TRANSPOWER

North Island 400 kV Upgrade Project

Investment Proposal

Part III – Analysis of Options for Meeting the Investment Need

1 Summary

Part III contains an analysis of all transmission options and alternatives to transmission (including generation and demand side management) to meet the demand identified as being required in the upper North Island from 2010.

The transmission options and alternatives for transmission which are determined by Transpower as being credible options are then assessed against the proposed investment from an economic perspective (such analysis being contained within Part IV).

Transmission Options

Transpower's high level assessment of transmission options against technical, economic and environmental criteria showed that only 220 kV and 400 kV AC overhead transmission options are credible options to meet the need identified in Part II.

The following transmission options have been considered and assessed by Transpower in this Part III:

- 220 kV development
- 330 kV development
- 400 kV development
- 500 kV development
- Classic HVDC development
- HVDC Light development
- Undergrounding

Alternatives to Transmission

Transpower issued a Request For Information to determine the potential alternatives to transmission. Transpower assessed all alternatives offered through this RFI process and concluded that peaking plant is the sole alternative to transmission which would avoid or defer the need for the proposed investment and/or have a reasonable likelihood of proceeding.

2 Assessment Criteria

The criteria that Transpower has considered in assessing all transmission and non transmission options are:

- ***System Security*** *– Whether the power supply to the upper North Island meets an N-1 security standard in accordance with Transpower's security standard given the assumed demand and generation forecasts as set out in this submission.*

- ***Asset Availability*** *– The availability of the various power system components forming an essential part of the proposed development.*
- ***Economic Benefit*** *– The net present value of the benefits that accrue from the transmission option less all estimated capital and operating costs.*
- ***Environmental Feasibility*** *– The feasibility of development options given environmental constraints. The details of this assessment criteria are in Appendix III-A.*
- ***Timing*** *– The ability of the proposed development to be delivered by 2010.*
- ***Flexibility*** *– The ability of the proposed development to be harmoniously used together with the existing grid assets and future grid upgrades for meeting the future demand growth and generation developments.*

3 Sustainability

Transpower is committed to incorporating sustainability into its business activities and to working with key stakeholders to promote sustainable outcomes for the electricity sector.

In line with the government policy direction on sustainability[1], the extent to which transmission options contribute to sustainability can be assessed using the following criteria:

1. Integration of generation from diverse sources at appropriate locations.
2. Improvement in network reliability/resilience
3. Reduction of transmission losses
4. Mitigation of site specific environmental impacts
5. Reduction of overall cost of electricity to the consumer

These criteria are considered in the following sections.

3.1 Integration of Transmission and Diverse Generation

The advantage of all transmission options compared to non-transmission alternatives is through enabling integration of diverse generation sources (at appropriate locations). This can lead to the following benefits

- Reduction in emissions of local air pollutants and reduction in greenhouse-gas emissions where transmission provides connections to cleaner and/or renewable forms of generation;
- Reduction in human exposure to ambient pollution, where transmission allows separation of generation sources and points of electricity use (demand centres);
- Potential reduction in long-range pollutant transport and regional problems like acid rain where energy needs to be transported using forms other than electricity transmission;

Nationally, New Zealand is required to reduce greenhouse-gas emissions under the Kyoto Protocol. Without a reduced reliance on greenhouse gas emitting generation

[1] October 2004, the government released a discussion document, 'Sustainable Energy-Creating a Sustainable Energy System'

(and increased accessibility to hydro, solar, wind and/or other forms of energy), it is apparent that the present trajectory of greenhouse-gas emissions will make achievement of Kyoto targets a real challenge. A stronger grid will enable the efficient use of renewable forms of energy such as wind power and hydro power whilst maintaining a reliable supply of electricity to consumers.

3.2 Reliability and Resilience of Transmission

The reliability and resilience of the transmission network is also relevant from a sustainability perspective and transmission upgrade options are evaluated taking these into consideration.

Reliability of the transmission network refers to the ability of the network to make the supply insensitive to a failure of a transmission component or a generating unit.

Resilience of the transmission network refers to the ability of the network to sustain its value and functionality over a longer time and to accommodate the new generation developments and meet long term demand growth.

3.3 Transmission Losses

Minimising transmission losses is an important consideration in meeting long term sustainability. Transmission options are identified and selected taking the cost of transmission losses into account. For example, options associated with an increase in operating voltage provide greater environmental benefits through reduced transmission losses over comparable line lengths. In general, transmission options which reduce transmission losses are preferred because they:

- Reduce additional power generation needed to overcome power losses in long-distance transfers;
- Reduce combustion emissions at the points of electricity generation;
- Reduce methane emissions from natural gas extraction, processing, and distribution, if gas plants are the source of the electricity;
- Reduce possible human health and ecosystem effects from additional generation plants and transmission lines; and
- Reduce environmental effects associated with generation from specific forms of energy (nuclear, hydro, wind etc.).

The economic benefits of reducing transmission losses under each option are considered in Section 4.

3.4 Site Specific Mitigation

Site specific environmental impacts of transmission options have been considered in some detail under each option in Section 4 and will be further elaborated through the RMA process. Environmental impacts are considered and assessed against the other possible alternatives along each step of the transmission development process, including area, corridor and route selection, transmission tower design and conductor selection, employment of construction techniques and long term maintenance of the assets and location, planning and construction of the terminating stations. The transmission options are identified and selected with the objective of minimising any site specific adverse impacts and considering the ability for providing most effective and economically efficient mitigation measures. Appendix III-A summarises the process being followed.

3.5 Overall Electricity Cost to the Consumer

Transmission options are evaluated economically, using the Grid Investment Test, which is a national cost-benefit analysis. To pass the Grid Investment Test a proposal must maximise the net economic benefits to the market as a whole. Hence, transmission options are evaluated in a manner which ensures the cost of producing electricity is minimised.

Further, the transmission network is the platform upon which the electricity market operates. By allowing consumers to access the cheapest form of generation available any where in the country, competition is enhanced, ensuring the the cost of electricity to consumers is minimised.

4 Transmission Options

Transpower has assessed a range of transmission options that it considers are capable of providing the necessary power transfer capacity to the upper North Island. In summary this assessment includes:

- High voltage alternating current (HVAC) options at 220 kV, 330 kV, 400 kV and 500 kV.
- High voltage direct current (HVDC) transmission options at 350 kV, 500 kV and HVDC light.
- The use of overhead transmission lines and or underground cables for HVAC and HVDC applications.

The commitment to a new voltage level for the core grid is a strategic decision involving the entire national grid and a decision on the appropriate voltage for grid reinforcement between Whakamaru and Auckland needs to be considered in that light.

4.1 HVAC Power Transmission Options

There are two broad development paths for HVAC transmission, namely:

- Continuing with future grid development using 220 kV assets – in other words maintaining the maximum voltage for New Zealand's core grid at 220 kV.
- Selecting a new maximum voltage (e.g. 330 kV, 400 kV or 500 kV) which would be introduced as appropriate in the North and South Island transmission systems.

All transmission proposals, including the use of higher voltages for the core grid, would require the continued use of 220 kV for other parts of the grid where it is economic to do so.

In assessing the preferred future transmission voltage, Transpower has analysed future possible grid developments under several generation scenarios and a medium confidence load growth forecast. Of the HVAC options, the 220 kV and 400 kV alternatives were ranked has the best two HVAC solutions and the results are compared in detail in this section. A summary of the rationale for not following a development path with maximum transmission voltage of 330 kV and 500 kV are also included.

4.2 HVDC Power Transmission Options

Two generic HVDC transmission options to increase the power transfer levels into Auckland were investigated. These options were:

- A bulk HVDC power transfer option connecting South Island generation and transferring this directly to Auckland.
- The establishment of a short 200 km HVDC link between Whakamaru and Otahuhu which is interconnected into the HVAC system at each end.

There are also two main choices of HVDC technology that are applicable to high voltage power systems. HVDC power transmission requires the conversion of power to HVDC using power electronic devices. Bulk electricity is then transferred at HVDC through overhead lines or underground cables (or a combination). An inversion process then converts HVDC power back to HVAC power at the receiving end. Two means of converting the AC power to DC are presently available and are considered as possible options:

Classical HVDC	• High voltage, high power, thyristor-based power conversion technology. • Power transmission could be by way of overhead line or underground cable.
HVDC Light	• Relatively new, medium voltage (150 kV), transistor-based power conversion technology. • With the current technology, power transmission possible only by underground cable

4.3 220 kV HVAC Development Plan

The following sections describe the future development of the grid under different generation scenarios, if 220 kV is retained as the maximum transmission voltage.

As electricity demand increases, regional transmission connections and supply transformers will become increasing overloaded and will require reinforcement. For the purposes of this analysis, the focus is on the core transmission network and therefore regional upgrades have been added to the power flow models as necessary to remove overloading problems. While these solutions have not been optimised, they are not considered material to the analysis of the core grid.

In this section a number of stages have been developed to group the necessary grid upgrades into discrete steps. Stage 1 represents grid upgrades which are planned to take place approximately from 2010 to 2015, stage 2 are developments up from 2015 to 2020, and stage 3 are developments beyond 2020.

It should be noted that the high-level development plans in this section are based on system planning studies. Detailed studies are required to confirm optimal location and sizing of some reactive power investments and detailed engineering work is still required to confirm feasibility and the appropriateness of the type of solution employed. For example where an existing line is proposed for upgrading by installing duplex conductors the existing towers may not be strong enough and they may require replacement. Furthermore, where two single circuit lines are proposed for duplexing, a single double circuit line may be built instead.

4.3.1 Grid Developments Before 2010

A number of tactical transmission upgrade projects are planned for implementation in the North Island before 2010. A summary of these projects is given in the Transpower publication: Future of the National grid – Transmission Plan Summary 2004. These projects are summarised in Appendix III-B.

Before 2010, the transfer capability into Auckland will be increased by a combination of thermal upgrades of key transmission lines and increasing the level of reactive power compensation in the region. After 2010, the power transfer into the Auckland region will be mainly constrained by a voltage stability limit and the benefits of installing more reactive compensation become limited as set out in Part II of this submission. At this point Transpower considers that a major step change in transmission investment is required.

4.3.2 220 kV Grid Development Plan for Generation Scenario 1 (Gas) from 2010-2040

The lines to be newly built or upgraded with duplex conductors under Generation Scenario 1 (gas) at different stages are:

Stage	Transmission Line
1	Construct a 220 kV double circuit line Whakamaru to Auckland.
	Upgrade 220 kV Tokaanu – Whakamaru A&B lines to duplex conductor.
	Upgrade 220 kV Bunnythorpe – Haywards A&B lines to duplex conductor.
	Auckland cross Isthmus reinforcement with new 220 kV circuit (cable or overhead).
	Construct a 220 kV double circuit line Wairakei - Atiamuri - Whakamaru in duplex zebra. String one circuit only.
2	Upgrade the 220 kV double circuit Stratford - Taumarunui – Te Kowhai - Huntly line to duplex conductor.
	New double circuit 220 kV –Taumarunui - Whakamaru line.
	New double circuit 220 kV Stratford – Whakamaru line.
	Upgrade the 220 kV Bunnythorpe – Tokaanu - Whakamaru lines to duplex.
	New double circuit 220 kV Bunnythorpe – Redclyffe line. String one circuit only.

3	String second circuit of 220 kV Wairakei – Atiamuri – Whakamaru line.[2]
	Upgrade Atiamuri – Tarukenga A line with duplex conductor.
	New single circuit 220 kV Hamilton - Huntly line.
	Possibly dismantle 220 kV Otahuhu – Whakamaru A&B lines[3].
	New switching station near Huntly.

Table 4-1: 220 kV Grid Development Plan 2010-40 for Generation Scenario 1

In stage 1, the thermal upgrades and a new 220 kV double circuit line will be needed to supply the Auckland load.

The existing HVDC link is also assumed to be upgraded to 1400 MW capacity by the end of 2010. The associated core grid HVAC developments include upgrading the existing 220 kV single conductor Hayward – Bunnythorpe A&B lines and Tokaanu - Whakamaru A&B lines with duplex conductors (for increased HVDC transfer to the South Island during low hydro periods, and increased northwards transmission respectively).

In stage 2, upgraded and new lines will be required out of the Taranaki region to Taumarunui, Huntly and Whakamaru to facilitate unconstrained dispatch of generation in the Taranaki region to Auckland.

Additional new lines are also required to dispatch the generation from the Bunnythorpe region and south (including HVDC import) to areas north of Whakamaru.

Augmentation in stage 2 will need to be followed in stage 3 by reinforcement of the 220 kV grid for the transfers into Hamilton, into Bay of Plenty and through the Wairakei ring.

The new switching station near Huntly is to connect the increased generation from Huntly to the Otahuhu – Whakamaru lines.

The ultimate grid augmentation plan for a 220 kV transmission system for Scenario 1 is shown in Figure 4-1.

[2] At this stage it may be possible to dismantle the existing lower capacity single circuit Wairakei – Ohakuri – Atiamuri – Whakamaru line.
[3] Towards the end of the planning horizon for this scenario there is a large increase in generation capacity in the Auckland area, so the capacity of the Otahuhu – Whakamaru A&B lines may not be required. As these lines will be old, they could be considered for dismantling.

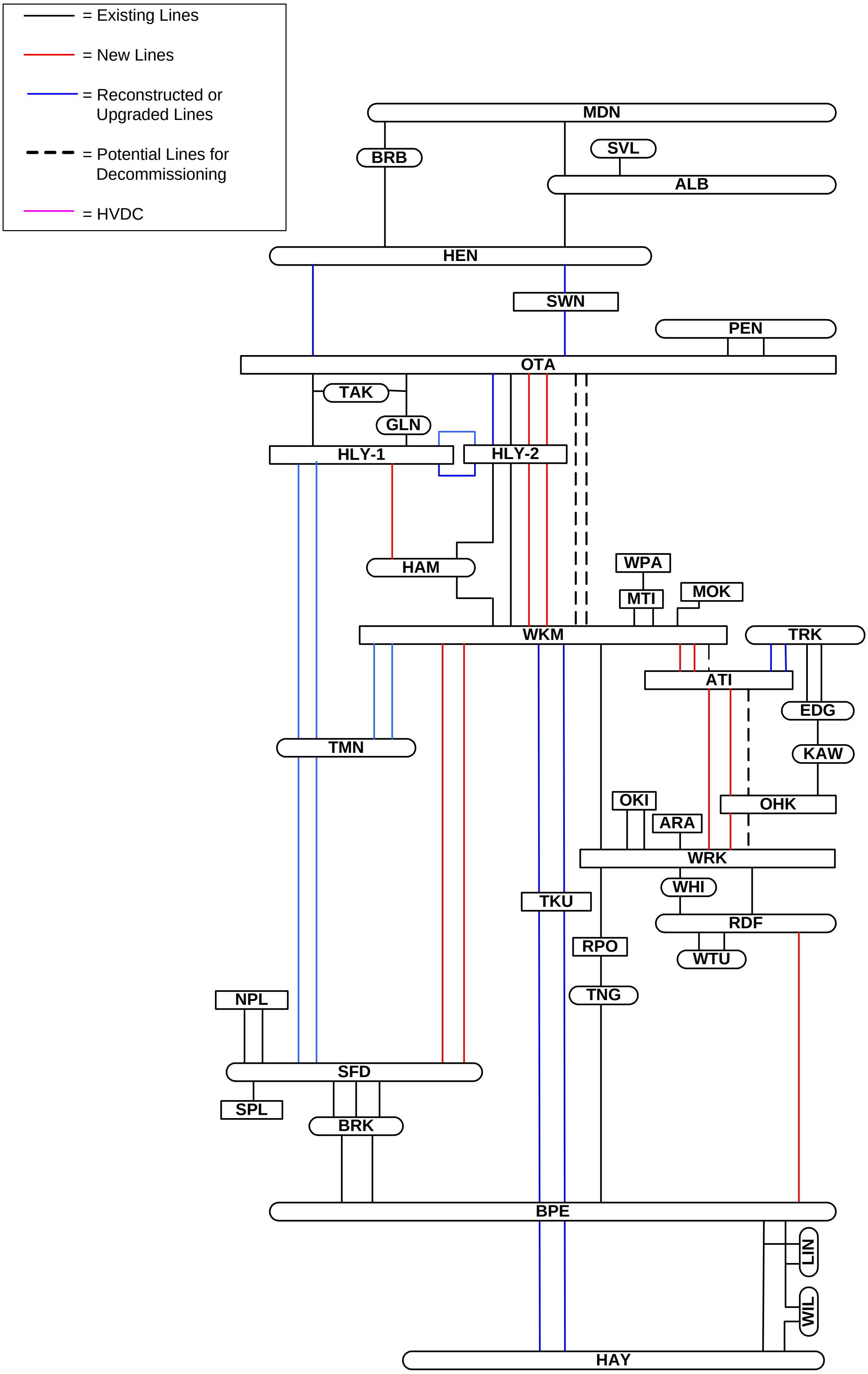


Figure 4-1: 220 kV grid configuration for Generation Scenario 1 at 2040

4.3.3 220 kV Grid Development Plan for Generation Scenario 2 (Coal) from 2010-2040

The new lines to be built and those that are to be upgraded with duplex conductors under Generation Scenario 2 (coal) are given below:

Stage	Transmission Line
1	Construct a 220 kV double circuit line Whakamaru to Auckland.
	Upgrade 220 kV Tokaanu – Whakamaru A&B lines to duplex conductor.
	Upgrade 220 kV Bunnythorpe – Haywards A&B lines to duplex conductor.
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead).
	Construct a 220 kV double circuit line Wairakei - Atiamuri - Whakamaru in duplex zebra. String one circuit only.
2	Upgrade double circuit 220 kV Bunnythorpe – Whakamaru line to duplex conductor.
	New double circuit 220 kV Bunnythorpe – Redclyffe line. String one circuit only.
3	Upgrade Atiamuri – Tarukenga A line with duplex conductor.
	String second circuit of the 220 kV Wairakei – Atiamuri – Whakamaru line[4].
	Upgrade the 220 kV double circuit Stratford - Taumarunui – Te Kowhai - Huntly line to duplex conductor.
	New double circuit 220 kV Taumarunui – Whakamaru line.

