

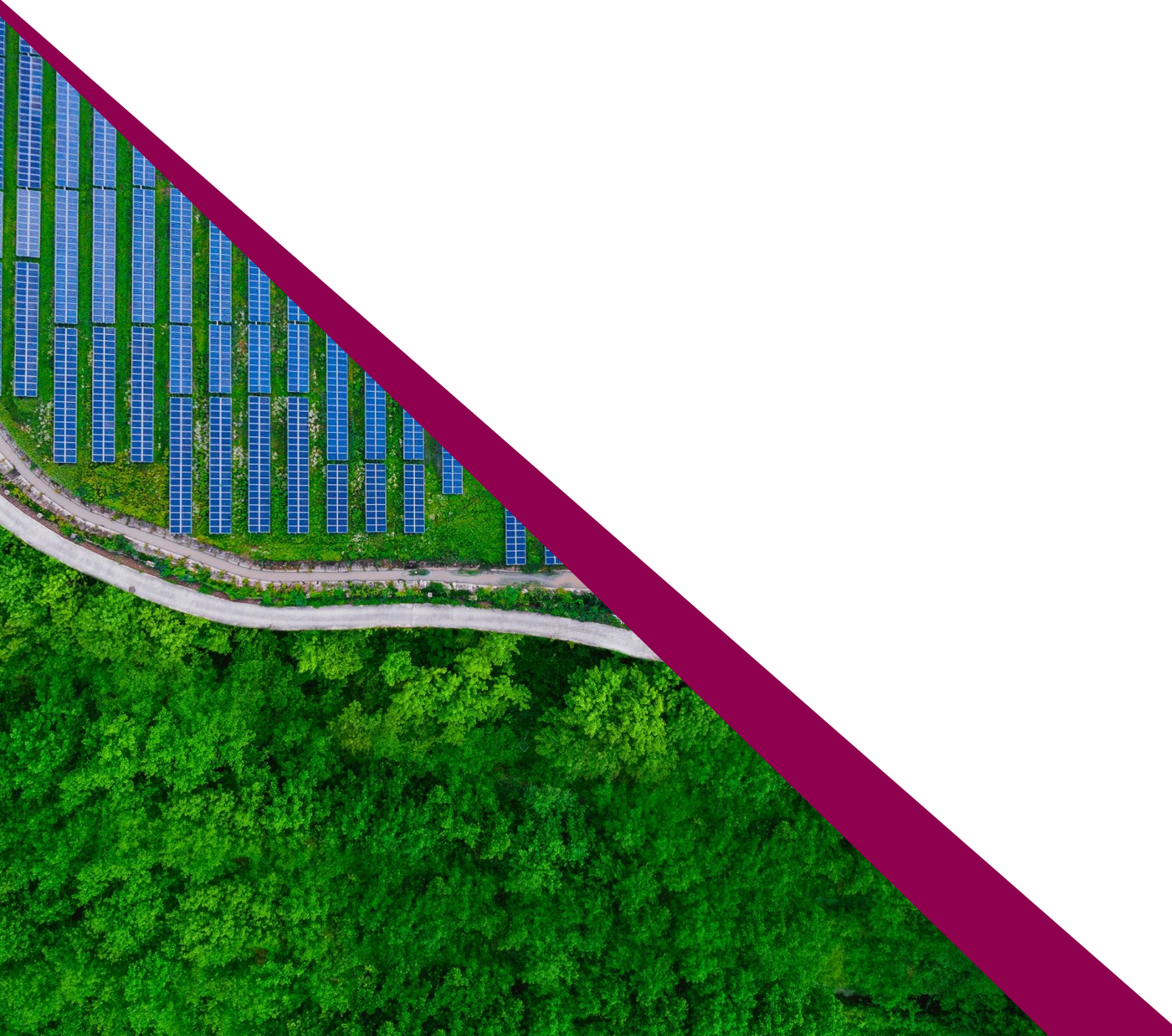


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BHL-PAK MAJOR CAPEX PROPOSAL ASSURANCE: BENEFIT-BASED INVESTMENT

TRANSPower NEW ZEALAND LIMITED



Document Information

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Table of Contents

<i>Executive Summary</i>	1
1 <i>Introduction</i>	2
1.1 Purpose of this Report.....	2
1.2 Key finding	2
2 <i>Methodology</i>	2
3 <i>Files reviewed</i>	3
4 <i>Findings from Internal QA</i>	5

Executive Summary

Broad Solutions Limited (BSL) has been engaged by Transpower New Zealand Limited (TPNZ) to undertake external assurance related to the market modelling involved for TPNZ's Brownhill – Pakuranga B Cable Joint Replacement Benefit-Based Investment (BHL-PAK BBI). The purpose of this work is to provide comfort over TPNZ's internal QA and to identify any potential issues that may exist in TPNZ's modelling and analysis process. This report contains our independent expert assessment of the modelling and analysis related to the BHL-PAK project.

