NEW ZEALAND GEOTHERMAL : …a personal journey from 132 dB to supercritical and back again…..

NZGW 2021, 13:00, 3rd February 2022

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"semi-retired"

(NB this is a reduced version of original presentation)

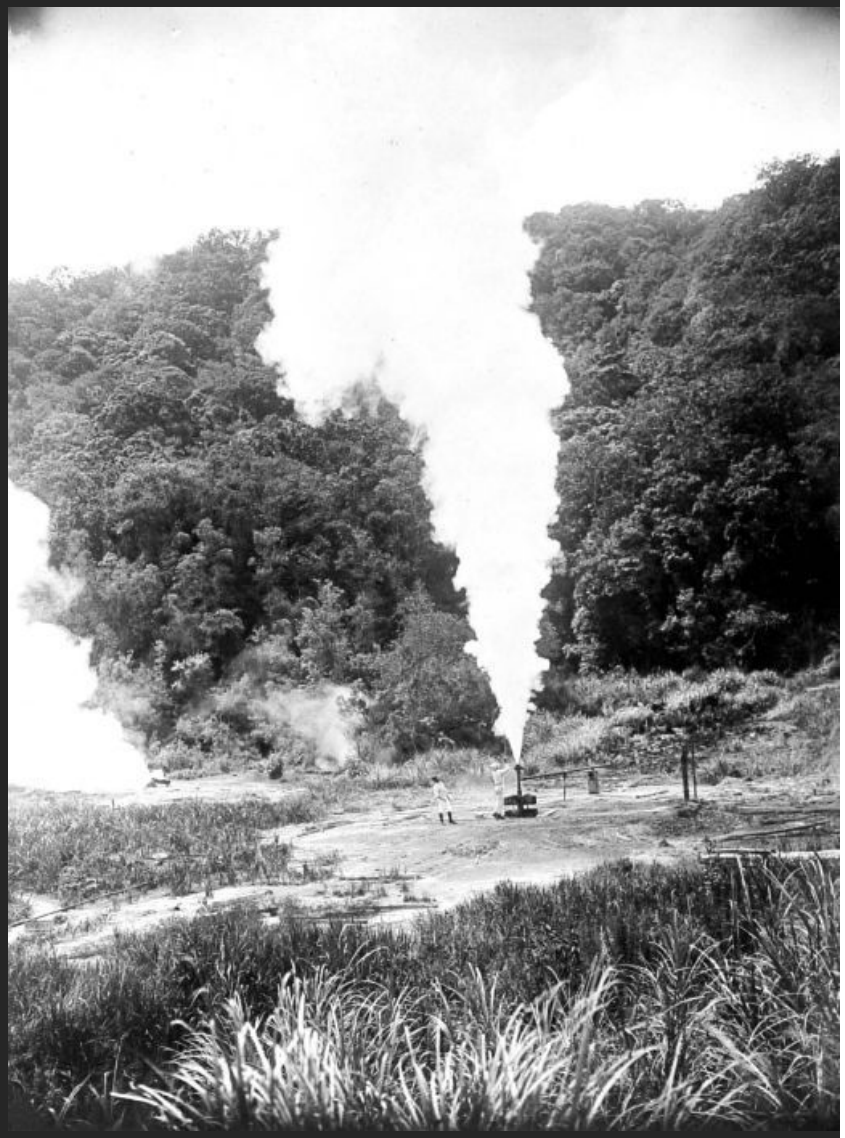
GNS SCIENCE TE PŪ AO

Sound level measurements at Kamojang 1979

With help from Neville Dench, Paul Jepson, and Hagen Hole
Presented at 2nd NZGW workshop in 1980

Up to 132 dBa at 8m
(from horizontal superheated steam discharge)

A sequence of sound level measurements was obtained at Kamojang between 1978 and 1980, to compare the performance of various pit silencers (or mufflers) connected to discharging wells. During the process of individual well output testing, the design of the rock-pit silencers was varied, and the effects measured, to test theories relating to the emission and propagation of sound from these silencers.