Table 4-2: 220 kV Grid Development Plan 2010-40 for Generation Scenario 2

In stage 1, the thermal upgrades and a new 220 kV double circuit line will be needed to supply the Auckland load. The existing HVDC link is assumed to be upgraded to 1400 MW capacity by the end of 2010. The associated core grid AC developments include upgrading the existing 220 kV single conductor Hayward – Bunnythorpe A&B lines and Tokaanu - Whakamaru A&B lines with duplex conductors (for increased HVDC transfer to the South Island during low hydro periods, and increased northwards transmission respectively).

For stage 2, the upgraded and new lines from Bunnythorpe are for the new generation in the Bunnythorpe and south regions to supply the load to the north.

For stage 3, the upgraded and new lines from Stratford to Taumarunui, Huntly and Whakamaru are principally due to the new generation at Stratford and south of Bunnythorpe, and for voltage stability to the Auckland area. The second Wairakei – Atiamuri – Whakamaru circuit is for the new generation in the Wairakei area, and to supply the Bay of Plenty load. The ultimate grid augmentation plan for a 220 kV transmission system for Scenario 2 is shown in Figure 4-2.

[4] At this stage it may be possible to dismantle the existing lower capacity single circuit Wairakei – Ohakuri – Atiamuri – Whakamaru line.

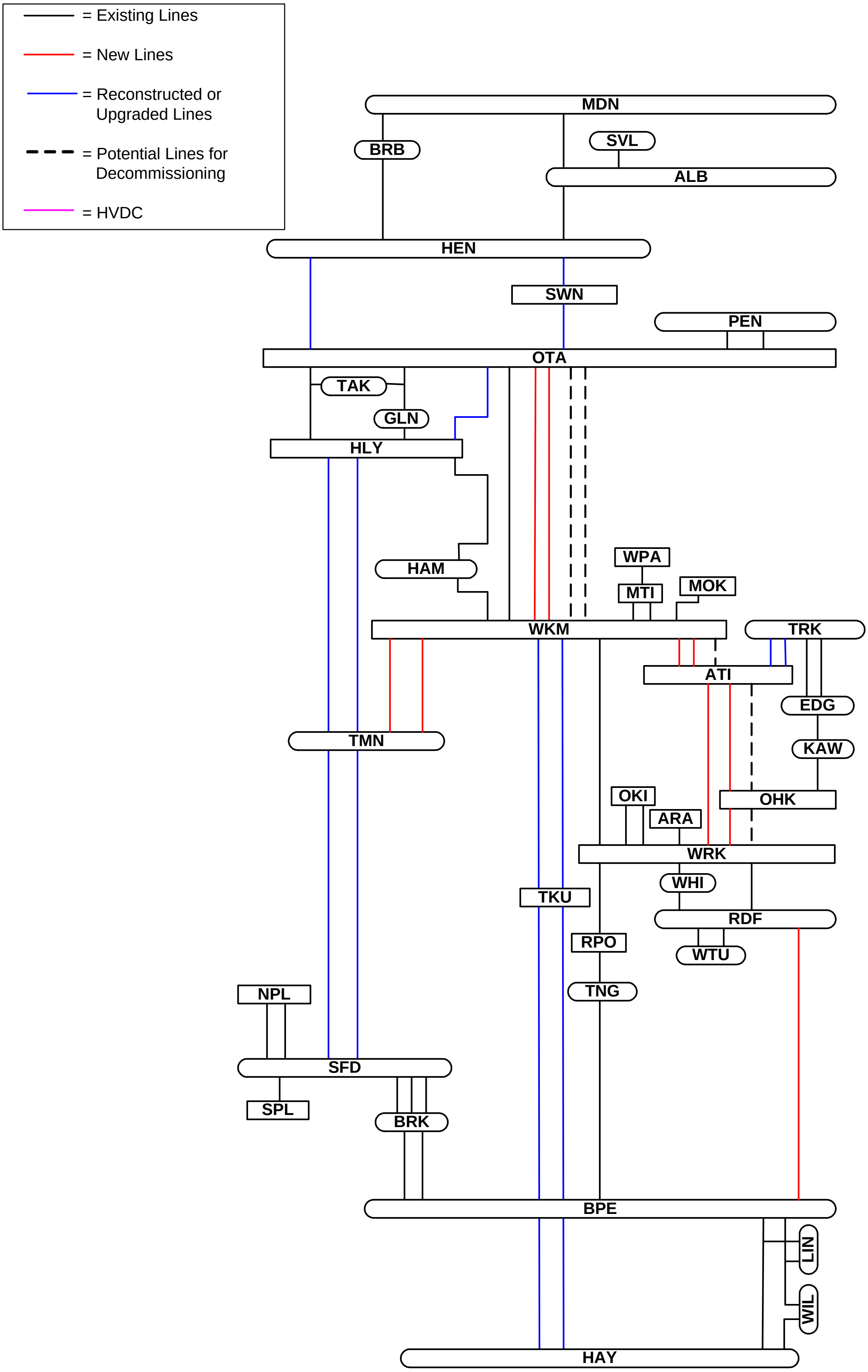


Figure 4-2: 220 kV grid configuration for Generation Scenario 2 at 2040

4.3.4 220 kV Grid Development Plan for Generation Scenario 3 (Renewable) from 2010-2040

The lines to be newly built or upgraded with duplex conductors under Generation Scenario 3 (renewables) at different stages are:

Stage	Transmission Line
1	Construct a 220 kV double circuit line Whakamaru to Auckland.
	Upgrade 220 kV Tokaanu – Whakamaru A&B lines to duplex conductor.
	Upgrade 220 kV Bunnythorpe – Haywards A&B lines to duplex conductor.
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead).
	Construct a 220 kV double circuit line Wairakei - Atiamuri - Whakamaru in duplex zebra. String one circuit only.
2	Upgrade double circuit 220 kV Bunnythorpe – Tokaanu - Whakamaru line to duplex conductor.
	New double circuit 220 kV Bunnythorpe – Redclyffe line. String one circuit only.
3	String second circuit of 220 kV Wairakei – Atiamuri – Whakamaru line[5].
	New double circuit 220 kV Whakamaru – Auckland line.
	Upgrade the 220 kV double circuit Stratford - Taumarunui – Huntly line to duplex conductor.
	New double circuit 220 kV Taumarunui – Whakamaru line.
	New single circuit 220 kV Hamilton – Huntly line.
	New double circuit 220 kV Whakamaru – Otahuhu line[6].
	New double circuit 220 kV Whakamaru – Otahuhu line.

Table 4-3: 220 kV Grid Development Plan 2010-40 for Generation Scenario 3

In stage 1, the thermal upgrades and a new 220 kV double circuit line will be needed to supply the Auckland load.

The existing HVDC link is assumed to be upgraded to 1400 MW capacity by the end of 2010. The associated core grid AC developments include upgrading the existing 220 kV single conductor Hayward – Bunnythorpe A&B lines and Tokaanu - Whakamaru A&B lines with duplex conductors. (for increased HVDC transfer to the South Island during low hydro periods, and increased northwards transmission respectively).

For stage 2, the upgraded and new lines from Bunnythorpe are for the new generation in the Bunnythorpe and south regions to supply the load to the north.

5 At this stage it may be possible to dismantle the existing lower capacity single circuit Wairakei – Ohakuri – Atiamuri – Whakamaru line.

6 It is assumed that the Otahuhu – Whakamaru A&B line routes would each be used for a new double circuit line. Alternatively, these lines could be duplexed, in which case one less double circuit line is required.

In stage 3 upgrades for the transfers into Hamilton, into Bay of Plenty and through the Wairakei ring, will be as per generation scenarios 1 and 2.

For this scenario very little new generation is projected in the region North of Whakamaru. Therefore, significant reinforcements will be required in stage 3 between Whakamaru-Otahuhu, in addition to the double circuit line built in stage 1.

The ultimate grid augmentation plan for a 220 kV transmission system for Scenario 3 is shown in Figure 4-3.

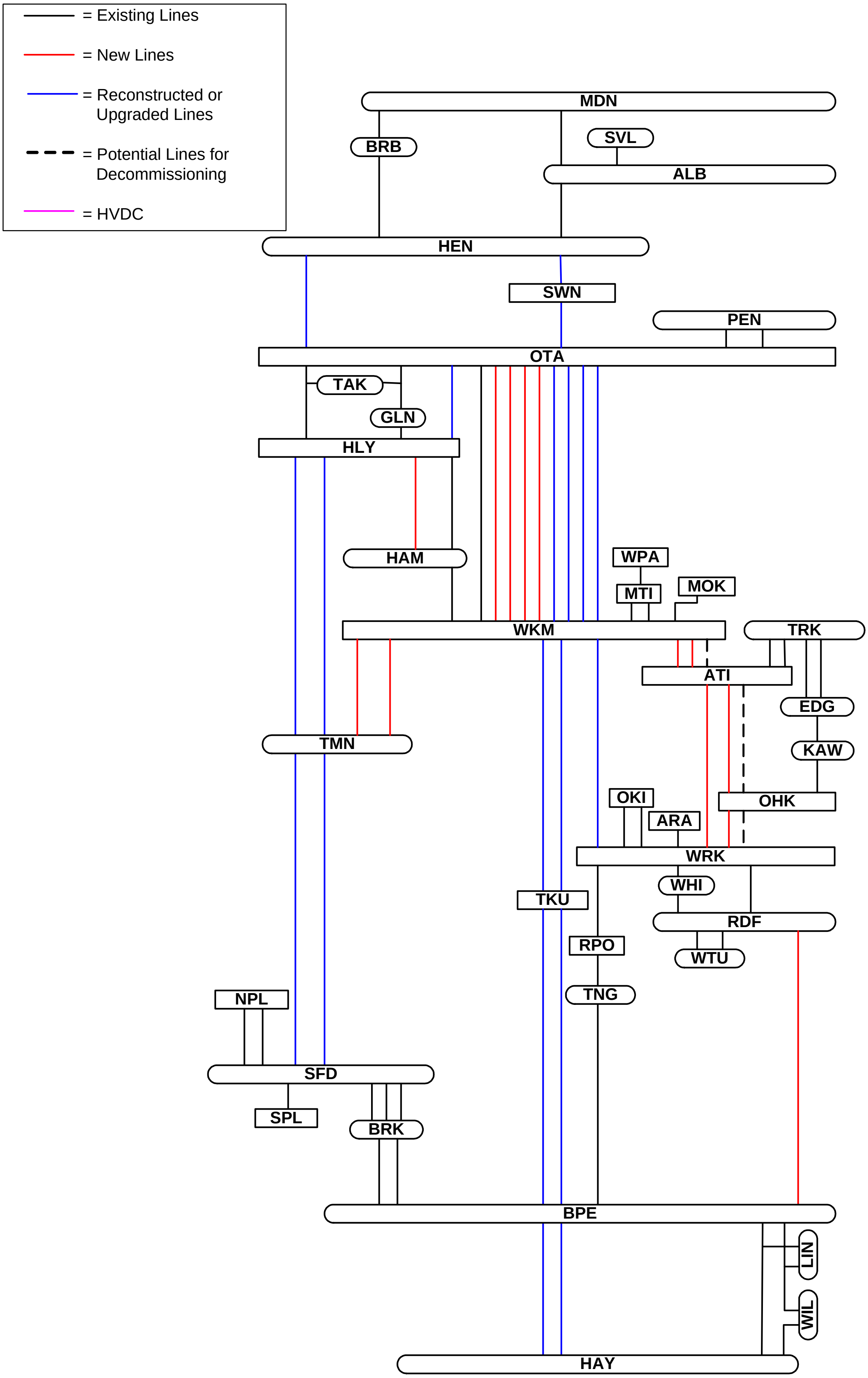


Figure 4-3: 220 kV grid configuration for Generation Scenario 3 at 2040

4.3.5 220 kV Grid Development Plan for Generation Scenario 4 (Southern Hydro) from 2010-2040

The new lines to be built and those that are to be upgraded with duplex conductors under Generation Scenario 4 (hydro) are given below:

Stage	Transmission Line
1	Construct a 220 kV double circuit line Whakamaru to Auckland.
	Upgrade 220 kV Tokaanu – Whakamaru A&B lines to duplex conductor.
	Upgrade 220 kV Bunnythorpe – Haywards A&B lines to duplex conductor.
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead).
	Construct a 220 kV double circuit line Wairakei - Atiamuri - Whakamaru in duplex zebra. String one circuit only.
2	New HVDC link of capacity 600 MW from the South Island into Auckland[7].
	Upgrade Atiamuri – Tarukenga line to duplex conductor.
3	Construct a new 220 kV double circuit line Whakamaru to Auckland.
	Upgrade the new HVDC link from 600 MW to 1200 MW.
	String second circuit of 220 kV Wairakei – Atiamuri – Whakamaru line[8].

Table 4-4: 220 kV Grid Development Plan from 2010-2040 for Generation Scenario 4

In stage 1, the thermal upgrades and a new 220 kV double circuit line will be needed to supply the Auckland load.

The existing HVDC link is assumed to be upgraded to 1400 MW capacity during the period 2010 - 2015. The associated core grid AC developments include upgrading the existing 220 kV single conductor Hayward – Bunnythorpe A&B lines and Tokaanu - Whakamaru A&B lines with duplex conductors. (for increased HVDC transfer to the South Island during low hydro periods, and increased northwards transmission respectively).

An increasing generation deficit develops in the North Island from 2010 onwards, primarily caused by a large increase in load and a lack of new generation in the Auckland and Northland region. With the upgrade of the existing HVDC, this deficit can be supplied until 2020, at which point n-1 security under generation contingencies can no longer be maintained.

For stage 2, a new HVDC link is assumed to be built from the South Island directly to Auckland. It is built in two stages, and is required to import power from the South Island directly to the major load centre in Auckland. Reinforcement of the 220 kV grid into the Bay of Plenty by duplexing Atiamuri - Tarukenga will also be required.

[7] The HVDC link is based on transmission capacity requirements only. The link must be such that it provides 600 MW reliable supply capacity to the Auckland region. Security considerations may require an arrangement, such as a double bipole.
[8] At this stage it may be possible to dismantle the existing lower capacity single circuit Wairakei – Ohakuri – Atiamuri – Whakamaru line.

For stage 3, the new HVDC link to Auckland is upgraded to 1200 MW to provide for additional load growth in the Auckland area. A new double circuit line is also required from Whakamaru to Auckland for transferring power from the new generation developments around Whakamaru and south of Whakamaru.

The ultimate grid augmentation plan for a 220 kV transmission system for Scenario 4 is shown in Figure 4-4.

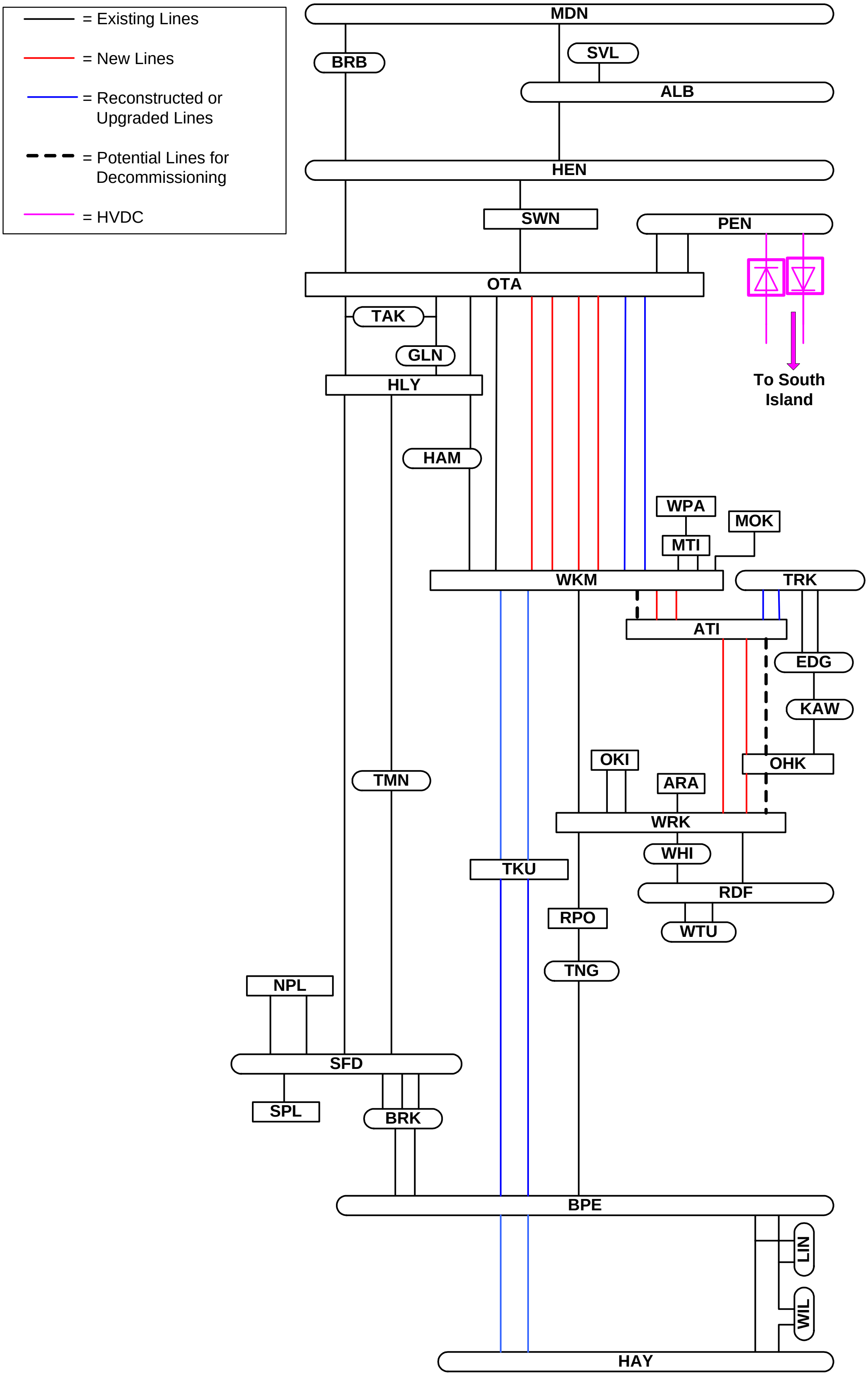


Figure 4-4: 220 kV grid configuration for Generation Scenario 4 at 2040

4.3.6 220 kV Grid Development Plan for Generation Scenario 5 (Reduced Demand) from 2010-2040

The new lines to be built and those that are to be upgraded with duplex conductors under Generation Scenario 5 (reduced demand) are given below:

Stage	Transmission Line
1	Construct a 220 kV double circuit line Whakamaru to Auckland.
	Upgrade 220 kV Tokaanu – Whakamaru A&B lines to duplex conductor.
	Upgrade 220 kV Bunnythorpe – Haywards A&B lines to duplex conductor.
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead).
	New 220 kV double circuit Whakamaru-Atiamuri-Ohakuri-Wairakei line.
2	Connect second circuit on Otahuhu-Whakamaru C line into Huntly.
	Upgrade Bunnythorpe-Tokaanu circuits to duplex conductor.
	Upgrade Bunnythorpe-Tangiwai-Rangipo circuits to duplex conductor.
	Connect Bunnythorpe-Tokaanu circuits into Rangipo.
	Upgrade Rangipo-Wairakei circuits to duplex conductor.
3	Upgrade 220kV Otahuhu - Whakamaru A and B lines to duplex conductor.
	Upgrade Atiamuri – Tarukenga A line to duplex conductor.
	Connect second circuit of Otahuhu-Whakamaru C line into Hamilton.
	New 220 kV double circuit Otahuhu - Whakamaru line.
	Upgrade existing Wairakei-Whakamaru A line to duplex conductor.

