BOARD OF INQUIRY
TE MIHI GEOTHERMAL POWER STATION PROPOSAL

In the Matter	of the Resource Management Act 1991
And	
In the matter	of resource consent applications by Contact Energy Limited in respect of the Te Mihi Geothermal Power Station Proposal

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BRIEF OF EVIDENCE IN CHIEF OF GREGORY F SISE

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Introduction

1. My name is Gregory Fleetford Sise. I am Managing Director of Energy Link Ltd and Ellsoft Ltd**.**

2. I have the following qualifications and experience relevant to the evidence I shall give:

    - ME, Electronic and Electrical Engineering, Canterbury, 1986
    - BSc (Hons, First Class in Physics), Otago, 1982
    - Prior to starting Energy Link I held the following relevant positions:
        - (i) Energy Adviser, Central Electric and MainPower (NZ), 1996: advising on and assisting with risk management strategy and implementation in the new wholesale electricity market in 1996.
        - (ii) General Manager, Energy Consultants (NZ) Ltd, 1994 – 1996: general management of an energy consultancy practice.
        - (iii) Special Projects Manager, Univord Energy Ltd, 1989 – 1993: energy auditing, tariff analysis and energy management programs for large energy consumers.
        - (iv) Scientific Officer, Energy Management Unit, Otago University, 1984 - 1985: development of software for energy management in buildings.
    - Completion of many transmission analyses since 1996 using the EMarket and EMarketOffer software developed by Ellsoft Ltd
    - Development and presentation of Energy Link's "Nodal Pricing of Electricity" which includes material covering the theory, implementation and effect of line ratings and security constraints on dispatch and pricing in the spot market
    - Member of the Market Pricing Working Group (of the New Zealand Electricity Market) 1998 – 2004, including development and refinement of market rules relating to security constraints and their influence on dispatch of generation on the grid

3. I was the principal author of the report on electricity, transmission issues prepared by Energy Link in 2007 which was included in the technical

appendices to Contact Energy Ltd's consent applications. I will refer to that report as *"the 2007 study"*.

4. I confirm that I have read the 'Code of Conduct for Expert Witnesses' contained in the Environment Court Consolidated Practice Note 2006. My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

Scope of Evidence

5. My evidence will assess the impact of the proposed Te Mihi geothermal power station on the likelihood of transmission constraints in the area of the national grid known as the 'Wairakei ring', into which the additional electricity produced by the Te Mihi Power Station will feed.

Summary of Conclusions

6. Assuming normal operation of the grid (specifically all grid lines in the Wairakei ring in service), the capacity of the Wairakei ring is limited by the combined flow of power through the lines OHK_WRK and WRK_PPI[1]. These lines together feed power west and north from the WRK node on the grid at the eastern apex of the Wairakei ring.

7. All other things being equal, adding generation at Te Mihi will reduce the likelihood of the key security constraint in the Wairakei Ring (OHK_WRK_2) limiting power flows through the Wairakei ring. The likelihood will reduce further as the output of the Wairakei geothermal station reduces.

8. The probability of OHK_WRK_2 reaching its limit during normal operation of the grid and connected generating stations is so low that the frequency of this event could not readily be estimated. In a qualitative sense, I have concluded that the constraint is unlikely to limit power transfers under normal operating conditions, either now or in 2012. This conclusion applies regardless of whether Te Mihi is developed in one or two stages.

9. This assessment includes an allowance for new generation coming on line, specifically relevant projects either within or to the east or north of the Wairakei ring that already have resource consents, whether or not they are committed for development. These include:

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1 Ohakuri to Wairakei and Wairakei to Poihipi respectively- see Exhibit GFS 1.

9.1 the consented but not yet committed 60MW geothermal power station project of Geotherm Group Ltd (in receivership);

9.2 the 225MW consented but not yet committed wind farm project of Wind Farm Developments Ltd;

9.3 the 90 MW Kawerau geothermal plant currently under construction;

9.4 the 132 MW second stage of the Rotokawa geothermal power station due for completion in May 2010; and

9.5 the 48 MW consented but not yet committed wind farm project at Titiokura on the East Coast.

10. I have also assumed that existing limitations (constraints) on electricity flow through the Wairakei Ring will remain as at present. This is unlikely to be the case in practice (Transpower, the owner and operator of the national grid, is currently investigating upgrades of the Wairakei Ring, for instance) but the nature and scope of any changes to the capacity of the Wairakei Ring are too uncertain to be assessed at present with any degree of confidence.

