NZIER
NEW ZEALAND INSTITUTE OF ECONOMIC RESEARCH

Net Zero Grid Pathways 1

Shortlist consultation

NZIER report to MEUG

15 August 2022

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Key points

What Transpower is consulting on?

Transpower is consulting on the shortlist for 'Stage 1' grid upgrades to the High Voltage Direct Current link (HVDC), the Central North Island grid (CNI) and the Wairakei Ring with estimated commissioning dates over 2023 to 2026 and the indicative allocation of the costs of these investments to consumers. The benefit estimates are based on variations of the EDGS 2019 scenarios that Transpower completed in December 2021 (NZGP1 Scenarios Update).

These reports are a precursor to a Major Capital Proposal (MCP) from Transpower to the Commerce Commission and do not include the detailed explanation of the benefit modelling that would normally accompany an MCP.

Our comments are focused on aspects of the benefit analysis that we would like to see clarified in the next round of consultation papers particularly with respect to the proposed timing of the investment and the calculation of the timing and incidence of the benefits.

Selection of shortlist options on benefits and 'grid capacity'

Transpower's proposed shortlist of HVDC and CNI options excludes four options with higher net present value benefits on the basis that the shortlisted options allow a wider range of generation futures which Transpower argues is good for consumers.

> *We consider the long-term interest of consumers is best served by not limiting the possibilities for generation investors and ensuring those investors can build their generation where they would prefer.*[1]

The description of the options and demand/generation scenarios do not clearly describe which generation options are precluded by each transmission option or the extent to which this difference is already factored into the net investment test formula (which is used to calculate the net present value of benefits).

Allowing investors to build generation where they prefer is not a sufficient condition for ensuring competitively priced supply of electricity. The TPM allocates benefit-based charges to users of the grid at the time the asset is commissioned and responds with a lag to the arrival of new beneficiaries. Therefore designing the grid to allow options for the location of generation imposes a cost at least temporarily on existing grid users until new generation is commissioned.

If the flexibility in generation sites is going to be considered in the selection of grid upgrade options, then the benefits to consumers that are attributable to that flexibility need to be quantified so that they can be compared to the additional costs that consumers will incur.

[1] Net Zero Grid Pathways 1, Major Capex Project, (Staged) Investigation, Shortlist consultation, 30 June 2022. page 69

Not clear how cost allocation varies for change in benefits over time

The change in electricity demand and generation which justifies the Stage 1 grid upgrade (and subsequent but unidentified upgrades) are based on two major structural changes:

- Adoption of electric vehicles by residential consumers and electrification of process heat by industrial consumers. (Most of the increase in energy demand between 2024 and 2050 in the NZGP1 Scenarios Update is attributable to these factors.)
- Increase in wind and solar generation to both replace most of the existing fossil fuel generation and meet increased electricity demand.

These structural changes will materially alter the distribution of benefits to grid users over time. The indicative allocation of costs to consumers does not describe how changes in the location of load and generation have been modelled and how the structural changes might affect the allocation of benefits and therefore costs to grid users over time as new generation is connected and industrial use changes.

Delay option is not considered

All these structural changes are complex and so far, are proceeding more slowly than expected. However, Transpower's preferred mix of demand and generation scenarios ('Growth', 'Environmental' and 'Disruptive') assumes these changes are underway and will proceed at more or less the same gradual rate from now until 2050.

They effectively preclude consideration of a slower initial pace of these structural changes and therefore consideration of delaying the upgrade. Transpower is using a discount rate of 7 percent to calculate net present value. At this rate approximately half of the net present value of a 30 to 40 year project is achieved within the first 10 years of project. Therefore timing the upgrade investment so that it matches the need for increased capacity is important in achieving the net benefit for grid users. Given the uncertainty around the timing and speed of the expected structural change on both the demand and generation sides of the market a more detailed discussion of the costs and benefits of different timings of the upgrade would be required to satisfy parties that will be paying for this work that the timing is optimal.

