maintain
- have limited data on failure modes, even internationally, as the equipment rarely fails in service due to proactive renewal (given its high criticality)
- are subject to unique electrical stresses requiring highly specialised design and materials.

The asset management approach for HVDC assets is consequently different to that for AC systems. Our long-term replacement and refurbishment plans are informed by expected lives, which are based on manufacturer recommendations and advice from specialists. Actual interventions are triggered by specialist condition assessments, failure modes and asset by asset strategies. The asset management approach is reliability based are consistent with the approach used in process facilities including power stations.

The approach taken to develop the strategies and capital program for RCP3 is appropriate and consistent with above asset-by-asset reliability and risk based approach.

With improving asset knowledge, Transpower has stated that they will consider whether there are potential benefits to develop a specific HVDC asset health model. We recommend the model should still be a bespoke asset health model which can be consistent with the overarching Asset Management Framework but should be based on asset criticality and condition models used typically in power station facilities.

The HVDC system is a key component of the power system and a primary enabler of the electricity market. Its integration with the market makes it an economic investment requiring a bespoke service performance criticality model (versus other asset classes). Given that the HVDC criticality framework uses the market cost of HVDC outages rather than value of loss load, the HVDC criticality framework cannot be used to compare HVDC assets to their AC counterparts.

Future improvements to the asset management of the HVDC assets are:

- Date updates including asset populations, performance data, and asset feedback information.
- Development of an Asset Strategy Plan to reflect the content and structure of the Strategic Asset Management Plan and the Decision Framework.
- Updating asset objectives and measures based on new performance information and alignment to SAMP objectives.
- Explicit linkages between objectives and supporting strategies to be set out.

**Asset strategy, planning and estimating - HVDC Assets**

Transpower's general asset management approach for AC system equipment is, first, to establish and understand common failure modes. Asset health models are then developed, which help specify replacement, refurbishment, and maintenance triggers to manage these identified failure modes.

This knowledge is well-established with high confidence for AC system assets typically with large populations, international data and with well-understood electrical, mechanical and environmental stresses. In contrast, the HVDC link consists of assets that:

- have small and diverse populations
- require highly specialised knowledge to operate and maintain
- have limited data on failure modes, even internationally, as the equipment rarely fails in service due to proactive renewal (given its high criticality)

- are subject to unique electrical stresses requiring highly specialised design and materials.

Consequently, the asset management approach for HVDC assets is different to that for AC systems. The long-term replacement and refurbishment plans are informed by expected lives based on manufacturer recommendations and advice from specialists. Actual interventions are triggered by specialist condition assessments. The outputs of these assessments refine the planned interventions and their timing. These condition assessments require detailed planning as they can only be undertaken during short annual outages, which is like power station plant condition assessment. In summary interventions for HVDC assets is condition-based.

The key strategies for achieving these objectives are:

- Replace and refurbish Pole 2 and 3 equipment when it reaches manufacturer's recommended operating/duty limits, or reaches expected life;
- Ensure sufficient plans, skilled manpower and emergency equipment are in place to enable rapid restoration of HVDC transmission service following failure; and
- Maintain necessary resources to undertake a prompt cable 'cut and cap' operation, to reduce water propagation in the insulation, in the event of a fault.

As Pole 2 has a design life of 30 years, most of the Pole 2 assets are reaching their end of design life and the remainder of Pole 2 assets are either being replaced, or are planned to be replaced or refurbished in RCP3. Life extension work is required to obtain the expected extended 50-year life for Pole 2. Accordingly, a comprehensive life extension programme has been planned for Pole 2 and the majority of the HVDC expenditure in RCP 3 will be driven by continuation of mid-life refurbishment work on Pole 2.

RCP4 work is then expected to reduce to conducting routine replacements and refurbishments. The replacement of remainder of Pole 2 primary AC assets will coincide with refurbishment and replacement of some Pole 3 assets and its secondary systems commencing in RCP5, which will continue across RCP 6.

Due to the uniqueness and long lead times for HVDC assets, most are covered by emergency spares. These are either located on site, Miramar cable station, or at one of the Transpower warehouses. Where practical, testing and/or condition assessments of the spares are carried out every 8 years to identify the need for procuring more spares and for emergency planning purposes. The converter transformer spares located at each site require minor refurbishments if they are expected to reach a life of 50 years.

The proposed replacement capex works is considered in conjunction with other scheduled programmes of work to achieve synergies with other planned works, outage planning, and to minimise market impacts. A key objective is to reduce the number of planned HVDC outages required and to achieve delivery efficiencies. Assets that fall under the same outage block will be grouped together to reduce outage requirements (i.e. HVDC local services supply-related assets such as transformer circuit breakers, transformers, switchboards, etc.).

Work is then planned based on resource availability; what can be managed within the annual maintenance outage, electricity market behaviour constraints, and availability of specialised resources (i.e. cable laying vessel).

Based on the outcome of this process, the work is packaged considering equipment positions or assets types and then scheduled as a whole project. The need for the work, work packaging and scheduling are reviewed by HVDC subject matter experts throughout the process to ensure key issues are addressed and the proposed work is achievable. This is approach is again standard practice in power stations.

As the HVDC system is a unique asset class, the work is predominately bespoke and capital works are characteristically one-off projects. This reduces the extent to which historic project costs can be relied on to forecast future project costs. The cost estimation for each project is therefore customised, accounting for the specific context, risks, and requirements of the project, and requiring specialist manufacturer support.

The projects for RCP3 (predominately Pole 2 midlife) are priced through estimates sought from manufacturers, previously supplied quotes, and discussions with other HVDC owners with comparable assets. The Transpower HVDC team collectively challenge the costs prior to setting the baseline investment plan, and consider this approach the best practice possible given the limited competitive market place for the supply of HVDC equipment and services and considering the advantage that the Original Equipment Manufacturer (OEM) has in providing replacement assets and the project work in many cases.

Business Cases are developed using information from suppliers, asset information systems, and other internal and external resources. Due to the unique nature of HVDC projects, a standalone Delivery Business Case (DBC) is prepared for each build project. Where required, Investigation Business Cases (IBC) are prepared to seek funding to undertake formal capital investigations. Capital investigations help with narrowing the scope and confirming the budget for the specific build project.

**Key Drivers for HVDC Assets in RCP3**

The key driver for RCP3 projects is the end of design life for Pole 2 of 30 years.

Refurbishment work in RCP3 is prudent to avoid under-utilisation of new assets and to minimise the risk of asset failures due to delayed interventions. If this work is delayed, the availability of the HVDC system will start to degrade over time due to reducing reliability of Pole 2 era assets.

**Verification assessment - HVDC Assets**

Due to the specific project expenditure on Pole 2 assets in RCP3, upon request, Transpower provided a copy of the planning document for HVDC Assets Pole 2 to review more detailed information for the project justification.[107]

This document detailed additional information on the justification for this project:

- Delaying life extension work beyond RCP3 would increase risks without increasing benefit and Pole 2 is unlikely to run for more than 50-55 years, supported by experience with Pole 1 and international experience (CIGRE Working Group). This working group gave confidence that a life extension of 15-20 years is achievable.
- Delaying investment into RCP4 would result in the new equipment being under-utilised and the old equipment being pushed past its design life, increasing the risk of failure.
- Bringing forward the replacement of Pole 2 into RCP4 at the end of the original design would be a very large and expensive project.
- Extending the life of Pole 2 to delay this investment is the least whole-of-life cost option.

Pole 1 was in operation for 47 years and this was considered a long life. CIGRE, the International Council on Large Electric Systems, has produced a paper on Guidelines for Life Extension of Existing HVDC Systems and Transpower was involved in this working group. From this group's work, international practice gives Transpower confidence that a life extension of 15-20 years is achievable.

The Pole 2 Plan reference document[108] provided an asset by asset analysis of the life extension work and we can verify from this review the proposed investments at the asset level are reasonable and adequate.

107 Transpower, *HVDC Assets Pole 2 Plan reference Document: Asset Status 2018*, March 2018, Document [65]

108 Transpower, *HVDC Assets Pole 2 Plan reference Document: Asset Status 2018*, March 2018, Document [65]

Transpower considers that Pole 3 at its current stage in its lifecycle can be reliably maintained in-service with only preventive and corrective maintenance, and does not require major capital expenditure.

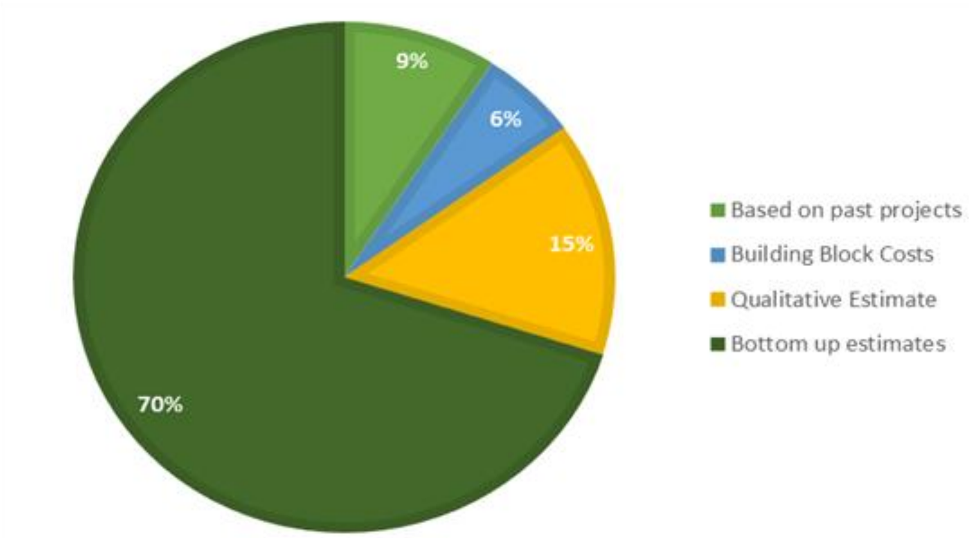
We have reviewed the consideration of an Asset Health (AH) Model for HVDC Assets and found;

- There is no Asset Health Model for the HVDC Assets consistent with the Asset Management Framework.
- The asset management approach for HVDC assets is need to be different to that for AC systems. Actual interventions are triggered by specialist condition assessments, failure modes and asset by asset strategies and the asset management approach is reliability based and consistent with the approach used in process facilities including power stations.
- The approach taken to develop the strategies and capital program for RCP3 is appropriate and consistent with above asset-by-asset reliability and risk based approach.
- Transpower has stated that they will consider whether there is potential benefits to develop a specific HVDC asset health model.
- We recommend the model should still be a bespoke asset health model which can be consistent with the overarching Asset Management Framework but should be based on asset criticality and condition models used typically in power station facilities. This should be a priority for RCP3.
- The HVDC criticality framework uses the market cost of HVDC outages rather than value of loss load, the HVDC criticality framework cannot be used to compare HVDC assets to their AC counterparts.

We agree with Transpower's view that due to the unique and diverse nature of the HVDC assets, asset health modelling is not applicable or practical. To support decision-making, HVDC assets are subject to specialist and individual condition monitoring and assessment. Several of the HVDC assets are monitored in real time and telemetry data is continuously fed back into the control and monitoring systems. Where possible, the trend in condition data and performance is analysed for early detection of asset failures. Hence the facility is managed with a high degree of ongoing condition-based maintenance and intervention.

In order to assess the accuracy of the price build up for this one off Pole 2 life-extension project, Transpower provided us with a breakdown of costs for HVDC assets,[109] which showed that the total capital forecast of $64.6 million was developed from 109 individual estimated items, with the highest individual line item less than $3 million. The prices for each bottom up estimate, which in total represents 70% of the total costs as shown in Figure 51, have a cost range of around ±20%. The accuracy for the total rolled up estimate will statistically be less than the individual items and hence we consider the proposed RCP3 expenditure estimate to be consistent in accuracy with TEES building block estimates for other identified capital programmes.

**Figure 51 HVDC estimating methods**




Based on our analysis of the asset class strategy, the Portfolio Management Plan and the HVDC Assets Pole 2 Plan Reference Document, we are satisfied the planned investment in HVDC assets is reasonable and prudent. Transpower has demonstrated in the HVDC Assets Pole 2 Plan that the approach described in the Portfolio Management Plan has been followed. We also consider the cost estimate build up is consistent with the work scope and with the asset strategy.

The asset management objectives for the portfolio are also supported by the asset strategies and will contribute to achievement of grid output reliability measures.

Transpower has arranged for consultations with key stakeholders to discuss the HVDC programme and these discussions will inform the decision whether this work remains

109 Transpower, *20180720 To IV HVDC breakdown* Excel model , Document [66]

as Base Capex or becomes a Listed Project in RCP3. This issue is discussed in Chapter 13 (Key issues for Commerce Commission's consideration) of our report.

We consider Transpower's RCP3 HVDC capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - HVDC Assets

Table 49 summarises our verification assessment and opinion.

**Table 49 Verification summary - HVDC Assets**

| Expenditure category | Capex - HVDC Assets | |
|---|---|---|
| **Transpower RCP3 forecast** | $64.6 million | |
| **Recommendation** | **Accept:** $64.6 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Reliable estimate of efficient costs based on historic project costs at item level<br>* Planned investment considered prudent based on asset class strategy | N/A |
| **Other relevant criteria from ToR** | General evaluation of the Base Capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | * Decision on whether project is Base Capex or Listed Project | N/A |
| **Potential scope for improvement** | * Develop bespoke asset health model consistent with the overarching Asset Management Framework based on asset criticality and condition models used typically in power station facilities | N/A |

*Reactive Assets*

Transpower's asset strategy and expenditure forecasts for reactive assets are detailed in the SA Reactive Power Portfolio Management Plan and three corresponding

Asset Class Strategies for Capacitors and Reactors, Synchronous Condensers and Static Var Compensators.

Reactive power is needed in an alternating-current transmission system to support the transfer of real power over the network. Transpower use a combination of static and dynamic reactive assets to supply the required reactive power.

This portfolio covers the following reactive power asset types:

- Capacitor banks
- Reactors
- Synchronous condensers
- Static Var Compensators (SVCs)
- Static Synchronous Compensators (STATCOMs), including those located at the HVDC converter stations
- Control and protection systems, auxiliary systems and primary assets directly related to the operation of synchronous condensers, SVCs, and STATCOMs.

Transpower has forecast a total capex for Reactive assets in RCP3 of $39.5 million in real 2017/18 dollars. Table 50 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 50 Comparison of Reactive assets RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Reactive assets | 9.4 | 39.5 | 320% |

Table 51 shows the annual forecast capex for Reactive assets in RCP3 in real 2017/18 dollars.

**Table 51 Annual forecast capex for Reactive assets in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Reactive assets | 8.9 | 8.7 | 6.6 | 11.7 | 3.6 | 39.5 |

Figure 52 shows the annual Reactive assets capex for the regulatory periods RCP1 to RCP3, and Figure 53 shows the total Reactive assets capex for the regulatory periods RCP1 to RCP5 indicating its lumpy nature.

**Figure 52 Annual reactive assets for RCP1 to RCP3**

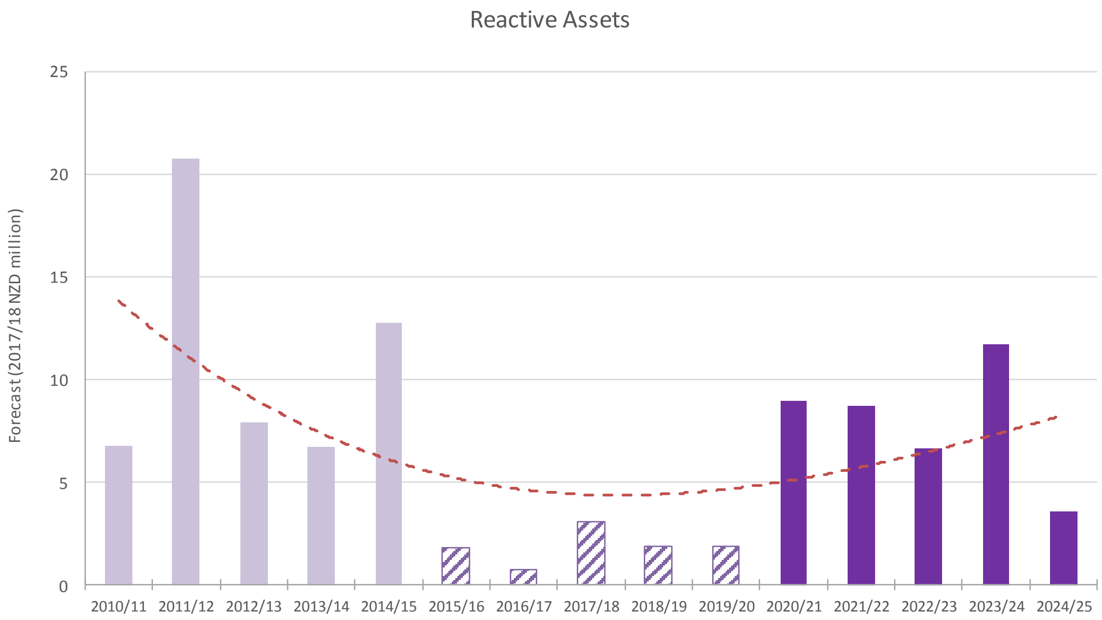
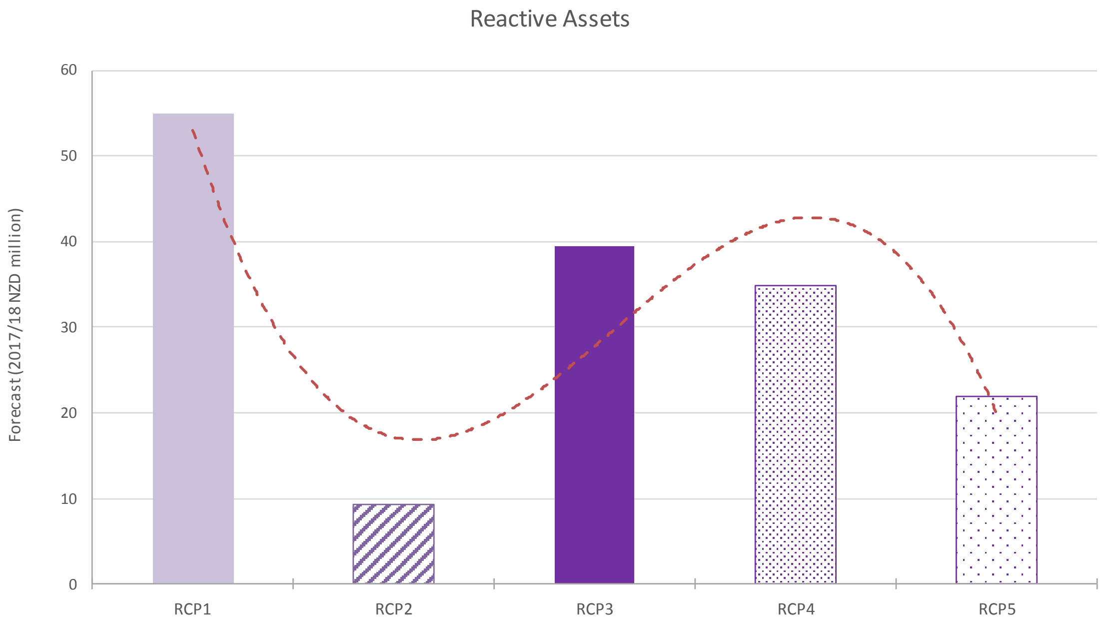



**Figure 53 Total reactive assets capex for RCP1 to RCP5**



**Asset Health Modelling – Reactive Assets**

Apart from capacitor banks, other asset classes covered under reactive plant do not use asset health modelling for expenditure planning. This is mainly due to relatively small and highly specialised asset populations.

- Reactors: Asset health modelling for reactors have not been developed as these are a simple and relatively few asset and can be retained in service using simple and low cost maintenance interventions.
- SVCs and Statcoms: Asset health modelling for these assets have not been developed as they are fewer in number (hence not a fleet of assets) and asset strategies can be best managed as individual assets with the specialist knowledge required.
- Capacitor Banks: Asset health modelling for the capacitor bank fleet is in its infancy and development is limited by historical capacitor can failures not having been recorded accurately. Updates the capacitor banks data structure will address this issue and enable better records of can failure rates, failure modes, capacitor can population age. This will eventually support development of an accurate asset health model. In the interim age and the probability of failure is used as a proxy for asset health.
- Synchronous Generators: Asset health modelling for these assets have not been developed as they are also few in number (hence not a fleet of assets) and asset strategies can be best managed as individual assets with the specialist knowledge required. The knowledge of synchronous condensers asset health is ongoing through regular assessment by independent rotating machine experts.

Transpower have initiated a data quality improvement initiative for capacitor banks in RCP2. A new data structure will divide capacitor banks down to capacitor can level and capacitor can failures can be recorded along with the cause of the failure, and improvements to standard maintenance practices are also expected to provide more quality asset information. This information will improve the accuracy of the capacitor bank asset health model.

A planned nationwide condition assessment of capacitor banks and reactors in RCP3 will improve the accuracy of long-term expenditure forecasts. This will also inform contingency planning and maintenance programmes.

Collection and monitoring asset condition and data quality poses some risk to whether the forecast for capital expenditure on reactive assets is sufficiently accurate. The relative size of expenditure and any increase in expenditure due to this risk would be manageable.

Transpower have developed a preliminary criticality model for capacitor banks which still requires further improvement. In some cases, network development studies have provided relevant information to determine the criticality of reactive power assets.

Reactive power assets do not fit in to standard network asset criticality frameworks. While they are primary equipment, their function serves regions, rather than individual substations, circuits, or branches. Therefore, a more complex criticality model is required to compare reactive power assets to other network assets. This will become more important changes if changes to occur to reactive plant due to the impact of changing load and generation centres across New Zealand.

In the regions where the power electronics assets are installed, there is typically little spare reactive power support capacity. Therefore, all power electronics assets are relatively critical. Transpower plans to develop a criticality model in RCP3 for reactive power assets that takes this into account and that provides information on which dynamic reactive power assets would have the greatest impacts if they failed.

The current approach is to assess criticality of power electronics equipment on a case-by-case basis as required, such as when replacement is being considered.

Transpower engage specialist advisors for assessing asset strategies for their synchronous generators and these advisors also provide a risk management tool that considers the design with operational, maintenance and test data in the model to identify and determine intervention actions.

**Asset strategy, planning and estimating - Reactive Assets**

The main strategies for Synchronous Condensers are set out below.

- Undertake major overhauls to extend the life of the synchronous condenser main units, typically at 15-20 year intervals, or based on condition.
- Apply a condition-based approach for planning replacement for primary and auxiliary equipment associated with each synchronous condenser.
- Apply a risk-based approach to planning the replacement of control, protection, monitoring and excitation systems associated with synchronous condensers, including consideration of risk arising from obsolescence and the availability of parts and support from original manufacturers.

- Maintain synchronous condenser assets at a level that will ensure continuing acceptable levels of safety and reliability performance.

Transpower has a key strategy for reactive plant to retain on-going access to essential professional, technician and trades skills, in particular, for the maintenance and support of the synchronous condensers. For example, Transpower has a safety-critical requirement for 24-hour access to approved handlers to operate the gas management systems of the six hydrogen-cooled machines.

The asset strategies for STATCOMs and SVCs are:

- Undertake half-life refurbishments of SVCs and STATCOMs to ensure that the main plant can achieve reliable operation until the end of its engineering life; and
- Review asset planning strategies following control system refurbishments. A key assumption is that mid-life refurbishments of the SVCs include control system replacement at end of life (20 years) to fully utilise the primary equipment expected life (40 years). The first mid-life refurbishments (SVC3 and SVC7) are to be carried out in RCP3.

Similar to synchronous condensers, Transpower's intent is to increase its in-house power electronics engineering expertise. There is a significant risk that attrition of skilled personnel will lead to future difficulties with maintenance and support of the control equipment. Given the specialised nature of the skills and the risks associated with the longer-term maintenance of the power electronics fleet, Transpower has decided to develop and retain suitable engineering expertise in-house rather than through external service providers.

Transpower's main strategies for the Capacitors and Reactors are to:

- Undertake a mix of individual capacitor can replacements, reactor refurbishments and full capacitor bank replacements based on knowledge of asset condition, risk, cost and future needs; and
- Improve monitoring of capacitor can failures, undertake forensic analysis on failed capacitor cans where failure rate exceeds expectations and review the need for an asset health model for capacitor banks.

Transpower is continuing to review its capacitor bank replacement strategy. One of the main assumptions in the economic justification for capacitor replacements is the estimated probability of failure curve beyond 30 years of age. Transpower is tracking the failure rate curve on an annual basis. If the failure rates increase significantly beyond those assumed, a strategy review will be triggered.

Capacitor banks replacement criteria is a mix of individual can and bank replacements. Individual installation strategies are updated by tracking probability of failure of capacitor cans, the system criticality need and cost of can replacement.

Transpower states that reactive power assets do not fit into their standard network asset criticality framework. While they are primary equipment, their function serves regions, rather than individual substations, circuits, or branches. Transpower has developed an improvement plan for asset criticality that includes reactive power assets.

The service performance dimension of asset criticality for reactive power assets will include running scenarios in the power system models and either development of the criticality, or application of the criticality. The scenarios will consider future changes to power generation in New Zealand with forecasted decommissioning of coal power plants e.g. Huntly, and a likely scenario of increased renewables. It is forecast that the need for reactive power management and voltage control will increase to support a reliable Grid.

Due to the unique nature of reactive power assets, there is only a limited number of building blocks for cost estimation. As such, the majority of the estimates are customised. Many projects require individual cost estimates with some input from suppliers as they are specialised assets. Even with manufacturer inputs, more complex projects carry higher cost uncertainty (i.e. SVC refurbishment work).

Larger projects generally require design work, which is often undertaken externally. Refurbishment and other minor projects have a relatively small design component, which is primarily carried out by Transpower engineers or external service providers, as part of the delivery phase.

Transpower reviews and maintains spare holdings and ensures an adequate level of emergency preparedness, to enable rapid restoration of transmission service following reactive power asset failure.

Business case development is undertaken using a multi-disciplinary approach tailored to the size and complexity of the job. Due to the unique nature of the asset fleet, a single business case is developed for each project.

The original RCP2 allowance for reactive power portfolios was $16 million. As explained, reprioritisation of the work plan has reduced this initial forecast to $9 million. Expenditure across RCP2 has been relatively even apart from the commissioning of larger projects. 2017/2018 expenditure is higher than average due to funding of nine fire repairs to SVCs. Transpower anticipates expenditure in the remainder of RCP2 to be relatively low with the commissioning of smaller projects.

Due to lack of historical failure data and other data quality issues, condition assessment of all the capacitor banks is planned for RCP3. This improvement will further inform future expenditure plans.

With capacitor banks following a strategy of reactive replacement of capacitor cans, capacitor bank protection is required to improve protection functionalities. As part of this protection replacement, Transpower plans to introduce a standard capacitor bank protection design that will minimise the consequences of asset failures through early detection of faults. Future capacitor bank installations will also make use of this new standard protection design.

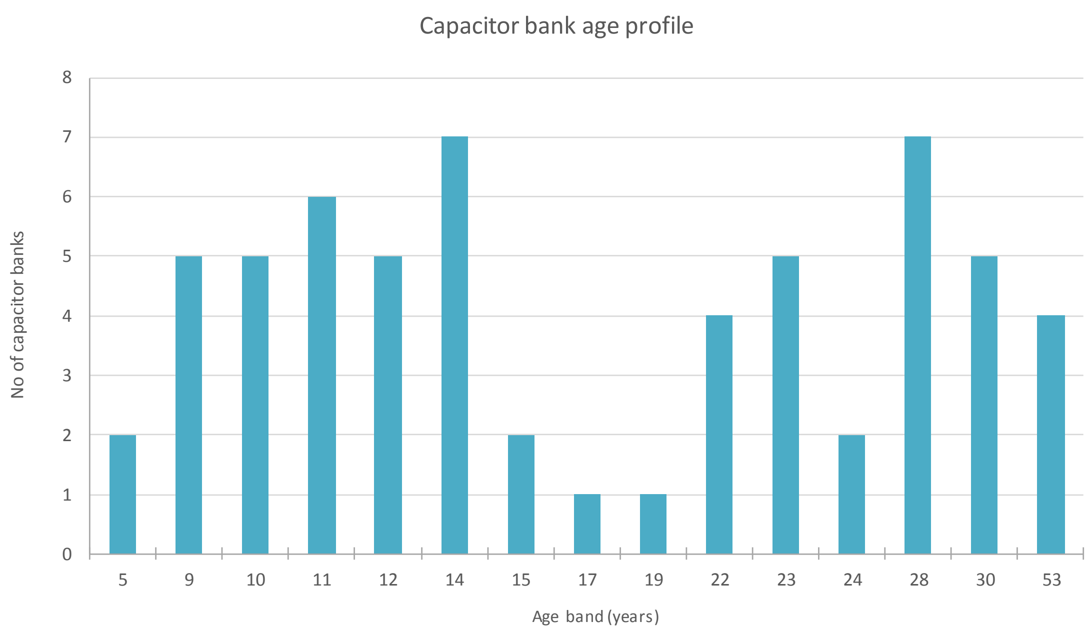
**Reactors**

Transpower has planned minor refurbishments of reactors in RCP 3, 4, and 5 to extend their operational life beyond their design life. Condition assessment data, age, operational cost information, and system needs are used to plan reactor refurbishment or replacements. Maintenance procedure improvements initiated in RCP 2 will further inform decisions.

**Capacitors**

Figure 54 shows the age profile for capacitor banks.

**Figure 54 Capacitor bank population age profile**



From the age profile, 26% of the total population has been in-service beyond the nominal design life of 25 years. The RCP3 forecast includes the replacement of capacitor banks ranked as critical. In replacing capacitor banks, Transpower reviews the optimum location for each bank as this could vary with changes in network condition over the years.

**Key drivers for RCP3 - Reactive Assets**

The key drivers of RCP3 forecast expenditure are:

- Proactive replacement of capacitor cans on three capacitor banks with Roderstein capacitors where there has been higher failure rates over the life time of the banks. Based on economic analysis and criticality modelling, the identified banks are deemed to be more critical than others;
- Reactive replacement of failed capacitor banks, which is more economical for many capacitor banks than proactive can replacements, based on failure rate functions and whole of life costs;
- Increase the level of capacitor spares to reduce the impact on availability of capacitor banks;
- Nationwide condition assessment projects are planned for RCP3 to further develop the failure rate model and to better understand the condition of the capacitor bank fleet;
- Replace Reactive Power Controllers due to obsolescence and technical issues at Brydone (BDE), Blenheim (BLN), Greymouth (GYM), North Makarewa (NMA). and wide area Christchurch;
- Repair/refurbish several reactors based on their condition, which is an effective mean of extending their life expectancy rather than replacing them, including refurbishing all reactors at Haywards;
- Replace or refurbish reactors located at Whirinaki substation, which were deferred from RCP2 based on acceptable condition;
- Replace Haywards SC 1-4 synchronous condenser cooling towers;
- Refurbish secondary and auxiliary systems on Synchronous condensers SC 3 and SC 4. This will conclude the condenser refurbishment work started in RCP1;
- Minor improvements to the condensers, such as upgrading brush gear, and replacing HMI systems are forecast for RCP3;

- Internal inspection of synchronous condensers is carried out every two years. If vibrations or electrical testing suggests an internal issue, internal inspections are required, which is a major undertaking. Funding has been forecast to cover this major cost if the need arises in RCP3;
- Complete removal of Islington synchronous condensers is planned for RCP3. These machines were mothballed in RCP1 and the work requires careful planning to manage the risk of asbestos contamination. Depending on the extent of the asbestos issue, extra funding might be required to fund the removal of these machines;
- All the SVC control systems will require replacements within next 5-10 years. Based on their criticality and the condition, SVC3 and SVC7 control systems are planned to be replaced in RCP3 along with other auxiliary systems, such as the cooling systems and the valve base electronics system. Thyristor valves will be replaced along with the control system due to incompatibility issues with the new control systems;
- Replacement of capacitor cans and refurbishment of the SVC 3 reactors is forecast for RCP3. The capacitor cans and reactors have been in continuous service for more than 20 years;
- Minor replacement and refurbishment work on SVCs, such as the replacement of battery banks and air conditioning units, is also planned for RCP3; and
- Based on operational experience with SVCs, Transpower will increase stock of STATCOM control system and power module spares to provide sufficient spares coverage until the next planned replacement of the control systems in around 15 years' time.

**Synchronous Condensers**

The main drivers for expenditure on synchronous condensers in RCP3 are life extensions and reducing the risk of asset failures. Condenser auxiliary systems and control systems require significant investments to ensure reliable operation of the main machine.

Future investment is dependent on the recommendations from failure investigations, assuming common failure modes across all of the assets.

**SVCs and STATCOMs**

In general, SVC and STATCOM control system design lives are around 20 years and require replacement due to obsolescence and lack of manufacturer support. With a control system replacement at around 20 years, the life expectancy of the entire installation can be expected to be around 40 years where the primary components will reach their end of life.

Ongoing issues with SVCs and STATCOMs, such as air conditioning unit failures, also influence future expenditure, and if not addressed, these issues will increase operational expenditure and availability due to regular call-outs.

One major risk associated with STATCOMs are the Windows XP-based control system, which is no longer supported by Microsoft. Sufficient spares coverage and cyber security improvements are being carried out to address this concern.

**Verification assessment of Reactive assets**

The need for intervention for Reactive Assets is based on either condition, the asset feedback process, or asset health (i.e. failure rate model for capacitor cans), depending on the specific asset involved. We consider Transpower's asset strategies adopted for Reactive Assets in RCP3 are prudent.

Reactive power assets do not fit in standard network asset criticality frameworks because, while they are primary equipment, their function serves regions rather than individual substations, circuits or branches. In the regions where the power electronics assets are installed, there is typically little spare reactive power support capacity. Therefore, all power electronics assets are relatively critical.

We have reviewed the Asset Health (AH) Model and the development for Reactive Assets and found;

- Apart from capacitor banks, other asset classes covered under reactive plant do not use asset health modelling for expenditure planning. This is mainly due to relatively small and highly specialised asset populations.
- This approach is appropriate for assets other than capacitors as condition is monitored and asset strategies developed by specialists for each individual asset on the system. This alternate approach would not have a negative impact on intervention actions determined for RCP3. Asset Health Modelling is applicable to fleets of assets when condition monitoring each individual asset is cost prohibitive.
- Asset health modelling for the capacitor bank fleet is in its infancy and development is limited by historical capacitor can failures not having been recorded accurately. Updates to the capacitor banks data structure during RCP3 will address this issue and enable better records of can failure rates, failure modes, capacitor can population age.

- Transpower have initiated a data quality improvement initiative for capacitor banks in RCP2. A planned nationwide condition assessment of capacitor banks and reactors in RCP3 will improve the accuracy of long-term expenditure forecasts.
- Collection and monitoring asset condition and data quality poses some risk to whether the forecast for capital expenditure on reactive assets is sufficiently accurate. The relative size of expenditure and any increase in expenditure due to this risk would be manageable.
- Transpower have developed a preliminary criticality model for capacitor banks which still requires further improvement. In some cases, network development studies have provided relevant information to determine the criticality of reactive power assets.
- Reactive power assets do not fit in to standard network asset criticality frameworks. While they are primary equipment, their function serves regions, rather than individual substations, circuits, or branches. Therefore, a more complex criticality model is required to compare reactive power assets to other network assets.

Overall, we believe Transpower's RCP3 Reactive Assets capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - Reactive Assets

Table 52 summarises our verification assessment and opinion.

**Table 52 Verification summary - Reactive Assets**

| Expenditure category | Capex - Reactive Assets | |
|---|---|---|
| **Transpower RCP3 forecast** | $39.5 million | |
| **Recommendation** | **Accept:** $39.5 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Asset strategies support prudent replacement based on assets at end-of-life | N/A |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | * Improved data for capacitor bank fleet<br>* Develop criticality model for capacitor banks | N/A |

### 7.3.3 Grid capex - AC Substations

*Power transformers*

Transpower's asset strategy and RCP3 expenditure forecasts for power transformers are detailed in ACS Power Transformers Portfolio Management Plan and the corresponding Asset Class Strategy.

The scope of this asset portfolio encompasses major power transformers operating at system voltages of 11 kV and above. It includes supply and interconnector transformers in the main AC transmission network and the small auxiliary earthing and local service transformers.

The Asset Class Strategy does not include oil interception and containment systems, electrical protection systems, converter transformers in the HVDC system and the transformers that connect reactive power equipment to the grid. These latter assets are included within other respective asset class strategies. We noted an error in the stated scope in Power Transformers Asset Class Strategy that included HVDC converter transformers and reactive plant transformers.

There are about 360 major power transformers in service, with a mix of three-phase types and mostly older banks of three single-phase units.

Transpower has forecast a total capex for power transformers in RCP3 of $60.1 million in real 2017/18 dollars. Table 53 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 53 Comparison of power transformers RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| AC Substations - Power transformers | 93.0 | 60.1 | -35% |

Table 54 shows the annual forecast capex for power transformers in RCP3 in real 2017/18 dollars.

**Table 54 Annual forecast capex for power transformers in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| AC Substations - Power transformers | 18.0 | 17.2 | 11.3 | 8.9 | 4.7 | 60.1 |

Figure 55 shows the annual power transformers capex for the regulatory periods RCP1 to RCP3, and Figure 56 shows the total power transformers capex for the regulatory periods RCP1 to RCP5.

**Figure 55 Annual power transformers capex for RCP1 to RCP3**

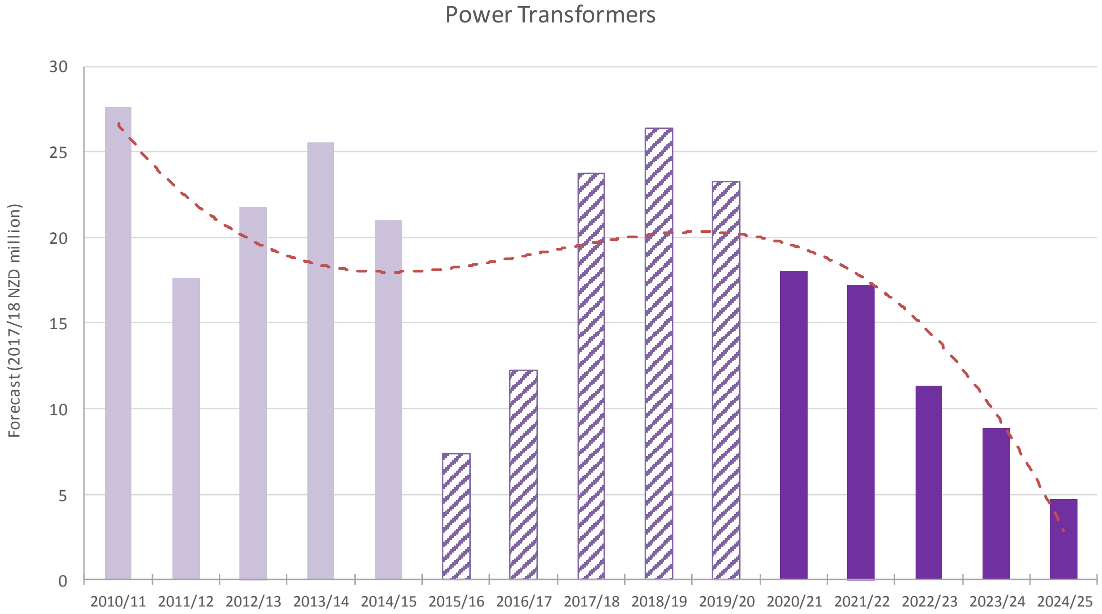
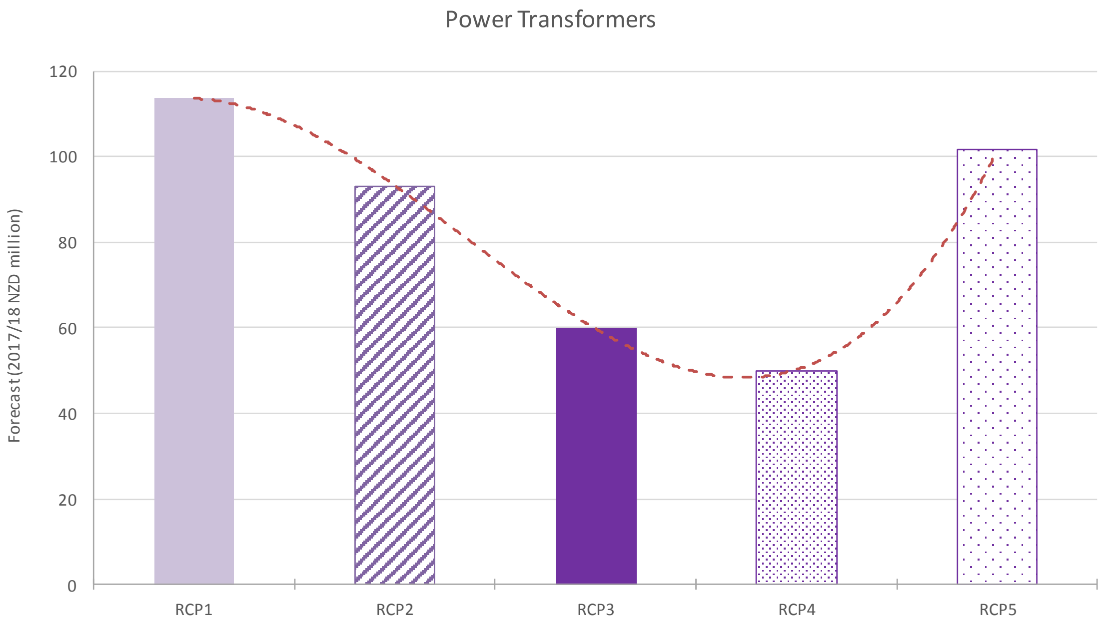



**Figure 56 Total power transformers capex for RCP1 to RCP5**




Power transformer capex decreases from $93 million in RCP2 to a forecast of $60.1 million in RCP3 due to more life extension projects and less transformer replacements. RCP4 and RCP5 spend are forecast at $50 million and $101.5 million respectively. Transpower indicates that these forecasts reflect the benefits of life extensions over RCP4, which are expected to end in RCP5.

In 2009, Transpower began replacing the worst performing units, focussing on ageing single-phase transformer banks. This programme led to a significant improvement in transformer reliability. Transpower advises the annual rate of forced and fault outages of power transformers has reduced and now is close to the average reliability reported by peers in international benchmarking.

During RCP2, Transpower had difficulty in justifying a large proportion of the RCP2 baseline-named transformers for replacement, when each unit was studied in more detail. A significant reason for this occurring was because the RCP2 plan was a list of transformers based on a combined consideration of unquantified asset health and criticality.

Transpower has applied lessons learnt from the RCP2 experience and developed a site-specific monetised risk-based options analysis tool. This is now applied to each transformer site with detailed analysis to create the long-term plan. This analysis considers cost benefit analysis of a range of major intervention options on each power transformer to find the pathway of lowest whole-of-life cost. This is a fundamental change in strategy and planning approach compared to RCP2.

A further lesson learned by Transpower inRCP2 has resulted in a changed approach to cost estimates such that it is now using top-down TEES high level building blocks for power transformer replacement projects. These building blocks provide a better estimate of the likely work scope at an early stage of a project and are used as an input to the economic options analysis model.

The original estimates made for the RCP2 submission were based on a bottom-up assessment with little scope certainty at the time, which resulted in the original estimates being inadequate with missed scope items that were later identified during more detailed design.

For each power transformer replacement project, two types of business cases are developed: the Investigation Business Case (IBC) seeks funding to undertake the capital investigation; and depending on the outcome of the IBC, the Delivery Business Case (DBC) seeks funding to undertake the project.

**Asset Health Modelling - Power Transformers**

The asset health model for power transformers is based on the Common Network Asset Indices Methodology (CNAIM) approach, published by the Office of Gas and Electricity Markets (OFGEM), in the United Kingdom. This is commonly referred to as Condition

Based Risk Management (CBRM). The methodology details the inputs, calculations, and calibration parameters to be used in the calculation of asset health. The investment planning approach for transformers is also generally based on undertaking asset health modelling with CBRM.

The standard methodology for power transformers incorporates a health model for the tap changer, a health model for the rest of the power transformer (i.e. main tank and active part), and then combines the output of them together. Transpower extended this approach in RCP2 to incorporate a specific asset health model for the transformer bushings. Hence the asset health of the transformer system requires consideration of the asset health of these three major components.

The planning approach for existing transformers considers the likelihood and consequence of severe failure modes, including transformer fires, and takes site and unit-specific factors into account. Asset management options for all major intervention options, including most bushing replacements, are evaluated using the quantified benefits analysis.

There were no issues found with the asset health model developed for power transformers that would have a significant impact on the accuracy of the input volumes forecasted for RCP3. The asset health model would be the most mature and based on an internationally recognised risk assessment software system for this asset class. The system benefits from international data on power transformer probability of failure based on condition. It has the capability to predict future health with or without investment intervention and uses a monetised criticality assessment approach.

Transpower has forecasted a reduction in capital expenditure from $113M in RCP2 to $66M in RCP3 due to undertaking more life extensions and less transformer replacements.

During RCP2, Transpower had difficulty in justifying a large proportion of the RCP2 transformers planned for replacement, when each unit was studied in more detail. A significant reason for this occurring was because the RCP2 plan was a list of transformers created based on a combined consideration of unquantified condition and criticality. None of the RCP2 named transformers had undergone cost/benefit options analysis when the long-term plan was created.

Applying lessons learnt from the RCP2 experience Transpower have also development a site specific monetised risk based options analysis tool. This is applied to each transformer site with a need case commensurate with detailed analysis (i.e. likely need for a major intervention) to create the long-term plan. One of the improved strategies developed in RCP 2 has been to replace aging bushings, where relevant, instead of the full replacement of the transformer at much higher costs.

Overall the functionality and maturity of asset modelling for power transformers has already provided benefits to be achieved during RCP3. Further refinements of failure probability and risk assessments will continue to provide benefits into RCP4 and RCP5.

With the high level of maturity of the model, Transpower should continue to review the probability of failure curves from all available sources. One of the issues for all assets is the lack of valid data to inform the increasing probability of failure nearer to end of life. It is in this area of the curve that determines the timing of optimum intervention.

In this respect Transpower has stated that "*… the normal expected life is one of the key inputs to the asset health model. We will define and adjust the normal expected life assumption for power transformers having regard to local and international experience of asset performance.*"

**Asset strategy, planning and estimating - Power Transformers**

A key focus for Transpower, for the next 15-20 years, is managing approximately 150 ageing 1960s and 1970s (50-60 year old) single phase transformer banks, primarily 110/33 kV units. Transpower reports that these transformers generally have good winding and core condition, but many have inoperable tap changers and bushings, which are suspect based on type or sister unit failures and are past their useful life.

Transpower has made significant improvement to its asset health modelling, asset strategy processes and analysis of power transformer failure risks during RCP2, incorporating best international practice. The knowledge and analysis of the condition and failure modes for power transformers is systematically demonstrated in the Asset Class Strategy and Portfolio Management Plan.

The asset strategy approach for existing transformers is to first identify the need for interventions based on asset health indicators and relevant asset feedback, and then to evaluate and select solutions based on economic analysis of risk and cost of alternative options.

The solution options considered for major condition-based interventions for transformers include:

- total replacement
- replacement of bushings
- major refurbishment to mitigate corrosion and/or leaks, or high moisture levels

- retrofitting firewalls between closely spaced transformers.

The option of condition-based replacement of an existing power transformer is selected when this is the least whole-of-life cost option, taking failure probabilities and consequences into account. Replacement of bushings will be selected only where this is the least whole-of-life cost, taking failure probabilities and consequences into account.

Tap changer problems make a disproportionately large contribution to forced and fault outages, particularly for banks of single-phase transformers. Other common causes of unreliability of single-phase transformer banks and to a lesser extent three phase banks are oil leaks/low oil levels and bushings.

Winding failures make up a lower proportion of the total number of forced and fault outages, and is one of the most severe failure modes. When these occur, they tend to be longer in duration and often require mobilisation of a spare transformer.

Transpower's rate of winding failures, observed over a 20-year period, is in line with international benchmarks and is approximately 1 each year across the entire fleet. The main causes of winding failures are weaknesses in design or construction. Contingency measures to restore transmission security can take several weeks to implement, and full replacements may take more than a year. However, transformers with a vulnerability to winding failure are not able to be easily predicted and an allowance, based on historical failure rates, has been allowed for in RCP3 for these types of failures.

Some power transformers with poor oil condition results, significant corrosion or oil leaks, or risk factors, such as aged and defective bushings and instrumentation or deteriorated off-load tap selector switches, may be candidates for a major refurbishment, where the unit is removed from service for an extended period. A major refurbishment of a power transformer typically takes 8-12 weeks. Economic analysis indicates that typically, at least a further 10-20 years' service life must be obtained following major refurbishment, for this work to be economically justified.

Transpower's key asset strategies for power transformers are as follows:

- Asset Health and Criticality
  - Continue to develop and operate an asset health forecasting model based on the CNAIM (Common Network Asset Indices Methodology approach. published OFGEM and commonly referred to as Condition Based Risk Management (CBRM)).[110]

[110] Transpower (2018), Portfolio Managment Plan: High Voltage Direct Current Assets, p. 19, Document [61]

- Define normal expected life having regard to local and international experience.
- Calibrate the forecast probability of failure vs asset health, having regard to local and international experience.
- Monitor long term performance of composite bushing insulation and adapt asset health models accordingly.

- Engineering Design
  - Undertake preliminary design studies for replacement projects to identify constraints, solutions and costs for planning purposes.

- Cost Estimation
  - Use high level building blocks for long range planning and customised cost estimating for short to medium term project planning incorporating contingencies for unknowns in scope and complexity.

- Site Services Continuity Planning
  - Maintain a fleet of strategic and operational spare transformers.
  - Maintain site-specific contingency plans and undertake pre-work to optimise a response where appropriate.
  - Maintain contingency plans for transformer failure at N-security sites.
  - Procure specialist servicing of on-load tap changers from original equipment manufacturers and maintain long term relationships with original equipment manufacturers.

Table 55 shows the volumes of power transformer work by activity from RCP2 to RCP5.

**Table 55 Power transformer activity work volumes RCP2 to RCP5**

| Activity | RCP2 | RCP3 | RCP4 | RCP5 |
|---|---|---|---|---|
| Transformer replacement (including contingency) | 22 | 13 | 10 | 18 |
| Bushing replacements (including provisions) | 34 | 23 | 13 | 13 |
| Retrofit firewall | 3 | 4 | 0 | 0 |
| Retrofit new bund and oil containment | 1 | 0 | 0 | 0 |
| Retrofit noise barrier | 1 | 0 | 0 | 0 |
| Pre-enabling works | 0 | n/a | 0 | 0 |

**Key Drivers for RCP3 - Power Transformers**

The change in strategy from complete transformer replacement over RCP1 and RCP2 to enhanced options assessments, results in an overall reduction in the number of total unit replacements planned for RCP3 when compared to previous RCPs. In total, Transpower is presently planning to replace up to 13 transformers when a contingency allowance is included.

Power transformer capex in RCP3 is therefore much lower than RCP2 expenditure due to more life extensions and less transformer replacements. Further life extensions will also result in a reduction in RCP4 expenditure.

One key example of life extension is the bushing replacement programme with 23 units expected to undergo replacement along with some firewall retrofits and some potential strategic spare pre-enabling works. The cost of bushing replacements is lower than the benefits of extending the overall life of the power transformers.

It is worth also mentioning though that with a fleet of around 350 transformers and an expected life of 60 years, this represents a requirement to replace approximately six transformers annually on average. The average from 2008 to 2019 has tended to be three to five transformers replaced per year. The RCP3 and RCP4 plan less than three transformer replacements per year, which is a low percentage replacement rate and will lead to significant numbers of older transformers in service that have are being deferred into RCP5 and RCP6. However, we consider that extending the life of power transformers will not result in any issues with delivering a higher quantity of replacements in the future.

**Verification assessment - Power Transformers**

Transpower has applied lessons learnt from its RCP2 experience and developed a site-specific monetised risk-based options analysis tool. This is now applied to each transformer site with detailed analysis to create long-term asset plans. Applying this tool has resulted in greater expected use of deferred replacement of power transformers in RCP3 compared to RCP2.

A potential risk of this change in approach recognised by Transpower is the consequence of deferring replacement of significant numbers of older transformers into RCP5 and RCP6. Our analysis of the age of transformers suggests the costs of replacement in RCP6 may be up to $150 million. We recommend that Transpower considers the deliverability of this level of transformer replacement during RCP3 to better inform forecasts for RCP4 and RCP5. However, our view is that this level of construction work and the skills sets required will not be an issue for Transpower.

As part of our review we requested responses from Transpower on two matters stated in the Transformer Portfolio Management Plan as follows: [111]

- The biggest risks to the transformer portfolio are externalities and transformer failure. The most significant externality is customer decision-making.[112] Uncertainties will exist around customer decisions in the case of N-security sites to maintain supply, uncertainties with load and fault levels for transformers and whether the customer will remain connected into the future resulting in stranded asset risk. During RCP2, there were 2 out of 15 changes to plans that noted customers as a consideration for the change.
- A risk allowance is forecasted in the portfolio to cover transformer failures which are not expected to be covered by insurance.[113] We confirm that is a valid approach with respect to determining the expenditure contingency within the portfolio as Transpower explained.

