Net Zero Grid Pathways

Phase One:
Enabling Lower South Island Renewables

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Rio Tinto's announcement to wind-down, and eventually close, the New Zealand Aluminium Smelter (NZAS) at Tiwai Point has the potential to accelerate New Zealand's transition to a highly renewable energy future. There are several opportunities for utilising the renewable electricity used to supply NZAS under consideration. One is to enable it to be used across New Zealand through further enhancements to the electricity grid, in addition to our $100m Clutha Upper Waitaki Lines project already underway. It is projected that these enhancements will transition the electricity system from being around 85% renewable today to at least 96% renewable in 2025.

In September 2020 Transpower updated industry with our response to the announced NZAS closure. Since then we have explored a variety of possible grid enhancements that would enable further access to the low-cost renewable generation made available by the NZAS closure. This paper summarises work to date on our prioritised programme of grid enhancements that could likely result in network investment.

The Ministry of Business Innovation and Employment (MBIE) provides an independent set of supply and demand scenarios such that the Commerce Commission can assess our proposals for capital investment in the transmission grid. The Commerce Commission may accept reasonable variations to these scenarios that Transpower puts forward. We are currently consulting with industry on what variations could be considered and this process is likely to reach completion in early 2021. As these scenarios are still being developed[1] we have used a single generic scenario in studies to enable fast prioritisation of our investigation.

The grid enhancement initiatives discussed in this paper do not include Upper South Island (USI) and Waikato and Upper North Island (WUNI) transmission constraints as these are primarily demand driven and are covered by separate ongoing investigations.

[1] Net Zero Grid Pathways: Scenario Development – draft EDGS 2019 consultation on the website https://www.transpower.co.nz/net-zero-grid-pathways-latest-updates

1. Uncertainty

We acknowledge there are still many uncertainties regarding the nature of the NZAS exit and its flow on effects across the electricity system and market. In the absence of other confirmed uses for NZAS supply within the lower South Island, even with a delayed exit, the lead times for key transmission investments to enable greater access to this renewable generation outside of the region would still be on the critical path. It is important we start investigating now on a base case, even without certainty on additional industrial demand, or generation development in the region. Our investigations will be cognisant of future announcements as they are made.

2. Update on our Net Zero Grid Pathways work

Since our September webinar, we have:

- progressed the design and delivery of the Aviemore–Benmore circuit overload protection scheme (AVI–BEN COPS)
- consulted with a panel of external advisors to understand what reasonable variations should be made to the 2019 EDGS to reflect the latest information and industry developments
- explored how we could expect the electricity market to operate with NZAS closed and the completion of current Clutha Upper Waitaki Lines Project (CUWLP) work to inform our approach to our Accessing Lower South Island Renewables work.

AVI–BEN Circuit Overload Protection Scheme in delivery

After the completion of the CUWLP works underway, the Aviemore–Benmore circuits are the next constraint for power flow from the Lower South Island to the HVDC link. Our investigation has confirmed that installing the AVI–BEN Circuit Overload Protection Scheme (COPS)[2] to manage the circuit constraints between Aviemore and Benmore will increase the potential of the CUWLP stage 2 upgrades currently underway. The scheme is expected to cost around $500,000 but deliver benefits of $3-4 million over the first five years after the NZAS closure. The scheme will be delivered as part of the current Clutha Upper Waitaki project and it is expected to be commissioned by the end of 2021.

Electricity Demand and Generation Scenarios consultation

Under the Capex IM, Transpower is required to have regard for the Electricity Demand and Generation Scenarios (produced by MBIE) when assessing the benefits of any major grid enhancements. The EDGS were last updated in 2019, prior to the Rio Tinto announcement and other significant events such as COVID-19, the New Zealand Generation Stack update, and the New Zealand battery project. Due to the rapidly changing landscape, Transpower has been publicly consulting with a panel of external advisors to understand what reasonable variations are required to ensure the EDGS reflect the latest information. Video recordings of these panel discussions are available on our website along with a consultation document describing our draft EDGS 2019 variations[3].

There is some urgency to complete this piece of work as it will provide us with the inputs for our Net Zero Grid Pathways work discussed in the following section.

[2] The proposed Aviemore–Benmore Circuit Overload Protection scheme (AVI–BEN COPS) trips the 220 kV Aviemore–Waitaki–1 circuit if an Aviemore–Benmore circuit trips and the remaining circuit is overloaded. The scheme reconfigures the grid to stop through transmission between the lower South Island and Benmore, removing the overload on the remaining Aviemore–Benmore circuit.