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1 Purpose

1.1 Scope

This report comments on two reports published by Transpower for consultation:

- 'Net Zero Grid Pathways 1, Major Capex Project, (Staged) Investigation, Shortlist consultation, Date: 30 June 2022' (referred to in this report as the NZGP1 shortlist).
- NZGP1 shortlist consultation, Indicative covered costs and starting BBI customer allocations, Date: 14 July 2022 (referred to in this report as the NZGP1 indicative allocation).

These Transpower reports also are informed by 'NZGP1 Scenarios Update, NZGP1 Scenarios and modelling results for an unconstrained transmission grid, December 2021' (referred to in this report as the NZGP1 scenarios). This report describes the variations on the EDGS 2019 scenarios that Transpower has used for its modelling of the benefits of the grid upgrade options.

These reports are a step in a consultation on Transpower on the first stage of the NZGP1 that started in 2020 and are a precursor to a Major Capital Proposal (MCP) from Transpower to the Commerce Commission. They do not include the detailed explanation of the benefit modelling that would normally accompany an MCP.

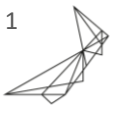
The objective of the consultation seems to be to converge on a small number of options for the short-term upgrade. This has been impeded by uncertainty about outlook for the Tiwai aluminium smelter and more importantly the uncertainty about the timing and effect of the structural changes in electricity demand and generation required to meet the Government's decarbonisation goals.

1.2 Our approach

The consultation questions listed by Transpower (see Appendix A) cover the NZGP1 shortlist but the comparison of short-term grid upgrade options is dependent on the change in the level and peakiness of demand and generation mix considered in NZGP1 scenarios. Similarly the allocation of the benefits from these grid upgrades and the allocation of the costs of these investments is likely to change over time as new generation is built and the pattern of demand changes.

Our comments are focused on aspects of the benefit analysis that we would like to see clarified in the next round of consultation papers particularly with respect to the proposed timing of the investment and the calculation of the timing and incidence of the benefits. In addition to the responses to the consultation questions, our comments cover aspects of the:

- NZGP1 scenarios (which is referred to in Appendix A of the NZGP1 shortlist).
- NZGP1 indicative allocation (which is discussed in sections 2 and 4.1 and Appendix B of the NZGP1 shortlist).



2 Selection of shortlist options

2.1 Transpower assessment of options

This section focuses on Transpower's application of the net investment test to the shortlist options. Most of the net present value of net benefits for most of the combinations of grid upgrade options and demand/generation scenarios are negative. For those combinations of grid upgrade option and demand/generation scenarios with a positive net present value of net benefits, the net benefits are modest relative to the cost of the project. This is an indicator at the very least that the proposed grid upgrades are being made too early.

2.2 Following the assessment process to a preferred option

The following comments focus on the HVDC and CNI upgrade bundle. The cost of the Wairakei Ring upgrade is much lower and the net present value of net benefits for the grid upgrade options are much more tightly grouped than for the HVDC and CNI grid upgrade options.

2.2.1 Net benefits for are highest for HVDC 1,400 MW and CNI 1

The description of the grid upgrade option assessment in section 4.52 of NZGP1 shortlist is confusing because the options with the highest net present value net benefits in 'Table 12: Net benefit of intermediate list of CNI options' and 'Table 13: Net benefit of intermediate list of HVDC and CNI options with various scenario weightings' are not the options placed in the shortlist in 'Table 14: Short list of options for HVDC and CNI'.

Table 12 of NZGP1 shortlist[2] reports the net present value of net benefits for the combinations of the demand/generation scenarios and that:

- All combinations of the HVDC and CNI grid upgrade for the 'Global' and 'Reference' scenarios and all combinations of the HVDC 1,200 MW upgrade and the CNI upgrades have negative net present value of net benefits.
- For the combination of the 'Disruptive' scenario with:
  - the HVDC 1,200 MW upgrade all of the CNI grid upgrade options have negative net present value of net benefits.
  - the HVDC 1,400 MW upgrade all of the CNI grid upgrade options (except for CNI 10 and CNI 11) have positive net present value of net benefits.
- For the combination of the 'Environmental' scenario with:
  - the HVDC 1,200 MW upgrade CNI grid upgrade options CNI 1, CNI 3 and CNI 5 have positive net present value of net benefits while CNI 2, CNI 4, CNI 8 and CNI 10 have negative net present value of net benefits.
  - the HVDC 1,400 MW upgrade CNI grid upgrade options CNI 1, CNI 2, CNI 4, CNI 5, and CNI 6 have positive net present value of net benefits while CNI 7, CNI 8, CNI 9, CNI 10 and CNI 11 have negative net present value of net benefits.

