

New Zealand's EnergyScape™





2000



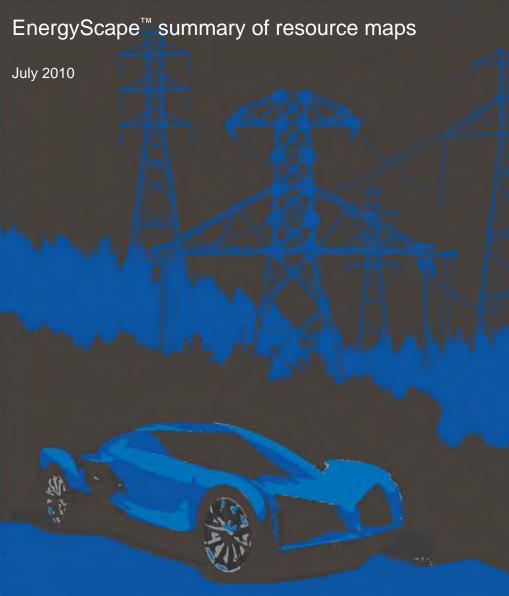


2030



















EnergyScapeTM summary of resource maps

Authors

Rilke de Vos, NIWA Stefan Fortuin, NIWA

Prepared for

Foundation for Research, Science & Technology (FRST)

Project:

NZES091- New Zealand's EnergyScape

Document number:

AKL-2009-045

Publisher:

NIWA, Auckland July 2010

Reviewed:

Georgina Griffiths Senior Climate Scientist Approved:

Ken Becker Regional Manager - Auckland



41 Market Place Auckland Central 1010 \$\mathbb{E}\$+64 9 375 2050 \$\exists +64 9 375 2051 www.niwa.co.nz



CRL Energy Ltd

68 Gracefield Road Lower Hutt \$\mathbb{C} +64 4 570 3700 \$\mathbb{M} +64 4 570 3701 www.crl.co.nz



1 Fairway Drive, Avalon, Lower Hutt ♣+64 4 570 1444 ♠ +64 4 570 4600 www.gns.cri.nz







PURPOSE OF THIS DOCUMENT

One of the objectives of the EnergyScape project was to collate data on New Zealand's energy resource potential into a consistent format that enabled comparision between fuel types. In order to provide this data in a visual and accessible format, we have collated the maps of key energy resources produced for the project. Typically each resource map has two forms:

- Resource potential
- Realisable potential

The <u>resource potential</u> maps identify the energy that could be harnessed if there were no technical or economic barriers to energy capture. The energy potentials are defined relative to the performance of 'typical' energy capture devices, for instance photovoltaic cells capture only 10% of insolation, and wind turbines have performance curves which only start to harness energy when wind speeds are greater than 5 m/s.

The <u>realisable resource potential</u> maps depict the energy that could be harnessed when some economic and technical barriers are applied. Some of the barriers depicted include: accessiblity, visual amenity and distance from transmission grid.

To enable readers to readily identify the literature supporting these maps, the figure numbers and titles in this document are the same as those in the EnergyScape Basis Review (NIWA report AKL-2009-034).

All maps have been developed to illustrate the variation in energy resource potential at a national scale, hence printing at A4 page scale is considered sufficient. It should be noted that many of these maps have been rendered based on limited data, hence it is not appropriate to extract regional scale or sub-regional data from these maps.

DISCLAIMER

The data contained in the maps developed as part of the EnergyScape project were created using a wide range of models and assumptions, and should not be used without understanding the basis of the data and data limitations. An explanation of all map development methodologies and assumptions is contained in the relevant sections of the EnergyScape Basis Review document (NIWA report AKL-2009-034).

Every map comes with a disclaimer, which is reproduced below:

Data has been sourced from a number of Data Providers including, but not limited to: NIWA, Eagle Technologies Ltd, and Land Information New Zealand (LINZ). The maps are protected under Copyright ©. All rights Reserved.

The Data providers have prepared these data excercising all reasonable skill and care. Nevertheless, the Data Providers can give no warranty that the data supplied are free of errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or inaccuracies of the data, or from all liability, whether direct, indirect or consequential, arising out of the provision of the data.

Data from widely spaced sites were used in research-based spatial models to estimate surfaces intended for use at 1:250,000. Data mapped at this scale will not show variation that occurs at larger scales.

The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business.

LIST OF ILLUSTRATIONS

Figure 2.1.4 – Mean, annual, global, solar insolation (irradiance) on a horizontal surface.	6
Figure 2.1.5 – Mean, annual, global insolation (irradiance) on surface tilted with respect to its degree of latitude angle	7
Figure 2.1.6 – Mean, annual, direct, insolation (irradiance) accumulated by a direct-solar-energy collector fitted with a solar-tracking device	8
Figure 2.1.9 – The realisable solar energy capture (tilted plate) under restricted urban and agricultural developments	9
Figure 2.2.5 – Potential wind power density (on-shore)	10
Figure 2.2.6 – Potential wind power density (off-shore)	11
Figure 2.2.7 – Realisable wind power density (on-shore)	12
Figure 2.2.8 – Realisable wind power density (off-shore)	13
Figure 2.3.2 – Potential hydropower generation	14
Figure 2.3.5 – Realisable hydropower generation	15
Figure 2.4.3 – Marine potential wave power (arrows indicate the direction of energy propagation).	16
Figure 2.4.9 – Marine (wave) exploitable energy for a point source device typically deployed in 50-100 m water depth.	17
Figure 2.5.3 – Average tidal speed for Cook Strait from the Tide2D model, as generated for the EnergyScape Project.	18
Figure 2.5.5 – Marine (tidal) potential energy resource	19
Figure 2.5.13 – Marine (tidal) realisable energy resource	20
Figure 3.1.6 – Potential purpose grown biomass production	21
Figure 4.1.8 – Log of New Zealand's geothermal resources	22
Figure 4.1.9 – Development classification of geothermal fields	23
Figure 4.1.10 – Realisable geothermal power generation	24
Figure 4.2.8 – Area of New Zealand's proven and potential oil resource.	25
Figure 4.2.9 – Oil generation potential	26
Figure 4.4.6 – Gas generation potential	27
Figure 4.5.3 – Potential methane hydrate resources	28
Figure 4.6.2 – New Zealand coal regions and coal fields – North Island	29
Figure 4.6.3 – New Zealand coal regions and coal fields – South Island	30
Figure 3.2.6 – Solar power density above Maori land holdings	31
Figure 3.2.7 - Wind power density above Maori land holdings	32

2. RENEWABLE RESOURCES

2.1 SOLAR RESOURCES

Figure 2.1.4 – Mean, annual, global, solar insolation (irradiance) on a horizontal surface.