Our assurance process is summarised below:

We checked each item listed in TPNZ's set of internal QA records. We first verified that all stated records correspond to relevant internal materials (e.g. Excel worksheets, HTML outputs, Python scripts and notebooks, etc). We then verified that these internal materials correspond accurately to their related QA test records (e.g. correct scenarios are checked, outcomes are the same as those stated in QA records).

We also assessed the OptGen and SDDP modelling input assumptions that TPNZ used. Input files for each scenario (with different assumptions) were independently validated and verified to have been used for the correct scenario.

We assessed all internal QA records. **In general, we found that internal QA records are accurate, and that the modelling process carried out is sound.** In some cases, minor issues have been identified and commented upon by TPNZ during the internal QA process, which have been commented upon by BSL. This also includes instances of missing QA files which were independently verified and commented on by TPNZ and BSL.

1 Introduction

Broad Solutions Limited (BSL) has been engaged by Transpower New Zealand Limited (TPNZ) to undertake external assurance of the electricity market modelling undertaken for the Brownhill – Pakuranga B Cable Joint Replacement Project (BHL-PAK) Major Capex Proposal (MCP).

BSL is a long-standing consultancy company that services various markets - both domestic and international - in advice, assurance services, model development and analytics relating to energy market modelling and market risk. We regularly undertake development and audit/review projects in the areas of electricity market analysis with a focus on the renewable transition and energy storage solutions.

1.1 Purpose of this Report

The purpose of this report is to present the findings of a range of assurance tests that BSL has completed to provide assurance over the market modelling process undertaken in the application of the TPM for TPNZ's BHL-PAK MCP.

This report provides an independent expert review and report on the modelling relating to TPNZ's OptGen and SDDP modelling used in the application of the Benefits-Based Investment Test for the BHL-PAK proposal. This relates to checking that the OptGen and SDDP input files align with TPM Assumption Book where they should, and where they do not, to ensure that the differences are justified, and reviewing specific SDDP and OptGen input files are both reasonable and consistent with TPNZ's internal documentation. This will involve checks and reviews of the internal QA carried out by TPNZ to provide assurances surrounding the IT process.

1.2 Key finding

All results in the report are based on modelling undertaken for the BHL-PAK MCP. The review focuses on the market modelling undertaken and checks associated with the BBI test. **BSL found that all results were within acceptable tolerances.**

2 Methodology

This report contributes to a comprehensive chain of assurance over TPNZ's modelling, which includes:

- Checking materials referenced in TPNZ's internal assurance records, verifying that stated outcomes can be traced back to their source material.
- Verification of input assumptions and files referenced in the modelling process.
- Verifying that stated outcomes are an accurate reflection of the tests carried out.
- Providing commentary on any notable outcomes and consideration of further assurance tests that may be carried out to provide comfort surrounding the modelling process and outcomes.

3 Files reviewed

- TPM Assumptions Book v3
- CreateInputs_Optgen.zip
- report_case_ab_con.html
- report_case_ab_env.html
- report_case_ab_gro.html
- report_case_ab_ino.html
- report_case_ab_ref.html
- optgen_sddp_inputs_qa_report_OPTGENCASES.ipynb
- dclink.dat
- mdclink.dat
- cbatteryini.dat
- cbatteryisi.dat
- cgndni.dat
- cgndsi.dat
- chidroni.dat
- chidrosi.dat
- ctermini.dat
- ctermisi.dat
- mgndni.dat
- mgndsi.dat
- TPR2025Nodes to SDDP_March2026_Growth_EG_Check.xlsx
- sddp_eg_gxp_verification.pdf
- gcgndni.dat
- gcgndsi.dat
- gndrps.dat
- BHL-PAK BBI Memo seeking approval of approach.docx
- changed_dat_files_analysis.xlsx
- dbf021ni.dat
- dbf021si.dat
- dese21ni.dat
- dese21si.dat
- duvase21.dat
- hrbmap21_w.dat
- hrloadni_w.dat
- hrloadsi_w.dat
- cluster_remap.dat
- clusters_average_spread.dat
- remap_w.dat
- optgen_policy_qa_report.ipynb
- file copier yaml files
- file copier csv files