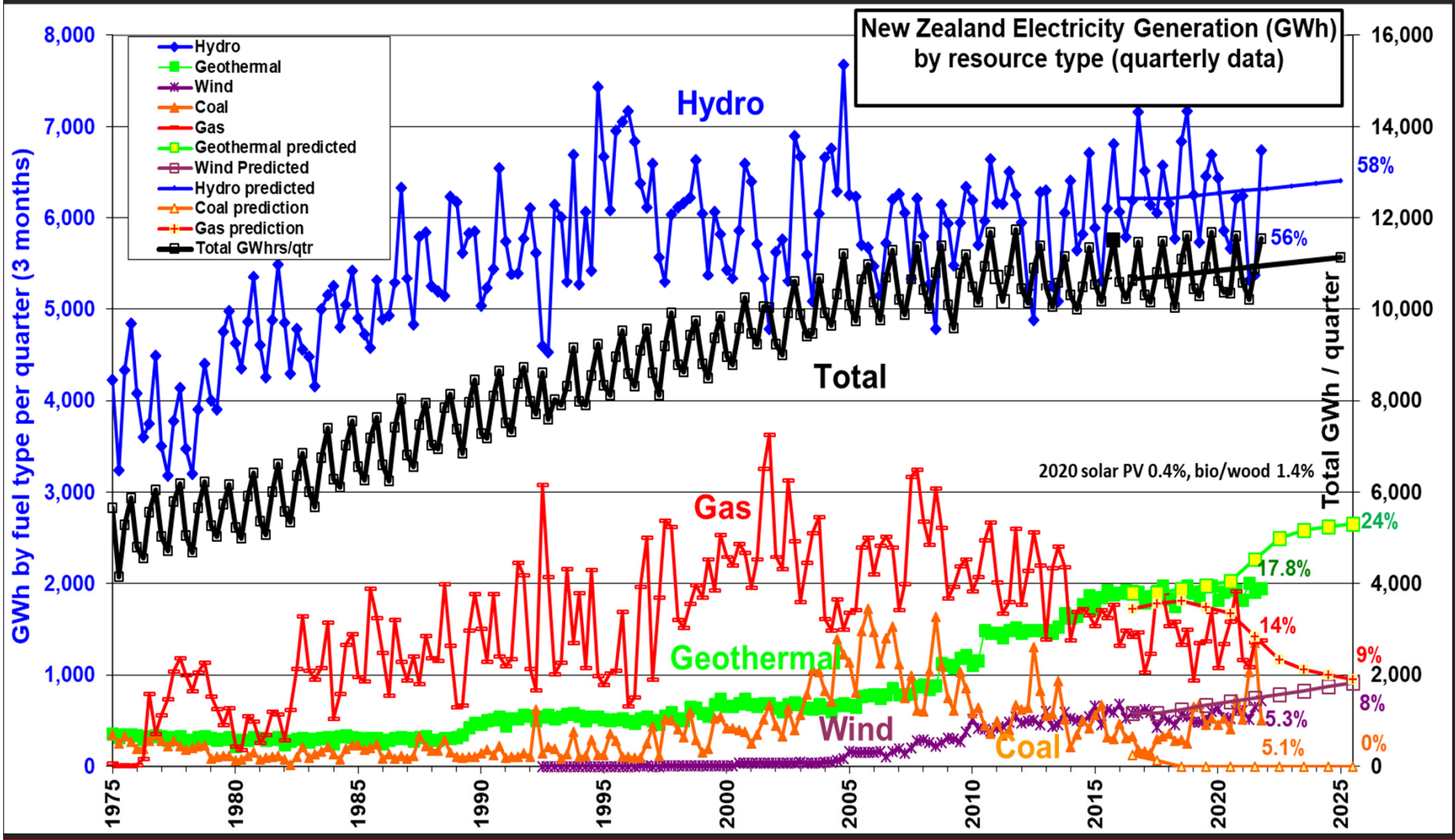
The successful first well at Kamojang was drilled in 1926..it is still discharging superheated steam…