Table 4-5: 220 kV Grid Development Plan 2010-2040 for Generation Scenario 5

In stage 1, the thermal upgrades and a new 220 kV double circuit line will be needed to supply the Auckland load. A new double circuit line between Wairakei and Whakamaru is also required for transferring the generation from south of Bunnythorpe.

The existing HVDC link is assumed to be upgraded to 1400 MW capacity during the period 2010. The associated core grid AC developments include upgrading the existing 220 kV single conductor Hayward – Bunnythorpe A&B line and Tokaanu - Whakamaru A&B line with duplex conductors. (for increased HVDC transfer to the South Island during low hydro periods, and increased northwards transmission respectively).

In stage 2, the Otahuhu-Whakamaru C line is connected into Huntly to increase the transmission capacity due to increased generation at Huntly. The Huntly-Stratford circuit is connected into Taumarunui to ease voltage problems during a contingency with new generation at Stratford. The Bunnythorpe-Tokaanu circuits are connected into Rangipo to improve sharing between the three circuits north of Bunnythorpe for high HVDC transfer.

Other developments in this stage include duplexing the existing 220 kV Bunnythorpe-Tokaanu A&B lines and the Bunnythorpe-Wairakei A line to meet the increasing transfer requirement in the corresponding regions.

In stage 3, the Otahuhu-Whakamaru A&B is upgraded to relieve grid constraints from south of Otahuhu. The Otahuhu-Whakamaru C line is connected into Hamilton to increase transmission capacity into the Waikato region and relieve constraints on the existing Hamilton-Whakamaru circuit during low Huntly generation. A new 220 kV circuit between Otahuhu-Whakamaru will be constructed to relieve the constraints between Otahuhu and Whakamaru. Reinforcement of the 220 kV grid into Bay of Plenty, and between Whakamaru and Wairakei, is also required.

The ultimate grid augmentation plan for a 220 kV transmission system for Scenario 5 is shown in Figure 4-5.

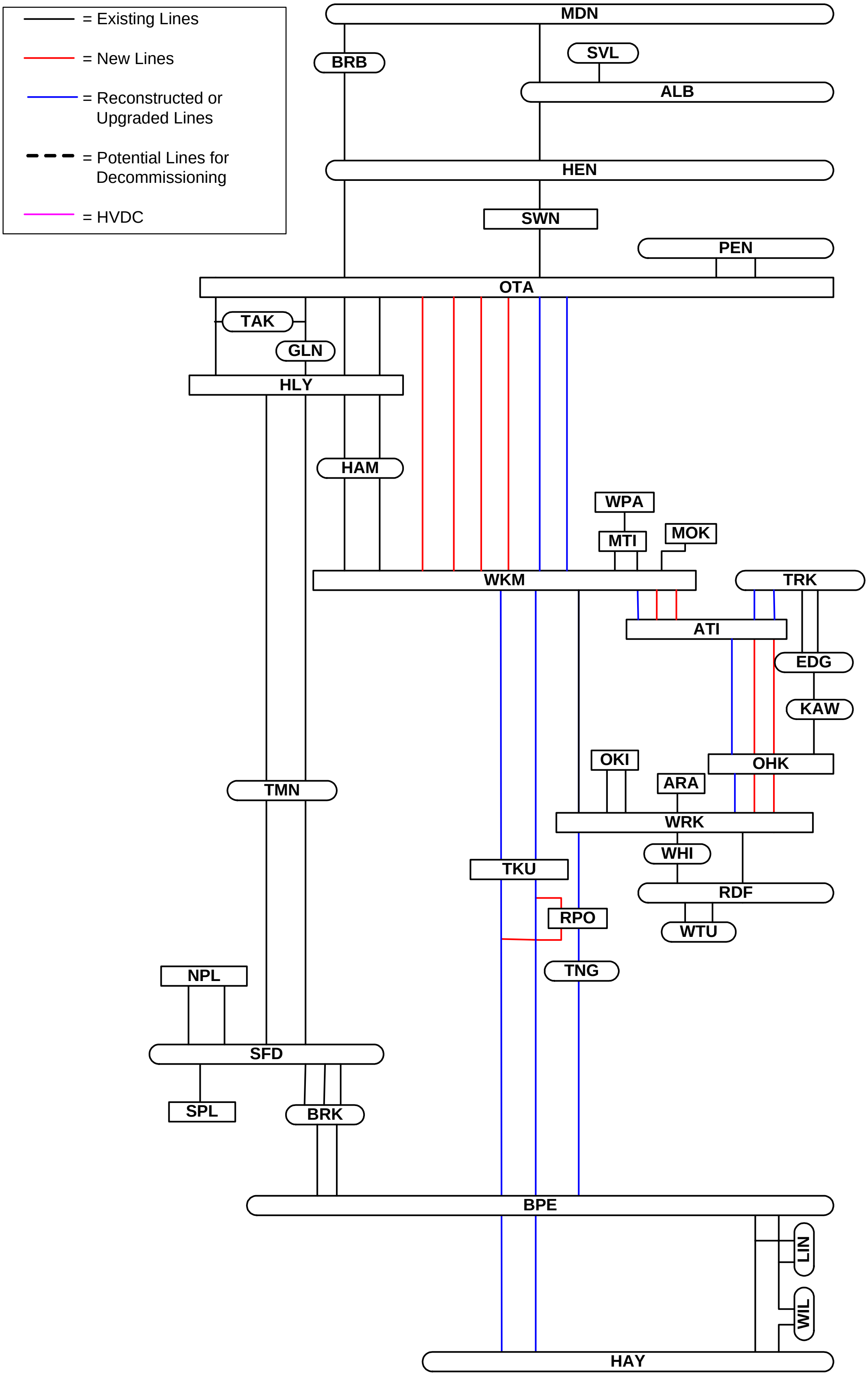


Figure 4-5: 220 kV grid configuration for Generation Scenario 5 at 2040

4.4 Assessment of 220 kV HVAC Grid Upgrade Plan

4.4.1 System Security

The proposed 220 kV HVAC grid development plan can be planned and implemented to meet Transpower's current grid reliability standards.

4.4.2 Asset Availability

Table 4-6 shows the historical availability of the HVAC assets. The availability of the new overhead 220 kV transmission assets is expected to be similar or better than the existing 220 kV transmission assets, which is an acceptable level of performance.

Year	33/50/66	110kV	220kV	Total
1999 / 00			99.7%	99.2%
2000 / 01	98.4%	98.6%	99.6%	98.9%
2001 / 02	99.2%	98.9%	99.4%	99.1%
2002 / 03	99.1%	98.6%	99.3%	98.9%
2003 / 04	99.2%	98.7%	99.4%	99.0%

Table 4-6: Historical Availability of HVAC Assets

4.4.3 Flexibility

All 220 kV transmission development plans allow flexibility for future expansion of the grid, depending on the future generation developments and load growth.

4.4.4 Environmental Considerations

Power transfer capabilities of transmission systems increase as the system voltage increases. Consequently, continuing with a 220 kV grid development strategy will result in the greatest number of new transmission lines to be constructed between major generation facilities and load centres across the country (when compared to other higher voltage options).

While 220 kV transmission line tower heights are lower than the other high voltage upgrade options, it is considered that the benefit of lower tower heights is substantially outweighed by the need to establish more transmission line routes to connect the major load centres to generation.

System losses are also highest for a 220 kV development plan when compared to higher voltage choices. This brings forward the need for investment in generation when compared to higher voltage (lower loss) alternatives.

In summary, when assessed over a 30-40 year period, a 220 kV development plan is considered to cause the greatest overall environmental impact. This is based on this development plan having the largest number of new transmission lines which cause greatest disruption to land use and have a wider impact on communities over greater areas the other higher voltage options.

4.4.5 Economic Analysis

The detailed economic analysis of this plan is contained in Part IV of this submission. In summary the 220 kV development plan is has a national benefit assessed as $133 million lower than the 400 kV development plan.

4.4.6 Conclusion

A 220 kV HVAC development plan to cater for the needs of New Zealand's demand growth would provide satisfactory security of supply outcomes. However a 220 kV development plan would require the highest number of new transmission lines to be build especially between Whakamaru and Auckland, when assessed against all generation scenarios. Given the difficulty in obtaining transmission corridors for building new lines, and considering the adverse environmental impact, the ability to implement such a plan in the long term is a concern. This option is also substantially more expensive in national benefit terms than moving to a higher system voltage choice such as 400 kV.

Transpower does not consider that a "no investment" outcome is a viable long term choice for New Zealand as the amount of energy forecast to be unserved would have massive consequences for the country as a whole. For this reason the 220 kV option has been considered as the base case against which the economic benefits of the other options are tested.

4.5 400 kV HVAC Development

The following sections describe the future development of the grid under different generation scenarios, if the maximum transmission voltage for new core grid transmission is increased to 400 kV. The 400 kV developments would be focussed in the transmission corridors where significant power transfer is expected to take place in the future. Development of the grid at 220 kV and 110 kV will also continue in areas of the network with lower power transfer requirements.

In this section a number of stages have been developed to group the necessary grid upgrades into discrete steps. Stage 1 represents grid upgrades which are planned to take place approximately from 2010 to 2015, stage 2 are developments up from 2015 to 2020, and stage 3 are developments beyond 2020.

It should be noted that the high-level development plans in this section are based on system planning studies. Detailed studies are required to confirm optimal location and sizing of some reactive power investments and detailed engineering work is still required to confirm feasibility and the appropriateness of the type of solution employed. For example where an existing line is proposed for upgrading by installing duplex conductors the existing towers may not be strong enough and they may require replacement. Furthermore, where two single circuit lines are proposed for duplexing, a single double circuit line may be built instead.

4.5.1 Development Plans before 2010

A summary of the grid upgrade projects which are expected to be implemented in the North Island Power System before 2010 are given in the Transpower publication: Future of the National grid – Transmission Plan Summary 2004. For conciseness, the salient upgrade projects are summarised in Appendix III-B.

Before 2010, the transfer capability into Auckland is increased by thermal upgrades of lines and increasing the level of reactive power compensation in the region. After 2010, the power transfer into the Auckland region will be mainly constrained by a voltage stability limit and no further significant transmission capacity can be provided by thermal upgrades or reactive compensation. Further increase in transmission capacity will require building new transmission lines especially between Auckland and Whakamaru.

4.5.2 400 kV Grid Development Plan for Generation Scenario 1 (Gas) from 2010-2040

The new lines to be built and those existing lines to be upgraded with duplex conductors under this generation scenario are shown below in Table 4-7:

Stage	Transmission Project
1	New 400kV double circuit Otahuhu – Whakamaru line
	New 220 kV double circuit Wairakei – Atiamuri – Whakamaru line (string one side only)
	Duplex 220 kV Tokaanu – Whakamaru A&B lines
	Duplex 220 kV Bunnythorpe – Haywards A&B lines
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead)
2	New 400 kV double circuit Bunnythorpe – Whakamaru line
	New 400 kV double circuit Stratford – Whakamaru (new) line
	New 220 kV Tokaanu-Taumarunui line[9]
	Tap Rangipo 220 kV bus onto Bunnythorpe-Tokaanu 220 kV A&B lines
3	Duplex 220 kV Atiamuri – Tarukenga A line
	String second side of 220 kV Wairakei – Atiamuri – Whakamaru double circuit line
	Connect 400 kV double circuit line constructed in stage 1 into Huntly
	Bond 220 kV Otahuhu – Whakamaru C line to create a single circuit

Table 4-7: 400 kV Grid Development Plan 2010-2040 for Generation Scenario 1

In stage 1 a new double circuit 400 kV line will be required between Otahuhu and Whakamaru, to relieve grid constraints from south of Otahuhu. 400 kV substations will be required at Otahuhu and Whakamaru to provide interconnection to the 220 kV grid. Other developments in this stage include duplexing the existing 220 kV Hayward – Bunnythorpe A&B lines and Tokaanu – Whakamaru A&B lines and building a new double circuit line between Wairakei and Whakamaru to meet the increasing transfer requirement in the corresponding regions. Reinforcement of the grid across the Auckland Isthmus will be completed with a new 220 kV cable or overhead line to increase the transfer capability to the North Isthmus and Northland regions.

In stage 2**,** the 400 kV network will be extended south to Bunnythorpe from Whakamaru and west to Stratford to allow generation from Taranaki region and

[9] This development assumes that the Stratford-Taumaranui-Huntly line and Tangiwai-Rangipo section of the Bunnythorpe-Tokaanu A&B lines are decommissioned. However, the need fro decommissioning will be assessed closer to the time depending on the condition of the asset and the generation developments (especially wind generation) in the region.

Bunnythorpe south (including HVDC import) to areas north of Whakamaru. This development will allow the existing 220 kV Stratford – Taumarunui and Huntly – Taumarunui line, the Tangiwai – Rangipo section of the Bunnythorpe – Tokaanu A&B lines, and the entire Bunnythorpe – Wairakei line to be decommissioned.[10] New 400 kV substations at Bunnythorpe, Stratford will also be built in this stage.

In stage 3 the 400 kV line built in stage 1 will need to be diverted to Huntly power station by constructing a short section of 400 kV double circuit line for transporting generation from Huntly. Reinforcement of the 220 kV grid into Bay of Plenty and through the Wairakei ring will also be required.

The ultimate augmentation plan based on 400 kV option for Scenario 1 is shown in Figure 4-6

[10] The need for decommissioning will be assessed closer to the time depending on the condition of the asset and the generation developments (especially Wind Generation) in the region.

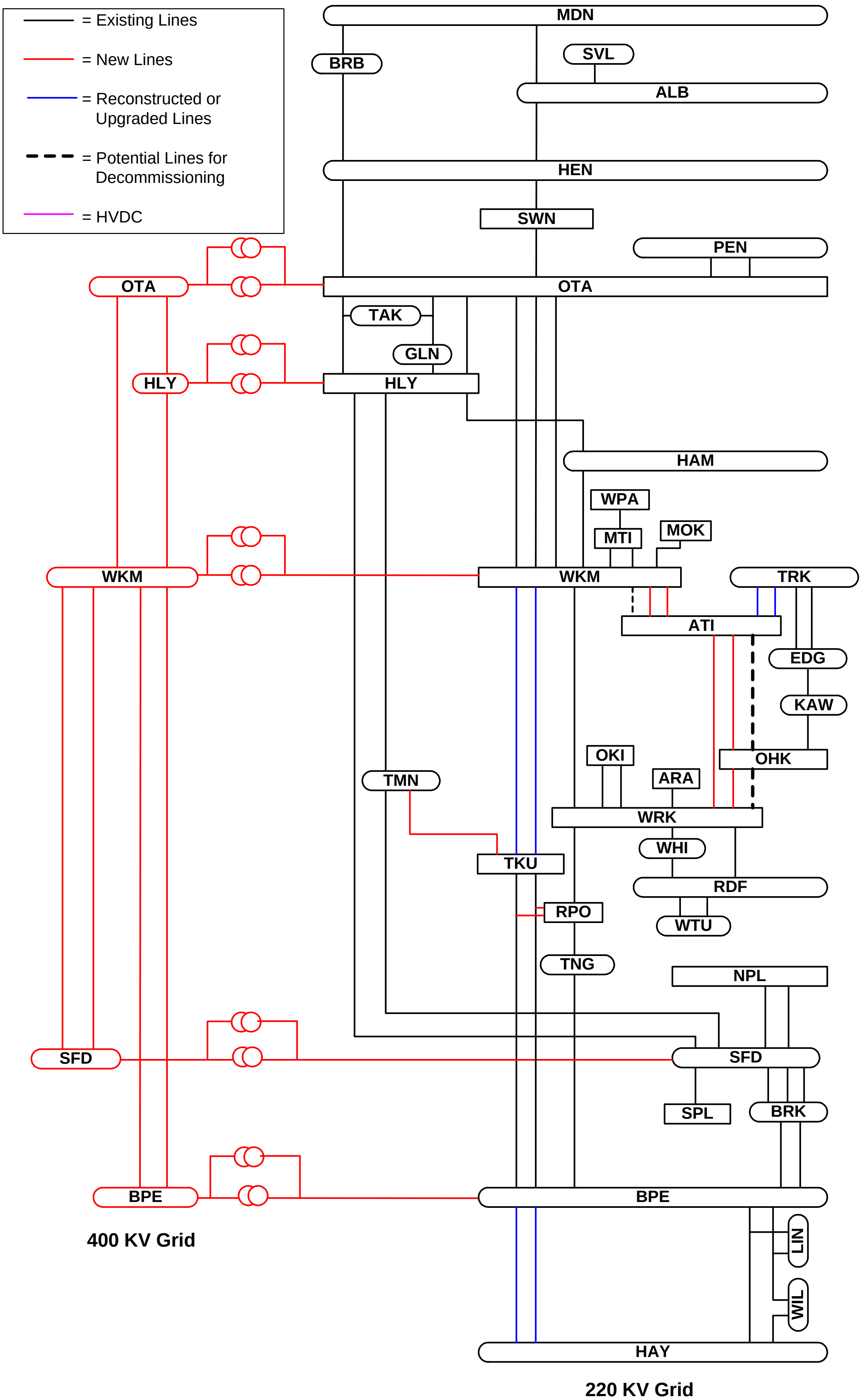


Figure 4-6: 400 kV Grid Development Plan for Generation Scenario 1 at 2040

4.5.3 400 kV Grid Development Plan for Generation Scenario 2 (Coal) from 2010-2040

The new lines that are to be built and those existing 220 kV lines that are to be upgraded to duplex conductors for this generation scenario are shown below:

Stage	Transmission Project
1	New 400kV double circuit Otahuhu - Whakamaru line
	New 220 kV double circuit Wairakei – Atiamuri – Whakamaru line (string one side only)
	Duplex 220 kV Tokaanu – Whakamaru A&B lines
	Duplex 220 kV Bunnythorpe – Haywards A&B lines
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead)
2	New 400 kV double circuit Bunnythorpe – Whakamaru line
	Tap Rangipo 220 kV bus onto Bunnythorpe-Tokaanu 220 kV A&B lines
3	Duplex Atiamuri – Tarukenga A line
	String second side of 220 kV Wairakei – Atiamuri – Whakamaru double circuit line
	Connect 400 kV double circuit line constructed in stage 1 into Huntly

Table 4-8: 400 kV Grid Development Plan 2010-2040 for Generation Scenario 2

The gird development plan in stage 1 is identical to the one developed for Generation Scenario 1.