[3] Net Zero Grid Pathways: Scenario Development – draft EDGS 2019 consultation on the website https://www.transpower.co.nz/net-zero-grid-pathways-latest-updates

Accessing Lower South Island Renewables

In parallel to the electricity demand and generation scenario consultation, we have used our 2020 Transmission Planning Report (TPR) demand scenario to proactively identify several areas of the transmission system that restrict the ability to maximise access to South Island low cost renewable generation following the closure of the NZAS smelter. This is to ensure that we are being methodical in identifying all areas for investigation and to gain a high-level view of the benefits associated with resolving different grid constraints. This aids prioritising our investigations commensurate to the likely scale of investments to maximise value for consumers.

Our modelling has shown there are benefits to electricity consumers over the short and medium term by resolving transmission constraints on the HVDC link and North Island AC network. Some of the solutions may result in investments in excess of $20 million and so require us to submit Major Capex Proposals to the Commerce Commission. In the New Year, we will engage with the Commerce Commission over the process and timeline we will follow in developing these Major Capex Proposals. We will also refine further the scenarios and assumptions we will use to analyse these grid upgrades.

A key finding of this investigation to date is that the collective benefits of potential grid enhancement amplify each other's benefits when constraints are closely matched. Our approach will therefore be to analyse the benefits of these upgrades as a single workstream.

3. Current Status of our Accessing Lower South Island Renewables work

In summary from our analysis to date has confirmed that in addition to our current work to complete the CUWLP stage 2 and AVI–BEN COPS:

- Enhancing the HVDC capacity to 1400 MW in conjunction with specific North Island grid upgrades work well together to maximise benefits to consumers.
- Relieving constraints in the North Island AC network provides significant benefit to consumers
- These HVDC and North Island grid enhancements, together, will increase access to low cost lower South Island renewables in the short term
- In the medium to longer term they will enable other renewable generation options to meet growing demand.
- While there are some further benefits from added enhancements in the lower South Island HVAC network beyond the those being delivered by CUWLP the cost of further upgrades is likely to outweigh the benefits over the next 10-15 years.

We already have a detailed investigation underway for enhancements to the HVDC. We will now also start an Investigation in early 2021 to investigate in more detail the investment case for the North Island HVAC network. We will continue to monitor constraints on the South Island HVAC network. The following sections cover the transmission constraints we have identified and update on our scenario development work as it is a critical input into our near-term investment planning.

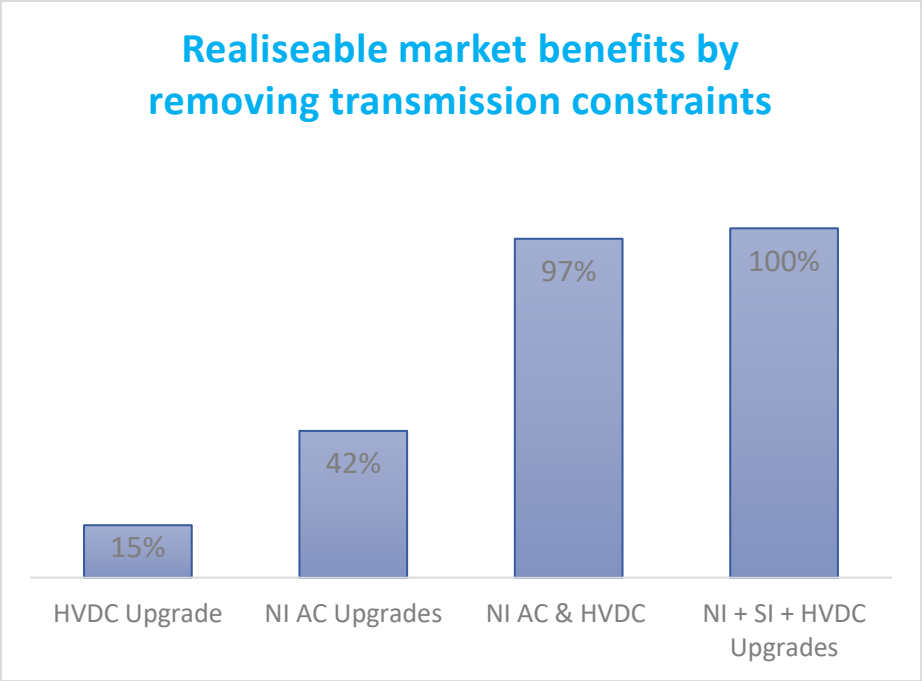


Figure 1 - High level market benefits for constraints under consideration. Note that combinations of projects can realise greater benefits than the individual parts

4. Next Steps

With our investigations advancing we will host another industry panel in March 2021 to discuss the results of the Scenario Consultation and our approach to asset investigations, scope and timing. In addition, our HVDC enhancement project will release a long list consultation in the first half of next year advising the projects assumptions and options.
If justified, the most major enhancement options being considered would be commissioned in the late 2020's and would have an indicative cost of $150 - $200 million (HVDC) and $300-$350 million (North Island upgrades). Other less significant options will be considered as part of our assessments and maybe able to be completed in shorter timeframes for less cost.