11. The major uncertainties around my conclusion, therefore, are:

11.1 how the security constraints and line ratings in the Wairakei ring will change over time; and

11.2 how much new generating capacity is added over time to the south, north and, more particularly, to the east of WRK, over and above the relevant projects that are currently consented and listed in paragraph 9.

Background

12. It is proposed to construct the new Te Mihi geothermal power station at or near the Poihipi (PPI) node on the North Island grid, which is located in the region of the grid known as the 'Wairakei ring'.

13. The Wairakei ring is located to the north of Lake Taupo (see Exhibit GFS 1 and Exhibit GFS 2) and consists of the five transmission lines joining the nodes Whakamaru (WKM), Atiamuri (ATI), Ohakuri (OHK), Wairakei (WRK) and Poihipi (PPI and PPT – these can be treated as the same node for the purposes of this evidence). The red bars in the exhibits show the location of existing generators, e.g. hydro stations on the Waikato river at WKM, ATI

and OHK, and geothermal stations at WRK and PPI. The white bars show electricity demand and the green dashed lines are transmission lines in the grid, although in these exhibits some dashed lines may represent more than one physical line, e.g. two lines running parallel.

14. The five transmission lines making up the Wairakei ring are shown in Exhibit GFS 3, where the line names include the node at each end of the line.

15. Te Mihi is proposed to connect to the grid at PPI where the existing Poihipi geothermal station connects. Te Mihi's output would increase while the output of the existing Wairakei geothermal station would decrease. These developments will jointly impact on the power flows through the Wairakei ring and perhaps also on the likelihood of transmission constraints in the Wairakei ring.

16. When a transmission constraint reaches its limit, there can be a significant impact on the dispatch of generating plant relative to the case where the constraint is not at its limit. In the case of the Wairakei Ring, if OHK_WRK_2 were to reach its limit then we would expect this to occur with high levels of power transfer north and west through WRK. The impact could include substantially limiting the output of generators connected directly to WRK, or on the East Coast, below what it would otherwise be.

Limitations on Power Flow

17. Transmission constraints arise because electricity sought to be injected onto the grid exceeds the limitations imposed by Transpower on power flow across the grid. Limitations on power flow through the grid are primarily imposed either as line ratings or as security constraints. A line's rating imposes an upper limit on the power flow allowed on the line and is the safe physical capacity of a particular line to transmit electricity. The safe physical capacity of an electricity line is affected by ambient air temperatures, so line ratings may be different between Transpower's summer and winter seasons, where summer is defined as 7:00 am to 9:00 pm each day from 20th October to 10th May each year. In all other periods the winter ratings apply.

18. The line ratings for the five lines in the Wairakei ring are shown in Exhibit GFS 4. However these ratings are not the limiting factors for power flow through and around the Wairakei ring.

19. The grid is managed, where possible, so that the loss of one transmission line will not disrupt the delivery of electricity to consumers – this is known as "N – 1" security management. Security constraints are developed and applied after analysis of an outage of each line in the grid, in this case one of the lines in the Wairakei ring. Because security constraints reflect allowances for supply contingencies, the security constraints will typically reach their limit before the line ratings are reached.

20. There are three permanent security constraints applying to the lines in the Wairakei ring, shown in Exhibit GFS 5. ATI_WKM is used as the name of both a line and a security constraint so its meaning depends on context.

21. Of the three relevant security constraints, OHK_WRK_2 is the most likely to reach its limit during normal operation. It is therefore this security constraint that will typically determine the capacity of the Wairakei Ring to transmit electricity west and north from WRK. OHK_WRK_2 is in place to limit the power flowing in the OHK_WRK line to safe levels in case the WRK_PPI line suddenly becomes unavailable, for whatever reasons (known as an 'unplanned outage' of the line.) As long as OHK_WRK_2 does not exceed its limiting value, the power flow in OHK_WRK will not unduly exceed its relevant rating immediately after an unplanned outage of the WRK_PPI line, during a period with low Upper North Island generation (generation from Huntly and above) and when all other lines are in service, and the grid will continue to safely deliver electricity through the Wairakei ring, at least for as long as it takes to re-dispatch generation to ensure that all lines are operating within their line ratings.