We have reviewed the Asset Health (AH) Model and the development for Power Transformers and found:

- The asset health model for power transformer is the most mature and based on an internationally recognised risk assessment software system for this asset class (CBRM). The system benefits from international data on power transformer probability of failure based on condition. It has the capability to predict future health with or without investment intervention and uses a monetised criticality assessment approach
- The asset health model for power transformers is based on the Common Network Asset Indices Methodology (CNAIM) approach, published by the Office of Gas and Electricity Markets (OFGEM), in the United Kingdom (Commonly referred to as Condition Based Risk Management - CBRM)
- There were no issues found with the asset health model developed for power transformers that would have a significant impact on the accuracy of the input volumes forecasted for RCP3.
- Improvement to the asset health modelling during RCP2 included:

[111] Transpower, *Portfolio Management Plan: ACS Power Transformers*, April 2018, Document [55]

[112] Ibid., p. 5

[113] Ibid., p. 5

  - Development of a site specific monetised risk based options analysis tool. Applied to each transformer site, a need case is developed commensurate with detailed analysis to create the long-term plan.
  - Inclusion of an asset health model for bushings into the CBRM tool which has extended the life of transformers by replacement only the bushings, justified by the risk based analysis.

- Overall the functionality and maturity of asset modelling for power transformers has already provided benefits to be achieved during RCP3. Further refinements of failure probability and risk assessments will continue to provide benefits into RCP4 and RCP5.

- Given the high level of maturity of the model, Transpower should continue to review the probability of failure curves from all available sources to remove potential conservativeness in failure probability.

Based on our review of the asset class strategy and the extensive level of maturity of this programme, we verify that the investment in power transformer Base Capex in RCP3 is reasonable and prudent.

Transpower has demonstrated improvements to cost estimating over the RCP2 and previous regulatory periods and Transpower is continuing to explore opportunities to optimise the strategies for reducing the lifecycle cost of transformers while managing the critical risks of transformer failure.

The asset management objectives for the portfolio are supported by the asset strategies and will contribute to achievement of grid output reliability measures.

We believe Transpower's RCP3 power transformers capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - Power Transformers

Table 56 summarises our verification assessment and opinion.

**Table 56 Verification summary - Power Transformers**

| Expenditure category | Capex - Power Transformers | |
|---|---|---|
| **Transpower RCP3 forecast** | $60.1 million | |
| **Recommendation** | **Accept:** $60.1 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Based on site-specific monetised risk-based options analysis tool, applied to each transformer site with detailed analysis to create long-term asset plans. Applying tool has resulted in greater expected use of deferred replacement of power transformers in RCP3 compared to RCP2<br>* Mature asset health model based on internationally recognised risk assessment software with enhanced future health prediction capability<br>* Inclusion in asset health model for life extension through bushing replacement based on risk | N/A |
| **Other relevant criteria from ToR** | General evaluation of the Base Capex Proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | * Due to deferments, consider deliverability of transformer replacement during RCP3 to better inform forecasts for RCP4 and RCP5 | N/A |
| **Potential scope for improvement** | N/A | N/A |

*Outdoor 33 kV switchyards: Outdoor to Indoor Conversion*

Transpower's asset strategy and expenditure forecasts for outdoor 33 kV switchyards are detailed in the ACS Outdoor to Indoor Conversions (ODID) Portfolio Management Plan and the corresponding Outdoor 33 kV Switchyards Asset Class Strategy.

The outdoor 33 kV switchyards area covers all the main primary asset types within the switchyards including the support structures, buswork, circuit breakers, disconnectors and earth switches, and other associated equipment, such as instrument transformers, surge arrestors and local service supply components. Indoor switchgear, supply transformers and control and protection equipment are covered in other asset class strategies.

These switchyards were designed between 1950 and 1983. There is a significant difference between the designs of these switchyards and the design standards that apply to new installations (particularly spacings and distances for electrical safety).

Safety hazards associated with the outdoor 33 kV switchyards include the small safety clearances to adjacent live equipment, the requirement for work at heights, and the need to climb into structures to undertake work. Four maintenance workers have died in the outdoor 33 kV switchyards in the past 35 years, and there has been numerous serious harm, medical treatment injuries and near-miss incidents in these structures. Converting the switchyards to a modern equivalent indoor switchboard largely eliminates the hazards of close approach to live equipment.

In response to the safety and reliability concerns, and the need to replace existing equipment, Transpower commenced a nationwide programme in 2008 to convert most of the outdoor 33 kV switchyards to indoor switchgear. At that time, there were 75 substation sites with outdoor 33 kV or 22 kV structures. Of these, 18 sites are currently forecast to remain as outdoor switchyards for the long term, these sites being small installations where the hazards can be well controlled.

Transpower has forecast total capex for Outdoor 33 kV switchyards conversion in RCP3 of $42.1 million in real 2017/18 dollars. Table 57 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex, and reflects the planned completion of the conversion programme in 2025/26.

**Table 57 Comparison of Outdoor 33 kV switchyards conversion RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Outdoor 33 kV switchyards: Outdoor to Indoor Conversion | 88.9 | 42.1 | -53% |

Table 58 shows the annual forecast capex for Outdoor 33 kV switchyards conversion in RCP3 in real 2017/18 dollars.

**Table 58 Annual forecast capex for Outdoor 33 kV switchyards conversion in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Outdoor 33 kV switchyards: Outdoor to Indoor Conversion | 16.0 | 9.9 | 7.1 | 5.7 | 3.3 | 42.1 |

Figure 57 shows the annual Outdoor 33 kV switchyards conversion capex for the regulatory periods RCP1 to RCP3, and Figure 58 shows the total Outdoor 33 kV switchyards conversion capex for the regulatory periods RCP1 to the planned completion in the first year of RCP4.

**Figure 57 Annual Outdoor 33 kV switchyards conversion capex for RCP1 to RCP3**

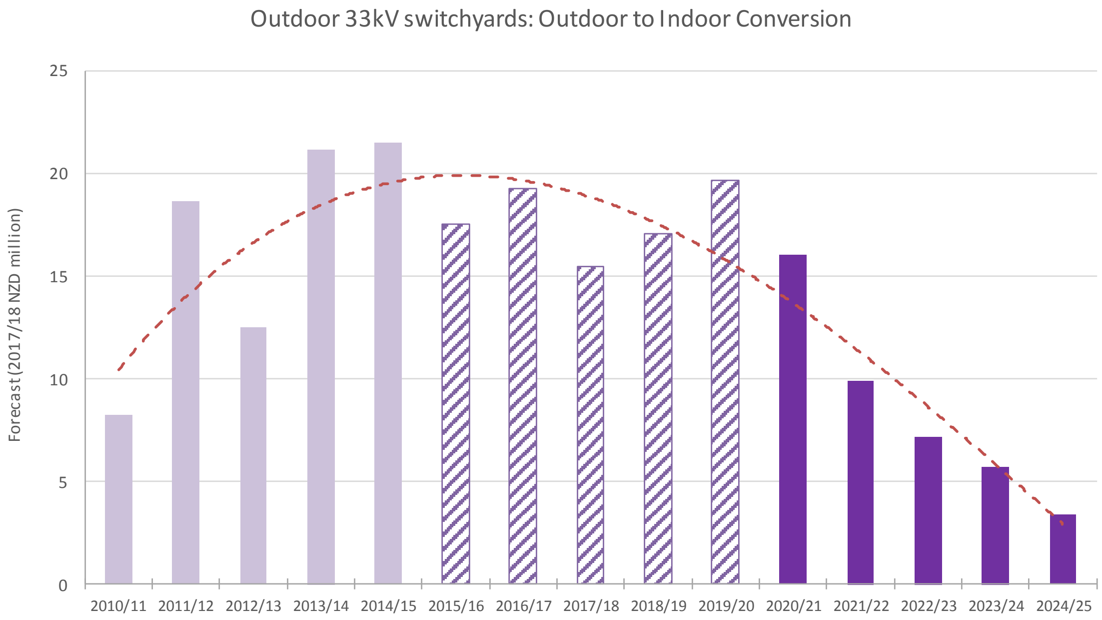
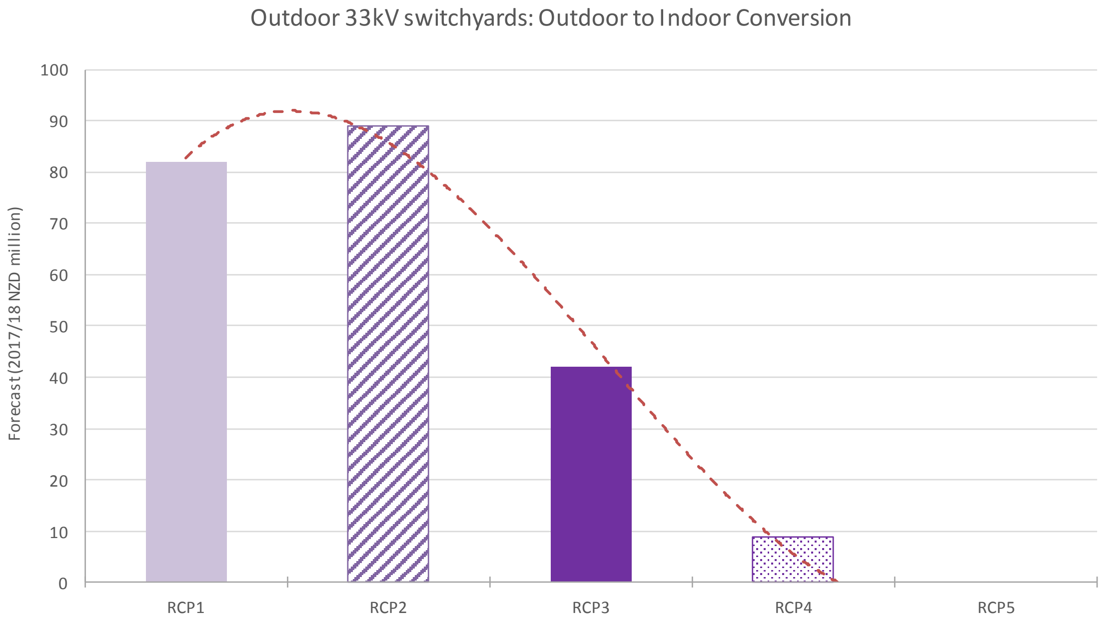



**Figure 58 Total Outdoor 33 kV switchyards conversion capex for RCP1 to RCP5**



In RCP4, the forecast of $9 million reflects only three potential ODID conversions. RCP5 has no expenditure. Transpower indicates that the RCP4 and RCP5 expenditure may change if the strategies change with respect to what options are undertaken at small and N-security sites.

Transpower highlights the largest risks to the ODID portfolio are externalities, with the most significant of these being customer decision-making. Distribution customers are required to commit to and provide the information required for the projects to continue and delays can result in deferred expenditure and changes to the programme.

An asset divestment policy in the early to mid-1990s led to the sale of outdoor 33 kV feeder circuit breakers to distribution network customers at several sites, particularly in the North Island. At these sites, the point of interface with the customer moved to the bus-side disconnector for each feeder circuit breaker, rather than at the line-side disconnector (as in the conventional arrangement). This mixed ownership of the equipment contributes to the programme risks.

The following table shows the quantities of conversion work planned for RCP2 to RCP5.

**Table 59 ODID work volumes for RCP2 to RCP5**

| Category | RCP2 | RCP3 | RCP4 | RCP5 |
|---|---|---|---|---|
| Outdoor 33 kV switchyard conversions | 14 | 12 | 3 | 0 |

**Asset Health Modellling - 33 kV Switchyards Outdoor to Indoor Conversion**

There are no specific strategies (or asset health modelling) defined for the Outdoor 33 kV Switchyards asset class with respect to the safety and reliability replacement program. Outdoor circuit breakers (component of the switchgear) are included though in the CBRM system with a defined Asset Health Model and mature model functionality.

Asset investment decisions for outdoor 33 kV switchyards are based on a quantified benefits evaluation of options. The option evaluation process currently requires the following information:

- Evaluated safety risk of the switchyard
- Value of estimated future unserved energy from the switchyard, including the size and criticality of the load, and estimates of probability of failure using the asset health of circuit breakers as a proxy for the likelihood of the failure of switchgear asset as a whole

Asset investments decisions relate to prioritisation of the conversions. Most of the remaining outdoor switchgear will be replaced in RCP3, hence no improvement to asset health modelling is required or planned in RCP3.

**Asset strategy, planning and estimating - 33 kV Switchyards Outdoor to Indoor Conversion**

The main strategies for outdoor 33 kV structures are to convert outdoor 33 kV switchyards that do not meet current expectations for safety in design or reliability to modern equivalent indoor switchboards. The highest priorities for conversion are switchyards with small safety clearances, complicated structures and buswork, and aged bulk oil circuit breakers. More specifically:

- Convert outdoor 33 kV switchyards that do not meet current expectations for safety in design or reliability to modern equivalent indoor switchboards.
- Prioritise switchyards for conversion to indoor switchgear using a quantified benefits approach.
- Replace equipment in remaining outdoor 33 kV switchyards to extend life of the overall installation where appropriate and carry adequate critical spares.
- Aim for clear and simple asset boundary with customers.
- Consider and implement asset transfers in accordance with the Asset Divestment Strategy.

The investment planning for outdoor to indoor conversions is based on using a combination of asset health and site-specific consequence modelling to establish the total risk at each site, which is then compared with cost estimates to complete the ODID projects. This allows all sites to be ranked in terms of risk return on investment.

This prioritised list is then reviewed to ensure other factors, such as synergies with other work and customer plans, have been considered in determining the final plan. Prospects for changes in ownership boundary and divestment of 33 kV switchyard assets are also considered.

Transpower is incorporating lessons learned from the original cost estimates for these sites as part of the RCP2 submission. Despite reduction from 15 to 14 ODIDs, the commissioned forecast is higher than the RCP2 allowance by $13 million ($102 million vs $89 million). One area of cost increase which realistically could not have been foreseen is a significant increase in the cost of feeder reconnection cable works with certain customers.

The estimates have been updated to reflect known issues, primarily related to under scoping due to the bottom-up nature of these estimates. These updates have added work scope in areas where it is now known to be missing or additional estimates to cater for expected scope increase that cannot be easily quantified until the detailed design has been completed and is site-specific in nature. These estimates underpin the RCP3 expenditure forecasts.

Transpower is also exploring alternatives for more efficient delivery of outdoor-to-indoor conversion projects, including new building designs and design/build solutions that include a transportable building option.

For delivery business cases (DBCs), a customised, bottom-up cost estimate for each project is completed, as site-specific details are well understood. The customised estimate is then compared via a top-down review to the end-costs of similar projects. Two business cases are developed for each ODID, an Investigation Business Case (IBC) and subsequently the Delivery Business Case (DBC), which seeks funding to undertake the project, and sets out a more detailed scope and budget, together with project timing.

**Key Drivers for RCP3 - 33 kV Switchyards Outdoor to Indoor Conversion**

The main drivers for conversion of outdoor 33 kV switchyards to indoor switchgear have been design-related safety and reliability performance risks, rather than condition.

As a result of the programme of conversion to indoor switchgear, the asset performance objective of reducing the number of fault and forced outages caused by outdoor 33 kV equipment can be achieved (less than 5 per annum by 2025 from the current average of approximately 15 events each year). This outcome will mainly be achieved by reducing the quantity of outdoor 33 kV switchyards from around 50-60 over the recent past down to 18 by 2025.

**Verification assessment - 33 kV Switchyards Outdoor to Indoor Conversion**

This programme has been in place since 2008 and with that a lot of experience and lessons learned are built into the forecast programme and expenditure for RCP3.

There is no asset health model for the entire outdoor 33 kV switchyard system given it is a collection of many asset classes and priority is assigned to the risk and criticality of each site. For 33 kV outdoor switchyards, this data and in-field assessment of condition of the equipment is considered along with safety risks to determine priorities for replacement in the programme.

The main drivers for conversion of outdoor 33 kV switchyards to indoor switchgear have been the design-related safety and reliability performance risks, rather than condition.

The performance and safety risks associated with the outdoor switchgear will inherently be removed or reduced because of the programme.

We have reviewed the asset strategy for the 33 kV Switchgear – Outdoor to Indoor Conversions and found:

- There are no specific strategies (or asset health modelling) defined for the Outdoor 33 kV Switchyards asset class with respect to the safety and reliability replacement program.
- Outdoor circuit breakers (component of the switchgear) are included though in the CBRM system with a defined Asset Health Model and mature model functionality.
- Asset investments decisions relate to the prioritisation of the conversions.
- Most of the remaining outdoor switchgear will be replaced in RCP3, hence no improvement to asset health modelling is required or planned in RCP3.

Based on our analysis of the asset class strategy and the maturity of this programme, we verify that the investment in outdoor to indoor conversions of 33 kV switchyards is reasonable and prudent. Transpower has demonstrated improvements to estimating over the RCP2 and previous regulatory periods. Transpower is also continuing to explore opportunities to reduce the costs of the conversion projects.

The asset management objectives for the portfolio are supported by the asset strategies and will contribute to achievement of grid output reliability measures.

We believe Transpower's RCP3 ODID Substation Conversion capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - 33 kV Switchyards Outdoor to Indoor Conversion

Table 60 summarises our verification assessment and opinion.

**Table 60 Verification summary - 33 kV Switchyards Outdoor to Indoor Conversion**

| Expenditure category | Capex - 33 kV Switchyards OD to ID Conversion | |
|---|---|---|
| **Transpower RCP3 forecast** | $42.1 million | |
| **Recommendation** | **Accept:** $42.1 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Asset Class Strategy supports prudent investment | N/A |

| | | |
|---|---|---|
| | * Maturity of ongoing programme that began pre-RCP3<br>* Demonstrated improvement in estimating costs | |
| **Other relevant criteria from ToR** | General evaluation of the Base Capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | Ongoing improvement in estimating costs | N/A |

### 7.3.4 Grid capex - Secondary Assets

*SA Protection, Battery Systems and Revenue Meters*

Transpower's asset strategy and RCP3 expenditure forecasts for Conductors and Hardware are detailed in SA Protection Battery Metering PMP and the corresponding Protection Asset Class Strategy and Protection DC Supplies Asset Class Strategy.

The assets in this portfolio are:

- Protection schemes used throughout the grid to rapidly detect and isolate electrical faults to protect primary equipment, and provide safe and reliable operation of the network. Protection systems includes outdoor junction boxes (ODJB).
- Station DC systems required to provide power to protection schemes, circuit breaker trip and close coils, control and metering.
- Revenue meters to record electricity usage for wholesale market reconciliation and billing.

Transpower has forecast a total capex for SA Protection in RCP3 of $141.6 million in real 2017/18 dollars. Table 61 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 61 Comparison of SA Protection RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| SA Protection, Battery Systems & Revenue Meters | 63.2 | 141.6 | 124% |

Table 62 shows the annual forecast capex for SA Protection in RCP3 in real 2017/18 dollars.

Table 62 Annual forecast capex for SA Protection in RCP3 ($2017/18 million)

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| SA Protection, Battery Systems & Revenue Meters | 29.3 | 27.9 | 31.2 | 26.3 | 27.0 | 141.6 |

Figure 59 shows the annual SA Protection capex for the regulatory periods RCP1 to RCP3, and Figure 60 shows the total SA Protection capex for the regulatory periods RCP1 to RCP5.

**Figure 59 Annual SA Protection capex for RCP1 to RCP3**

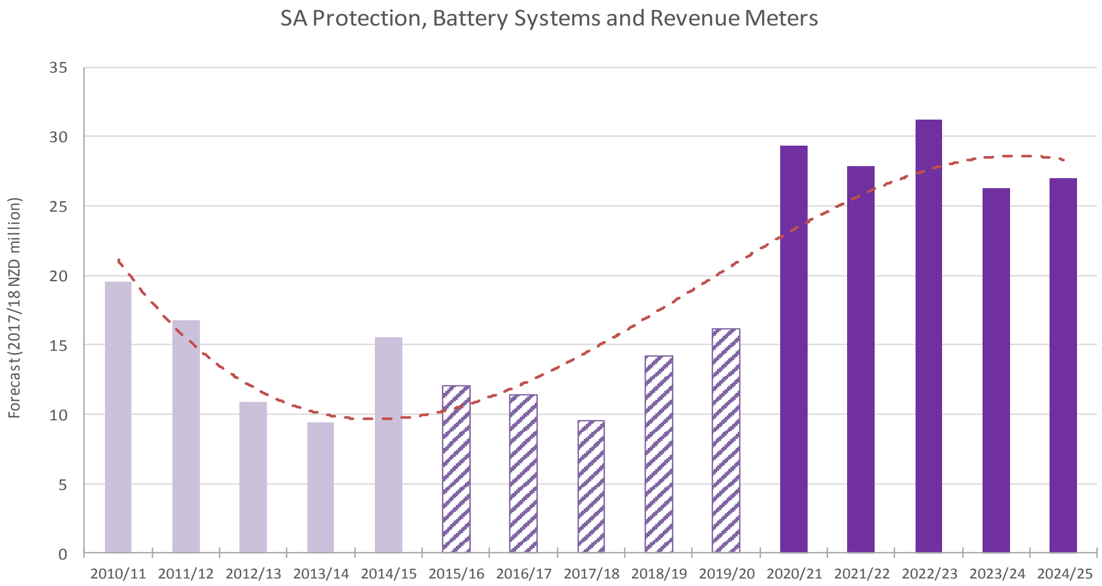
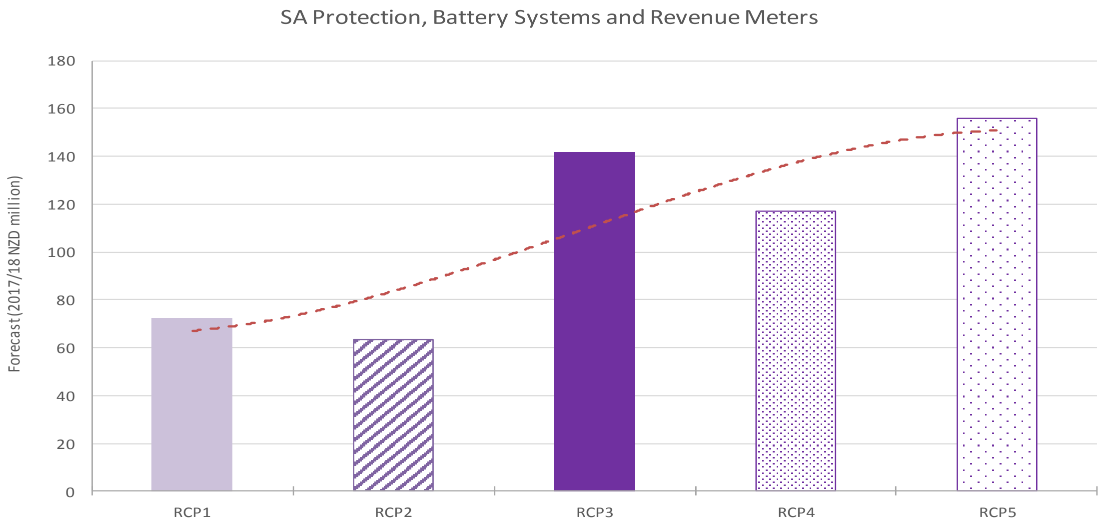



**Figure 60 Total SA Protection capex for RCP1 to RCP5**



The volume of replacement works fluctuates across RCPs. This can be seen in the estimated expenditure for RCP4 and RCP5 at $117 million and $155.9 million respectively.

In general, protection work that was planned at the start of RCP2 has changed and evolved due to several reasons including:

- Line protection replacement, bus zone replacement and bus zone duplication works were costlier than initially forecast. This resulted in bus zone duplication works deferred into RCP3, 4 and 5.
- Arc flash protection retrofits were also re-assigned and included into the bus zone portfolio during RCP2.
- Significantly less feeder protection replacements were required than planned as many were replaced along with switchboard replacements and the outdoor to indoor switchyard conversions carried out in RCP2.
- A reassessment of the performance of duplicated line protection schemes resulted in an increase in estimated life expectancy and replacement work deferred.

The substation 125V DC systems supply power to protection schemes and other items, such as circuit breaker trip and close coils, control, and metering. During RCP2, work planned for station 125V DC systems changed over the course of the regulatory period, as follows:

- The costs for station battery replacement works were lower than initially forecast as battery costs were lower than expected under a period-supply contract set up at the start of RCP2.
- Several battery and charger replacements were brought forward after data cleansing discovered several batteries and chargers that needed to be replaced earlier than expected.
- Uninterruptible Power Supply (or UPS) systems and their batteries associated with the reactive asset portfolio were included in this portfolio during RCP2.

Transpower’s overall approach to the protection fleet planned for RCP3 is to replace old technology relays and install additional bus protection, putting additional focus on assets that are critical to reliability and safety. The primary strategy is to replace assets based on age and where either the increased probability of failure, or technical obsolescence, poses an unacceptable operational risk.

**Asset Health Modelling - Secondary Assets**

- How are the AH Frameworks being applied to determine input values and the degree of conformance to actual input values determined for RCP3

A simple Asset Health Model has been developed in RCP2 for protection schemes (excluding ODJBs) and station DC systems driven by the age of the assets which are included in the Decision Framework spreadsheets for each portfolio. There is no Asset Health Model in place for revenue metering.

Transpower's overall strategy for protection assets is to replace relays on obsolescence or endemic failure, replace relays based on unavailability of spares or where a model shows signs of endemic failure, subject to a maximum life expectancy of 20-25 years. This approach has determined the input values for RCP3.

- Improvements made in RCP2 to the Asset Management Strategy and implications for RCP3

A key point that impacts on the investment forecast for this portfolio is that generally these assets cannot be maintained or inspected. Any intervention is typically the replacement of the asset or the scheme at the end of its life. Because of the criticality of protection relays and DC battery systems, these replacements are likely to be conservative as the risk of allowing the assets to enter into periods of high rates of failure is not tolerable.

An issue generally internationally with a replacement of age strategy is that failure rate data on ageing protection relays is limited and this makes determining an asset health model difficult.

However in 2017, Transpower was able to extend the replacement interval for duplicated line protection from 20 years to 25 years. With the assistance of failure rate data from OEMs, Transpower could extrapolate with sufficient confidence beyond the normal life expectancy of the relays to make this decision. The analysis indicated potential to increase replacement age to 35 years.

Transpower is planning in RCP3 to develop a risk-based framework for evaluation and cost benefit analysis of protection scheme capital expenditure planning, including Implementing and enhancing criticality-adjusted replacement strategies for protection schemes.

With the relatively short life of current secondary system technology (20-25 years), the benefits of extending life by just 5 years is substantial and hence this should be a priority in RCP3 for developing further the asset health and criticality models for secondary assets.

**Asset strategy, planning and estimating - Secondary Assets**

Transpower's overall strategy for protection assets is to replace relays on obsolescence or endemic failure, replace relays based on unavailability of spares or where a model shows signs of endemic failure, subject to a maximum life expectancy of 20-25 years. ODJBs are replaced when maintaining them is no longer practical or cost effective and revenue meters are replaced based on age.

Table 63 lists the expected replacement intervals by protection scheme.

**Table 63 Protection scheme and relay expected replacement intervals**

| Scheme | Type | Relay types | |
|---|---|---|---|
| | | Numerical / Micro-processor | Electromechanical / Solid State |
| Line protection | duplicate | 25 years | 35 years |
| | single | 20 years | 35 years |
| Transformer protection | duplicate | 25 years | 35 years |
| | single | 20 years | 35 years |
| Feeder protection | duplicate | 25 years | 35 years |
| | single | 20 years | 35 years |
| Special Protection Schemes | | 20 years | N/A |
| Bus Zone & Bus Coupler protection | | 20 years | 35 years |
| Reactive Asset protection | | 20 years | 35 years |

Secondary drivers may be considered to bring forward replacements, if economically justified, as follows:

- Equipment is not able to provide the required functions (such as fault recording, distance to fault, high-sensitivity Directional Current Earth Fault (DCEF) protection for lines).
- A small model population, meaning lack of engineering support and technical familiarity with the model is an issue.
- The primary equipment that the relay is being replaced and the relay is at more than 60% of its nominal design life.
- Assets may be replaced as part of an optimised integrated works plan.

In developing asset strategies, Transpower quantifies and monetises the consequences of failure of protection relays to represent criticality. This includes direct costs from planned and unplanned replacements, impact of unserved energy, workplace or public safety.

The replacement of protection relays is generally repeatable and Transpower uses a volumetric cost estimating approach based on standard building blocks for a given asset type and equipment rating. Standard building block estimates are based updates from historic costs.

Substation programme work often involves combining plans for work by site, scheme, or by circuit. For example, protection works may be combined with Substation Management System replacements, Outdoor to Indoor conversions, and replacement of primary equipment. Battery and charger replacement work is mostly grouped by service area as they are largely independent of other works and do not require outages of primary equipment for replacement work to be done.

The asset strategy for station DC Systems is to:

- Replace all assets in a timely manner addressing battery degradation, corrosion, operation outside of desired thermal ranges and replace hardware before failure rates become operationally problematic. Currently based on condition, subject to an expected life of 8 years for existing and 12 years for new assets.
- Increase system redundancy where appropriate to minimise the impact of unavoidable failures and the consequence of failure.
- Monitor real-world failure rates and adjust replacement timeframes accordingly.

ODJBs are replaced when maintenance can no longer achieve an acceptable standard of condition, or it is not cost-effective. Replacement of ODJBs are often included with planned replacements of protection systems or primary assets, wherever reasonably practicable.

Revenue meters are replaced at the end of their expected useful life of 12 years of age. Criticality is not used to prioritise Revenue Metering replacements as meter reading accuracy is prescribed by the Electricity Industry Participation Code (EIPC).

**Key Drivers for RCP3 - Secondary Assets**

The SA Protection expenditure forecast for RCP3 is $141.6 million.

The driver for this expenditure compared to RCP2 largely reflects the increase in additional work required from the wave of protection schemes and station DC equipment coming due for replacement compared to RCP2. The replacement programme for protection and station DC equipment alone totals $94.5 million.

Replacement of revenue metering approaching end of life totals $14.1 million.

An additional $33.0 million is included in this portfolio for work either deferred from RCP2, transferred from other portfolios in RCP2, or driven by other factors than end-of-life replacement as follows:

- SPS Replacement work - this was not previously included in the RCP2 submission.
- ODJB work - this was previously included in another portfolio in the RCP2 submission.
- Arc Flash Protection Retrofits - this work was previously included in the Indoor Switchgear Portfolio in the RCP2 submission.
- Requirement to relocate Transpower assets from Genesis Control Room at Huntly to Transpower's Relay room.
- Requirement to ensure that all sites can provide station DC supply for island wide blackout scenario.
- Requirement to segregate redundant batteries and chargers to mitigate against common mode failure at Otahuhu and Whakamaru substations.

**Verification assessment - Secondary Assets (Protection)**

The current state of protection, station DC systems and revenue metering is generally good. Reliability performance and critically reviews have led to the subsequent extension of some types of protection relays from 20 to 25 years.

A key point that impacts on the investment forecast for this portfolio is that generally these assets cannot be maintained or inspected. Any intervention is typically the replacement of the asset or the scheme at the end of its life. Because of the criticality of protection relays and DC battery systems, these replacements are likely to be conservative as the risk of allowing the assets to enter into periods of high rates of failure is not tolerable. The flow on issue from this need is that failure rate data on ageing protection relays is limited and this makes determining an optimum replacement age difficult.

A good example of this was the decision by Transpower in 2017 to extend the replacement interval for duplicated line protection from 20 years to 25 years. Duplicated relays significantly reduce the probability of protection function failure and uses two different OEM relays to remove common mode type risks.

The economic model and associated analysis primarily considered the capital cost of planned replacement against the monetised consequence of failure of the duplicate 220 kV line protection scheme. With the assistance of failure rate data from OEMs, Transpower could extrapolate with sufficient confidence beyond the normal life expectancy of the relays to make this decision. The analysis indicated potential to increase replacement age to 35 years.

While extending the replacement age for all protection relays may not be optimum, an extension of 5 years for these short life assets means that capital replacement costs are reduced by 25%. With respect to the proposed $141.6 million RCP3 expenditure, this would equate to a reduction of $35.4 million.

We recommend that Transpower continue its work with OEMs to support developments, which can extend the reliable operation of current modern relays and analyse further opportunities to extend the life of the current fleet. Our analysis, at current life expectancies for protection relays, DC systems and revenue meters, suggests a long run average cost of around $120 million for each price reset period (based on population quantities and expected population life). This confirms that Transpower is currently running into a bow-wave of replacements from RCP3 to RCP5 that should then reduce.

We have reviewed the volumes of relays, DC systems and revenue meters forecast for replacement in RCP3 and consider the volumes to be reasonable given the unknown and potential high risks to extend the life of the current aged assets. Most of the remainder of the fleet is in good condition but many assets eventually will require replacement in RCP5 at life replacement ages.

Transpower has actively targeted actions to reduce human error incidents (HEI), which are controllable and cause a high number of incidents with protection systems. The high incidence of HEIs affects the reliability of the asset fleet and is generally decreasing, but the number of HEI-caused incorrect operations remains a focus for Transpower to reduce. This issue is not uncommon though for all electricity network owners and operators.

Transpower has also demonstrated improvements to its estimating approach over the RCP2 and previous regulatory periods and we consider the current practice has provided more accurate and appropriate forecasting of expenditure for the identified replacement programmes.

We have reviewed the Asset Health (AH) Model and the development for Secondary Assets and found:

- A simple Asset Health Model has been developed in RCP2 for protection schemes (excluding ODJBs) and station DC systems driven predominantly by the age of the assets. There is no Asset Health Model in place for revenue metering.
- Transpower's overall strategy for protection assets is to replace relays on obsolescence or endemic failure, replace relays based on unavailability of spares or where a model shows signs of endemic failure, subject to a maximum life expectancy of 20-25 years. This approach has determined the input values for RCP3.
- In 2017 (RCP2), Transpower was able to extend the replacement interval for duplicated line protection from 20 years to 25 years with the assistance of failure rate data from OEMs. The analysis indicated potential to increase the replacement age to 35 years, however with high uncertainty to this extent.
- Transpower is planning in RCP3 to develop a risk-based framework for evaluation and cost benefit analysis of protection scheme capital expenditure planning, including implementing and enhancing criticality-adjusted replacement strategies for protection schemes.
- With the relatively short life of current secondary system technology (20-25 years), the benefits of extending asset life by just 5 years is substantial and hence this should be a priority in RCP3 for developing further the asset health and criticality models for secondary assets.

In summary, we verify that the investment in protection, battery systems and revenue meters is reasonable and adequate. We believe Transpower's RCP3 SA Protection capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - Secondary Assets (Protection)

Table 64 summarises our verification assessment and opinion.

**Table 64 Verification summary - Secondary Assets (Protection)**

| Expenditure category | Capex - Secondary Assets (Protection) | |
|---|---|---|
| **Transpower RCP3 forecast** | $141.6 million | |
| **Recommendation** | **Accept:** $141.6 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Replacement based on end-of-life - extension of replacement interval for duplicated line protection by 5 years considered | - |

| | | |
|---|---|---|
| | to reduce overall capex by $35 million<br>* Improvement in estimating approach since RCP2 generating more accurate forecasting | |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | - |
| **Potential scope for improvement** | * Recommend Transpower continue work with OEMs to support developments which can extend the reliable operation of current modern relays and analyse further opportunities to extend the life of the current fleet | - |

*SA Substation Management Systems*

Transpower's asset strategy and expenditure forecasts for Substation Management Systems are detailed in the Substation Management System Portfolio Management Plan and the corresponding Substation Management Systems Asset Class Strategy.

Substation Management Systems (SMS) refers to the systems that enable real-time monitoring and remote control of substation equipment. They communicate directly with Transpower's SCADA/EMS System and therefore SMS reliability is essential to maintaining visibility and control of the power system.

This PMP covers the tactical planning for the following SMS asset types:

- Remote Terminal Units (RTUs)
- Substation Management Platforms (SMPs)
- Human Machine Interfaces (HMIs)
- GPS clocks

Transpower has forecast a total capex for SA Substation Management Systems in RCP3 of $58.6 million in real 2017/18 dollars. Table 65 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 65 Comparison of SA Substation Management Systems RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| SA Substation Management Systems | 61.7 | 58.6 | -5% |

Table 66 shows the annual forecast capex for SA Substation Management Systems in RCP3 in real 2017/18 dollars.

**Table 66 Annual forecast capex for SA Substation Management Systems in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| SA Substation Management Systems | 15.8 | 12.8 | 13.0 | 8.4 | 8.6 | 58.6 |

Figure 61 shows the annual SA Substation Management Systems capex for the regulatory periods RCP1 to RCP3, and Figure 62 shows the total SA Substation Management Systems capex for the regulatory periods RCP1 to RCP5.

**Figure 61 Annual SA Substation Management Systems capex for RCP1 to RCP3**

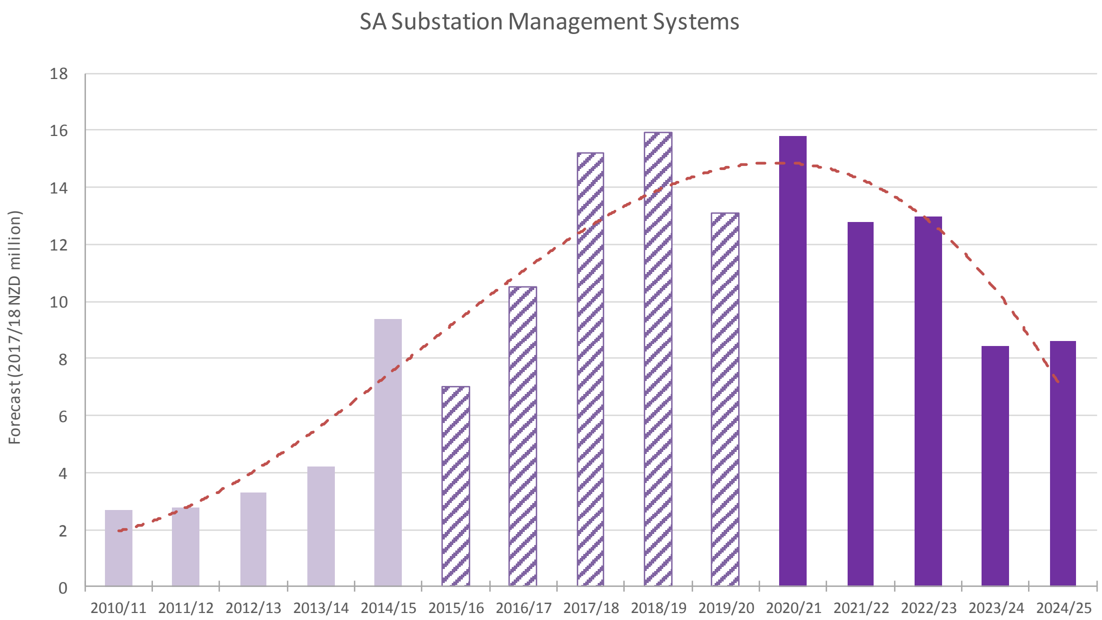
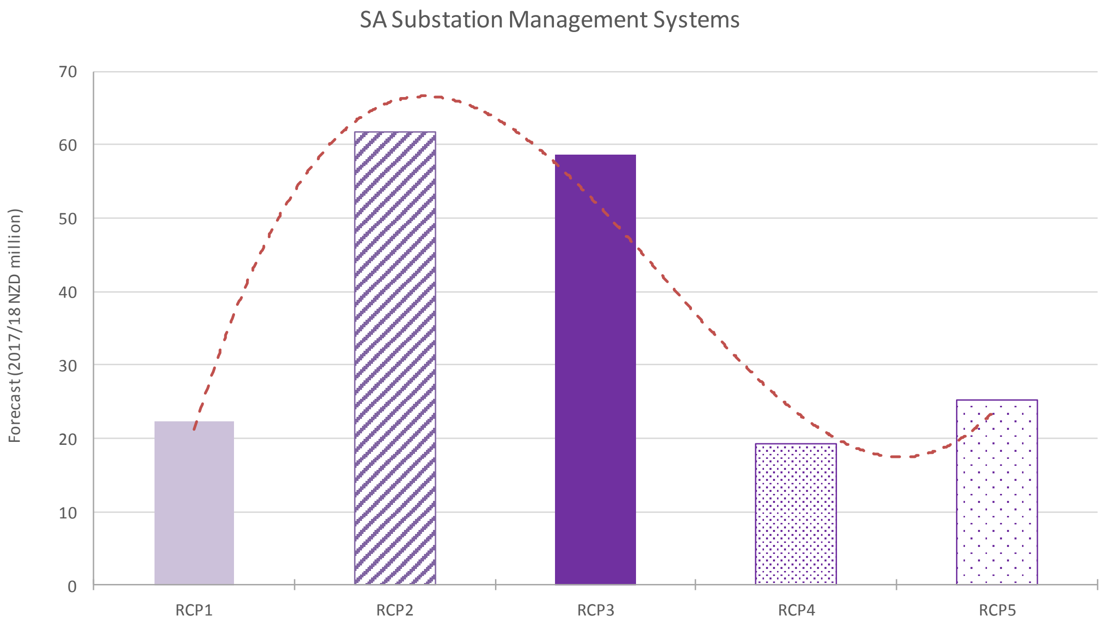


**Figure 62 Total SA Substation Management Systems capex for RCP1 to RCP5**




As a backdrop to the review of the SMS strategies and expenditure, it is worth noting that as electrical systems are driven harder, information systems, data quality and quantity, and communication-related assets will place higher demands on reliability from SMS Assets. There are also wider benefits that will result from the coordination between the SMS, telecommunication, SCADA and information systems.

At present, Transpower's main programme of work is focused on phasing out legacy serial-based Remote Terminal Units and Input/output modules and replacing these with new Ethernet-capable Substation Management Platform systems. This new technology also includes Remote Engineering Access (REA), which allows interrogation and management of secondary systems without needing to be on site.

Human Machine Interface capabilities (which provide local situational awareness and direct control over the site's assets) began to be installed in RCP1 and is expected to be completed by the end of RCP3. Transpower is no longer undertaking RTU-only replacements as this approach leads to increasing lifecycle costs and fails to realise the business benefits associated with remote engineering access services.

In RCP1, a total of 54 sites were upgraded to SMS, but many of these sites were only partially completed as typically no REA services were deployed. In RCP2, Transpower has undertaken to complete 56 SMS projects, increasing planned expenditure in RCP2 from $39.2 million to $61.7 million. This increase reflects baseline cost and estimation corrections, and several strategic and tactical initiatives.

**Asset Health Modelling - Substation Management Systems**

There are no specific Asset Health Modelling and Criticality strategies in place for this fleet. The investment plan is based on the result of age-based replacement policies.

Transpower rely on spreadsheet-based data sets that contain site information and lists of the assets identified as being at each site. This information is combined with other data such as site criticality rating, site communications profile, and planned site works to build a forecast of the required investment.

Due to the systems consisting of modular electronic components there is a view that there is no meaningful way of determining the health of the units then by age. Hence, there is a reliance on manufacturer recommendations, measured Mean Time Between Failures (MTBF) statistics, and real-world failure rates (both Transpower's own and other comparable customers) to set the expected useful life of the assets. Individual asset health ratings are based on the age of the specific asset (relative to its target replacement age), though this rating may be revised downwards if the asset is no longer fit-for purpose.

Transpower has reviewed types of assets in its Substation Management System asset class and applied asset strategies in RCP2 which we consider valid in determining the input values for RCP3 expenditure forecasts.

Improvement in data accuracy is a priority for improvement. Transpower relies on manufacturer recommendations, measured Mean Time Between Failures (MTBF) statistics, and real-world failure rates (both our own and other comparable customers) to set the expected useful life of our assets. These are considered within the asset class strategy.

Transpower have stated the criticality of the SMS assets is based on the criticality of the site at which they are located. Site criticality ratings are determined by the amount of sustained load or generation lost after a High Impact Low Probability (HILP) event at the site, the amount of load that is transferred through the substation, strategic importance (e.g. black start capability), and the grid exit point's long-term performance targets (if applicable).

We consider the above approach valid for these assets as we agree these assets of critical to the operation of the network as a whole. Transpower has stated that, "due to the reliance of grid operations on the SMS assets the continued operation of the SMS assets is critical". However the Portfolio Management Plan assesses 70% of the SMS Assets to be graded as either "low" or "medium" relative criticality.

Transformer also state the "Substation Telemetry Management System Failure bowtie" applies to this portfolio, and that "*… the relative level of risk for this asset class is very low, based on current information about the causal likelihoods and the applied controls with their respective effectiveness levels. This level of risk indicates that robust controls are in place and that this critical service is generally well managed.*"

With the relatively short life of SMS Assets, the benefits of extending asset life is substantial and hence this should be a priority in RCP3 to consider developing further the asset health and criticality models for SMS assets.

**Asset strategy, planning and estimating - Substation Management Systems**

Transpower's overarching strategies for the SMS fleet are:

- Replace legacy RTUs and I/O modules with SMS equipment when they reach 15 years of age: A tolerance of five years either side of the nominal replacement date may be allowed, to enable efficiency in delivery through project bundling, or to allow for prioritisation of replacement expenditure based on asset criticality.
- Implement remote engineering access (REA) while deploying SMS: The REA installation work will be carried out at the same time as SMS deployment or legacy I/O replacements, to reduce overall costs by avoiding double handling and rework.

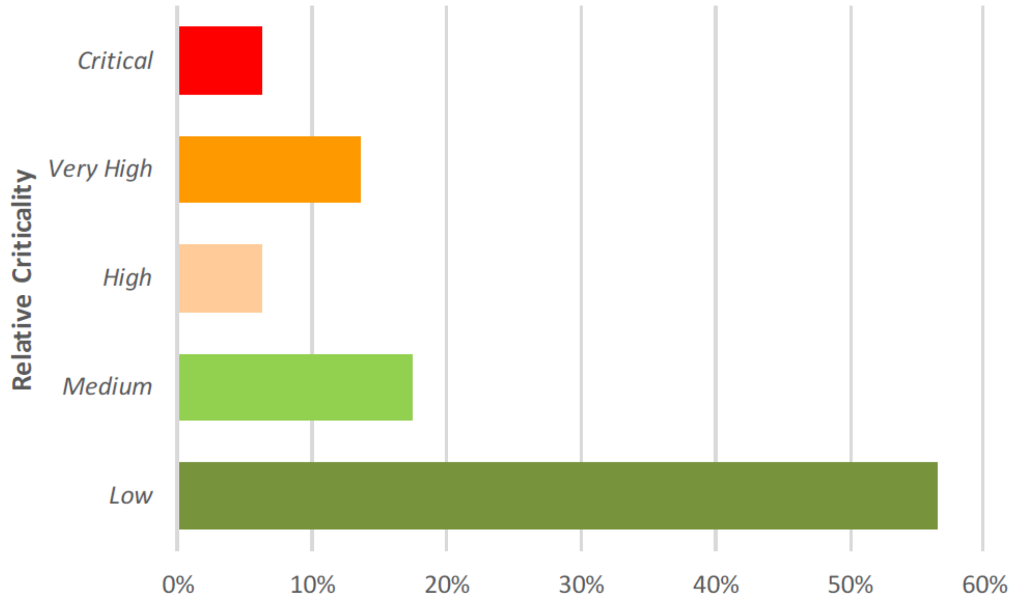
Transpower has adopted several tactical Asset Management Strategies which include:

- Replace legacy RTUs and I/O modules with SMS equipment when they reach 15 years of age.
- Replace GPS clocks based on obsolescence drivers subject to a maximum age of 15 years.
- Upgrade sites with hybrid SMS and legacy I/O modules when they reach 15 years of age, by replacing the I/O modules with SMS equivalent.
- Implement remote engineering access while deploying SMS.
- Centrally manage the configuration and substation IEDs using a suite of vendor-provided tools.
- Estimation of costs by undertaking detailed site investigations prior to finalising cost estimates for SMS projects, applying volumetric cost estimating where applicable and using customised project estimates for SMS installations at very large sites.

- Reduce whole-of-life costs and procurement risk by using a sole system vendor with detailed SMS specifications, and managing the relationship with the sole system vendor to encourage long-term technical support and cost control.

The criticality of the SMS assets is based on the criticality of the site at which they operate. Site criticality ratings are determined by, for example, the amount of sustained load or generation lost after a High Impact Low Probability (HILP) event. The following indicates the relative criticality of the SMS assets.

**Figure 63 SMS site criticality distribution**




Controls implemented to reduce the likelihood of causal pathways include lifecycle planning, predictive modelling, data quality improvements, and strategic interventions to target at-risk assets. The key preventive controls are replacing assets in a timely manner or increasing system redundancy. Monitoring international data on component failure rates assists in informing these preventive controls.

**Key Drivers for RCP3 - Substation Management Systems**

Transpower plans to complete SMS implementations at a remaining 71 sites and with the intention to maintain the delivery momentum achieved in the preceding RCP2 period. The completion of the RTU replacement programme in RCP3 is reflected in the lower forecast investment requirements for RCP4 and RCP5.

Transpower's overarching driver for SMS is that the assets operate reliably and meet operational needs, at least lifecycle cost. A second driver for expenditure is for the replacement of assets that are at the point where either the probability of failure, or technical obsolescence, poses an unacceptable operational risk. Often replacement is based on age before these issues become an issue for the safe and reliable operation of the network.

When SMS was first installed in the 1990s it was based on serial RTUs. In the early 2000s the RTUs were upgraded, however the I/O modules were not replaced. RTU technology is now obsolete and increasingly unreliable, most of the equipment is no longer supported by manufacturers and few, if any, spares are available to support or upgrade the legacy asset base. Further, modern communication protocols are not supported, and much of the in-service RTUs have insufficient computing capacity to meet the signal processing requirements demanded by modern intelligent electronic devices (IEDs). This has a material impact on the viability of planned work in other portfolios such as protection upgrades and outdoor to indoor switchyard conversions (ODID).

In 2006, Transpower embarked on a 15-year programme of substation modernisation to replace the aging RTU assets with a new Substation Management Platform (SMP). Due to budget constraints in the initial delivery stages of the programme (2011-2015) the focus was on the replacement of the aging RTUs. As a result, not all I/O modules were replaced, REA and HMI were often not implemented, and data rationalisation was not addressed.

Due to these issues Transpower undertook a detailed review of the programme in 2016 with the objective of identifying the work required to successfully complete the implementation of the programme, which is continuing and aimed to be practically completed in RCP3.

**Verification assessment - Substation Management Systems**

The SMS asset class seems more difficult than others to assess the criticality of performance and the required reliability of the assets. Transpower states:

*"… with the increasing reliance on automation, remote control and telemetry to control the grid, failures in the SMS are becoming less acceptable. It is increasingly important that we maintain an operable SMS system that is reliable and meets the increasing demand for more functionality.*

*Therefore, due to the operational criticality of our SMS assets, our approach is to ensure that:*

- *Assets remain within manufacturer support (ensuring software tools support current operating systems and assistance is available if required);*

- *Assets must be replaced before the rate of failure becomes operationally unacceptable.*"[114]

However, elsewhere in its failure bowtie[115] analysis, Transpower indicates that the relative level of risk for this asset class is very low, based on the causal likelihoods and the applied controls and performance of the assets. The latter statement is referring to the residual level of risk, after assessment of the current controls that are in place and how well the assets are being managed.

Our view is that Transpower's current management of the assets is valid. It is generally based on replacing systems on age and prior to the assets failure rates becoming problematic, or components becoming obsolete and unsupported by OEMs.

Transpower has an age-based profile for assets that are part of the SMS, and are planning to develop a specific Asset Health model. SMS are a critical asset and as such are supported by Transpower's asset strategy. The current criticality models do not align at a granular level because they do not value the functionality of the SMS/SCADA value chain. As such, Transpower considers asset criticality for SMS (and/or its components) as a potential longer-term goal. Criticality will need to reflect the impact of legacy systems and assets on the ability for the system to respond to any concurrent event, combined with the additional direct costs of managing legacy systems and potentially the benefits of the SMS solution as a whole.

The continued roll out and completion of SMS implementations at the remaining 71 sites in RCP3 is also considered reasonable to enable smart network technology and data analytics capability over the next 5-10 year timeframe.

Transpower has no specific asset health or grid output measures applying to the SMS assets. Currently the portfolio analysis relies on spreadsheet-based data sets that contain site information and lists of the assets identified as being at each site. This information is combined with other data, such as site criticality rating, site communications profile, and planned site works, to build a forecast of the required investment.

We support the development of an asset criticality model and asset heath model for this portfolio. The asset health model could be based on using systems reliability tools to model component failure contribution to the consequence of loss of functionality. This would improve the alignment of high-level component failure rates against service performance objectives, and with a review of the criticality model, likewise the services performance objective can be optimised.

114 Transpower (2018), Portfolio Managment Plan: Substation Management Systems, p. 29, Document [64]

115 Ibid., p. 22

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Transpower has demonstrated improvements to its estimating approach over the current and previous regulatory periods and we consider the current practice has provided more accurate and appropriate forecasting of expenditure for the identified projects.