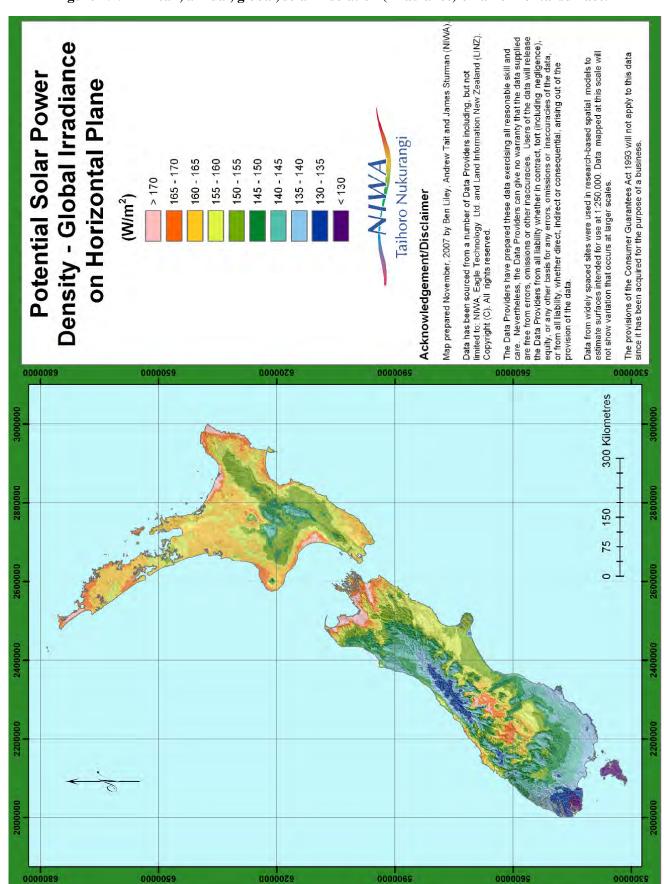


Figure 2.1.5 – Mean, annual, global insolation (irradiance) on surface tilted with respect to its degree of latitude angle.

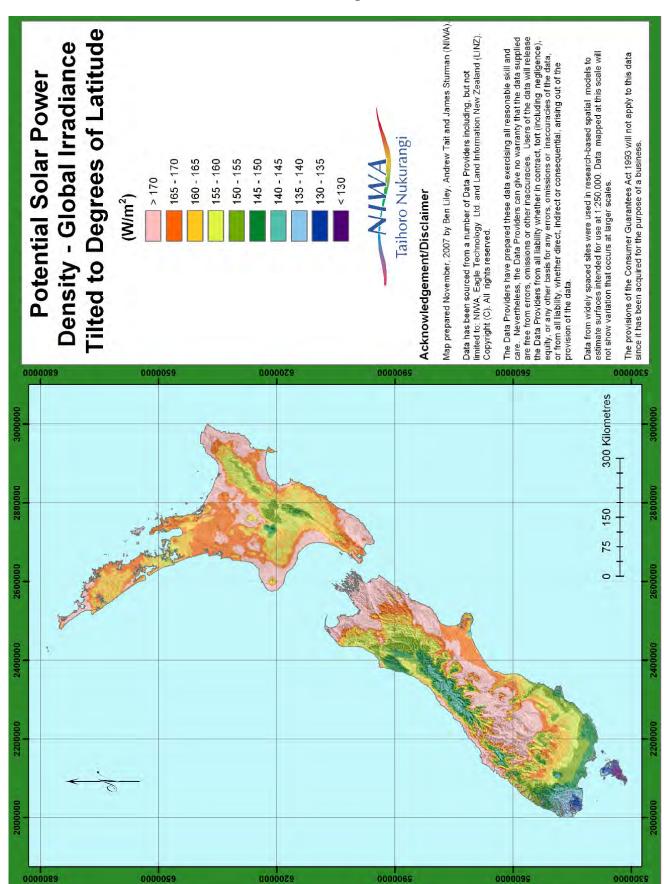


Figure 2.1.6 – Mean, annual, direct, insolation (irradiance) accumulated by a direct-solar-energy collector fitted with a solar-tracking device.

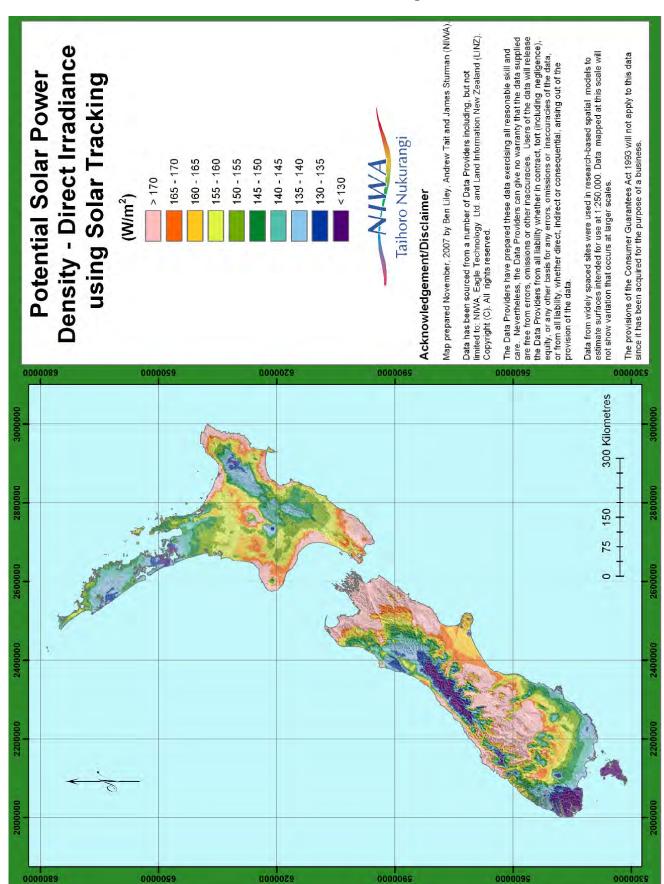
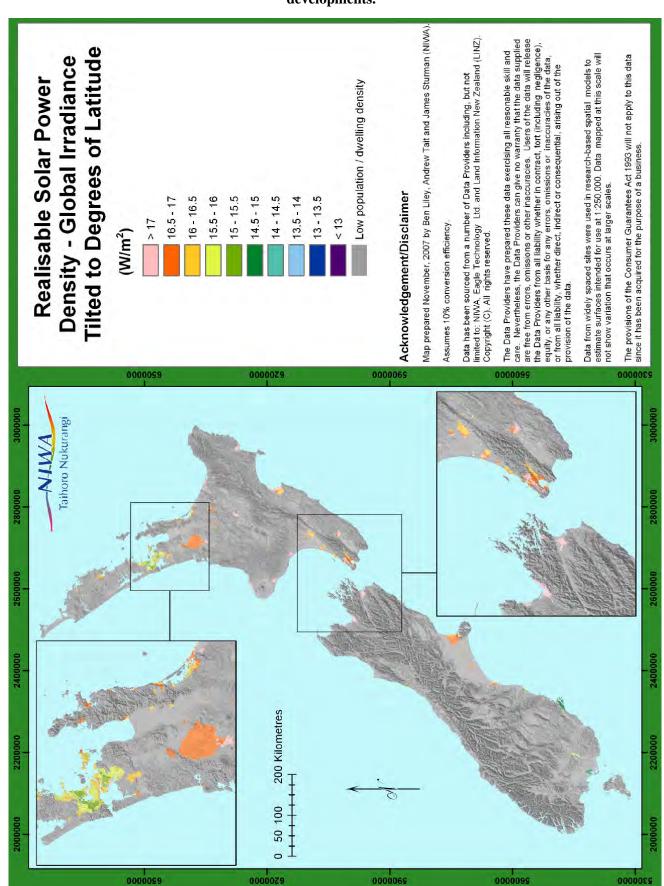
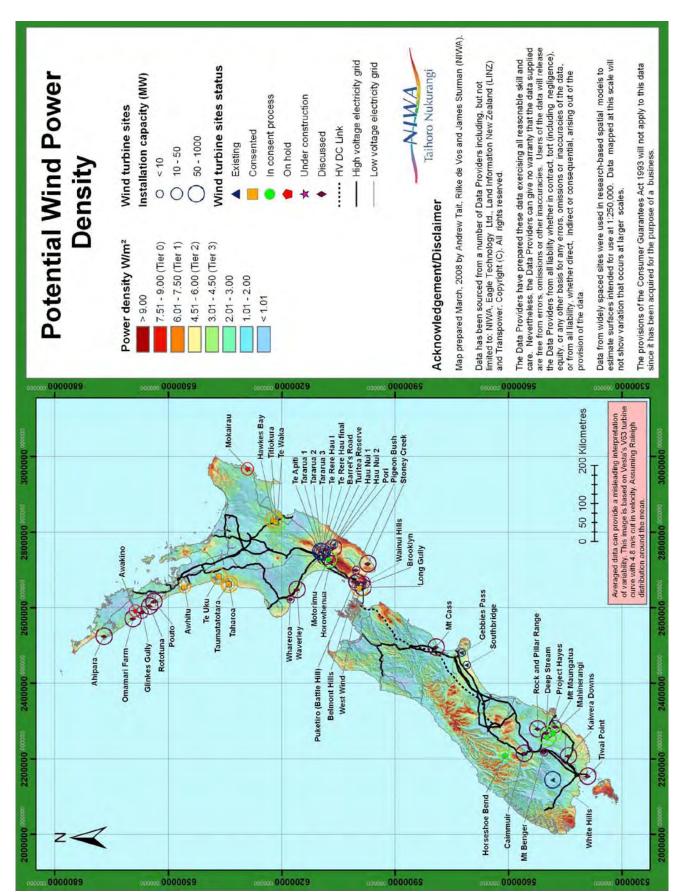