22. The value of OHK_WRK_2 at any particular point in time, is the sum of 1.25 × OHK_WRK power flow + 0.85 × WRK_PPI power flow. For example, if the power flowing through OHK_WRK is 100 MW and 80 MW flows through WRK_PPI then the value of OHK_WRK_2 will be 125 + 68 = 193 MW.

23. Generation will always be dispatched in a way which ensures that the value of OHK_WRK_2 does not exceed its relevant limiting value, as determined by the full formula for OHK_WRK_2:

Summer: $-1.25 \times OHK\_WRK + 0.85 \times WRK\_PPI \leq 439$

Winter: $-1.24 \times OHK\_WRK + 0.85 \times WRK\_PPI \leq 471$

where the negative sign on the power flow in OHK_WRK indicates power flow from WRK to OHK.

24. The formula above can be partly understood as follows: modelling shows that if WRK_PPI has an unplanned outage, then (all other things being equal) 85% of the pre-outage flow on WRK_PPI instantaneously transfers to OHK_WRK – hence the multiplier of 0.85 on the power flow in WRK_PPI. At least in simple terms, this tells us that it is safe to run OHK_WRK below its relevant rating value by 85% of the power flow in WRK_PPI.

25. The actual formula for OHK_WRK_2 (shown in paragraph 23) is more complex than the simple constraint suggested in paragraph 24, because other factors are taken into account, and the formulation takes advantage of any opportunities to maximise the total pre-outage power flow west and north from WRK.

Transpower Publications

26. Transpower publishes an Annual Planning Report, updated earlier this year (APR08), and a System Security Forecast 2006 (SSF06) last updated December 2007, both of which include information on grid capacity issues in the Wairakei ring.

27. Section 7.3.3 of the APR08 states that "as [new] generation develops [in and around the Wairakei ring], an outage of one of the Wairakei Ring circuits may begin to constrain north power flows during high loads." This is consistent with my conclusion – power flow through the Wairakei ring will not be significantly limited during normal operation, although it may occur after an unplanned outage of WRK_PPI, for example.

28. Depending on other factors, principally the amount of new generation built in the Upper North Island, the APR08 states that Transpower intends to investigate two options for increasing the capacity of the Wairakei ring: "Replace the conductor on the existing Wairakei Ring 220 kV circuits (2010-15) and/or a new 220 kV transmission line between Whakamaru, Atiamuri and Wairakei (2015-21)." Given the statement in section 7.3.3 of the APR08, and the conclusion of this brief, it would appear that these grid capacity upgrades are considered potentially desirable in order to preserve grid capability in the event of an outage in the Wairakei ring.

29. If one or more grid upgrades proceed as proposed above, then it can be assumed that security constraints around the Wairakei ring will be relaxed,

further reducing the probability of limitations on transmission in this region under normal conditions.

30. If grid upgrades do not occur, security constraints on the Wairakei Ring may change, but it is not possible to predict the nature of such changes or their effect on electricity transmission across the Wairakei Ring with any certainty.

New Generation

31. With the exception of Te Mihi itself, Exhibit GFS 6 shows the status of new generation projects (for which information is in the public domain) in or immediately adjacent to the Wairakei ring. From any given list of projects, history shows that only those that are under construction or committed for construction, can reliably be assumed to be connected at some point in the foreseeable future. All other projects, even if consented, must be treated as ‘possible’ or ‘probable’ at best.

32. In my view, any assessment of transmission capacity which takes into account uncommitted projects is speculative. Nevertheless, for the purposes of this brief (and the 2007 study) we took a conservative approach - the projects included in the assessment in this brief are those which are either committed or already consented, but not owned by Contact Energy. The Geotherm geothermal project is consented and was in the early stages of development, but I understand the developer is now in receivership. It is however included in the assessment.

33. For avoidance of doubt, projects shown in Exhibit GFS 6 which are neither committed nor consented are shown for information only and are not considered in any assessment of grid capacity or the likelihood of OHK_WRK_2 reaching its limiting value.

34. Exhibit GFS 7 shows the marginal impact on the OHK_WRK_2 security constraint of an increase in net generation at a range of nodes on the grid. For example, the first row of the table shows what happens when, with all other things held the same, generation is increased at TUI (Tuai node on the East Coast where the Waikaremoana hydro scheme connects to the grid) by 1 MW – power flow increases by 0.47 MW in WRK_PPI in the direction WRK => PPI; power flow increases by 0.30 MW in OHK_WRK in the direction WRK => OHK (power flow is positive in this line when running

from OHK to WRK); and the overall impact on OHK_WRK_2 is to bring it 0.77 MW closer to its relevant limiting value.