Tongariro Geothermal field

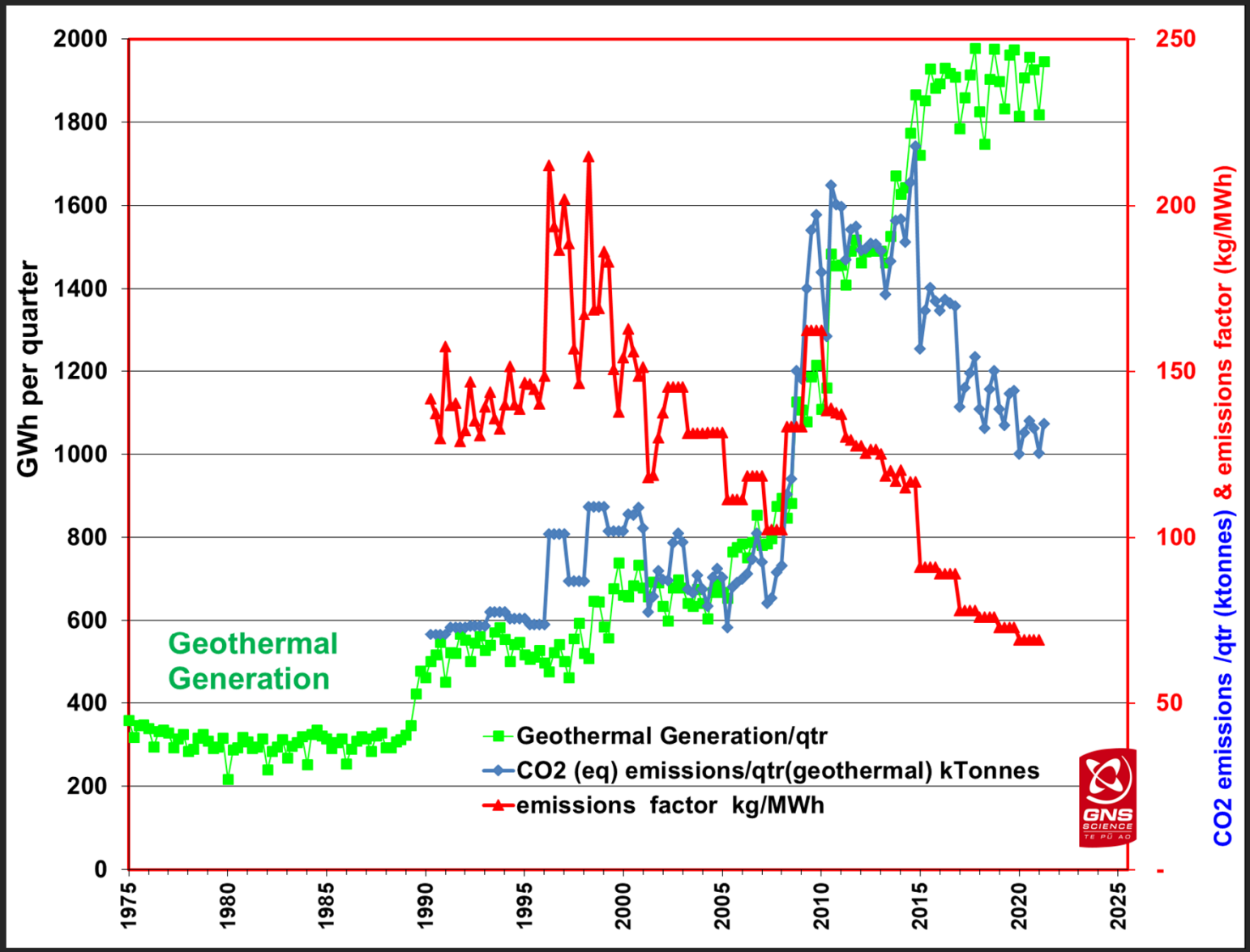
The early days of research with Manfred Hochstein in 1978
Resistivity, MT and heat loss from fumaroles

Lesson #1 for today…. for safety, take someone with you into thermal areas
Lesson #2 … active volcanoes can (occasionally) interact with overlying geothermal systems creating violent phreatic eruptions (eg 2012 Te Maari Crater eruption)