- hay_flow.html
- ben_flow.html
- sddp.log
- mcirc_counterfactual_check2-1.xlsx
- SDDP inputs_BHL-WKM cables_BBI.pdf
- sddp_qa_report.ipynb
- investment_test_output.xlsx
- Benefits_by_year.ipynb
- scen25_sumCircFlows_through_cut.html
- scen25_bhl_2035onward_wFs.html
- scen25_bhl_pre2035_wFs.html
- scen25_hlyUn5_2035onward_wFs.html
- scen25_hlyUn5_pre2035_wFs.html

4 Findings from Internal QA

The tables below record our review of TPNZ's set of internal QA tests. It contains notable commentary on these tests and the files that were used in our review process.

Possible test outcomes are as follows:

- Pass: test passed without caveat
- Pass*: test passed with non-material issues noted
- Failure: test failed

SDDP and OptGen Input Checks

Check	QA Check Result	BSL Comment on Internal QA outcome	Files Checked/Reviewed
Master model inputs have been used	Pass	None	master_model_inputs_related\optgen_master_model\CreatelInputs_Optgen.zip master_model_inputs_related\optgen_master_model\CreatelInputs_SDDP.zip
Inputs are consistent with the BBI Assumptions Book	Pass	None	report_case_ab_con.html report_case_ab_env.html report_case_ab_gro.html report_case_ab_ino.html report_case_ab_ref.html
Bus configuration mapping is correct	Pass	None	SDDP and Optgen input checks\optgen_sddp_inputs_qa_report_OPTGENCASES.ipynb

Optgen minimum and maximum constraint plant id numbers are correct	Pass	None	SDDP and Optgen input checks\optgen_sddp_inputs_qa_report_OPTGENCASES.ipynb
HVDC configuration mapping is correct	Pass	None	SDDP and Optgen input checks\optgen_sddp_inputs_qa_report_OPTGENCASES.ipynb
Check HVDC upgrade timings and capacities are correct	Pass	None	dclink.dat and mdclink.dat files in each of the cases
Plant configurations are correct	Pass*	TPNZ made comment about not including AtiamuriGeo and Horohoro because they were both <10MW (cut off to be included) and hence, there was no need for “Optgen plant precedents” check	cbatteryini.dat, cbatterysi.dat, cgndni.dat, cgndsi.dat, ctermini.dat, cterminisi.dat, chidroni.dat, chidroshi.dat, and dbus.dat mgndsi.dat, mgndni.dat gcgndni, gcgndsi and gndrps.dat
Embedded generation is modelled correctly	Pass*	Plant buses for Kapuni, W_KaiwaraDow, W_Mahinerant, Waipori2A2, and Waipori2A3 did not match with the nodes in TPR2025Nodes to SDDP_March2026_Growth_EG_Check.xlsx. Correct bus configuration was validated from TPNZ and verified in model inputs.	TPR2025Nodes to SDDP_March2026_Growth_EG_Check.xlsx sddp_eg_gxp_verification.pdf

Existing grid SDDP circuit inputs are correct	N/A	Previously assured	
Hydro inflows have been updated correctly	N/A	Previously assured	
Cogeneration and hydro plant constraints are correct	Pass	Previously assured	

Optgen and SDDP policy run input and configuration checks

Check	QA Check Result	BSL Comment on Internal QA outcome	Files Checked/Reviewed
Modelling scope is as agreed with the project team	Pass	None	BHL-PAK BBI Memo seeking approval of approach.docx
File copiers are correct	Pass	All input files from master model inputs were independently verified and changes addressed with TPNZ. Changes relate to project specific modelling assumptions which are reasonable and expected.	optgen_master_model\CreateInputs_Optgen optgen_master_model\CreateInputs_SDDP file copier yaml and csv files from: master_model_inputs_related\master_model_fix\file_copy

Optgen configuration has been checked	Pass		optgen_master_model\CreateInputs_SDDP\ExecutionOptions
SDDP configuration has been checked	Pass*	For sddp.dat and index.dat, TPNZ commented that certain parts of this file will change because of project specifics, for example the modelling horizon. Both files match with the ones found at: "ExecutionOptions\SDDPPolicy_NonChronHybrid_RH_hotstart"	optgen_master_model\CreateInputs_SDDP\ExecutionOptions master_model_fix\CreateInputs_SDDP\ExecutionOptions
Case folder contents are correct	Pass	None	Optgen and SDDP policy run checks\changed_dat_files_analysis.xlsx