Figure 2.1.9 – The realisable solar energy capture (tilted plate) under restricted urban and agricultural developments.



2.2 WIND RESOURCES

Figure 2.2.5 – Potential wind power density (on-shore).



care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or inaccuracies of the data, Wind turbine sites status Installation capacity (MW) Data from widely spaced sites were used in research-based spatial models to estimate surfaces intended for use at 1:250,000. Data mapped at this scale will not show variation that occurs at larger scales. The Data Providers have prepared these data exercising all reasonable skill and Data has been sourced from a number of Data Providers including, but not limited to: NIWA, Eagle Technology Ltd., Land Information New Zealand (LINZ) The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. or from all liability, whether direct, indirect or consequential, arising out of the **Potential Wind Power** Under construction In consent process Wind turbine sites Map prepared May, 2008 by James Sturman and Peter Franz (NIWA) Consented Discussed 50 - 1000 Existing On hold 10 - 50 < 10 Taihoro Nukurangi Density status and Transpower. Copyright (C). All rights reserved. 0 Acknowledgement/Disclaimer High voltage electricity grid Low voltage electricity grid Power density W/m2 7.51 - 9.00 (Tier 0) 3.01 - 4.50 (Tier 3) 6.01 - 7.50 (Tier 1) 4.51 - 6.00 (Tier 2) 40m depth contour HV DC Link 2.01 - 3.00 1.01 - 2.00 provision of the data. < 1.01 2200000 0000029 000000 0000069 20000095 occao 0000059

Figure 2.2.6 – Potential wind power density (off-shore).

Map prepared March, 2008 by Andrew Tait, Rilke de Vos and James Sturman (NIWA) The Data Providers have prepared these data exercising all reasonable skill and care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or inaccuracies of the data. High voltage electricity grid Low voltage electricity grid Wind turbine sites status Data has been sourced from a number of Data Providers including, but not limited to: NIWA, Eagle Technology Ltd., Land Information New Zealand (LINZ) and Transpower. Copyright (C). All rights reserved. estimate surfaces intended for use at 1.250,000. Data mapped at this scale will Realisable Wind Power The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. Installation capacity (MW) Data from widely spaced sites were used in research-based spatial models to Taihoro Nukurangi or from all liability, whether direct, indirect or consequential, arising out of the In consent process Under construction Wind turbine sites HV DC Link Consented Discussed 50 - 1000 On hold 10 - 50 Existing × 10 Density 0 not show variation that occurs at larger scales. Acknowledgement/Disclaimer National park barrier Power density W/m² 7.51 - 9.00 (Tier 0) 4.51 - 6.00 (Tier 2) 3.01 - 4.50 (Tier 3) Urban areas barrier 6.01 - 7.50 (Tier 1) Maori land barrier Lake/river barrier Elevation barrier Slope barrier 2.01 - 3.00 1.01 - 2.00 > 9.00 < 1.01 000000 0000089 02000 0000059 6200000 cccoco 00000069 200 Kilometres Averaged data can provide a misleading interpretation of variability. This image is based on Vesta's V63 turbine curve with 4.8 m/s cut in velocity. Assuming Raleigh Mokairau Hawkes Bay Tararua 2
Tararua 3
Te Rere Hau I
Te Rere Hau final
Barrel's Road Titiokura Te Waka Pori Pigeon Bush Stoney Creek Hau Nui 1 Te Apiti 50 100 distribution around the mean Wainui Hills Brooklyn ong Gully Gebbies Pass Motorim Horowhenu Te Uku Mt Cass Taumatatotara Southbridge Taharoa Rock and Pillar Range Whareroa Rototuna Glinkes Gully Project Hayes Omamari Farm Deep Stream Puketiro (Battle Hill) **Belmont Hills** West Wind Horseshoe Bend White Hills Caimm Mt Benger 2300000 000000 0500000 2000000 00000069 200000 000000 0000089 6500000 mmcon