[2] NZGP 1 shortlist, Table 12: Net benefit of intermediate list of CNI options, page 67.

- All combinations of the HVDC and CNI grid upgrade options (except for CNI 10 and CNI 11) for the 'Growth' scenario have a positive net present value of net benefits.
- CNI 1 has the highest net present value of net benefits of all the CNI options for each combination of the demand/growth scenarios and HVDC grid upgrades.
- The net present value of net benefit for all of the grid upgrade options is highest for the 'Growth' scenario. This 'Growth' scenario has lower demand volume and peak capacity but 'peakier demand[3]' than either the 'Environmental' or 'Disruptive'.

Table 13 of NZGP1 shortlist[4] reports the weighted average of the net present value of net benefits for grid upgrade options for four different weighted combinations of the demand generation scenarios. The four weightings of the demand/generation scenarios are:

- Weighting Set 1 with equal weighting for each of the 'Reference', 'Global', 'Growth', 'Environmental' and 'Disruptive' scenarios. For Weighting Set 1, only the HVDC 1,400 MW grid upgrade combined with CNI 1, CNI 2, CNI 4, CNI 5 and CNI 6 gird upgrades have a positive net present value of net benefits.
- Weighting Set 2 with weightings for the scenarios as follows: 'Reference' 10 percent, 'Global' 5 percent, 'Growth' 20 percent, 'Environmental' 30 percent and 'Disruptive' 30 percent. For Weighting Set 2, only the HVDC 1,400 MW grid upgrade combined with CNI 1, CNI 2, CNI 4, CNI 5, CNI 6 and CNI 7 grid upgrades have a positive net present value of net benefits.
- Weighting Set 3 with weightings for the scenarios as follows: 'Reference' 0 percent, 'Global' 10 percent, 'Growth' 30 percent, 'Environmental' 30 percent and 'Disruptive' 30 percent. For Weighting Set 3, only the HVDC 1,400 MW grid upgrade combined with CNI 1, CNI 2, CNI 4, CNI 5 and CNI 6 grid upgrades and HVDC 1,200 MW grid upgrade combined with the CNI 1 grid upgrade have a positive net present value of net benefits.
- Weighting Set 4 (Transpower's preferred option) with weightings for the scenarios as follows: 'Reference' 0 percent, 'Global' 0 percent, 'Growth' one third, 'Environmental' one third and 'Disruptive' one third. For Weighting Set 4, only the HVDC 1,400 MW grid upgrade combined with CNI 1, CNI 2, CNI 4, CNI 5, CNI 6 and CNI 7 grid upgrades and HVDC 1,200 MW grid upgrade combined with the CNI 1 and CNI 5 grid upgrade have a positive net present value of net benefits.

2.2.2 Two shortlists of HVDC and CNI options

'Table 14: Short list of options for HVDC and CNI'[5], reports the shortlist options as: HVDC 1 and HVDC 2 with CNI 6, CNI 8 and CNI 9. However, 'Table 18: summary of our shortlisted options'[6] includes a different combination of CNI grid upgrade options: CNI 1, CNI 8 and CNI 11. The reason for the difference in the two shortlist recommendations is not clearly explained. However, the second choice CNI 1, CNI 8 and CNI 11 appears to be the short list that is taken forward for further analysis. It remains unclear what influence the comments

[3] NZGP scenarios includes minimal information on how demand varies over trading periods. This comment is based on the difference in growth rates for peak demand and volume demand over the forecast period.

[4] NZGP 1 shortlist, Table 13: Net benefit of intermediate list of HVDC and CNI options with various scenario weightings, page 68.