We have reviewed the Asset Health (AH) Model and the development for Substation Management Systems and found:

- There are no specific Asset Health Modelling and Criticality strategies in place for this fleet. The investment plan is based on the result of age-based replacement policies.
- Due to the systems consisting of modular electronic components there is a view that there is no meaningful way of determining the health of the units then by age.
- Transpower has reviewed types of assets in its Substation Management System asset class and applied asset strategies in RCP2 which we consider valid in determining the input values for RCP3 expenditure forecasts.
- Improvement in data accuracy is a priority for improvement.
- Improving asset knowledge will allow consideration of potential benefits to develop an asset health model.
- In terms of criticality of the assets there appears to be inconsistencies which should be clarified. If the asset are not critical then there is clear opportunities to extend the life of the assets and run to failure. We however do not consider this to be valid.
- Transpower have stated the criticality of the SMS assets is based on the criticality of the site at which they are located. We consider the above approach valid for these assets as we consider these assets to be critical to the operation of the network as a whole. However the Portfolio Management Plan assesses 70% of the SMS Assets to be graded as either ”low” or “medium” relative criticality.

With the relatively short life of SMS Assets, the benefits of extending asset life is substantial and hence this should be a priority in RCP3 to consider developing further the asset health and criticality models for SMS assets.

In summary, we verify that the investment in SMS is reasonable and adequate. While the programme to install the modern SMS platforms could be deferred, it would not allow Transpower to develop the digital systems and improved knowledge of the health of substation assets, network performance, which should lead to further optimisation of capex and opex expenditure of substation assets into the future.

We believe Transpower's RCP3 SA Substation Management Systems capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - Substation Management Systems

Table 67 summarises our verification assessment and opinion.

**Table 67 Verification assessment - Substation Management Systems**

| Expenditure category | Capex - Substation Management Systems | |
|---|---|---|
| **Transpower RCP3 forecast** | $58.6 million | |
| **Recommendation** | **Accept:** $58.6 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Expenditure will allow for improved knowledge of substation asset health and network performance, leading to optimised and efficient substation capex and opex<br>* Supported by reliable asset strategies demonstrating prudency | - |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | * Inconsistencies in criticality rating of some assets to be addressed | - |
| **Potential scope for improvement** | * Benefits of life extension can be significant so development of asset health and criticality models for SMS assets should be priority<br>* Improve data accuracy | - |

### 7.3.5 Enhancement & Development

System planning identifies the constraints and opportunities across the Grid, particularly those relating to enhancing or reducing the capability of the Grid. Enhancement & Development (E&D) capex[116] is the primary means of addressing the system issues identified including:

- investments that increase or decrease the capability of the Grid;

[116] Transpower (2014), Enhancment and Development Base Capex; Response to Draft Decision, slide 3, Document [30],

- ensure Grid capability matches generation, demand, security, reliability and market requirements;
- system needs to provide system capacity, reliability and security required to meet future customer and grid requirements; and
- external drivers, such as customer developments and new connections, economic conditions and statutory requirements.

Transpower has forecast a total capex for E&D in RCP3 of $76.4 million in real 2017/18 dollars. Table 68 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 68 Comparison of E&D RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Enhancement & Development | 97.5 | 76.4 | -22% |

Table 69 shows the annual forecast capex for the E&D works programme in RCP3 in real 2017/18 dollars.

**Table 69 Annual forecast capex for E&D in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Enhancement & Development | 15.3 | 15.3 | 15.3 | 15.3 | 15.3 | 76.4 |

Figure 64 shows the annual E&D capex for the regulatory periods RCP1 to RCP3, and Figure 65 shows the total E&D capex for the regulatory periods RCP1 to RCP5.

**Figure 64 Annual E&D capex for RCP1 to RCP3**

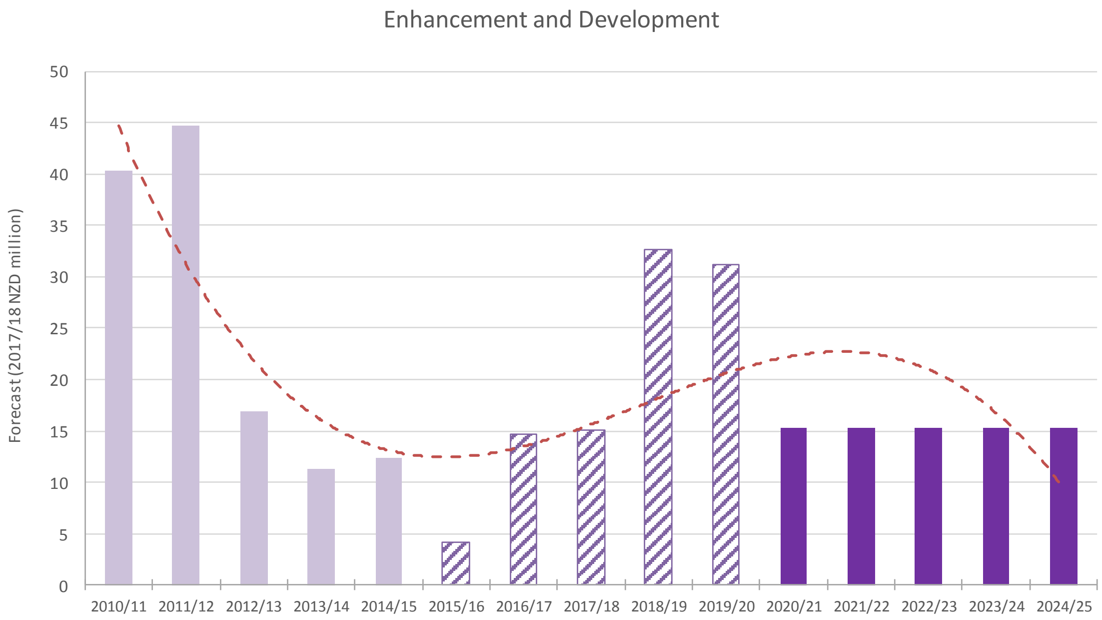
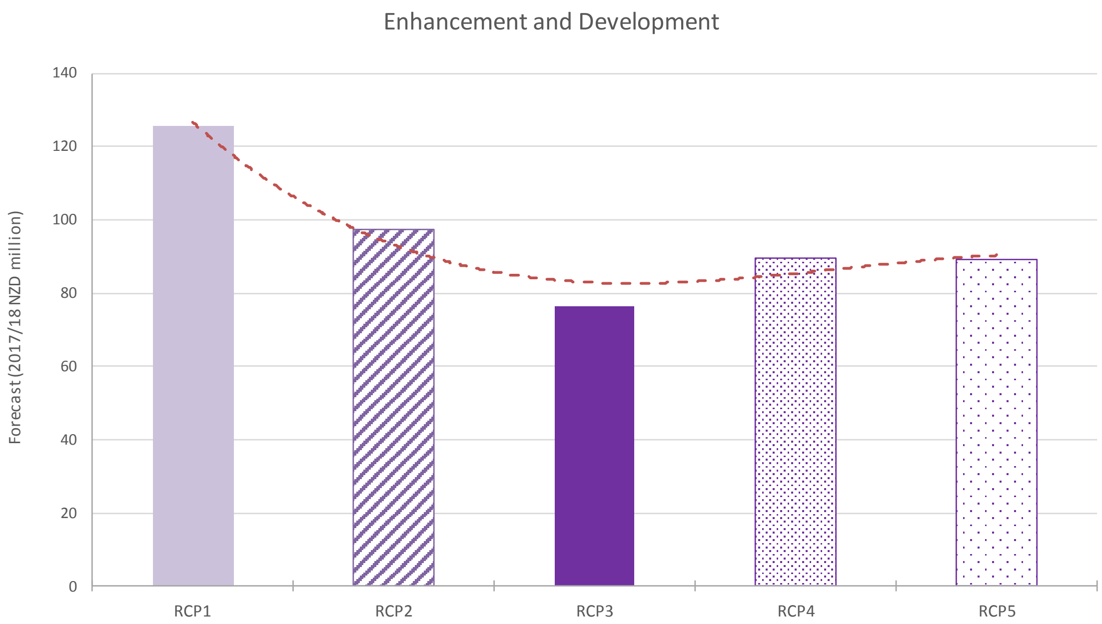



**Figure 65 Total E&D capex for RCP1 to RCP5**



*RCP2 forecast process*

In forecasting E&D capex for RCP2, Transpower followed a generic approach that applied to all capital investment planning.[117] This involved:

- planning, including needs identification and options analysis
- cost estimation for approval
- integration into the project and programme works delivery.

This resulted in a list of 15 growth-related projects to address anticipated regional capacity and security issues. Projects estimated to be less than $20 million were included, with projects of greater estimated value submitted to the Commission for separate approval.

The key considerations in the RCP2 E&D forecast review[118] of the 15 projects listed were typical of a capex project review:

- accuracy and reliability of demand forecasting
- clear justification of the project need
- robust option analysis and preferred solution selection
- reliable project cost estimation and timing.

Using this approach, the RCP2 review identified several areas where the project list was not robust and did not sufficiently justify the Transpower forecast expenditure. In particular, the review noted:

- concerns about the demand forecasting method, given prudent peak demand forecasts contrast with recent national and regional peak demand trends, apparent disconnect between the peak demand growth and GDP forecast whilst retaining an economic forecast in the approach, and an *"… overall impression of ongoing conservatism underpinning …* [the] *P90 prudent forecast"*
- insufficient justification for project needs and lacking well-defined drivers
- "weak" option analysis
- insufficient detail in project timing.

117 GHD (2018), GHD RCP3 Capex and Opex forecast_IV review, section 6.3.2, pp. 69-70, Document [118]

118 Ibid, Annex A, pp. 155-167

Consequently, the RCP2 review recommended an alternative forecast of $56.7 million compared to the Transpower original forecast of $123.8 million, or a decrease of 54%. This amended forecast included consideration of a productivity adjustment of 7.5% that was also applied to other expenditure categories.[119]

Following Transpower's response to the Commerce Commission draft decision, including additional justification for the proposed programme, the Commission reinstated $38.4 million of the reduction in forecast, making the RCP2 allowance $95.1 million.[120] In the final decision, the Commission noted that Transpower had provided additional information in response to the draft decision, which re-tested the Grid need dates for some of the projects and revised the proposed E&D capex to $99.4 million.

The Commerce Commission regarded the updated information as "*… significantly improved compared with documents included with Transpower's* [original] *proposal*." Transpower stressed that E&D capex should be reviewed on a top-down basis given the discrete assessment of individual projects does not adequately recognise the uncertainties inherent involved in this expenditure category. However, as part of the RCP2 final decision, the Commerce Commission persisted with assessing each project as it considered Transpower had submitted the E&D projects as single projects and "*… not as a group or pool of projects with probabilities attached to each project*." The Commerce Commission accepted most of the revised E&D project justifications detailed by Transpower in its response.[121]

As shown in Figure 65, the actual E&D expenditure during RCP2 was $96.8 million, which was $28.7 million or 23% less than for RCP1.

### *Capex IM requirements for E&D base capex*

In its March 2018 capex IM paper, the Commerce Commission proposed to "*… amend the capex IM to introduce the option for an expenditure adjustment mechanism for base capex E&D projects. The adjustment will be an automatic mechanism that updates the standard incentive rate base capex allowance.*"[122]

[119] Ibid., Table 7, p. 77

[120] Commerce Commission (2014) Setting Transpower's individual price-quality path for 2015-20, clauses 5.69 to 5.80, pp. 75-77, Document [120]

[121] Document [30], The main exclusion was $3.7 million to upgrade the Wiri Tee to Wiri substation line section

[122] Clause 181

In the Commerce Commission capex IM amendments determination dated 25 May 2018, Schedule F details the information required in a Base Capex proposal, including the following clause:

*"F2 List of identified programmes, listed projects, low incentive rate base capex projects and E&D base capex projects …*

*(4) Identify all E&D base capex projects or E&D base capex programmes that Transpower considers should be subject to the base capex allowance adjustment mechanism and explain the extent to which the cost and/or timing uncertainties are linked to -*

*(a) a certain level of demand or connection of new generation; and/or*

*(b) any other drivers of E&D base capex"*[123]

In evaluating the E&D Base Capex allowance Transpower proposes for RCP3, the Commerce Commission requires an assessment by the verifier of:

- whether, due to the level of cost or timing uncertainty and the drivers of base capex, Transpower should consider proposing some of the projects under the expenditure adjustment mechanism; and
- any E&D Base Capex proposed for inclusion in the adjustment mechanism for the appropriateness of the proposed amount of Base Capex and the nature of any triggers.

### *Development of RCP3 forecast*

We recognise the nature of E&D capex is that it relates to probable or potential projects that typically do not have the level of project definition as other Base Capex programmes (e.g. renewals). This is due to the inherent uncertainty in some of the key drivers and shifting Grid requirements that will affect timing for the project. Consequently, the projects are unlikely to withstand the close scrutiny typically applied to network and non-network capex projects, and as was applied during the RCP2 review to the 15 listed growth-related projects.

Transpower has acknowledged that the E&D process used for RCP2 proposal was not sound. The RCP2 proposal appeared as a list of projects to be delivered and did not have

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[123] Transpower (2014), Enhancment and Development Base Capex: response to Draft Decision, Schedule F, p. 80, Document [30]

sufficient information to individually justify the projects due to the characteristic uncertainties.

We note that Transpower has adopted a different process in developing its RCP3 forecast for E&D capex, by considering any inherent risks in the proposed E&D projects including uncertainties in scope or changing customer or network requirements. The RCP3 approach focuses on the likelihood of various Grid augmentations progressing during RCP3 based on four inter-related processes:

- system planning;
- customer needs;
- asset health; and
- a decision framework to identify and prioritise the best option.

The approach assumes a standard base demand forecast and considers customer feedback on regional load growth, generation development currently in the construction phase and committed Grid investments. The transmission planning studies aim to identify capability gaps in the existing Grid.

The projects identified by Transpower through this process are grouped according to the degree of certainty for the expenditure into one of three broad headings:

- Extremely Likely - project with well-defined external drivers, confidence in project execution, option identified though Options Assessment Approach (OAA), cost estimate to pass economic approval stage gates.
- Highly Likely - project with less certain external drivers, probable project will proceed, option identified through OAA, lower accuracy in cost estimate for economic approval.
- Likely - project with high-level definition only, problem recognised but no confidence in project proceeding, no OAA investigation, order-of-magnitude estimate only.

Details of the projects included in these three likelihood headings are in Attachment B.9.

To generate a forecast expenditure for RCP3, Transpower created two scenarios:

- High-expenditure scenario ($98.4 million) based on all projects identified (Extremely Likely, Highly Likely and Likely) totalling $88.4 million, plus a nominal $10 million added for anticipated but un-scoped work for industrial load growth and generation changes.

- Low-expenditure scenario ($63.6 million) based on Extremely Likely and Highly Likely projects, excluding consideration of all generation-driven developments, totalling $65.6 million, plus a nominal $5 million for anticipated but un-scoped work for moderate industrial load growth, less 10% for potential technology development and investment deferral.

Transpower nominated a forecast for RCP3 of $76.4 million, being the average of the two scenarios and with a $4 million adjustment reflecting an agreement with the Commerce Commission on the best categorisation of the Bombay and Otahuhu-Wiri projects.

Unlike RCP2, Transpower has presented the RCP3 E&D forecast as a total expenditure averaged over the RCP3 period (i.e. $15.3 million per annum) to reflect the current view of system needs in lieu of a list of specific investments due to the perceived high level of uncertainty in the customer and network requirements. Transpower regards this approach as a "least regrets" outcome and allows for prompt response to short-term changes in investment decisions.[124]

### *Key drivers for RCP3*

In its long-term strategy[125] for the transmission network, Transpower has identified several key trends that will likely drive significant changes to the business. One of these is urbanisation, noting that 60% of the population growth in New Zealand by 2045 will be in Auckland. In response, Transpower has published an "Auckland Strategy Direction"[126] which details the challenges and strategy to support this future growth and growing requirements for the Grid.

The projects associated with addressing network constraints, security of supply and forecast load growth in the Auckland area within the Extreme Likely project baseline for RCP3 represent approximately 55% of the total forecast expenditure for the Extremely Likely category and approximately 18% of the total E&D RCP3 forecast.

Table 70 summarises the breakdown of the projects proposed by Transpower as being potential E&D projects during RCP3 by the primary driver described in the 2017 Transmission Planning Report.[127] Attachment B.9 shows a detailed listing of the RCP3 E&D forecast expenditure.

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124 Transpower (2014) Enhancement and Development Base Capex: Response to Draft Decision, section 4.3.3, p. 7 Document [30]

125 Transpower, Transmission Tomorrow, pp. 8-13, Document [2]

126 Transpower, Powering Auckland's Future, Document [3]

127 Transpower (2017), Transmission Planning Report, Document [31]

**Table 70 RCP3 E&D forecast expenditure**

| Likelihood | Primary driver | No. of projects | RCP3 forecast (2017/18 $ million) | | |
|---|---|---|---|---|---|
| | | | Investigation | Construction | Total |
| Extremely likely | Asset condition | 1 | $ 0.13 | $ 5.00 | $ 5.13 |
| | Compliance | 1 | $ 5.13 | $ - | $ 5.13 |
| | Load growth | 4 | $ 0.31 | $ 14.79 | $ 15.10 |
| | Transmission constraint | 2 | $ 0.18 | $ 3.09 | $ 3.27 |
| | *Subtotal* | *8* | *$ 5.75* | *$ 22.88* | *$ 28.63* |
| Highly likely | Load growth | 2 | $ 0.26 | $ 5.50 | $ 5.76 |
| | Security of supply | 1 | $ 0.05 | $ 1.00 | $ 1.05 |
| | System security | 2 | $ 0.13 | $ 6.50 | $ 6.63 |
| | Transmission constraint | 5 | $ 0.40 | $ 25.20 | $ 25.60 |
| | Voltage | 2 | $ 0.15 | $ 9.98 | $ 10.13 |
| | *Subtotal* | *12* | *$ 0.99* | *$ 48.18* | *$ 49.17* |
| Likely | Load growth | 2 | $ 0.40 | $ 4.50 | $ 4.90 |
| | Security of supply | 2 | $ - | $ 4.90 | $ 4.90 |
| | Transmission constraint | 1 | $ 0.10 | $ 0.70 | $ 0.80 |
| | *Subtotal* | *5* | *$ 0.50* | *$ 10.10* | *$ 10.60* |
| **TOTAL** | | **25** | **$ 7.24** | **$ 81.16** | **$ 88.40** |

Localised load growth as a primary driver represents a total of $25.76 million or 29% of the total expenditure forecast. In response to concerns raised in the RCP2 review, Transpower added an additional short-term scenario to the demand forecasting model suite. A review in 2016 following public consultation with stakeholders recommended the Ministry of Business, Innovation and Employment (MBIE) have oversight in validating the demand forecasts. The NZ Institute of Economic Research (NZIER) reviewed the methodology and recommendations considered and implemented for improved confidence in demand forecasts.

With reference to section 11.2, the regional peak demand forecasts generated for the next 10 years are considered reliable and sufficient to support the development of E&D projects. Transpower's demand forecasting methodology is discussed further in Chapter 11 (Other key forecasting input assumptions) of our report.

### *Stakeholder engagement*

Transpower has advised that it conducts quarterly forums with regional customers to gain feedback on local issues and meet one-on-one where required to discuss any particular connection issues. Regular meetings are held with corporate customers to discuss any operating or market changes that have occurred year-on-year.

As a customer, given investment may impact on how the network is planned, Transpower advised that it examines connection requests from new generation or customers to identify any planning review that may be required either at the time of the enquiry or later.

Transpower publishes a Transmission Planning Report annually and customers have input concerning local developments (refer section 4.3 of Chapter 4 of our report for additional commentary regarding the stakeholder engagement process Transpower has used for the RCP3 proposal).

### *Verification assessment of E&D*

We have verified that the current list of E&D projects are linked to known network constraints, and there are both Grid need and customer-initiated triggers with varying levels of commitment, leading to uncertainty in the RCP3 forecast. We have reviewed project system planning reports for a selection of the nominated RCP3 projects and verified that as the certainty level for an E&D project develops, through application of the Decision Framework the OAA identifies a preferred solution (refer section 5.6) with more defined scope and budget. We are therefore satisfied that the list of projects used in developing the high and low scenarios are reasonable and relevant for the RCP3 forecast.

We are satisfied that the first pass high/low scenario approach in determining the range of E&D expenditure based on a list of projects graded by their likelihood is a sound approach as it:

- recognises the inherent uncertainty in the projects for the upcoming period;
- highlights the projects that are most likely to proceed during RCP3;
- identifies the projects by Grid need date to indicate those projects with impending need timeline that should have less uncertainty than those that remain with high uncertainty;
- allows for the identification of possible external triggers for projects;
- includes consideration of stakeholder feedback through classification of likelihood for each project; and
- allows for an assessment of projects that are well-defined both in scope and external triggers for potential inclusion in the adjustment mechanism defined by the Commerce Commission in the amended Capex IM.

Upon request, Transpower provided a selection of project summary documents and initial business cases as examples of the way in which E&D projects develop as project drivers and Grid need become clearer, with a clear preferred option that is well defined and more accurately estimated for formal stage gate approval (refer Attachment B.9.1).

We accept the five examples Transpower provided give a good demonstration of the differing rigor that applies for projects at differing likelihood levels and highlights the inherent uncertainties in this expenditure category. As such, we believe an "envelope" expenditure forecast based on a list of projects that Transpower believes are the most likely to proceed during E&D is an appropriate approach, rather than evaluating each of the listed projects individually as was the practice for the RCP2 decision.

We acknowledge that in developing these high/low scenarios that Transpower has included nominal provisions for projects not yet identified ($10 million in the high scenario and $5 million in the low scenario), together with nominal adjustments in the low scenario for generation connection projects that may not proceed during the RCP3 period and cost savings due to emerging technology.

Transpower has examined several weighted average approaches to determining the RCP3 forecast, using nominal weighting percentages for the Extremely Likely/Highly Likely/Likely projects and the unidentified provisions discussed above. However, given the inherent uncertainties, Transpower has preferred to adopt the mid-point of the range as the RCP3 forecast.

We accept that in setting the high expenditure scenario, it is reasonable to include all the projects (Extremely Likely, Highly Likely and Likely) that have been identified through a review of known network capacity and security constraints, and potential load increases as advised by customers.

Similarly, for the low expenditure scenario, we agree with the approach of including all Extremely Likely and Highly Likely projects, excluding generation connection projects as a proxy for generation development not proceeding. We accept as reasonable a nominal 10% adjustment for potential savings through emerging technologies and deferred investment.

Following discussions with Transpower based on our draft report findings, our recommendation for business rules (for the generation of the high and low scenario estimates, including justification for any unidentified project allowances and any deductions in the low scenario for emerging technologies or other factors) was adopted in the draft 2018 Transmission Planning Report. We are satisfied that these business rules provide good guidance and verification of the development of the high and low scenario values through:

- identifying key assumptions behind the projects nominated (refer Attachment B.9);
- identified system needs
  - high scenario considers all projects expected to occur in RCP3;
  - low scenario considers all Extremely Likely and Highly Likely projects less all generation driven investment needs in Highly Likely;
- unidentified system needs
  - high scenario includes a $10 million allowance based on four unidentified projects at a historic average cost of $2.5 million per project;
  - low scenario includes a $5 million adjustment based on two unidentified projects at $2.5 million per project; and
- 10% cost savings in the low scenario recognising the potential for new technology or changes in the external environment that allow for either lower cost solutions or expenditure to be deferred beyond RCP3.

In setting the RCP3 forecast, we accept that adopting the average of the high and low scenarios is a reasonable and conservative approach and should set a value with equal likelihood of being either under or over spent within the nominated range for expenditure.[128]

We note the adjustment mechanism proposed by the Commerce Commission in the amended Capex IM of 25 May 2018 and we believe that a suitable project for inclusion in the adjustment mechanism would be characterised as follows:

- classed as an Extremely Likely project;
- clearly defined scope of work;
- clearly defined and scheduled project triggers, either confirmed external customer needs or changes in network operating environment that requires mitigation of known network constraints; and
- the project not already in progress.

[128] We acknowledge the submission by Fonterra to the Transpower RCP3 Ausust 2018 consultation paper that suggested that "*… the midpoint between the upper and power ranges appears to be an arbitrary figure*" and that delivery constraints may better inform the "*… right level of funding*". We were advised by Transpower that the delivery of E&D projects is done as part of the overall capital project portfolio and not separately, and therefore it would be difficult to identify any specific delivery constraints that could be considered in setting the E&D RCP3 forecast. In support of the approach used by Transpower, Northpower and Genesis Energy were satisfied with the forecasting approach used, including adopting the average value as the forecast.

Having regard to these criteria, we have not identified any projects for possible inclusion in the low capex incentive adjustment mechanism.

### Verification opinion - Enhancement & Development

Table 71 summarises our verification assessment and opinion.

**Table 71 Verification summary - Enhancement & Development**

| Expenditure category | Capex - Enhancement & Development | |
|---|---|---|
| **Transpower RCP3 forecast** | $76.4 million | |
| **Recommendation** | **Accept:** $76.4 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Forecast based on revised methodology using high and low expenditure scenarios for potential projects categorised by their likelihood demonstrating prudency<br>* Transpower developed business rules around allowances included in high and low scenarios based on historic expenditure<br>* Forecast methodology considered good basis for estimate with consideration of inherent uncertainties without exaggeration | - |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

### 7.3.6 ICT capex

Information and Communications Technology (ICT) relates to software and hardware systems required to support the operation and control of the Grid and support Transpower's business functions, particularly in asset management, planning and operations. The changing requirements and business needs for Transpower, as outlined in the corporate strategy *Transmission Tomorrow*[129], require ICT asset investment to deliver the required capability improvements in line with the target-operating model.

The other driving factor in ICT forecasts is the vendor product lifecycle for many of the systems, which is typically 5 to 7 years.

Transpower's broad strategic goals for ICT are based on:

- business-focused solutions;
- reliable and resilient systems;
- strategic resourcing to have staff with the necessary skills and knowledge available when needed;
- improved information management; and
- effectively assessing security risks and putting appropriate information protections in place.

The five asset portfolios within ICT are:

(a) Asset Management Systems to support maintenance/management of Grid assets;

(b) Corporate Systems to support core business functions;

(c) Shared Services for business solutions and development of corporate information management;

(d) Telecommunications, Network and Security Services to provide secure, high capacity telecommunications, network services to support corporate and critical communication services, and cyber-security protection;

(e) Transmission Systems to support operation and management of the Grid.

Figure 66 shows the annual ICT capex for regulatory periods RCP1 to RCP3 and Figure 67 illustrates the total ICT capex for regulatory periods RCP1 to RCP5.

[129] Transpower, Transmission Tomorrow, Document [2]

**Figure 66 Annual ICT capex for RCP1 to RCP3**

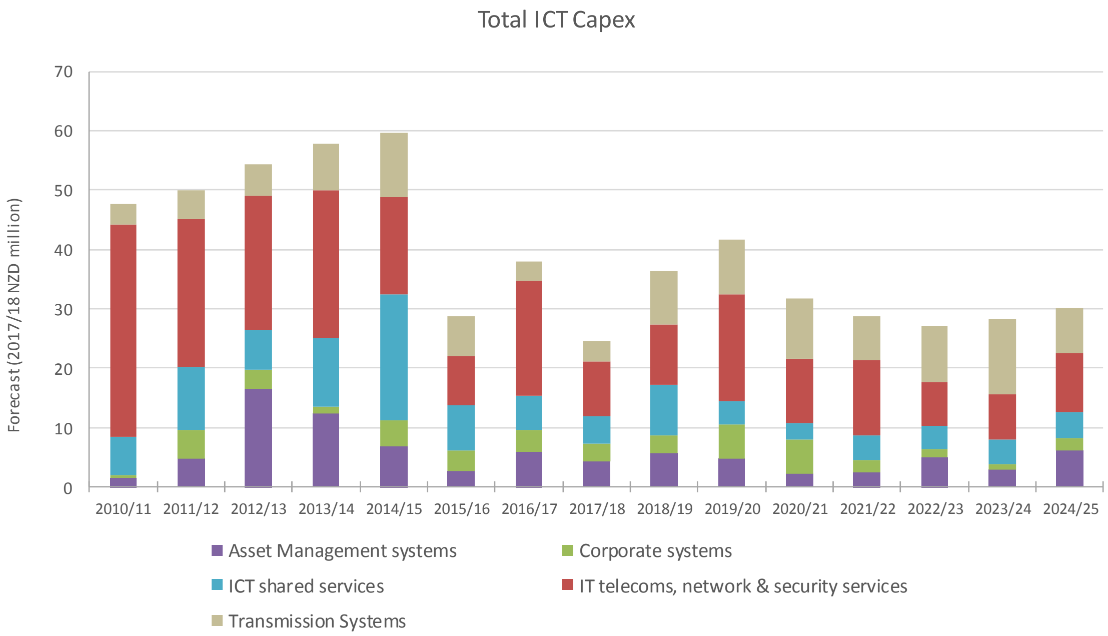
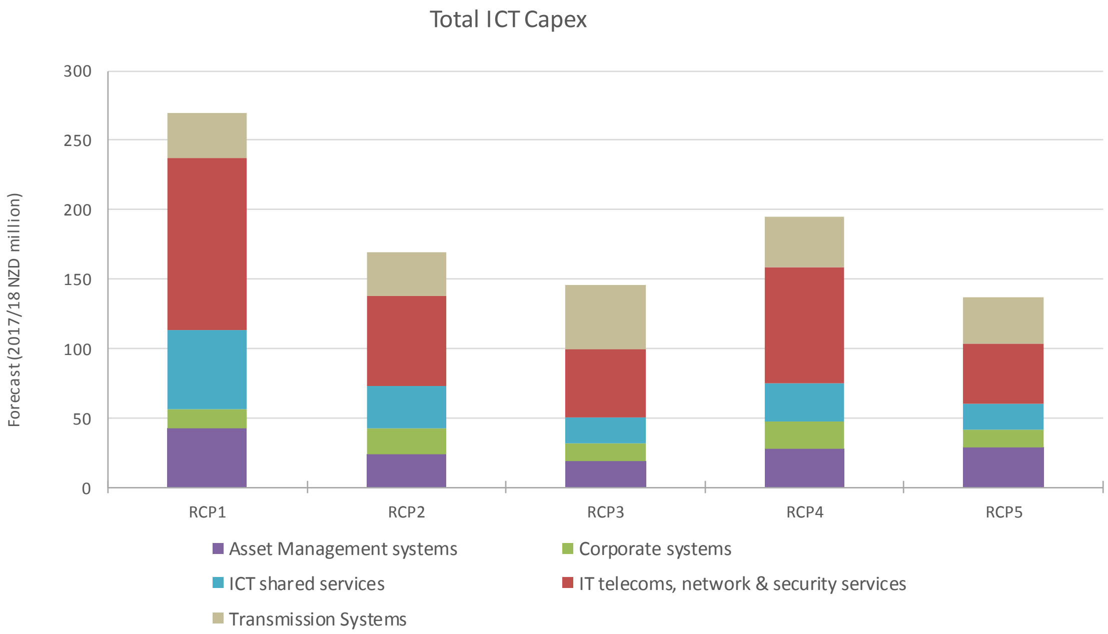



**Figure 67 Total ICT capex for RCP1 to RCP5**




RCP1 focused on major investments in system replacements and the building of asset management capability through the Maximo asset management system and TransGO national and local data networks.

During RCP2, Transpower characterised ICT investment as "*… moving from a period of major investment in new capability to one of maintaining capability established by past investment.*"[130] As a result, projected expenditure for RCP2 is 37% lower than RCP1, and is biased towards maintaining capability rather than adding new capabilities. The Transpower Enterprise Estimation System (TEES) was improved, as Transpower adopted centralised cost estimation and was more heavily used between preparation of the RCP1 and RCP2 regulatory submissions.

Transpower has advised that the ICT expenditure forecast for the remainder of RCP2 and to the end of RCP3 includes 193 business enhancement-related ICT initiatives each with a one-page Initiative Brief that includes preliminary (low certainty) cost/benefit analysis inputs, including problem statement, outcomes and impacts.

The cost/benefit analysis is developed in three stages:

- Forecasting - this includes a four step process:
  - identify business outcomes and capability requirements by business function;
  - identify the life cycle needs of existing systems;
  - develop the ICT roadmap by portfolio using a bottom-up build approach; and
  - challenge the ICT investment overall from a deliverability perspective.
- Business Case - on an ongoing basis, the preliminary qualitative analysis included in the Initiative Brief is refined as a project Business Case is prepared, assessed, approved or rejected. As an input to Business Cases, key business stakeholders are engaged to identify the benefits of conducting each project, seeking quantifiable, financial or tangible benefits wherever possible. These are typically documented in a Benefits Plan. Transpower advised us that examples are available for RCP2 investments.
- Investigation - we requested a copy of a post-implementation benefits report for the introduction of Maximo. This is discussed further in the Asset Management Systems review in section 7.4.2.

Ahead of RCP3, Transpower developed its processes in planning ICT asset investment by aligning business needs in Grid operation and management, corporate and Information Systems with key system capabilities, and identifying gaps in capabilities and system lifecycle needs. This capability and outcomes-based planning approach uses a Needs Statement for investments to assess the value-for-money for both stakeholders

[130] GHD (2018), GHD Capex and Opex forecast_IV review, section 7.2.1, clause 455, p. 109, Document [118]

and customers, key assumptions, reviews the level of risk and the priority for project implementation and the required business outcome.

### *RCP3 forecast by project types*

Table 72 shows project classification defined in the framework introduced during RCP2.

**Table 72 ICT project classification**

| Classification | Definition | Target investment mix[131] |
|---|---|---|
| Lifecycle | Asset capability still required for business operations; however asset is obsolete and no longer has vendor support. Unacceptable risk in operating out of support. | 65% |
| Benefits Driven | Project provide operational savings, allow capital deferral or improve stakeholder/customer relations | 32% |
| Risk Mitigation | Provides controls that either reduce threats or minimise impact of risks | 3% |
| Compliance | Projects obligated through legislation, regulations or standards | |

For RCP3, Transpower proposes the following mix of ICT capex project types.

**Table 73 ICT capex for RCP3 by project type ($2017/18 million)**

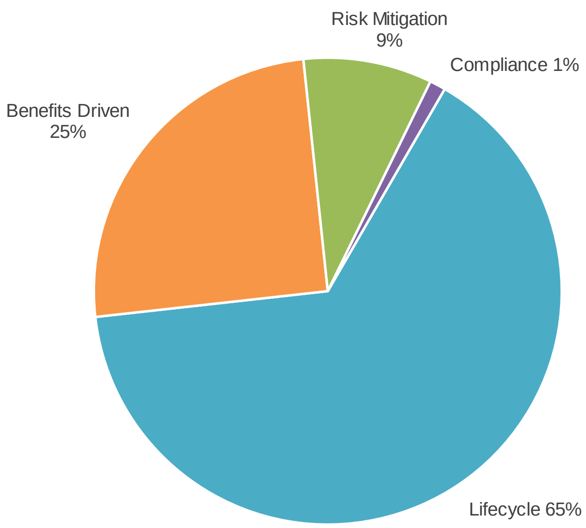
| Classification | No. of projects | Description | RCP3 ($ M) | % Total |
|---|---|---|---|---|
| Lifecycle | 170 | Asset capability still required for business operations but asset is obsolete & no longer has vendor support. Unacceptable risk in operating out of support. | 94.8 | 65% |
| Benefits Driven | 62 | Projects with a minimum Internal Rate of Return (IRR) of 8%[132] | 36.7 | 25% |
| Risk Mitigation | 29 | Risk mitigation on company-wide risk register | 13.0 | 9% |
| Compliance | 5 | Streamline health, safety and assurance systems, integrate Maximo & Safety Culture systems, enhance hazard identification & communications | 1.6 | 1% |
| **TOTAL** | | | **146.1** | **100%** |

Figure 68 shows the split of the ICT capex forecast for RCP3 by project type.

[131] Transpower, ICT Strategy 2016-2025, p. 5 Document [77]. For the transmission network (excluding System Operator functions), this investment profile is considered appropriate to "*… steadily gain efficiencies through improved information management, remote interrogations and automated control, while controlling the cost, quality, security and risk exposure of our current asset investments in alignment with our ICT strategic direction.*"

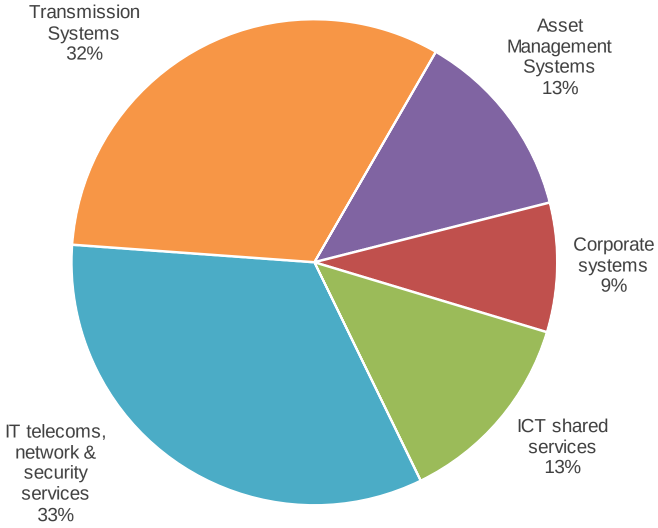
[132] Calculated from expected net cashflow for the 5 years following commissioning year

**Figure 68 RCP3 ICT project type breakdown**




From Table 73, the RCP3 forecast is split across the ICT portfolios as shown in Figure 69.

**Figure 69 RCP3 ICT business enhancement by portfolio**



### *ICT capex deliverability*

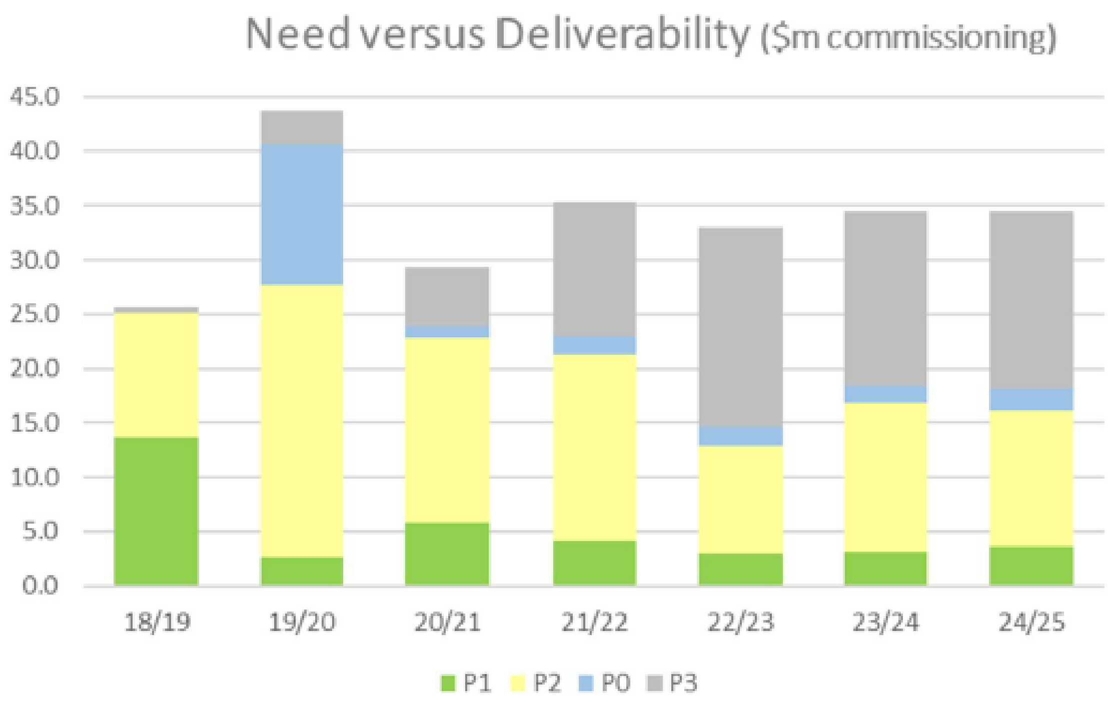
To assist with assessing the deliverability of ICT projects, Transpower uses a four level rating system to categorise the level of certainty for projects as shown in Table 74.

**Table 74 ICT project ratings**

| Rating | Certainty | Definition | Typical timeline |
|---|---|---|---|
| P0 | Major physical asset | Need is clear & requires large physical asset | |
| P1 | High certainty | Need is clear & solution relatively well-defined | 12 - 18 months |
| P2 | Medium certainty | Need is clear & multiple solutions | 18 months - 3 years |
| P3 | Low certainty | Need or solution is not well-defined | > 3 years |

This rating system is used to generate a "need vs deliverability" perspective to show the relative value of project certainty. It shows the current level of medium and low certainty, which will improve as investigations identify better defined solutions.

**Figure 70 ICT capex need vs deliverability for 2018/19 to 2024/25**




Transpower's price quality review assessed the ICT works programme for:

- programme composition in terms of certainty
- planned work volumes against delivery group to identify constraints.

Transpower has assumed in generating the RCP3 forecast that there are currently two delivery groups that are "*… unlikely to be constrained*" in delivering the RCP3 programme.[133]

### *Quantifying benefit-driven investments*

In the review of the RCP2 proposal, the Commerce Commission included the following improvement initiative:

> I63.4 Transpower has offered no tangible benefits assessment for its proposed ICT expenditure. It is therefore difficult to be sufficiently certain about what benefits customers will see from the investment in terms of operational savings for the same or higher service levels.

For RCP3, Transpower has reiterated its view expressed in the RCP2 proposal regarding the quantifying of benefits for benefit-driven investment:

> While we undertake quantitative benefits analysis for business cases (i.e. closer to implementation), we typically do not undertake quantitative benefit analysis as part of our early ICT forecasting process because of uncertainties that are intrinsic to ICT investments. At the early forecasting stage, we undertake qualitative analysis only.
>
> The relatively rapid pace of technology change means that the horizon in which early cost / benefit analysis becomes invalid is relatively short compared to non-ICT investments. Ongoing technology improvement means that there are progressive opportunities to take advantage of better benefit realization options at a lower cost.
>
> Instead, we trigger cost / benefit analysis as the needs become clearer and as the solution and technology choices become more defined. We use a four-level rating system to categorise the level of certainty for projects [as shown in Table 74].
>
> For an investment in quantitative analysis to be justified, the "need" and/or "solution" aspects for a benefit-related ICT initiative must be well defined. This generally only happens once initiatives have a P0 or P1 rating.

Referring to Figure 70, the grey areas highlight the planned initiatives with the greatest uncertainty.

Figure 71 shows the benefit-related initiatives only. The RCP3 forecast is predominately at an early stage in its development and consequently very few of the initiatives have been defined to a P0 or P1 level where benefits may be accurately quantified.

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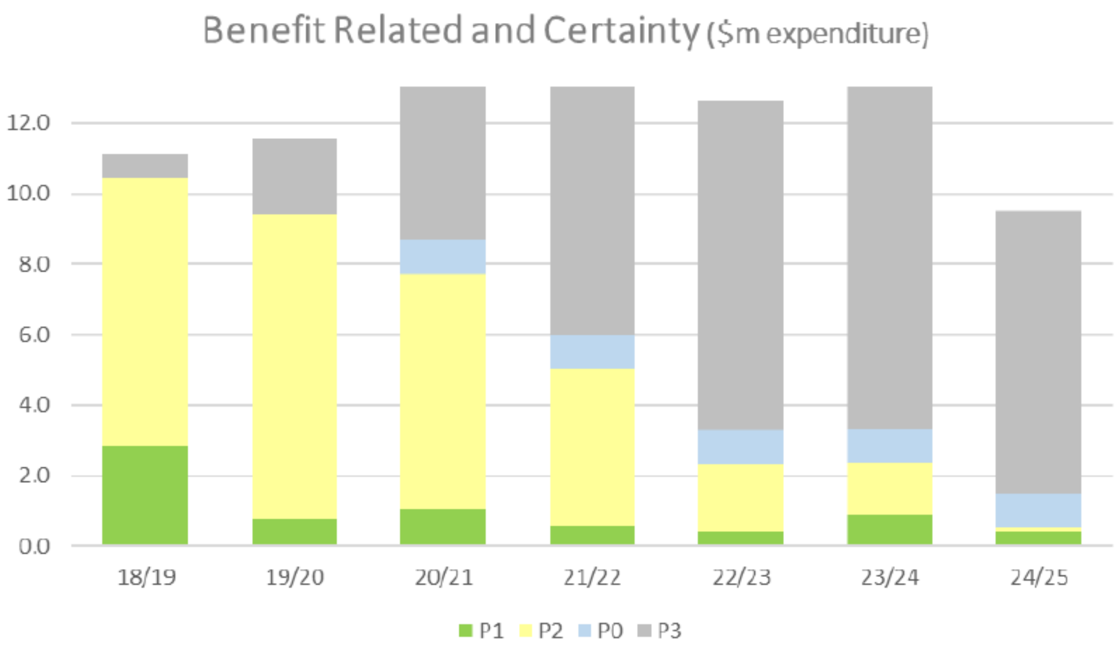
[133] Transpower (2018), RCP3 Price/Quality Trade-off, Document [4]

**Figure 71 ICT capex benefit-driven by project rating**




Following a request based on our draft report findings, in assessing the anticipated benefits for the 62 benefit-driven classified projects, Transpower provided an assessment by primary expenditure category and the associated areas of the business that are expected to benefit from the proposed project.

Table 75 shows the anticipated benefits associated with the proposed portfolio of 62 projects.

**Table 75 RCP3 benefit assessment by expenditure category[134]**

| Expenditure category | ICT Capex ($ M) | Deferred capex ($ M) | Anticipated capex benefit ($ M) | Anticipated opex benefit ($ M) |
|---|---|---|---|---|
| Asset Management | 8.4 | 11.5 | 1.7 | 2.6 |
| Business Support | 1.7 | 0.0 | 1.5 | 0.5 |
| Grid Operations | 9.3 | 0.0 | 3.0 | 5.3 |
| Grid Project Delivery | 1.8 | 0.0 | 0.8 | 0.3 |
| ICT Data Transmission Capacity | 7.8 | 60.0 | 0.0 | 0.0 |
| IST Operations & Maintenance | 4.9 | 0.0 | 0.0 | 4.2 |
| Maintenance | 2.9 | 0.0 | 0.0 | 2.6 |
| **TOTAL** | **36.7** | **71.5** | **7.0** | **15.4** |

134 Transpower (2018), ICT Capex Forecast and Benefits, section 6, pp. 8-14, Document [79]

The significant deferred capex projections are associated with:

- $3.4 million in expenditure intended to avoid the need for asset upgrades and replacements through more effective and efficient use of Grid assets. This targeted expenditure is anticipated to defer $11.5 million to later regulatory control periods.
- Six projects totalling $7.8 million in expenditure relating to the re-arrangement of the network to increase capacity within the core Wide Area Network (WAN) and substations. The impact of these projects is expected to defer a previously planned $60 million upgrade of the IT network.

The reduction in Base Capex for Grid and ICT expenditure during RCP3 has already been considered in the RCP3 forecasts, and includes:

- $3.3 million in projects that are anticipated to reduce RCP3 Grid Base Capex by $2.7 million through the deployment of new technology;
- $1.2 million in ICT capex in delivery tools and automation in Central Control, Network Management and Solution Development anticipated to achieve savings of $1.4 million; and
- approximately $1 million in ICT projects are forecast to contribute to an overall annual Transpower productivity improvement of $1 million in Base Capex and $0.2 million in opex. However, no separate adjustment has been applied to Business Support Base Capex as the projected savings within the 0.2% efficiency gain (step change of $2.3 million) already accounts for this benefit.

Transpower has identified $15.4 million in forecast annual reductions in opex due to the proposed ICT Base Capex, including:

- A total of $8.1 million savings in Asset Management & Operations opex (refer section 8.6.6 of our report) through:
  - $5.5 million in ICT Base Capex that is expected to reduce Operations opex by $5.2 million across activities in information management and control centre;
  - $3.3 million in ICT Base Capex that should decrease Grid Development opex by a total of $2.6 million through improved work and service delivery, data enabling and planning activities;
  - $2 million in ICT Base Capex in the Customers & Projects division that should reduce RCP3 opex spend in that division by $0.3 million through improved planning and work management;

- $2 million in field control capex that is expected to achieve a benefit of $1.6 million in opex efficiencies that will be reinvested in the opex programme to deliver the identified RCP3 opex need; and
- $5 million in connectivity projects that are forecast to reduce overall non-departmental opex, including leases by $4.2 million during RCP3. The direct saving against Leases in ICT opex is projected to be $1.4 million.

*Verification assessment of ICT capex*

From the examples provided by Transpower and the detailed benefits management plan provided post-implementation of Maximo (refer section 7.4.2), we are satisfied that Transpower has an established procedure for identifying and quantifying the benefits for ICT investments which are categorised as benefit-driven rather than lifecycle driven.

We accept the inherent difficulties in accurately detailing benefits for ICT solutions in the latter part of a regulatory period, given uncertainty about the final preferred solution.

Transpower has provided a high-level analysis of the anticipated benefits for the $36.7 million in benefits-driven projects proposed in RCP3, forecasting savings of $71.5 million in deferred capex, reductions of $7 million in Base Capex and $15.4 million in opex. We accept that this analysis provides the Commerce Commission with a view of the relative merit and high-level justification for the proposed ICT Base Capex, and that the approach Transpower has used is in line with GEIP.

We have not tested any supporting information in relation to the lifecycle replacement of assets or risk mitigation projects, but we are satisfied that the overall approach that Transpower applies in challenging any asset upgrade or replacement is in line with GEIP and should ensure that replacement through lifecycle issues or identified risks, such as cyber-security, are fully scrutinised before being added to the RCP3 portfolio.

*Identified programmes for RCP3*

The forecast expenditure in RCP3 for Telecommunications, Network and Security Services and Transmission Systems represent 66% of the total. These two capex programmes are Identified Programmes (refer section 7.3) and are reviewed in detail.

*IT telecoms, network and security services*

The telecommunications, network and security systems provides the underlying components and infrastructure essential to supporting the Transpower business.

This capability is provided via:

- Underground, submarine, elevated fibre and radio - physical cables and wireless communications used to carry and connect Transpower assets;
- Network infrastructure (WAN, LAN, Connect) - providing data services for local sites, inter-site, and external sites;
- Collaboration and communication technology - allowing communication internally and externally;
- Management services - providing monitoring and control of Transpower assets; and
- Security services - providing protection against malicious and negative impact activities towards Transpower.

The objective for Base Capex related to ICT is to ensure delivery of resilient, reliable and security-focused business solutions to further enable Transpower to move towards a digital business model.

Transpower has forecast a total capex for IT telecoms in RCP3 of $48.8 million in real 2017/18 dollars. Table 76 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 76 Comparison of IT telecoms RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| IT telecoms, network & security services | 64.7 | 48.8 | -25% |

Table 77 shows the annual forecast capex for IT telecommunications in RCP3 in real 2017/18 dollars.

**Table 77 Annual forecast capex for IT telecoms in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| IT telecoms, network & security services | 11.0 | 12.6 | 7.4 | 7.7 | 10.0 | 48.8 |

Figure 72 shows the annual IT telecommunications capex for the regulatory periods RCP1 to RCP3, and Figure 73 shows the total IT telecommunications capex for the regulatory periods RCP1 to RCP5.

Figure 72 Annual IT telecoms & services capex for RCP1 to RCP3

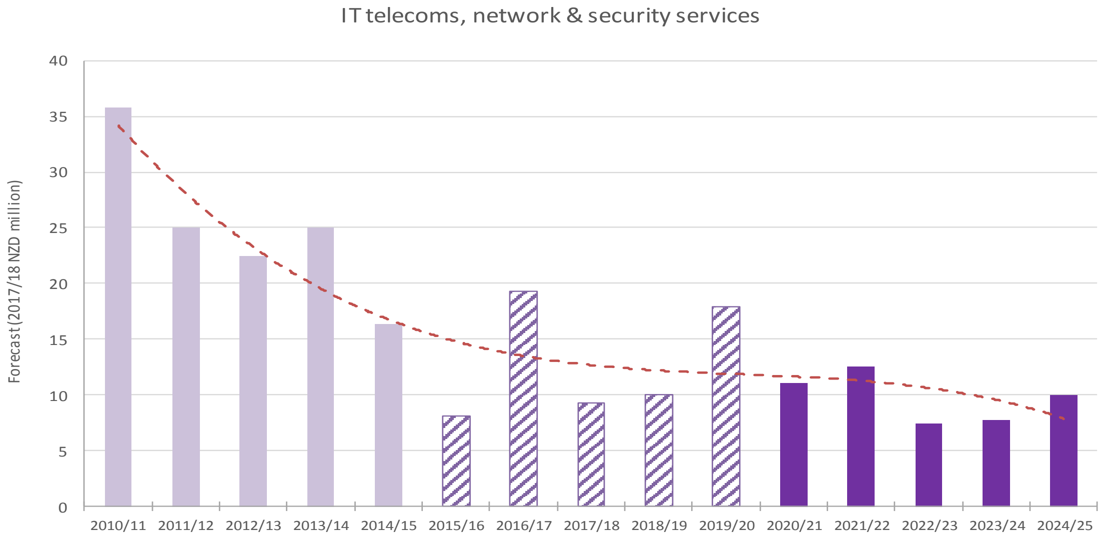
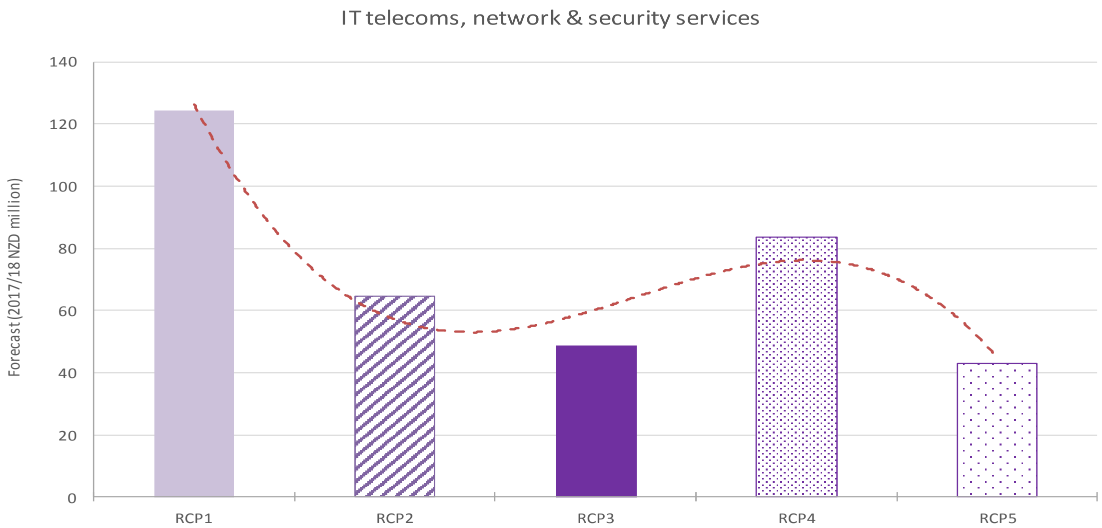



Figure 73 Total IT telecoms & services capex for RCP1 to RCP5




For RCP3, Transpower has proposed ICT capex of $48.8 million in real 2017/18 dollars which is a reduction of $15.9 million or 25% on ICT capex during RCP2. The higher expenditure in RCP2 was due to increased investments for fibre and equipment to finalise the TransGO network, including replacement of two submarine fibre cables.

