Kaimai Wind Farm
Ventus Energy

High Level Response

By: Transpower New Zealand Ltd

Date: August 2009
November 2012 (minor updates)
October 2017 (updated to include uprated windfarm size)

1. Introduction

Ventus Energy is investigating a 100-160 MW wind farm, known as Kaimai, 6.5 km from Waikino. The wind farm array sits aside the 110 kV double circuit Waihau–Waikino A transmission line between structures 29 and 30.

Ventus Energy has requested a High Level Response from Transpower for the connection of this wind farm proposal.

Note that all comments in this High Level Response are preliminary only, unless otherwise noted, and must be confirmed by specific studies.

2. Transmission system

The Kaimai wind farm would connect to the "Valley spur" transmission lines, which are connected to a major, high capacity substation at Hamilton. The Valley spur is made up of the following 110 kV double circuit transmission lines:

- Hamilton–Waihou 1&2 circuits, each rated 154/161/168 MVA summer/*shoulder*/ winter[1];
- Waihou–Waikino 1&2 circuits, each rated 101/113/123 MVA summer/*shoulder*/winter; and
- Waikino–Kopu 1&2 circuits, each rated 114/114/114 MVA summer/*shoulder*/winter, constrained by a protection limit.

If required, it may be possible to increase the rating of the Waihou–Waikino 1&2 circuits to about 147/156/162 MVA by increasing their maximum operating temperature, but that would need to be confirmed by a detailed technical assessment and is also subject to potential property right and consenting issues.

This part of the transmission system has only very simple and basic protection, with no protection signalling, to detect and clear any faults on the transmission system. Connecting any generation is likely to require a protection upgrade, with the extent and cost of the upgrade depending on the connection option chosen.

3. Transmission Capacity

There is adequate transmission capacity to connect the 100 MW Kaimai wind farm without any restrictions due to the capacity of the transmission system, but additional measures would be required to enable more generation. The following should also be noted:

- If more generation, such as other wind farms, connect to the Valley spur then the output from the Kaimai wind farm may need to be restricted at times to prevent circuits from overloading;
- Depending on the details of how the Kaimai wind farm was connected (see next section), there is adequate transmission capacity for up to 100 MW of Kaimai wind farm output at all times even with one circuit out of service; and
- More than 100 MW of output may require additional investment in the transmission system, such as a special protection scheme, to manage loading during planned or unplanned transmission outages.

[1] The summer rating applies from 1st December to 14th March, between 07:00 hours and 21:00 hours ("during the day").
The shoulder rating applies from 15th March to10th May and from 20th October to 30th November, between 07:00 hours and 21:00 hours ("during the day").
The winter rating applies at all other times ("during the night in summer and shoulder periods, and continuously during winter").

4. Connection Options

There are several potential options for connecting the Kaimai wind farm to the grid. The final option chosen, if the wind farm development proceeds, would depend on several factors, including:

- the cost / security trade-off selected by the wind farm developer;
- property issues for any transmission line and substation work;
- obtaining the required consents; and
- the size of the windfarm.

For a connection greater than 100 MW, n-1 security may not be possible in certain system conditions without further investment in the transmission system. One option could be an automated special protection scheme to manage overloads is one circuit experiences a contingency. This would require a system study to understand both the likely cost and the prospective capacity increase.

Some connection options are described in the following sections.

4.1 Hard Tee Connection

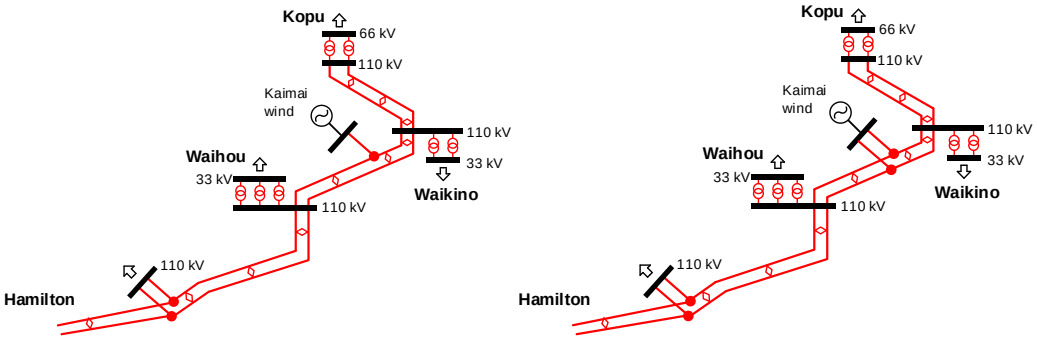

Figure 1: Possible single and double hard Tee configurations

It may be possible to "tee" connect the wind farm to the Waihou–Waikino circuit(s). A tee connection involves one (or two) 110 kV circuits from the wind farm connecting directly onto the existing circuits without a substation, effectively creating a three-terminal circuit. This is often the least cost connection configuration, however, the following points need to be noted:

- Tee connections can cause difficulties with protection, and a specific protection study would need to be completed before Transpower could commit to this option. It is usually necessary to replace the existing line protections at the other ends of the circuits (Waihou and Waikino). Very good communications would be required between Waihou, Waikino and the wind farm for the associated protection signalling. If the required communication system is not already in place, then this connection configuration could be more expensive than a new Kaimai substation.
- If there is only a single tee connection, then the wind farm would be disconnected whenever the associated circuit was out of service due to a fault or for maintenance (ie n security). Maintenance would normally be scheduled primarily taking into account the requirements of the off-take customers and landowners (for line work), rather than the requirements of generators (such as the wind farm). This configuration is unlikely to be appropriate for a connection greater than 100 MW due to lack of capacity.
- If there is a double tee connection, the wind farm would have two 110 kV transformers, each connected to one of the tee circuits. There would be no 110 kV bus. In addition, the wind farm may need to be "split" with each half of the wind farm connected to one tee circuit. If split, half the wind farm would be disconnected if a 110 kV circuit trips. However, it may then be possible to connect both halves of the wind farm to one transformer and tee circuit to resume output up to 100 MW (assuming the transformer

and new line section are adequately rated (ie there is partial n-1 security after switching, but not n-1 security with no break).

- The new 110 kV line section forming the tee circuit(s) from the existing Waihou–Waikino circuit to the wind farm would need to be designed, owned, operated and maintained by Transpower. This is because faults on the new tee circuit would affect through transmission between Waihou and Waikino.

Connecting generation of 100 MW through a single tee connection, giving n security for circuit faults, is unusual in the New Zealand context. Most, but not all, generation of this capacity or higher is connected with n-1 security for circuit faults.

Although appearing cheaper than a new Kaimai substation, as it requires two fewer circuit breaker bays and eliminates the 110 kV bus at the wind farm, as discussed above this option may require duplicate communication for protection signalling to be established between the wind farm, Waihou and Waikino, and the existing protections at Waihou and Waikino to be replaced. The cost and/or project risk for the duplicate communication infrastructure may be greater than that for option

4.2 New Kaimai Substation

A dedicated 110 kV substation could be built near the Kaimai wind farm and the Waihou–Waikino double circuit transmission line.

The wind developer would need to make their own judgement if there should be one or two 110 kV connections from the substation to the wind farm. If there is only one connection, then the wind farm would need to be disconnected whenever there is bus maintenance.

The "connection" to the wind farm could either be a short 110 kV transmission line, or 110 kV transformers.

A protection study will determine if protection signalling is required due to the connection of Kaimai. If so, additional communication infrastructure is likely to be needed between Kaimai, Waihou and Waikino.

For a <100 MW sized windfarm:
Only one of the two circuits on the Waihou–Waikino transmission line would need to be connected to the substation i.e. an 'in-out' connection. If one circuit is out of service due to a fault or for maintenance, then full output from the wind farm will still be possible (ie there is n-1 transmission security). This configuration therefore offers more security than a Hard-tee connection.

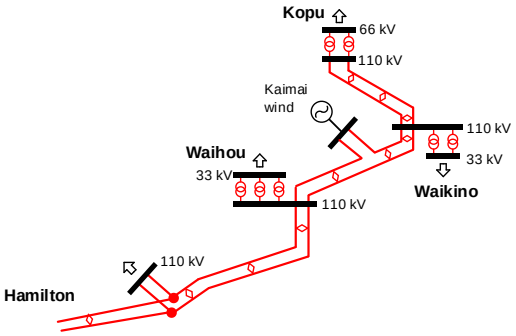

Figure 2: : Possible new substation "in-out" connection to two Waikino-Waihou circuits

For a >100 MW sized windfarm
Both the two circuits on the Waihou–Waikino transmission line could be connected to the substation (to essentially create four circuits out of Kaimai). This configuration could offer more flexibility a single 'in-out' connection.

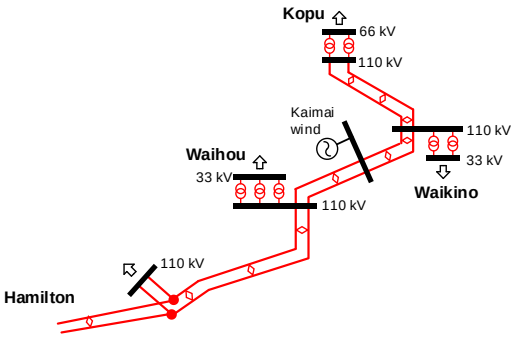

Figure 3: Possible new substation connection to two Waikino-Waihou circuits

This configuration would be more significantly larger and more expensive than for a sub-100 MW connection, with a more equipment required to handle the increased number of connections e.g. circuit breaker bay(s).