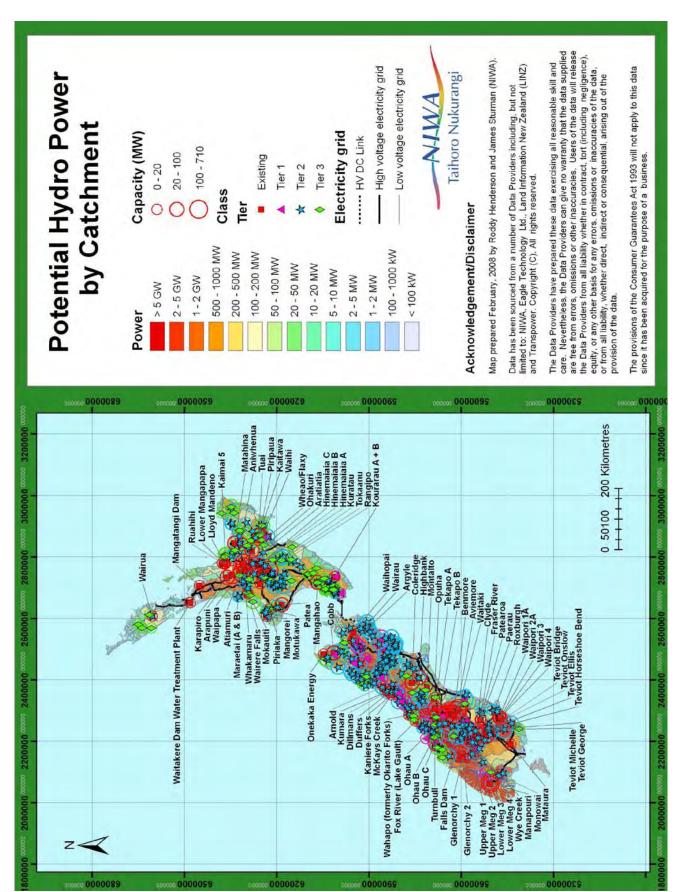
Figure 2.2.7 – Realisable wind power density (on-shore).

care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or inaccuracies of the data, Wind turbine sites status Installation capacity (MW) Data from widely spaced sites were used in research-based spatial models to estimate surfaces intended for use at 1.250,000. Data mapped at this scale will not show variation that occurs at larger scales. The Data Providers have prepared these data exercising all reasonable skill and Data has been sourced from a number of Data Providers including, but not limited to: NIWA, Eagle Technology Ltd., Land Information New Zealand (LINZ) The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. Realisable Wind Power or from all liability, whether direct, indirect or consequential, arising out of the In consent process Under construction Wind turbine sites Map prepared May, 2008 by James Sturman and Peter Franz (NIWA). Consented Discussed 50 - 1000 Existing On hold 10 - 50 < 10 Taihoro Nukurangi Density status and Transpower. Copyright (C). All rights reserved. 0 Acknowledgement/Disclaimer High voltage electricity grid Low voltage electricity grid Power density W/m2 7.51 - 9.00 (Tier 0) 6.01 - 7.50 (Tier 1) 4.51 - 6.00 (Tier 2) 3.01 - 4.50 (Tier 3) 40m depth contour ····· HV DC Link 2.01 - 3.00 1.01 - 2.00 provision of the data. < 1.01 Averaged data can provide a misleading interpretation of variability. This image is based on Vesta's V63 turbin curve with 4.8 m/s out in velocity. Assuming Raleigh distribution around the mean. 200 Kilometres Hawkes Bay Titiokura Te Waka Mokairau Te Apiti Taranua 1 Taranua 3 Taranua 3 Te Reve Hau I Te Reve Hau final Bartel's Road Hun Nui 1 Pori 50 100 Stoney Creek Wainui Hills Brooklyn Long Gully Pigeon Bush 2800000 wakino Pouto **Gebbies Pass** Rock and Pillar Range Mt Cass Southbridge 26000000 Te Uku Taumatatotara Awhitu Taharoa Rototuna Project Hayes Horowhenua Deep Stream Mt Maungatua Motorimu Omamari Farm Glinkes Gully Whareroa -- Waverley --Ahipara Mahinerangi Kaiwera Downs Puketiro (Battle Hill) Belmont Hills West Wind Tiwai Point 2200000 Horseshoe Bend Caimmuir Mt Benger White Hills 00000029 200000 0000069 20000095 0000005

Figure 2.2.8 – Realisable wind power density (off-shore).

2.3 HYDRO RESOURCES

Figure 2.3.2 – Potential hydropower generation.



High voltage electricity grid Low voltage electricity grid The Data Providers have prepared these data exercising all reasonable skill and care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or inaccuracies of the data, Realisable Hydro Power Data has been sourced from a number of Data Providers including, but not limited to: NIWA, Eagle Technology Ltd., Land Information New Zealand (LINZ) and Transpower, Copyright (C). All rights reserved. The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. Taihoro Nukurangi or from all liability, whether direct, indirect or consequential, arising out of the Map prepared June, 2008 by Roddy Henderson and James Sturman (NIWA) **Electricity grid** Capacity (MW) ····· HV DC Link 100 - 710 by Catchment Excluded 20 - 100 Existing Tier 3 Tier 1 Tier 2 Class Acknowledgement/Disclaimer DoC conservation areas 500 - 1000 MW 100 - 1000 kW 200 - 500 MW 100 - 200 MW 50 - 100 MW 20 - 50 MW 10 - 20 MW 5 - 10 MW < 100 kW 1-2 GW 1-2 MW 2-5 MW 2-5 GW > 5 GW provision of the data Power 6200000 000000 0000089 020000 000009 2800000 0000005 2000000 000000 2300000 000000 200 Kilometres I 50 100 0 0000029

Figure 2.3.5 – Realisable hydropower generation.

2.4 MARINE (WAVE) RESOURCES

Figure 2.4.3 – Marine potential wave power (arrows indicate the direction of energy propagation).