Transpower indicated that the initial two years of RCP3 have higher expenditure in order to complete the network re-arrangement to enable Transpower to realise the benefits sooner.

**Forecasting Process**

The forecasting process used for ICT follows a basic four-step process:

(a) identify business outcomes and capability requirements by business function;

(b) identify the lifecycle needs of existing systems;

(c) develop the ICT roadmap by portfolio using a bottom-up build approach;

(d) challenge the ICT roadmap from a deliverability perspective.

This approach is aligned with the delivery model of plan, build and operate[135] and is focused on a three year refresh cycle[136] resulting in a triennial forecast spike.

The ICT Strategy defines the 2016-2025 Overview through defining strategic goals aligned with business, reliability, strategic sourcing, information management and security, identifying measures of success and incorporating Transpower enterprise architecture.

**Key Drivers for RCP3**

Transpower identified three sequential planning trajectories, focusing on evolving generation, load, and storage. These translate into business requirements to ensure Transpower avoids over-investment in Grid and generation due to the move to storage solutions, while focusing on smart power, delivery and digital solutions.

RCP3 focuses on life-cycle support in order to ensure assets are adequate to support the Transpower business. Where viable, Transpower will focus on delivering new fibre solutions, provided a benefit can be identified within 8 to 10 years.[137] This is a reasonable move from the previous 'run, grow, transform' model utilised to forecast RCP2.

Further drivers for RCP3 are delivering cybersecurity solutions to manage the evolving threat landscape, with focus on pervasive network, connectivity to IP networks, and managing the increased threat likelihood as realised by WannCry, NotPetya ransomware, and ICS targeting malware, such as Stuxnet and Trisis.

There is a relatively smaller investment in benefit-driven investment that focuses on re-configuration of the TransGO network to increase network capacity available for substations to support expected demand for new services and capabilities, whilst

135 Transpower ICT Strategy 2016-2025, p. 6, Document [77]

136 Transpower (2018) Portfolio Management Plan: ICT telecommunications, Network and Security, p. 9, Document [78]

137 Transpower (2018), ICT Capex Forecast, p. 56, Document [76]

deferring a major upgrade of the network. Transpower estimates this work to cost $8 million during RCP3.

**Verification assessment of IT telecoms**

We accept that the approach to forecasting based on lifecycle management, benefit driven and leading investment is a sound approach to evaluating IT telecoms-related projects and understanding their necessity in maintaining and growing the business in a sustainable manner.

This approach:

- identifies and evaluates critical business requirements to meet regulatory and risk management requirements;
- focuses on delivering solutions that will provide direct benefit to the organisation through NPV and ROI; and
- requires projects to be well-defined and assessed in order to identify business benefit.

We believe the greater focus on lifecycle management (68% of forecast) for the network and security services portfolio is appropriate, identifying a three-year cycle for most equipment, 20-year lifecycle for substation infrastructure, migration of WAN services, and appropriate asset management practices.

The proposed capital investment is focused on ensuring assets installed in previous years remain in good condition to support business services. Condition assessments of existing substation infrastructure and network assets show that no major refurbishment investment will be required during RCP3. Whilst the cybersecurity arrangements that Transpower has in place have proven effective in protecting against cyber-attacks, it will be continuing to develop cybersecurity measures during RCP3 to counter the continually evolving threat , which we consider to be a prudent initiative.

The small investment in reconfiguring the TransGO network is considered prudent and efficient in deferring more expensive upgrade work to RCP4.

We believe Transpower's RCP3 IT telecoms & services capex forecast is consistent with the expenditure outcome having regard to GEIP.

## Verification opinion - IT telecoms

Table 78 summarises our verification assessment and opinion.

**Table 78 Verification summary - IT telecoms**

| Expenditure category | Capex - IT telecoms | |
|---|---|---|
| **Transpower RCP3 forecast** | $48.8 million | |
| **Recommendation** | **Accept:** $48.8 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Investment is prudent based on lifecycle management, benefits to support business<br>* Focuses on solutions with positive NPV and ROI consistent with efficient outcomes<br>* Requires projects to be well-defined to identify business benefit<br>* Ongoing awareness of cybersecurity needs of business demonstrating prudency | - |
| **Other relevant criteria from ToR** | General evaluation of the Base Capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

### *Transmission Systems*

Transmission systems are essential in the monitoring and control of the network to ensure security of supply, in scheduling and managing planned outages and restoring supply after an unplanned outage or event.

These systems are used to operate assets to satisfy network, operational and asset performance requirements, together with effectively managing network incidents and events. These systems are also required to support any follow-up analysis of outages and remedial actions. Asset reliability, cost, safety and environment are all key considerations in the operation of transmission systems.

The primary assets and systems included in the Transmission Systems portfolio are:

- Supervisory Control and Data Acquisition (SCADA) to monitor network equipment and power system performance, and issue control signals to field equipment.
- Energy Management System (EMS) to predict power system performance and report to network operators.

- Outage planning and management systems - Transpower uses an Integrated Notification System (IONS) to support a rolling 12-month outage planning process, and a SCADA Outage Scheduler (SOS) for real-time scheduling and co-ordination of outages in the National Grid Operating Centres and with the National Co-ordination Centre.
- Grid operations, including Situational Distance to Fault (SDTF) to manage field teams and supporting systems to model and management network asset operation and protection.

Transpower has forecast a total capex for Transmission Systems in RCP3 of $47.0 million in real 2017/18 dollars.

Table 79 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 79 Comparison of Transmission Systems RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Transmission Systems | 31.8 | 47.0 | 48% |

Table 80 shows the annual forecast capex for Transmission Systems in RCP3 in real 2017/18 dollars.

**Table 80 Annual forecast capex for Transmission Systems in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Transmission Systems | 10.0 | 7.4 | 9.4 | 12.6 | 7.7 | 47.0 |

Figure 74 shows the annual Transmission Systems capex for the regulatory periods RCP1 to RCP3, and Figure 75 shows the total Transmission Systems capex for the regulatory periods RCP1 to RCP5.

**Figure 74 Annual Transmission Systems capex for RCP1 to RCP3**

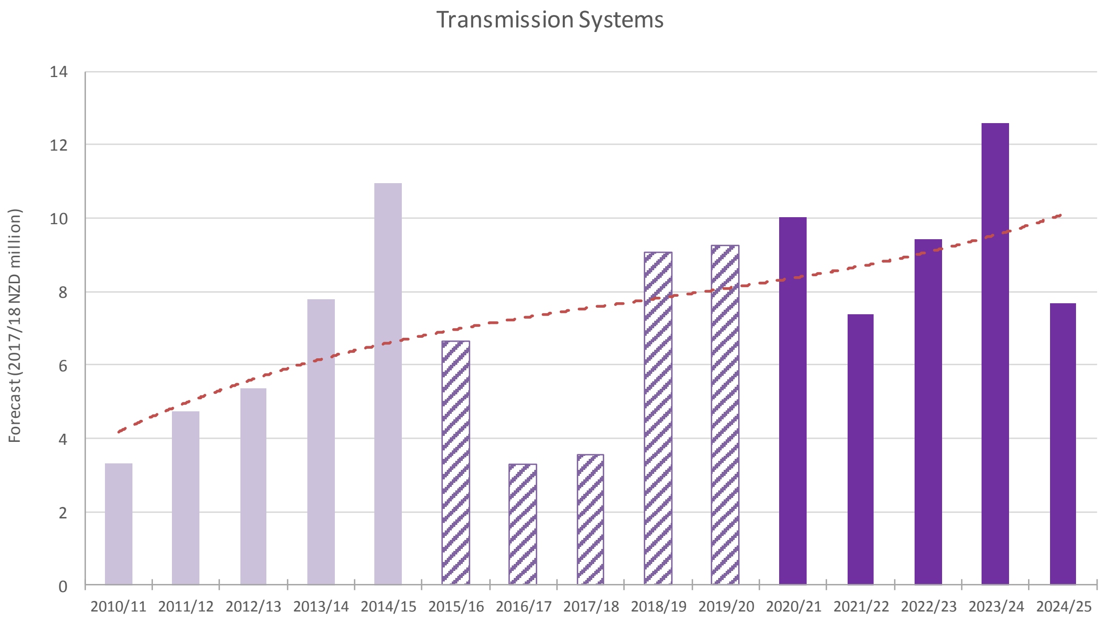
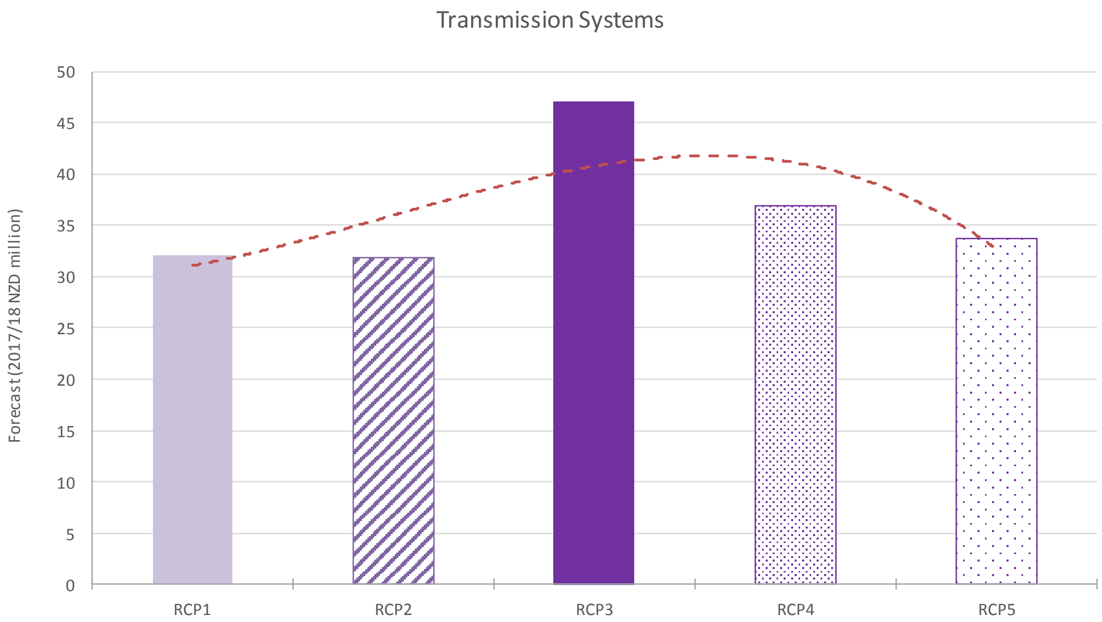



**Figure 75 Total Transmission Systems capex for RCP1 to RCP5**



**Current RCP2 activities**

During RCP2, Transpower has focused on:

- implementation of operational switch management system that integrates with SCADA/EMS for safer, systematic and more efficient equipment switching capabilities;
- enhancements to existing outage planning systems implemented for outage switching and asset works planning (AMPS);
- statistical analysis of SCADA alarm information to standardise, simplify and troubleshoot alarms to reduce unwanted alarms and improve response; and
- improved view of SCADA configuration and remote substation devices for better data acquisition to support automated data standardisation, simplifying work for operators and achieve efficiencies in operational and device management and less risk.

**Asset strategy and planning**

The overall ICT strategy is part of Transpower's Corporate Strategy that sets corporate directions and priorities for the business, and informs investments in both its transmission and system operator areas.

The long-term business strategy supported by the Corporate Strategy is defined in *Transmission Tomorrow* (refer section 2.5.1), which sets directions in three key areas:

- generation
- changing loads, particularly due to the anticipated market penetration of solar photo-voltaics, batteries and electric vehicles
- off-grid energy storage through batteries.

The implications of these key strategies for Transmission Systems are:

- Increased use of digital devices across the network to provide smarter power system control; and
- increased use of digital technology to provide better analytics, performance measurement and operational integrity for management/control of assets

Given the rapidly changing ICT environment, Transpower has elected to move from a model of installing and developing equipment to a principle of 'lifecycle, benefits driven, leading' strategy which considers:

- *Lifecycle investments – These represent the technology investment 'must dos' to meet various regulatory requirements (compliance), manage risk (risk) and maintain the value of our existing productive assets (lifecycle).*
- *Benefits driven investment – Investments in this category deliver enhancements (business benefits) and value to Transpower, in the form of new capabilities that reduce costs or enhance the value of grid and system operations services. These investments typically have a positive net present value (NPV) and return on investment (ROI).*
- *Leading investment – The business value of investments in innovation is not always easy to justify at the outset, but allows capacity to invest in new and emerging technology that supports the move to a smarter more efficient grid. Leading investments could be across any category (compliance, risk, business benefits or lifecycle).*[138]

The implications of this strategy for Transmission Systems in RCP3 are:

- investigating SCADA/EMS system upgrade - using a modular upgrade approach to reduce delivery risks but deferred until late in RCP3 for technology that will enhance the capability of combining operational status with spatial, weather and lightning information for better system and market operator decision making;
- improve field communication and co-ordination for more efficient asset condition assessment, co-ordination of outage response and grid incidents;
- improvements in outage and operational switch management capabilities to improve outage planning, increase automation, reduce operational risks and improve safe operation of the Grid; and
- extend telemetry data capabilities and power systems modelling.

**Development of RCP3 forecast**

Table 81 and Figure 76 illustrate the lifecycle and benefit driven investments planned for RCP3 as percentages of the total forecast expenditure.

[138] Transpower ICT Strategy 2016 -2025, p. 5, Document [77]

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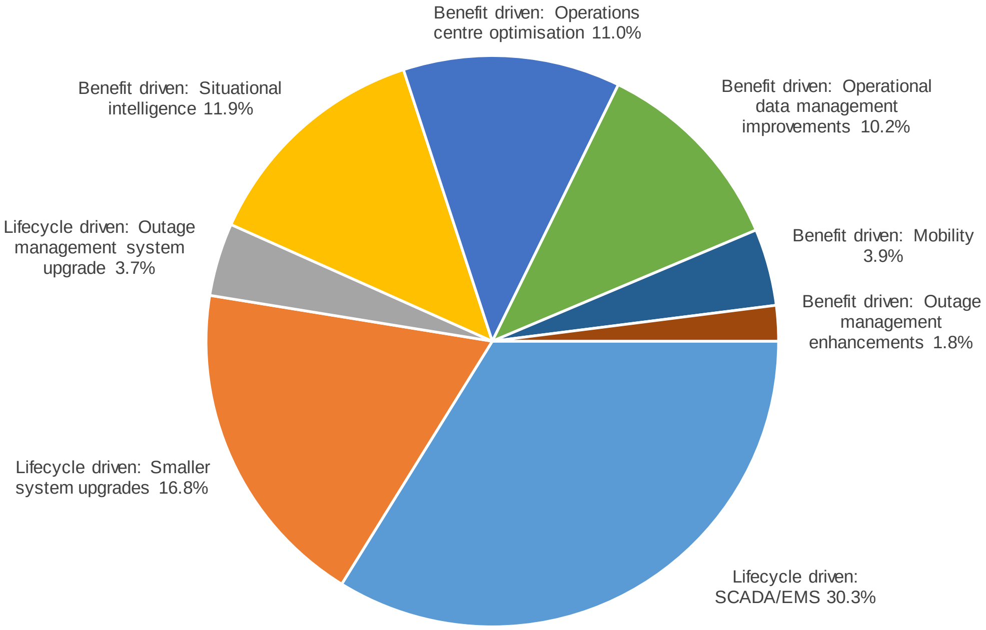
**Table 81 Transmission systems RCP3 programme portfolio**

| Project driver | Investment | Contribution |
|---|---|---|
| Lifecycle driven | SCADA/EMS | 30.3% |
| | Smaller system upgrades[139] | 16.8% |
| | Outage management system upgrade | 3.7% |
| | *Subtotal* | *50.8%* |
| Benefit driven | Situational intelligence | 11.9% |
| | Operations centre optimisation | 11.0% |
| | Operational data management improvements | 10.2% |
| | Mobility | 3.9% |
| | Outage management enhancements | 1.8% |
| | *Subtotal* | *49.2%* |
| **Total** | | **100.0%** |

**Figure 76 Transmission Systems RCP3 capex split as % of total**




139 Include lightning detection, PowerFactory power system analysis software, StationWare asset control and protection setting management

**Key drivers for RCP3**

Transpower has nominated the following key outcomes for the RCP3 Transmission Systems works programme:

- increased capability to safely drive the grid closer to its limits, meeting service levels and minimising impacts of outages on the electricity market;
- enhance real-time monitoring of grid assets to improve service performance;
- improve processes in transmission operations and asset management;
- standardise/simplify operational data for better automation and advanced analytics; and
- enhance communication systems for field workforce to improve co-ordination between field and operation control staff.

Much of the capex programme in RCP3 is a continuation of upgrades and enhancements started in RCP2.

The largest activity in RCP3 is the replacement of the existing SCADA/EMS assets. Transpower will undertake these upgrades in a modular fashion to reduce the project delivery costs and complexity. The following factors have been taken into account in planning the next two upgrade cycles:

- Software component compatibility
- Number of customers on each component version (used as a measure of software quality)
- Software/hardware lifecycle
- Project delivery efficiency.

Transpower advised the core components of SCADA/EMS have the following nominal asset lives:

- Server hardware and virtualisation technology - 5 years
- Desktop hardware, operator screens & equipment - 4 years
- Core platform applications - 5 to 7 years, depending on version taken
- Core platform operating systems and compatibility layer (Windows and Habitat) - 4 years

- Independent subsystems (ICCP, Front End Processors etc.) - 4 years.

Transpower is proposing to upgrade each of these components independently so that the lifecycle can be optimised. To reduce the overall whole-of-life costs for these assets, it is considering purchasing extended support, or redundant hardware, where appropriate. Examples from the current upgrade cycle include:

- Desktop hardware, operator screens & equipment - upgrade underway and will complete in 2018/19, mainstream support ended February 2017 - redundant equipment is available;
- Server hardware - upgrade underway and will complete in 2018/19, with support of existing system ending in December 2018;
- Core platform operating systems and compatibility layer - upgrade in 2018/19, Transpower arranged extended support as mainstream Habitat support ended in November 2017; and
- Independent subsystems (ICCP, Front End Processors etc.) - plan to upgrade before Windows Server 2008 R2 support ends in January 2020.

Transpower advises that it "*… is reviewing the vendor's roadmap annually and compare our plans to our industry peers to manage the trade-off between the software life and software quality. It is common practice within the utility industry to align target software versions with industry peers to reduce the associated quality assurance costs. It is often less expensive to choose an n-1 software version that has been tested thoroughly, even if it shortens the useful life of the software by a year or two. This is necessary due to the niche nature of the SCADA/EMS product market where vendors typically only service a few hundred customers each.*"

**Delivery**

In the price-quality assessment for the 24 May 2018 presentation, Transpower stated that there are two delivery groups for the ICT capex programme and are "unlikely to be constrained."

**Verification assessment of Transmission Systems**

The system improvements identified by Transpower are typical of the enhancements that an electricity utility will periodically make to its SCADA, operational, planning and modelling capabilities as part of more efficient and safer grid operations. In that way, we have noted similar ICT capex programmes for Australian electricity utilities, with SCADA generally replaced when it reaches obsolescence, and software improvements as additional service capabilities are required.

Transpower has provided sufficient information for us to be satisfied that there is a tight rigour to the identification of a need, justification for investigation into a solution, and verification of the economic and operational benefits of the preferred option.

From our experience, we note that technical obsolescence is typically the major driver in renewing software and hardware associated with transmission systems, particularly where vendors will no longer provide support. We are satisfied that the proposed staged programme of software and process updates for outage management, field communications and power system modelling is appropriate and prudent. We are satisfied that the RCP3 expenditure for the planned replacement of SCADA/EMS is prudent.

We believe Transpower's RCP3 Transmission Systems lifecycle driven capex forecast is prudent expenditure, and consistent with the expenditure outcome having regard to GEIP. The benefits-driven capex is considered prudent, due to the rigour in identifying and analysing the preferred option and the qualitative expected benefits from the investment.

### Verification opinion - Transmission systems

Table 82 summarises our verification assessment and opinion.

**Table 82 Verification summary - Transmission Systems**

| Expenditure category | Capex - Transmission Systems | |
|---|---|---|
| **Transpower RCP3 forecast** | $47.0 million | |
| **Recommendation** | **Accept:** $47.0 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Investment is prudent based on lifecycle management, benefits to support business<br>* Focuses on solutions with positive NPV and ROI consistent with efficient outcomes<br>* Requires projects to be well-defined to identify business benefit | - |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

## 7.4 Non-identified programmes

Non-identified programmes are those expenditure categories that were outside the agreed criteria for Identified Programmes reviewed in section 7.3 of this chapter).

The reasons for the non-identified programmes we have reviewed are as follows:

- ACS Buildings and Grounds - we have included a review of substation buildings and grounds to include the remaining asset category within the broad renewals capex category in our assessment, particularly given the 13% increase over the RCP2 expenditure
- Asset Management Systems - this expenditure category was reviewed for RCP2, with a focus on the benefits of Maximo. We have included this category to review the benefits achieved from RCP2 initiatives and the forecast RCP3 programme.

Inclusion of these asset categories increases the coverage of the RCP3 forecast capex in our independent verification to $1,035.6 million or 86% of the total RCP3 capex forecast.

A review of these non-identified programmes provides additional testing of the prudency and efficiency of Transpower's RCP3 forecast expenditure.

### 7.4.1 Grid capex - ACS Buildings and Grounds

AC Substations Buildings and Grounds cover approximately 750 buildings across 200 sites and include the following components as follows:

- Buildings - substations, warehouses, National Grid Operating Centres.
- Building services - heating ventilation and air-conditioning systems (HVAC), fire suppression and security systems.
- Site infrastructure - switchyard aggregate, cable duct covers, road and access ways, water supply, drainage, waste water and switchyard metalling.
- Fencing - switchyard security and boundary fencing.

The objective for ACS Buildings and Grounds expenditure is to ensure substation primary and secondary network assets are properly secured against physical and environmental risks, at least whole-of-life cost.

Transpower has forecast a total capex for ACS buildings and grounds in RCP3 of $39.5 million in real 2017/18 dollars. Table 83 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 83 Comparison of ACS Buildings & Grounds RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| ACS Buildings & Grounds | 32.1 | 39.5 | 23% |

Table 84 shows the annual forecast capex for RCP3 in real 2017/18 dollars.

**Table 84 Annual forecast capex for ACS Buildings & Grounds in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| ACS Buildings & Grounds | 8.3 | 10.2 | 7.6 | 6.7 | 6.7 | 39.5 |

Figure 77 shows the annual capex for the regulatory periods RCP1 to RCP3, and Figure 78 shows the total capex for the regulatory periods RCP1 to RCP5.

**Figure 77 Annual ACS Buildings & Grounds capex for RCP1 to RCP3**

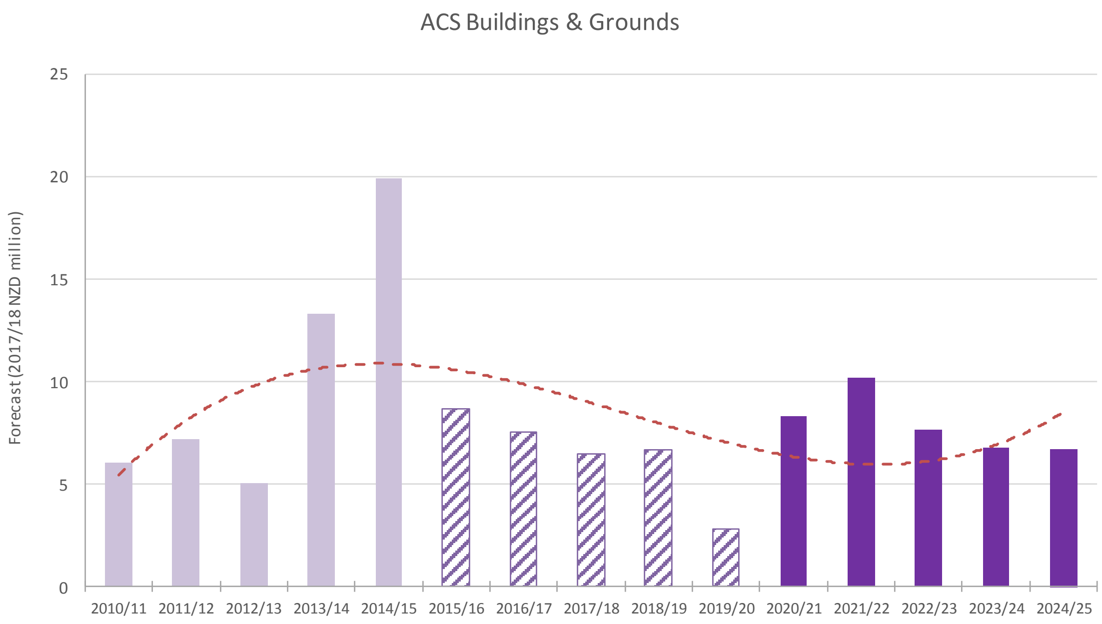
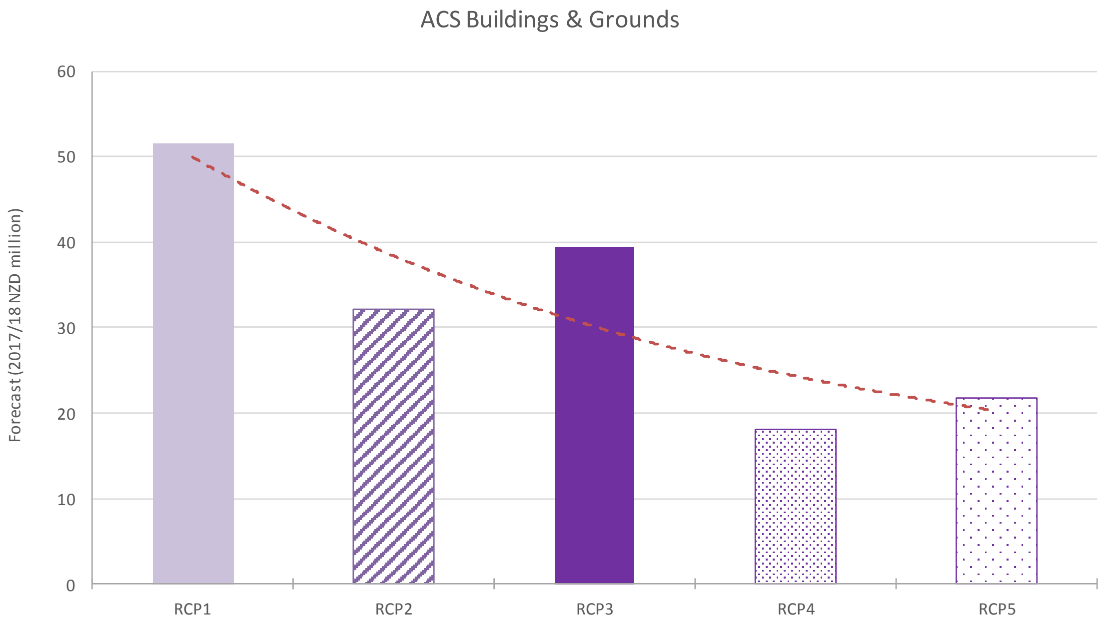


**Figure 78 Total ACS Buildings & Grounds capex for RCP1 to RCP5**




For RCP3, Transpower has proposed ACS Buildings & Grounds capex of $39.5 million ($2017/18) which represents an increase of $7.4 million or 23% compared to RCP2. Transpower advised the main reason for the increase in RCP3 is condition and risk-based deferrals made in RCP2.

### *Asset strategy and planning*

The key strategies applied to ACS Buildings and Grounds are:

- condition-based replacement of major asset types; and
- maintain assets to ensure ongoing acceptable performance in safety and reliability.

Transpower uses SPM Assets software as the asset planning model for ACS Buildings and Grounds assets, except for outdoor security fencing, and applies the 5-step condition scoring system defined by the International Infrastructure Management Manual (IIMM).

Investment in buildings and grounds is based on asset condition, including factors such as corrosion code and building function. Asset health models have been developed for the non-electrical commercial buildings and grounds. Aside from the outdoor switchgear fencing, which is subject to the Transpower standard criticality methodology, work is prioritised in SPM Assets by building type and function.[140]

[140] Transpower (2018), Asset Class Plan – Buildings and Grounds, p. 2, Document [67]

The main cost drivers are:

- replacement of security fencing when condition score is 4 (poor) or worse, and maintenance is no longer economic;
- installation of fibre-reinforced cable trenching covers to protect against vehicle damage;
- replacement of switchyard metalling based on condition, risk and cost;
- re-sealing road and access ways when localised maintenance and repair no longer economically viable;
- water proofing of buildings for protection of electrical equipment through painting and planned maintenance/replacement of roofs;
- mitigation of identified seismic risks for essential buildings;
- mitigation and removal of asbestos; and
- replacement/refurbishment of fire protection and building and underground infrastructure services.

*Key drivers for RCP3*

During RCP2, responsibility for warehouses moved into the AC Substation Buildings and Grounds portfolio and urgent warehouse improvement projects resulted in an increase in replacement/refurbishment work.

With the improvements identified by Transpower in asset management of the various components of the AC Substation Buildings and Grounds since 2013/14, including asset condition assessments and the implementation of SPM Assets, the RCP3 forecast expenditure has been based on:

- standard asset lives for the various components
- standard degradation curves
- adjustment factors for corrosion codes[141]
- condition assessments.

The increase in forecast expenditure in RCP3 compared to RCP2 as shown in Figure 78 is in part due to substation security fencing replacement and road access way

[141] Corrosion codes are categorised as Extreme, Very Severe, Severe, Moderate, Low and Benign

refurbishment previously deferred from RCP2 following a risk assessment that showed deferral was cost effective. In addition, the asbestos management proposed during RCP3 will focus on key sites such as Otahuhu, Henderson, Penrose and Wilton substations. The following table summarises the increased work volumes planned for RCP3.

**Table 85 ACS Building & Grounds capex & maintenance volumes for RCP2 to RCP5[142]**

| Activity | Network population | Regulatory period | | | |
|---|---|---|---|---|---|
| | | RCP2[143] | RCP3 | RCP4 | RCP5 |
| Fencing (outdoor switchyard, security, power, perimeter, stock) | approx. 1,200 | 36 | 88 | 26 | 13 |
| Switchyard metalling | 156 sites | 9 | 20 | 4 | 1 |
| Cable trench lid | - | 3 | 48 | 28 | 13 |
| Underground infrastructure | 201 sites | 4 | 20 | 1 | 0 |
| Roofs | 749 buildings | 23 | 60 | 9 | 5 |
| Road access ways and entrances | 201 sites | 7 | 71 | 10 | 10 |
| Air-conditioning systems | 820 HVAC | 9 | 34 | 23 | 20 |

Transpower has forecast that by the end of RCP3, all projects deferred from RCP2 will be completed. As shown in Table 85, the primary drivers for RCP3 will be fencing, switchyard metalling and replacing/refurbishing roofs, and the start of the replacement of cable trench lids and underground infrastructure.

The first national seismic upgrade programme, focusing on critical buildings, was completed by the end of RCP1. This programme targeted a seismic strength for all essential buildings achieving a minimum 75% of the New Zealand 1170.5.2004 *Structural design actions - Earthquake* standard. The focus in RCP3 will be to investigate the strengthening work required for the next level of buildings, particularly for those constructed or reinforced in the 1990s.

During RCP3, Transpower will continue with the asbestos removal/containment program.

### *Verification assessment of ACS Buildings and Grounds*

We note the level of rigour and detail that Transpower applies to the management of its buildings and grounds assets, particularly the detailed modelling in the SPM Assets system of each component using current condition data and asset life. This generates a

142 Transpower (2018), Asset Class Plan – Buildings and Grounds, Table 4, p.25, Document [67]

143 Based on three years in RCP2 from 2017/18

condition assessment score based on typical deterioration curves and generates a first-pass intervention year for replacement.

This intervention year is further refined by adjusting the base life for the various components depending upon the criticality of the substation site and the corrosion zone in which the substation is located. As the time for replacement reaches the 0 to 2-year planning stage, Transpower does an NPV analysis to verify when maintenance to extend operational life is no longer economically viable.

By analysing the various components separately, the asset management method used by Transpower provides a robust approach to the replacement and refurbishment of assets with significantly different nominal asset lives, such as security fencing, gates, road access ways, roofs and HVAC units. The three primary failure causes are:

- substation security
- weather tightness
- seismic performance in accordance with revised building codes.

We have reviewed the planned volumes of work for RCP3 (refer Table 85) against the reported asset condition for fencing and roofs and conclude that:

- fencing is generally in good (C1 to C3) condition (refer Attachment B.11), with most of the fences in poor condition in severe corrosion zones. We note the components that have been assessed as being in poor (C4 or C5) condition (refer Attachment B.11) are part of ODS fencing, which is essential to the security and safety of the substation switchyard. There are 84 fences that are 46-50 years old and a further 13 that are 51-55 years old (refer Attachment B.11). The planned volume of work for RCP3 is consistent with the number of fences that have reached the end of their nominal operational life of 50 years for ODS fence components (refer Attachment B.11). Therefore, we consider the proposed fencing work volume for RCP3 to be appropriate.
- while Transpower has not incurred any network outages as a direct result of extreme weather affecting substation equipment, there have been several incidents where control rooms have suffered water ingress over switchboards in control rooms, posing potential risks to the network. Transpower has identified that colour sheet and metal roofs have the highest level of assessed poor condition sites, together with the inherent problems with the historic preferred design incorporating flat or low-pitched roofs with rubber membranes. A significant amount (by replacement cost) is in severe corrosion zones, and the planned volume in RCP3 (8% by volume) is consistent with the identified poor condition roof assets

(by replacement cost) for Severe and Moderate corrosion codes. On this basis, we consider the planned work volume appropriate.

The relatively large expenditure in RCP1 was due to seismic upgrading of essential substation buildings following the 2011 Christchurch earthquake and the subsequent revisions of building codes with regards seismic resilience requirements. We believe the asset management practices adopted for substation buildings and grounds are generating a long-term view of the replacement and refurbishment needs, with RCP3 being for the improvements in key areas such as fencing and roofs, and RCP4 for seismic upgrade construction works in substation buildings following detailed investigations during RCP3.

Based on our analysis of the asset management strategies and condition assessments provided by Transpower, we are satisfied that the investment in buildings and grounds for AC substations is well targeted and is prudent and efficient in maintaining safe and reliable operations in these substations.

We believe Transpower's RCP3 AC Substation Buildings & Grounds capex forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - ACS Buildings & Grounds

Table 86 summarises our verification assessment and opinion.

**Table 86 Verification summary - ACS Buildings and Grounds**

| Expenditure category | Capex - ACS Buildings and Grounds | |
|---|---|---|
| **Transpower RCP3 forecast** | $39.5 million | |
| **Recommendation** | **Accept:** $39.5 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Detailed modelling in SPM Assets for condition assessed replacement of infrastructure assets underpining prudency<br>* Forecast based on various asset categories to support robust replacement estimate, considering different asset lives underpniing efficiency | - |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |

| | | |
|---|---|---|
| **Potential scope for improvement** | N/A | N/A |

### 7.4.2 ICT capex - Asset Management Systems

Asset Management Systems supports the planning and maintenance of transmission services. Transpower categorises the asset management capabilities under six functional areas:

(i) strategic and tactical planning

(ii) asset and work planning and delivery

(iii) asset risk and performance management

(iv) asset management

(v) mobility services

(vi) asset data, information and business intelligence.

The primary systems included in this asset portfolio are:

- PowerPlan - Asset Management Planning System (AMPS)
- Maximo - operational asset register and maintenance management tool
- Geospatial systems for location based data
- Condition Based Risk Management (CBRM) tool - risk-based asset health modelling
- Transpower Integrated Project Utility (TIPU) – enterprise-wide planning and project/portfolio management platform
- Drawing management system.

Transpower has forecast a total capex for Asset Management Systems in RCP3 of $18.6 million in real 2017/18 dollars.

Table 87 shows the RCP2 actual and approved expenditures and the proposed RCP3 capex.

**Table 87 Comparison of Asset Management Systems RCP2 and RCP3 capex ($2017/18 million)**

| Asset class | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Asset Management Systems | 23.3 | 18.6 | -20% |

Table 88 shows the annual forecast capex for RCP3 in real 2017/18 dollars.

**Table 88 Annual forecast capex for Asset Management Systems in RCP3 ($2017/18 million)**

| Asset class | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Asset Management Systems | 2.1 | 2.4 | 5.1 | 2.8 | 6.1 | 18.6 |

Figure 79 shows the annual capex for the regulatory periods RCP1 to RCP3, and Figure 80 shows the total capex for the regulatory periods RCP1 to RCP5.

**Figure 79 Annual Asset Management Systems capex for RCP1 to RCP3**

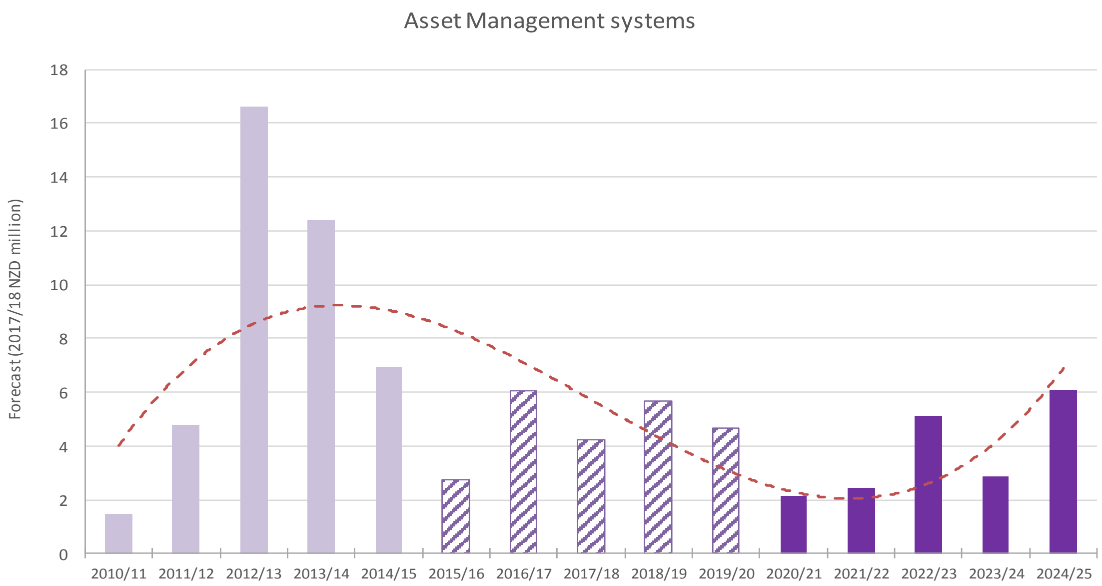
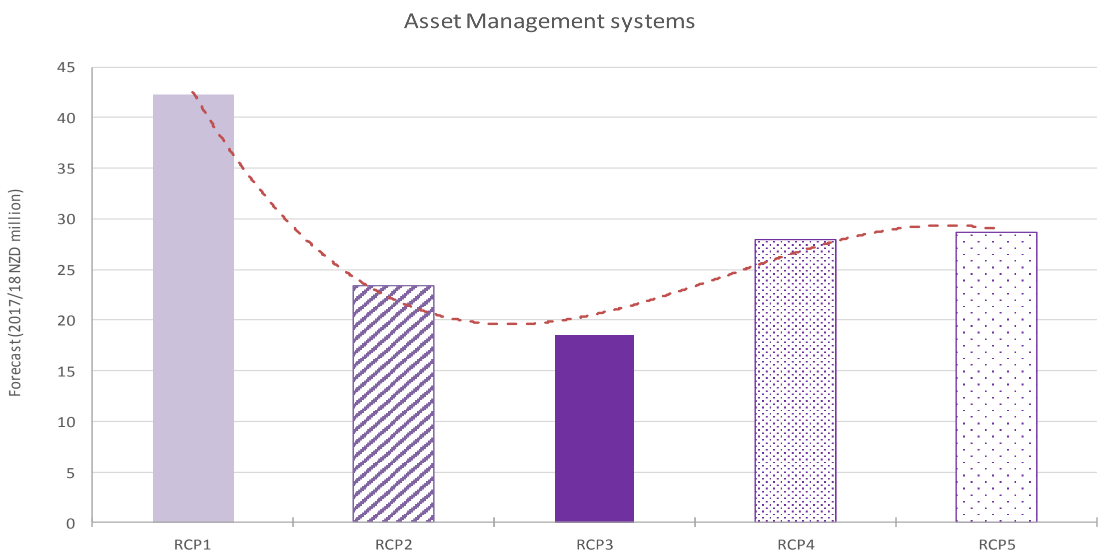



**Figure 80 Total Asset Management Systems capex for RCP1 to RCP5**



### *Current RCP2 activities*

During the latter part of RCP2 and continuing into RCP3, Transpower is implementing major lifecycle refreshes of some key systems (TIPU, TEES, Maximo), along with leveraging new technology to implement near real-time asset condition monitoring and data collection.[144]

In addition, Transpower invested in PowerPlan in mid-RCP2 as the new corporate asset management planning system to improve the Decision Framework (refer section 5.6 of our report) and optimise asset planning for both capex and opex. For the remainder of RCP2, Transpower will focus on integrating PowerPlan with Maximo, CBRM and outage management systems.

During late RCP2 and continuing into the early stages of RCP3, Transpower is investing in system improvements to improve vegetation management and enhancements to spatial imagery to support the Auckland Strategy.[145]

### *Asset strategy and planning*

Transpower has stated that their overall approach to ICT investments is "*… to utilise emerging market trends to refresh … existing systems and improve integration and consolidation of systems.*"

For asset management systems, Transpower is planning to upgrade, consolidate and integrate systems to provide better asset condition and risk assessments, and reduce the number of customisations. Maximo will remain the asset management system until RCP4, with enhanced health, safety and assurance functionalities.

### *Key drivers for RCP3*

Figure 81 shows the proposed split of expenditure by the primary driver.

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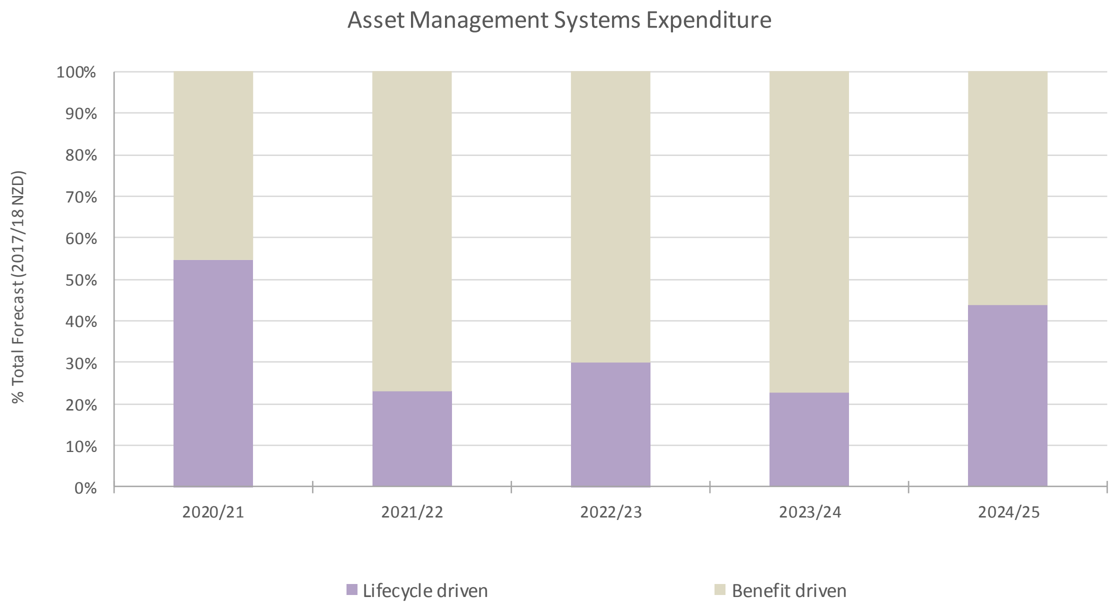
144 Transpower (2018), ICT Capex Forecast, section 5.2, p. 31, Document [76],

145 The *Auckland Strategy* considers the development and growth plans (especially large infrastructure projects) for the Auckland and Northland, maintaining high levels of security of supply, forecast major maintenance of existing overhead lines to 2050, 110/220 kV grid optimisation opportunities and emerging technologies.

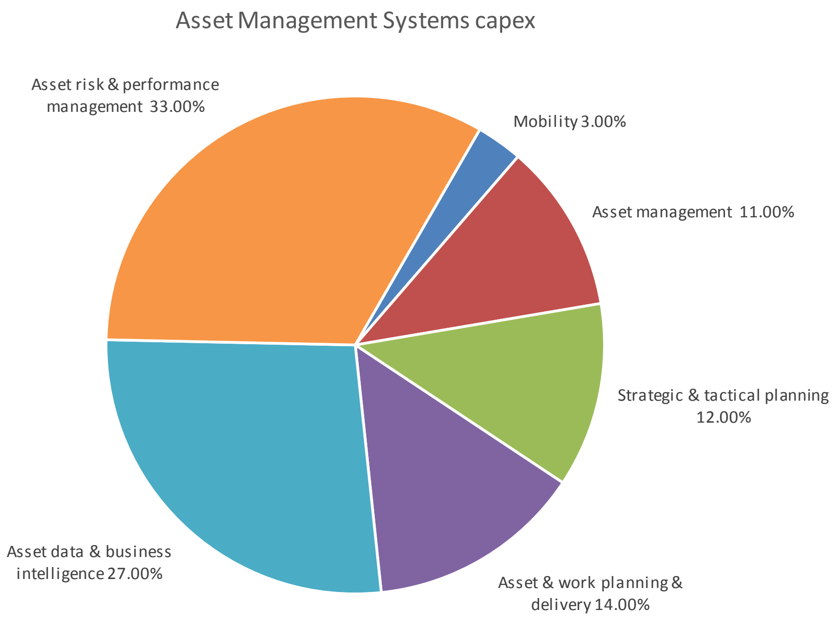
**Figure 81 Asset Management Systems RCP3 capex by primary driver**




Overall, 64.6% of the RCP3 expenditure forecast is allocated to benefit-driven initiatives and 35.4% to lifecycle-driven projects.

Figure 82 shows the investment areas by business theme.

**Figure 82 Asset Management Systems RCP3 capex split as percentage of total**



For each of the six functional areas, the main activities for RCP3 are:

(i) strategy and tactical planning: real-time asset health data will be added to AMPS, to support increasing utilisation of an asset through real-time performance and operational data; TEES will be replaced at the end of RCP3 as it reaches end-of-life;

(ii) asset and work planning and delivery: implementation of AMPS, incorporating reliability-informed maintenance in asset planning, improvement in delivery of volumetric projects;

(iii) asset risk and performance management: real-time asset condition and performance monitoring;

(iv) asset management: further improvements to Maximo and improved integration with existing environment, and health and safety systems;

(v) mobility services: upgraded communication and co-ordination with field staff, improved delivery of condition assessments and site risk reviews;

(vi) asset data, information and business intelligence: replace current asset photo system, upgrade to grid drawings system

*Post implementation benefit analysis*

Upon request, Transpower provided the benefits management plan[146] for the implementation of Maximo (referred to as the Core AMIS Project). The delivery of this project was expected to provide the following key improvements to Transpower's asset management systems:

- targeting maintenance activities and capex through improved knowledge of asset condition, performance, criticality, and likelihood of failure;
- safety and quality management and planning, with crews systematically accessing consistent, relevant information on works procedures, site conditions, equipment, and competencies;
- coordination and scheduling of works with external service providers through higher visibility of their works planning, and timely updating of its progress in Transpower's systems;
- integrity of collected data and its timely availability for decision-making for works management and by asset managers; and

[146] Transpower (2018), ICT Capex Forecast and Benefits, p. 5, Document [79],

- transparency of asset management delivery in support of Transpower's regulatory submissions.

Table 89 shows the key annual benefits that have been achieved with the implementation of Maximo.

**Table 89 ICT financial benefits for Maximo implementation ($2011/12 million)**

| Benefit category | Measure | Benefit Value ($M) |
|---|---|---|
| Maintenance opex - reduced inspections & repairs, improved fault response, reduced maintenance project costs | Reduced maintenance opex | 2.50 |
| Maintenance opex | Reduced external service providers invoiced service charges | 0.22 |
| Maintenance opex | Reduced Transpower's overhead costs associated with maintenance & outage management | 0.25 |
| Maintenance capex - fewer unplanned capex projects due to equipment failure | Reduced minor capex | 5.22 |
| Improved reliability (RCP2 incentive regime) | Reduction in one system minute attributed to reduction in equipment failure | 0.90 |
| Supply Chain Efficiency improvement | Reduced stock holding costs, reduced depreciation on in-stock items | 0.21 |
| **Total** | | **9.30** |

Other non-quantified benefits identified are:

- improved safety performance through improved access for staff to work procedures, site and asset conditions and training in identifying and avoiding hazards;
- improved situational awareness through more reliable asset information;
- improved response to customers; and
- more effective management and reporting of asset and works data to comply with regulatory requirements.

We note that the Benefits Management Plan includes detailed analysis of tangible benefits that have been recorded on the Transpower Grid Performance Benefit Register to support the annual benefits shown in Table 89.[147]

[147] Transpower (2018), ICT Capex Forecast and Benefits, Appendices A and B, pp. 9-12, Document [79]

*Verification assessment of Asset Management Systems*

We are satisfied that the post-implementation benefit analysis for Maximo demonstrated significant annual savings in maintenance expenditure and has provided a platform for improved asset performance and operational decision making, together with reduced response times to outages.

Transpower has provided qualitative analysis of benefits to support the planned RCP3 expenditure of asset management systems. Transpower has undertaken preliminary assessments against several capabilities (the most significant being asset criticality & risk management, asset health & performance management and asset strategic & tactical planning), which will support the ongoing development of asset health modelling, a key initiative going forward.

Therefore, we are satisfied that the RCP3 Asset Management Systems expenditure is prudent and consistent with both the overall corporate direction and GEIP.

### Verification opinion - Asset Management Systems

Table 90 summarises our verification assessment and opinion.

**Table 90 Verification summary - Asset Management Systems**

| Expenditure category | Capex - Asset Management Systems | |
|---|---|---|
| **Transpower RCP3 forecast** | $18.6 million | |
| **Recommendation** | **Accept:** $18.6 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Forecast considered consistent with expenditure outcome with regard GEIP because:<br>* Post-implementation benefit analysis demonstrated significant annual savings in maintenance expenditure<br>* Provides platform for improved asset performance and operational decision making<br>* Reduced response time to outages<br>* Consistent with overall corporate direction | N/A |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

# 8 Opex forecast verification

In this chapter, we assess Transpower's RCP3 opex forecast against the TOR. This required us to:

- assess Transpower's policies and planning approaches, assumptions, drivers and forecasting methodologies, focussing on Identified Programmes; and
- provide our verification opinion on Transpower's RCP3 opex forecasts, including whether these forecasts satisfy the expenditure outcome regarding GEIP.

## 8.1 Background

Transpower has forecast a total opex for RCP3 of $1,342.9 million in real 2017/18 dollars. Table 91 shows the RCP2 actual and approved expenditures and the proposed RCP3 opex.