Check OptGen case results

Check	QA Check Result	BSL Comment on Internal QA outcome	Files Checked/Reviewed
Optgen has successfully converged	Pass	None	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb
The generation plan is reasonable	Pass*	The unlisted retirements test failed. TPNZ commented that it can be ignored as these retirements (WairakiNet and WRKreduced) are to satisfy Section 2.3.4.5 of the Assumptions Book	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb TPM Assumptions Book v3

Check SDDP policy case results

Check	QA Check Result	BSL Comment on Internal QA outcome	Files Checked/Reviewed
SDDP has successfully converged	Pass	sddp.html was not provided, so convergence was independently verified using log files	sddp.log
Average SDDP operating costs are reasonable	Pass	None	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb
SRMCs are reasonable	Pass*	Growth SRMC check was verified outside of the provided script from TPNZ. TPNZ commented on 2052 price differences in growth scenario being 11.5 \$/MWh (higher than other scenarios' \$10/MWh) can be tracked to thermal retirements.	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb
New projects are revenue adequate within acceptable bounds	Pass*	Several tech types have been noted in various scenarios that do not meet revenue adequacy thresholds. TPNZ has provided reasonable commentary for all such cases.	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb
The amount of deficit is reasonable	Pass*	None	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb

Generation flows are reasonable	Pass*	Instances of Recip dropping below Minimum utilization are all after 2030 (2036 and 2042 in constraint, 2031 in Environmental), and 21 out of 32 instances of OCGT dropping below minimum utilization happens in 2020s. This is in line with TPNZ's notes	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb
Renewable spill is reasonable	Pass	None	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb
HVDC flows are reasonable	Pass	None	Optgen and SDDP policy run checks\optgen_policy_qa_report.ipynb hay_flow.html, ben_flow.html

SDDP simulation run input and configuration checks

Check	QA Check Result	BSL Comment on Internal QA outcome	Files Checked/Reviewed
Modelling scope is as agreed with the project team	Pass	None	BHL-PAK BBI Memo seeking approval of approach.docx
Check SDDP configuration	Pass	None	CreateInputs_SDDP/ExecutionOptions/SDDP_Sim_Hourly
File copiers are correct	Pass	None	File copier csv and yaml files
Case folder contents are correct	Pass	None	changed_dat_files_analysis.xlsx

SDDP simulation circuit checks

Check	QA Check Result	BSL Comment on Internal QA outcome	Files Checked/Reviewed
SDDP circuit inputs are correct	Pass	None	mcirc_counterfactual_check2-1.xlsx SDDP inputs_BHL-WKM cables_BBI.pdf

SDDP simulation checks

Check	QA Check Result	BSL Comment on Internal QA outcome	Files Checked/Reviewed
Average SDDP operating costs are reasonable	Pass	None	sddp_qa_report.ipynb
Average bus price for BEN220, HAY220 and key buses are reasonable	Pass	BRB220 prices exceptionally high in growth scenario CF. Reasonable due to high demand combined with network constraint.	sddp_qa_report.ipynb
Average plant utilisation is reasonable	Pass	Several plants have been noted which lie outside of generation utilisation thresholds. These occurrences are limited and reasonable.	sddp_qa_report.ipynb

HVDC flows are reasonable	Pass	None	sddp_qa_report.ipynb
Average SDDP benefits are reasonable	Pass	Replicated benefit calculations.	investment_test_output.xlsx Benefits_by_year.ipynb
SDDP benefits over time are reasonable	Pass	None	investment_test_output.xlsx Benefits_by_year.ipynb
SDDP circuit inputs are correct (visual spot check)	Pass	None	sddp_qa_report.ipynb
Transmission flows are reasonable	Pass	Transmission flows constraints are relieved in this factual relative to the counterfactual.	scen25_sumCircFlows_through_cut.html scen25_bhl_2035onward_wFs.html scen25_bhl_pre2035_wFs.html scen25_hlyUn5_2035onward_wFs.html scen25_hlyUn5_pre2035_wFs.html
Transmission loss benefits are reasonable	Pass	None	sddp_qa_report.ipynb

THANK YOU

The future of energy begins with you

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