However, the new 220 kV circuits between Stratford –Whakamaru (new) required in stage 2 for Scenario 1 are not required in this scenario. This is because the new generation in the Taranaki region for Generation Scenario 2 is much less than that for Generation Scenario 1 and therefore the capacity requirement between Stratford and Whakamaru is significantly reduced.

The grid augmentation required in stage 3 is mainly for reinforcing the transfer into the Bay of Plenty and through the Wairakei ring. Also the 400 kV line built in stage 1 will need to be diverted to Huntly power station by constructing a short section of 400 kV double circuit line for dispatching generation from Huntly.

The ultimate augmentation plan based on 400 kV option for Scenario 2 is shown in Figure 4-7.

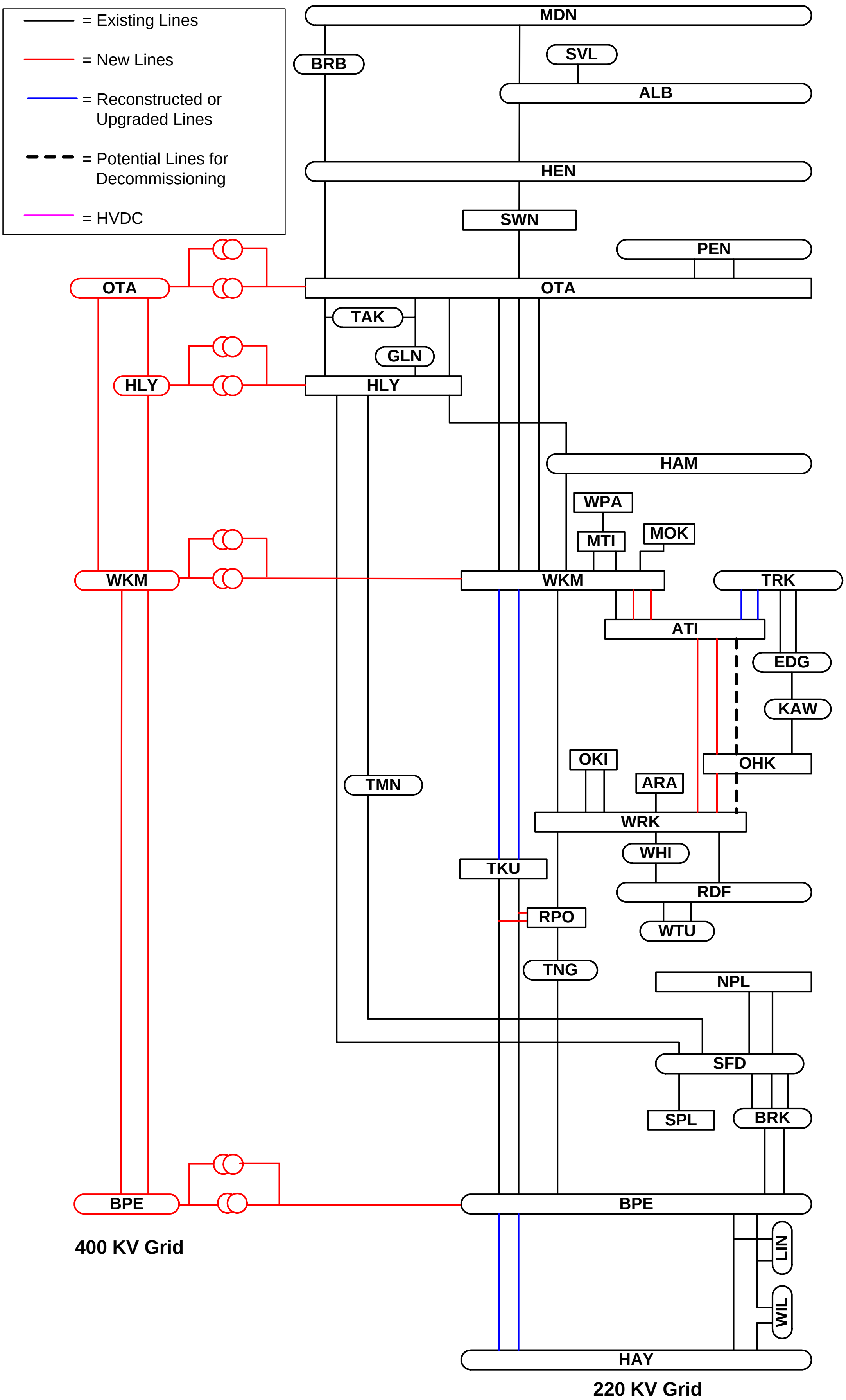


Figure 4-7: 400 kV Grid Development Plan 2040 for Generation Scenario 2

4.5.4 400 kV Grid Development Plan for Generation Scenario 3 (Renewables) from 2010-2040

For Generation Scenario 3, the new lines to be constructed and the 220 kV lines that are to be upgraded to duplex conductors are shown below:

Stage	Transmission Project
1	New 400kV double circuit Otahuhu – Whakamaru line
	New 220 kV double circuit Wairakei – Atiamuri – Whakamaru line (string one side only)
	Duplex 220 kV Tokaanu – Whakamaru A&B lines
	Duplex 220 kV Bunnythorpe – Haywards A&B lines
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead)
2	New 400 kV double circuit Bunnythorpe – Whakamaru line
	Tap Rangipo 220 kV bus onto Bunnythorpe-Tokaanu 220 kV A&B lines[11,12]
3	New 400 kV double circuit Whakamaru – Pakuranga
	String second side of 220 kV Wairakei – Atiamuri – Whakamaru double circuit line
	New 220 kV double circuit Taumarunui-Whakamaru line
	Connect 400 kV double circuit line constructed in stage 1 into Huntly
	New 220 kV single circuit Whakamaru – Wairakei line
	Bond 220 kV Otahuhu – Whakamaru C line to create a single circuit

Table 4-9: 400 kV Grid Development Plan (Generation Scenario 3)

The stage 1 grid augmentation plan for this scenario is identical to those developed under scenarios 1 & 2. Similarly, stage 2 development is identical to that developed under Scenario 2.

In stage 3, a second double circuit 400 kV transmission line from Whakamaru to Auckland will have to be constructed. This is because in Generation Scenario 3, very little new generation is projected north of Whakamaru compared with generation scenarios 1 and 2. Consequently, more transmission capacity into Auckland will be required compared with other generation scenarios. Additional 220 kV lines will be required into Bay of Plenty via the Wairakei ring, similar to the requirement under scenarios 1 and 2. The 400 kV line built in stage 1 will need to be diverted to Huntly power station by constructing a short section of 400 kV double circuit line for dispatching generation from Huntly. The Huntly-Otahuhu section of the existing 220 kV Otahuhu - Whakamaru C line could be decommissioned in this stage.[13] Also in stage 3, a new small section of 220 kV line from Taumarunui to Whakamaru will need to be built.

[11] This development assumes that the Tangiwai – Rangipo section of the Bunnythorpe – Tokaanu A&B lines are decommissioned.
[12] The need for decommissioning will be assessed closer to the time depending on the condition of the asset and the generation developments (especially wind generation) in the region.
[13] The need for decommissioning will be assessed closer to the time depending on the condition of the asset and the generation developments (especially wind generation) in the region.

The ultimate augmentation plan based on 400 kV option for Scenario 3 is shown in Figure 4-8.

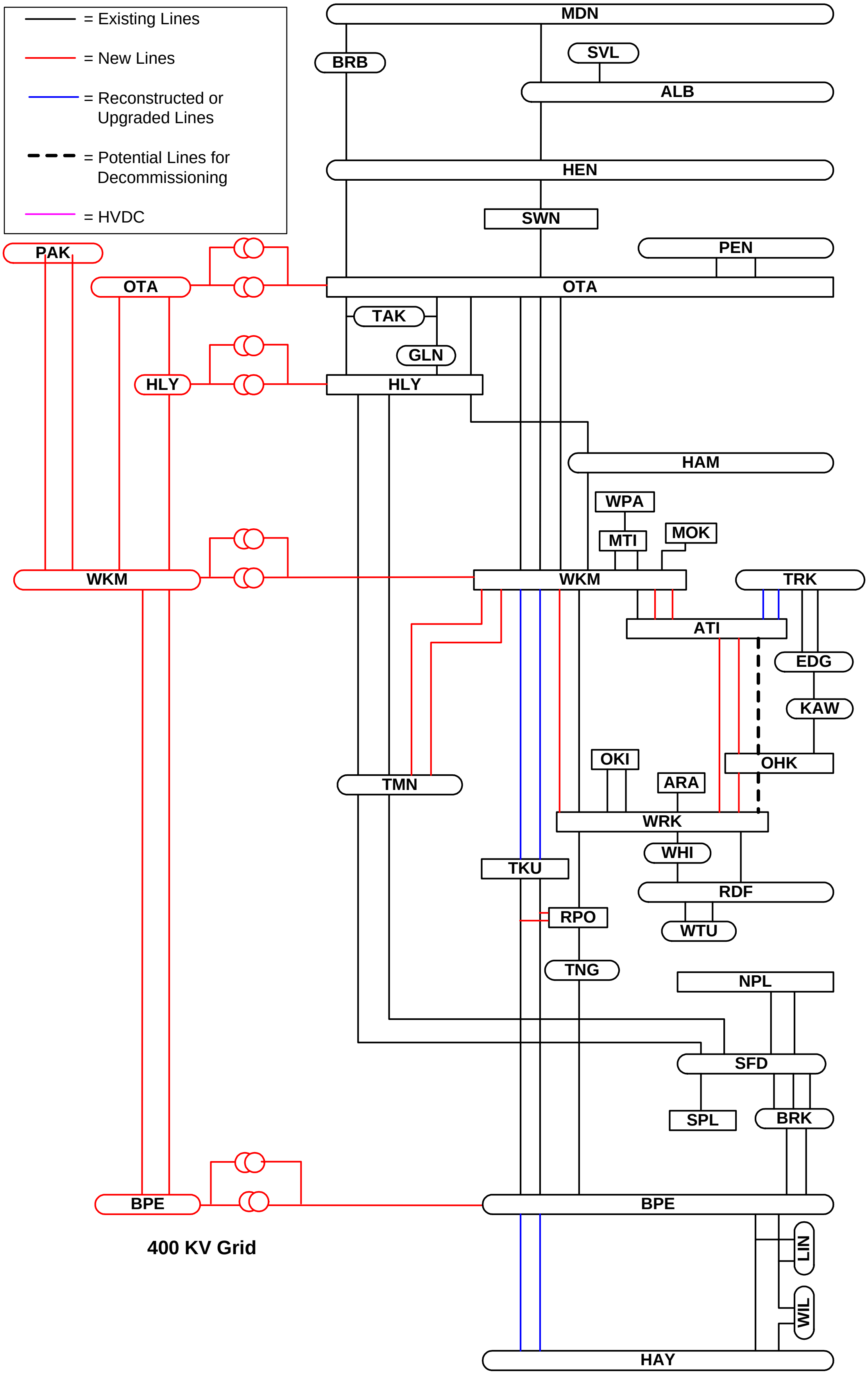


Figure 4-8: 400 kV Grid Development Plan 2040 for Generation Scenario 3

4.5.5 400 kV Grid Development Plan for Generation Scenario 4 (Southern Hydro) from 2010-2040

The major projects, new lines that are to be built and those existing 220 kV lines that are to be upgraded from single conductor to duplex conductors for this generation scenario is shown below:

Stage	Transmission Project
1	New 400kV double circuit Otahuhu - Whakamaru line
	New 220 kV double circuit Wairakei – Atiamuri – Whakamaru line
	Duplex 220 kV Tokaanu – Whakamaru A&B lines
	Duplex 220 kV Bunnythorpe – Haywards A&B lines
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead)
2	New HVDC link of capacity 600 MW from the South Island into Auckland
	Duplex 220 kV Atiamuri – Tarukenga A line
3	Upgrade the capacity of new HVDC to Auckland from 600 to 1200 MW
	New 220 kV double circuit Otahuhu – Penrose line

Table 4-10: 400 kV Grid Development Plan (Generation Scenario 4)

The stage 1 grid augmentation plan for this scenario is identical to those developed under scenarios 1, 2 & 3.

In this generation scenario there is an increasing generation deficit in the North Island from 2010 onwards. With the upgrade of the capacity of the existing inter-island HVDC link to 1400 MW, this deficit can be supplied up to a point where n-1 security under generation contingencies can no longer be maintained. In stage 2 of this upgrade plan, a new HVDC link is required to import power from the South Island. This link is planned to inject power directly into Auckland. Reinforcement of the 220 kV grid into Bay of Plenty and through the Wairakei ring will also be required.

In stage 3 of this grid augmentation plan, the capacity of the new HVDC link between the South Island and Auckland will have to be increased. This is once again driven by insufficient generation capacity in the North Island for ensuring the supply security. The 220 kV grid between Otahuhu and Penrose will have to be reinforced to cater for the increased demand north of Otahuhu.

The ultimate augmentation plan based on 400 kV option for Scenario 4 is shown in Figure 4-9.