**Table 91 Comparison of RCP2 and RCP3 opex ($2017/18 million)**

| Expenditure category | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Preventive Maintenance | 194.0 | 198.8 | 2% |
| Predictive Maintenance | 280.9 | 335.9 | 20% |
| Corrective Maintenance | 24.4 | 15.0 | -39% |
| Proactive Maintenance | 2.7 | 2.5 | -8% |
| Maintenance deliverability adjustment | - | (29.1) | |
| Asset Management and Operations[148] | 302.6 | 309.5 | 2% |
| Business Support | 237.3 | 226.5 | -5% |
| ICT | 191.6 | 195.9 | 2% |
| Insurance | 72.1 | 88.0 | 22% |
| **Total** | **1,305.6** | **1,342.9** | **3%** |

The RCP3 forecast includes a productivity adjustment based on 0.2% productivity adjustment across all components within Asset Management and Operations (except ancillary services) in addition to those that are already reflected in reported opex in RCP2 and hence in base year expenditure where the base-step-trend opex forecasting methodology is applied.

[148] This is a new expenditure category for RCP3. Previously, overhead costs were accounted for in a more generic *Departmental* expenditure category, which included costs other than those associated with the business support, asset management and operation functions, such as contractor and consultancy, investigations, accommodation, and travel

From its RCP3 baseline opex forecast, Transpower advised the maintenance forecast was reduced by $29.1 million to mitigate the risk that delivery constraints will make the proposed scope of work unachievable. In the Price-Quality analysis of the RCP3 baseline maintenance forecast, Transpower concluded the intended programme outcomes can still be delivered if expected efficiency gains are achieved and are reinvested in the maintenance programme. Should this not occur, it will be necessary to re-prioritise work.

Table 92 shows the annual forecast opex for RCP3 by expenditure category in real 2017/18 dollars. The categories that have been shaded are RCP3 Identified Programmes, which account for around 80% of the total RCP3 baseline opex forecast.

**Table 92 Annual forecast opex for RCP3 ($2017/18 million)**

| Expenditure category | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Preventive Maintenance | 38.6 | 39.3 | 39.7 | 40.4 | 40.8 | 198.8 |
| Predictive Maintenance | 68.1 | 64.2 | 66.8 | 70.3 | 66.5 | 335.9 |
| Corrective Maintenance | 3.0 | 3.0 | 3.0 | 3.0 | 3.0 | 15.0 |
| Proactive Maintenance | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 2.5 |
| Maintenance deliverability adjustment | (5.9) | (5.4) | (5.8) | (6.3) | (5.7) | (29.1) |
| Asset Management and Operations | 62.9 | 62.9 | 62.4 | 61.4 | 59.9 | 309.5 |
| Business Support | 45.0 | 44.9 | 46.1 | 46.0 | 44.6 | 226.5 |
| ICT | 38.7 | 39.4 | 39.2 | 39.3 | 39.3 | 195.9 |
| Insurance | 16.6 | 17.1 | 17.6 | 18.1 | 18.6 | 88.0 |
| **Total** | **267.5** | **265.7** | **269.5** | **272.7** | **267.5** | **1,342.9** |

Transpower has advised us that the four grid maintenance categories identified in Table 92 were adopted as business-as-usual (BAU) classifications in 2015, and is now aligning the RCP3 submission to the BAU classifications as follows:

- Preventive – which relates to routine servicing to prevent failure or inspections to understand asset condition. This programme is time-based maintenance schedules that allow Transpower to understand asset condition and identify any defects.
- Predictive – which relates to known equipment condition before its condition deteriorates into an unsatisfactory state (e.g. outside service specification). Unlike corrective maintenance, this work occurs prior to failure;
  - predictive maintenance includes the trade-off of extra maintenance that is allowed due to deferral in programmed capital renewals and replacements.
- Corrective – which relates to an expenditure programme of fault response or maintenance work undertaken on equipment or systems to return it from an

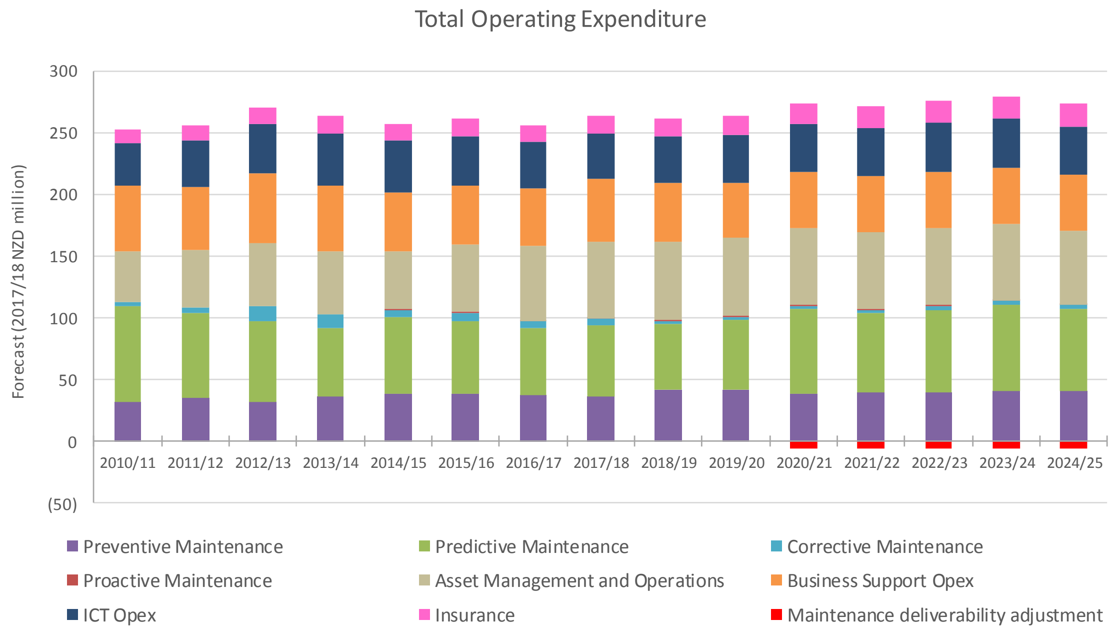
unsatisfactory or failed condition back to a serviceable condition (e.g. within specification). Unlike predictive maintenance, this work occurs after failure.[149]

- Proactive – which relates to a collection of activities, inspections, tests and procedures used to prevent the failure of equipment, a machine or a material in the future. It focuses on determining potential root causes of machine or material failure and dealing with those issues before problems occur.

In doing so, Transpower has back-cast historic costs from RCP1 and RCP2 into these new categories to identify relative contributions to overall Grid maintenance expenditure historically and to support the preferred forecasting approach for RCP3.

Figure 83 shows annual opex for periods RCP1 to RCP3 (reflecting reported and forecast data) broken down by major expenditure category.

**Figure 83 Annual opex for RCP1 to RCP3[150]**




The key features of the annual expenditure profile since 2010/11 are:

- consistent contributions to total annual opex for preventive maintenance (14%), predictive maintenance (22-25%) and Asset Management and Operations (since start of RCP2) (23%);

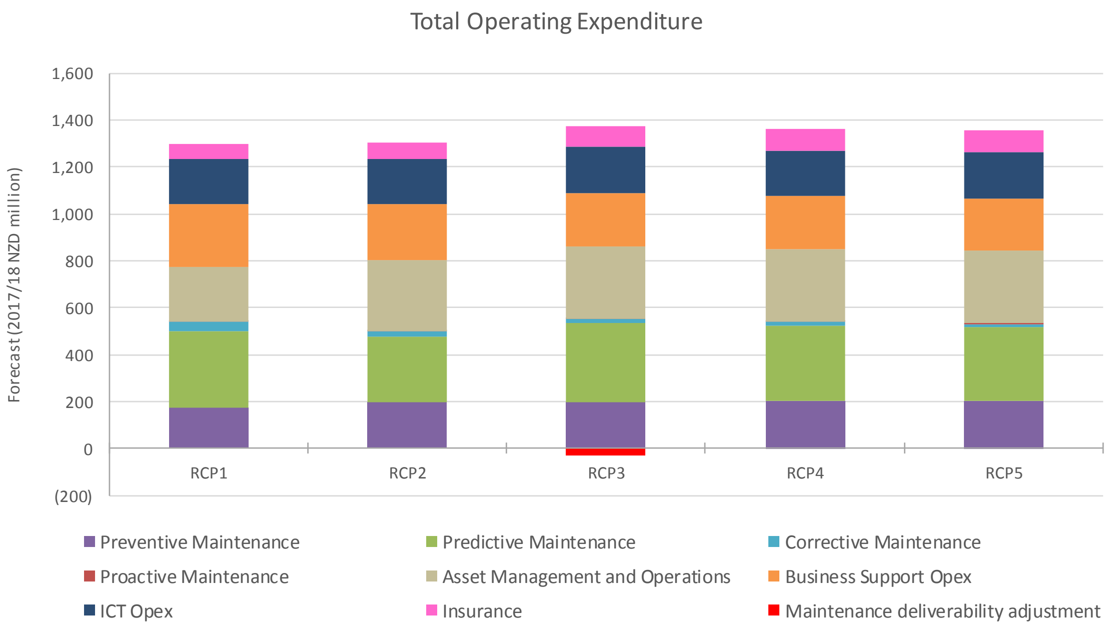
149 This can often result in collateral damage, resulting in higher costs than if picked up as planned maintenance.

150 Includes RCP3 maintenance deliverability adjustment

- marginal allowances for corrective and proactive maintenance; and
- variable costs for insurance over time, reflecting external insurance market conditions.

Figure 84 shows a comparison of historic expenditure for RCP1 and RCP2, with the forecast opex for regulatory periods RCP3 to RCP5.

**Figure 84 Total opex for RCP1 to RCP5[151]**




The primary drivers for the higher RCP3 forecast expenditure compared to RCP2 are:

- an increase of $26 million or 20% in predictive maintenance;
- a downwards adjustment of $29 million for maintenance deliverability;
- an increase of $16 million or 22% in insurance costs; and
- an increase in asset management and operations costs of approximately $7 million or 2%.

151 Includes RCP3 maintenance deliverability adjustment

## 8.2 Opex evaluation criteria

Attachments A1 and A2 of the TOR provide both general and specific evaluation criteria for the independent verifier to have regard to in reviewing Transpower's RCP3 opex forecast.

This includes having regard to the reasonableness of key assumptions and forecasting methodologies relevant to Transpower's RCP3 opex forecasts.

We are also to have regard to the following factors in reviewing the RCP3 opex forecasts:

- existence of a risk-based approach consistent with good asset management practice directed towards cost effective and efficient solutions;
- dependencies between the proposed grid output measures and targets at the grid level and opex category level;
- the relationship between the RCP3 Base Capex and opex forecasts;
- the reasonableness of opex reduction initiatives undertaken or planned during RCP2 and any efficiencies built into the RCP3 forecasts, including due to the investment programme carried out in RCP1 and RCP2.

## 8.3 Assessment approach

The assessment technique applied for verifying the RCP3 opex forecasts includes several stages:

- Review of the selected base-step-trend forecasting methodology for most of the opex categories, as opposed to the Maintenance Activity and Cost Model (MACM) modelling tool used for the RCP2 forecasts;
- Review of the preventive maintenance category which uses a forecasting methodology based on identified work activity:
  - review of the approach to determine work volumes, including reliability of source; and
  - review of standard building blocks and unit rates.
- Review of any top-down adjustments made to the RCP3 opex baseline forecast including due to:
  - Executive or Board-related challenge processes; and
  - deliverability issues.

## 8.4 RCP2 forecast process

Transpower's RCP2 opex forecast was broken down into Grid and non-Grid (IST and corporate) components.

For Grid activities, these were split into either routine maintenance, or maintenance projects for specific asset categories (HVAC substations, HVDC, transmission lines, buildings and grounds).

The review for the Commerce Commission identified that routine maintenance constituted 75% of the total Grid opex, and 79% of routine opex was allocated to preventive and corrective maintenance of transmission lines and AC substations.[152]

Transpower used a MACM forecasting model to develop the RCP2 routine maintenance forecast, which was considered to optimise between capex and opex, consider work history analysis and incorporate ongoing improvements to the maintenance regime. The Commission's consultant's review noted that "*… Transpower … targeted a 7%* [efficiency] *adjustment in preventive and corrective maintenance for RCP2.*"[153] In the final decision, the Commerce Commission accepted this opinion and was satisfied that Transpower had made "*… significant investment in improving the efficiency of its grid opex.*"[154]

## 8.5 Transpower's RCP3 opex forecasting methodologies

During RCP2, Transpower elected not to fully implement the MACM maintenance modelling tool, as it was considered too complex, and was not readily auditable.

Transpower has developed base-step-trend opex forecasts for each of the expenditure categories (excluding preventive maintenance) using 2017/18 as the base year:

- forecasts were based on actual costs incurred in 2017/18, which are the most recently audited costs and are considered to embed efficiency gains made since the Commission's RCP2 final decision;
- removed non-recurring costs for efficiency initiatives from the base year business support costs, as these initiatives are self-funding via the incentive arrangements; and

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152 GHD (2018), GHD RCP3 Capex and Opex forecast_IV review, Document [118]

153 Ibid., clause 536, p. 130

154 Commerce Commission (2014), Settign transpower's indivudal price-quality poath for 2015-20, clause 5.125, p. 84, Document [120]

- excluded prospective efficiency gains from the forecast to incentivise it identifying and pursuing gains at any time through the regulatory cycle to ultimately be shared with customers under the Commerce Commission's opex incentive scheme (IRIS).

In contrast, for preventive maintenance, Transpower has generated standard jobs for the routine maintenance activities and used work volumes generated by Maximo to calculate an aggregated [quantity] x [standard job cost] forecast.

### 8.5.1 Transpower's application of base-step-trend forecasting methodology

The base-step-trend forecasting approach is common practice for electricity utilities in Australia in forecasting opex as part of regulatory proposals to the AER, with the regulator typically focusing on the following aspects:

- determining the base year and its suitability, including its efficiency;
- removing one-off costs from the base year and including adjustments, where appropriate, to reflect non-recurrent costs;
- identifying any step changes, where appropriate, to reflect changes in scope resulting from factors outside of the network's control; and
- applying a trend factor (escalation) over the regulatory control period to account for:
  - output drivers: network and customer growth
  - efficiency drivers: technical efficiencies, economies of scale
  - real cost escalation: labour, materials and contractor costs.

In an Australian context, it is usual practice for the base-step-trend forecasting methodology to be applied to the total opex forecast, which results in a relatively pure 'top down' forecast compared to an aggregation of 'ground up' individual expenditure programme forecasts. In contrast, we note that Transpower (and other NZ electricity utilities) tend to apply the methodology at the operating and maintenance programme/category level, with the total opex forecast being an aggregate of these individual programme/category costs each estimated using the base-step-trend methodology.

We consider either approach is valid, but the different basis of the resulting forecasts requires a somewhat different interpretation. Hence, the ground-up base-step-trend forecasts generated using the NZ approach have not been subject to the same top down discipline applied under the Australian approach. The risk with this approach is that the aggregation of several ground-up expenditure forecasts may result in a total opex forecast that is too high because the scope for efficiencies across expenditure programs is not considered. This suggests that some form of top-down challenge must be applied to Transpower's RCP3 opex forecasts to test the prudency and efficiency of the ground-up forecasts.

*Transpower's selection of 2017/18 as base year for RCP3 forecasts*

Transpower has selected 2017/18 as the base year for its RCP3 opex forecasts. This will be the most recent financial year for statutory reporting purposes prior to Transpower's submittal of its RCP3 proposal to the Commerce Commission in December 2018.

The key requirement for the base year when applying the base-step-trend forecasting methodology is that the year is not atypical compared to Transpower's historical annual business-as-usual opex profile. This means that any large one-off (non-recurring) expenditure items should be removed from the base year.

From a regulatory perspective, it is also important that the base year is efficient. In this regard, we note that in RCP2 Transpower is subject to an opex incentive scheme (IRIS), such that it is being financially rewarded for out-performance compared to the Commerce Commission's RCP2 forecasts. For this reason, in principle, we are inclined to accept that Transpower's reported total opex for 2017/18 is an efficient base for the RCP3 forecasts.

The economic benchmarking results we presented in Chapter 3 of our report indicated that Transpower's total opex was relatively high compared to Australian transmission networks. However, we concluded that this result could be the result of capex-opex trade-offs that Transpower has been implementing as part of its asset management decision-making framework. Further, given the constraint of a very small sample of benchmarked transmission networks, we are not confident in relying on the benchmarking evidence to form a firm view that Transpower's reported 2017/18 total opex is inefficient.

However, we have not been able to verify whether the 2017/18 base expenditure for each of the individual grid and non-grid maintenance and opex programmes is efficient.

*Step changes*

Base year expenditure is adjusted to account for any forecast operating cost changes over the RCP that are not otherwise captured in base year opex or the trend factors. This may be due to new legislative or regulatory obligations in the forecast period and efficient capex/opex trade-offs.

Transpower has identified several step changes across its maintenance and opex programmes.

*Trend factors*

Opex can be expected to change over time due to input price changes, growth in outputs and productivity movements, which should be reflected in the opex forecast as a trend factor.

Price growth is made up of labour and materials price growth based on the assumed proportion of these costs in the relevant expenditure programme. Given Transpower's maximum allowable revenue and price path are expressed in nominal terms, real price escalation is the primary concern in any trend calculation it applies (ie price growth greater than forecast CPI).

Output drivers are used to escalate expenditure over the regulatory control period. These drivers are used to account for an increase to the opex program because of an increase in the size of the network eg length of lines, installed substation capacity and customer numbers. Demand growth is the primary driver of output growth.

The productivity trend factor is usually assessed in terms of recent observed labour productivity movements.

### 8.5.2 Transpower's assumptions

Transpower's RCP3 maintenance forecast is based on the following key assumptions:[155]

- there will be no material impact on the delivery and cost of the maintenance works from the contractual reset occurring in the first year of RCP3;
- future efficiency gains are realised while sustaining existing work practices and carrying out prudent deferred maintenance. Efficiency gains are sufficient to offset the deliverability adjustment made to the overall maintenance forecast;
- no significant events (e.g. major earthquake, storms or unexpected equipment failure) occur during the period. Such events could create the additional need for corrective maintenance, resulting in the need to substitute expenditure from another category;
- health and safety requirements will not result in material additional costs beyond those incurred during 2017/18;

155 Transpower (2018), Maintenance Opex Overview, section 2.1, pp. 12-3, Document [70]

- ongoing defect remediation will remain at approximately 15,000 per year; and
- additional preventive maintenance work on new assets will be offset by the reduction in preventive maintenance resulting from asset decommissioning.

### 8.5.3 Planned improvements

Transpower has identified the following improvement opportunities for RCP3, looking to build on the system and process developments in RCP2:

- continue development of reliability-informed maintenance approach, through more proactive works and increasing condition-based predictive maintenance programmes;
- optimisation of preventive maintenance jobs to ensure appropriate level of maintenance is done;
- ongoing testing of specific decommissioned assets to improve understanding of condition and related maintenance and replacement decisions; and
- targeted asset improvement programmes addressing known condition problems.

### 8.5.4 Capex/opex trade-offs

An opex solution to extend the in-service life of the existing asset(s) is considered a valid option in addressing an identified need in the capex planning process. That is, if an opex solution is assessed as the best intervention, the costs are included in the opex forecasts and not capex.

Transpower provided the following example with regards to the transformer bushing replacement programme for RCP3 to illustrate:

- portfolio planning work has identified bushing replacements as the optimal intervention for some of the transformers - this allows transformer replacement to be deferred;
- the accounting and regulatory treatment of work is the same. For bushing replacements, bushing replacements are expensed if the transformer is less than 44 years old. This approach is agreed with the financial auditor as being consistent with generally accepted accounting principles (GAAP);
- predictive maintenance forecast includes a step change component for replacing the bushings on certain transformers;

- transformer capex forecast excludes replacement of the transformers affected; and
- for bushings replaced on transformers older than 44 years, these will be included in the Base Capex forecast.

Table 95 (below) shows capex/opex trade-off allowances in proposed predictive maintenance step-changes for RCP3 to defer capex to later RCPs.

For ICT, Transpower includes a step change in the ICT opex to recognise any capex/opex trade-off.[156] For example, one group of ICT capex benefits related to RCP3 initiatives are expected to realise about $1.4 million reduction in ICT opex against the Leases category.

The ICT capex forecast includes a proposed investment of around $5 million to build new fibre assets to avoid existing high cost leases (captured within ICT opex). The related downward step change in opex of $1.4 million related to leases was derived via a comparison to a similar RCP2 initiative. It is anticipated that the $5 million RCP3 investment has the potential to reduce future lease costs by a total of about $12 million over the 20-year life of the asset realising a $7 million net benefit.

## 8.6 Identified Programmes

### 8.6.1 Selection process

The list of Identified Programmes for Transpower's RCP3 proposal was based on criteria developed and agreed by Transpower and the Commerce Commission between November 2017 and February 2018. The selection of Identified Programmes covers the following:

- expenditure categories for a range of different asset classes;
- asset classes with the larger expenditure forecasts; and
- asset classes with RCP3 expenditure forecasts that vary significantly from RCP2.

The agreed selection criteria for RCP3 identified opex programmes is:

(a) Top four expenditure categories across the total opex forecast;

(b) Should the opex programmes identified by (a) not represent a minimum of 75% of the total RCP3 opex forecast, additional opex programmes ranked from largest to smallest until the 75% minimum threshold is satisfied.

156 A key example of ICT capex/opex trade-off is the deferral of TransGO project capex to RCP4, with additional opex during RCP3 identified as the optimal solution.

### 8.6.2 RCP3 identified opex programmes

For our RCP3 forecast assessment, preventive maintenance replaces ICT opex as an identified capex programme from the RCP2 review.

The Identified Programmes are as follows:

- Maintenance, further broken down by:[157]
  - Preventative
  - Predictive

  (We note that non-identified programmes of Corrective Maintenance and Proactive Maintenance are additional to these and are discussed in section 8.7).

- Non-network opex, including:
  - Asset management and operations
  - Business support

The four identified opex programmes representing 80% of the total RCP3 opex forecast of $1,342.9 million (refer Table 92) are shown in Table 93.

**Table 93 RCP3 identified opex programmes ($2017/18 million)**

| Capex | Expenditure category | RCP3 forecast |
|---|---|---|
| Direct network | Preventive Maintenance | 198.8 |
| | Predictive Maintenance | 335.9 |
| | Maintenance deliverability adjustment | (29.1) |
| Indirect network | Asset Management & Operations | 309.5 |
| | Business Support | 226.5 |
| **Total** | | **1,070.6** |

We have addressed the non-identified programmes of ICT opex and Insurance in section 8.7 of our report.

### 8.6.3 Network opex - Preventive maintenance

The relatively flat trend for preventive maintenance expenditure over time, including forecast for RCP3, reflects the cyclic nature of the works programme, with any year-on-year variations due to specific maintenance tasks falling due on slightly longer timelines.

[157] There are issues associated with allocation of expenditure across these four categories, including a lot of proactive work is being classified as predictive work, which we should note.

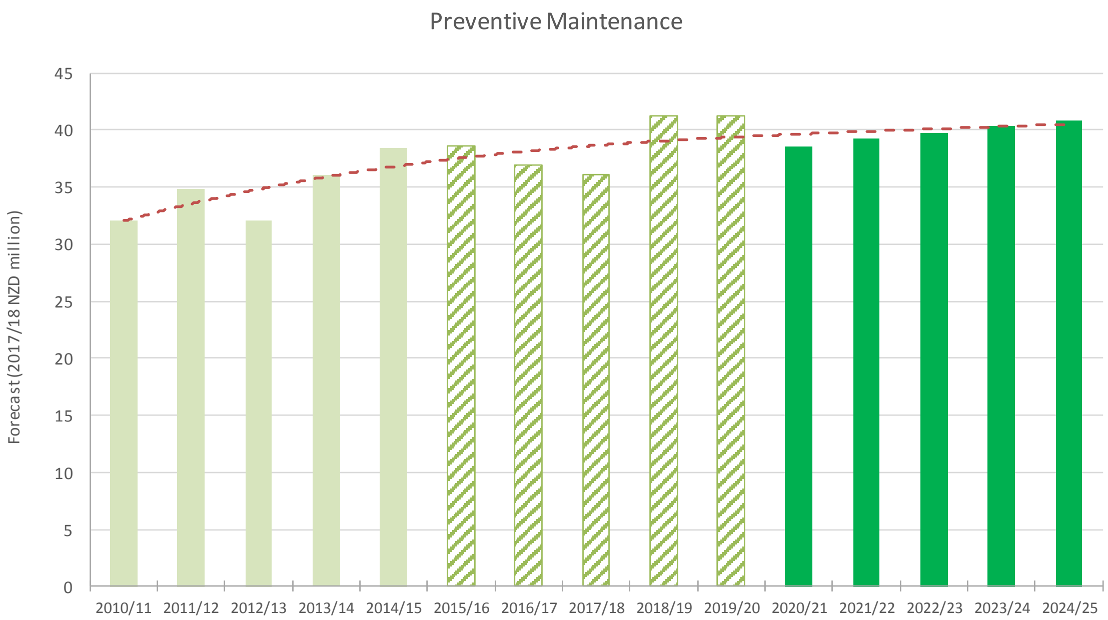
Any additional costs incurred due to changes in health and safety, statutory or performance requirements appear to have been offset by efficiencies gained through optimisation of preventive maintenance tasks.

The high forecast expenditure in the final two years of RCP2 (2018/19 and 2019/20) are predominantly due to additional management contracts being implemented for Transpower emergency towers and associated overheads, and contractual obligations or provisions associated with the removal of live line works for the remainder of RCP2. These costs are either absorbed or not present in RCP3.[158]

Hence, 2017/18 base year expenditure is more reflective of Transpower's recurring preventive maintenance expenditure.

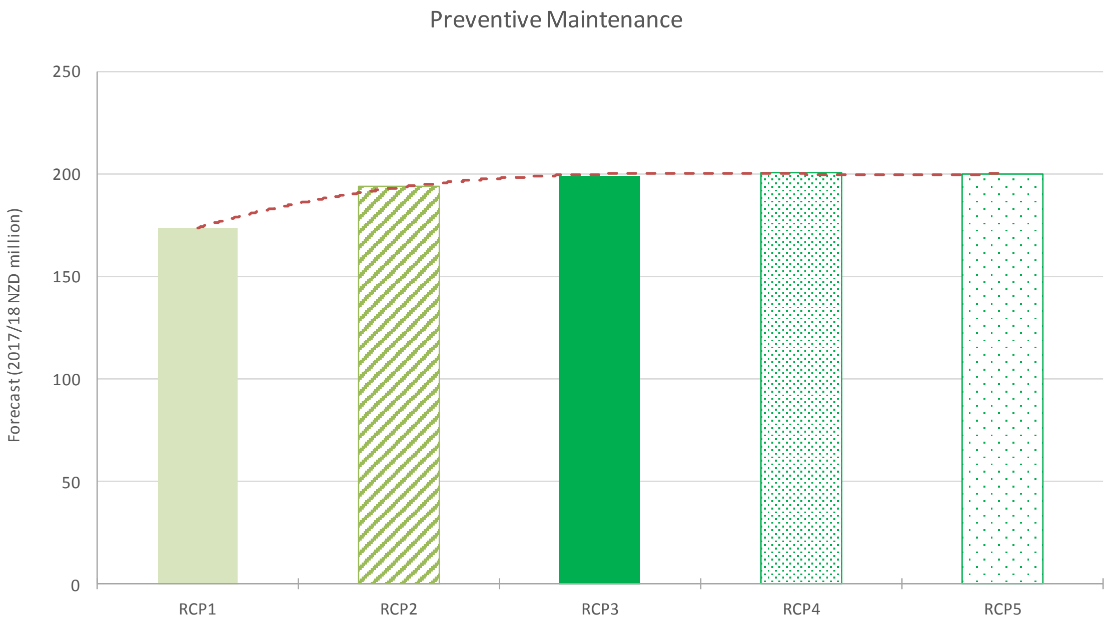
Figure 85 shows the annual preventive maintenance expenditure for the regulatory periods RCP1 to RCP3. Figure 86 shows total Preventive Maintenance expenditure for the regulatory periods RCP1 to RCP5.

**Figure 85 Annual preventive maintenance for RCP1 to RCP3**




[158] During RCP2, maintenance expenditure was classified as either "grid routine" or "maintenance projects" for nominated asset categories. For RCP3, Transpower has adopted four classes for maintenance - preventive, predictive, corrective and pro-active. In back-casting actual and approved expenditure allowances for RCP2 into the RCP3 classes, there are examples where there appears to be high annual expenditure, which Transpower attributes to difficulties in the back-casting of a particular external service provider's recording of their maintenance work.

**Figure 86 Total preventive maintenance for RCP1 to RCP5**




### *Development of RCP3 forecast*

The RCP3 forecast includes a total of approximately 128,000 Standard Maintenance Procedures (SMPs), covering work activities such as asset-specific major interval services and diagnostic inspection, equipment inspection and calibration, and surveys.[159] The schedules for these works (tasks and intervals between jobs) for each asset are held in Maximo. These scheduled work volumes, together with the standard job costs are used to forecast preventive maintenance expenditure.

The core assumptions are:

- the current SMPs, which define the scope of work and repeat intervals, apply for all RCP3;
- material costs remain constant during the period; and
- all scheduled work is loaded into Maximo. Transpower suggests that "*… new assets that have not yet been commissioned do not have schedules in Maximo, but we expect this will be balanced out by work on assets that we expect to decommission (which are currently still included in Maximo) over the period to 2025*".

[159] Transpower (2018), Maintenance Opex Overviewsection 4.1, p. 20, Document [70]

Whilst the RCP2 forecast was based on MACM and the RCP3 forecast relies upon work schedules held in Maximo, the basic approach of using work volumes and standard job costs to develop the expenditure forecast for preventive work is consistent between RCP2 and RCP3.

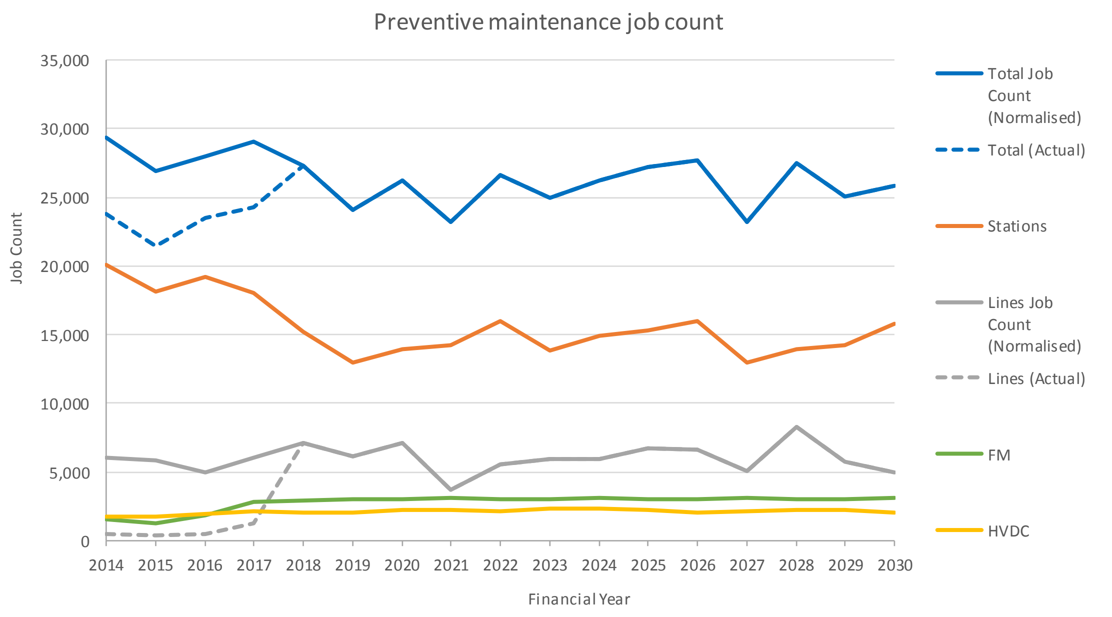
**Work volumes**

Maximo stores the SMPs for each asset, including the standard maintenance tasks and the required frequency for the work. The preventive maintenance forecast is based on extracts from Maximo detailing annual work volumes by standard job type.

These SMPs are programmed based on their nominated interval frequency (e.g. 4 years, 6 years etc.) on an asset-by-asset basis.

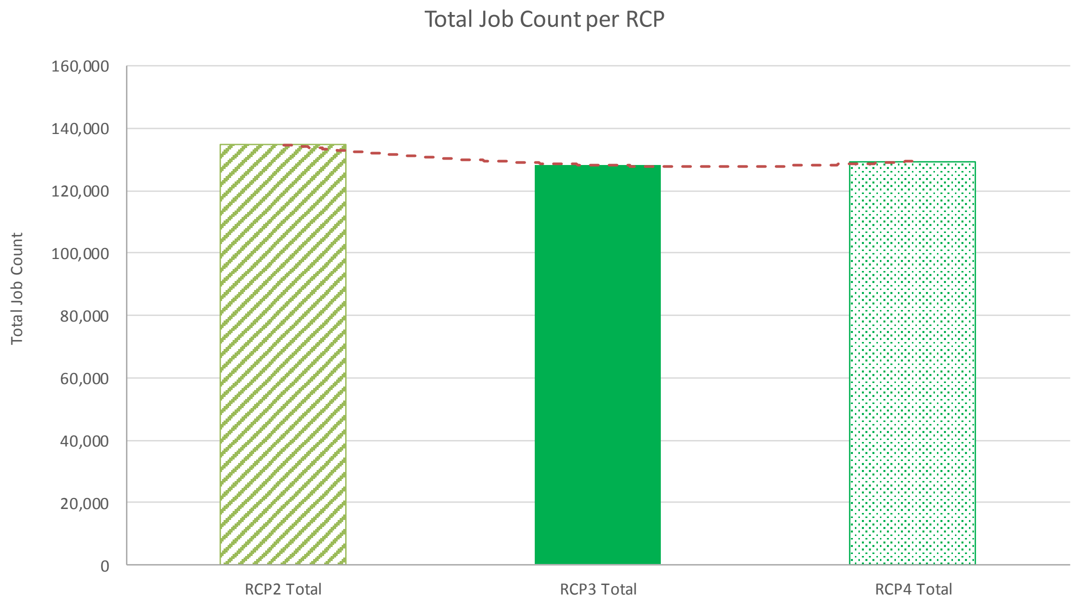
Figure 87 shows the annual preventive work volumes by asset class for the periods RCP2 to RCP4 and Figure 88 illustrates the 5-year total work volumes and trends across the same regulatory periods.

**Figure 87 Annual Preventive Maintenance work volumes for RCP2 to RCP4**[160]




160 Prior to 1 July 2017, condition assessment based preventive maintenance tasks on transmission lines was scheduled at the Structure level. The dotted lines in Figure 87 are based on historic work order numbers. Post 1 July 2017, Transpower has changed the job count on transmission line work to the Line level, which has increased the job numbers but not the actual work volume.

**Figure 88 Total preventive maintenance work volumes for RCP2 to RCP4[161]**




Previously, Transpower relied on high-level job specifications to define preventive maintenance tasks, with the external service providers undertaking the work in line with their work procedures. With the introduction of Maximo, Transpower has developed a suite of SMPs that define preventative maintenance jobs at the task level, to provide for consistent work practices by the different service providers.

For each existing asset, the SMPs and maintenance cycles are used in Maximo to develop the preventive maintenance work plans. Transpower uses asset class bowtie diagrams to identify any significant risks to be managed and the appropriate critical controls.[162]

For new assets, plans for existing assets are reviewed for any changes in asset strategy, or any new data that highlights deficiencies. Other key inputs are information from manufacturers such as user manuals, specifications, proposed maintenance procedures and design materials, plus any available history for similar assets used in the industry. Transpower has done work to optimise the preventive maintenance plans for each asset or system, acknowledging that there are differences in assets in a common category.

The optimisation requires:

161 Include normalised Lines work volumes for 2016 and 2017 in RCP2 total job count

162 A bowtie diagram illustrates proactive and reactive risk management, with the hazard at the centre of the diagram, with causes and preventive controls to the left, and consequences and recovery procedures to the right.

- reviewing the standard operation and maintenance history of the asset or system and their known or likely mode of failure; and
- establishing a set of applicable and effective PM tasks based on considerations of asset/system safety, criticality and cost.

In adding preventive maintenance plans for new assets, consideration is given to future year workloads in setting the first maintenance date. In adding new assets to the Maximo schedule, Transpower is conscious of maintaining a relatively consistent workload and expenditure across all years whilst maintaining an acceptable level of risk. Future preventive maintenance forecasts are required to avoid creating spikes in work volumes or costs for external service providers, without compromising the required maintenance intervals for each asset.

Provided there are no over-riding statutory compliance requirements, Transpower allows for a maximum ±20% variance on the maintenance interval to allow for work scheduling that levels deliverability requirements.[163]

**Standard job costs**

As discussed in section 6.7, Transpower has developed a set of SMPs for maintenance activities in Maximo.

Figure 89 shows the annual variation in total work volumes and the associated expenditure across the period 2014 to 2030, and Figure 90 illustrates the relative consistency in volumes and costs across the regulatory periods RCP2 to RCP4.

[163] As an example, a PM plan on an 8-year interval may be brought forward or deferred by a maximum of 18 months.

**Figure 89 Preventive maintenance annual volumes and costs for 2014 to 2030**

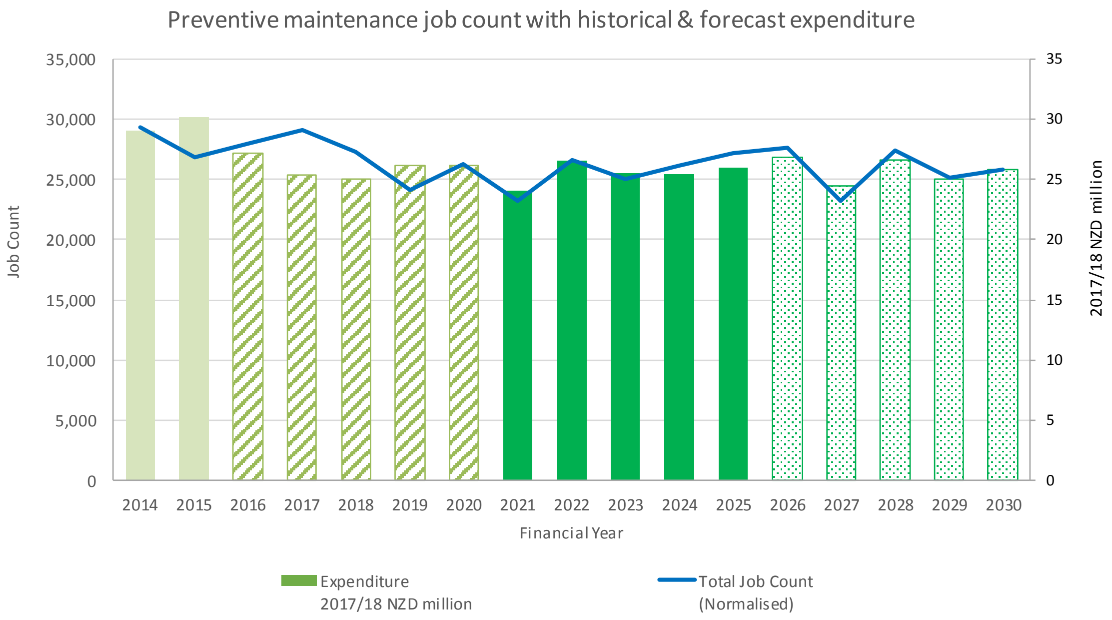
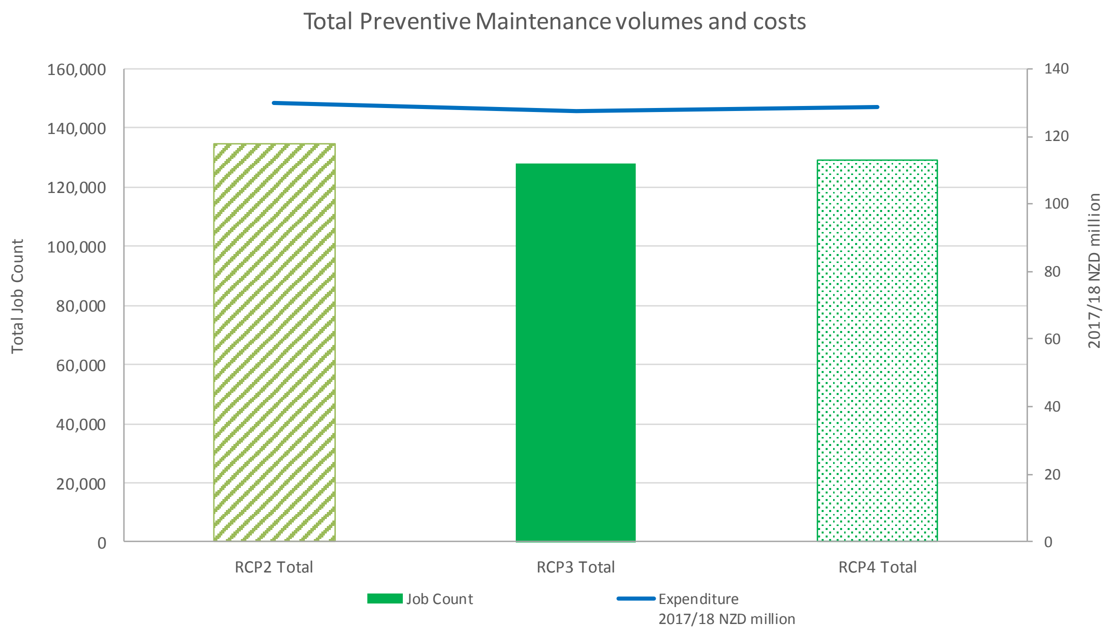



**Figure 90 Total preventive maintenance volumes and costs for RCP2 to RCP4**




The RCP3 preventive maintenance forecast is based on unit rates for the SMPs agreed under the current Maintenance Service Provider contracts, excluding any performance incentive adjustments. Transpower considers these unit rates to be efficient as they have been competitively negotiated and market tested (refer section 6.7). The costs for the SMPs are held in Maximo.

*Verification assessment of preventive maintenance*

Transpower plans for a slightly higher (2%) level of preventive maintenance in RCP3 compared to RCP2.

This aligns to Transpower's strategic focus on higher predictive maintenance as it progresses from a time-based maintenance approach (RCP1) to a risk-based approach (RCP2), toward a more advanced optimisation approach in RCP3, where best-value is achieved by predicting and balancing (trading-off) service, cost, risk and safety, as well as through the risk-based standard job optimisation of both tasks and maintenance intervals for some asset types.

We have seen examples of Australian utilities who have adopted a similar approach to preventive maintenance forecasting using standard jobs and costs. For example, in their regulatory submission to the AER for 2014-19, Endeavour Energy included an expenditure forecasting methodology[164] that outlined a similar approach of developing a bottom-up estimate for preventive works as a first-pass estimate, with a top-down review to ensure that the bottom line maintenance expenditure is consistent with a base-step-trend analysis for their total opex forecast.

Endeavour Energy include regional adjustments to the standard maintenance job costs for work in remote areas. The approach was summarised as *"… we will forecast opex at the category or activity level where appropriate … for the activity level forecasts, we will firstly develop forecast unit costs for the identified network maintenance activities using a trend based on 1 to 3 years of historical costs (inclusive of saving initiatives) which will be applied to the future Network Maintenance plan volumes … to determine the Network maintenance operating expenditure forecasts."*[165]

This methodology allowed for a direct link with their network maintenance planning and a risk assessment of maintenance programmes to support works prioritisation. In detailing the methodology, Endeavour Energy noted *"… the forecasts under the volume trend method will be reflective of our efficiency programs and reforms … These efficiency programs and reforms have identified operational improvements across a number of business*

[164] Endeavour Energy (2014), Expedniture Ofrecastign Methodology, Document [129]

[165] Ibid., section 2.1, p. 3

*processes within Endeavour Energy that will result in one-off or ongoing savings and deferred or avoided costs.*"[166]

In its draft decision, the AER did not endorse this bottom-up approach, arguing that it "*… can produce biased opex forecasts inconsistent with the opex criteria.*"[167]

We disagree with the AER's assessment of the Endeavour Energy opex forecasting methodology with regards to the approach introducing potential bias, as such an approach relies upon the reasonableness of the standard job descriptions, the accuracy of standard job costs and the identification of work volumes through the asset management system - in Transpower's case, Maximo.

Rather than introducing any bias, this approach to preventive maintenance forecasting provides more opportunities for efficiency gains through more efficient work practices in doing the routine work, efficiencies in the planning and scheduling of work with the external service providers and capturing any cost efficiencies that may result.

The year-on-year fluctuations for each asset class and in the annual total number of jobs shown in Figure 87 are due to different maintenance tasks being scheduled based on different standard time-intervals. However, for the 5-year totals for regulatory periods, the work volumes are relatively consistent, with the RCP3 total (128,160) being 5% less than that for RCP2 (normalised to 134,708 for the change in job counts for Lines), and the RCP4 total (129,341) an increase of 1% on the RCP3 total.

Therefore, whilst we have not reviewed or verified the standard intervals for each standard preventive maintenance task nominated by Transpower, the relatively minor variances between regulatory periods for total work volumes between 2016 and 2030 suggests that the scheduled work volume for RCP3 represents business-as-usual and suitable to support a base year forecast for preventive maintenance work.

Given Transpower's annual work volume forecasts for the RCP3 period are consistent with the identified base year of 2017/18 and show no material step changes, we are satisfied that the standard job building block approach used by Transpower provides a sound basis for forecasting preventive maintenance expenditure. This bottom-up approach is dependent upon robust standard job costing, which should be possible

[166] Ibid., section 2.6, p. 8

[167] TransGrid (2016), Network Asset Health – Overview and Approach, section D.4, p. 7-164. Document [126], The preferred approach for the AER is base-step-trend for all opex forecasts. Whilst the AER *Expenditure Forecast Assessment Guideline for Electricity Transmission* (November 2013) provides for alternate approaches, the AER has a strong preference for a uniform opex forecasting methodology, rather than a hybrid of base-step-trend and other methods.

given the work is outsourced to service providers and market forces should drive efficient costs.

We are of the opinion an advantage of the bottom-up approach is assisting the scheduling and subsequent delivery of the preventive programme, particularly in identifying any potential regional constraints and the opportunity for efficiency gains through standard job optimisation.

We believe it is also useful in identifying any step changes in preventive maintenance due to new or decommissioned assets, although Transpower has projected that scheduled work for new assets and those expected to be decommissioned will "balance out".

Further, Transpower's approach of doing a separate top-down review of the expenditure forecasts to check the ability of external service providers to deliver the works programme and adjust it where constraints are identified, should support an efficient expenditure forecast.

Given the RCP3 preventive maintenance forecast is like that used and approved for routine maintenance in RCP2, we accept that the use of bottom-up standard job building blocks (with unit costs that have been tested in a competitive market) and Maximo-scheduled work volumes should provide for a sound methodology to generate the RCP3 preventive maintenance forecasts.

Given Transpower's RCP3 forecast is consistent with its spending in RCPs 1 and 2, with no forecast step changes, our verification opinion is that the RCP3 preventive maintenance forecast satisfies the expenditure outcome having regard to GEIP.

### Verification opinion - Preventive Maintenance

Table 94 summarises our verification assessment and opinion.

**Table 94 Verification summary - Preventive Maintenance**

| Expenditure category | Opex - Predictive Maintenance | |
|---|---|---|
| **Transpower RCP3 forecast** | $198.8 million | |
| **Recommendation** | **Accept:** $198.8 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Satisfied that forecast meets expenditure outcome with regard to GEIP.<br>Forecast based on [work volume] x [unit rate] for standard maintenance jobs. Satisfied that annual work volumes forecast for RCP3 are consistent with | N/A |

| | | |
|---|---|---|
| | base year 2017/18 and rest of RCP2.<br>Unit rates tested in competitive market supporting efficiency of expenditure.<br>Accept forecasting methodology is prudent. | |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

### 8.6.4 Network opex - Predictive maintenance

Figure 91 shows the annual predictive maintenance opex for the regulatory periods RCP1 to RCP3 and Figure 92 shows the total predictive maintenance opex for the regulatory periods RCP1 to RCP5.

**Figure 91 Annual predictive maintenance opex for RCP1 to RCP3**

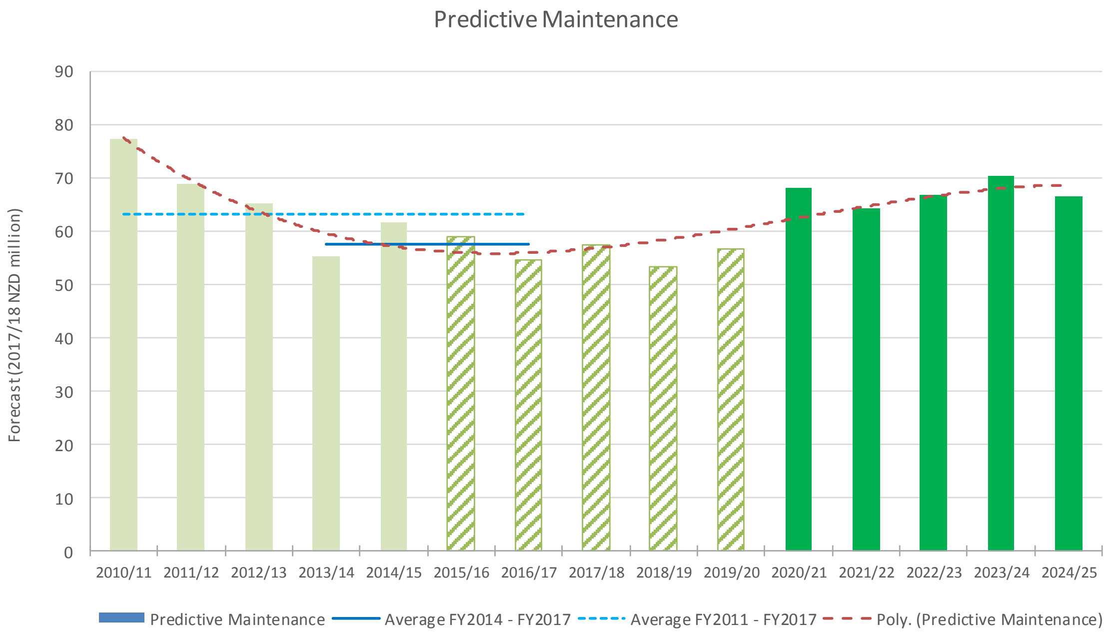
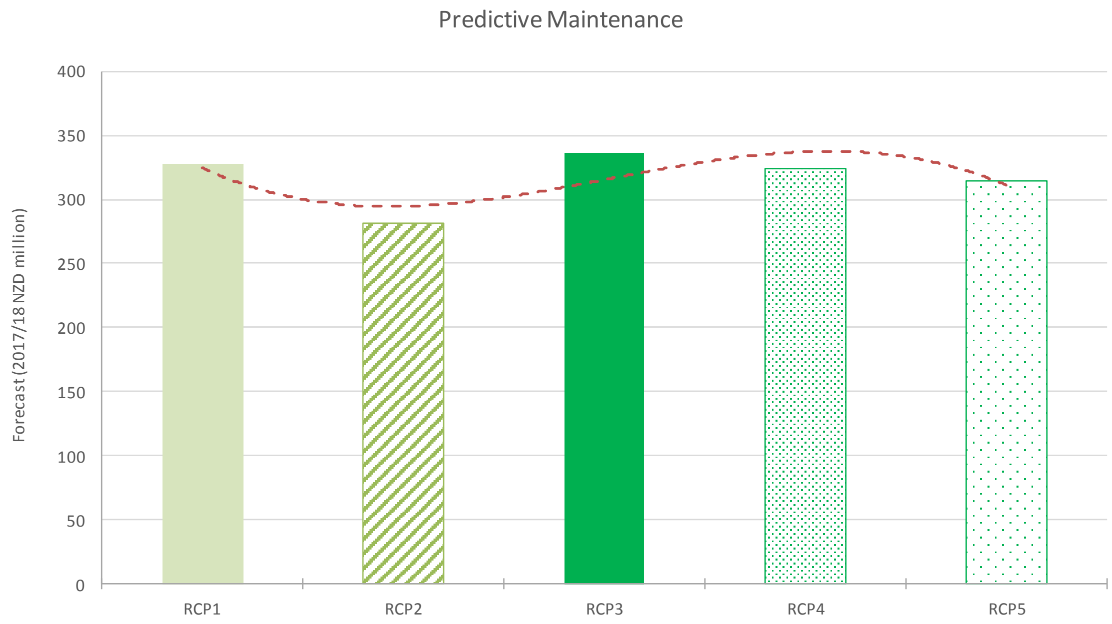


**Figure 92 Total predictive maintenance opex for RCP1 to RCP5**




Predictive maintenance addresses defects identified through inspection activities and asset feedback. The goal of predictive maintenance is to ensure any deferred maintenance is undertaken and asset health is managed in line with the corporate strategic objectives for each asset category.