2021 - Q1

- Complete consultation on reasonable variations to EDGS
- Refresh our analysis with updated scenarios
- Finalise approach to Accessing Lower South Island Renewables Investigations.

2021 - Q2 +

- Confirm and start Accessing Lower South Island Renewables MCP investigation program
- Longlist consultation for HVDC upgrade project.
- Communicate via industry panel of timelines for project milestones via our industry pannel

HVDC Capacity

HVDC link constraint

The HVDC north flow capacity is constrained by the Cook Strait cables and reactive support at Benmore and Haywards.

The HVDC link's north flow capacity is limited by the Cook Strait cables and reactive support at the Benmore and Haywards terminal stations. The closure of the NZAS increases the need to send surplus South Island renewable energy to the North Island via the HVDC. Our modelling shows that the utilisation of the HVDC will significantly increase and is positively correlated to South Island hydro inflows. Upgrading the HVDC north transfer capacity from 1200 MW to 1400 MW by itself provides only a modest benefit to consumers as the North Island HVAC network then constrains the ability to send this energy further north than Bunnythorpe. The HVDC upgrade needs to be complimented by a combination of North Island HVAC network upgrades to maximise benefits to consumers.

The HVDC upgrade project is currently the subject of a formal investigation as we will need to complete a condition-based replacement of the existing cables in Cook Strait in any case. As part of this investigation we are considering options of increasing the capacity of the HVDC link by the addition of another cable and voltage support equipment releasing the HVDCs full 1400 MW capacity. As cable installation is expensive, we will need to consider if it is justified bringing forward the cable replacement to allow for the increase in capacity. Alternatively, another option is wait until the cable replacement date and upgrade the cables at that time.

North Island HVAC Constraints

110kV Constraints

110 kV Bunnythorpe–Mataroa–1 constraint

Bunnythorpe–Mataroa circuit may overload pre-contingency during high HVDC north flow. This constraint is exacerbated by low Waikato 110 kV generation.

110 kV Masterton–Greytown–Upper Hutt constraint

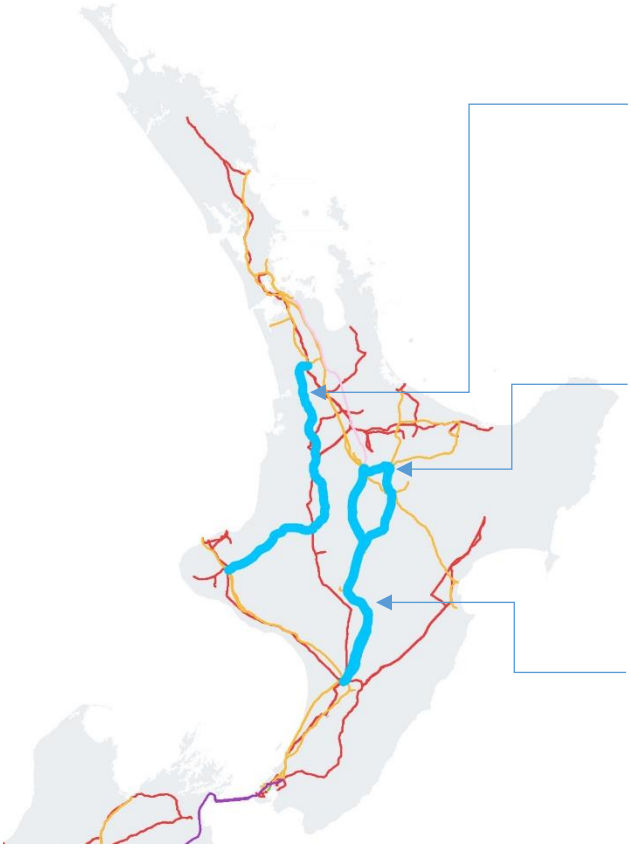
A Masterton–Greytown–Upper Hutt circuit outage may overload the parallel circuit during high HVDC north flow.