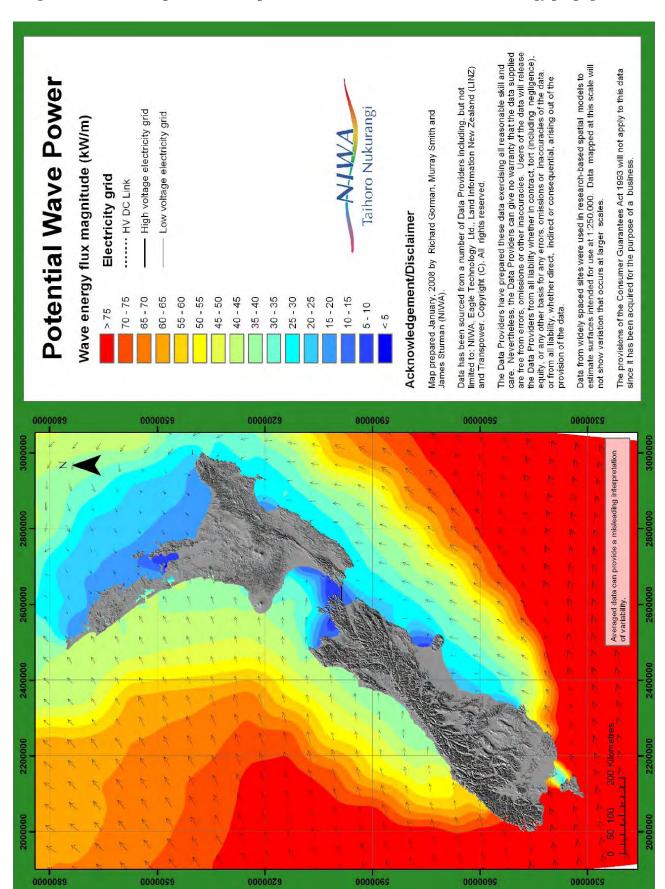
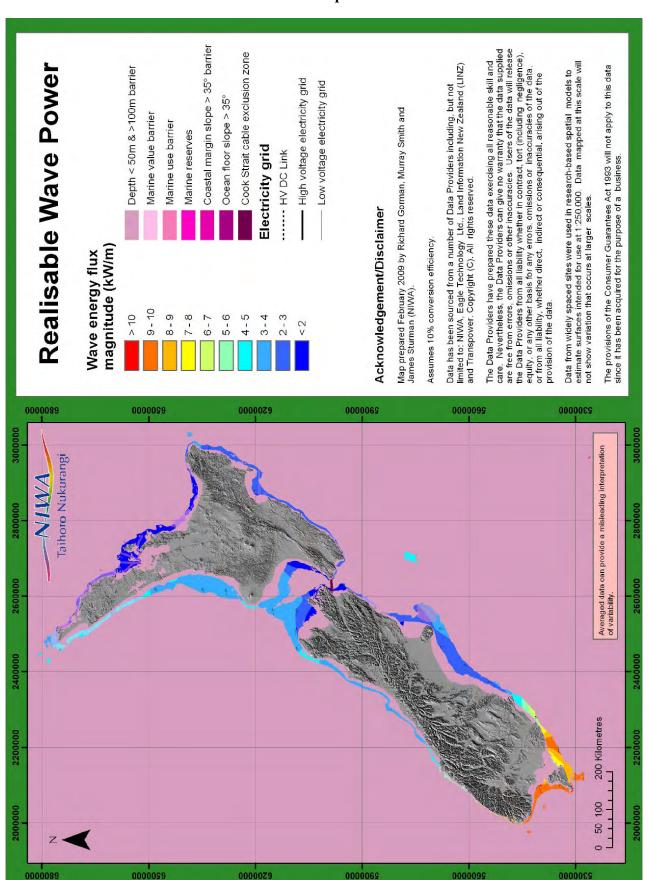
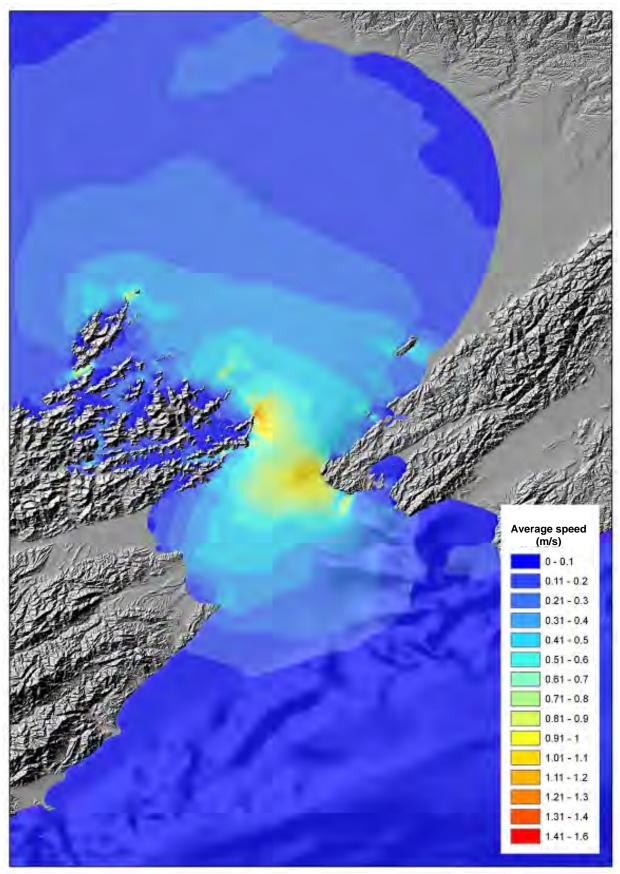


Figure 2.4.9 – Marine (wave) exploitable energy for a point source device typically deployed in 50-100 m water depth.



2.5 MARINE (TIDAL) RESOURCES

Figure 2.5.3 - Average tidal speed for Cook Strait from the Tide2D model, as generated for the EnergyScape Project.



High voltage electricity grid Low voltage electricity grid The Data Providers have prepared these data exercising all reasonable skill and care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or inaccuracies of the data, or from all liability, whether direct, indirect or consequential, arising out of the Data from widely spaced sites were used in research-based spatial models to estimate surfaces intended for use at 1,250,000. Data mapped at this scale will not show variation that occurs at larger scales. Data has been sourced from a number of Data Providers including, but not limited to: NIWA, Eagle Technology Ltd., Land Information New Zealand (LINZ) and Transpower. Copyright (C), All rights reserved. The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. Map prepared August, 2007 by Murray Smith, David Plew and James Sturman using a tidal model of Roy Walters (NIWA). **Potential Tidal Power** Taihoro Nukurangi Power density (kW/m²) HV DC Link Acknowledgement/Disclaimer 0.03 - 0.04 0.51 - 0.75 0.06 - 0.250.26 - 0.5 1.01 - 1.5 4.01 - 5 1.51 - 2 0-0.02 3.01 - 4 2.01 - 3 0.76 - 1 0.05 0000089 mass 0000059 9500000 cann ceccer 0000065 2300000 0000029 2800000 P200000 0000065 000000 D000D99

Figure 2.5.5 - Marine (tidal) potential energy resource.