With the outgoing circuits rated at 101/113/123 MVA summer/*shoulder*/winter, curtailment would be likely during equipment outages (e.g. circuit out of service), depending on system conditions. The extent of measures needed to address a lack of capacity, especially during outages, would require further work.

4.3 Dedicated 110 kV line to Waikino

The windfarm developer has indicated that this option which had been proposed previously is not considered feasible.

4.4 Voltage and reactive power considerations

In any connection arrangement, a reactive power scheme may need to be implemented to reduce the level of flicker observed to customers on the Valley Spur due to natural wind output fluctuations.

This part of the transmission system is also subject to low voltages and large voltage steps post-contingency which any newly connected generator will need to be specified to ride through.

5. Property rights requirements

Transpower will need agreement from the customer to:

- provide at no cost an unencumbered freehold title in favour of Transpower for the proposed new Grid Injection Point (GIP) at a location to be determined under the 'ACRE' site location and consenting process (see section 6.3, below). The area required for the GXP site will be determined by Transpower
- provide an access road to be specified by Transpower and ensure that Transpower has adequate legal access rights to the new GIP
- the extent of the Earth Potential Rise (EPR) 650v contour will need to be established around the new GIP site and any new transmission structures and either outright ownership of the EPR zone or an EPR easement limiting certain activities within the 650v contour will be required
- secure adequate property rights for any associated equipment (e.g. telecommunications)

- easements over and inclusive of any transmission line connection arrangements to the new GIP will be required. Easements to be in Transpower's standard form and content (easement rights to be provided will include the construction, inspection, operation, upgrade and maintenance of transmission lines and/or cables and associated equipment and these rights will apply to both the conveyance of electricity and of telecommunications associated with operating the asset and the National Grid)

- easement arrangements will embody (amongst other things) the following specific conditions;
    - easements to be in perpetuity but may contain sunset provisions
    - easement width to be determined by Transpower
    - length of easement to capture extent of all works between and inclusive of existing transmission lines and the new GIP
    - land use within new easements will be restricted to exclude new structures or any 'inappropriate' development
    - any new easements will require 'clear' easement corridors – i.e. any existing buildings will need to be removed
    - compensation will by one off lump sum payment only
    - registered rights of way (at no cost to Transpower) will be required to each new transmission structure on alignments to be determined by Transpower

6. Environmental Planning

6.1 Confirming customer /Transpower responsibilities

Where Transpower is to own an asset, we will also own and manage the associated environmental designation/consenting processes to ensure that the site/route selection processes and statutory approval processes meet our requirements. Designation/consenting responsibilities must be discussed and confirmed early on in the project. An MOU may be useful to confirm agreement on these matters.

6.2 Environmental Approvals Required

As a requiring authority, the Resource Management Act 1991 (RMA) authorises Transpower to seek a designation for the construction and ongoing operation and maintenance of its assets. Wherever possible, Transpower will designate new assets because this:

- protects land for future transmission development from encroachment by other activities;
- removes any requirement to obtain resource consents for the maintenance and upgrade of the designated works under any relevant District Plan;
- gives Transpower the authority to operate, maintain, upgrade and develop the assets in accordance with the designation;
- prevents others using the land in a manner that would prevent or hinder Transpower using it for its purposes; and
- allows for the compulsory acquisition process to be triggered under the Public Works Act 1981 (PWA).

6.3 Site and Route Selection Process Requirements

Before a Notice of Requirement (NOR) for a designation or a resource consent can be lodged for a new substation and/or any new lines, Transpower is required under the RMA to assess alternative site and line route options. Transpower's approach for new greenfield assets is to follow the ACRE process (Area, Corridor, Route, Easement) to achieve an integrated and consistent approach for route and site selection. The ACRE process enables Transpower to demonstrate that it has undertaken the appropriate level of investigations (including

consideration of alternative sites, routes and methods) required by various pieces of legislation, primarily the RMA, PWA and also the National Policy Statement on Electricity Transmission.

The overall timeframe required to determine a preferred route/site and to secure the designation for a new line and/or substation can be approximately 14 - 26 months. Numerous variables will influence this process (including consultation, the need for specialist consultants, council processing costs, potential appeals, etc).

7. Cost Estimates

It is not possible to give a meaningful cost estimate in a HLR because of the significant unknowns. Costs will vary greatly, for example, for the different connection options and level of security required for the wind farm. There are also even greater cost variations due, for example, to the location of the substation site and transmission line route, and modifications that may be required to the existing transmission line route and structures. These costs often cannot be estimated until at least part way through the Environmental Planning process.

8. Next Steps

The next step is for Transpower and Ventus Energy to decide the scope for further investigation. For this Ventus Energy will be required to sign a Detailed Solution Development (DSD) agreement to fund the necessary investigation work. Significantly more investigation is required before a preferred connection option could be recommended.

We would be happy to meet to discuss the scope and indicative timeframes and costs.