[5] NZGP 1 shortlist, page 70.

[6] NZGP 1 shortlist, page 73.

about enabling generation futures and maximizing grid capacity made about Table 14 have on the selection and analysis of a preferred option.

Table 14: Short list of options for HVDC and CNI' commentary

The commentary supporting this choice of option argues that for grid upgrade options[7]:

- *The long-term interest of consumers is best served by not limiting the possibilities for generation investors and ensuring those investors can build their generation where they would prefer*.
- CNI 1, CNI 2, CNI 5 and CNI 6 can all be regarded as similar by the Commerce Commission under the investment test because their net present value of net benefits are within 15 percent. (Transpower will be proposing that the Commerce Commission increase the similarity test range from 10 percent to 15 percent.)
- CNI 1 is excluded from the short list because it would *not enable a wide range of generation futures*.
- CNI 6 would enable the most competitive generation market and would be Transpower's preferred option.
- CNI 8 squeezes the most capacity out of the existing assets, only has a negative net present value of net benefits for one of the four weighted scenarios, provides more transmission capacity on the CNI lines than CNI 6 and can be built faster than CNI 9.
- CNI 9 would *maximise the extent to which new generation is enabled* but would take longer.

The criteria of *enabling generation futures* and adding generation capacity are not clearly quantified in NZGP 1 shortlist. A more detailed discussion of where generation capacity could be built based on the MBIE generation stack reports and the permits held by generators would help to answer the two open questions in Transpower's discussion of the shortlist:

- How the choice of grid upgrade option affects the choice of sites where new generation is built?
- How much of the effect of the grid upgrade option is already captured in the investment test?

Table 18: summary of our shortlisted options

In contrast to the discussion of the shortlist options for Table 14 the commentary for the shortlist options in Table 18 is simply '*For the purposes of applying the Investment Test, we have defined shortlist options …'*[8]. The CNI grid upgrade options CNI 1, CNI 8 and CNI 11 are the only grid upgrade options considered,

The net present value of the net benefits of each option are analysed in 'Table 19: Net benefit of shortlist of HVDC and CNI and Wairakei Ring options with balanced scenario weightings'[9] which reports that:

[7] The quotations in the following bullet points (which are formatted in italics) are from NZGP 1 shortlist page 69.

[8] NZGP1 shortlist page 73.

[9] NZGP1 shortlist page 74

- Grid upgrade option CNI 11 does not have a positive net present value of net benefit for any of the demand/generation scenarios.
- The grid upgrade options only have positive net present value of net benefits for the 'Growth' and 'Disruptive' scenarios.
- Under the 'Growth' scenario the grid upgrade options CNI 1 and CNI 8 have positive net present value of net benefits for both the HVDC 1,200 MW and HVDC 1,400 MW upgrade options.
- Under the 'Disruptive' scenario the grid upgrade options CNI 1 and CNI 8 have positive net present value of net benefits for and HVDC 1,400 MW upgrade option only.

Transpower also analyses[10] the grid upgrade options against the weighted combinations of the demand and generation scenarios described in section 2.2.1 above and reports that:

- All of the grid upgrade options for HVDC 1,200 MW have negative net present value of net benefits for all of the weighted scenarios.
- Nearly all the grid upgrade options for HVDC 1,400 MW have negative net present value of net benefits for weighted scenarios 1, 2 and 3 (except for grid upgrade option HDVC 1,400MW with CNI 1 in the weighted scenarios 2 and 3 which record small positive net present value of net benefits.
- For weighted scenario set 4 (Transpower's preferred scenario set) grid upgrade option HVDC 1,400 MW and CNI 1have the highest positive net present value of net benefits and two of the three CNI 8 gird upgrade options have positive net present value of net benefits.

At the end of this section Transpower concludes that its preferred grid upgrade option is HVDC 1,400 MW and CNI 1.