2014 and 2022 Historical and Projected Growth of NZ Power Generation

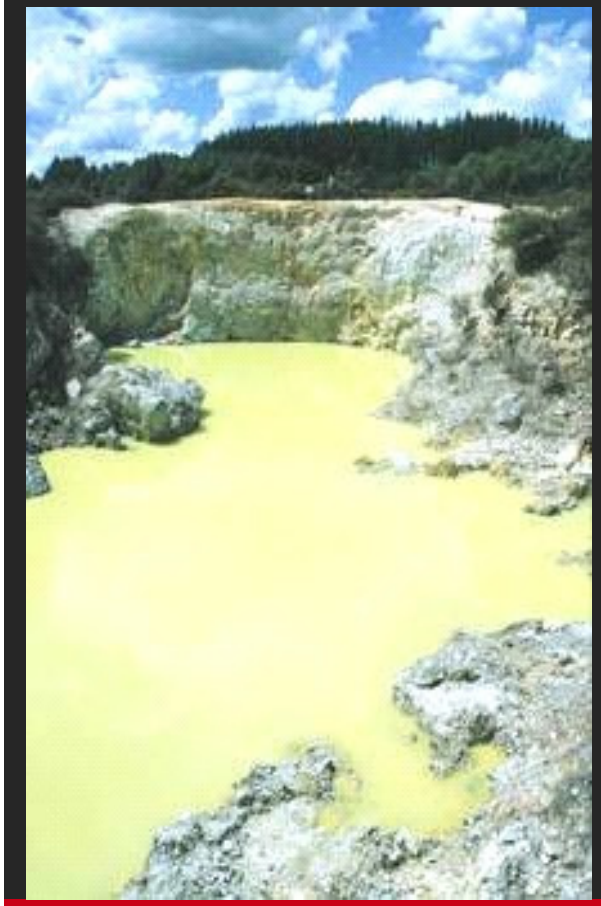


History of CO2 emissions and emissions factor versus generation per quarter



Environmental Issues Confronted

- Environmental effects uncertainty leads to precautionary approach
- 'Protection status' category locks up ~40% of NZ potential 4 GWe (1.6 GWe)
- But.. perceptions change with acquired knowledge and successful adaptive management practices, eg. injection to locally sustain pressures