35. Hence new generation at nodes which have a positive value in the OHK_WRK_2 column bring OHK_WRK_2 closer to its limit, and vice versa. The table shows that OHK_WRK_2 is more likely to constrain (in a relative sense) when either generation to the east and south of WRK increases, or demand to the east and south of WRK reduces. It is less likely to constrain (in a relative sense) when generation increases (or demand reduces) in the Bay of Plenty or otherwise to the north and west of the Wairakei ring.

36. Taken overall, the data in Exhibit GFS 7 suggests a scenario in which OHK_WRK_2 which might reach its limit (with all lines in the Wairakei ring in service):

36.1 high generation to the east and south of WRK – Tuai, Whirinaki (government controlled dry year reserve generation of 156 MW), Wairakei, Ohaaki (geothermal), Aratiatia (hydro station on Waikato River), Rangipo (hydro station south of Taupo on the Tongariro hydro scheme);

36.2 low generation and high demand in the Bay of Plenty;

36.3 low generation on the Waikato system which reduces the output of Arapuni and Ohakuri (hydro stations on the Waikato River).

37. Marginal analysis and related modelling suggest a dry year scenario as most likely to cause OHK_WRK_2 to reach its limit and would need to feature:

37.1 high output at Whirinaki – running because of a dry year when hydro storage breaches the Electricity Commission's 'Minzone' threshold for elevated risk of shortage;

37.2 high output at Tuai and at new wind farms (as yet neither built nor committed) on the East Coast;

37.3 high demand in the Bay of Plenty combined with low generation in this region of the grid (e.g. new geothermal station at Kawerau operating at low or no output);

37.4 low output on the Waikato (dry year scenario);

37.5 summer security constraint limit value (439 MW) in place for OHK_WRK_2, this being 32 MW lower than the winter limit.

38. In summary: OHK_WRK_2 is most likely to reach its limit, (given normal operating conditions, no outages), during peak demand in the Bay of Plenty between the hours of 7:00 am to 9:00 pm, late in a dry autumn with Whirinaki running at high output and future East Coast wind farms also running at high output. The likelihood would increase with the 90 MW Kawerau geothermal station (currently under development) running at low output.

Modelling Update for 2012

39. The 2007 study was undertaken in July 2007, at which point our conclusion for normal operating conditions for 2007 was that OHK_WRK_2 was unlikely to reach its limit with Te Mihi added. Given committed new generation known at the time, our conclusion for 2012 was that OHK_WRK_2 would be no closer to its limiting value, and hence no more likely to reach its limit, until total new generation on the East Coast exceeded approximately 120 MW. Above 120 MW, Exhibit GFS 7 shows that OHK_WRK_2 would be 0.75 MW closer to its limit for every 1 MW of additional East Coast generation, all other things being equal.

40. The marginal impact figures in Exhibit GFS 7 remain relevant today, but detailed modelling was repeated during the writing of this brief using all relevant existing, committed and consented stations shown in Exhibit GFS 6, and updated demand information, in order to estimate the total amount of new generation that can be connected on the East Coast before OHK_WRK_2 reaches its limiting value.

41. Three ‘snapshot’ demand scenarios were modelled for 2012 - winter peak, winter average and summer early morning – all with the Whirinaki dry year reserve station running at full output of 156 MW. 2007 demand was projected forward for five years at an annual growth rate of 1.95% at all nodes except Tiwai, for which it was assumed the aluminium smelter’s load would remain constant through to 2012. 1.95% per annum was the average growth rate in non-Tiwai demand since 2000.

42. In all three scenarios all committed and consented new generation projects in or adjacent to the Wairakei ring were included at their full nominal

installed capacity. The 90 MW geothermal station currently under construction at Kawerau was also included at full output.

43. In the winter average demand scenario 206 MW of new East Coast wind generation was dispatched, and 242 in the winter peak demand scenario.

44. In the summer early morning scenario only 113 MW of new East Coast wind generation was dispatched, but it must be said that it would be unlikely for Whirinaki (156 MW) to be running at all during low demand periods in summer, let alone at full output. This is because Whirinaki, which is operated by Contact Energy to parameters set by the Electricity Commission, is a standby plant primarily for use during prolonged dry periods during autumn and winter and only when the risk of shortage rises above specified levels. It may also run for short periods when, for reasons other than a dry year, there is a substantial risk of short-term interruptions to normal supply.