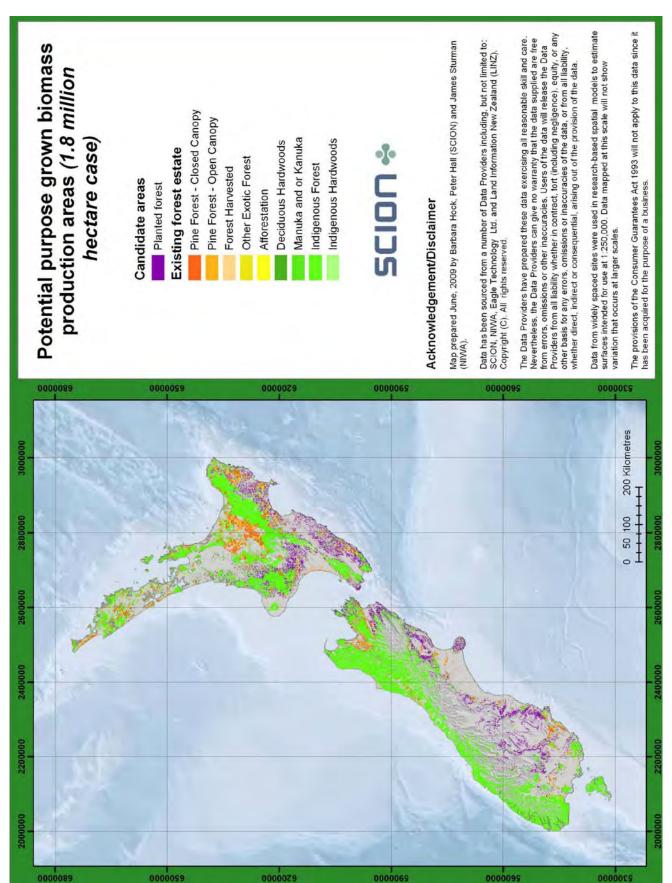
Coastal margin slope > 35° barrier The Data Providers have prepared these data exercising all reasonable skill and care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, onlissions or other inaccuracles. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or inaccuracles of the data or from all liability, whether direct, indirect or consequential, arising out of the Cook Strait cable exclusion zone Data from widely spaced sites were used in research-based spatial models to estimate surfaces intended for use at 1.250,000. Data mapped at this scale will not show variation that occurs at larger scales. Data has been sourced from a number of Data Providers including, but not limited to: NIWA, Eagle Technology Ltd., Land Information New Zealand (LINZ) and Transpower. Copyright (C). All rights reserved. The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. Realisable Tidal Power High voltage electricity grid Low voltage electricity grid Map prepared May, 2009 by Murray Smith, David Plew and James Sturman using a tidal model of Roy Walters (NIWA). Taihoro Nukurangi Depth < 100m barrier Marine value barrier Marine use barrier Marine reserves **Electricity grid** ····· HV DC Link Acknowledgement/Disclaimer Assumes 10% conversion efficiency Power density (W/m²) 400.1 - 500 300.1 - 400 200.1 - 300 150.1 - 200 100.1 - 150 provision of the data. 75.1 - 100 50.1 - 75 25.1 - 50 15.1 - 25 5.1 - 15 0000089 0000099 0000029 2000000 200000 2300000 2600000 2400000 Averaged data can provide a misleading interpretation of variability. 180 Kilometres 45 90 0000029 20000069 200000 00000089 0000099

Figure 2.5.13 - Marine (tidal) realisable energy resource.

3. BIOENERGY RESOURCES

3.1 BIOENERGY RESOURCES

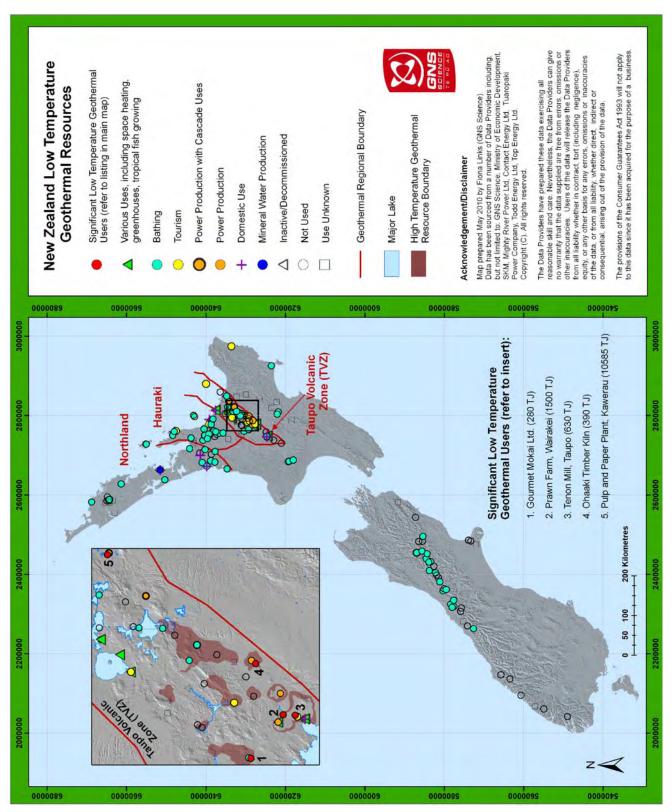
Figure 3.1.6 – Potential purpose grown biomass production.



4. EARTH RESOURCES

4.1 GEOTHERMAL RESOURCES

Figure 4.1.9 - Log of New Zealand's geothermal resources.



Wairakei - Tauhara (220) Classification for Geothermal Research Protected equity, or any other basis for any errors, omissions or inaccuracles of the data, or from all lability, whether direct, inclinect or consequential, axising out of the provision of the data.

The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. The Data Providers have prepared these data exercising all reasonable skill and care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or Ngatamariki (120) Map prepared in May 2010 by Fiona Links (GNS Science).
Data has been sourced from a number of Data Providers including that that third to: GNS Science, Ministry of Economic evelopment SKM, Mighty River Power Ltd, Contact Energy Ltd, Tuanopaki Power Company, Todd Energy Ltd, Top Energy Ltd Copyright (C). Horomatangi (0) High Temp Geothermal Resource Boundary Rotokawa (142) Tokaanu (200) Ketetahi (100) Rotoma (35) Ohaaki (115) Tongariro (0) Mokai (113) Field Development Geothermal Regional Boundary 4 15. 16. 17. 100 19 12 13 Generating capacity (MWe) Limited Development other inaccuracies. Users of the data from all liability whether in contract, to **Acknowledgement/Disclaimer** Tikitere-Taheke (240) Orakei-Korako (110) Major Lake/River Waimangu (280) Development Mangakino (47) Waiotapu (340) Reporoa (42) Te Kopia (96) Rotorua (35) Horohoro (5) Atiamuri (6) rights reserved 5 6 œ 6340000 6320000 0000829 6300000 6260000 6240000 Zone (TVZ) Taupo Vorthland 2760000 10 2740000 00000009

Figure 4.1.10 - Development classification of geothermal fields.

New Zealand Geothermal Fields: tial, arising out of the provision of the data.

ons of the Consumer Guarantees Act 1993 will not apply since it has been acquired for the purpose of a business **Producing and Undeveloped** Map prepared May 2010 by Frona Links (GNS Science).
Data has been sourced from a number of Data Providers inclut
but not limited to: GNS Science. Ministry of Economic Developt
SKM, Mights Never Power Ltd. Contact Energy Ltd. Tuaropak
Power Company, Tood Energy Ltd. Top Energy Ltd.
Copyright (C). All rights reserved. Undeveloped Geothermal Fields Generating Capacity (MWe) High Temperature Geothermal Resource Boundaries Geothermal Regional Boundary Producing Geothermal Fields Generating Capacity (MWe) Generating capacity for whole field Producing Geothermal Field Tauhara & Te Mihi (320)* Mokai I & II (140) * Rotokawa I (300) Kawerau (450) * Wairakei (510) Major Lake Ngawha (75) Ohaaki (130) Poihipi (55) 250 - 550 75 - 250 <75 0000099 0000009 6300000 Volcanic Taupo Zone (TVZ) Hauraki Northland 100 Kilometres 20

Figure 4.1.11 - Realisable geothermal power generation.

4.2 CONVENTIONAL OIL RESOURCES

Figure 4.2.10 - Existing petroleum infrastructure

The location of significant petroleum infrastructure (oil and gas users and oil / gas pipelines) in the context of discovered fields and frontier exploration basins.