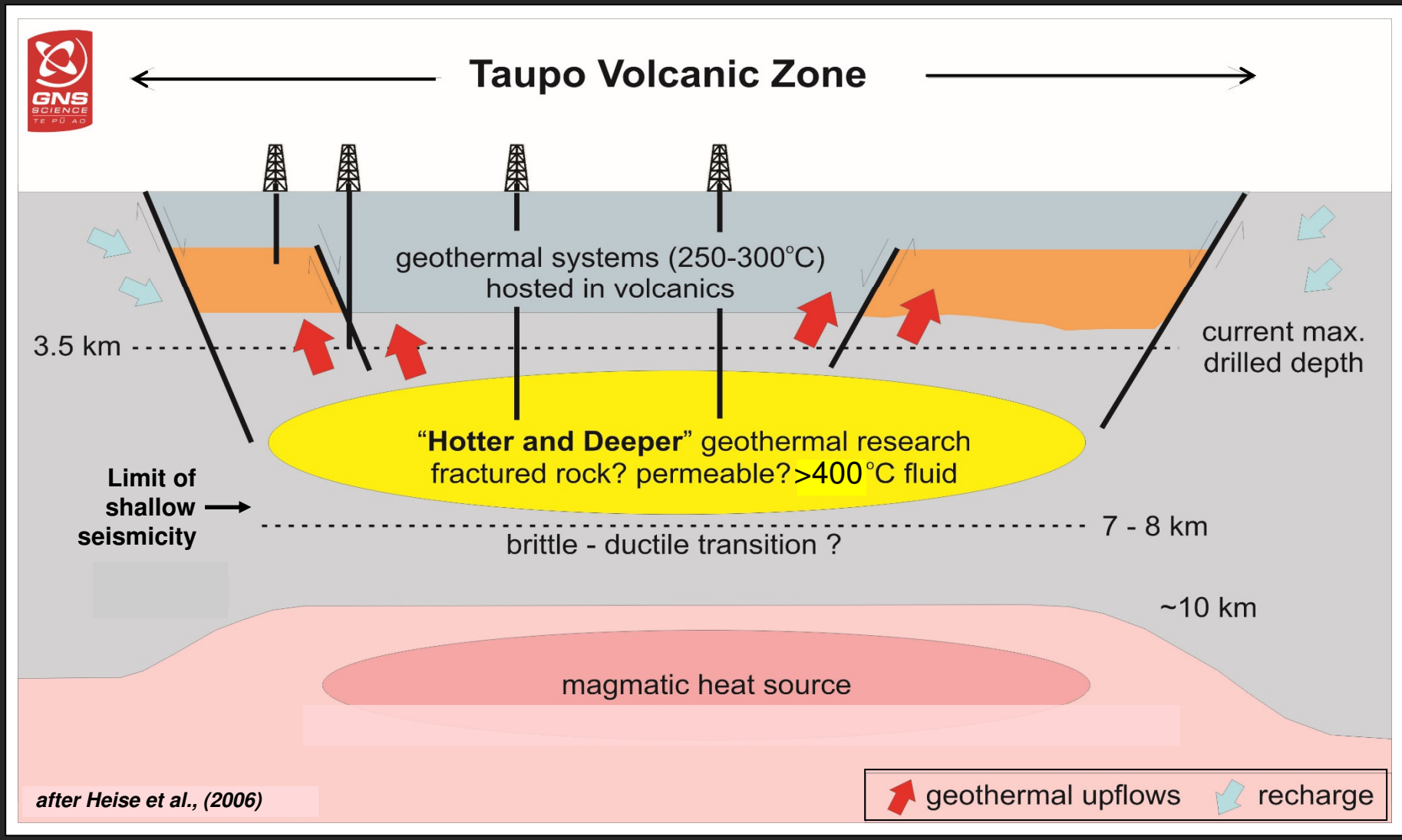


Optimum Management Strategy

- **Sustain** resources for the long term….maybe using cyclic (rotational) utilisation strategy
- **Manage** resources flexibly to allow recovery/remediation
- **Adapt** reinjection to control subsurface pressures
- **Stage** developments to reduce risk
- **Help balance** adverse & beneficial effects by enhancing thermal features and ecosystems

Wairakei borefield

Orakei Korako



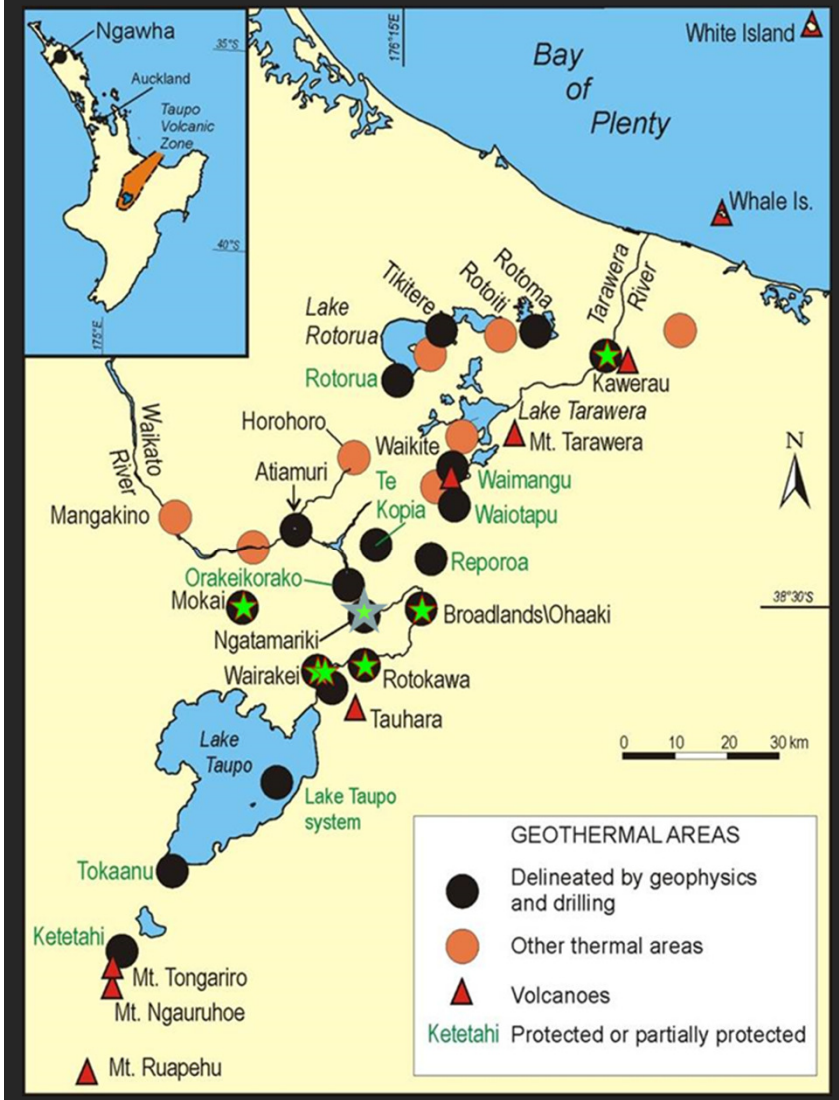
SUPERCRITICAL Realizing NZ's deep geothermal potential involves developing the ability to identify or create permeability, especially towards the brittle-ductile transition zone