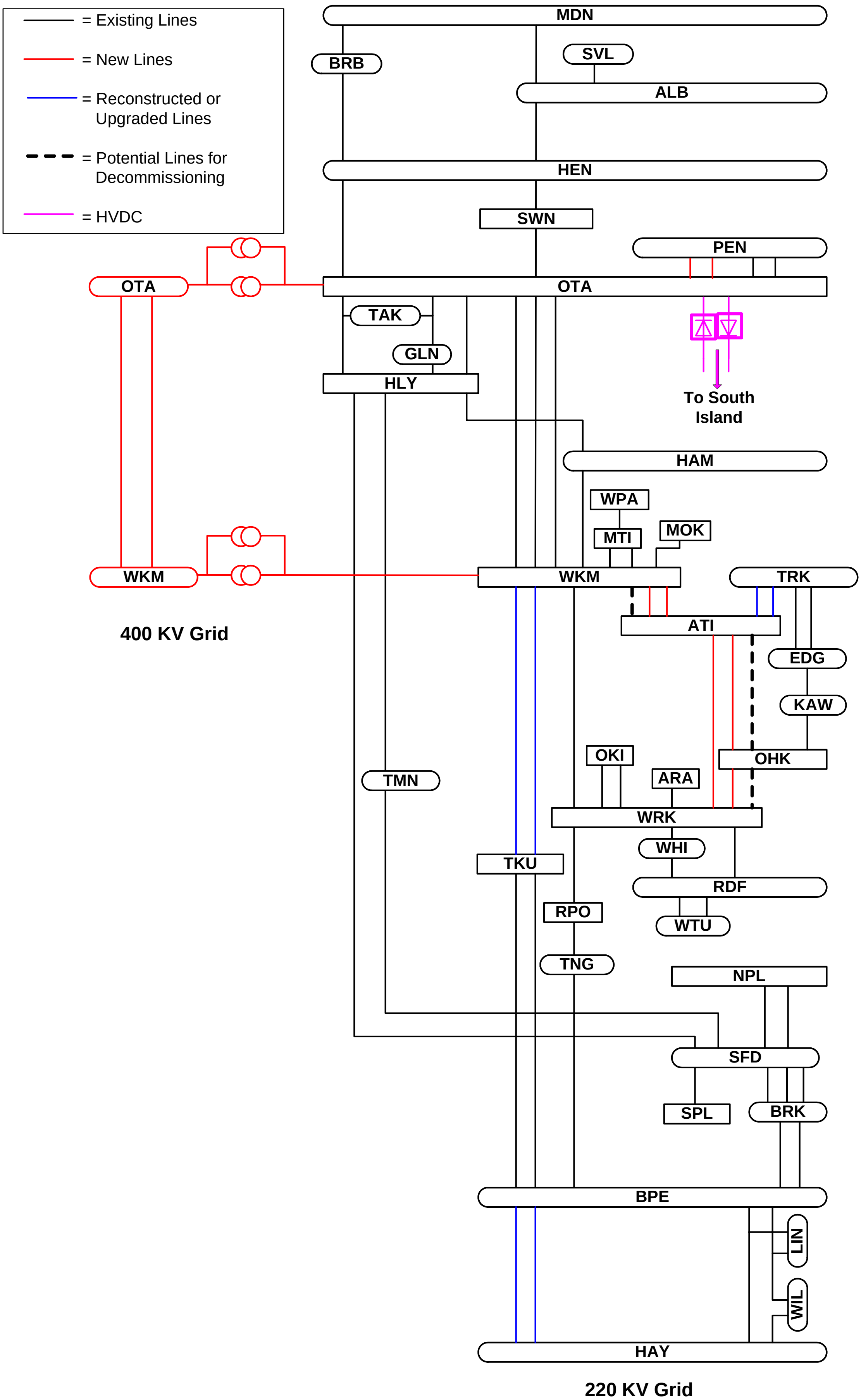


Figure 4-9: 400 kV Grid Development Plan 2040 for Generation Scenario 4

4.5.6 400 kV Grid Development Plan for Generation Scenario 4 (Reduced Demand) from 2010-2040

The major projects, new lines that are to be to be built and existing 220 kV lines that are to be upgraded from single conductor to duplex conductors for this generation scenario is shown below:

Stage	Transmission Project
1	New 400kV double circuit Otahuhu - Whakamaru line
	New 220 kV double circuit Wairakei –Ohakuri-Atiamuri – Whakamaru line
	Duplex 220 kV Tokaanu – Whakamaru A&B lines
	Duplex 220 kV Bunnythorpe – Haywards A&B lines
	Auckland cross isthmus reinforcement with new 220 kV circuit (cable or overhead)
2	Loop in one circuit of Otahuhu-Whakamaru 400 kV line at Huntly
	Tap the 220 kV Huntly-Stratford circuit at Taumarunui
	Duplex 220 kV double circuit Bunnythorpe-Tokaanu . Tap Rangipo 220 kV bus onto Bunnythorpe-Tokaanu A&B lines
	Duplex 220 kV Bunnythorpe-Tangiwai-Rangipo section of Bunnythorpe-Wairakei A line
	Duplex 220 kV Rangipo-Wairakei section of Bunnythorpe-Wairakei A line
3	Duplex 220 kV Atiamuri-Tarukenga A line
	Duplex 220 kV Wairakei-Ohaaki-Atamuri circuit

Table 4-11: 400 kV Grid Development Plan 2040 for Generation Scenario 5

The stage 1 grid augmentation plan for this scenario is identical to those developed under scenarios 1-4.

In stage 2 one circuit of the 400 kV line built in stage 1 will need to be diverted to Huntly power station by constructing a short section of 400 kV double circuit line. This will be required for dispatching the increased generation from Huntly and the Taranaki region. Increased Taranaki generation under this scenario necessitates sectionalising the 220 kV Huntly-Stratford circuit by tapping at Taumarunui. It is necessary to strengthen the system between Bunnythorpe and Whakamaru. Rangipo is tapped onto the two Bunnythorpe-Tokaanu circuits and the capacity of the three circuits out of Bunnythorpe is increased.

In stage 3, increased Wairakei generation results in the requirement for reinforcements of the 220 kV grid into Bay of Plenty and through the Wairakei ring.

The ultimate augmentation plan based on 400 kV option for Scenario 5 is shown in Figure 4-10.

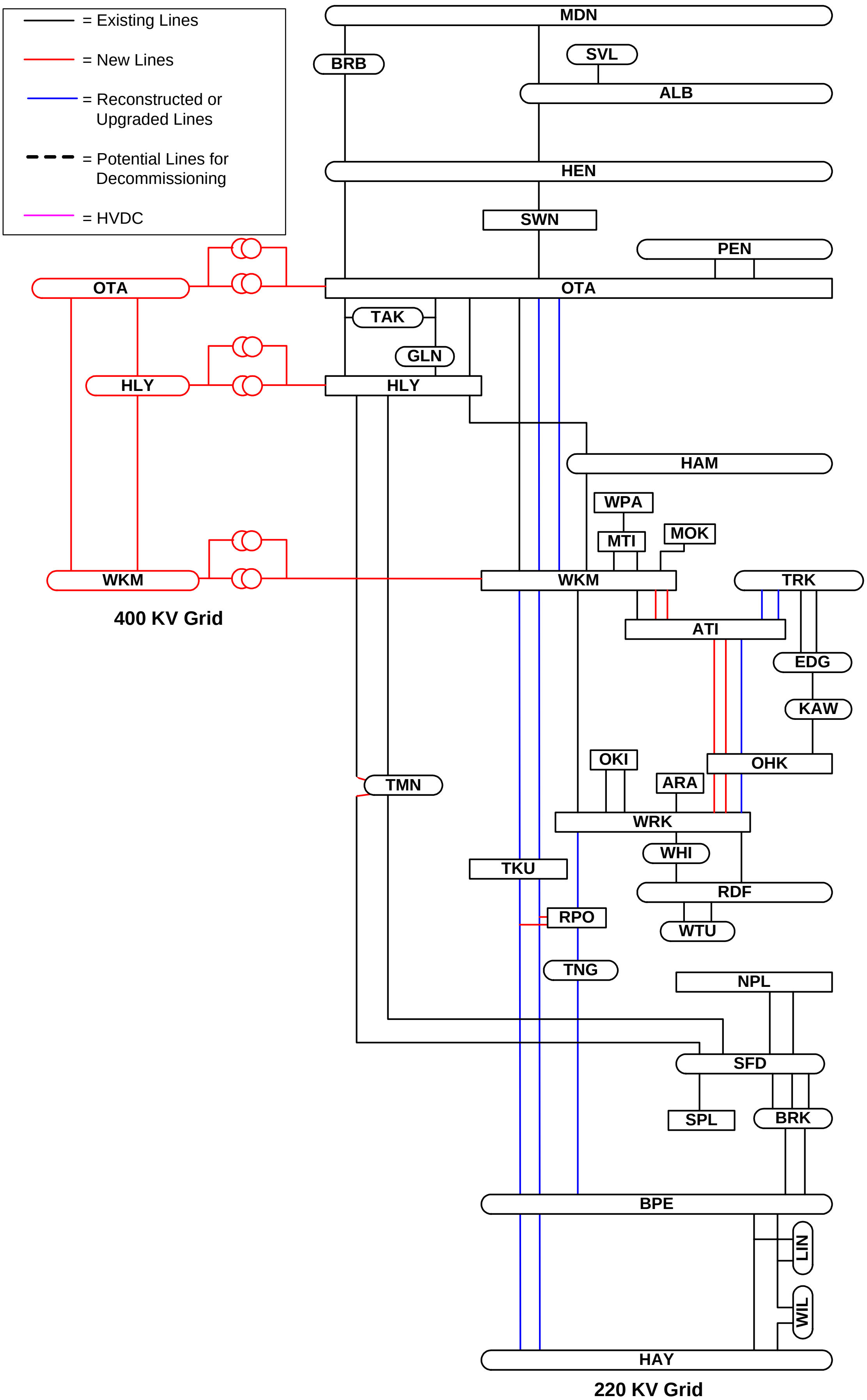


Figure 4-10 400 kV Grid Development Plan 2040 for Generation Scenario 5

4.6 Assessment of 400 kV HVAC Grid Upgrade Plan

4.6.1 System Security, Asset Availability and Flexibility

The 400 kV grid upgrade plan can be constructed to deliver equivalent outcomes to the 220 kV option when assessed against System Security and Asset Availability criteria. The flexibility of the 400 kV option to cater for a range of possible future demand and generation patterns is also equivalent to the 220 kV option. The criteria that provide a point of difference between 220 kV and 400 kV options are therefore environmental and economic.

4.6.2 Environmental Considerations

The 400 kV option, when compared to 220 kV or 330 kV options, will require substantially fewer new transmission lines to be constructed over the study period out until 2040. With fewer line routes required for 400 kV transmission, the environmental impact of transmission corridors, particularly those entering Auckland city will be better contained than continuing with 220 kV developments.

While tower heights are clearly a sensitive issue for communities, on balance Transpower considers that there are environmental benefits of having fewer high capacity lines with higher towers as opposed to more low capacity lines with lower height towers.

The choice of 400 kV as the main backbone voltage also reduces system losses substantially. The average difference in peak system losses between 220 kV and 400 kV development plans, across all five generation scenarios at 2040 is estimated as 50 MW.

4.6.3 Conclusions

A development plan based on introducing a 400 kV HVAC backbone into the transmission system will meet the needs of New Zealand's demand growth across a range of possible generation futures.

A 400 kV network will provide satisfactory security of supply outcomes and would require substantially fewer new transmission lines to be constructed, particularly into the high demand growth areas such as the upper North Island.

With fewer lines established in corridors of high power transfer, the environmental impact of a 400 kV development plan will be lower than that of an equivalent capacity 220 kV development plan.

Finally, a 400 kV HVAC development plan is expected to deliver substantially higher national benefits due to lower capital costs and lower transmission losses than a 220 kV development, as detailed in Part IV of this submission.

4.7 330 kV HVAC Development

This option considers adopting 330 kV as the main core grid voltage for the future long term development of the New Zealand transmission system, augmenting the transmission capacity of the present 220 kV system.

This option retains many parts of the network at 220 kV, especially where generating stations are already connected at that voltage or for regional supply only. The 220 kV network will also be retained where the expected transmission along the corridor is substantially small and does not warrant upgrading to a higher voltage.

One major driver as well as the attraction of the 330 kV option was the perceived possibility of physical modification of the existing 220 kV transmission lines to be operated at 330 kV. However, detailed investigations showed that significant rebuild is required for such a conversion and in many cases it is not practical to convert 220 kV lines for operation at 330 kV. The issues that make upgrading the existing 220 kV lines to 330 kV impractical are:

- The foundations will have to be strengthened or replaced as existing foundations are inadequate for the heavier loading required for 330 kV lines.
- If existing towers are to be re-used, a large number of temporary by-pass lines will have to be built while existing towers are modified or relocated and new conductors are installed to maintain security of supply.
- The existing 220 kV flat-top towers have insufficient strength to sustain the loads associated with a major upgrade of capacity. The lines would be limited in their current carrying capacity which in turn forces the choice of more, lower capacity lines as opposed to fewer high capacity lines. The existing clearance levels of the 220 kV lines are also likely to be insufficient to cater for 330 kV operation.
- Some of the existing tower steel is more than 50 years old. Even though these towers may be reused, it is likely that ageing and distortions while in service will increase the cost of recycling. Further, the compatibility of the strength of steel used in the old towers with modern tower designs needs to be re-assessed.
- All of the above points confirm that reusing the existing tower line infrastructure for 330 kV in infeasible and that the lines would need to be rebuilt to cater for a standard 330 kV performance specification.
- Long continuous line outages will be required during the course of conversion, with the associated risk that electricity supply to customers will be interrupted.
- Any such upgrades would not be able to be achieved under Transpower's existing use rights under the Electricity Act 1992. Therefore the 330 kV option offers no advantage in terms of avoiding the need to acquire property rights and consents under the Resource Management Act for rebuilding the existing towers.

Preliminary costing studies have shown that there would be no cost advantage in upgrading existing lines to 330 kV compared with construction of new lines at 330 kV.

4.7.1 System Security, Asset Availability and Flexibility

System Security, Asset Availability and Flexibility of the 330 kV option will be similar to that discussed in Section 3.3, 220 kV HVAC Development.

4.7.2 Environmental Considerations

This option provides similar advantages as the 400 kV option in terms of the number of routes required, and will limit potential adverse effects to a defined transmission easement, at least in the short term. However, over a long time period, 330 kV development will naturally require greater transmission routes than 400 kV development. Increase in the operating voltage to 330 kV from what is currently being used (i.e. 220 kV) is also likely to raise community concern and opposition.

4.7.3 Conclusion

330 kV AC was only initially considered as an option because it was perceived that the existing 220 kV lines could be easily converted to 330 kV AC operation.

Subsequent investigations showed that upgrading of the 220 kV lines for 330 kV operation essentially require the lines to be rebuilt. Furthermore there is no cost advantage for rebuilding the existing lines when compared to constructing a new line. If new lines are to be built, the past experience and high level economic analysis have shown that the new voltage to be migrated should be approximately twice the present voltage. Hence 330 kV is considered to be too low to deliver long run benefits, for adoption as the new core grid transmission voltage.

Because of the above reasons, it was concluded that 330 kV will not provide a suitable transmission option for long term upgrade of the transmission grid.

4.8 500 kV HVAC Development

Transpower has carried out detailed assessment of the viability of using 500 kV as the next voltage level for the long term development of the New Zealand high voltage grid, augmenting the capacity of the existing 220 kV grid.

Experience shows that, if there is a need to migrate to another system voltage, the next system voltage level should be about twice the existing voltage level. With the current principal transmission voltage in New Zealand being 220 kV, this suggests voltages of either 400 kV or 500 kV. The ultimate choice is a function of a number of factors including, the distance over which power transfers are required and the load density.

The electricity demand in North Island accounts for two thirds of the demand of New Zealand[14] and about one third is consumed in Auckland alone. Over the 40 year planning period, transfers on a number of corridors will require reinforcement depending on the assumed generation. The forecast corridor transfers are shown in Figure 4-11. Figure 4-11 also shows typical transfer capabilities of circuits at 220 kV, 400 kV and 500 kV although these may vary slightly depending on the choice of conductor and overhead line configuration[15] (ref: Peer review of choice of voltage for development of the New Zealand Grid).

[14] The remaining one third of the demand is associated with the South Island with a large proportion consumed in Christchurch.
[15] “Peer Review of Choice of Voltage for Development of the New Zealand Grid”– PB Power February 2004.

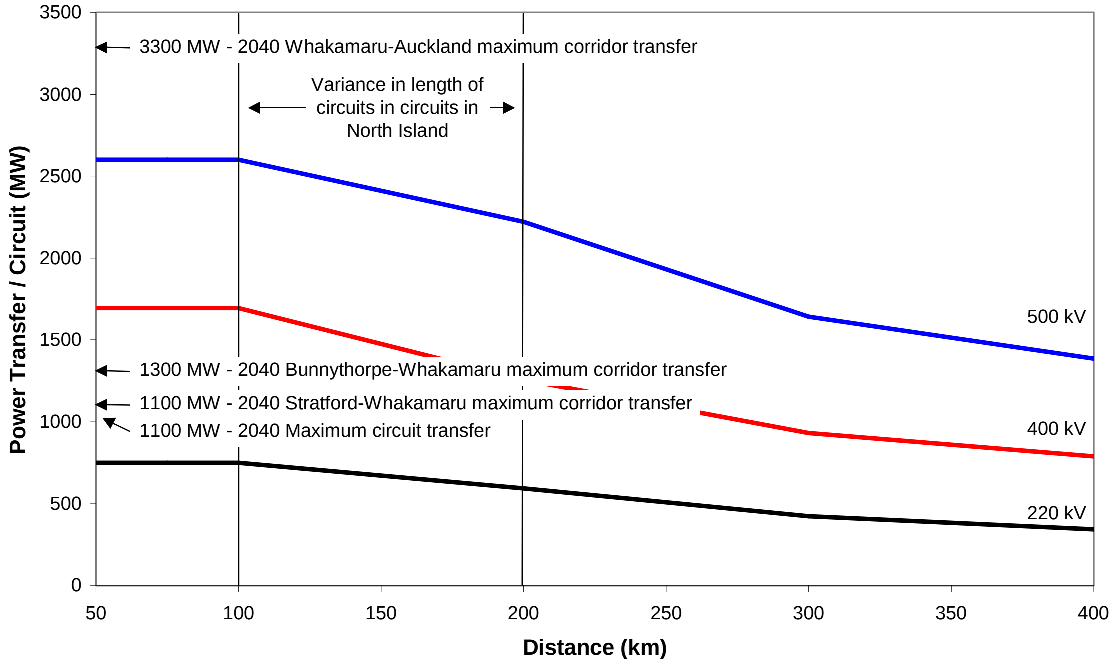


Figure 4-11 North Island - transfer capability at various voltage levels compared to expected corridor and circuit transfers.

In the North Island, the Whakamaru-Otahuhu, Bunnythorpe-Whakamaru and Stratford-Whakamaru corridor transfers are forecast to increase to approximately 3,300 MW, 1,300 MW and 1,100 MW respectively over the planning period. The number of additional circuits required to secure these transfers under contingency conditions is shown in Table 4-12.

Corridor	220 kV	400 kV	500 kV
Whakamaru-Otahuhu	8	4	3
Bunnythorpe-Whakamaru	4[16]	2	2
Stratford-Whakamaru	4[17]	2	2

Table 4-12 Requirements for additional circuits to secure corridor transfers by 2040

Therefore, while there may be an argument for the introduction of 500 kV to accommodate transfers from Whakamaru-Otahuhu, the capacity would be overly high for transfers required in the Bunnythorpe-Whakamaru and Stratford-Whakamaru corridor. High level economic analysis has also shown that 500 kV development options will yield lower economic benefits compared to 400 kV developments.

[16] Comprises 2 x Bunnythorpe-Whakamaru circuits and 2 x Bunnythorpe-Rangipo circuits

[17] Comprises 1 new double circuit and 1 rebuilt double circuit with heavier construction

4.8.1 System Security, Asset Availability and Flexibility

System Security, Asset Availability and Flexibility of the 500 kV option will be similar to that discussed in Section 3.3, 220 kV HVAC Development.