Defects that are identified are classified as P1 to P5, with P1 being faults that need to be addressed immediately, whilst P4 and P5 defects are low priority that, in some instances, may not need intervention at all. Each classification of defect has a timeline for its rectification. Transpower has advised that approximately 15,000 defects are addressed per year.[168] As external service providers supply outstanding lists of defects into Maximo, Transpower assesses the classification and identifies the appropriate action for each defect.

The RCP3 forecast has assumed rectification of a similar number of defects per annum, with any newly identified defects that have their priority determined based on risk assessment offsetting any defects carried over from RCP2.

Predictive maintenance activities also include vegetation management activities and data gathering.

168 Transpower (2018) Maintenance Opex Overview, section 3.1, p. 14, Document [70]

*Development of RCP3 forecast*

The forecasting method applied to predictive maintenance for RCP3 is base-step-trend, with the nominated base year being 2017/18.

From Figure 91, the dotted horizontal blue line represents the average annual expenditure of $63.1 million between 2010/11 and 2016/17. The solid blue line shows the average $57.5 million spend per year between 2013/14 and 2016/17, which is comparable to the nominated base year of 2017/18 with expenditure.[169]

**2017/18 base year**

The expenditure for the 2017/18 base year is $56.7 million. This includes performance incentive provision payments to compensate for the suspension of live-line work. Transpower expects that in future years, these payments will not be included as live-line work resumes.

Whilst these payments are applicable to all maintenance work undertaken by the external service providers, Transpower has elected to account for the performance incentive provision payments within the predictive maintenance category. The result is an annual reduction of $1.9 million, reducing the 2017/18 base year allowance from $56.7 million to $54.8 million. This equates to a base amount for RCP3 of $273.7 million.[170]

**Step changes and trend**

Table 95 shows the step changes proposed by Transpower for RCP3.

**Table 95 RCP3 predictive maintenance step changes ($2017/18 million)[171]**

| Step change | Detail | RCP3 total ($ M) |
|---|---|---|
| Asset health | Increased number of assets nearing condition where maintenance intervention necessary. Transpower uses asset health scores to predict work volumes. Current modelling shows both improved and worsening asset health among assets. | 5.2 |
| Asset health - conductor hardware maintenance | Programme to address condition issues with swinging gear, such as dampers and spacers. | 9.5 |
| Attachment points | Condition based replacement of conductor attachment points to address poor condition of components. Deferred | 8.9 |

169 Based on actuals to date and forecast to complete for 2017/18 period

170 Amount nominated by Transpower includes rounding-off

171 Transpower (2018) Maintenance Opex Overview, section 3.2.3, Table 7, pp. 17-18, Document [70]

| Step change | Detail | RCP3 total ($ M) |
|---|---|---|
| | maintenance and pre-requisite for upcoming conductor renewal. | |
| Steel and bolt | Replacement of rusty steel and bolts on transmission towers. Deferred maintenance to be progressed following in-depth strategy review of standard maintenance procedures. | 2.9 |
| Earth potential rise | Work to manage health and safety risk in urban locations on transmission towers. | 2.8 |
| General maintenance of substation facilities | Additional maintenance of substation facilities, such as switchyard gravel and fencing. | 2.6 |
| Deferred maintenance | Programme to address corrosion issues at substations. | 2.5 |
| Health & Safety asbestos procedures | Costs associated with working in an asbestos environment - part of accrued $7.5 million for asbestos programmes. | 2.0 |
| Totex - RCP4 & RCP5 programme support | **Capex/opex trade-off**: Testing and inspections of transmission lines, particularly conductors. Collection of additional condition assessment data for asset health modelling. Increase required to ensure conductor renewal programmes from RCP4 are targeted and cost effective. | 18.5 |
| Totex - Earth Switches & Disconnectors | **Capex/opex trade-off**: Cost-effective upskilling of maintenance staff and maintaining earth switches in lieu of replacement capex. | 3.0 |
| Totex - Auckland | **Capex/opex trade-off**: Maintenance of assets nearing end-of-life, in lieu of renewal investment, due to potential near-term decommissioning and relocation of lines and towers. | 2.3 |
| Totex - Paint | **Capex/opex trade-off**: Tower painting within minimum approach distances done by transmission linesmen rather than tower painters. | 2.0 |
| **Total** | | **62.2** |

Transpower has advised that there is no trend applied to the RCP3 predictive maintenance forecasts.[172]

Therefore, the total proposed RCP3 predictive maintenance forecast, based on the adjusted 2017/18 base year of $54.8 million plus a step change of $62.2 million is $335.9 million, subject to any deliverability adjustments.

**Verification assessment of predictive maintenance**

We note the 4% increase is consistent with Transpower's strategic focus on higher predictive maintenance as it progresses towards a more advanced optimisation approach in RCP3, where best-value is achieved by predicting and balancing (trading off) maintenance against capital renewals, service levels, cost, risk and safety.

[172] Transpower (2018) Maintenance Opex Overview, Table 5, p. 15, Document [70]

As previously noted, Transpower has used the base-step-trend methodology to develop the RCP3 predictive maintenance forecast.

We are satisfied that the adjusted base year Transpower has selected (2017/18) is reasonable, as it represents the latest audited maintenance costs that it has incurred from external service providers and these costs should include any efficiency improvements realised during RCP2 and are now embedded in forecast costs for RCP3.

We accept as reasonable the projected impact on predictive maintenance of savings totalling approximately $2 million per annum for the reintroduction of live-line work in RCP3. This results in an adjusted base year value that is less than the long-term annual average since 2010/11 of $63.1 million and lower than the average of actual costs for the past 4 years when predictive maintenance was transitioning to a more risk-based approach.

The underlying trend of historic expenditure from RCP1 and RCP2 does not support any trend in expenditure and we accept the Transpower RCP3 proposal excluding any trend increase during RCP3.

Table 96 shows a high-level review of the proposed step changes and a summary of our findings.

**Table 96 High-level review of proposed RCP3 predictive maintenance step changes**

| Step change | Detail |
|---|---|
| Asset health | Proposed step change to support enhanced and increased asset health modelling. Transpower has advised that external service providers are required to gather asset data in accordance with standard job procedures to ensure consistency in the data quality consistent with Transpower's move to more risk-based expenditure. **We have not been able to verify the $5.2 million step change as being consistent with GEIP, but we are satisfied it is prudent.** |
| Asset health - conductor hardware maintenance | Work described in TL Conductor PMP, highlighting need for replacement of degraded vibration dampers and spacers. Replacement necessary to avoid degradation in conductor condition. We consider this work prudent ahead of re-conductoring from RCP3 to RCP5 and verified as consistent with GEIP. |
| Attachment points | Proposed work volumes in TL Structures PMP. Work is a prerequisite for re-conductoring work to be done in RCP3 and later. Attachment points are subject to asset health modelling, with approximately 33% currently having an asset health score of 6-7 or higher. With increasing numbers of attachment points showing significant corrosion, a step change of $8.9 million in replacing deteriorated attachment points ahead of re-conductoring work is verified as consistent with GEIP. |
| Steel and bolt | Proposed work volumes in TL Structures PMP. Steel and bolt condition assessed. Work should be done ahead of tower painting, which is increasing during RCP4 and RCP5. Work with external service providers to better identify replacement needs during RCP2 supports RCP3 proposed volumes. The proposed step increase of $2.9 million is verified as consistent with GEIP. |

| Step change | Detail |
| --- | --- |
| Earth potential rise | Work described in TL Structures PMP. Design standard completed early in RCP2 and progressively rolled out. Earth potential rise required for public safety so accelerated implementation by 2023 is appropriate. Proposed step change of $2.8 million is verified as consistent with GEIP. |
| General maintenance of substation facilities | ACS Buildings and Grounds Asset Class Plan (ACP) shows projected increase in switchyard metalling refurbishment during RCP3 to address identified issues from monthly inspections. ACP does not include RCP3 opex forecast values, but we consider step up in work volume is consistent with the proposed step change of $2.6 million. We consider the proposed step change is verified as consistent with GEIP. |
| Deferred maintenance | Work required to address corrosion issues at substations. We accept the proposed step change is prudent. We have verified the efficiency of the step change against the provisions of the AC substation asset PMPs. |
| Health & Safety asbestos procedures | Additional asbestos removal work noted in ACS Buildings and Grounds RCP3 capex (refer section 7.4.1). Proposed step change of $2 million for safe working procedures for asbestos environments is verified as consistent with GEIP. |
| Totex - RCP4 & RCP5 programme support | With significant increases in tower painting and re-conductoring forecast in RCP4 and RCP5 in comparison with RCP3, Transpower is proposing an additional testing and inspections regime for transmission lines and condition assessment data collection for asset health assessment.<br>As for other asset health modelling (see above) Transpower has advised that external service providers are required to gather asset data in accordance with standard job procedures to ensure consistency in the data quality.<br>Work required to refine replacement programmes as currently shown in TL Structure and TL Conductor PMPs are to be more efficient and targeted.<br>**We have not been able to verify the $18.5 million step change as being consistent with GEIP but consider it is prudent, particularly given the significant projected increases in work volumes during RCP4 and RCP5.** |
| Totex - Earth Switches & Disconnectors | Replacement of earth switches and disconnectors currently completed based on condition assessments. Typical asset in-service life is 50-60 years but with improved understanding of assets and targeted maintenance, these switches should remain serviceable for longer periods. Proposed step change of $3 million is reflected in ACP and noted as a capex/opex trade-off by deferring replacement expenditure. We are satisfied that the step change is prudent and is verified as consistent with GEIP. |
| Totex - Auckland | There are some assets in the Auckland area that are due for replacement. We agree it is prudent to maintain assets that will be replaced during the implementation of the Auckland Strategy and therefore agree with a provision being included. **We accept the principle of not replacing assets that may be affected by the Auckland Strategy as prudent but have been unable to verify the step change of $2.3 million as being consistent with GEIP.** |
| Totex - Paint | With the $1.9 million annual adjustment to the base year for the performance incentive provision payments due to live line working, we accept as prudent transmission linesmen completing the tower painting within the Minimum Approach Distance (MAD) as an efficient work practice (assuming this is bundled with other tower maintenance work). We verify the step change of $2 million as consistent with GEIP. |

**RCP4 & RCP5 programme support**

Transpower's largest proposed step change relates to RCP4 & RCP5 programme support.

The TL Conductor PMP discusses the opex requirements for RCP3, highlighting four areas where the work volumes *"… reflect the change in strategy to undertake detailed condition assessment 20 years before the predicted end of life (rather than 10 years in advance), and ageing assets."*[173] These activities are:

- Close aerial surveys
- Cormon testing
- Conductor sampling
- Conductor testing

Based on the RCP3 forecast work volumes and TEES unit rates in the TL Conductor PMP[174], we have generated a comparative estimate of:

- Aerial survey of 7,000 circuit spans - assuming a standard span length of 400 metres, cost is 2,800 x $2.0 k = $5.6 million
- Cormon testing of 1,650 units x $4.0 k = $6.6 million
- Conductor sampling of 50 units x $16.3 k = $0.8 million
- Conductor testing of 50 units x $10.5 k = $0.5 million
- Total = $13.5 million, escalated to $2017/18[175] = $14.7 million

Whilst we cannot generate a comparative estimate to reflect the $18.5 million step change in RCP4 and RCP5 preparation costs, we have seen evidence of the long-range preparations that Transpower has begun (refer section 10 of our report).

### Verification opinion - Predictive Maintenance

Our verification opinion is that the base year for RCP3 predictive maintenance forecast satisfies the expenditure outcome having regard to GEIP. However, we cannot independently verify the step changes for the following items:

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173 Transpower, *Portfolio Management Plan: Transmission Lines - TL Conductor*, April 2018, Document [60], p. 46

174 Ibid., pp. 39-46

175 Based on 4.2% pa escalation applied to Asset Management & Operations black-start costs

- Asset Health - $5.2 million
- Totex - RCP4 & RCP5 programme support - $18.5 million
- Totex - Auckland - $2.3 million

In total, we cannot verify $26 million in step changes as being in accordance with GEIP.

### Verification opinion - Predictive Maintenance

Table 97 summarises our verification assessment and opinion.

**Table 97 Verification summary - Predictive Maintenance**

| Expenditure category | Opex - Predictive Maintenance | |
|---|---|---|
| **Transpower RCP3 forecast** | $335.9 million | |
| **Recommendation** | **Accept:** $309.9 million | **Do not accept:** $26.0 million |
| **Expenditure outcome assessment** | Satisfied these allowances are in accordance with GEIP.<br>The base year used ($273.7 million) is in accordance with 2017/18 actual expenditure as it represents the latest audited maintenance costs that it has incurred from external service providers. These costs should include any efficiency improvements realised during RCP2 and are now embedded in forecast costs for RCP3<br>Base year also includes adjustment for live-line work.<br>Verified $36.2 million of step changes against relevant PMPs. | We accept several step changes as prudent but were unable to verify step change allowances for:<br>* Asset health $5.2 million<br>* Totex - RCP4 & RCP5 programme support $18.5 million<br>* Totex - Auckland $2.3 million<br>We are unable to verify the efficiency of the allowances against reference documentation. |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | For step changes relaing to asset health, Totex - RCP4 & RCP5 programme support and Totex - Auckland, Transpower needs to provide clearer information on the source of the allowances |
| **Potential scope for improvement** | N/A | Substantation of the efficiency of the three step changes noted above |

We consider Transpower should be able to address the substantiation issues we have raised regarding the outstanding step changes between now and submittal of the RCP3 proposal to the Commission.

### 8.6.5 Network opex - Deliverability adjustments

A deliverability adjustment of $29.1 million has been applied to the total RCP3 maintenance forecast of $552.1 million, or a 5% decrease. The unadjusted RCP3 forecast for network maintenance of $552.1 million represents a $50.1 million or 10% increase on the $502.0 million for RCP2. This increase is largely due to the increase in predictive maintenance (i.e. the step changes from the 2017/18 base year assessed in the previous section).

Refer section 9.3.5 and section 9.5 for our verification opinion of this network opex adjustment as part of the broader discussion of deliverability adjustments on the proposed RCP3 capital and operational expenditure.

### 8.6.6 Network opex - Asset Management and Operations

Asset Management & Operations is a new portfolio for RCP3, with these costs previously included as part of a broader category called Departmental that formed part of Corporate Opex in RCP2.

Core functions of this area are:

- long-term strategic planning for network assets while providing the required service levels;
- tactical planning to develop solutions to maintain and enhance the asset base in line with the long-term development strategies;
- programming and scheduling of works based on the portfolio management plans developed in the Decision Framework (refer separate Attachment B);
- safe and efficient delivery of project-based enhancements, refurbishments and renewals;
- interfacing with external service providers for scheduling and efficient delivery of maintenance programmes; and
- efficient day-to-day Grid operation and real-time management of operating centres.

Key cost categories are:

- staff and consultancy costs associated with the different Grid Divisions, including for asset management and planning, and network operations tasks;
- investigation work for enhancement and development of the Grid; and
- any new technology innovations.

Figure 93 shows the annual Asset Management & Operations opex for the regulatory periods RCP1 to RCP3 and Figure 94 shows the total Asset Management & Operations opex for the regulatory periods RCP1 to RCP5.

The total forecast expenditure for RCP3 is $309.5 million.

**Figure 93 Annual Asset Management & Operations opex for RCP1 to RCP3**

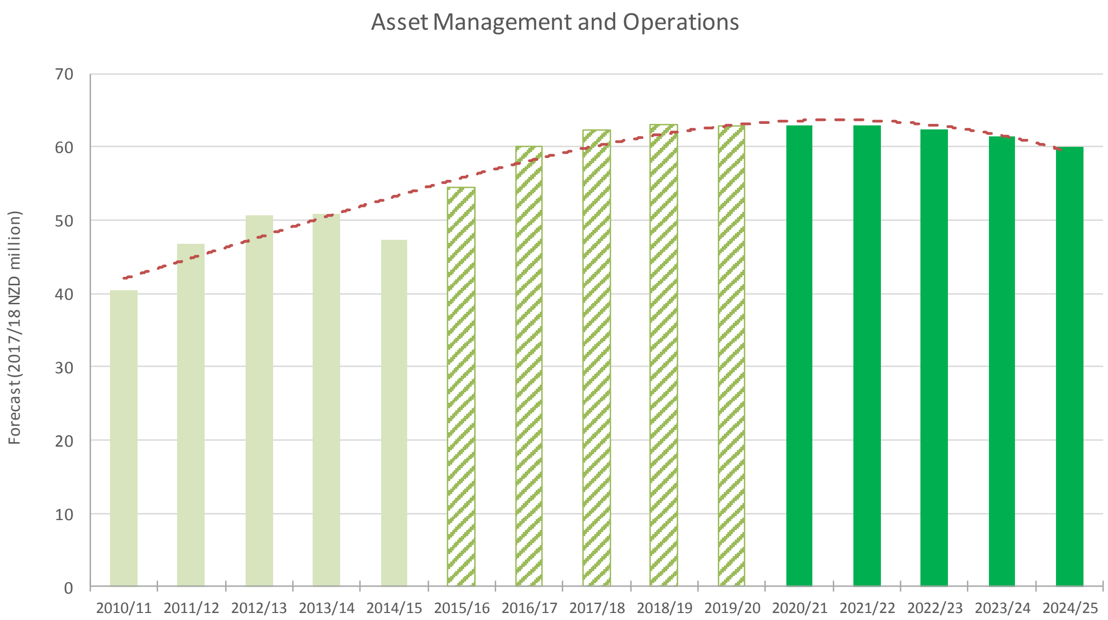
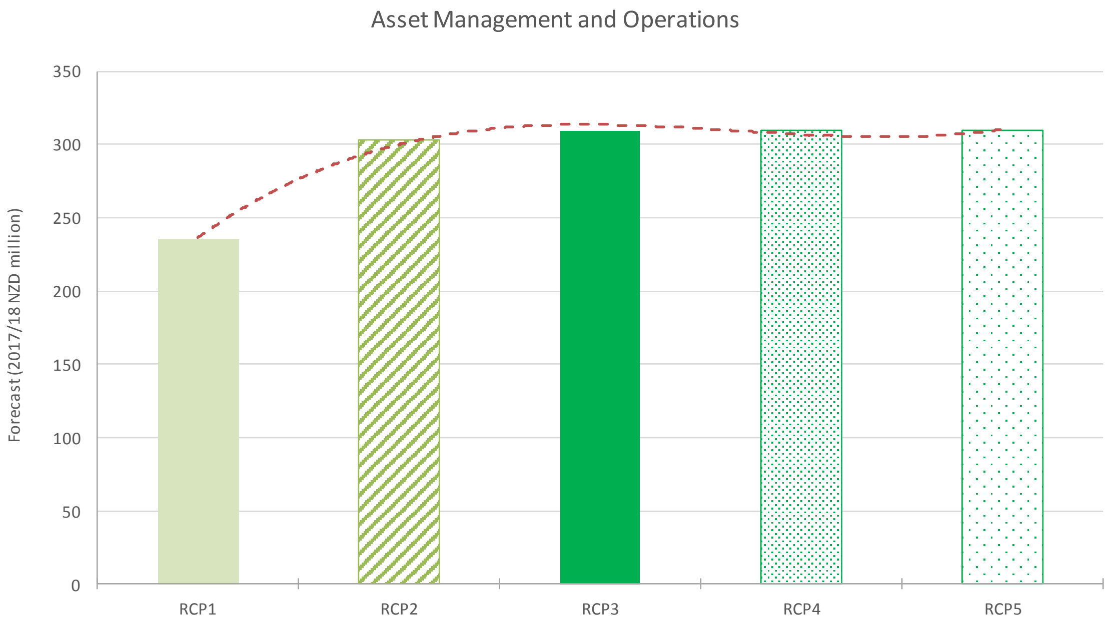


**Figure 94 Total Asset Management & Operations opex for RCP1 to RCP5**




In RCP1, the maintenance approach for Transpower was time-based, with most work being preventive and reactive management of defects and failures.

During RCP1, Transpower decided to resume operational control activities, such as maintenance scheduling from the external service providers to enable better integration of operations and maintenance activities. Maximo was introduced as the asset management information system to allow better scheduling of preventive maintenance and to store asset data and related condition assessment results. Previously external service providers were responsible for recording asset condition data.

For RCP2, the maintenance planning changed to optimised, risk-based maintenance strategies using failure modes for many of the assets and continued time-based maintenance where it was more appropriate for other assets (such as power transformers and circuit breakers). This was supported by a review of frequency and scope of preventive maintenance work.[176]

This fundamental change in maintenance philosophy required increased planning/scheduling resources through Maximo and the introduction of several new reliability-informed processes such as:

[176] Transpower (2018), Maintenance Journey, pp. 3-4, Document [69]. Transpower considers that as at May 2018, maintenance planning is "*… about halfway along the path from fully time-based maintenance to risk-based maintenance*"

- developing processes for Reliability Centred Maintenance (RCM) and Failure Mode and Effects Analysis (FMEA) for reliability-informed analysis of asset maintenance requirements;
- major condition assessment programmes for all substation primary assets;
- development of a Predictive Defect Maintenance (PDM) prioritisation process to consistently rank defects for improved planning of work;[177]
- improved response to high ranked defects (P1, P2); and
- improved understanding of asset risk through analysis of data now in Maximo to change maintenance regimes as appropriate.

The increased planning and analytical work required additional asset management and operations staff. From Figure 93, this is apparent as a progressive increase in Asset Management & Operations expenditure from 2015/16 to 2017/18.

The review of the RCP2 proposal undertaken for the Commerce Commission challenged the increased number of FTEs required to realise the efficiencies expected from the introduction of Maximo and the increased planning/scheduling of works programmes.[178]

However, the Commerce Commission approved the salaries allocation in the RCP2 proposal stating "*… [Transpower is forecasting] 591 full-time equivalent (FTE) staff in 2014/15 and is projecting an average number of staff of 586 during RCP2. This represents a steady, stable number of staff throughout RCP2.*"[179]

For RCP3, Transpower has advised that the corporate intention is to continue the development of processes for reliability-informed maintenance that commenced during RCP2, increase the use of condition-based predictive maintenance and scheduling of the proportion of work done proactively. Whilst external service provider contracts will be reset at the beginning of RCP3, the planning work that Transpower reclaimed from service providers during RCP2 will continue, with the expectation that the FTE level

[177] Transpower advised that service providers previously stored defects lists and there was little co-ordination or scheduling of defect rectification work, particularly at regional level. Using Maximo to store all reported defects and their assigned priorities allows for co-ordinated ranking, prioritising and scheduling of work.

[178] GHD (2018), GHD RCP3 Cpax and Opex forecast_IV review, section 8.4.2, clauses 560 to 571, pp. 134-6. Document [118]. It was noted that increased costs in 2012/13 and 2013/14 to implement Maximo and other business improvements were expected to be offset by a decrease in 2014/15 as initiatives transitioned to business-as-usual.

[179] Commerce Commission, *Setting Transpower's individual price-quality path for 2015-20*, 29 August 2014, clause 5.146, p. 88, Document [120]

from 2017/18 will be maintained through RCP3 and into future regulatory periods to reflect this activity being business-as-usual.

Transpower has identified three potential step changes for RCP3 that are expected to fully offset each other in terms of the RCP3 expenditure forecasts as follows without quantification:

- a decrease due to initiatives from RCP2 increasing the asset capability
- an increase in strategic investigations
- an increase in pre-capex investigations.

Whilst Transpower considers the staffing requirements have reached a business-as-usual level, Transpower has included a trend growth increase for costs related to 'black start'[180] capability and over-frequency reserves which Transpower has assessed as "*… steadily increasing*." Transpower has calculated the growth in black start costs and potential event charge costs[181] as being $3.3 million over RCP3.

These are expected to be offset by an annual improvement in productivity for Asset Management and Operations staff of 0.2%, which is based on forecast improvements in labour productivity in the New Zealand professions, scientific and technical services sector. The productivity gain over RCP3 is forecast to be $3.1 million.

The trend factor also includes consideration of the benefits arising from the proposed ICT capex programme during RCP3 (refer section 7.3.6 of our report). Transpower noted that some of the overall expected savings from the ICT investment is captured by the productivity adjustment, and to avoid double-counting that allowance, the net adjustment applied due to ICT capex is $5 million.[182]

Table 98 shows a summary of the RCP3 Asset Management and Operations forecast.

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180 Transpower (2018), Asset Management and Operations Opex Overview, section 2.1.3, p. 11, Document [71]. A 'black start' capability is a contingency arrangement for restoring supply in the event of a total or partial shutdown of the transmission grid. The black start service is procured from power stations that have the capability to start main blocks of generation on-site without reliance on external supplies. During a black start event, the service requires the provider to start up its main generator(s), carry out initial energisation of sections of the national electricity transmission system and distribution network, and support sufficient demand to create and control a stable 'power island'. The black start generator may be required to provide start up supplies to other power stations as the system restoration progresses and will eventually be required to synchronise to other power islands.

181 Based on probability of event occurring multiplied by cost

182 Transpower, *Asset Management and Operations Opex Overview*, 21 September 2018, section 2.1.3, p. 12. Document [71]. Footnote 8 states "Overall these benefits driven ICT capex investments resulted in $8.1 m in Opex savings. This $8.1 m opex saving has been partially netted off by the 0.2% productivity adjustment mentioned above ($3.1 m) as these types of industry wide productivity gains will in some cases be the same as the benefits realised from our ICT capex investment."

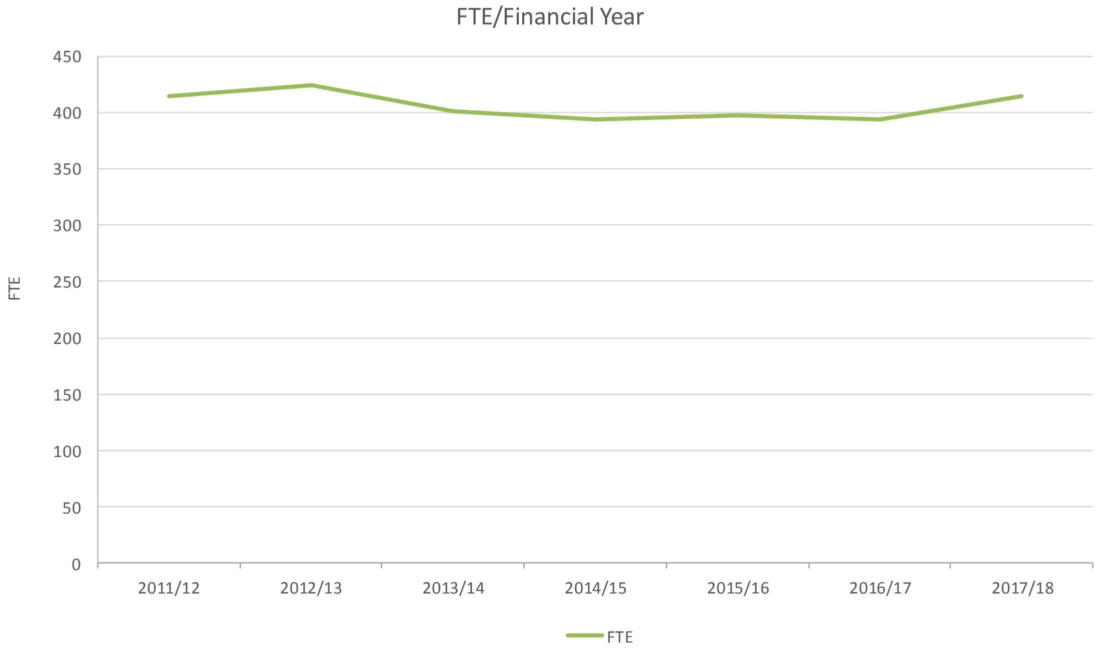
Table 98 Asset Management & Operations RCP3 forecast ($2017/18 million)

| Factor | Comments | RCP3 total ($M 2017/18) |
|---|---|---|
| Base year | 2017/18 base year of $62.2 million with adjustment of $0.6 million for as 2017/18 was atypical for annual investigation work that will be part of RCP3 but was otherwise included in base year - total $62.9 million pa | 314.3 |
| Step change | Decrease due to initiatives from RCP2 increasing the asset capability | - |
| | Increase in strategic investigations | - |
| | Increase in pre-capex investigations | - |
| | *Subtotal* | *0.0* |
| Trend | Growth factor for black start and over frequency services costs (indexation) | 2.7 |
| | Event charges | 0.6 |
| | 0.2% productivity factor | (3.1) |
| | Savings from Benefits Driven ICT capex investment | (5.0) |
| | *Subtotal* | *(4.8)* |
| **Total** | | **309.5** |

### *Structural changes*

Figure 95 shows the changes in the number of Full-Time Equivalent (FTE) staff from 2010/11 to the base year 2017/18.

**Figure 95 Number of FTE staff for RCP1 to Base Year 2017/18**



The Grid Operating Model (GOM) was implemented in 2016, which resulted in more focus on the front-end planning process (strategic and tactical planning through the Grid Development Division) and in programming, scheduling and delivery of projects, resulting in lower overall capitalisation of personnel costs to projects. With the implementation of the GOM, capitalisation has reduced since the start of RCP2, as illustrated in Figure 96.

**Figure 96 FTE costs capitalised to projects for RCP1 to Base Year 2017/18**

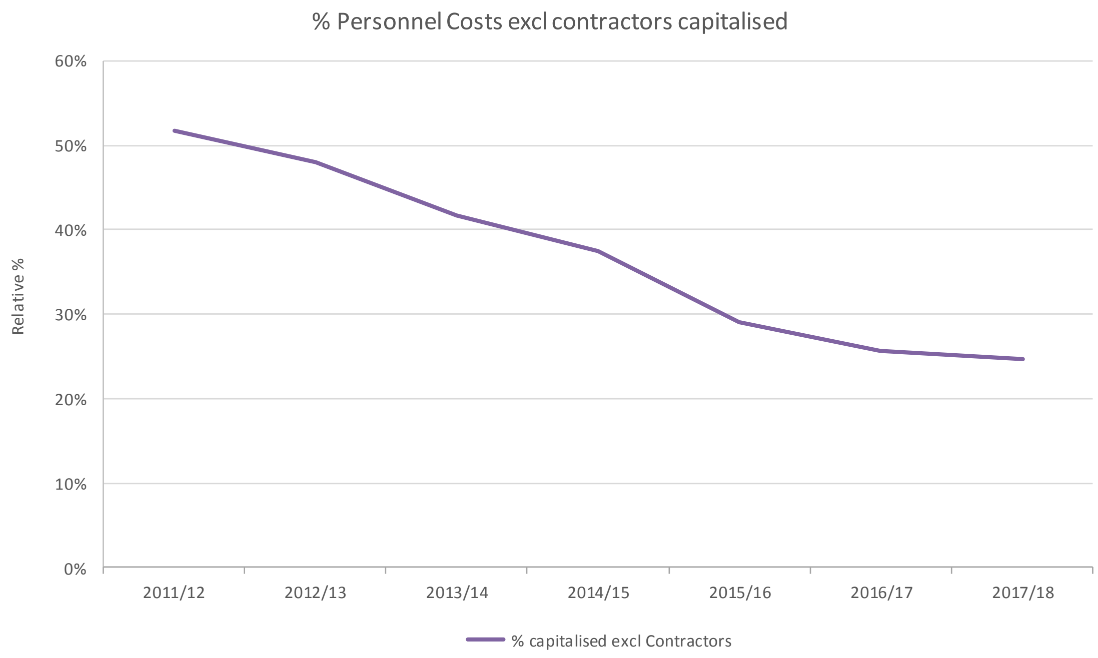
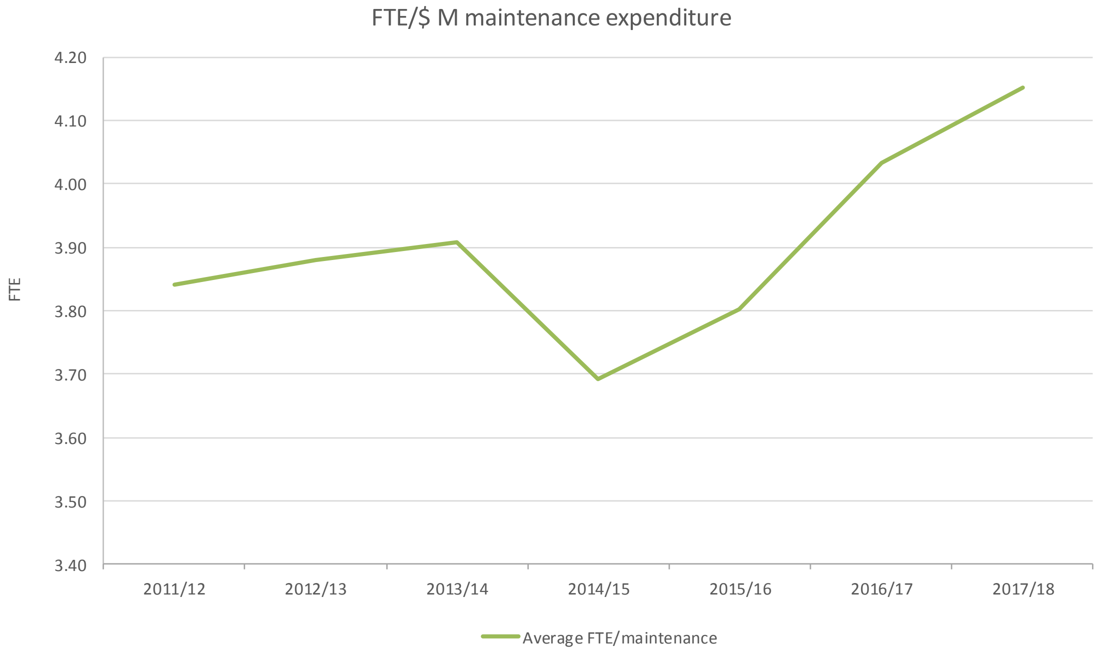



Figure 97 shows the total number of FTEs in Asset Management and Operations compared with the overall maintenance expenditure per financial year.

**Figure 97 Asset Management & Operations FTEs compared with maintenance expenditure for RCP1 to Base Year 2017/18**




We are satisfied that with a relatively consistent number of FTEs per year, as shown in Figure 95, the diagrams show that for the period between 2011/12 to 2017/18, the amount of FTE costs capitalised to projects decreased as the trend for total FTEs to total maintenance expenditure increased, reflecting a transition from major capital works to risk-based maintenance planning.

Transpower has advised that whilst the FTE count has remained relatively constant, the mix of skills has changed, with more planning staff and less project managers being used as Transpower transitioned to having a greater focus on maintenance.

### *Verification assessment of Asset Management and Operations*

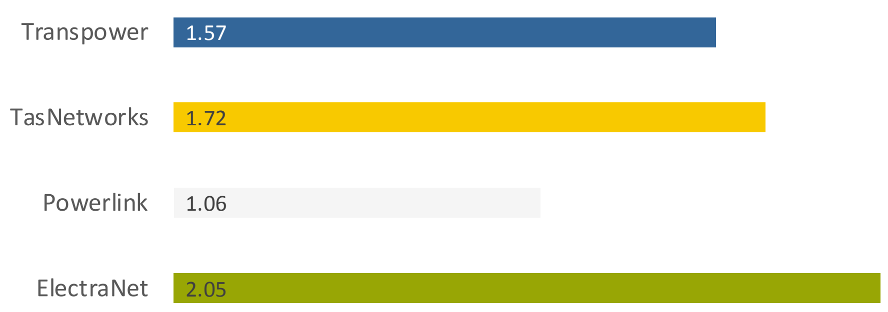
We note the Commission's RCP2 final decision accepted the salaries allocation proposed by Transpower without amendment and which was based on Transpower increasing the Grid planning and operations staffing level to that considered necessary to support the maintenance regime shift between RCP1 time-based and RCP2 reliability-informed activities.

Transpower's forward projections into RCP4 and RCP5 keep the FTE levels constant during these years. We are satisfied that Transpower has been looking to improve its planning activities by enhanced condition and risk assessments and additional data gathering and processing through the implementation and development of Maximo (as the asset management system) and the pending introduction of PowerPlan (asset management planning system).

We note that Transpower does not appear to be projecting that any further FTEs are required during RCP3 and beyond. The improvements in planning through proposed RCP3 ICT capex (refer section 7.3.6) have been included in the trend factor for RCP3, totalling -4.8 million.

As a high-level comparison, we have compared the number of people involved in network overhead activities for TasNetworks, ElectraNet and Powerlink with the number of FTEs nominated by Transpower on a per $ million of opex. Figure 98 shows that Transpower is comparable with TasNetworks, which has similar network characteristics as described in the benchmarking section 3 with regards boundary with electricity distribution, and who have a relatively small in-house workforce and therefore need to plan work for external service providers.

**Figure 98 Comparison of network overhead personnel per $ million of opex ($2017/18)**




We have verified from the historic 'black start' costs from 2010 provided by Transpower, using NZ CPI as indexation, that the long-term average annual increase for these costs is approximately 4%. This increase is expected to be largely offset by a projected annual improvement in productivity of 0.2% based on estimated improvements in NZ professions, scientific and technical services sector.[183]

We have verified that the RCP3 ICT capex forecast includes benefits totalling $8.1 million (refer section 7.3.6), part of which is the driver for the productivity improvement of 0.2%.

183 Stats NZ report for **Productivity statistics: 1978-2017 - productivity by industry tables** *Table 5.01 By sector and industry 1978 - 2017* shows that for Professional, scientific and technical services the annual increase for the 10-year period 2008-17 is 0.2%

*Verification opinion*

We note Transpower acknowledges there may potentially be savings through the implementation of PowerPlan. However, the strategic consideration of requirements from the corporate strategies *Transmission Tomorrow* and *Energy Futures* (refer section 2.5.1 and 2.5.2) are such that Transpower considers it prudent to maintain the number of FTEs allocated to Asset Management and Operations to support the anticipated additional investigation work.

We accept the 2017/18 base year as consistent with later year allowances for RCP2 previously approved by the Commerce Commission. The proposed trend and step changes for RCP3 have been verified, including the benefits from the RCP3 ICT capex programme, as part of the RCP3 forecast total of $309.5 million.[184]

Whilst there is evidence of the shift from a major capital works to an enhanced maintenance planning focus and the supporting Asset Management and Maintenance Overview outlines qualitatively the activities and benefits of the current resource levels, we have not been able to verify the effectiveness of the increased number of FTEs planning the maintenance expenditure, particularly as the overall maintenance expenditure for RCP3 is only 4% higher than RCP2. However, a high-level comparison with Australian transmission utilities suggests Transpower is comparable with regards FTE numbers to total annual opex spend.

To provide greater confidence regarding the efficiency of the Asset Management and Operations, as well as effectiveness of the relatively new Grid Operating Model, we believe that Transpower should consider developing a business case detailing the number of FTEs in each division, their role and contribution to planning of the maintenance programme and a projected long-term benefit in monetary terms that is reasonably expected from their planning and investigative work.

On balance, we verify the proposed expenditure for RCP3 of $309.5 million as being in accordance with GEIP.

### Verification opinion - Asset Management and Operations

Table 99 summarises our verification assessment and opinion.

[184] We were advised that Transpower is planning a price-quality analysis of the long-term price path for any changes in FTE numbers.

**Table 99 Verification summary - Asset Management and Operations**

| **Expenditure category** | **Opex - Asset Management and Operations** | |
|---|---|---|
| **Transpower RCP3 forecast** | $309.5 million | |
| **Recommendation** | **Accept:** $309.5 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Accept base year 2017/18 consistent with later year allowances in RCP2, have no view on step changes as not quantified, agree with trends proposed for growth in ancillary services, staff productivity and Benefits-Driven ICT capex (which is reflected in ICT capex). As base-step-trend forecast, accept forecast is in accordance with GEIP | - |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | Transpower implemented GOM in 2016 with greater focus on maintenance. We believe Transpower needs to make case for the number of FTEs involved in maintenance support, their role and the expected long-term benefits from this extended planning and investigative work. | - |
| **Potential scope for improvement** | Given change in operating model in 2016, consistency with past year expenditures in itself is not sufficient justification for base year as basis for RCP3 forecast. Transpower should outline how activities provide monetary benefits to maintenance programmes | - |

### 8.6.7 Non-network opex – Business Support

The Business Support category covers the personnel and service-related costs for the following divisions:

- Information Services and Technology (IST): responsible for developing and maintaining ICT systems for grid and non-network functions, enterprise information management and ICT strategy and architecture.
- The Chief Executive (CE) Office: responsible for governance and key advisory functions across the business, including corporate legal counsel, corporate communications.

- Corporate Services: responsible for providing financial support, treasury services, strategic planning, regulatory relationship management and corporate governance to Transpower.
- People: responsible for Transpower's human resources function, Health & Safety advisory services, management of technical training programmes and facilities management.

Figure 99 shows the annual Business Support opex for the regulatory periods RCP1 to RCP3.

**Figure 99 Annual Business Support opex for RCP1 to RCP3**

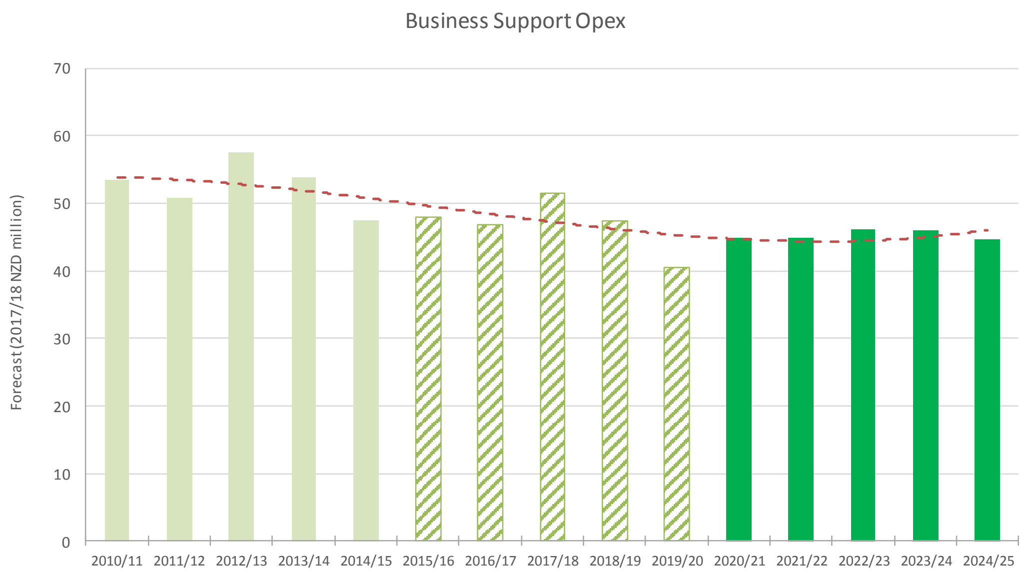
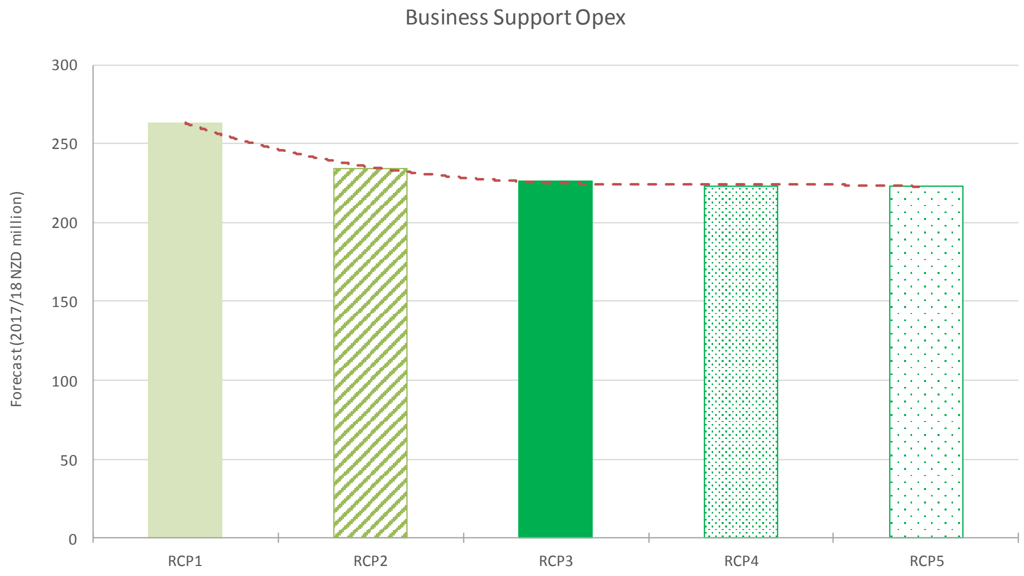



Figure 100 shows the total Business Support opex for the regulatory periods RCP1 to RCP5.

**Figure 100 Total Business Support opex for RCP1 to RCP5[185]**




### *Development of RCP3 forecast*

In RCP2, Business Support opex was included with expenditure for Ancillary Services, Insurance (both external and self-insurance), Investigations and Departmental under the broad heading Corporate opex.

The extracted Business Support costs for RCP1 are $263.2 million and for RCP2 $234.3 million. The periodic decreases are 11% between RCP1 and RCP2, a projected 3% decrease between RCP2 and RCP3, and a further 2% decrease from RCP3 to RCP4.

The RCP3 forecast has been developed using a base-step-trend approach, with 2017/18 as the base year. For RCP3, the Business Support opex includes $19.1 million for operating leases. The expected costs for 2017/18 are $51.5 million, including several identified non-recurring expenses.

Table 100 shows the adjusted base year amount.

**Table 100 Adjusted 2017/18 base year for Business Support opex ($2017/18)**

| Item | Value |
|---|---|
| 2017/18 actual costs | $51.5 million |

185 Current RCP3 forecast of $226.5 million includes $19.1 million for lease costs. Under IFIS 16 certain lease costs will be capitalised to the balance sheet from 1 July 2019. These estimates will be updated by April 2019 and removed from the RCP3 opex expenditure figures. We understand that Transpower and the Commerce Commission have been liasing on this issue.

| | |
|---|---|
| Transformation programme costs | - $5.2 million |
| RCP3 project costs | - $1.3 million |
| Building lease cost increase | + $0.3 million |
| **2017/18 base year (recurring only)** | **$45.3 million** |

Transpower has projected that the step change in RCP3 for the preparation of the RCP4 proposal is $2.6 million, which is offset by an ongoing productivity improvement trend factor for RCP3 of $2.3 million.

The total RCP3 forecast for Business Support opex is $226.5 million.

*Verification assessment and opinion*

The decreasing trend in costs in RCP3 compared to earlier RCPs is consistent with the corporate strategies previously reviewed as part of the RCP2 proposal review process and reflects an organisation that continues to deliver cost efficiencies in both Grid and non-grid activities.

The proposed RCP3 Business Support opex is based on the adjusted 2017/18 base year, with the one-off costs for the RCP4 proposal offset by a comparable productivity improvement applied to the Asset Management and Operations professional staff of 0.2% per annum (refer section 8.6.6).

We have not verified the specific reasons for the annual variances in Business Support opex for the years in RCP3 compared to the base year 2017/18. However, we believe Transpower's RCP3 Business Support forecast in aggregate reflects continuation of an historical downward trend and is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - Business Support

Table 101 summarises our verification assessment and opinion.

**Table 101 Verification summary - Business Support**

| Expenditure category | Opex - Business Support | |
|---|---|---|
| **Transpower RCP3 forecast** | $226.5 million | |
| **Recommendation** | **Accept:** $226.5 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Satisfied that forecast is consistent with expenditure outcome with regard to GEIP.<br>Accept adjusted base year 2017/18 with changes for impacts of Transformation | N/A |

| | | |
|---|---|---|
| | program, RCP3 project costs and building lease.<br>Step changes identified and offset each other, decreasing trend consistent with corporate strategies reflecting drive for cost efficiencies in both network and non-network activities. | |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

## 8.7 Non-identified opex programmes

Non-identified Programmes are those opex categories that did not satisfy the agreed criteria for Identified Programmes (refer section 8.6). We have not subjected these expenditure categories to the same level of scrutiny as the Identified Programme categories.

We have selected the following Non-Identified Programmes:

- Corrective and Proactive Maintenance - including these maintenance categories in our review means that all network maintenance has been assessed;
- ICT opex - this expenditure category was classified as an Identified Programme in RCP2. The current forecast for RCP3 of $195.9 million includes $39.5 million for operating leases;[186] and
- Insurance – the increase in total RCP3 expenditure forecast is essentially due to projected market-driven increases in insurance costs from RCP3 onwards.

A review of these expenditure categories provides additional confidence about the efficiency of the RCP3 forecast expenditure.

### 8.7.1 Network opex - Corrective maintenance

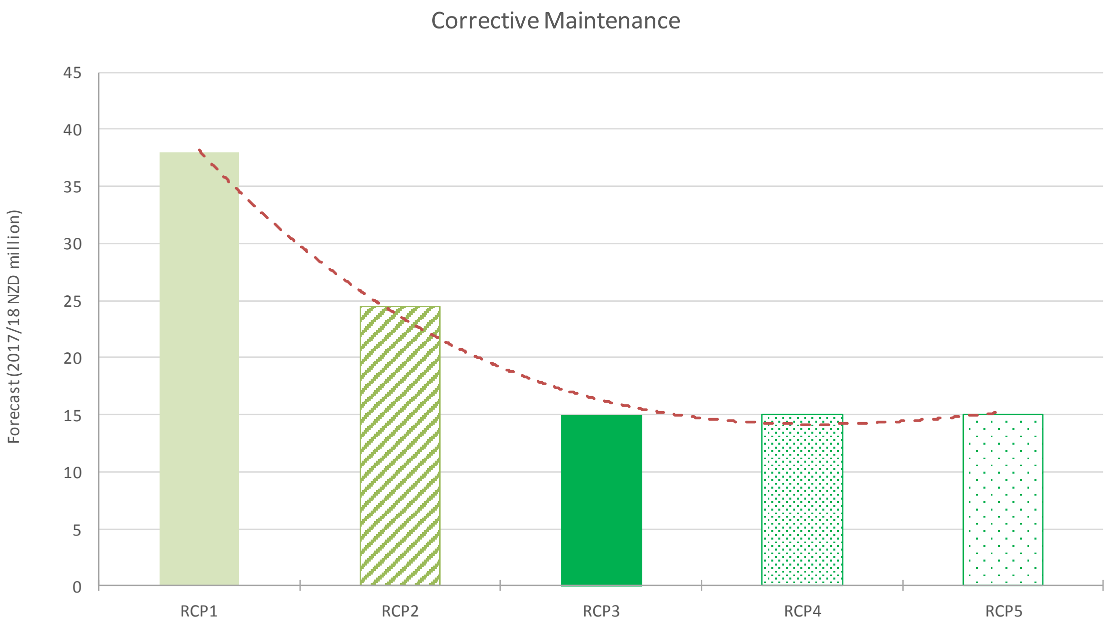
Figure 101 shows the annual corrective maintenance expenditure for RCP1 to RCP3. There are relatively small levels of historical and forecast expenditure in this category.

[186] Under IFIS 16, we understand Transpower intends that certain lease costs will be capitalised to the balance sheet from 1 July 2019. Transpower and the Commerce Commisison have been liasing on this matter.

**Figure 101 Annual corrective maintenance for RCP1 to RCP3**


Figure 102 shows the total corrective maintenance expenditure for RCP1 to RCP5.

**Figure 102 Total corrective maintenance for RCP1 to RCP5**



### *Historic trends*

As described in section 8.4, Grid maintenance was assessed on a different basis for RCP2, with maintenance categorized as either routine, or asset class specific. Therefore, in adopting the new categories for RCP3, it has been necessary for Transpower to back-cast historic expenditure, using the current definition for corrective maintenance work. In doing so, there has been some interpretation necessary and with this uncertainty there could potentially be skewing of the historical trend.

The significant expenditures in 2012/13 and 2013/14 (refer Figure 101) are due to several power transformer failures and rectification work following the Canterbury and Christchurch Earthquake events.

### *Development of RCP3 forecast*

The RCP3 forecast is developed using a base-step-trend approach, using 2017/18 as the base year. In identifying the annual recurring corrective maintenance, significant events that have been classified as Force Majuere are excluded. The allowance for 2017/18 corrective maintenance is $6.2 million.

Transpower has assumed that "*… the Grid continues to perform reliably, and no significant increase in corrective work will be required … the greater reliability and robustness of new equipment resulting from our asset replacement programme is expected to support this assumption.*"[187] Consequently, no step change or trend has been applied to the RCP3 forecast.

### *Verification assessment*

Transpower plans for a relatively low level of corrective maintenance in RCP3 (1% of the total opex). This aligns to Transpower's strategic focus on higher predictive maintenance as it progresses toward a more advanced approach of optimisation, where best-value is achieved by predicting and balancing (trading off) service levels, cost, risk and safety for RCP3.

In splitting historic expenditure, Transpower has relied upon General Ledger account codes for identifying corrective maintenance since 2010/11 as follows:

- AC lines corrective
- AC stations corrective

[187] Transpower (2018), Maintenance Opex Overview section 5.2, p. 22, Document [70]

- Coms corrective
- DC cables corrective
- DC lines corrective
- DC stations corrective
- Asbestos
- Maintenance accrual corrective

We accept that the nature of corrective maintenance work is the immediate response to faults, to maintain a safe and reliable network. Given that this expenditure category will be subject to unforeseen events, and that expenditure will vary significantly year-on-year as a result, the RCP3 forecast will be an average of rectification work required, excluding major events. [188]

Table 102 shows the annual actual expenditure for the first two years of RCP2, and the forecast expenditure to the end of RCP2. The base year 2017/18 is highlighted.