3 BBI allocation calculations

3.1 Allocation of BBI based on history

Transpower states that is applied the methodologies in the TPM to produce an indicative allocation of the cost of the HVDC CNI grid upgrade that while it is not at the level of detail that will be proposed for consultation under the TPM *is a reasonable indication of the distribution of EPNPB from the HVDC/CNI BBI using the modelling inputs and assumptions set out in this document (which themselves are indicative only).*[11]

The allocation appears to be based on the mean offtake or injection over the period 1 September 2014 to 31 August 2019[12]. Transpower states this approach will be updated before consulting on the allocations but does not indicate what the update will address.

10 NZGP1 shortlist, Table 20: Net benefit of shortlist of HVDC and CNI and Wairakei Ring options with various scenario weighting, page 75.

11 NZGP1 indicative allocation, page 6, paragraph 6.

12 NZGP1 indicative allocation, page 18.

3.2 Suggested update approach

The proposed upgrades are intended to enable new generation to and new load to be connected to the grid. This new generation and load are both likely to change the grid use profile of existing customers and may add new customers to the grid. While initially the benefit base charges will be allocated to the existing customers it would be helpful for Transpower to indicate how it plans to review changes in grid use over time and apply the provisions in the code for changing the allocation of benefit-based charges in response to major changes in grid use. Presumably changes in the benefit allocation attributable to the connection of new generation will be discreate and substantial and therefore easy to detect. The changes in load profile particularly due to the electrification of process heat may be harder to detect and analyse.

The calculation for the net investment test should provide a starting for the analysis of when and how the grid use profile is likely to change.

4 Demand and generation scenarios

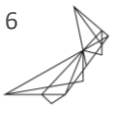
4.1 Clarification of assumptions

The NZGP1 indicative allocation report lists key modelling inputs some of which we think require clarification or consultation[13]. These are discussed briefly in the following bullet points:

- Indicative allocations use only the 'Growth' scenario because it is the middle of the five scenarios (see paragraph 35.2). We would appreciate clarification on how this approach is reconciled with the use of weighted scenario sets for the application of the investment test and Transpower's preference of a one third weighting for the 'Growth' scenario.
- No modelling of the upgrades to the HVDC/CNI BBI associated with stage 2 of NZGP1 (see paragraph 35.3 ii). A more detailed discussion of these options, their dependence on the upgrade options selected for stage 1 would be useful for the consideration of the timing of stage 1.c
- Inclusion of additional generation units (see paragraph 36.1). It would be helpful to have information on the capacity of these
- Environmental scenario carbon price projections (see paragraph 36.2). It would be useful to consider whether the Climate Change Commission Advice on the NZ ETS[14] requires a reassessment of the medium-term outlook for carbon price projections.
- A reduced discount rate for solar projects (see paragraph 36.5). Lower consent, construction and maintenance costs are not usually reasons for a lower discount rate for the purposes of economic cost-benefit analysis but instead affects the expected range of cashflows. It would be helpful for Transpower to clarify what effect this assumption has on the modelled development of solar generation. Irrespective of the range of views on the discount rate, the key grid upgrade question from the higher proportion of solar generation, is how the location and supply profile of solar differs

[13] NZGP1 indicative allocation, section 4.1 pages 14 to 15.

[14] 'Advice on NZ ETS unit limits and price control settings for 2023-2027, July 2022' Climate Change Commission.



from that of the wind generation it displaces. In particular is solar generation likely to be closer to load than wind generation and how much more hydro-firming will solar require than wind.

- A 50 percent reduction in the capital cost of geothermal generation (see paragraph 36.6). Could Transpower clarify how this assumption compares to existing geothermal generation and what effect it has on the modelled development of geothermal generation.