4.8.2 Environmental Considerations

Capacity is considerably in excess of that required to meet reasonable transmission requirements and will result in increased tower heights and easement area (to accommodate EMF levels). This option provides similar advantages as the 400kV option in terms of the number of routes required, and will limit potential adverse effects to a defined transmission easement. Overall effects within this easement will be greater than the 400kV option, without any real advantage.

4.8.3 Conclusions

The capacity offered by the 500 kV transmission lines, while under some generation scenarios would be suitable for high power transmission corridors, the utilisation would be small for many line corridors considered with the planning horizon until 2040. Hence 500 kV is not considered as the preferred voltage for future development of the New Zealand transmission system.

4.9 HVDC Link between South Island and Auckland

Transpower operates an HVDC link between Benmore in the South Island and Haywards in the North Island. Equipment forming the HVDC link includes:

- Converter stations at Haywards and Benmore. These stations convert electricity between HVAC and HVDC;
- Overhead transmission lines between Benmore and Fighting Bay in the South Island and Oteranga Bay and Haywards in the North Island.
- Undersea cables between Fighting Bay and Oteranga Bay which are laid across the Cook Strait.

The HVDC link is “bi-polar” which means that the power transferred between the North and South Islands can be transmitted through one or two HVDC poles. Pole 1 of the HVDC link was commissioned in 1964 and consists of mercury-arc converters. Pole 2 was commissioned in 1992 and is constructed using newer thyristor technology. The mercury-arc pole is nearing the end of its economic and physical life and is due for replacement within the next ten years. Therefore, the most viable option for extending the HVDC link to Auckland is to decommission pole 1 at Haywards, construct a new HVDC transmission line from Haywards to Auckland and establish a new HVDC pole in Auckland. The new HVDC pole from Benmore to Auckland would be rated at 350 kV and 700 MW in order to match the existing thyristor based pole 2 at Haywards.

The HVDC link between the South Island and Auckland was assessed as follows:

4.9.1 System Security

The HVDC alternative would provide up to 700 MW of “non-firm” additional transmission capacity into the Auckland area. This capacity must be regarded as non-firm because loss of the HVDC line from Benmore to Auckland (via

Haywards) or failure of a single converter pole at either Auckland or Benmore will result in the complete loss of 700 MW of power transfer into Auckland. This does not provide a grid augmentation alternative comparable with the preferred HVAC transmission option of 400 kV which would provide approximately 1000 MW of firm capacity (1000 MW on each circuit, with a total capacity of 2000 MW[18]) into Auckland.

The critical concern regarding HVDC augmentation is its inability to transport power into Auckland during dry year periods in the South Island. Historically, during dry years, power transmission through the HVDC link from the South Island to the North Island reduces significantly. For extended periods during dry years, power flows are often north to south. Figure 3.18 shows the HVDC transfer southward during a period of low hydro inflows in 2001 in the South Island (indicated as negative power flows). If southward power flows across the HVDC link occur at the time of high system demand, as evidenced in 2001, then an HVDC upgrade will provide no security of supply enhancement to the Auckland region during dry years.

It is not considered a feasible grid augmentation option to implement a transmission alternative that will not meet the peak demand requirements of a region under a realistic generation scenario (in this case, dry year conditions). Therefore, even if an HVDC alternative was implemented, HVAC grid augmentation into Auckland would still be required to provide a secure power supply. For this reason, HVDC augmentation between the South Island and Auckland was not considered to be a realistic transmission alternative to solve the security of supply concerns into the upper North Island.

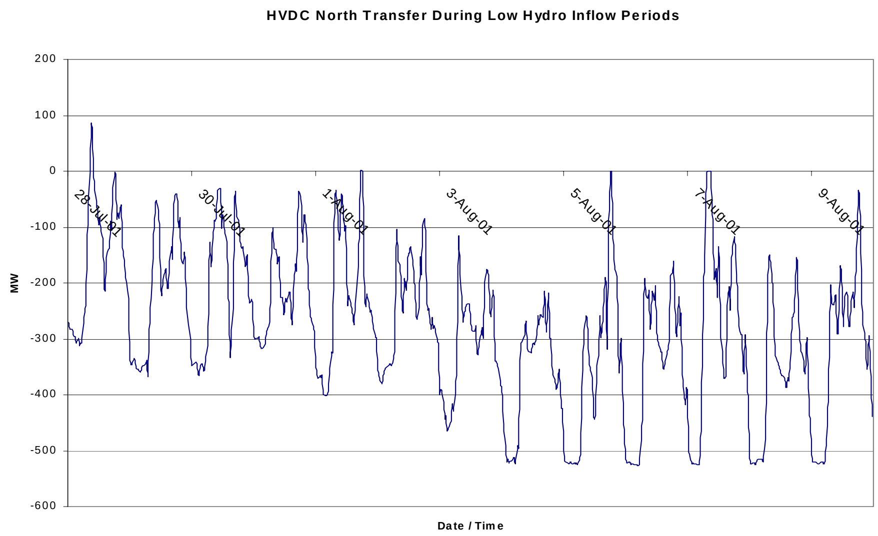


Figure 4-12: HVDC Power flows during a typical dry year (2001)

[18] While a new double circuit 400 kV line will provide 1000 MW of firm and 2000 MW of total thermal capacity, voltage stability limitations will reduce the actual power transferable into Auckland to a lesser quantity. The actual quantity will depend on the generation and reactive support that is established in the area.

4.10 HVDC Link between Whakamaru and Otahuhu - Classical Configuration

In consideration of HVDC as an alternative to HVAC transmission between Otahuhu and Whakamaru, Transpower assessed a number of HVDC transmission configurations of differing operating voltages and transfer capacities. The most suitable HVDC option is a 350 kV link which could provide a secure and reliable supply with 1000 MW of firm capacity. The link would consist of a double bi-pole arrangement with each pole of the two converter stations (one at Whakamaru and the other at Otahuhu) rated to 500MW.

The choice of a 350 kV HVDC pole design rated at 500MW would allow the use of proven technology. Modular designs with this rating are available from a number of manufacturers and would likely be offered at competitive prices.

The double bi-pole option was assumed to be implemented in two discrete stages.

Stage 1

- Completion of the entire transmission line and the short length of underground cable within Auckland urban area.
- Installation of 1000 MW, 350 kV bi-pole converter stations, at Whakamaru and Otahuhu.

Stage 2

- The ultimate design would be achieved by installing another 1000MW, 350 kV bi-pole converters, at Whakamaru and Otahuhu. This would augment the capacity of the HVDC link to1000 MW of firm capacity.

This ultimate design which includes the independent operation of two bi-poles between Whakamaru and Otahuhu is shown in Figure 4-13.

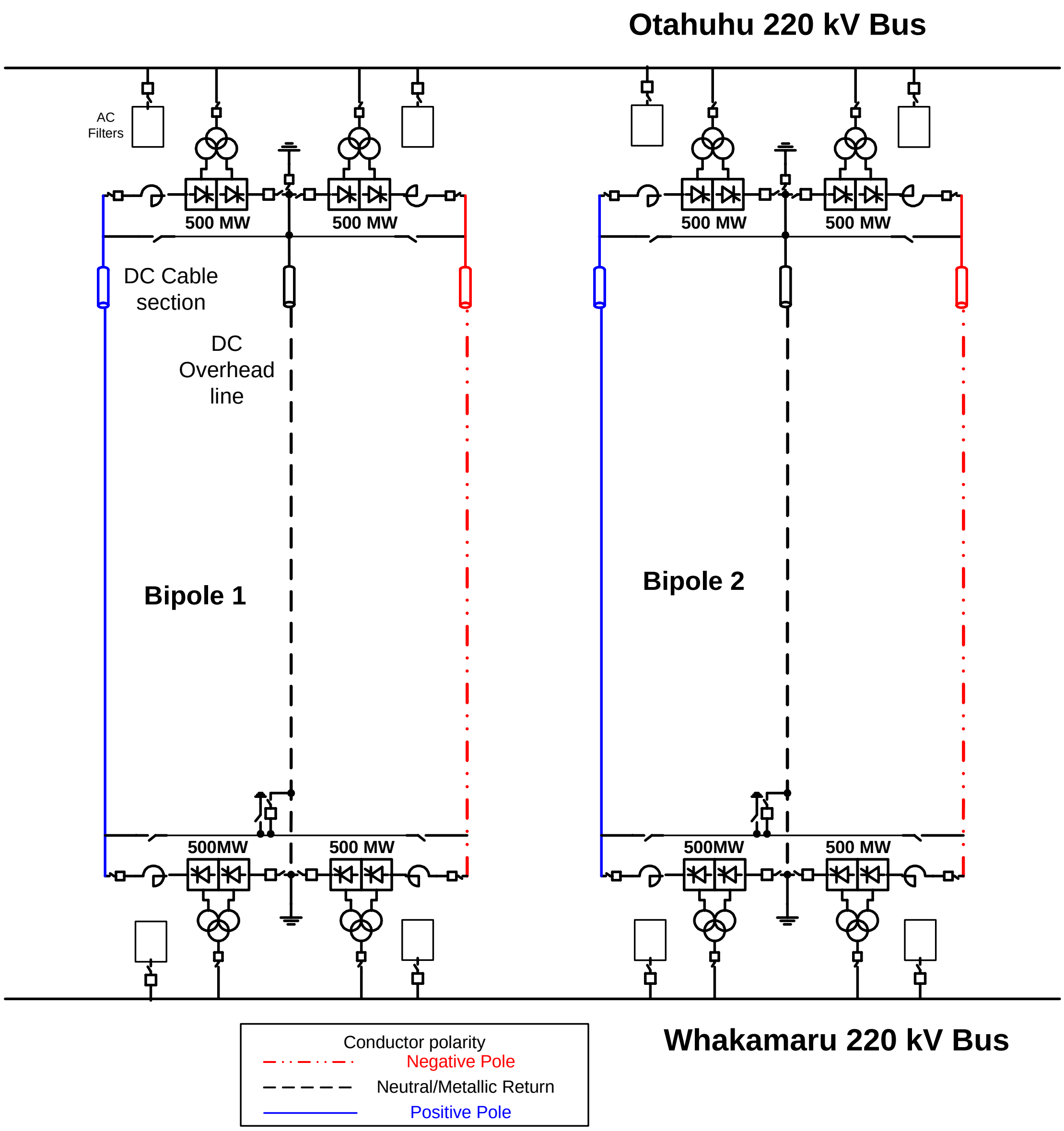


Figure 4-13: Schematic for 350 kV HVDC Transmission Link Between Whakamaru and Otahuhu

Establishing a 350 kV double bipole HVDC link between Whakamaru and Auckland was assessed follows:

4.10.1 System Security

The HVDC option described above provides sufficient capacity to maintain supply security into the Auckland region in a level comparable to that provided by all HVAC transmission options.

4.10.2 Asset Availability

Considering the transmission lines in isolation (i.e. apart from the terminal equipment), the double bi-pole HVDC transmission line is likely to have an equivalent availability to that offered by the proposed 400 kV HVAC transmission line.

However, the AC-DC-AC converter stations do not provide the same reliability as 400/220 kV HVAC transformers. Converter stations are inherently complex and contain a large number of components which can contribute to partial or total converter station failure. Further, there are a significant number of items common to both poles of an HVDC bi-pole scheme, leading to increased risks of common-mode failures.

In summary, the HVAC system will provide an overall higher level of asset availability and therefore system reliability into the Auckland region. While HVDC remains a potential fit for purpose solution, the risks of reduced reliability - in particular converter station failure - must be taken into consideration in the decision making processes.

4.10.3 Economic Benefit

Because of the high capital investment required for HVDC converter stations, development of the converter capacity in several stages as described above will provide significant economic benefits.

However, even with the staged development, when the net present value of the HVDC versus HVAC costs are considered, the HVDC solution is found to be significantly more expensive compared to the HVAC options.

4.10.4 Environmental Considerations

The DC option operates at 350 kV and thereby offers similar advantages to the 330 and 400 kV AC voltage options in terms of the overall number of transmission line routes. Tower numbers are also likely to be similar.

Although both the AC and DC options will be required to comply with ICNIRP guidelines pertaining to electric and magnetic fields, overall levels from DC lines enable reduced height of towers compared to equivalent voltage AC options. Visual effects (and associated effects on tourism and recreational values), although subjective, would arguably be less than the AC option.

The DC technology also requires increased density of structures at Whakamaru and Otahuhu, with associated effect on local amenity. Adverse effects of such termination structures are site specific and can most likely be mitigated within existing industrial landscapes at Whakamaru and Otahuhu sites.

4.10.5 Timing

HVDC systems are inherently complex and need to be designed carefully, taking into account the variability of the operating conditions and the dynamic performance of the connected power system. Typically, the lead time for construction, form the time of awarding the contracts, ranges from 3 to 4 years. However, the developments are also associated with significant pre-tendering technical investigations and therefore the total lead time required would be in the order of 5 – 6 years.

Therefore, if HVDC developments are to be used for providing the supply security to the Auckland region by 2010, investigation and construction time needs to be significantly compressed. Such expediency will result in significant commercial and technical risks to the development project.

4.10.6 Flexibility

HVDC options provide less flexibility for future grid expansion and will continue to be associated with higher level of capital investments compared to the HVAC options.

One significant disadvantage of the HVDC options is that, once an HVDC link is established, the opportunities for "tapping off" (i.e connecting) at different points in order to accommodate future grid developments become very limited. At present, it is the generally accepted view that HVDC transmission linking more than three terminals is not technically sound. While a point-to-point HVDC link can be augmented at a significant cost to make a three terminal link for tapping off at a single point between its original terminals, it does not allow for any further tapping off.

In a future with deregulated generation investments, whose locations are significantly uncertain, such a limitation in the flexibility of making new connections to the grid is a significant concern.

4.10.7 Conclusions

Overall, the adoption of an HVDC transmission backbone would deliver a more expensive, less reliable and relatively inflexible transmission system in the long run than a National Grid supported by an interconnected HVAC transmission network. More details of this analysis are contained in the supporting document titled "Comparison of HVDC and HVAC Grid Upgrade Alternatives – May 2005".

4.11 HVDC Link between Whakamaru and Otahuhu – HVDC Light Configuration

This option uses voltage sourced converters consisting of insulated gate bipolar transistors (IGBT) as switching devices rather than thyristors. The power handling capability of IGBTs is not as large as thyristors and with present technology the Pole capacity is limited to a maximum of about 330MW.

At present technology limitations also require underground cable(s) for the entire length of transmission link.

Similar to HVDC Classical option the transmission capacity of HVDC light option can be increased in several stages. The circuit configurations for a two stage development are shown in Figure 4-14.

HVDC Light also has the advantage over the HVDC Classic option that converter stations are more compact due to the reduced size of filters. However, the disadvantages are that converter losses are much higher due to higher switching frequencies compared to classic HVDC, and the higher transmission losses due to a lower DC operating voltage.

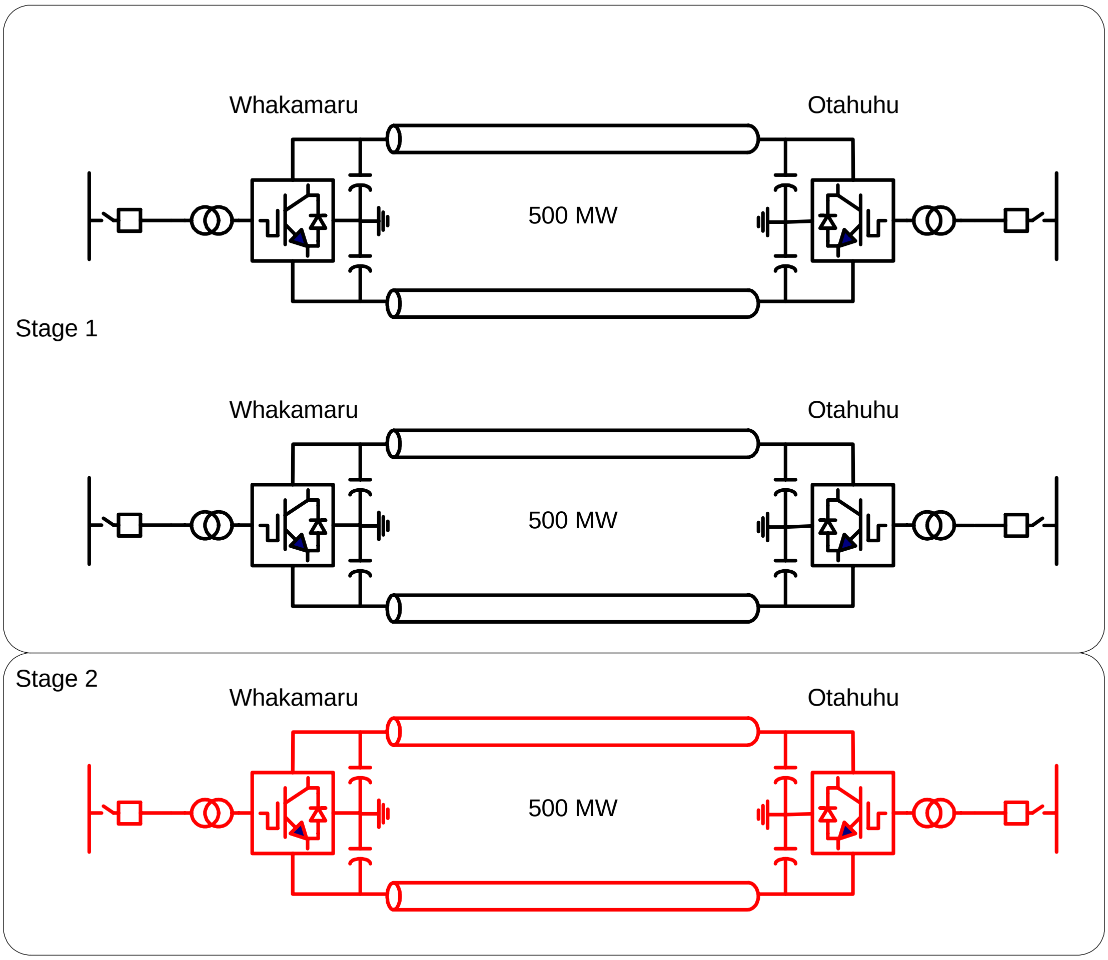


Figure 4-14: Circuit Configuration Stages 1 & 2 HVDC Light Transmission System 1000 MW Firm

Stage 1

- Installation of 2 x 500 MW converters in year 2010

Stage 2

- Installation of 1 x 500 MW as required under the corresponding generation scenarios.