**Table 102 Corrective maintenance opex RCP1 and RCP2 ($2017/18 million)**

| Activity | RCP1 | | | | | | RCP2 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 10/11 | 11/12 | 12/13 | 13/14 | 14/15 | Total | 15/16 | 16/17 | 17/18 | 18/19 | 19/20 | Total |
| AC lines | 0.8 | 2.0 | 2.5 | 2.9 | 1.2 | 9.4 | 0.5 | 1.2 | 0.9 | 0.5 | 0.5 | 3.2 |
| AC stations | 1.9 | 1.7 | 7.0 | 7.0 | 5.0 | 22.6 | 4.5 | 3.6 | 3.5 | 2.1 | 2.1 | 14.6 |
| Comms | 0.4 | 0.3 | 1.1 | 0.7 | 0.2 | 2.7 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.6 |
| DC cables | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| DC lines | 0.1 | 0.1 | 0.2 | 0.1 | 0.1 | 0.6 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.5 |
| DC stations | 0.2 | 0.3 | 1.3 | 0.7 | 0.5 | 3.0 | 0.4 | 0.4 | 0.5 | 0.3 | 0.3 | 1.8 |
| Asbestos | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.3 | 0.0 | 0.0 | 0.0 |
| Maintenance accrual | 0.0 | 0.0 | 0.0 | 0.0 | (0.3) | (0.3) | 0.6 | 0.0 | 0.0 | 0.0 | 0.0 | 0.3 |
| **Total** | **3.4** | **4.4** | **12.1** | **11.4** | **6.6** | **37.9** | **6.5** | **5.5** | **6.2** | **3.1** | **3.1** | **21.2** |

Transpower has identified that the $1.3 million expense in 2017/18 for asbestos removal is non-recurring and should be removed from the base year. In developing the RCP3 forecast, Transpower has used 2017/18 as the base year ($4.9 million) which "*… while broadly in line with historic expenditure*"[189] with the planned range of asset reliability

[188] Major events are generally considered to be force majeure - events that are unforeseen with impacts that are extraordinary, uncontrollable and not manageable, occur infrequently, outside the ability of Transpower to either prevent or mitigate the impact of the event

[189] Transpower email advice of 8 October 2018

improvements, Transpower has "… *adjusted* [the] *base year by $1.9 million, resulting in a base amount of $3 million* [per annum]."

*Verification opinion - Corrective Maintenance*

The adjusted values nominated for 2017/18 base year reflect the level of confidence that Transpower has in its recent asset replacement programmes, particularly for assets in AC substations. In reviewing atypical expenditure, Transpower suggested that, in comparing with the previous year, the breakdown of the 2017/18 expenditure was "*broadly similar*". Table 102 suggests that the expenditure pattern for 2017/18 is close to that for 2010/11, which pre-dated the earthquake events in the South Island and the related rectification work. In doing so, we are satisfied that the 2017/18 allocations do not include consideration of major events.

We believe Transpower's RCP3 corrective maintenance forecast is consistent with the expenditure outcome having regard to GEIP.

### Verification opinion - Corrective Maintenance

Table 103 summarises our verification assessment and opinion.

**Table 103 Verification summary - Corrective Maintenance**

| Expenditure category | Opex - Corrective Maintenance | |
|---|---|---|
| **Transpower RCP3 forecast** | $15.0 million | |
| **Recommendation** | **Accept:** $15.0 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Satisfied forecast is consistent with expenditure outcome with regard to GEIP<br>Accept adjusted base year 2017/18 as consistent with impact of recent asset replacement programmes, no step or trend applied. | N/A |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | Refinements in allocation of expenditure across the new maintenance categories | N/A |

### 8.7.2 Network opex - Proactive maintenance

Figure 103 shows the annual proactive maintenance expenditure for the regulatory periods RCP1 to RCP3 and Figure 104 shows the total proactive maintenance expenditure for the regulatory periods RCP1 to RCP5.

**Figure 103 Annual proactive maintenance for RCP1 to RCP3**

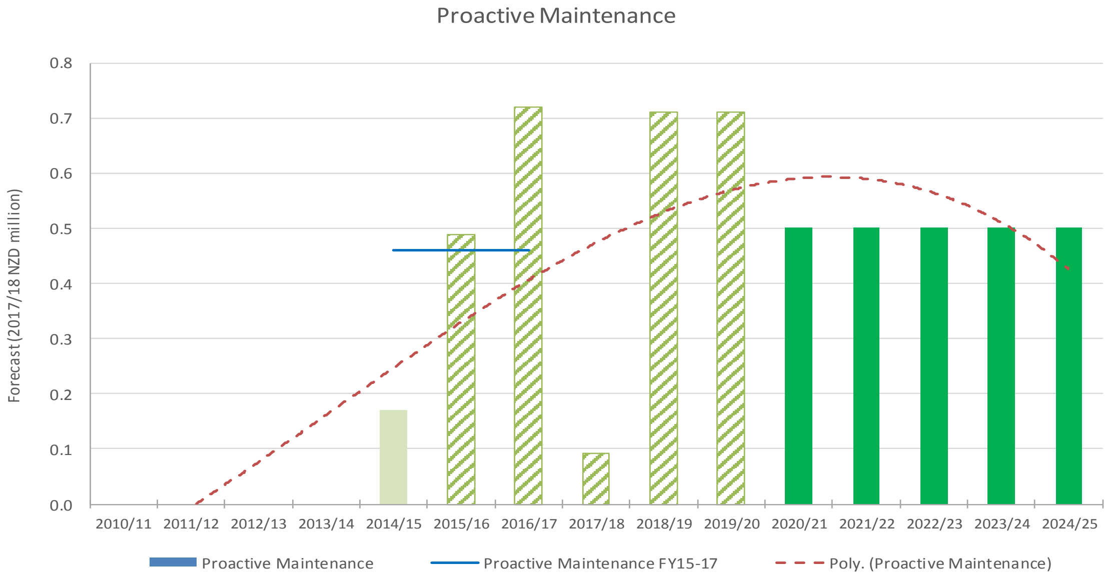
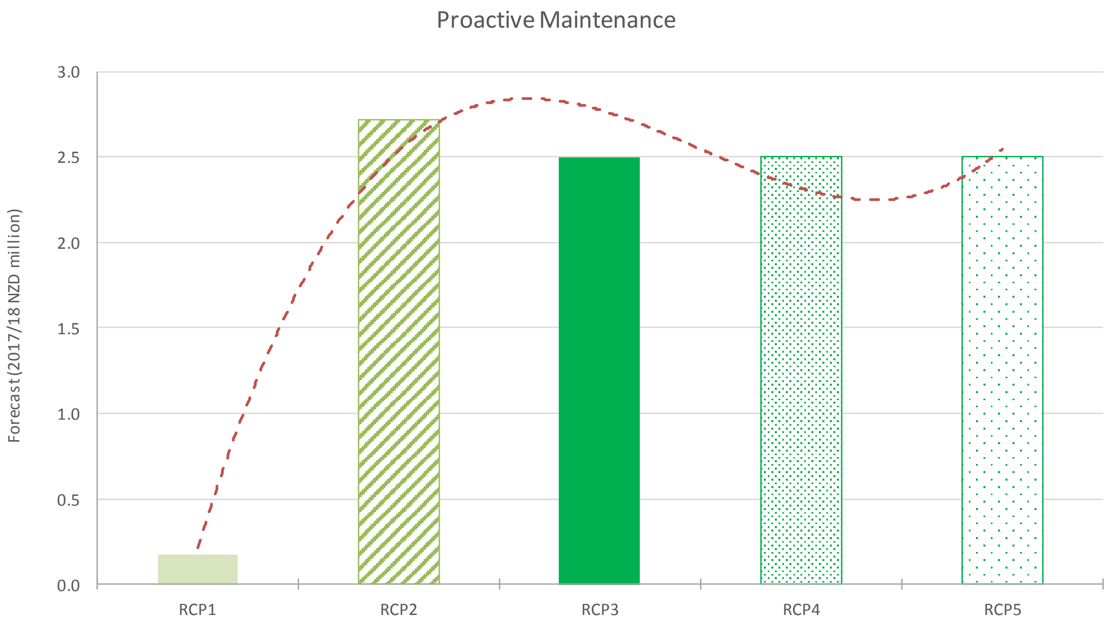



**Figure 104 Total proactive maintenance for RCP1 to RCP5**



### *Historic trends*

As for corrective maintenance, historic expenditure on proactive maintenance activities has been back-cast, from General Ledger entries for RCP1 and the first half of RCP2.

The process for categorizing work as proactive maintenance is not yet well defined, with much of the activity that in future will be classed as proactive has historically been considered as predictive maintenance.

Classifying work as proactive maintenance commenced in 2014/15, leading to a very small historic expenditure in RCP1 as shown in Figure 103 and Figure 104.

### *Development of RCP3 forecast*

The RCP3 forecast is developed using a base-step-trend approach, using 2017/18 as the base year. The average for the three-year period (as shown in Figure 103) for which expenditure data is available (2014/15 to 2016/17) is $0.46 million.[190]

The 2017/18 base year expenditure is $0.1 million. Given the inexperience in capturing proactive maintenance activity costs and the uncertainty in differentiating between proactive and predictive work, Transpower has adopted the base year allocation plus a small step change to match the three-year average for an annual allocation of $0.5 million ($2017/18). No trend factor has been applied.

### *Verification assessment - Proactive Maintenance*[191]

Given the limited historic expenditure data available, we accept that using the three-year average, which is $0.4 million more than the 2017/18 base year, is reasonable. We have not been able to verify the higher expenditure forecasts for the last two years of RCP2 (refer Figure 103).

We believe Transpower's RCP3 proactive maintenance forecast is consistent with the expenditure outcome having regard to GEIP.

## Verification opinion - Proactive Maintenance

Table 104 summarises our verification assessment and opinion.

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190 Average in $2017/18

191 In reviewing Proactive maintenance, we have applied clause 18.4 of the Terms of Reference regarding the proportionate scrutiny principle - i.e. that the level of scrutiny applied should generally be commensurate with the price and quality impact on consumers of the aspect of the proposal being scrutinised.

**Table 104 Verification summary - Proactive Maintenance**

| Expenditure category | Opex - Proactive Maintenance | |
|---|---|---|
| **Transpower RCP3 forecast** | $2.5 million | |
| **Recommendation** | **Accept:** $2.5 million | **Do not accept:** - |
| **Expenditure outcome assessment** | Satisfied forecast is consistent with expenditure outcome with regard to GEIP<br>With limited historical data, accept use of 3-year average as base year rather than 2017/18 spend. | N/A |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | Refinements in allocation of expenditure across the new maintenance categories | N/A |

### 8.7.3 ICT opex

Figure 105 shows the annual ICT opex for the regulatory periods RCP1 to RCP3, and Figure 106 shows the total ICT opex for the regulatory periods RCP1 to RCP5.

**Figure 105 Annual ICT opex for RCP1 to RCP3**

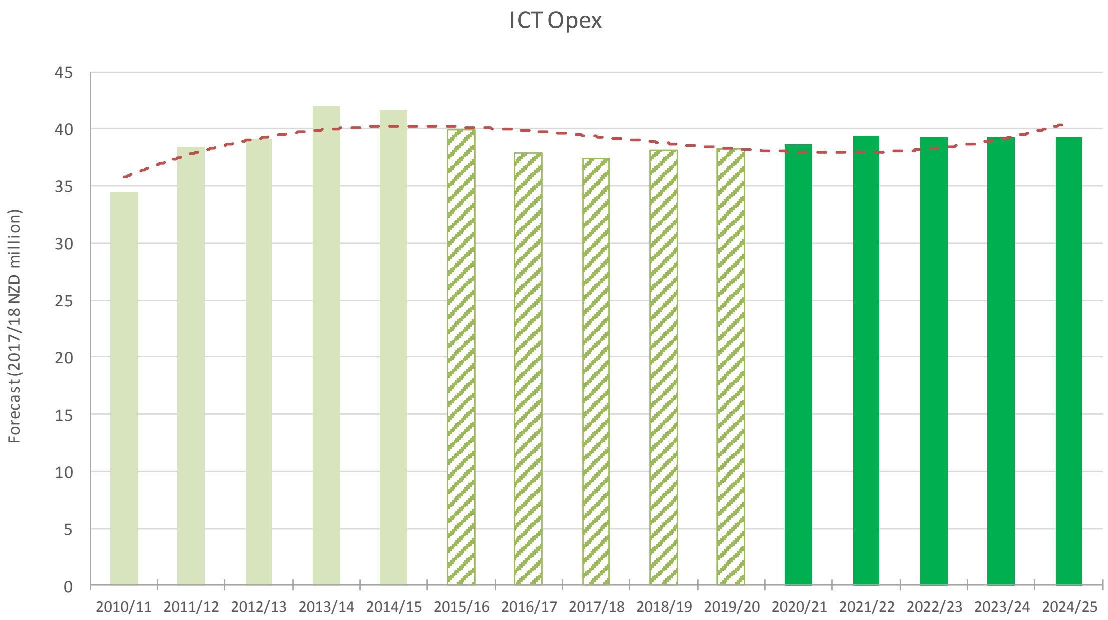
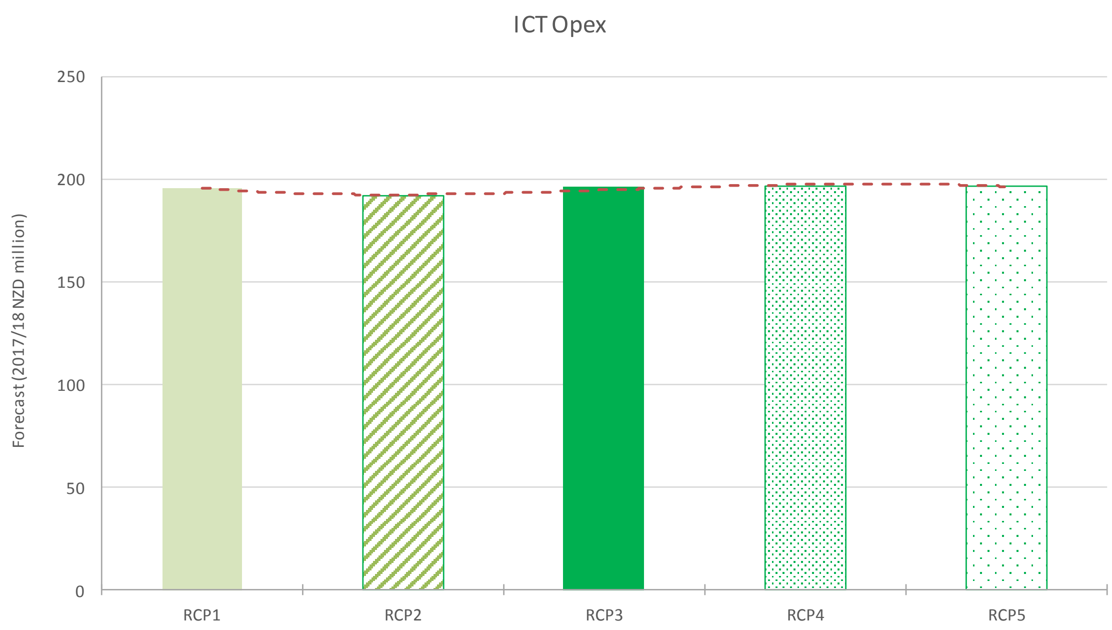


**Figure 106 Total ICT opex for RCP1 to RCP5**




The RCP3 forecast of $195.9 million[192] represents a 2% increase on RCP2 expenditure.

*Historic trends*

During RCP2, the major ICT cost drivers are:

- increased cybersecurity measures resulting in increased licence costs;
- operational benefits of TransGO through reduced data network maintenance and lease costs; and
- use of virtual environments and rationalising of licence models used by Transpower reducing software licencing costs.

The review for the Commerce Commission of the RCP2 ICT opex noted that whilst the RCP2 expenditure was characterised as "*… a period of consolidation*", real costs were projected to rise by 7%.[193] The review concluded that whilst the key drivers were well defined, there was insufficient evidence provided with regards to operational efficiencies being identified and achieved.

192 Value reflects forecast presented to Transpower Board 27 September 2018

193 GHD (2018), GHD RCP3 Capex and Opex forecast_IV review, section 8.4.3, clause 617, p. 149, Document [118]

Consequently, the review recommended a 2% "productivity factor"[194] be applied, which was endorsed by the Commerce Commission in its final decision.[195]

*Development of RCP3 forecast*

Similar to the forecasting approach used for RCP2, Transpower has relied on top-down estimates of needs by category, based on historic cost trends and anticipated changes in the operating environment.

Transpower has adopted 2017/18 as the base year for the RPC3 forecast and identified specific step changes.[196]

There are three key steps in Transpower's planning process:

- identifying operational impacts of any planned capital investment;
- considering relevant trends in the ICT industry; and
- internal challenge to anticipated changes to operational support with regards to deliverability and cost effectiveness.

The opex requirements are guided by the overall ICT strategy aligned to corporate strategies including *Transmission Tomorrow* (refer section 2.5.1). The main factors influencing the RCP3 forecast are:

- a move to enterprise applications being standard solutions delivered via a public cloud, with more focus on managing interfaces;
- critical services to be retained in Transpower-managed data centres;
- DevOps initiative to deliver operational efficiencies through effective resourcing, enhanced delivery and operational automation and better overall operations reliability;
- ongoing investment in cybersecurity; and
- deferring the TransGO upgrade to RCP4 requiring leasing of additional network capacity for substation data.

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194 Ibid., section 8.5, clause 620, p. 150

195 Commerce Commission (2014), Settign Transpower's individual price-quality path for 2015-20, clauses 5.128 to 5.133, p. 85, Document [120]

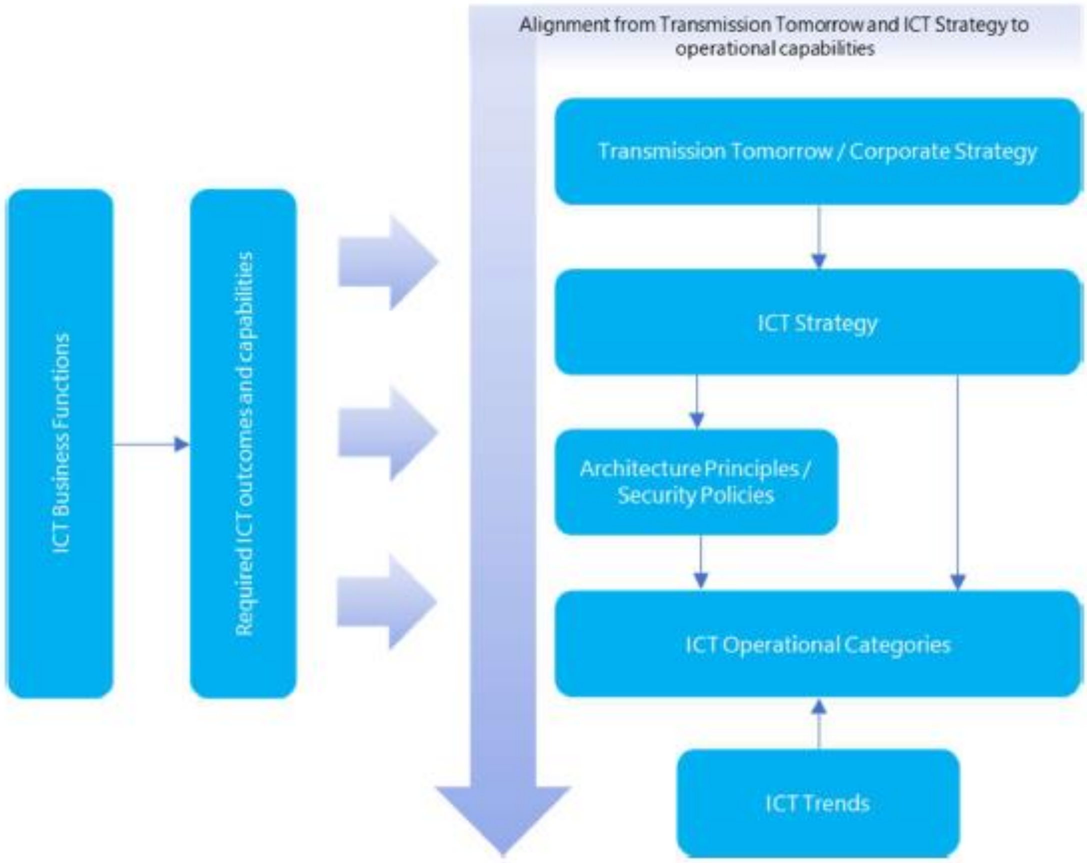
196 Transpower adopted a similar forecasting approach in RCP2, using 2012/13 as the base year and identifying specific step changes for the RCP2 period

The key planning assumptions for the RCP3 forecast include:

- operational activities and costs will remain broadly the same as those for RCP2;
- adoption of standard application solutions in lieu of customised solutions;
- increased costs for cloud services as volume of use increases; and
- continued need for specialist resources to support Transpower business services such as SCADA/EMS and Grid asset management.

Figure 107 shows the alignment of the overall strategy and key drivers for ICT opex.

**Figure 107 ICT management approach**[197]




197 Transpower, ICT Opex Forecast, section 3.1, Figure 2, p. 8, Document [82]

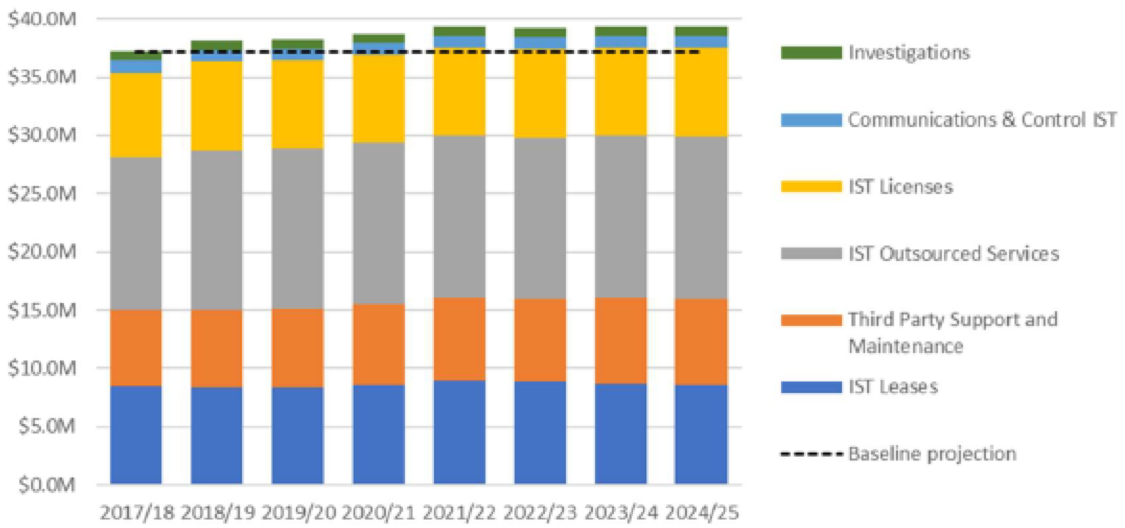
Table 105 shows the generation of the RCP3 forecast, using the expenditure for the selected base year 2017/18 ($37.2 million) as the baseline amount and step changes for the key initiatives during RCP3.

**Table 105 Annual ICT opex forecast for RCP3 ($2017/18 million)[198]**

| Cost item | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Baseline | 37.2 | 37.2 | 37.2 | 37.2 | 37.2 | 186.0 |
| Step changes | 1.5 | 2.2 | 2.0 | 2.1 | 2.1 | 9.9 |
| Productivity trend | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **Total** | **38.7** | **39.4** | **39.2** | **39.3** | **39.3** | **195.9** |

Figure 108 summarises the planned opex expenditure.

**Figure 108 Annual ICT opex for RCP3[199]**




The key drivers for the RCP3 forecast and approximate contribution to the total opex forecast are:

- Outsourced services (35%) - primarily due to a move to using outsourced Cloud solutions for standard applications;
- Leases (23%) - to avoid a major upgrade of the TransGO network to allow for transferring larger volumes of data from substations, Transpower has elected to

198 Values reflect the forecast presented to Transpower Board on 24 May 2018

199 Transpower, *ICT Opex Forecast*, version 1.0, 18 April 2018, section 5.3, Figure 4, p. 18, Document [82]. Values may be subject to change, pending final decision regarding the potential capitalisation of leases

shift non-critical data traffic from the current TransGO network to a leased network operated by a telecommunications service provider. This will result in an annual lease increase of $2.6 million for extra capacity for corporate traffic, which is partially offset by an annual $0.5 million saving in renegotiated leasing contracts;

- Licences (19%) - supporting new capabilities across the business, such as maintenance optimisation, planning optimisation and increased use of advanced data analytics; and
- Third party support and maintenance (18%) - enhancements to cybersecurity capabilities through security enforcement point capabilities, independent security testing, Cloud security, Privileged Access Management (PAM) and security awareness training.

The remaining 5% constitutes communications & control and investigations.

Table 106 shows the breakdown of the proposed base step of $9.9 million.

**Table 106 Proposed RCP3 ICT opex step changes ($2017/18 million)**

| Step change | Description | RCP3 total ($M) |
|---|---|---|
| Leases | Leased network capacity for core data traffic to allow TransGO to support increasing substation traffic services | 2.6 |
| | Offset - fibre leases with shared capital investment | (1.4) |
| Third Party Support and Maintenance | Cyber-security risk reduction | 1.9 |
| | Support additional substation Local Area Networks (LANs) | 1.0 |
| | General support & maintenance for new & expanded ICT services required to support business outcomes using new technology solutions | 0.7 |
| Outsourced Services | Contracted increase in Data Centre electricity costs following completion of migration to outsourced data centres | 0.7 |
| | Cloud service costs due to adoption of cloud-based services for commodity ICT - to reduce capex costs & support required for commodity systems | 1.9 |
| | Telecommunications & Networking connection fee increases | 1.0 |
| Licences | Microsoft licence increases | 1.5 |
| **Total** | | **9.9** |

No trends have been identified for RCP3.

### *Verification opinion*

Transpower has used a base-step-trend approach in generating the RCP3 forecast and has relied on the 2017/18 base year value of $37.2 million. The proposed 5-year step changes of $9.9 million represent an increase of 5% on the RCP3 base value of $186 million. The total ICT opex forecast is an aggregate of base-step-trend estimates for the following categories (refer step changes in Table 106):

- Leases - base year of $8.5 million, total step change of $1.2 million and no trend
- Third Party Support and Maintenance - base year of $6.5 million, total step change of $3.6 million and no trend
- IST Outsourced Services - base year of $13.1 million, total step change of $3.6 million and no trend
- IST Licences - base year of $7.3 million, total step change of $1.5 million and no trend
- Communications & Control - base year of $1.0 million, no step change or trend
- Investigations - base year of $0.8 million, no step change or trend

The opex benchmarking (refer section 3.3.2) highlighted the difficulties in comparing Transpower with Australian transmission utilities because of the different treatments of ICT opex, although with the qualifications and normalisations suggested, the Transpower ICT costs would be comparable to the Australian electricity network sector. We accept that there are operating environment factors specific to the New Zealand market, particularly with increased leasing costs compared to Australia.

We note that the increase in RCP3 expenditure over the RCP2 allowance is $4.1 million, which is relatively small in terms of the overall forecast expenditure of $195.9 million. The step changes proposed for RCP3 are clearly defined, as is the strategic link from the overall corporate direction for Transpower to the ICT necessary to support the current corporate initiatives. In that respect, we consider the proposed changes are prudent, considering the key planning assumptions and the overall corporate factors influencing the RCP3 plan.

Consequently, we consider that the ICT opex forecast for RCP3 is consistent with GEIP.

### Verification opinion - ICT opex

Table 107 summarises our verification assessment and opinion.

**Table 107 Verification summary - ICT opex**

| Expenditure category | Opex - ICT | |
|---|---|---|
| **Transpower RCP3 forecast** | $195.9 million | |
| **Recommendation** | **Accept:** $195.9 million | **Do not accept:** - |

| | | |
|---|---|---|
| **Expenditure outcome assessment** | Satisfied forecast is consistent with expenditure outcome with regard to GEIP.<br>Base year consistent with spend in 2017/18 for recurring opex. Total ICT opex developed as aggregate of base-step-trend forecasts for each of six areas of activity. Step changes applied are clear and justified and linked to corporate strategy. | N/A |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

### 8.7.4 Non-network opex - Insurance

Transpower procures around $1 billion of insurance cover annually. It self-insures for risks it considers appropriate and externally insures for risks it considers are prudent to cover externally.

While not an identified programme, Transpower's forecast insurance costs form a significant ongoing component of its total opex programme.

Transpower has forecast total insurance costs in RCP3 of $88.0 million in real 2017/18 dollars, which represent a step change increase compared to its RCP2 insurance costs. Table 108 shows RCP2 expected expenditure and the RCP3 forecast.

**Table 108 Comparison of insurance costs in RCP2 and RCP3 ($2017/18 million)**

| Expenditure category | RCP2 | RCP3 | Variance |
|---|---|---|---|
| Insurance | 71.1 | 88.0 | 22% |

Table 109 shows the annual forecast insurance costs in RCP3 in real 2017/18 dollars.

**Table 109 Annual forecast capex for HVDC in RCP3 ($2017/18 million)**

| Expenditure category | 2020/21 | 2021/22 | 2022/23 | 2023/24 | 2024/25 | Total |
|---|---|---|---|---|---|---|
| Insurance | 16.6 | 17.1 | 17.6 | 18.1 | 18.6 | 88.0 |

Figure 109 shows Transpower's annual insurance costs for the regulatory periods RCP1 to RCP3 indicating the upward trend in costs.

**Figure 109 Annual Insurance costs for RCP1 to RCP3**

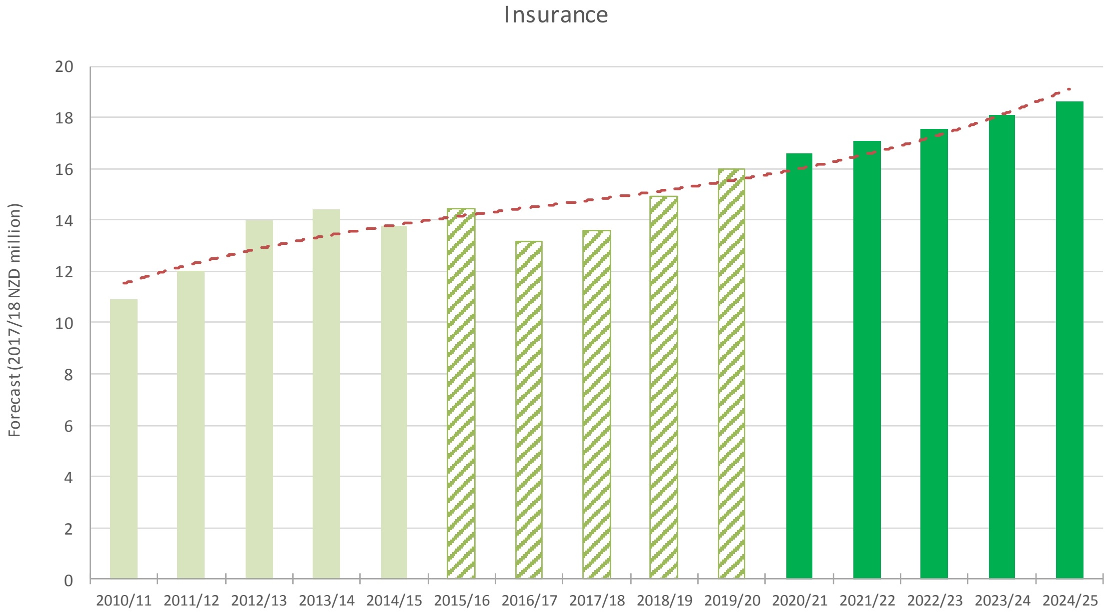
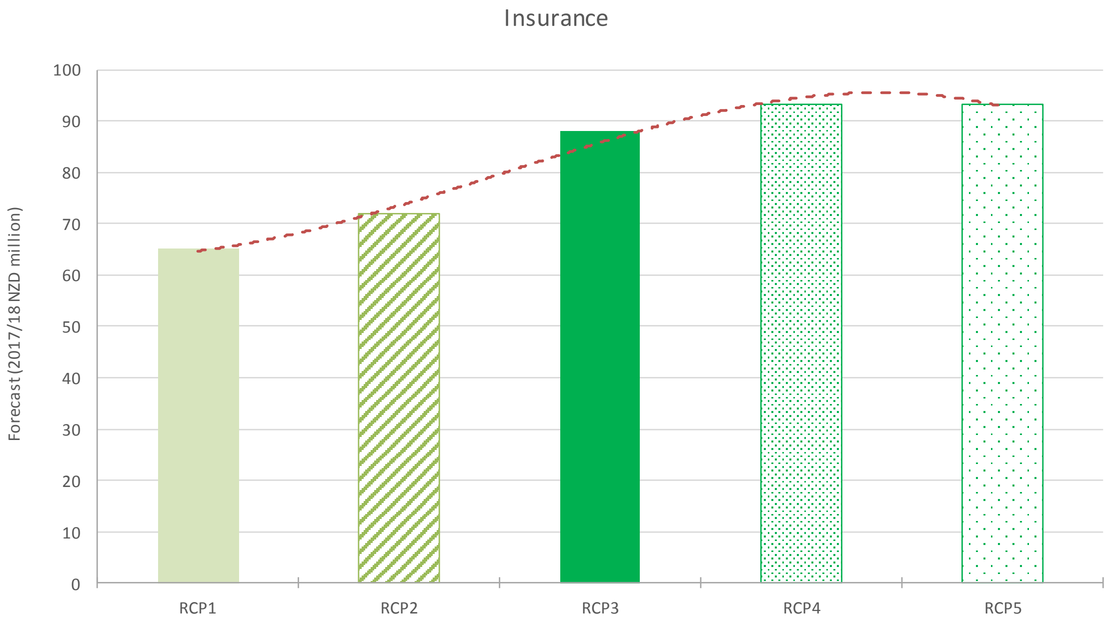



Figure 110 shows the total insurance cost forecasts for the regulatory periods RCP1 to RCP5 indicating the RCP3 step change in an historical and forward-looking context.

**Figure 110 Total Insurance for RCP1 to RCP5**



### *Verification assessment*

We would expect a prudent network service provider to manage its insurance programme by holding insurance policies for specific risk exposures with external service providers, as well as retaining self-insured risk exposures where it retains the risk but has, in theory, set funds aside to compensate for any potential future losses.

A combination of external insurance and self-insurance should provide the best cover for each of the service provider's risk exposures. The predictable low-level losses associated with a specific exposure would be self-insured, forming a first layer of cover up to a defined loss threshold. An external insurance policy would then pay for losses above the specified self-insurance limit, thereby limiting the self-insured losses. In this way, the self-insured element of the insurance cover for a specific risk exposure is the deductible on the external insurance policy.

However, in practice, for those risk exposures where external insurance is not available and/or the insurance premiums are prohibitively expensive, the prudent network service provider has little option other than to self-insure.

**Transpower's risk exposures**

Historically Transpower's network has been subject to losses from the following perils:

- storm damage (including wind, hail and lightning strike);
- earthquake;
- bush fire;
- flood;
- accidental damage (by a third party);
- malicious damage (by a third party); and
- equipment failure.

**Transpower's externally insured policies**

Transpower's insurance programme incorporates several insurance policies held with external insurance providers which cover specified risk areas including:

- Material Damage and Business Interruption (MDBI);
- Submarine Cables;
- General Third-Party Liability (GTPL);

- Directors & Officers (D&O); and
- Minor Insurance Classes, such as vehicle, travel, marine cargo.

**Self-insured policies retained wholly with Risk Reinsurance Limited**

Transpower self-insures several risks using its captive insurance subsidiary Risk Reinsurance Limited (RRL). RRL is a wholly owned subsidiary of Transpower New Zealand Limited that is incorporated under the laws of the Cayman Islands, Monetary Authority Law (MAL). The self-insured risks are:

- Under Deductible Material Damage;
- Under Deductible Submarine Cables and Internal
- Electrical Breakdown;
- Transmission Lines and Underground Cables;
- Liability under the Consumer Guarantees Act; and
- Cyber Risks.

We are satisfied, from the information that The Commission has previously found that RRL is subject to the same or similar prudential tests as provided for in the Insurance (Prudential Supervision) Act 2010.[200]

**Transpower's substantiation of its RCP3 forecast insurance costs**

Transpower applies the base-step-trend forecasting methodology to forecast its RCP3 insurance costs. It has adopted 2017/18 as the base year (baseline annual cost of $13.6 million), with an adjustment of $2.9 million for the effects of atypical and/or one-off insurance events assessed by historical standards for a 5-year base of $78.1 million.

The RCP3 step change increase of $2.7 million relates to an expected cost increase in the Fire Service Levy due to legislative changes. Transpower has applied a trend increase of $7.2 million for asset growth, assuming an annual growth rate of $1.44 million or 9%.

**Table 110 RCP3 forecast insurance costs ($2017/18 million)[201]**

| Component | RCP3 total |
|---|---|
| Base expenditure | $ 78.1 |

200 Commerce Commission (2014), Setting Transpower's individual price-quality path for 2015—2020, [2014] NZCC 23, p. 94

201 Transpower, *RFR041 Base Step and Trend for Opex* model, worksheet BST Ins, 23 July 2018

| Component | RCP3 total |
|---|---|
| Step changes | $ 2.7 |
| Trend - asset growth | $ 7.2 |
| **Total RCP3 insurance** | **$ 88.0** |

*Verification opinion - Insurance*

We consider that Transpower is acting prudently in managing network risk exposures through its existing insurance programme. It is not proposing to make any material changes its approach to managing the identified risk exposures in RCP3.

However, we have not been able to verify Transpower's proposed step change increase in its RCP3 insurance costs because this requires external actuarial expertise.

## Verification opinion - Insurance

Table 111 summarises our verification assessment and opinion.

**Table 111 Verification summary - Insurance**

| Expenditure category | Opex - Insurance | |
|---|---|---|
| **Transpower RCP3 forecast** | $88.0 million | |
| **Recommendation** | **Accept:** | **Do not accept:** $88.0 million |
| **Expenditure outcome assessment** | Consider Transpower acting prudently in managing network risk exposures through existing insurance programmes. | The efficiency of the RCP3 step change cannot be verified because an actuarial opnion is required |
| **Other relevant criteria from ToR** | General evaluation of the base capex proposal and the opex proposal (A1); Specific evaluation of the opex proposal (A2); Evaluation of identified programmes (A3); Evaluation techniques (A5) | |
| **What needs to be done** | N/A | N/A |
| **Potential scope for improvement** | N/A | N/A |

# 9 Deliverability of RCP3 forecast programme of work

Transpower relies upon external contractors for the delivery of it capital and operational works programmes. As such, it is essential that all capex and opex works are integrated and scheduled to avoid or mitigate constraints in delivering the work on time.

In its RCP2 decision, the Commerce Commission expressed concerns with Transpower's management of external service providers. Table 112 presents the Commission's recommended performance management development (PMD) initiatives to address its concerns.

**Table 112 Commerce Commission's resourcing recommendations**

| PMD initiative | Recommendation |
|---|---|
| Undertake strategies to mitigate resource availability risks | • Transpower undertakes regular long-term forecasting of resource requirements against availability and develops mitigation plans to address any resource shortfall;<br>• Transpower assesses the effects on service levels and the economic effects of changes in forecasts due to resource constraints; and<br>• Transpower provides annual reports on resource requirement against availability, any issues that have been identified, the mitigation strategies, and the economic effects of any shortfalls. |

The Commerce Commission considered the PMDs will help address the following areas of concern: [202]

- lack of resource has been cited as a reason for Transpower's inability to deliver some capex and opex work in RCP1 in general, but in some specific areas (such as tower painting) the issue is significant;
- Transpower has identified lack of labour resource as the main reason for its inability to deliver the optimal programme for tower painting; and
- notwithstanding some improvements, Transpower has indicated that in RCP2 it may still not have enough resources to meet the work required to maintain the optimal risk profile in this fleet, causing the backlog in required work to grow.

## 9.1 Developments since RCP2

Since the RCP2 final decision, Transpower has introduced several initiatives to reduce the risk of non-delivery of the works programmes, including through the Planning Optimisation Workstream (POW)

[202] Commerce Commission (2014), Setting Transpower's indivudal price-quality path for 2015-20, Attachment I, clauses I64-I65, p. 213, Document [120]

The POW, introduced as part of the broader Transformation Programme 2, examines the ways in which efficiencies may be achieved in planning and delivery to increase the total capital and operating works completed. This initiative commenced in RCP2, with some benefits expected in the later part of RCP2, and will assist in the delivery of the capex and opex programmes in RCP3.

### 9.1.1 Strategic contracting strategy

This initiative called for revisions to future commercial arrangements with external service providers as the existing maintenance and project installation service contracts end. The changeover is scheduled to happen during the initial years of RCP3.

### 9.1.2 Experience from RCP1 and RCP2

Transpower has advised that two key lessons were taken from the previous regulatory periods:

- ensure continuity in the planning and delivery processes between regulatory periods and avoid resetting schedules in the first year of a new regulatory period - a high delivery in the final year of RCP1 and a low delivery in the first year of RCP2 complicated work scheduling for external service providers and had a flow-on impact across RCP2; and
- top-down adjustments to expenditure forecasts need careful management - the 7.5% productivity adjustment for RCP2 was allocated down to programme level, which required amendments to planning and led to disruptions in delivery. For RCP3, adjustments to whole-of-programme forecasts will be allocated to specific projects and programmes over time.

## 9.2 Governance framework

This section provides a summary of the governance framework applying to Transpower's out-sourcing of the field services component of its total programme of work, including management of external service providers.

### 9.2.1 Programme Delivery Governance

The Programme Delivery Framework[203] describes:

[203] Transpower (2017), GridWorks Plan Milestones for 2016 to 2018 Calendar Years, Document [20]

- function of Grid programme delivery
- activities that are performed by Programme Delivery Managers in planning and managing Grid programmes in the programming and scheduling, and delivery phases (refer Appendix A.2)

Previously, Transpower was focused on delivering major build projects through a dedicated project group. With the shift in asset management strategies that are based on balancing costs, risks and service performance, the delivery model focus has changed to large volumes of Grid renewal work. As such, the work is now predominately programmes that are on-going across multiple regulatory periods, with a smaller number of major build projects to increase Grid capability.

Therefore, the key issues for delivery are:

- consistency and identifying efficiencies in planning and delivery volumetric programmes; and
- effective monitoring and control of Grid programme delivery by service providers, including quality assurance and control.

Governance is based on programme-type based on complexity, size and risk of the works as detailed in Table 113.

**Table 113 Programme governance**

| Type | Description of works | Governance |
|---|---|---|
| 1 | Small-scale, repetitive, low risk, volumetric programmes | Programme Delivery Manager and Portfolio Owner |
| 2 | Complex volumetric programmes | Steering Group at programme level (not individual project level) |
| 3 | Non-volumetric, large scale, high risk, high cost, complex multi-discipline construction | Steering Group at programme or project level e.g. large-scale re-conductoring project<br>Technical or Strategic Advisory Group to suit programme |

Governance is provided by a steering group that has the following responsibilities:

- maintains alignment to corporate strategy and direction and control of a programme to meet its objectives;
- provides decision making and resolves issues; and
- Provides assurance that programmes are being well managed.

Programme Delivery Managers determine the appropriate governance for a given programme and define this in the Programme Management Plan.

### 9.2.2 Processes

Figure 1 in separate Attachment A outlines the elements within the asset planning process used by Transpower. The diagram shows the key inputs into the generic asset planning process that lead into the Decision Framework (refer section 5.6) and then to the development of a portfolio plan for capital and maintenance/opex projects and routine maintenance opex on a 15-year baseline.

At the Decision Framework stage, there are two key considerations for the scheduling of work:

- prioritising solutions based on either the Grid need date or the highest net benefit for risk-based projects; and
- developing a programme management plan where a programme may be brought forward or deferred to integrate into the capital and operational works expenditure programme to support deliverability, with an assessment of the associated risks and costs for any additional maintenance or any deferment.

A central part of the asset planning process is the Programme and Schedule work phase where the annual deliverability of the plans is tested by reviewing known constraints such as:

- scheduled outages
- circuit availability
- resourcing and capability constraints.

The timing of works is adjusted to level the workload for the necessary resources available. For RCP3, Transpower has made adjustments due to delivery constraints to the original RCP3 capex forecast we received dated 15 March 2018 totalling $65 million ($2017/18), primarily for renewal capex for transmission lines and substation protection, and a total of $16 million ($2017/18) in the total opex programme forecast.

### 9.2.3 Management of external service providers

The Programme Delivery Managers have direct accountability for the "*… successful delivery of programmes safely, to time, cost quality and risk requirements as well as ongoing* *programme improvements."*[204] They are required to work within known constraints and dependencies in programming and scheduling work as follows:

- internal and external resources are finite;
- circuit availability and outage management must be arranged with Works Planning.

For the procurement phase of programmes, the Programme Delivery Manager has the following responsibilities:

| | |
|---|---|
| **Works programming and scheduling** | Determine most appropriate approach to design and build<br>Packaging of work<br>Risk management<br>Levelling resource need and ensuring adequate resources in long-term<br>Provide for bulk material procurement through forward planning |
| **Contractual/commercial arrangements in delivery** | The main two panels are:<br>* 'EC Panel' consists of 10 Engineering Consultants for design services<br>* 'Grid Maintenance Services and Project Work' consists of 4 Service Providers for our maintenance and Yours to Lose projects<br>Transpower also has period supply agreements with suppliers (transformers, switchgear, protection equipment, etc) and 5 Service Providers able to contest for the larger projects that are outside the 'Grid Maintenance Service and Project Work' framework.<br>There is a separate panel for asbestos related work. |

Transpower advised that "*… the EC Reset is undertaken every five years to reconfirm service requirements and rates. A Service Provider Reset is undertaken annually to renegotiate contract renewals and confirm prices and rates for the coming delivery year."*[205]

To assist with the delivery phase, Programme Delivery Managers lead the evaluation of grouped tenders, and review Service Provider trends and gaps from a programme perspective and implement solutions. National Delivery Managers monitor Service Provider performance against agreed Key Performance Indicators (KPIs) and Critical Success Factors (CSFs). SS&C manage the procurement processes and relationships with

[204] Transpower (2017), GridWorks Plan Milestones for 2016 to 2018 Calendar Years, section 1.8, p. 5, Document [20]

[205] Transpower (2017), GridWorks Plan Milestones for 2016 to 2018 Calendar Years, section 3.10.1, p. 28, Document [20]

Service Providers during the procurement process, and Project Managers are responsible for work during the investigation and delivery stage.

### 9.2.4 Planned improvements

The current service contracts have been extended out to 2020/21, which is the first year of RCP3. This will be Contact Year 9 (CY9). The review process is currently underway, with the contract renewal starting 2021/22. Transpower is reviewing any regional features for the type of work to be done, to identify where skill sets are needed - by region, by schedule. Transpower advised that some work has already been done in this space.

As part of the RCP3 contract renewal process, Transpower has the following improvements planned:

- standardising contracts by reducing the number of contract variations, and increase the number of standard contracts
- targeted, value/risk based approach to relationship management
- review of stock levels to be more consistent and cost efficient
- reducing indirect costs wherever possible

As part of managing the planned tower painting works programme, Transpower will be looking at their relationship with tower painting suppliers.

## 9.3 Consideration of deliverability

Deliverability issues during RCP2 resulted in a number of network capex programmes and some maintenance being deferred. For the RCP3 expenditure forecasts, with a decrease in substation work, and an increase in secondary systems and transmission lines, deliverability remains a consideration in forecasting RCP3 expenditure.

In developing their RCP3 capex and opex forecasts, Transpower has considered the impact of resource constraints in determining the achievable work volumes and timing, together with any measures that can be taken to mitigate the deliverability risk.

Transpower conducted a deliverability review as part of the RCP3 proposal preparation phase, with the outcomes presented to the Board in May 2018. Five broad risks were identified:

- forecast work in transmission lines and secondary assets projected to increase to a level beyond the service provider capability to deliver

- uncertainties in planning delivery for some portfolios due to their risk or condition-based replacement asset strategy
- reduced service provider capabilities in recent years which affects ability to respond to changes in works programmes
- reducing workloads allocated to service providers could see their workforces rationalised, creating new resource shortages in future
- significant shifts in regional work that may create shortages in available resources

In the expenditure forecasts approved by the Board on 27 September 2018, $58 million was removed from the proposed capex forecast for RCP3 due to deliverability constraints.

### 9.3.1 Substations

The reduced substation work is due to the Outdoor to Indoor Conversion for 33 kV switchyards programme approaching completion by the first year in RCP4, and reduction in the number of power transformer replacements (estimated at $10 million). Work levels around substation buildings and grounds increases during RCP3 with a focus on outdoor switchyard fencing, building roofs and asbestos removal/containment. Transpower expects this planned work for ACS buildings and grounds will be sufficiently resourced.

The only other substation work area to increase during RCP3 is in HVDC renewal programme, replacing capacitor banks, refurbishment of synchronous condenser secondary systems and Static VAr Compensators (SVCs) which is done by specialist service providers.

### 9.3.2 Secondary systems

The availability of technicians is a key issue to service the increased forecast work volumes in secondary protection systems, requiring an additional 20,000 hours, planned for RCP3.

Transpower estimates the reduction in the Outdoor to Indoor Conversion for 33 kV switchyards programme will reduce technician workload by 10,000 hours.

Changes in the original proposed RCP3 expenditure were reported to the Board in May 2018 following a review of the small number of technicians available and a significant shift in the workload from large projects to multiple small projects in regions where technician resources are fewer. Transpower is conducting trials within the Substation management Systems programme during the remaining years of RCP2 to simplify and standardise work to minimise the number of hours required for technicians.

As a result of the technician constraint, the planned secondary asset workload was reduced by $14 million. The availability of protection technicians and protection designers will be a key RCP3 challenge.

### 9.3.3 Transmission lines

The increase in transmission line capex for RCP3 is predominately due to tower painting work, and Transpower has re-phased the work to enable the planned programme of work to be delivered.

Re-conductoring work during RCP3 has been reduced by Transpower from the original works programme following an internal price-quality review, which determined that at the peak of the programme, the work will require over 100 of the 190 line mechanics available from the external service providers. Transpower recognised the risk of this commitment compromising other capex and opex activities, and reduced the forecast capex for re-conductoring through a deliverability adjustment.

However, Transpower acknowledged that "*… retaining and utilising line mechanics efficiently will be a challenge for RCP3.*"

### 9.3.4 Overall phasing of RCP3 works programme

Transpower noted that its RCP2 forecast was heavily loaded towards the early years in the regulatory period. With external service provider contracts being renegotiated at the beginning of RCP3, Transpower is anticipating that productivity may decrease in the initial year of the period. Therefore, a phasing adjustment was applied to the original RCP3 forecast to reduce the planned work at the start of RCP3 and ramp up towards the end of the period.

### 9.3.5 Network maintenance opex

As noted in section 0, Transpower has proposed a deliverability adjustment of $29.1 million applied to the total RCP3 maintenance forecast of $552.1 million, or a 5% decrease.

The unadjusted RCP3 forecast for total network maintenance of $552.1 million represents a $50.1 million or 10% increase on the $502.0 million for RCP2. This increase is largely due to the increase in predictive maintenance (i.e. the step changes from the base year).

## 9.4 Implementation

Transpower has advised us of the following delivery approach for the remainder of RCP2, which highlights the current specific risks, and the Transpower approach to managing the risk associated with resourcing and delivery, and the potential impact on expenditure and Grid output measures.

**Table 114 Delivery approach for remainder of RCP2**

| Risk | Mitigation strategies | Comments |
|---|---|---|
| Resource constraint to deliver work by end RCP2 | Re-grouping & levelling of remaining works in RCP2 considering external workforce capabilities and capacity, for both timing and location | After discussion with service providers, some secondary protection work moved from 19/20 to 18/19 to reduce technician workload in last year of RCP2<br>Some ODID work rescheduled |
| | Early awarding of large project work to core service providers to ensure current level of specialist resources retained for RCP2 and later. | Sole sourcing of ODID & SMS projects to particular service providers to ensure resource retention |
| Transpower unable to get work to market in time for delivery | Use of different procurement processes - Early Contractor Involvement (ECI) and design optimisation (through T2) | |
| Delays in completing initial stages of work e.g.procurement, outages, landowner negotiations | Use of prefabricated buildings to reduce site time for ODID work | 6 of 7 remaining ODID works in RCP2 by this method |
| | Order bespoke materials as early as possible | Monitor and manage items with long lead times |
| | Early engagement on access with landowners and consenting requirements with stakeholders | 18/19 volumetric works have been consented |
| | Pre-work site assessment for asbestos | |
| | Early view on key outages required, recent operational team changes to streamline consideration of grid & market impacts of required outages | |
| Unable to incorporate changes to plan due to revised asset management strategies or customer needs | Advice to customers of delivery issues for RCP2 & early notice required for any necessary work | |
| | Governance to approve any further RCP2 programme changes due to asset management changes | Several transformers advanced from RCP3 with planned ODIDs |

The RCP3 proposal relies largely on business-as-usual programme planning timeframes. The routine planning cycle is on a 3-year rolling horizon, and relies on preceding planning activities being completed first. The current focus is on a deliverability review of the total RCP3 programme of work.