Appendix A Consultation questions

A.1 Response to consultation questions

Table 1 Response to NZGP1 shortlist questions

Number	Question	Comment
1	Do you agree with our staged approach to this major capital investment programme?	Yes, but more information of the expected change in the load and generation is needed for an informed discussion of the timing of the staged investment.
2	Is our approach to NTS reasonable?	Yes.
3	Is our reduced list of options for enhancing capacity of the HVDC reasonable?	The process used to assess the long-list options against the screening criteria is not described in NZGP1 shortlist. The following comment refers to Appendix A. *'…analysis to reduce the intermediate list to a shortlist for Investment Test analysis. Our approach and results are described in Appendix A.'* page 52, However Appendix A describes the variations on EDGS 2019 scenarios used to estimate the benefits of grid upgrades. and does not seem to describe the long-list screening process.
4	Is our reduced list of options for enhancing capacity of the CNI 220 kV corridor reasonable?	
5	Is our reduced list of options for enhancing capacity of the Wairakei Ring reasonable?	
6	Are our scenario weighting sets reasonable?	No. The 'Growth', 'Environmental' and 'Disruptive' scenarios have similar volume and peak demand growth paths. Transpower's preferred weighting set narrows the range of variability that should be considered. None of the scenarios consider a more 'S' shaped adjustment path for demand over the forecast period.
7	Is our shortlist of HVDC and CNI options reasonable?	The shortlist and related discussion around Table 13 and Table 14 seem to contradict the preferred option analysis in Table 20 A.
8	Is our shortlist of Wairakei Ring options reasonable?	Yes.
9	Is our choice of the preferred option reasonable?	Yes, but it seems to contradict the assessment in Table 13 and Table 14.
10	Is our conclusion that upgrading existing assets is more economic than bypassing the existing grid reasonable?	Yes.
11	Do you agree that our choice of preferred option is robust against sensitivity analysis?	Not completely. The sensitivity tests do not materially alter the net present value of the net benefits from Option 10 (the preferred option). This value is $63 million in Table 20 and varies between $48 million[15] and $67 million for the sensitivity analysis. This suggest the sensitivity tests may not be affecting key drivers of the project benefit.
12	Do you agree with our staged approach to this major capital investment programme?	Yes, but the staging should also consider an option to delay the upgrade.

Source: NZIER

[15] This value is for the 'Mobilise to Decarbonise' scenario and is an outlier. The nest highest value is $54 million.

The clear message from the scenario analysis is that the preferred option is the combination of the HVDC 1,400 MW and the CNI 1 grid upgrade which is superior to the other HVDC and CNI combinations. However two of the Wairakei Ring options deliver similar net benefits.

A.2 Scenario development

A.2.1 EDGS scenarios

An update for the EDGS 2019 scenario and the associated consultation would support a better engagement around the scope and timing of the grid upgrade options. Transpower has worked hard to update the EDGS 2019 scenarios to reflect the current situation, but this is unsatisfactory as:

- The EDGS should be available to Transpower as an independently prepared input to its proposals for grid upgrade options.
- The increased volatility in electricity markets since the 2019 EDGS suggests that scenarios for demand and generation need to consider a wider variation in the medium-term forecasts and some scenarios that consider more of an "S" shaped increase in demand.

A.2.2 NZGP1 shortlist scenario sensitivities

Section 4.7 of the NZGP1 shortlist[16] describes a set of potential futures that test the availability of South Island hydro generation[17] along with higher-than-expected demand and different sources of generation in the long term. The Tiwai potential futures are useful examples of short-term variation in grid capacity requirements, but it would be useful to add some North Island generation and lower initial demand potential futures to provide a more balanced assessment of possible short-term variation in requirements for grid capacity.

The potential futures: 'South Island dry year solution', 'Hydrogen future', 'Taranaki offshore wind', 'Taranaki demand grows', 'Wind:solar generation mix 50:50' and 'Climate change effects' are interesting to consider but take effect over a long period. They are all likely to have too much uncertainty about their timing and effect for their impact to be quantified nearly as accurately as the short-term futures.

If the point of the 'potential futures' is to consider factors that impact on the MCP for the stage 1 grid upgrade options, then it would be better to focus on the drivers of short-term variations in grid capacity requirements as they are easier to quantify and more relevant to selecting the best stage 1 option than the potential futures that take effect over a long period.

16 NZGP1 shortlist 'Table 29: Sensitivity Scenarios' page 85

17 Both Table 29 and 'Table 21: Investment test sensitivities to be reported' on page 78 state that closure of Tiwai in 2030 was modelled as an investment test sensitivity but I was not able to find the results of this analysis in this case in