Establishing a HVDC Light between Whakamaru and Auckland was assessed follows:

4.11.1 System Security

The HVDC light option configuration as shown in the above figure will provide (n-1) security to the Auckland load, at a level of reliability similar to that provided by the HVAC options.

4.11.2 Asset Availability

With the present state of technology, the HVDC Light option can only work with underground cables and the maximum operating voltage is below 200 kV thus requiring many cables. This means total undergrounding with multiple cables and multiple routes.

Underground land based cables are not as reliable as overhead lines options due to the large number of joints in land cables and the substantial mean time to repair any cable failures. The number of joints is high due to the practical length of cable sections that can be transported and installed using vehicles in New Zealand in roads. Furthermore, fault location and repair times would generally be higher than for overhead conductors.

4.11.3 Environmental Considerations

The HVDC Light option is visually very attractive due to the entire length of line being undergrounded. Converter stations can be compact (as compared with the Classic HVDC options). This means that the land area required for the converter stations may be less than for the classic HVDC options.

Potential adverse impacts of HVDC light option are similar to other underground cables, including earthworks and vegetation removal during the construction phase, and longer term requirements to maintain areas along the cable length free of vegetation.

4.11.4 Timing

Implementation of the HVDC Light option will require a typical of 28-36 months to complete, from the date of issuing a contract. A full length cable solution will involve an easement acquisition process and cable installation, which will likely to take a longer time than the construction of overhead transmission lines.

4.11.5 Future Flexibility

HVDC light can be applied as a new link at any time in the future. However to meet N-1 security levels and a level of reliability comparable to the HVAC options it is probable that any new link to another location would need to be duplicated. This increases costs, and given the already high cost of converters, cables and losses make it unlikely that new HVDC Light links would be attractive.

4.11.6 Economic Benefits

The cost of HVDC Light transmission development must consider the cost of undergrounding the cables over the total length of the route. The cost of supply of HVDC light cables is estimated to be in the order of $224 million per 500 MW HVDC Light link. The installation cost is expected to be more than the cable cost since trenching rather than ploughing would be needed. Thus for three HVDC Light links, the total installed cost of cables and converters would be approximately over $2.1 billion.

4.11.7 Conclusion

Overall, the adoption of an HVDC light transmission backbone would deliver a very expensive and unreliable transmission system in the long run than a National Grid supported by an interconnected HVAC transmission network.

4.12 Underground Transmission Options

Extra high voltage (EHV) cables are increasingly being used worldwide to supply electrical power for large cities and metropolitan areas. This is due to the increasing difficulty in obtaining overhead transmission line routes through high density built up areas. Other special reasons include, entry to substations, crossing other overhead lines, safety reasons at airports, land value enhancement and social/environmental concerns which require undergrounding.

Transpower has investigated a range of issues associated with partial or complete undergrounding of the proposed 400 kV AC transmission link between Whakamaru and Otahuhu substations.

4.12.1 Reliability

The reliability of the underground cable systems (for 220 kV and above) was investigated and compared with the overhead transmission in terms of expected performance including failure rates, outage times and availability due to forced outages.

If the present grid availability is to be maintained then the failure rates and outage times for 400 kV links would have to be to be equal to or better than those for the existing 220 kV lines.

There is a very high level of uncertainty in the estimation of the failure rates for 400 kV cables because of the small number of circuit kilometres installed and recent changes in technology with the introduction of XLPE type cables at this voltage. Repair times for faults on cables, joints and terminations are much longer than for overhead lines and at best will take between 10 and 19 days. This assumes that the contracting cable jointers would be immediately available from overseas, that spares were immediately available in New Zealand and the site is accessible and fault easily located.

Even with optimistic assumptions on failure rates and outage durations the availability of a 400 kV cable circuit will be significantly worse than for an overhead line when transmission over long distances is concerned. The expected levels of reliability are far too low to consider a complete underground cable system between Whakamaru and Otahuhu is a feasible transmission option.

4.12.2 Economic Benefit

Financial cost of underground transmission between Otahuhu – Whakamaru would be significantly expensive compared to overhead transmission. The costs would be in approximately 10:1 ratio. The costs are further increased by the need to provide intermediate stations at approximately 50 km intervals along the cable route for cable charging current compensation.

Operation and maintenance of such an underground cable system will depend on availability of skilled cable jointers and specialised equipment. Therefore, operating costs would also be significantly higher compared to overhead transmission.

4.12.3 Environmental Considerations

The environmental impacts of underground cables are most obviously associated with short term effects during the construction phase. These include earthworks, vegetation removal and general construction nuisance. Longer term effects are limited to the need to maintain areas without vegetation along the cable length. Selection of a cable route that avoids sensitive ecological and social environments is equally relevant to cable locations as overhead lines. As with overhead cables, public exposure to electrical and magnetic fields will be required to comply with ICNIRP guidelines.

While, the visual impact of underground transmission is minimal, easements need to be maintained throughout the route and loss of use of land (at least partially) can not be avoided. Furthermore, excavations associated with installation of underground cables are more likely to expose sites of cultural or archaeological significance during the installation phase, thereby holding up work until appropriate approvals are obtained.

4.12.4 Timing

There would be a longer lead time in manufacturing and procuring long lengths of cable. Availability of skilled cable jointers and specialised equipment for installation will also slowdown the progress of the project compared to building an overhead line.

Therefore, it is unlikely that an underground installation can be completed in time (i.e. 2010) for ensuring the security of supply to Auckland load.

4.12.5 Flexibility

Compared with overhead lines, operational issues associated with cable transmission such as, the need to match compensation with load and harmonic impedance resonance problems exacerbated by the higher capacitance of cables, could significantly limit the operational flexibility of a long underground transmission system compared to overhead transmission.

4.12.6 Conclusion

A review of available information and advice from its consultants confirm Transpower's views that installing underground cables at 400 kV AC from Whakamaru to Otahuhu is not a technically fit-for-purpose solution. The reliability of the underground cable route is far less than what is required for a high security backbone of the core grid.

The cost of undergrounding will also be substantially higher than overhead. Transpower estimates that underground cabling would be approximately ten times the cost of overhead line.

4.13 Summary of Transmission Options

The following summarises the results from the assessment of transmission options:

220 kV AC

220 kV HVAC development could meet the future demand growth in the North Island and would be a credible approach for the future long term development of the core transmission grid in the North island. However, 220 kV development would require a number of transmission lines to be build, especially between Whakamaru and Auckland under some generation scenarios. Given the difficulty in obtaining transmission corridors for building new lines, and considering the environmental impact, the ability to implement such a plan in long term is a concern.

330 kV AC

Conversion of the existing 220 kV lines to operate at 330 kV will require significant changes to the construction of the existing towers, foundations and replacement of the existing conductors. Significant outages would also be required which would place security of supply to the upper North Island at risk. On this basis conversion of existing lines is considered impractical and new lines would be required to be constructed to carry any new 330 kV infrastructure. If new lines are to be built, system studies have shown that the increase in voltage does not provide a substantial change in the number of additional lines required, particularly into the upper North Island. Transpower therefore considers that migration of the core network to 330 kV is too low for to provide sufficient technical and economic benefits to warrant further consideration.

400 kV AC

400 kV HVAC development could meet the future demand growth in the North island and would be a credible approach for the future long term development of the core transmission grid in the North island. A 400 kV development option would enable the future core grid transmission requirements to be met using substantially fewer lines than 220 kV and 330 kV options.

500 kV AC

500 kV HVAC development could meet the future demand growth in the North island and would enable the future core grid transmission requirements to be met using only a few lines. Although 500 kV is a viable transmission voltage it provides significant transmission capacity in excess of that required for most of the transmission corridors in the North Island within the planning horizon. Furthermore it has no advantages over a 400 kV solution but it has a number of disadvantages. Consequently, 500 kV is not considered as the preferred voltage for future development of the New Zealand transmission system.

HVDC

An HVDC link was considered as a transmission alternative to high voltage AC options, but the lower reliability, the inflexibility for future developments and higher costs of the HVDC make the high voltage AC options a more suitable option.

Underground Cables

A review of available information and advice from its consultants confirm Transpower's views that installing long lengths of high voltage underground cables from Whakamaru to Otahuhu is not a technically fit-for-purpose solution. The reliability of the underground cable route is far less than what is required for a high security backbone of the core grid and the cost of undergrounding will also be substantially higher than an overhead option.

5 Alternatives to Transmission

The EGRs define the term "alternatives to transmission" as:

" :*alternatives to investment in the grid, including investment in local generation, energy efficiency, demand-side management and distribution network augmentation…"*

Transpower has considered the following four broad categories of alternatives to transmission as part of its analysis of the proposed 400kV AC investment:

- electricity substitutes
- generation alternatives
- energy efficiency alternatives
- demand-side management alternatives

These four categories are described below:

5.1 Electricity substitutes

Natural gas reticulation is an example of an electricity substitute.

On a smaller scale (e.g. by increasing domestic reticulation) gas could defer transmission, but in some situations (e.g. when building a new industrial plant) gas could be used instead of transmission. To be considered as a feasible transmission alternative for the upper North Island, Transpower notes that future gas supplies would need to be certain and gas transmission infrastructure would need to be augmented to deal with the significant increase in volume. Future gas supplies are not certain and there are no committed projects to switch consumers from electricity to gas, so Transpower considers that this cannot be relied upon as a transmission alternative.

Transpower has neither the information nor expertise to properly evaluate natural gas reticulation, or other electricity substitutes. Therefore they are not discussed further in this document.

5.2 Generation Alternatives

The potential for large scale base-load generation plant to be a transmission alternative is assessed by considering the market development scenarios. For more specific generation proposals, Transpower used a Request for Information (RFI) process to obtain details of proposals directly from the industry. More detail on the RFI is included in Section 4.5.

The market development scenarios include various views of the major base-load generation plant that may develop in the future, including in the upper North Island. Because the scenarios have been developed to represent the extremes of likelihood, it is assumed that at least some of them reflect the maximum amount of new generation that is likely to appear in the upper North Island. The market development scenarios include the following new generation:

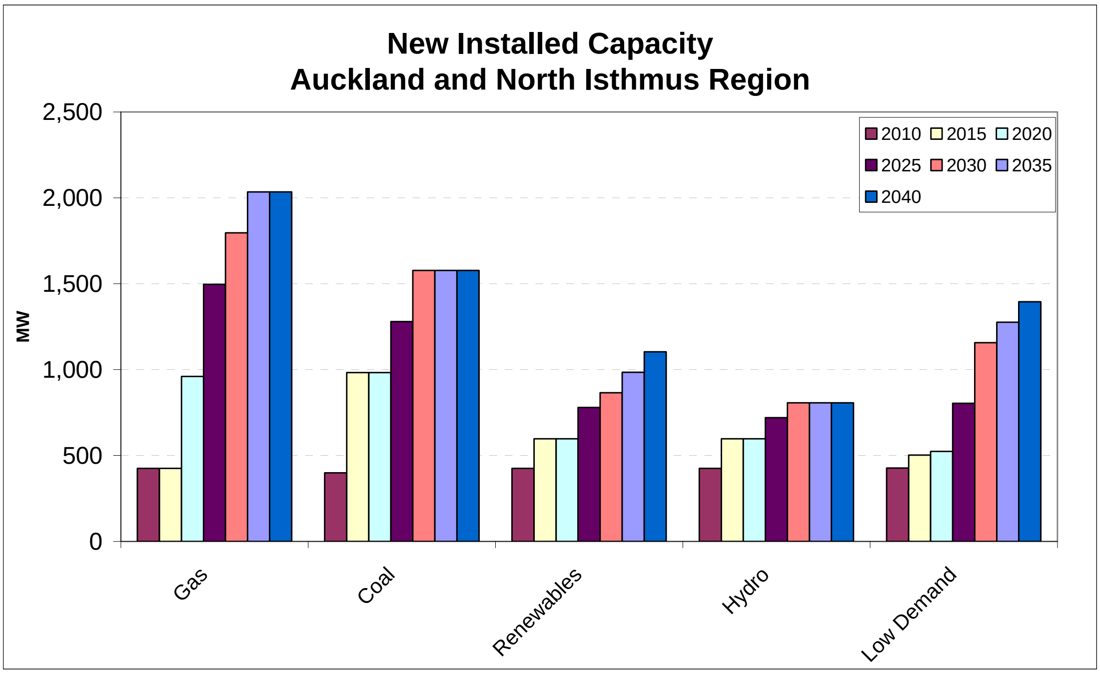


Figure 4-15: Cumulative new generation in the upper North Island

As a first step, the amount of demand growth that is forecast to be unserved in the upper North Island was calculated. The following assumptions were made in the calculations:

- Demand growth is between the low and high growth estimates
- The maximum load capability in the Auckland region is 2285MW
- New generation is commissioned according to the market development scenarios and is available for dispatch at a de-rated capacity to allow for planned maintenance outages, in the case of thermal plant 84% of installed capacity rating was assumed and in the case of wind generation35% of installed capacity rating was assumed to be available.

This results in the following estimates of unserved energy for each market development scenario:

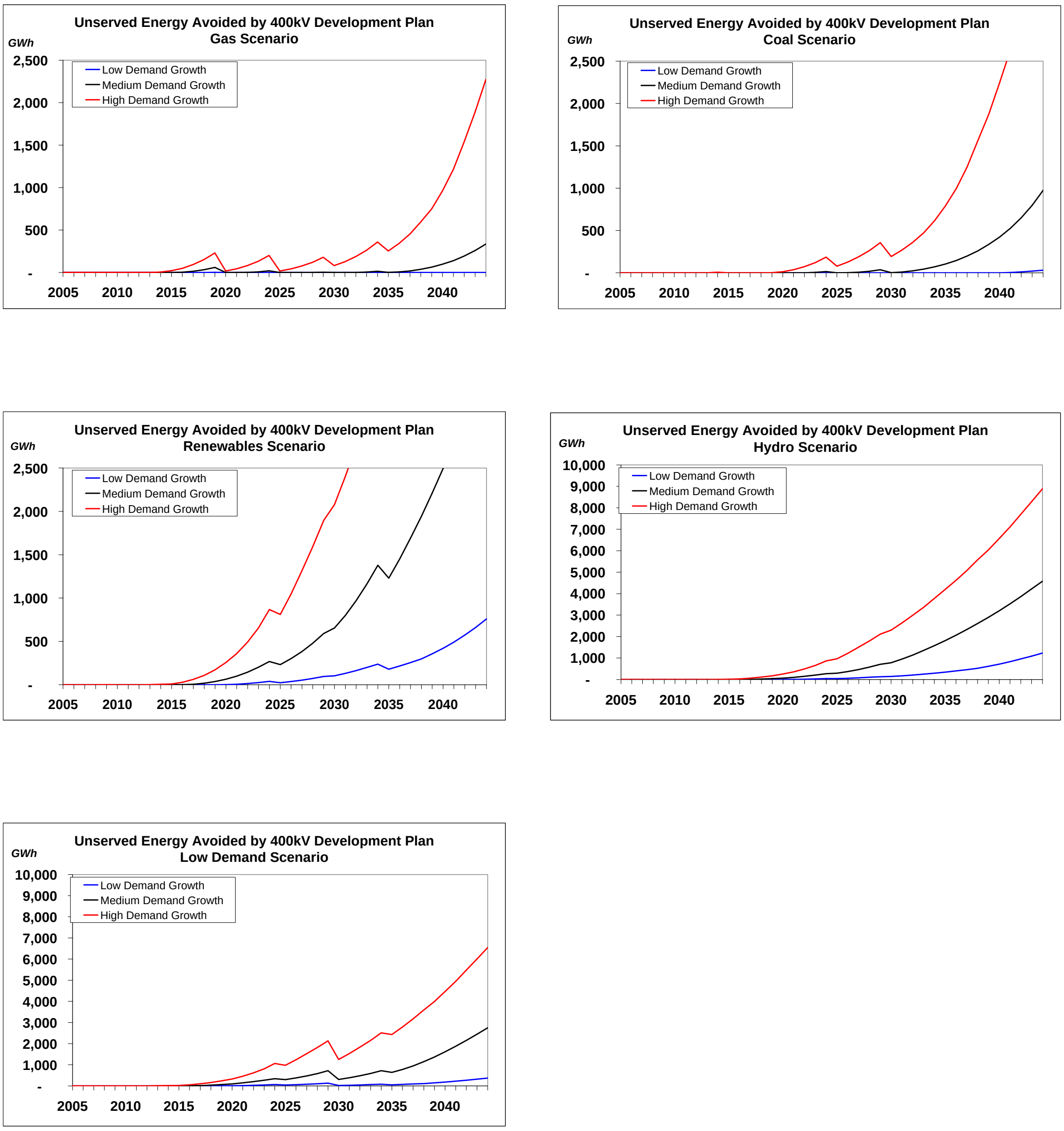


Figure 4-16 – Graphs of unserved energy per market development scenario

As can be seen, there is unserved energy in all of the scenarios, indicating that there is insufficient new generation emerging in the upper North Island to meet the forecast demand growth.

Accepting that the market development scenarios represent reasonable extremes of the potential new generation in the area, it can be concluded that large scale base-loaded generation has already been considered as part of the analysis and cannot be considered as a transmission alternative as well. This conclusion is also tested economically in Section 1, where the cost of installing new transmission to avoid the unserved energy is compared to the value of the unserved energy itself.