The next step will be the preparation of work integration plans for individual programmes of work. Once the overall approach has been confirmed, detailed programme planning will assess any deliverability adjustments that may be required. Transpower noted that *"… assigning the deliverability adjustment to any one portfolio or programme requires complex trade-off scenarios to level the plan as there are interactions through common field resources, availability of outages and engineering design resources."*[206]

Transpower has developed a timeline of grid works planning activities for the calendar years 2016-18 covering the last years of RCP2, early year of RCP3 and major projects during this 2-year period. Four examples were provide to demonstrate the current programme management planning for RCP3:

- Tower painting[207] - classified as Type 2 programme, bulk of tower painting work offered on sole source (your-to-lose regional basis) to service provider, no programme schedule for tower refurbishment with intention to capture current project schedules by region in Tranpower project planning and management tool, which includes project milestones
- Secondary assets[208] - classified batteries and metering as Type 1 programme, and SMS and protection as Type 2 programme, procurement strategies have been nominated, protection construction phase to be pre-allocated on "your-to-lose" framework
- Re-conductoring programme - detailed Gantt chart for re-conductoring by transmission line scheduled in blocks between 2 October 2017 to 15 April 2025
- Large re-conductoring major project[209] - detailed project management Plan for re-conductoring of Bunnythorpe - Haywards transmission line. This Project management plan describes the project in terms of its background, scope, objectives and the strategies for its implementation. It is a significant project by value and extent of scope, combined with a high number of landowners and other affected

[206] For example, technicians are shared across the Primary Plant and the Secondary Asset portfolios. As the workload decreases in Primary plant and increases in Secondary assets, Transpower has calculated the effect on technician workload and estimated a deliverability adjustment. These adjustments are discussed with the Service Providers.

[207] Transpower (2017), Programme Managmner Plan: Tower Refurbishment, Document [18]

[208] Transpower (2017), Programme Managment Plan: Second Assets Programmes, Document [19]

[209] Transpower (2017), Project Management Plan: Bunnythorpe – Haywards Reconductoring, Document [21]

stakeholders it will require a high level of planning and effective stakeholder communication.

– A key outcome for the project is to safely complete the scope of work to the quality specified with the final project cost to be minimised and in particular to be less than the Commerce Commission approved expected cost of $148.8 million ($2020).

## 9.5 RCP3 August 2018 consultation paper

In the August 2018 consultation paper, Transpower invited submissions on a wide range of issues, including two involving the deliverability of the capex and opex programmes.

For the capex programme, Transpower noted that the "*… RCP3 capex forecast has been reduced … in anticipation of constraints in two skilled labour areas - protection technicians and line mechanics … Reducing this capex forecast reduces the risk that funding levels are set too high but means Transpower still faces challenges in completing the renewal work its modelling indicates as optimal.*"[210]

For opex, Transpower included a deliverability adjustment as there was insufficient confidence whether the forecast uplift in maintenance activity would be delivered. Transpower stated that any efficiency gains made will be re-directed into the maintenance programme instead of reducing costs.

Generally, the responses, whilst acknowledging the labour issues as they apply to the RCP3 proposal, did not support the reduction of capex and/or opex programmes as a consequence. It was in turn suggested that Transpower should be considering ways of addressing the skills shortages and that Transpower should identify the risk associated with any deferred work from the optimal programmes.

## 9.6 Verification assessment

Transpower has good practices for programme management, with a robust framework that has defined roles with responsibilities for the procurement, planning, quality control, risk management and engagement with approved external service providers. The governance establishes a standard management plan framework for each programme and major product.

[210] Transpower (2018), Securing our future 2020-225, Regulatory Control Period 3, p. 28, Document [91]

### 9.6.1 Capital expenditure

We have received examples of Base Capex programmes and a major re-conductoring project that reflect the planning for the efficient and safe delivery of planned works in RCP3. We are satisfied that these examples reflect a deliverability process that is suitable and robust.

We note that the Deliverability Review largely focused on delivery issues for RCP3, with a mitigation strategy that involves reducing programmes and reallocating resources to address revised programme needs.

Our review of renewal Base Capex has identified that beyond RCP3, there are two portfolios that are forecasting significant increases in work beyond current external service provider capabilities. The Deliverability Review is limited to RCP3 and does not address the longer-term view, other than suggesting that workforce retention and awareness of regional requirements needs to be addressed to avoid losing staff. In addition, there is no discussion about risks associated with deferring expenditure from RCP3 into RCP4, or net effect on the overall corporate risk profile of reduced maintenance spend in RCP3 because of current delivery constraints.

We understand that Transpower is intending to update the Deliverability Review noting this limitation, and that consideration is required on the changing resource profiles as the main portfolio spend profiles change and ensuring 'bridging' between RCPs to smooth longer term resource requirements. We acknowledge that the intent of the deliverability adjustments for both opex and capex are high-level only. Transpower has advised that as work is prioritised, the expectation is that the higher risk items are completed resulting in a net reduction in corporate risk profile.

We have seen evidence of Transpower considering deliverability requirements for the anticipated RCP4 increase work in re-conductoring through increased investigations into asset condition, and with planning of wiring gang resources profile (refer section 10.2).

### 9.6.2 Operational expenditure

For the opex deliverability adjustment (refer section 0), Transpower notes that a "*… deliverability adjustment recognises that over a typical period there are likely to be constraints or specific circumstances such that we do not complete all specified work. Therefore, we have not allocated the deliverability adjustment to any particular maintenance category or project*."[211]

[211] Transpower (2018), Maintenance Opex Overview, section 6.3, p. 27, Document [70]

We recognise that Transpower has RCP3 maintenance works that are a pre-requisite for works that are projected in RCP4 and RCP5, particularly with regards to tower painting and re-conductoring, but also that support the implementation of a more risk-informed maintenance approach across the asset categories.

The increase in the unadjusted maintenance expenditure in RCP3 is forecast to be $50 million or approximately 10% higher than that spent in RCP2. The deliverability adjustment of $29 million proposed by Transpower. We note that Transpower has suggested that any efficiency gains will be reinvested.

We believe that as $29 million represents approximately 6% of the RCP2 total expenditure, Transpower should be targeting an efficiency improvement of approximately 5-6% to offset any deliverability constraints, as the increase in RCP3 maintenance is largely due to work that has been previously deferred and is now considered necessary to support RCP4 and RCP5 activities.

### 9.6.3 Summary

We are satisfied that Transpower has considered deliverability of the RCP3 Base Capex and opex programmes appropriately and with rigour and have adjusted the forecast expenditure where necessary to account for any identified delivery constraints. We consider these practices to be in accordance with GEIP.

However, in the absence of the risk of deferring work being quantified, we consider that:

- In response to the submissions to the consultation paper, Transpower adjusted the Protection Systems programme and reduced the deliverability adjustment by $7 million to $58 million. Whilst we accept that the practices used in assessing deliverability of capex programmes is sound, we are of the opinion that for RCP3 base capex, Transpower should be targeting efficiency gains to fund the $58 million (which represents 4.8% of the total base capex) to deliver the programme of works identified for RCP3. We believe this is most important given the delivery challenges Transpower may have to address in RCP4 and RCP5 due to the anticipated significantly higher work volumes in reconductoring and tower painting.
- We consider Transpower should target a 5-6% efficiency improvement in its maintenance activities to be reinvested in the maintenance expenditure in RCP3 to ensure all of the identified work is completed. There is a significant step change in predictive maintenance due to previously deferred work, and preparatory work required to support forecast higher volumes in tower painting and re-conductoring activities during RCP4 and RCP5. We agree with the respondents to the August 2018 consultation paper that Transpower should be addressing any constraints

rather than adjusting the total programme, which will likely defer work into RCP4. We consider that an efficiency gain of 5-6% is comparable with targets set for electricity transmission utilities in Australia.

We also note that the economic benchmarking of Transpower opex against Australian utilities showed Transpower benchmarking comparatively low in the opex partial factor productivity (refer Figure 16). We are of the opinion that an efficiency improvement in opex comparable to improvements set by the AER for Australian utilities is reasonable over RCP3.

# 10 Preparation for anticipated transmission line programme workloads

Section 7.3.1 reviews the proposed Grid Base Capex for transmission lines, focusing on Transpower's RCP3 forecasts, but also identifies the current forecast significant increases in re-conductoring and tower painting work in RCP4 and later.

We noted evidence that Transpower has started to identify the key questions and strategic challenges that will need to be addressed to develop optimal solutions.

## 10.1 Approach

We have sighted high-level preliminary internal papers where Transpower has begun to identify the need for additional long term planning for the tower painting and re-conductoring programmes, particularly given the potential business-wide implications of the significant future increase in size of these programmes. The governance for this project team will include oversight from senior management.

The initial considerations will focus on identifying the key sensitivities and a better understanding of the future uplift in required tower painting and re-conductoring work volume, so that a tailored solution may be developed. In line with the existing asset management framework, Transpower has suggested it will look to review the practices of international utilities and industries who have experience with HV conductors and lattice support towers.

We note that Transpower recognises the need to have a strategy and implementation plan in place prior to the start of RCP3, with an expectation that the project implementation will extend through a 10-year period over RCP3 and RCP4.

## 10.2 Conductor replacement

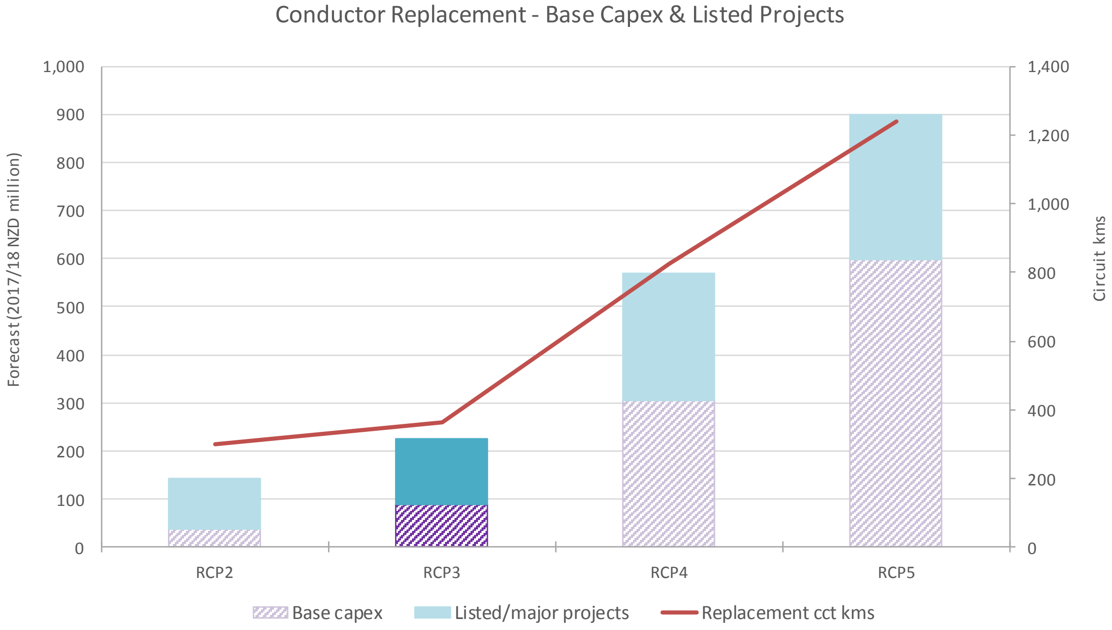
Table 115 and Figure 111 illustrate the current forecast increase in conductor replacement work between RCP2 and RCP5.

**Table 115 Current conductor volumes and capex for RCP2 to RCP5 ($2017/18 million)[212]**

| | RCP2 | RCP3 | RCP4 | RCP5 |
|---|---|---|---|---|
| Conductor "need" replacement circuit kms | 300 | 363 | 825 | 1,238 |
| Conductor replacement volume change | - | 21% | 127% | 50% |
| Total conductor base & listed capex | $142 | $226 | $569 | $898 |

[212] Transpower advice via email 3 Oct 2018

**Figure 111 Conductor expenditure and quantities for RCP2 to RCP5**




Transpower has advised the issues to be investigated will include:

- an international review of electricity utility practices for conductor management and replacement with HV conductors and steel pipelines;
- effectiveness of current inspection and condition assessment techniques and current results for existing HV conductor population;
- current asset health modelling assumptions, data and intervention points;
- risk assessment of deferring replacement beyond the preferred point for intervention;
- current preferred conductor type/specifications;
- extent of replacement - full spans, sections, spans or isolated repairs;
- environmental and landowner constraints, risks and issues; and
- planning and delivery, including how different needs are established and met, key resourcing requirements and risks are identified, as well as any alternative construction techniques and potential outage requirements.

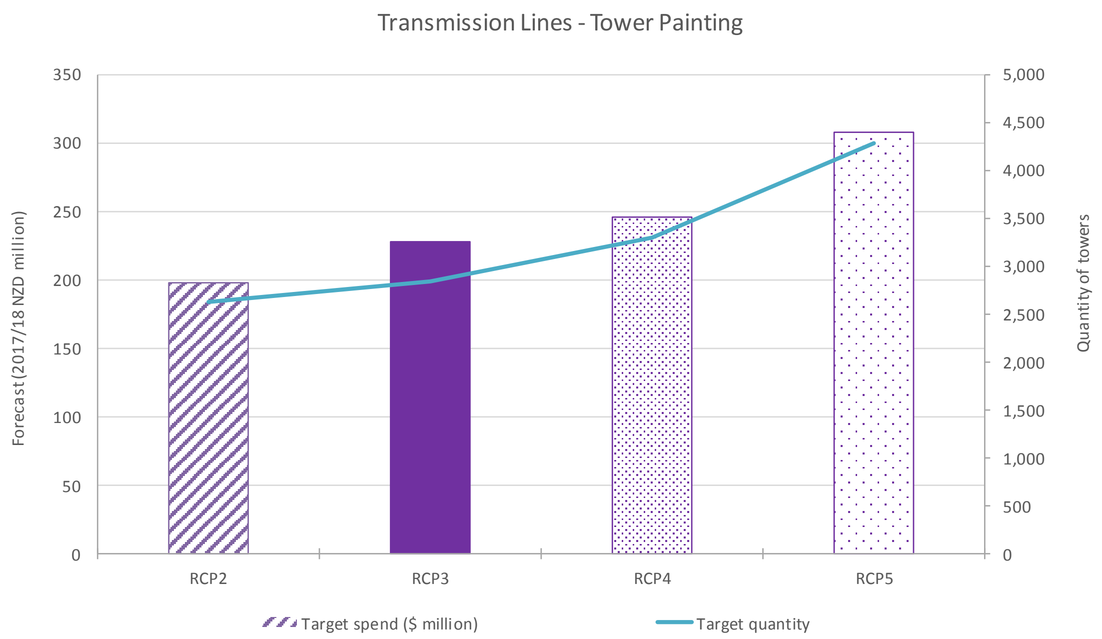
## 10.3 Tower painting

Table 116 and Figure 112 illustrate the current forecast increase in volume and value of tower painting work between RCP2 and RCP5.

**Table 116 Current tower painting volumes and capex for RCP2 to RCP5 ($2017/18 million)[213]**

| | RCP2 | RCP3 | RCP4 | RCP5 |
|---|---|---|---|---|
| Tower painting target quantities | 2,627 | 2,845 | 3,292 | 4,286 |
| Tower painting work volume change | - | 8% | 16% | 30% |
| Tower painting base capex ($ million) | $197.4 | $227.6 | $245.5 | $307.7 |

**Figure 112 Tower painting expenditure and quantities for RCP2 to RCP5**




The issues to be investigated will include:

- a review of practices of international companies with experience of HV towers or other complex steel structures regarding the management of lattice support towers;
- effectiveness of current condition assessment techniques and current results for existing HV steel lattice towers;

[213] Transpower, *Portfolio Management Plan: Transmission Lines - TL Paint*, April 2018, Document [57], section 7.2, tables 12-16, pp. 41-42

- current asset health modelling assumptions and data, and existing corrosion codes and degradation curves;
- risk assessment of deferring replacement beyond the preferred point for intervention;
- environmental and landowner constraints, risks and issues
- planning and delivery, including how different needs are established and met, key resourcing requirements and risks are identified, as well as any alternative construction techniques and potential outage requirements

## 10.4 Verification assessment and opinion

We are satisfied that Transpower is aware of the predicted large increases in volume of conductor replacement and tower painting work in the post-RCP3 period and has started to consider appropriate asset management and delivery strategies to best address the issues.

We understand that the present post-RCP3 forecasts for conductor replacement and tower painting are based on currently available asset condition/in-service data, current asset management strategies and intervention criteria, current asset specifications and asset health modelling. Whilst this framework is appropriate for RCP3 planning and delivery, we believe it will be necessary for Transpower to revisit the various parameters of this framework to verify if the predicted materially higher work volumes for reconductoring and tower painting are justified, as well as whether some of the current assumptions are appropriate or should be challenged.

The evidence we have received from Transpower suggests that they have started the review process, putting in place the appropriate governance arrangements and a target timeline for the strategic review and implementation during RCP3 and RCP4. We agree that the multi-faceted nature of this review will require a detailed examination of the core issues first, clearly understanding the primary questions to be addressed and identifying potential solutions for further investigation. We note at the time of this verification report that Transpower's project currently appears to be focused on asset strategies, whilst program planning and delivery will be addressed at a later phase once the strategies are determined.

# 11 Other key forecasting input assumptions

The purpose of this chapter is to discuss the following key forecasting assumptions applied in Transpower's development of its RCP3 forecasts:

- peak demand forecasting methodology
- capitalisation policy

## 11.1 Our assessment approach

We have assessed these key forecasting input methodologies based on our understanding of GEIP, including approaches used by other electricity network service providers.

## 11.2 Demand forecasting

Every two years, under Part 12 of the Electricity Industry Participation Code, Transpower is required to publish a Grid Reliability Report (GRR) which sets out:

- 10-year forecasts of demand at grid exit points and generation at grid injection points; and
- whether the Grid can reasonably be expected to meet (n-1) security requirements.

Transpower achieves this requirement through the publication of TPRs every one to two years. Peak demand at Grid exit points and for regions, as well as the entire North or South Islands, are key inputs to the planning that underlies a TPR.

### 11.2.1 Transpower's peak demand forecasting methodology

*Key documentation*

We have reviewed Transpower's peak demand forecasting methodology document used in the development of its RCP3 expenditure forecasts, as well as in its TPRs.[214]

This document includes a discussion of the changes made to its forecasting methodology in 2016 in response to a review undertaken by the New Zealand Institute of Economic Research, at the request of the Ministry of Business, Innovation and Employment (MBIE).

[214] Transpower, *Electricity Peak Demand Forecasts - Overview of our peak demand forecast methodology*, September 2016

Transpower has advised that the forecasting methodology used for TPR 2017 and for the recently released TPR 2018, is substantively unchanged from that outlined in the 2016 peak demand forecasting methodology document we have reviewed.

Transpower also advised that in the TPR 2017, it enhanced its treatment of distributed generation by using data from the Reconciliation Manager. In the past, it had focused only on identifying the contribution of the larger distributed generators and used the data available from the Electricity Authority's (EA) Centralised Dataset (CDS) and data portal.

*Overarching approach*[215]

Transpower develops forecasts for peak demand (MW) at the national, island and regional levels using a 'top-down' approach and ensemble of forecasting models. The top down forecasts are complemented with independent 'bottom-up' forecasts at each grid exit point (GXP). A consolidation process is used to reconcile the top-down and bottom-up forecasts.

In terms of its top-down forecasts, Transpower defines 'modelled demand' as Grid offtake demand plus the contribution of embedded generation to demand, minus industrial demand. Future industrial demand and embedded generation are forecast separately.

Transpower also develops forecasts for peak demand by season and region independently. Trough demand forecasts are also developed to test the ability of the Grid to export surplus generation from a specific region or to manage voltage levels.

Transpower appears to use a broad range of data sources in developing its peak demand forecasts, including from government agencies (including the National Institute of Water and Atmospheric Research, Electricity Authority and New Zealand Institute of Economic Research), electricity distribution networks, as well as its own market intelligence.

Transpower's peak demand forecasting methodology ultimately produces a distribution of possible future demand levels, which establishes a range of plausible future peak demand forecasts. From this range, Transpower derives an expected and a prudent (upper) estimate for planning purposes as follows:

- the expected forecast is based on the 50th percentile of the peak demand forecast; and

[215] Ibid, pp 5-9

- the prudent forecast is based on the 90th percentile of forecast peak demand for the first 7 years of the forecast period and beyond that is assumed to grow at the same rate as the P50 peak demand forecast.

### 11.2.2 Transpower's peak demand forecasts for RCP3[216]

Growth in peak demand is a primary driver of E&D capex on the Grid (refer Table 70).

The draft TPR 2018 indicates that peak demand at the national level has remained flat over the last six years and Transpower has generally adjusted its forecasts downwards from year to year.[217]

Transpower has produced updated forecasts for TPR 2018 that were provided to us in an Excel file named 'RFR048 Annual Peak Forecasts'. This spreadsheet provides regional, island and national peak forecasts. Actual peaks since 1997 are also reported in the spreadsheet. Compound annual expected and prudent growth in national grid load over the RCP3 period are 1.3% and 1.6% respectively, continuing the relatively flat peak demand profile in recent years.

However, this relatively flat national peak demand forecast hides different forecast growth rates across regions and GXPs. Transpower's annual TPRs identify major step increases in demand, which are linked to its Grid Backbone planning and Grid Enhancement Approaches identified in the TPRs.

We agree with Transpower that there is broad uncertainty over the uptake rates of new technology and associated consumer energy demand (eg. when consumers will charge their electric vehicles). However, these factors do not have a material effect on the RCP3 peak demand forecasts.

More generally, as outlined in TPR 2017 and discussed in Chapter 7 of our report, Transpower has adopted a scenario approach to developing demand forecasts in relation to its E&D portfolio.

*Implications for Transpower's RCP3 Base Capex and opex forecasts*

For our expenditure review, Transpower's RCP3 peak demand forecasts are of most relevance to the Base Capex component of its E&D portfolio. Our expenditure

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216 Transpower has not used energy throughput or aggregate customer number data in the development of its RCP3 expenditure forecasts. However, Transpower provided energy consumption data and forecasts for regions and islands in an accompanying document file name: RFR047.

217 Transpower (2018), Draft TPR 2018, p 18

verification of the E&D capex forecasts for RCP3 was discussed in Chapter 7 of our report.

In terms of Transpower's RCP3 opex forecasts, its peak demand forecasts are of most relevance to the trend component of its base-step-trend forecasting methodology, specifically the growth dimension. Our review of Transpower's RCP3 opex forecasts was discussed in Chapter 8 of our report.

### 11.2.3 Verification review

We consider Transpower's bottom up/top down peak demand forecasting methodology to be robust, well-documented and consistent with those we have seen used in an Australian electricity network context. Given its incorporation into Transpower's transmission planning process, we consider the methodology is consistent with an expenditure outcome reflecting GEIP.

Further, we consider that Transpower is enhancing its peak demand forecasting methodology over time, including in response to the challenges associated with electricity demand forecasting, particularly the highly uncertain potential future effects of new and emerging energy-related technologies.

We have not verified Transpower's energy volume forecasting methodology given it is not used in the development of its RCP3 Base Capex and opex forecasts.

## 11.3 Capitalisation policy

We understand that Transpower's statutory and regulatory accounts, including its Information Disclosure Statements, are prepared using the same capitalisation policy.

We are not aware that the Commerce Commission raised any concerns regarding Transpower's capitalisation policy in assessing its RCP2 expenditure proposal. Further, Transpower has advised that it has not made any material changes to its capitalisation policy during RCP2 such that the basis of its RCP3 expenditure forecasts is different to its reported RCP2 expenditure.

However, we are aware that Transpower and the Commission have been liaising regarding the forthcoming International Financial Reporting Standard change regarding the capitalisation of leases (IFRS 16), which impacts Transpower's ICT and Business Support expenditure in RCP3. This forthcoming change has not yet been reflected in the RCP3 ICT and Business Support forecast data that Transpower has provided to us and hence forms no part of our verification opinion.

# 12 Price-quality testing of Transpower's RCP3 expenditure proposal

The purpose of this chapter is to provide our opinion on the overall reasonableness of the price-quality testing that Transpower has applied in the development of the RCP3 expenditure forecasts by:

- summarising the basis of Transpower's price-quality testing, including chosen expenditure areas for testing; and
- assessing the outcomes of the price-quality testing and its impact on the RCP3 expenditure forecasts.

Transpower consulted on its price-quality testing in the August 2018 stakeholder engagement on its RCP3 proposal.

## 12.1 Key features of Transpower's price-quality testing

Transpower has undertaken what it refers to as price-quality testing of its RCP3 baseline expenditure forecasts.

The purpose of this high level testing process is to assess the revenue/price impact of adopting lower and higher risk options for specified expenditure areas compared to RCP3 baseline expenditure, recognising the potential service quality trade-offs of these options.

To this end, Transpower has identified the following seven expenditure areas:

- Area 1: Solution prioritisation
  - this involves several trade-off options applied across the power transformer, insulator, tower panting, protection and metering programmes, with relatively lower and higher risk trade-off options tested.
- Area 2: Tower painting
  - this involves either increasing or deferring tower painting and recoating relative to the baseline programme.
- Area 3: Re-conductoring
  - involves either funding an additional 63 km of base capex re-conductoring (assuming deliverability challenges are resolved) or deferring re-conductoring of the Urban Auckland section of OTA-WKM-A & B.
- Area 4: Grid enhancement

  - involves either the lower risk option of shifting E&D funding into the low incentive rate capex pool, or adopting the low E&D forecast scenario, with the capex trigger mechanism used to fund pre-defined projects if the specified trigger conditions are met.

- Area 5: Standards and specifications
  - involves testing potentially material reductions in the robustness and reliance of network assets through a loosening in existing standards and specifications.

- Area 6: ICT (summary scenarios)
  - involves testing the effect of moderately lower capex (7% reduction) through the cancellation of enhancements to capability areas and deferrals, or materially lower capex (14% reduction).

- Area 7: Asset maintenance
  - involves testing of higher expenditure to improve asset management, including scope increase, or implementing maintenance deferrals.

The quality dimensions Transpower has used in the price-quality testing are presented in the table below.

**Table 117 Quality dimensions**

| Network service | Asset quality | Asset risk | Organisational capability |
|---|---|---|---|
| **Reliability** – probability of experiencing an interruption to supply | **Build standard** – quality of the components of the grid as built | **Performance** – risk to network performance | **Customer services** – attributes of customer service not captured by network performance e.g. communications |
| **Restoration** – time taken to restore supply following an interruption | **Health** – current or forecast consideration of grid components | **Safety** – risk to workers or public | **Supporting infrastructure** – capability, reliability and efficiency of supporting tools and processes |
| **Built capacity** – energy transfer ability and level of redundancy | | **Environmental** – risk of environmental harm | **Business improvement** – rate of investment (eg innovation, effectiveness and efficiency) |
| **Available capacity** – availability of built capacity | | | |

Transpower has estimated the revenue impact of the identified options under each expenditure area in NPV terms for each of RCP3, RCP4 and RCP5. Most of the expenditure increases or reductions that are tested, including the large ones, appear to be capex-related, with the recovery of the Base Capex allowance generally spread over the long term with a less direct effect on prices in the short to medium term. In practice, this means that the revenue/price effects of the price-quality testing are relatively small.

As previously noted, these specified price-quality expenditure areas were the subject of stakeholder consultation in August 2018. As part of this consultation, Transpower sought feedback on the following four price-quality positions/scenarios:

- Draft Proposal – baseline with high delivery confidence and some asset management compromises.
- Enhanced – less constrained capital programme and enhanced maintenance outcomes, carrying higher deliverability risk offset by a softer long-term price path.
- Tightened – more solution prioritisation options, tightening pressure on standards and reduced ICT investment to reduce RCP3 prices, offset by lower quality and less resilient network over time.
- Further Tightened – further tightening of expenditure through deferred investment to reduce RCP3 prices, but likely to result in higher price path beyond 2025 (relative to the other options) with higher network risk.

The Draft Proposal option is Transpower's baseline RCP3 expenditure forecasts that we have reviewed in this report.

Transpower indicated in its August 2018 consultation paper that stakehdoler feedback will enable it to decide whether to amend its RCP3 expedniture proposal to shift the price-quality balance. Transpower links any such shift to changes in its proposed service performacen and asset health targets.[218]

### 12.1.1 Verification opinion

We consider Transpower's price quality testing to be well-intentioned. The expenditure areas that Transpower has identified appear reasonable, including several significant expenditure programmes (eg. tower painting and re-conductoring).

However, we do not consider Transpower's approach to be strictly price-quality testing. Rather, what Transpower appears to be doing is quantifying the revenue/price effects

218 Transpower (2018), Securing Our Energy Future 2020-2025, Regulatory Control Period 3, p 51

of re-calibrating its network risk tolerances, by reducing or increasing expenditure in certain programmes (eg re-conductoring, ICT), with only a qualitative assessment made of the effect on the various quality dimensions of service. Hence, there is no quantification of the economic consequences of changing risk tolerances.

We recognise the difficulty of quantifying explicit price-quality trade-offs. This includes because modest cuts in expenditure can be made with little or no immediate or short-term impact on service performance or asset health. It may only be over a longer period when the cumulative effects of the expenditure cuts are revealed through service degradation and/or it becomes apparent that a bow wave of 'catch-up' work is required to prevent further and highly disruptive service degradation presenting.

Considering these difficulties, there is a risk that because Transpower's price-quality testing is effectively being applied as a final gateway to determine the RCP3 forecasts, it creates the potential for the process to override the risk assessments (and price-quality testing) previously incorporated into asset management and planning decisions and ultimately the RCP3 baseline expenditure forecasts. In practice, we are concerned that the high level price-quality testing as it is currently developed lacks the rigour to play this role.

In response to our concern, Transpower has argued that the loop between whole-of-proposal price-quality testing and underlying planning will be closed over time and should mature for its RCP4 proposal. In its view, such testing has a valid role to play as long as Transpower is applying it cautiously and recognising that it can reprioritise expenditure within period and change tack at each new RCP. More generally, price-quality testing has helped Transpower understand trade-offs at an overall level and has the potential to do the same for customers, stakeholders and the Commission. In Transpower's view, the price-quality testing allows it to take a bigger picture perspective on inter-related expenditure issues that cannot really be addressed through asset class-by-class analysis.

Importantly, this issue links back to Transpower's asset health modelling development initiatives over RCP2, which are attempting to quantify and link network-related risk tolerances to the economic consequences of these risks, including safety, reliability and environmental. We consider this asset modelling approach is likely to be a more powerful tool in the longer term to robustly assess price-quality trade-offs than the proposed high-level RCP3 price-quality testing. This would also allow the embedding of the price-quality testing in Transpower's asset management decision-making framework.

In forming our opinion, we recognise that the network risk tolerances Transpower accepts in investing in and operating its network are appropriately set by the Board/Executive Management having regard to all relevant legislative and regulatory obligations, as well as guidance from its owner. It is how these risk tolerances are considered in Transpower's asset management framework and flow through to the expenditure programme forecasts that is our primary concern.

Finally, we have some concerns that it will be very difficult for customers to understand the price-quality trade-offs because it is only the expenditure/price/revenue outcome that is clear in the trade-off. In our view, the primary concerns of most directly connected transmission network customers will be the existing and prospective network service they receive and the price they are required to pay for it. It is far more difficult for these customers to provide an opinion on how potential changes in Transpower's network risk tolerances associated with changes in certain expenditure programmes will impact on them.

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# 13 Key issues for Commerce Commission's consideration

This chapter identifies several important issues regarding Transpower's provision of information during our verification review and several expenditure programmes where we consider closer scrutiny by the Commission is warranted.

- E&D portfolio forecasting methodology
- HVDC upgrade
- RCP4 and RCP5 Grid tower painting
- Grid Capex: Transmission line painting programme
- Grid Capex: Transmission line conductor replacement programme
- Insurance programme step change
- Asset Management & Operations
- Proposed new asset health grid output measures and RCP3 service performance targets

## 13.1 Transpower's information provision

We consider that Transpower has provided us with the type and depth of information needed to prepare our verification report.

This information has generally been provided in a timely manner recognising the tight project timeline and that this project is running concurrently with Transpower's broader RCP3 preparation processes. The information database and sharing process is explained in Chapter 2 of our report.

Transpower also made available to us staff with appropriate subject matter expertise across all areas of our review scope as part on our on-site visits.

## 13.2 Expenditure programmes and grid output measures requiring closer Commission scrutiny

In this section, we summarise the reasons why we consider there are several expenditure programmes that the Commission should subject to closer scrutiny during its RCP3 expenditure assessment.

### 13.2.1 E&D portfolio

As discussed in Chapter 7, Transpower has adopted a scenario-based E&D envelope forecasting methodology for RCP3 that aims to consider an expenditure range for projects characteristically uncertain in scope and timing and dependant on external triggers before proceeding.

We agree with Transpower that the high/low scenario is a sound approach as a first-pass for determining a reasonable forecast range and note that Transpower has developed business rules for the identified and unidentified project allowances, including the potential for cost savings under the low scenario.

Several respondents to the Transpower RCP3 2018 consultation paper commented on the forecasting approach adopted for the RCP3 E&D forecast and the opinion was generally supportive whilst acknowledging the inherent difficulty in forecasting due to uncertainties in system needs.

We consider the Commission should review Transpower's RCP3 E&D forecasting methodology to satisfy itself regarding the business rules Transpower has used in developing the RCP3 forecast. In doing so, we believe Transpower's RCP3 E&D forecasting methodology is sound and more robust than the one used to develop its RCP2 forecasts.

### 13.2.2 HVDC upgrade

We consider Transpower has taken a prudent approach to estimating the RCP3 forecast costs for the upgrade of its HVDC link, recognising the atypical nature of these assets and single equipment supplier.[219]

Transpower's August 2018 Consultation Paper raised the possibility of the RCP3 forecast expenditure for the HVDC link being treated as a Listed Project rather than as Base Capex and asked whether its customers preferred this option.[220]

Contact Energy, Genesis Energy, Mercury NZ, Fonterra Cooperative Group appeared to support for a Listed Project status for the HVDC link expenditure.[221]

219 The costs of the HVDC link are borne only by South Island generators.

220 Transpower (2018), Securing our Energy Future 2020–2025 Regulatory Control Period 3, p 60

221 Various submissions located on Transpower's web site: https://www.transpower.co.nz/keeping-you-connected/industry/rcp3/rcp3-submissions

In our view, the HVDC RCP3 project costs potentially satisfy the Listed Project criteria set out in Clause A10 of the Evaluation Criteria as follows:

(a) it will require capital expenditure greater than $20 million;

(b) it is reasonably required by Transpower;

(c) there is at least one asset that is likely to be commissioned in the regulatory period;

(d) the Base Capex forecast to be incurred is in relation to asset replacement, asset refurbishment, or both asset replacement and asset refurbishment;

(e) it has an anticipated commencement date within the regulatory period but that cannot be forecast with specificity; and

(f) it is not already accommodated in the Base Capex allowances for the regulatory period.

As discussed in Chapter 7, Transpower is currently proposing to accommodate the HVDC RCP3 forecast costs in its Base Capex allowance, so paragraph (f) of the criteria is not strictly satisfied at this point. More significantly, our understanding of Transpower's planning of the HVDC upgrade is that it is has an anticipated commencement date within RCP3 with a reasonably high degree of certainty. Hence, paragraph (e) of the criteria is not likely to be satisfied.

In light of this uncertainty and given the outcomes of Transpower's August 2018 stakeholder engagement, we consider that the regulatory treatment of the RCP3 HVDC forecast costs is a matter for closer scrutiny by the Commission.

### 13.2.3 Grid Capex: Transmission line painting programme

Transpower is continuing to investigate and trial new painting technologies and applications with a view to optimising future costs. These costs are reflected in increased asset management and maintenance expenditure over RCP3. We view this expenditure as prudent investment in opex trading off a significantly higher forecast in tower painting capex costs from RCP3 through to RCP5, and not peaking until after 2040.

A focus on investment is prudent in RCP3 to achieve ways to increase repainting life cycles.

A review of deliverability implications of the future painting programme is also warranted.

### 13.2.4 Grid Capex: Transmission line conductor replacement programme

Transpower has confirmed this outlook of expenditure peaking around 2050, which will require around 180% additional revenues compared to the recovery of costs in the RCP2 period. This view beyond RCP4 is important to RCP3 expenditure in terms of supporting Transpower's investment in asset strategies for improving the AH forecasting model, condition inspections and knowledge of conductor assets, and the planning, scheduling and deliverability of re-conductoring projects.

Like the tower painting programme noted above, we consider the Commission should give closer scrutiny to asset management approaches and future deliverability issues associated with Transpower's RCP3 re-conductoring programme and beyond.

### 13.2.5 Insurance programme step change

We consider that Transpower has taken a prudent approach to forecasting its RCP3 forecast insurance costs. However, the proposed large step change in these costs, which Transpower has argued relates to a tightening in international insurance markets, cannot be verified in terms of GEIP because an expert actuarial opinion is required.

We understand that Transpower has engaged an actuarial expert to provide the necessary opinion regarding the efficiency of its forecast RCP3 costs.

We consider the Commission should closely scrutinise this actuarial opinion when submitted by Transpower as part of its RCP3 proposal.

### 13.2.6 Asset Management & Operations

Transpower has provided a high-level analysis of the projected benefits from the proposed RCP3 expenditure in ICT base capex, including an analysis of the projected savings in both Base Capex and opex across various expenditure categories. It identifies $8 million in savings in Asset Management and Operations that we have been unable to verify.

We have sufficient information available to demonstrate the changing role of the Asset Management & Operations group from a focus on large capital works to renewals/maintenance. Howevet, we have not been able to assess the effectiveness of the contribution of the FTEs to the maintenance programme.

To provide the Commission with greater confidence regarding the efficiency of Asset Management and Operations, as well as the effectiveness of the relatively new Grid Operating Model, we believe that Transpower should develop a business case detailing the number of FTEs in each division, their role and contribution to planning of the maintenance programme and a projected long-term benefit in monetary terms that is reasonably expected from their planning and investigative work.

### 13.2.7 RCP3 asset health grid output measures and RCP3 service performance targets

As discussed in Chapter 5, Transpower has engaged extensively in the development of its proposed grid output measures for RCP3 and, as part of its August 2018 consultation the associated grid output targets.

Also, as part of its August 2018 consultation, Transpower presented its proposed new asset health measures and targets for consideration and feedback. These new asset heath measures are subject to ongoing close engagement between Transpower and the Commission, including a pilot trial being conducted over the remainder of RCP2.

In light of this, we consider the Commission will continue to be required to provide close scrutiny of the incorporation of these new asset health measures in Transpower's RCP3 proposal as revenue-linked grid output measures, including the detailed design features of the associated incentive arrangements.

In addition, we have not verified details regarding adjustments made to historical average data in setting Transpower's service performance grid output RCP3 targets and consider that this is required prior to the commencement of RCP3 to provide greater confidence to stakeholders regarding the levels of the targets.

# A. TOR's Evaluation Criteria

## A.1 Purpose

This attachment provides more detail on the evaluation criteria that the verifier is to apply in undertaking the verification.

The evaluation criteria for the base capex proposal largely reflect the evaluation criteria in Schedule A of the Capex IM, which the Commission must apply when assessing Transpower's base capex proposal. The evaluation criteria for the opex proposal are consistent with those for the base capex proposal where appropriate and include further criteria that are specific to assessing opex proposals. While some of the criteria below apply just to base capex, others just to opex, and some to both, the verifier should, where relevant, consider opex and base capex together given the potential cost trade-offs between opex and base capex.

In applying these evaluation criteria, the verifier should exercise its professional judgement about the relative consideration to give to each of the criteria, having regard to the proportionate scrutiny principle described at paragraph 19.6 above.

## A.2 Definitions

Terms in bold are defined in the Capex IM.

### A.2.1 General evaluation of the base capex proposal and the opex proposal

The verifier will have regard to the following factors when evaluating the base capex proposal and the opex proposal:

(a) the reasonableness of the key assumptions relevant to base capex and opex relied upon, including-

(i) the method and information used to develop them;

(ii) how they were applied;

(iii) for the base capex proposal, their effect on the proposed base capex allowance; and

(iv) for the opex proposal, their effect or impact on the proposed opex allowance.

(b) whether policies regarding the need for, and prioritisation of, projects and programmes demonstrate a risk- based approach consistent with good asset management practice and are directed towards achieving cost-effective and efficient solutions;

(c) the dependencies between the proposed grid output measures and the proposed base capex allowance and proposed opex allowance at the level of the grid and for each base capex category and opex category;

(d) the dependencies between the proposed grid output targets and the proposed base capex allowance and proposed opex allowance at the level of the grid and for each base capex category and opex category;

(e) the extent to which the grid output targets were met in the previous regulatory period;

(f) the overall deliverability of the proposed base capex and opex during the current regulatory period;

(g) the reasonableness and adequacy of any models used, including but not limited to asset replacement models, to prepare the proposed base capex allowance and proposed opex allowance including -

    (i) inputs to the model; and

    (ii) the methods used to check the reasonableness of the forecasts and related expenditure;

(h) the reasonableness of the key assumptions, key input data and forecasting methods used in determining demand forecasts;

(i) the appropriateness of using those demand forecasts and other key assumptions in determining the proposed base capex allowance and proposed opex allowance;

(j) the extent to which Transpower has demonstrated the type of efficiency improvements obtained in the current and previous regulatory periods; and

(k) the extent to which Transpower has demonstrated the scope for efficiency improvements during the regulatory period in question.

### A.2.2 Specific evaluation of the opex proposal

In addition to the criteria provided above in clause A1, when evaluating the opex proposal, the verifier will review and assess:

(a) any other opex drivers not covered by the key assumptions that have contributed the proposed opex allowance, and whether the opex associated with these drivers is consistent with the expenditure outcome described in paragraph 3.2;

(b) the reasonableness of the methodologies used in establishing the proposed opex allowance (such as cost benchmarking or internal historic cost trending), including the relationship between the proposed opex allowance and the proposed base capex allowance;

(c) the reasonableness of any opex reduction initiatives undertaken or planned during the current regulatory period or RCP3; and

(d) the reasonableness of any efficiencies built into the proposed opex allowance as a result of the investment programme carried out under RCP1 and RCP2.

## A.3 Evaluation of identified programmes

In evaluating the base capex proposal and the opex proposal, the verifier will undertake a review of each identified programme (as determined in accordance with the identified programmes criteria specified by the Commission on 28 March 2018), and such a review may include evaluation of at least -

(a) whether policies regarding the need for the identified programme and its priority demonstrate a risk-based approach consistent with good asset management practice and were applied appropriately;

(b) whether other relevant policies and planning standards were applied appropriately;

(c) Transpower's process to determine the identified programme's reasonableness and cost-effectiveness;

(d) Transpower's internal processes for challenging a need for an identified programme and the possible alternative solutions;

(e) how grid outputs, key drivers, assumptions, and cost modelling were used to determine its forecast capital expenditure;

(f) the capital costing methodology and formulation, including unit rate sources and the quantum of included contingencies;

(g) the effect of its forecast capital expenditure on other cost categories, including the relationship with operating expenditure;

(h) the effect of its forecast operating expenditure on other cost categories, including the relationship with capital expenditure;

(i) links with other projects or programmes, whether proposed or in progress; and

(j) the proposed approach to procurement of associated goods and services.

## A.4 Criteria for considering the low incentive rate base capex allowance

Where the verifier considers that a base capex project or base capex programme proposed by Transpower as a low incentive rate base capex project is likely to require capital expenditure greater than $20 million, it will take into account at least the following criteria in evaluating whether the base capex project or base capex programme should be specified by the Commission as a low incentive rate base capex project:

(a) the extent to which Transpower has demonstrated that it has considered whether there are viable alternatives that meet the same investment need; and

(b) the magnitude of cost uncertainty of the base capex project or base capex programme demonstrated by Transpower.

## A.5 Evaluation techniques

In undertaking the evaluations described in clauses A1–A4, A9 and A10, the verifier may employ one or more of the following techniques:

(a) process benchmarking;

(b) process or functional modelling;

(c) trending or time-series analysis;

(d) high level governance and process reviews;

(e) internal benchmarking of forecast costs against costs in the current period;

(f) project and programme sampling;

(g) critiques or independent development of -

- (i) demand forecasts;
- (ii) labour unit cost forecasts;
- (iii) materials forecasts;

(iv) plant forecasts; and

(v) equipment unit cost forecasts; and

(h) any other technique or approach that the verifier considers appropriate in the circumstances.

## A.6 Criteria for considering grid output measures

The verifier will take into account at least the following criteria in considering grid output measures:

(a) the extent to which a measure is a recognised measure of either or both of the following things:

(i) risk in the supply of electricity transmission services; and

(ii) performance of the supply of electricity transmission services;

(b) the relationship between a measure, base capex, major capex and operating expenditure including the extent to which the relationship can be quantified; and

(c) the extent to which the measure aligns with the business processes used by Transpower in its supply of electricity transmission services.

## A.7 Criteria for considering revenue-linked grid output measures

In addition to the criteria specified in section 13.2.7A.6, the verifier will take into account at least the following criteria in considering revenue-linked grid output measures:

(a) the extent to which a measure is a recognised measure of grid outputs that are valued by consumers;

(b) the strength of the relationship between a measure and base capex; and

(c) whether a measure is quantifiable, controllable by Transpower, auditable and replicable over time.

## A.8 Criteria for considering matters relating to revenue-linked grid output measures

The verifier will take into account at least the following criteria in considering caps, collars, the grid output incentive rate and grid output targets in respect of each revenue-linked grid output measure:

(a) the value that consumers place on that grid output measure and the relationship between this value and the proposed grid output incentive rate;

(b) quantification of relationship between base capex and the grid output both -

- (i) within the regulatory period in question; and
- (ii) over the longer term;

(c) the extent of the likely effect of factors unrelated to investment that may affect the grid output, such as -

- (i) natural degradation in asset condition;
- (ii) impact of changes in loading of the grid; and
- (iii) extreme weather events;

(d) the plausible range of grid outputs likely to be delivered taking into account factors described in paragraphs (b) and (c);

(e) the relationship between the range described in paragraph (d) and the proposed caps and collars; and

(f) the impact on return on capital implied by both the range described in paragraph (d) and the application of the proposed cap, collars and grid output incentive rate.

## A.9 Criteria for considering base capex allowance adjustment mechanism

Where the verifier evaluates whether any E & D base capex projects or E & D base capex programmes are subject to uncertainty such that a base capex allowance adjustment mechanism should be specified by the Commission in respect of such projects or programmes, the verifier will take into account at least one of the following criteria:

(a) the cost and timing uncertainties of any individual E & D base capex project or E & D base capex programme;

(b) the extent to which any timing uncertainties of an E & D base capex project or E & D base capex programme are linked to a certain level of demand or connecting new generation;

(c) any other relevant drivers of E & D base capex that may influence project or programme need or uncertainty.

## A.10 Criteria for considering listed projects

Where the verifier evaluates whether a base capex project or base capex programme meets the criteria specified to qualify as a listed project, the verifier will assess whether it is a base capex project or base capex programme that meets all of the following criteria:

(a) will require capital expenditure greater than $20 million;

(b) is reasonably required by Transpower;

(c) has at least one asset that is likely to be commissioned in the regulatory period;

(d) for which the base capex forecast to be incurred is in relation to asset replacement, asset refurbishment, or both asset replacement and asset refurbishment;

(e) has an anticipated commencement date within the regulatory period but that cannot be forecast with specificity; and

(f) is not already accommodated in the base capex allowances for the regulatory period.

# B. Relied-upon Documents

We have relied upon the following documents to support our verification of the development of the Transpower Independent Price-Path proposal for the RCP3 regulatory period.

## B.1 Transpower documents

### B.1.1 Corporate

1. Transpower, *Statement of Corporate Intent 2017/18*, 1 July 2017
2. Transpower, *Transmission Tomorrow*
3. Transpower, *Powering Auckland's Future*
4. Transpower, *RCP3 Price/Quality Trade-off*, Presentation to Board, 24 May 2018 [Confidential]

### B.1.2 Asset management

5. Transpower, *Grid Business Strategic Plan: 2017-2027*, 1 December 2017
6. Transpower, *Grid Asset Management System Framework*, April 2018
7. Transpower, *Strategic Asset Management Plan*, April 2018
8. Transpower, *Asset Management Plan 2017*
9. Transpower, *Portfolio Framework*, March 2018
10. Transpower, *Maintenance Planning Framework*, April 2018

### B.1.3 Benchmarking

11. Transpower, *Historical Performance of Transpower's Grid Output Measures*, May 2018
12. Parsons Brinckerhoff Australia, *Opex benchmarking review (RCP1)*, 10 February 2011
13. Parsons Brinckerhoff Australia, *Operating Expenditure Benchmarking (RCP2)*, 25 October 2013

### B.1.4 Deliverability

14. Transpower, *Service delivery RCP3 deliverability, and delivery performance presentation to Independent Verifier*, 14 May 2018

15. Transpower, *Procurement, Works Delivery and RCP3 Deliverability Review*, April 2018

16. Transpower, *RCP3 Deliverability Review*, June 2018

17. Transpower, *Grid Works Plan Milestones for 2016 to 2018 Calendar Years*, 15 March 2017

18. Transpower, *Programme Management Plan: Tower Refurbishment (Including TL Paint)*, June 2017

19. Transpower, *Programme Management Plan: Secondary Assets Programmes*, March 2017

20. Transpower, *Programme Delivery Framework: A Consistent Approach to Planning and Managing Grid Programmes*, 30 June 2017

21. Transpower, *Project Management Plan: Bunnythorpe - Haywards Reconductoring*, 29 March 2017

### B.1.5 Demand forecasting

22. Transpower, *Electricity Peak Demand Forecasts: Overview of our Peak Demand Forecast Methodology*, September 2016

### B.1.6 Expenditure modelling

23. Transpower, *RCP3 Capex and Opex forecast_pre-verifier 15 March 2018* Excel model, 30 April 2018

24. Transpower, *RCP3 Capex and Opex forecast_pre-verifier 15 April 2018* Excel model, 1 June 2018

25. Transpower, *RCP3 Opex forecast_pre-verifier 15 April 2018_with maintenance overall deliverability adjustment* Excel model, 25 July 2018

26. Transpower, *Grid RR RCP2 and RCP3 by Project expenditure model*, 7 June 2018

27. Transpower, *RCP2 Capital Performance review vs RCP2 Base capex baseline*, presentation to Board meeting, May 2018

28. Transpower, *RCP3 governance steps summary table*, September 2018

29. Transpower, *RT01 Capex and Opex Forecasts post September Board VALUES* Excel model, 28 September 2018

### B.1.7 Grid E&D capex

30. Transpower, *Enhancement and Development Base Capex: Response to Draft Decision*, 25 June 2014

31. Transpower, *Transmission Planning Report 2017*, July 2017

32. Transpower, *Transmission Planning Report 2018*, initial draft version 0.1, 12 July 2018

33. Transpower, *Transmission Planning Report - Enhancement and Development Portfolio*, April 2018

34. Transpower, *Enhancement and Development Portfolio Briefing*, 16 May 2018

35. Transpower, *Project Summary Document - Bombay Interconnection*, 18 June 2018

36. Transpower, *Initial Business Case: BOB 220/110 kV Interconnection Transformer - Capex investigation*, 11 June 2018

37. Transpower, *Project Summary Document - Hangatiki transmission capacity*, 27 March 2018

38. Transpower, *Initial Business Case: HTI Grid Constraints*, 18 June 2018

39. Transpower, *Project Summary Document - Benmore-Roxburgh Transmission Capacity*, 18 June 2018

40. Transpower, *Project Summary Document - Kawerau 110 kV Ring Bus*, 7 June 2018

41. Transpower, *Project Summary Document - Black Point Single Supply Security*, 7 June 2018

### B.1.8 Grid R&R capex

42. Transpower, *Overview of Asset Health and Asset Criticality for investment planning*, 15 May 2018

43. Transpower, *Power Transformers: Asset Class Strategy, TP.FS 20.01: Issue 2*, January 2018

44. Transpower, *Outdoor 33 kV Switchyards: Asset Class Strategy, TP.FS 01.01: Issue 2*, January 2018

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# C. Verification certificate

I certify that:

1. The RCP3 Expenditure Proposal prepared by Transpower has been verified by Synergies Economic Consulting and a verification report prepared in accordance with Terms of Reference for Verification of Transpower's RCP3 proposal dated 16 April 2018; and

2. The findings from this verification are documented in the report titled *Independent Verification report - Transpower's RCP3 expenditure proposal (2020-25)* and dated 11 October 2018 prepared by Synergies Economic Consulting and GHD Advisory.

This certificate is provided in accordance with the requirements of a Deed Relating to the RCP3 Independent Verification between Synergies Economic Consulting, Transpower and the Commerce Commission.

Matt Rodgers

Director

Synergies Economic Consulting

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I certify that:

1. GHD Advisory assisted Synergies Economic Consulting by reviewing and assessing the relevant technical aspects of the RCP3 Expenditure Proposal prepared by Transpower, including verifying capital and operating programmes; and

2. The findings from this verification are documented in the Synergies Economic Consulting report titled *Independent Verification report - Transpower's RCP3 expenditure proposal (2020-25)* and dated 11 October 2018

Jeff Butler

Technical Advisor – Regulatory

GHD Advisory