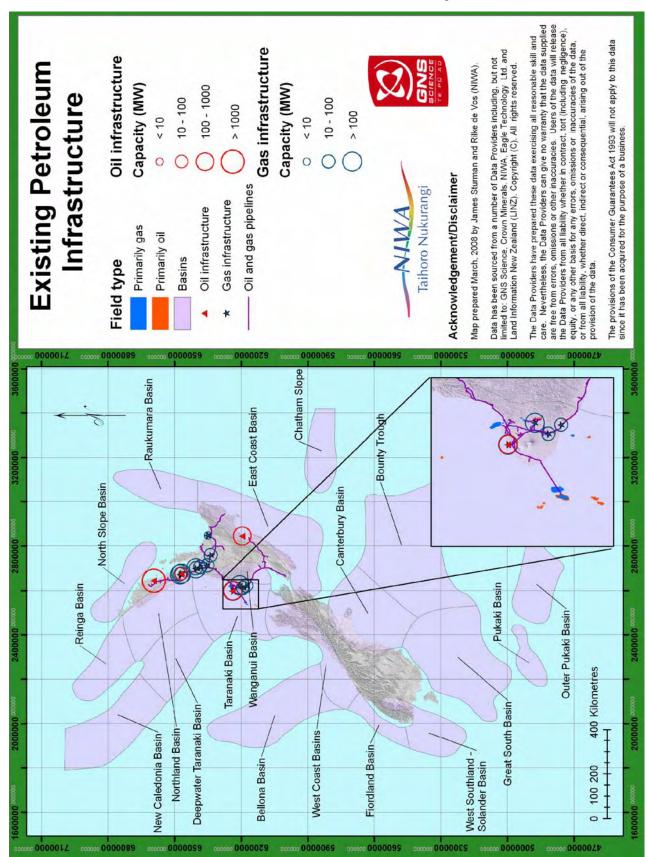
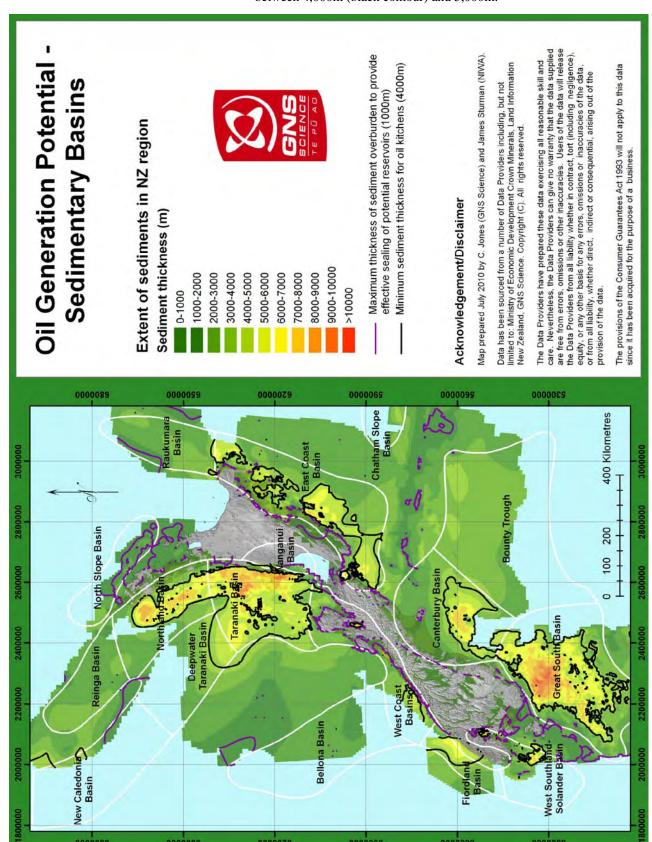


Figure 4.2.11 - Oil generation potential

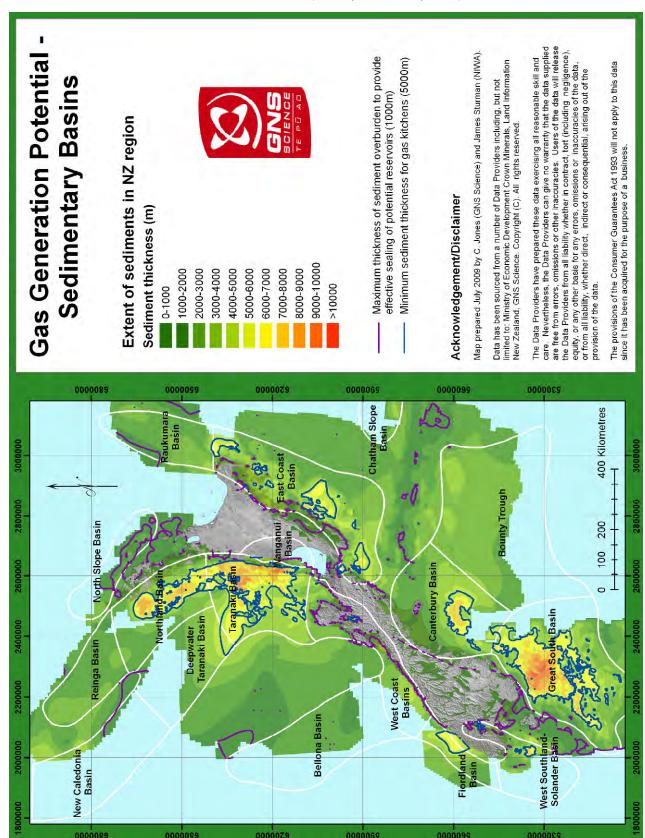
The regions for potential oil generation can be bounded by regions with sediment thickness between 4,000m (black contour) and 5,000m.



4.4 CONVENTIONAL GAS RESOURCES

Figure 4.4.15 - Gas generation potential

The regions for potential gas generation can be bounded by regions with sediment thickness between 5,000m (blue contour) and 6,000m.