As a comparison, the same calculations have been undertaken using the Electricity Commission's market development scenarios, as published in their Statement of Opportunities[19]:

19 Initial Statement of Opportunities, July 2005

Their market development scenarios include the following new generation:

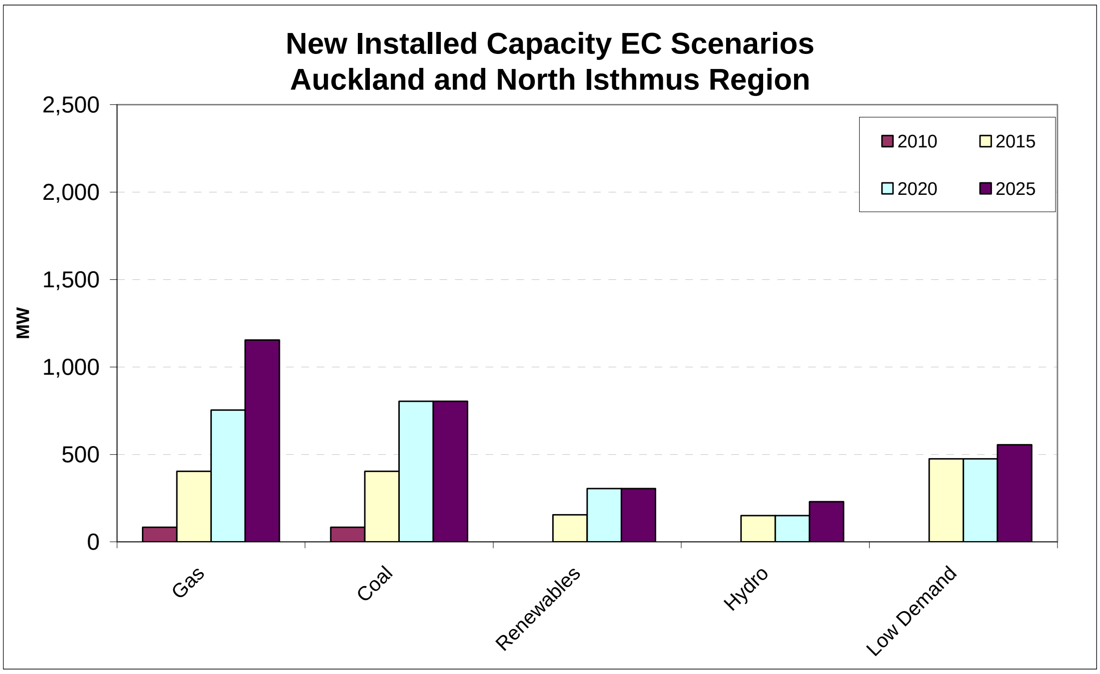
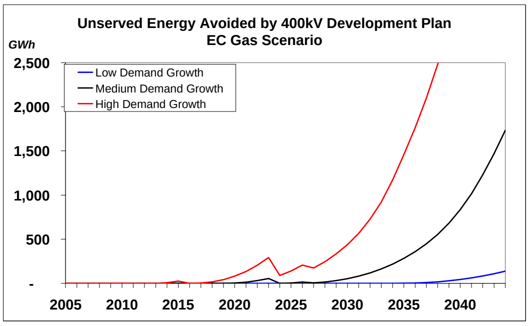
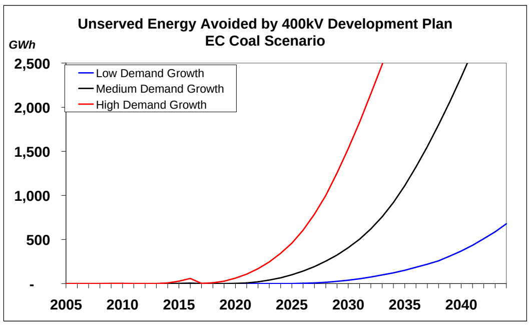
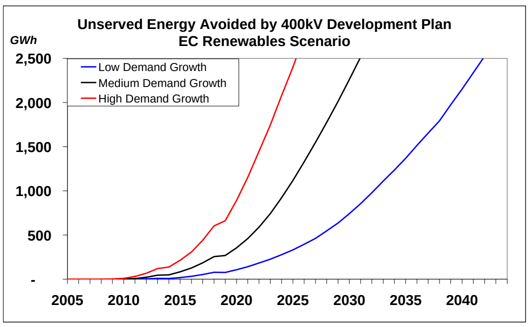


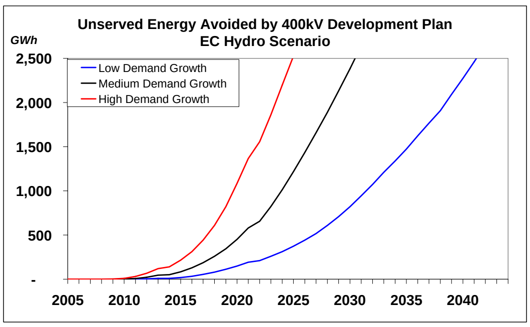
Figure 4-17: Cumulative new generation in the upper North Island in the Electricity Commission scenarios

This new generation results in the following estimates of unserved energy for each of the Electricity Commission's market development scenarios:









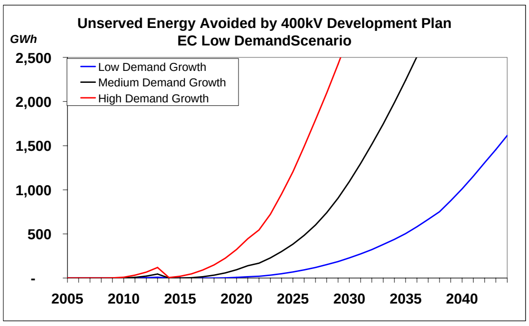


Figure 4-18: Graphs of unserved energy per market development scenario for the Electricity Commission's scenarios

As can be seen, the Electricity Commission scenarios reflect even less new generation appearing in the upper North Island than the Transpower scenarios and the same conclusion can also be drawn i.e. that large scale base-loaded generation cannot be considered as a transmission alternative as it has already been considered in the analysis.

5.3 Energy Efficiency Alternatives

Energy efficiency as an alternative to transmission is taken into account by sensitising demand forecasts. Energy efficiency initiatives tend to lower demand overall, and this is already captured in Transpower's demand forecasting models (see Part II). If energy efficiency initiatives are more economic than transmission, the expected net market benefit for low demand growth would be negative.

5.4 Demand Side Management Alternatives

Demand-side management alternatives are initiatives that take place on the distribution side of the power system. They are not otherwise captured in Transpower's analysis and together with generation proposals they have formed the subject of a Request for Information that Transpower sought from the electricity industry.

5.5 Request for Information document

Transpower's approach to determining the alternatives to transmission that have a reasonable likelihood of occurring, was to issue a Request for Information (RFI) document, seeking information on potential alternatives to transmission from interested parties.

The document was published in September 2004. A full copy of that document is available as a supporting document to this proposal.

In brief the RFI:

- described the regulatory requirement for considering alternatives to transmission
- described the process to be followed
- outlined the existing transmission system
- listed the existing generation in the upper North Island
- outlined Transpower's demand forecasts for the upper North Island
- described Transpower's grid planning criteria
- provided information on the energy shortfall and seasonality requirement that alternatives to transmission would need to meet in order to defer investment in transmission
- listed the criteria that transmission alternative proposals would be assessed against

5.5.1 Submissions received in reply to the RFI

A summary of the submissions received in reply to the RFI is included in the table below. To maintain confidentiality requested by some proposers, the submissions have been generalised. The table includes a list of the types of proposal received and the potential peak MW reduction on load if the proposal were implemented.

Alternatives to transmission	Approximate potential peak MW reduction (*)
Energy efficiency alternatives	
Range of general demand reduction initiatives that promote more efficient use of electricity.	150-300 MW
Peak Demand Management Programmes	
Demand bidding & communication programmes to target peak demand reductions.	150-250 MW
Generation alternatives	
Peaking and base load plant.	150 MW

(*) as estimated by the submitters

Table 4-13: Summary of submission types received in reply to the RFI

5.5.2 Application of initial screening process

The submissions were initially evaluated using a set of screening criteria developed by Transpower. These screening criteria supplanted the criteria outlined in the RFI document and served to eliminate several of the submissions which would not be useful as alternatives to transmission in practice.

The screening criteria require that, in order to be evaluated further, a transmission alternative must:

- result in peak MW load savings
- have reasonably guaranteed peak MW load savings
- defer the need for transmission investment by 12 months or more

The basis for these criteria is discussed below.

5.5.2.1 Would the proposal result in peak demand savings

Transmission is planned and implemented in a way that it enables demand to be met during peak load times. Any transmission alternative must therefore deliver a reduction in the peak demand required to be delivered by the transmission system during these critical peak load times.

For example, alternatives that offer general energy savings but do not reduce the peak demand on the transmission system were not considered as viable transmission alternatives as they do not provide the same peak loads in an area may occur on a daily basis between 7:00-7:30 am and 6:30-7:00 pm. An alternative which reduces load at say, midday, but which does not reduce the load during peak times, would not defer the need for transmission and therefore is not considered further.

Some of the proposals are based on demand reductions at off-peak times and as such they cannot be considered transmission alternatives in this case.

5.5.2.2 Are the peak demand savings reasonably guaranteed

One of Transpower's primary planning concerns is ensuring the transmission network will deliver a secure supply of electricity, in accordance with Transpower's transmission planning criteria, during times of peak demand.

In that regard, only those transmission alternative proposals where the forecast peak MW load savings can be reasonably guaranteed, were considered further.

Peaking generation plant, is an example of a transmission alternative which would meet this need. Presuming it is contracted as a transmission alternative, Transpower would advise the generator when to run, hence (reliability of the generating plant aside), Transpower can guarantee the peak MW load savings would be made.

Some of the transmission alternative proposals rely on demand response to price signals, which may reduce demand at peak times, but may not, depending on the preferences of the consumers concerned. On a particularly cold day, for instance, consumers may decide to consume "normal" levels of energy, irrespective of the cost and hence the peak MW load savings would not be realised. The peak MW load savings are too uncertain to reply upon from a security of supply point of view and therefore they cannot be considered alternatives to transmission.

5.5.2.3 Would the transmission alternative defer the need for transmission investment by one year or more

In the context of a six year transmission project, only those proposals that provide a substantial deferral of transmission plans can be considered as viable alternatives to transmission. With the risks that are associated with the current project timetable, only those proposals that defer the need for transmission investment by one year or more were considered further.

Application of the screening criteria resulted in the following outcome:

Transmission alternatives	Are there peak MW savings	Are the peak MW savings certain	Defer transmission for 12 months or more
Energy efficiency alternatives			
Range of general demand reduction initiatives that promote more efficient use of electricity.	?	?	×
Peak Demand Management Programmes			
Demand bidding & communication programmes to target peak demand reductions.	?	?	?
Generation alternatives			
Plant targeted at generating at during peak load times.	✓	✓	✓

Table 4-14: Application of Screening Criteria to Alternatives to Transmission

Energy efficiency initiatives were ranked low due to the fact that the initiatives could not provide reasonable certainty of providing the necessary demand reductions at time of peak load which is required for transmission investment deferral. The implementation path also is unclear and is reliant on consumers adopting certain technology and then continuing to use that technology for the long run.

Peak demand management initiatives were considered more likely to deliver the demand reductions at the time that they are required to defer transmission investment. However the implementation of such a system is unclear in terms of the quantity of benefits available and whether these would continue to be available during peak load times year on year. Transpower has commissioned work from independent consultants to investigate the feasibility and implementation strategy for such a system.

Therefore only the generation plant designed to operate at peak load times met the screening criteria and was considered further using cost/benefit analysis in Part IV of this submission.

5.6 Alternatives to Transmission Summary

According to the market development scenarios developed both by Transpower and the Electricity Commission, there is insufficient new generation emerging in the upper North Island to meet the forecast demand growth. On the basis that these scenarios capture the reasonable extent of generation possible in the region, additional large scale base-loaded generation cannot be considered as a realistic transmission alternative.

Transpower assessed the potential transmission alternatives not reflected in the market development scenarios, using a RFI process. Of the alternatives offered through the RFI process, only generation peaking plant is considered viable and further analysis is undertaken on peaking plant, using cost/benefit analysis, in Part IV of this submission.

Appendix III-A – Environmental Analysis & Process

Each of the transmission options will require a new transmission line extending from Whakamaru to Otahuhu, as well as substation investment at each termination location. This will require resource consents and designating the length of the route pursuant to the Resource Management Act 1991 (RMA). Potential adverse environmental effects of such a project are varied and may include, amongst others:

- Safety and health effects (associated with electric and magnetic fields)
- Social effects (disruption to communities).
- Property values (financial costs resulting from social effects – this issue is considered separately)
- Visual effects
- Effects on tourism and recreational values
- Impact on sites of ecological significance or heritage value
- Effects on cultural values
- Effects on existing infrastructure – including transmission lines and roads.
- Impact on land use (including disruption to agricultural activities as a result of the establishment of new structures).

Until a final centre-line of the preferred transmission route is known, it is not possible, or appropriate to identify the full environmental effects of each transmission option. Analysis of the preferred option is considered in detail during the Resource Management Act process, it is not expected to be relitigated outside that framework.

Transpower has developed the Area, Corridor, Route and Easement (ACRE) process which will be utilised to identify (through analysis) the final line easement location and any other mitigation measures to best manage adverse environmental effects of a transmission solution.

The model is designed to enable Transpower to secure designations and property rights for any new-build grid augmentation in a robust framework that meets the legislative requirements of the key statutes – the Resource Management Act (RMA), the Electricity Act and the Public Works Act (PWA) while also incorporating best environmental practice. The key stages of ACRE are noted below:

A = Identification of study 'Area' and environmental/social/engineering constraints and opportunities analysis mapping

C = Identification and confirmation of alternative 'Corridors' (500m to 5 kilometre wide corridors) ranking and selection of preferred corridor

R^{i} = Selection and evaluation of alternative 'Routes' within the confirmed corridor and public presentation (for consultation)

R^{ii} = Route confirmation following consultation.

E = Identification and confirmation of 'Easement' centre-line and designation boundaries (including ongoing consultation)

D = Documentation – preparation of full documentation and notices of requirement and resource consent application.

S = Statutory – lodgement of notices of requirement and resource consent applications, Council hearings, Transpower decision, Environment Court appeal process, (if required), and mediation, leading to confirmation (or otherwise of designation.

The model is generic and is readily adaptable to the various transmission options (220, 330, 400 kV etc.).

Detailed environmental analysis of each of the Area, Corridor and Route stages for the 400 kV option is available as separate reports. They provide the justification for identification of the two route options currently being consulted on, and more latterly the preferred interim route decision.

When deciding between transmission options, it is, however, possible to identify and assess broader environmental parameters that make one transmission option more preferable than another. For example, lower capacity lines will require greater numbers of transmission lines to transfer electricity. Furthermore, options that are able to utilise the location of existing transmission lines or substations within a similar envelope of environmental effects[20] (visual, acoustic, social, ecological etc.) are more preferable than options which require a new 'greenfield' location.

Site specific impacts of the various transmission options can be evaluated, to a limited extent, on the basis of average tower height. Tower height determines visual impact and also provides a useful proxy for potential impacts on site-specific issues identified above. Tower height is a function of compliance with electric and magnetic field limits contained in ICNIRP guidelines. It will, therefore, also provide an indication of the likely perceived health concerns of the transmission option.

In this report, for each transmission option, the environmental effects are considered on the basis of potential visual effects and the likelihood of any additional lines within the foreseeable future. This analysis is presented for comparative purposes only. It merely attempts to outline the primary differences between each transmission option to enable the extent to which mitigation will be required, and thus the potential for securing environmental approvals and associated costs (both of mitigation, and any further investigations). In so doing, it is noted that visual effects (and each of the other issues previously identified) are subject to the environment within which they are located and thus not absolute. It is not possible to draw any firm conclusions from this analysis until RMA processes are resolved.

[20] The options identified do not provide opportunity for this scenario and are not considered further.

Appendix III-B North Island Tactical Transmission Upgrade Project Summary

A number of tactical transmission upgrade projects are planned to be implemented in the North Island before 2010. A summary of these projects is as follows:

Region	Grid Upgrade Project	Capacity	Description
Auckland and North Isthmus	Increase the operating temperature of the Huntly - Otahuhu section of Otahuhu - Whakamaru C 220 kV line	671/614 MVA	Reduces constraints on Huntly Generation and increase thermal capacity into Auckland
	Thermal upgrade of Otahuhu - Whakamaru A&B lines	323/293 MVA	Increases the thermal capacity into Auckland
	Thermal upgrade of 220 kV Otahuhu-Penrose 5&6 circuits	492/469 MVA	Increase the capacity of the existing 220 KV Otahuhu-Penrose 5&6 circuits
	Thermal upgrade of 220 kV Otahuhu-Henderson circuits	984/938 MVA	Increases the capacity of both existing 220 KV Otahuhu-Henderson circuit
	Shunt capacitors at Penrose 110 kV	2x50 Mvar	Increases the transfer limit until the Huntly E3P unit is commissioned in 2007
	Shunt capacitor at Hepburn Road 110 kV	1x50 Mvar	Increases the transfer limit until the Huntly E3P unit is commissioned in 2007
Wellington	Increase the operating temperature of the Bunnythorpe- Haywards A&B 220 kV line	335/307 MVA	Increase transfer south to Haywards from 640/760 MVA to 920/960 MVA
Central North Island	Increase the operating temperature of the Tokaanu - Whakamaru A&B 220 kV lines	335/307 MVA	Increases the thermal limit between the Central North Island and the bay of Plenty region
	Thermal upgrade of the Rangipo-Wairakei 1	370/333 MVA	Increases the thermal limit between the Central North Island and the bay of Plenty region
	Thermal upgrade of the Wairakei-Pohipi-Whakamaru 220 kV circuits	448/421 MVA	Increases the transmission capacity in Wairakei ring
	Thermal upgrade of the Bunnythorpe-Tokaanu 1&2	335/307 MVA	Increases thermal limit of the Central North Island core grid corridor