45. These scenario results for East Coast generation, whilst not exhaustive, compare favourably to the 273 MW of consented East Coast wind farms shown in Exhibit GFS 6 and reinforces the conclusion of the original study: with all Wairakei ring lines in service, the addition of Te Mihi is unlikely to limit power flow through the Wairakei ring in 2012.

46. The modelling was intended to asses the likelihood of transmission constraints with all relevant generation wishing to run at full capacity, but it is also relevant to note that 273 MW of installed wind farm capacity represents between 82 MW and 123 MW of output taken on average over the long term (because wind farms load factors in New Zealand are expected to range from 30% to 45%.) The probability of a transmission constraint in the Wairakei ring is therefore influenced by the probability of the simultaneous occurrence of full output at all relevant stations including wind farms, geothermal stations and the Whirinaki dry year reserve station. This probability is so low that it could not readily be estimated either in the 2007 study or during the modelling undertaken during writing of this brief.

G F Sise

Exhibits

Exhibit GFS 1 - The North Island Grid

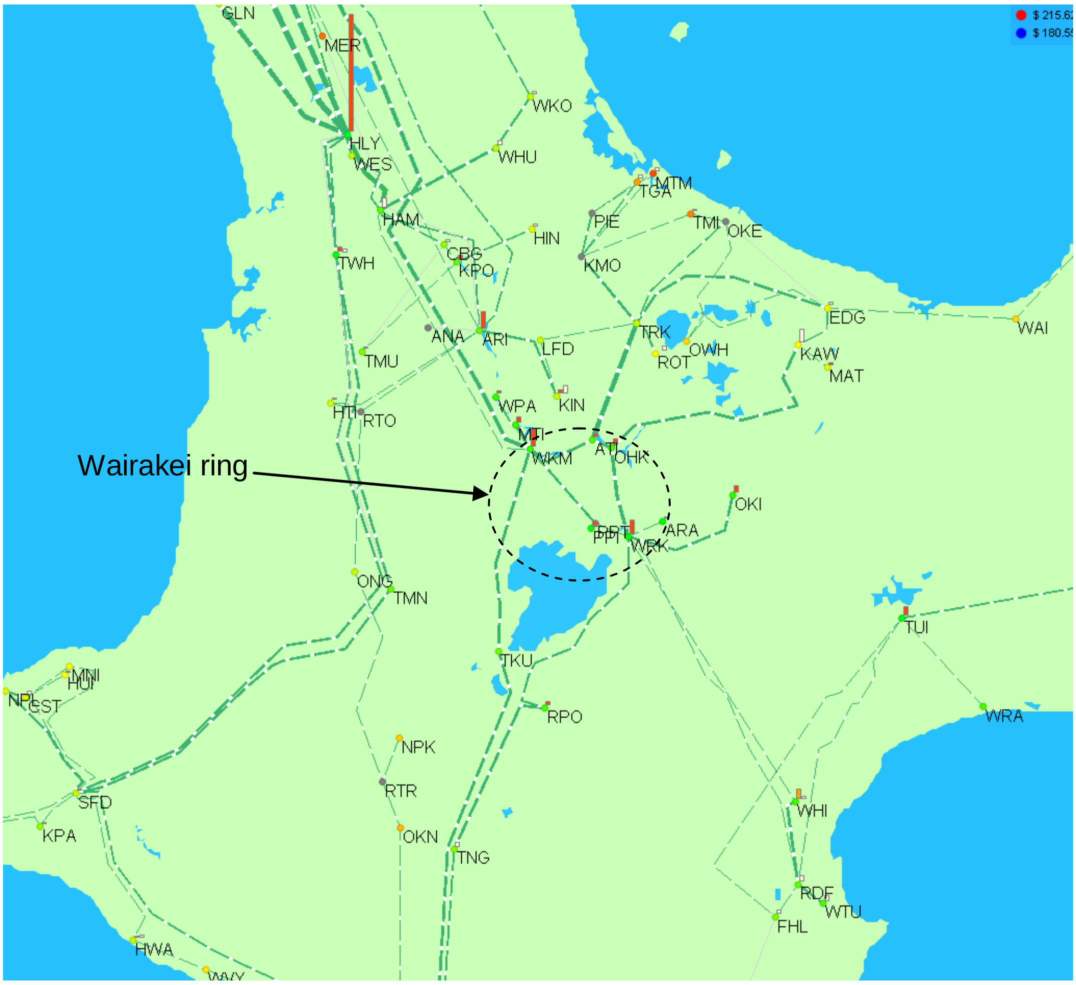

Exhibit GFS 2 -The Wairakei Ring

Exhibit GFS 3 – Lines in the Wairakei Ring

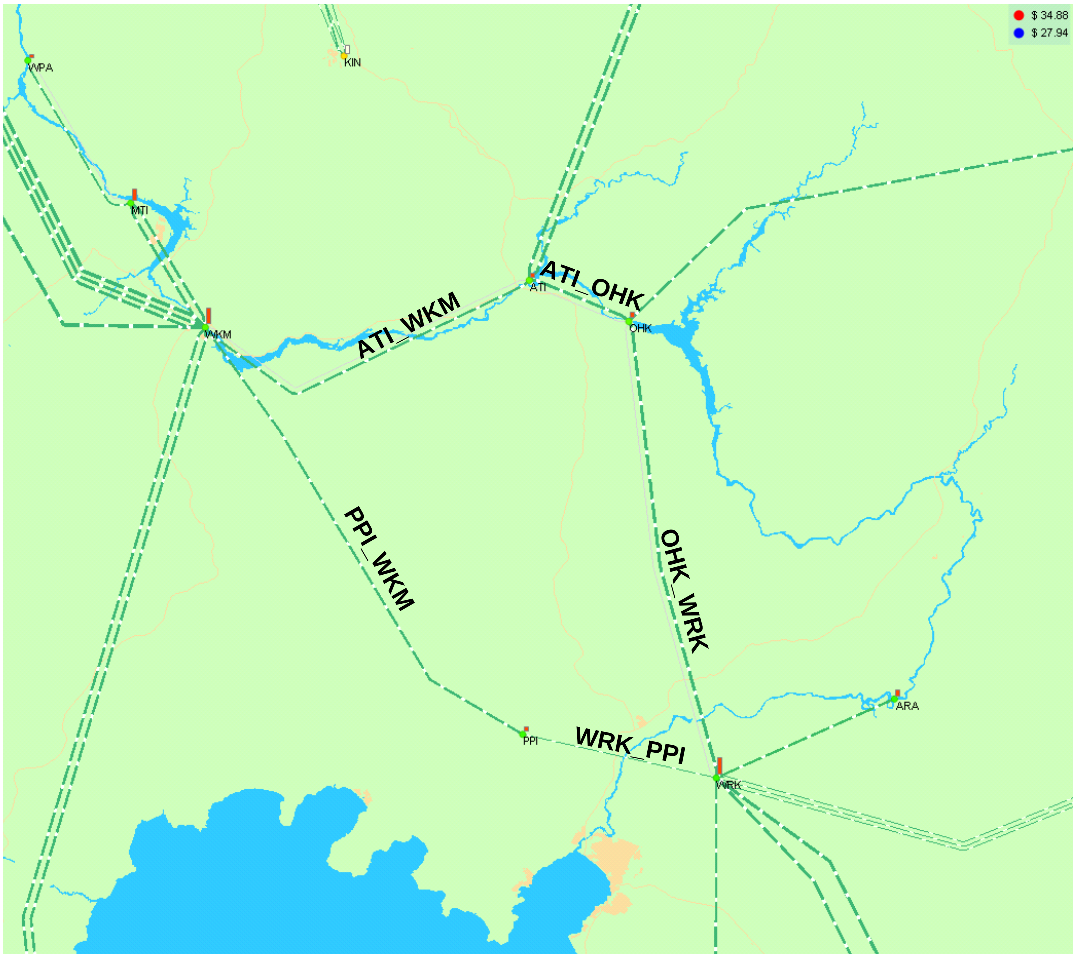

Exhibit GFS 4 – Line ratings in the Wairakei ring

Line Name	Summer Rating	Winter Rating
ATI_OHK	333	358
ATI_WKM	333	358
OHK_WRK	333	358
PPI_WKM	421	428
WRK_PPI	422	449