There are two regional 110 kV constraints that limit the ability to utilise the full capacity of the 220 kV grid backbone limiting transfers from the HVDC. These are the pre-contingency overloading of the 110 kV Bunnythorpe–Mataroa circuit and the overloading of the remaining Masterton–Greytown–Upper Hutt following an outage on the parallel circuit.

The 110 kV Bunnythorpe–Mataroa circuit may overload pre-contingency during high HVDC northflow conditions coupled with high generation in the lower North Island and Taranaki regions. This constraint is exacerbated by low hydro generation in the Waikato 110 kV network. The 110 kV Masterton–Greytown–Upper Hutt circuits may overload following an outage on the parallel circuit during high HVDC northflow conditions. Depending on operating conditions both of these 110 kV constraints can bind before 220 kV constraints.

Our modelling shows that both these constraints bind when NZAS closes, they bind more strongly when South Island hydro inflows are higher as more energy is exported to the North Island via the HVDC. The modelling also shows that resolving these 110 kV constraints along with North Island 220 kV constraints yields the most benefits as the 220 kV constraints follow closely behind the 110 kV constraints.

220kV Constraints



220 kV Huntly–Stratford constraints

A Stratford–Taumarunui–1 or Huntly–Te Kowhai –1 circuit outage may overload the Huntly–Stratford–1 circuit during high generation in Taranaki, Central North Island and Wellington regions.

220 kV Wairakei Ring constraints

An Edgecumbe–Kawerau-3 or Te Mihi–Whakamaru–1 circuit outage may overload the Atiamuri–Ohakuri–1 circuit during high generation in the Central North Island, Bay of Plenty and Hawkes Bay regions.

220 kV Central North Island constraints

A Tokaanu–Whakamaru circuit outage may overload the parallel Tokaanu–Whakamaru or Bunnythorpe–Tangiwai circuit during high generation in the Taranaki, Central North Island and Wellington regions.

There are three sets of constraints on the North Island 220 kV network that limit North Island consumer's access to South Island renewable energy following the NZAS closure. These are the 220 kV Huntly–Stratford, Central North Island and Wairakei Ring constraints. However, the Huntly–Stratford and Wairakei Ring constraints are driven by the development of new generation projects in the Bay of Plenty as identified in the MBIE generation stack rather than directly by the NZAS closure.

Huntly-Stratford 220kV constraint

The 220 kV Huntly–Stratford transmission corridor is constrained by the Huntly–Stratford circuit following an outage of either the Stratford–Taumarunui–1 or Huntly–Te Kowhai–1 circuit (depends on embedded generation at Te Kowhai). This constraint typically binds during high Waikato and Upper North Island (WUNI) load coupled with high generation in the Central North Island, Taranaki and Wellington regions (including high HVDC northflow). Our market modelling showed the constraint binds relatively infrequently over the short to medium term but binds a lot more frequently in the longer term if more thermal generation in the Auckland region is replaced by generation outside of the WUNI region.