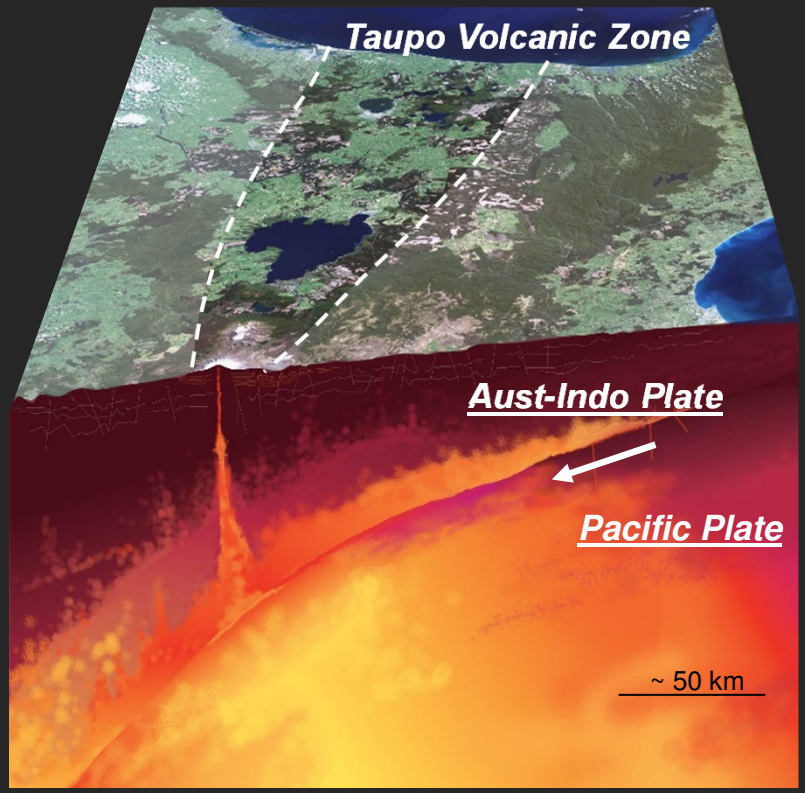
Supercritical (or ultra-hot) resources in NZ research https://www.geothermalnextgeneration.com/

- IEA Geothermal (TCP), has encouraged collaborative research into the deep, high-temperature roots of geothermal systems. Learnings from projects are helping guide future research.
- Remaining critical issues include: drilling problems at high temperature and pressure (cement, mud fluids, casing, and drill-string); material selection to deal with corrosion from gassy super-critical fluid; well-bore stability under super-critical operating conditions; and finding, or creating, and sustaining permeability in brittle-ductile transition conditions.
- Related to these issues, there are a number of environment aspects of potential strategies for utilizing supercritical resources.
- In New Zealand, the environmental risks, best practice procedures, and mitigation options need to form part of the considerations of consenting authorities. Early awareness of the significant differences between conventional and supercritical development strategies will assist the policy-makers and regulators to make informed and timely decisions.