Exhibit GFS 5 – Security constraints in the Wairakei ring

Name	Purpose	Season	Equation	Limit
ATI_WKM	The effect of this constraint is to manage flows through the ATI_WKM line for an unplanned outage of OHK_WRK during low generation and high load in the Bay of Plenty area.	Summer	-1.25 × ATI_WKM - 0.95 × OHK_WRK	444
		Winter	-1.24 × ATI_WKM - 0.95 × OHK_WRK	470
OHK_WRK_1	The effect of this constraint is to manage flows through OHK_WRK for an unplanned outage of the ATI_WKM line during low generation and high load in the Bay of Plenty area.	Summer	-1.27 × OHK_WRK - 0.87 × ATI_WKM	450
		Winter	-1.3 × OHK_WRK - 0.88 × ATI_WKM	483.5
OHK_WRK_2	The effect of this constraint is to manage flows through OHK_WRK for an unplanned outage of WRK_PPI during low Upper North Island generation and when all lines are in service	Summer	-1.25 × OHK_WRK + 0.85 × WRK_PPI	439
		Winter	-1.24 × OHK_WRK + 0.85 × WRK_PPI	471

Exhibit GFS 6 – New Generation in or Adjacent to the Wairakei Ring

- Capacity shown below is the total installed capacity. The long term average output of wind farms, however, is likely to be in the range of 30% - 45% of installed capacity (it is common to say the 'load factor' will be between 30% and 45%.) For example, a wind farm with capacity of 100 MW might actually achieve annual average of 40 MW.
- Connection nodes are indicative in some cases.

Project	Capacity (MW)	Status	Grid Connection Node
Kawerau geothermal	90	Under construction and due for completion end of 2008	KAW (Kawerau, Bay of Plenty)
Rotokawa stage 2 geothermal (a.k.a. Nga Awa Parua)	132	Consented and due for completion by Mighty River Power in May 2010	WRK
Hawkes Bay wind	225	Consented but not yet committed	WHI (Whirinaki, East Coast)
Titiokura (Unison) wind farm	48	Consented but not yet committed	WHI
Geotherm geothermal	60	Consented but not yet committed – company in receivership	PPI
Tauhara stage 1 geothermal	20	Consented but not yet committed – Contact Energy	WRK
Te Waka wind farm (Unison stage 2)	111	Not consented – called in	WHI
Tauhara geothermal expansion (Contact Energy)	225	Resource only, neither consented nor committed – Contact Energy	WRK
Kawerau geothermal stage 2	100	Possible	KAW
Mokai geothermal expansion	55	Possible	WKM

Exhibit GFS 7 – Marginal impact of generation on OHK_WRK_2

Node	Location	WRK_PPI	OHK_WRK	OHK_WRK_2
TUI	East Coast	0.47	-0.30	0.77
WHI	East Coast	0.46	-0.29	0.75
WRK	East Wairakei Ring	0.45	-0.29	0.75
OKI	Direct connect to WRK	0.45	-0.29	0.75
ARA	Direct connect to WRK	0.45	-0.29	0.74
RPO	Direct connect to WRK	0.32	-0.21	0.53
KPA	Taranaki	0.01	0.03	-0.03
SFD	Taranaki	0.01	0.04	-0.04
PPI	South Wairakei Ring	-0.50	-0.25	-0.11
TKU	South of WKM	-0.07	0.05	-0.12
OTA	Auckland	-0.07	0.06	-0.13
TWH	Hamilton	-0.06	0.08	-0.15
HLY	Huntly	-0.07	0.09	-0.17
GLN	Near Auckland	-0.08	0.09	-0.18
KPO	North of Wairakei Ring	-0.07	0.10	-0.18
TMU	North of Wairakei Ring	-0.06	0.11	-0.19
MDN	Whangarei	-0.08	0.10	-0.19
SWN	Auckland	-0.08	0.10	-0.19
WKM	North Wairakei Ring	-0.11	0.08	-0.19
WPA	North of WKM	-0.11	0.08	-0.19
MTI	North of WKM	-0.11	0.08	-0.19
ARI	Bay of Plenty	-0.01	0.16	-0.21
KIN	Bay of Plenty	0.03	0.22	-0.25
ATI	North Wairakei Ring	0.13	0.34	-0.31
ROT	Bay of Plenty	0.12	0.34	-0.32
TGA	Bay of Plenty	0.12	0.34	-0.32
MAT	Bay of Plenty	0.14	0.36	-0.33
KAW	Bay of Plenty	0.15	0.37	-0.33
OHK	North Wairakei Ring	0.19	0.41	-0.35

Adding generation (or reducing demand) at these nodes takes OHK_WRK_2 closer to its limiting value

Adding generation (or reducing demand) at these nodes takes OHK_WRK_2 away from its limiting value