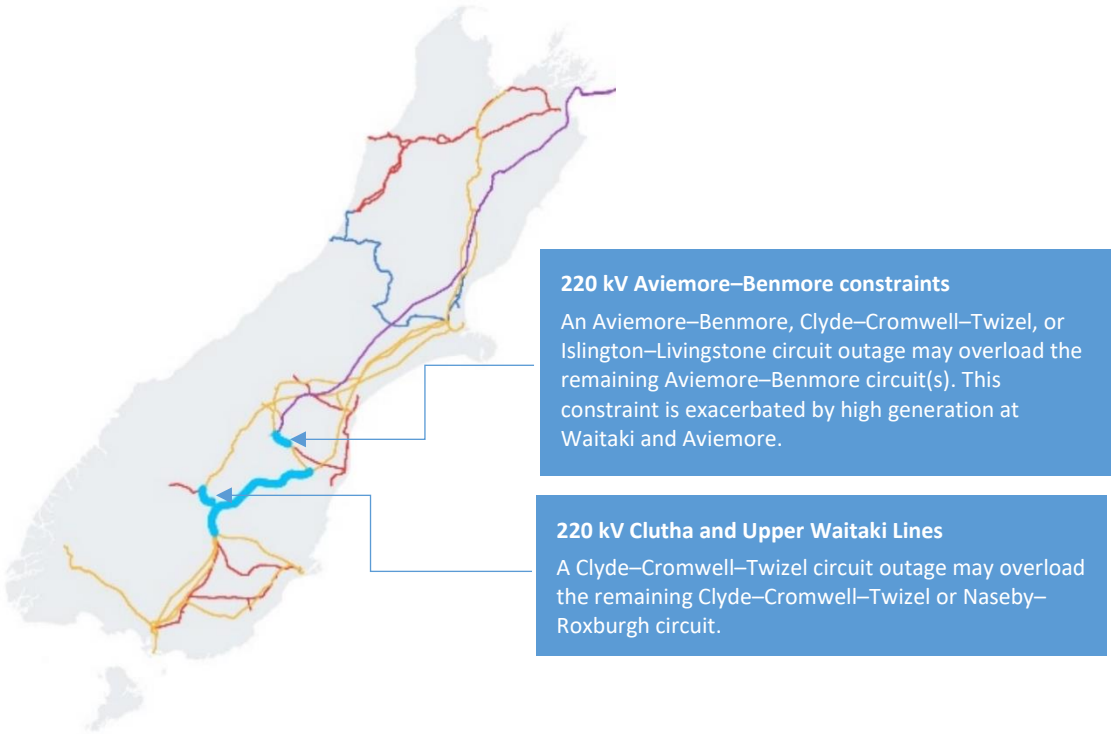
Wairakei Ring 220kV constraint

The 220 kV Wairakei Ring corridor is constrained by the Atiamuri–Ohakuri circuit following an outage of either the Edgecumbe–Kawerau–3 or Te Mihi–Whakamaru–1 circuit (depends on net generation at Kawerau). This constraint typically binds during high generation in the Central North Island, Bay of Plenty and Hawkes Bay regions. Our modelling showed the constraint binds with increasing frequency as more generation gets developed in the Wairakei area and Hawkes Bay region.

Central North Island 220kV constraint

The 220 kV Central North Island corridor is constrained by the remaining Tokaanu–Whakamaru or Bunnythorpe–Tangiwai circuit following an outage of a Tokaanu–Whakamaru circuit. This constraint typically binds during high generation in the Central North Island, Taranaki and Wellington regions (including high HVDC northflow). Our modelling showed that resolving this constraint along with the North Island 110 kV and HVDC constraints will reap most of the benefits available over the next 10-15 years. Central North Island corridor upgrades (in conjunction with North Island 110 kV and HVDC upgrades) will increase access to South Island renewables in the short to medium term but over the longer term it also provides access to large amounts of lower North Island wind resources identified in the MBIE generation stack.

South Island Constraints



Following the completion of the second stage of Clutha Upper Waitaki Lines Project (CUWLP), two sets of constraints in the South Island 220 kV network limit North Island consumer's access to South Island renewable energy following the NZAS closure. These are the 220 kV Aviemore–Benmore and Clutha and Upper Waitaki constraints.

The 220 kV Aviemore–Benmore corridor is constrained by the overloading of the remaining Aviemore–Benmore circuit following an outage of the parallel circuit. This is followed by the overloading of both Aviemore–Benmore circuits following an outage of the Islington–Livingstone–1 circuit then overloading of both Aviemore–Benmore circuits following a Clyde–Cromwell–Twizel circuit outage. The Aviemore–Benmore constraint typically binds when there is high north flow on the HVDC coupled with high generation from the Waitaki and Aviemore generating stations. Our analysis has shown that installing a special protection scheme (AVI-BEN SPS)[4] to manage this constraint provides a significant net benefit to consumers over the short to medium term. We have committed to installing the AVI-BEN SPS which will maximise the potential of the CUWLP stage 2 upgrades currently underway. Our modelling has shown that there is a small amount of residual benefits to further un-constraining the Aviemore–Benmore transmission corridor but the cost of further upgrades will likely outweigh the benefits over the short to medium term.

After the completion of CUWLP stage 2, the Clutha Upper Waitaki corridor is constrained by the overloading of the remaining Clyde–Cromwell–Twizel circuit (Clyde–Cromwell section only) following an outage of the parallel circuit. This is followed by the overloading of the upgraded Naseby–Roxburgh and Livingstone–Naseby circuits following a Clyde–Cromwell–Twizel circuit outage. Our modelling has shown that there is a small amount of residual benefits to further un-constraining the Clutha Upper Waitaki corridor, but the cost of further upgrades is likely to outweigh the benefits over the short to medium term.

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[4] The proposed Aviemore–Benmore Circuit Overload Protection scheme (AVI–BEN COPS) trips the 220 kV Aviemore–Waitaki–1 circuit if an Aviemore–Benmore circuit trips and the remaining circuit is overloaded. The scheme reconfigures the grid to stop through transmission between the lower South Island and Benmore, removing the overload on the remaining Aviemore–Benmore circuit.