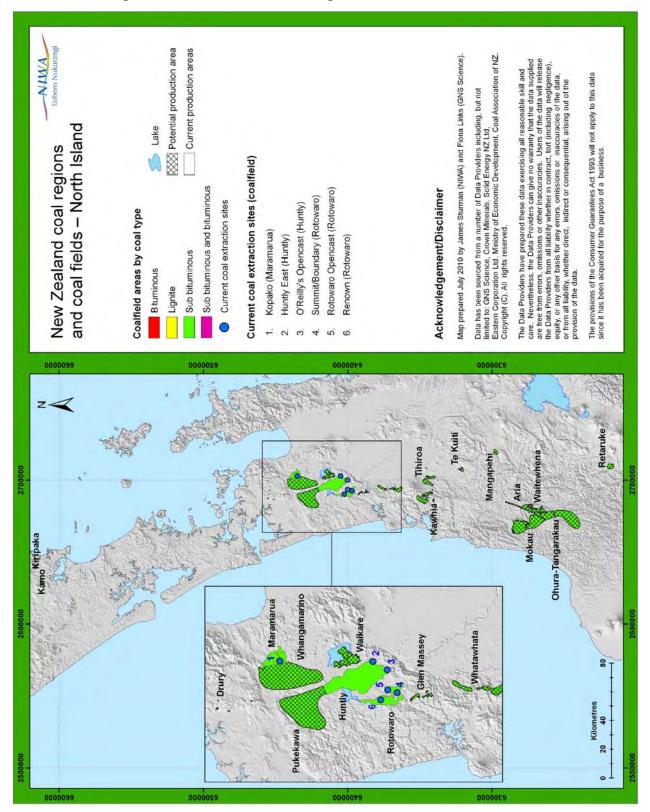
4.5 UNCONVENTIONAL GAS RESOURCES

The Data Providers have prepared these data exercising all reasonable skill and care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability, whether in contract, tort (including negligence), equity, or any other basis for any errors, omissions or naccuracies of the data, or from all liability, whether direct, indirect or consequential, arising out of the provision of the data. The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acqured for the purpose of a business. Data has been sourced from a number of Data Providers including, but not limited to: GNS Science, NIWA, Eagle Technology Ltd. and Land Information New Zealand (LINZ). Copyright (G). All rights reserved. 12 Nm territorial boundary (EEZ) Map prepared May, 2010 by Stewart Henrys (GNS), Crown Minerals and James Sturman (NIWA). **Unconventional Gas** Coal seam methane potential Gas hydrate potential (BSR) Methane seep locations 500m depth contour Potential Seismic lines Acknowledgement/Disclaimer Sweet spot Taihoro Nukurangi **Uruti Ridge** 0000089 0000099 0000029 0000069 200000 2300000

Figure 4.5.7 – Potential unconventional gas resources

4.6 COAL RESOURCES

Figure 4.6.5 – New Zealand coal regions and coal fields - North Island.



-NLWA Taihoro Nukurangi Potential production area Current production areas Malvern Hills (Canterbury Coal) Data has been sourced from a number of Data Providers including, but not limited to: GNS Science, Crown Minerals, Solid Energy NZ Ltd, Eastern Corporation Ltd, Ministry of Economic Development, Coal Association of NZ. Map prepared July 2010 by James Sturman (NIWA) and Fiona Links (GNS Science) Spring Creek (Greymouth) Waituna (Ashers-Waituna) The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. The Data Providers have prepared these data exercising all reasonable skill an care. Nevertheless, the Data Providers can give no warranty that the data suptare free from errors, omissions or other inaccuracies. Users of the data will rely the Data Providers from all liability whether in contract, tort (including negligen Strongman (Greymouth) No. 14 Opencast (Ohai) equity, or any other basis for any errors, omissions or inaccuracies of the dat or from all liability, whether direct, indirect or consequential, arising out of the Castle Hill (Kaitangata) Waimumu (Waimumu) Goodwin (Waimumu) Harliwich (Roxburgh) Nightcaps (Ohai) Wairaki (Ohai) and coal fields – South Island S Lake New Zealand coal regions Current coal extraction sites (coalfield) 13 15 16. 18 19 4 17. 20. 27. Sub bituminous and bituminous Acknowledgement/Disclaimer Current coal extraction sites Coalfield areas by coal type Berlins Creek (Inangahua) Giles Creek (Inangahua) Burkes Creek (Reefton) Island Block (Reefton) Copyright (C). All rights reserved Roa II (Greymouth) New Creek (Buller) Roa I (Greymouth) Terrace (Reefton) Cascade (Buller) Stockton (Buller) Sub bituminous Echo (Reefton) Bituminous Lignite 0000000 0000019 0000009 0000069 0000089 0000049 2000009 0000099 000000 2300000 200 9 20

Figure 4.6.6 – New Zealand coal regions and coal fields - South Island

5. FRAMEWORK SYNOPSIS

Maori Land Holdings - Globa Irradiance Tilted to Degrees Solar Power Density Above care. Nevertheless, the Data Providers can give no warranty that the data supplied are free from errors, omissions or other inaccuracies. Users of the data will release the Data Providers from all liability whether in contract, tort (including negligence), Data has been sourced from a number of Data Providers including, but not ilmited to: NIWA, Eagle Technology Ltd. and Land information New Zealand (LINZ). The Data Providers have prepared these data exercising all reasonable skill and Map prepared July, 2009 by Ben Liley, Andrew Tait and James Sturman (NIWA). The provisions of the Consumer Guarantees Act 1993 will not apply to this data since it has been acquired for the purpose of a business. Data from widely spaced sites were used in research-based spatial models to estimate surfaces intended for use at 1.250,000. Data mapped at this scale will equity, or any other basis for any errors, omissions or inaccuracles of the data, or from all liability, whether direct, indirect or consequential, arising out of the of Latitude 140 - 145 130 - 135 160 - 165 155 - 160 > 170 not show variation that occurs at larger scales Acknowledgement/Disclaimer (W/m^2) Copyright (C). All rights reserved provision of the data. 160 Kilometres Taihoro Nukurangi 80 4

0000029

Figure 3.2.6 - Solar power density above Maori land holdings

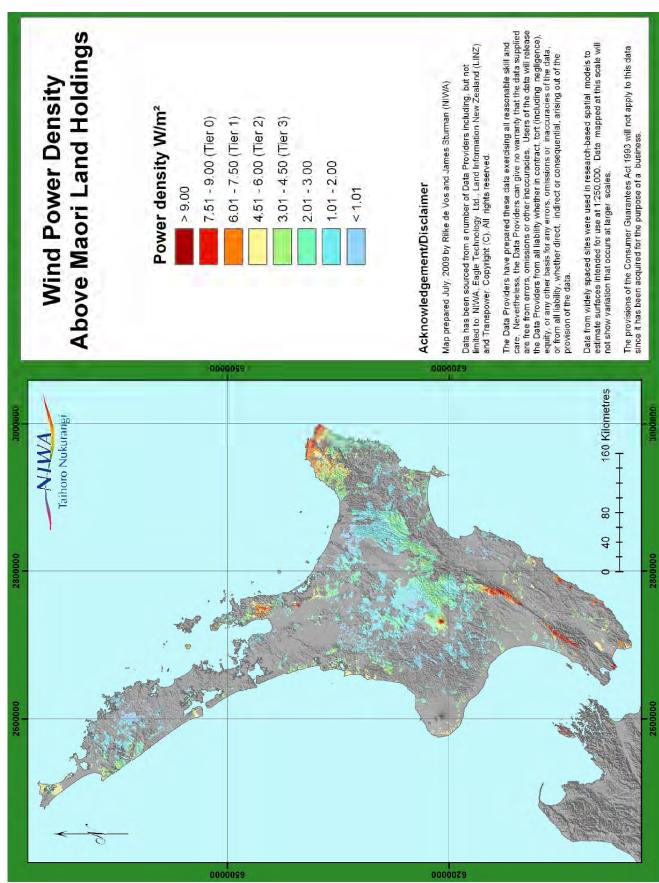


Figure 3.2.7 - Wind power density above Maori land holdings

6. REFERENCES

All maps in this document are provided in either the "EnergyScape Basis Review" document (NIWA report AKL-2009-034) or the "EnergyScape Framework Synopsis" document (NIWA report AKL-2009-046)