https://iea-gia.org/ultra-hot-supercritical-geothermal-symposium-series/

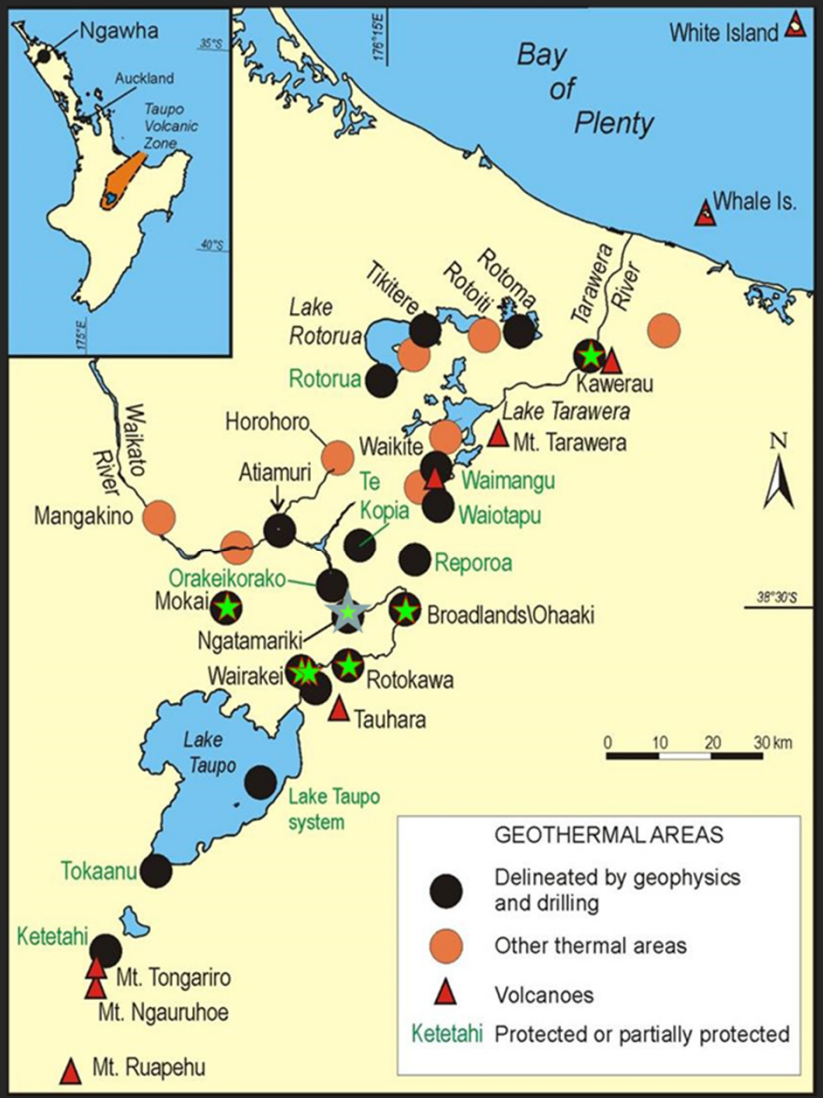
Where would you site a 4-6 km deep well to reach and test supercritical fluids in New Zealand?





1.0 GWe installed (2022)
+ 0.5 GWe planned
+ 1 GWe available
~ + 1.6 GWe protected
Total ~ 4 GWe (1-3 km depth)
+ ~ 10 GWe ? (3-6 km depth)

Given your preferred site, what special environmental considerations do you think are important to address?



Drilling risk : blowouts, gases, etc

Production risk : emissions, noise, well control ?
Pipeline corrosion and leaks?
Induced seismicity ?
Triggered hydrothermal eruptions ?
Impacts on surface features ?
Resource sustainability ?
Local community issues ?
Cultural issues ?

But these are typically addressed in existing resource development consenting processes (RMA)……

To the Future:

- Extra GW of geothermal resource potential (>2025) ?

1) buffer for demand growth;
2) backup (rotational heat grazing, allowing for recharge);
3) energy intensive industries;
4) electric vehicles

- New research directions: ultra-hot and deeper (4-6 km) & better use of lower enthalpy water, emissions reinjection

- NZ geothermal industry growth depends on growing a bigger market (so let's market ourselves better….)

..and back again : Larderello in 1947 - Captain Tuck (NZ army) and the Italian connection with engineers at Larderello – also the site of recent international research collaboration on accessing supercritical resources

Conclusions …

Vision for New Zealand's Geothermal Future ?

- Roots (deep, super-critical T/P, fracture stimulation)
- Efficient use - Hybrids (power, heat and vehicles)
- Connections (cables, H2 transport ?)
- Economic bi-products (algae, minerals, gases)
- Model refinements (better predictions)

…some feel-good take-away messages:

Geothermal extraction can be sustainable & environmentally beneficial
Geothermal fluid reinjection can be safe and effective
Creating and sustaining permeability to allow heat extraction can be effective
Peer-reviewed and shared decisions are the best way to achieve sustainable adaptive field management