Geothermal
G&A
Advice Limited

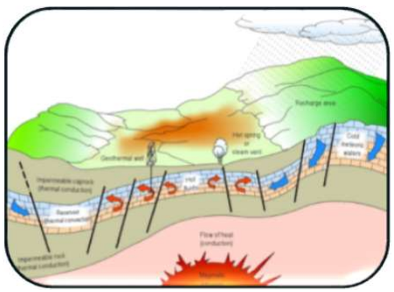
Te Kaunihera Māori o Aotearoa
New Zealand Māori Council

“WHY GOOD SCIENCE IS IMPORTANT”

and low enthalpy development options ….

DR. GREG BIGNALL - G&A GEOTHERMAL ADVICE LIMITED, NEW ZEALAND

GEOSCIENCE - OBJECTIVES



- **Clarify available geothermal energy**
  - resource characterisation (e.g., system structure, hydrology)
  - identify positive resource attributes, hazards and challenges
  - delineate extent and energy capacity of the system
- Support **strategic decision making**
  - propose work / surveys to prove the resource
  - recommendations for next-step drilling (exploration or development)
  - future investment, management decisions and ongoing operations
- Provide information for baseline environmental assessment
- **Clarify resource risk** – … and steps to mitigate challenges

WHAT DOES GEOSCIENCE REVEAL ?

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System Characterisation

- Representation of field geology and major fault structures
- Geophysically-defined, inferred reservoir chemistry, well data

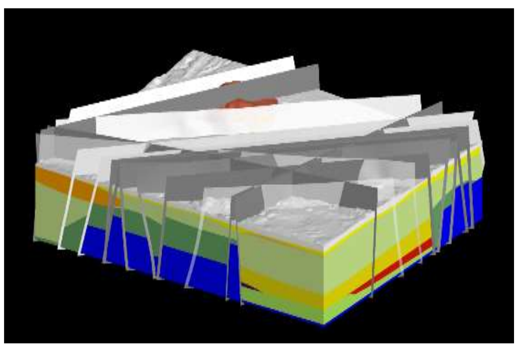
Conceptual Model asks …

- What is going on in the reservoir ?
- Where / how big is heat source ?
- What controls permeability ?
- Where do outflows occur ?

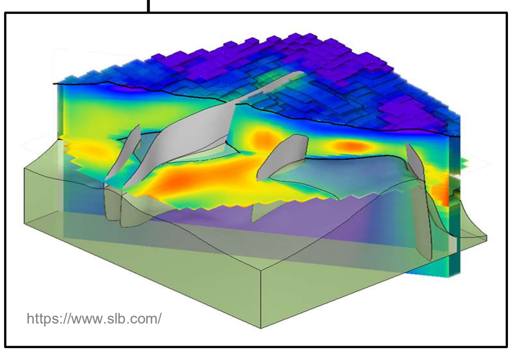
Reservoir Simulation …

Incorporates conceptual model to assess resource capacity

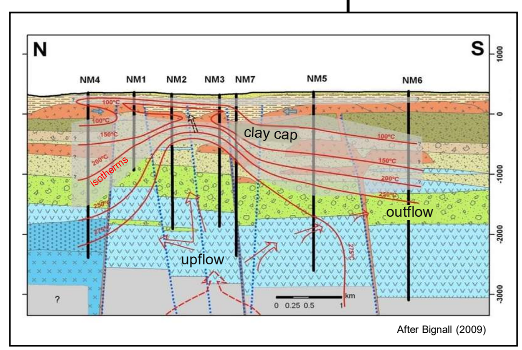
Predict reservoir response to production / injection scenarios



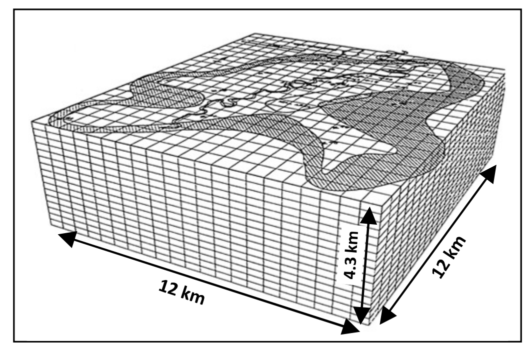
3D geological framework model - an effective well targeting tool



3D resistivity model with interpreted faults and structural model element

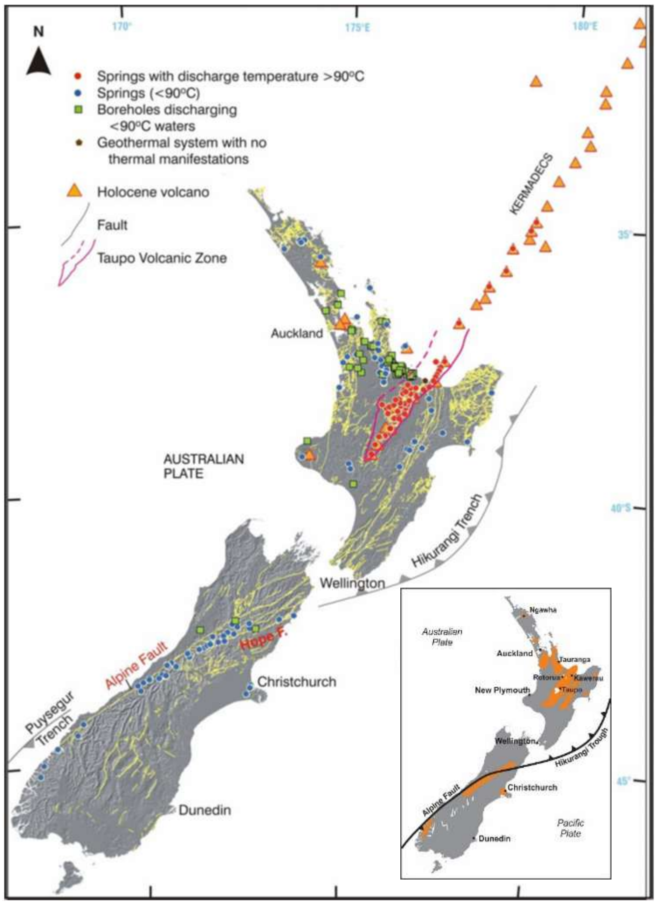


Conceptual model describes geothermal system dynamics



Numerical model used to inform resource capacity / sustainable use

WHAT HAS NEW ZEALAND DONE WELL ?



- We have **developed** geothermal fields for power and / or direct heat use, but also areas with **untapped potential** for electric power and / or other applications
- a **knowledgeable** geological, chemical and geophysical capability, well equipped to **support** iwi / industry aspirations and regulatory needs (e.g., for consenting, monitoring)
- **internationally recognised** capacity for academic tuition and research, but increasing need to invest in key skills : that need resourcing and continuity.
- existing **science** data needs to be collated and accessible, to support exploration, and avoid repetitive surveys …

CONSIDERING LOW ENTHALPY* SOURCES

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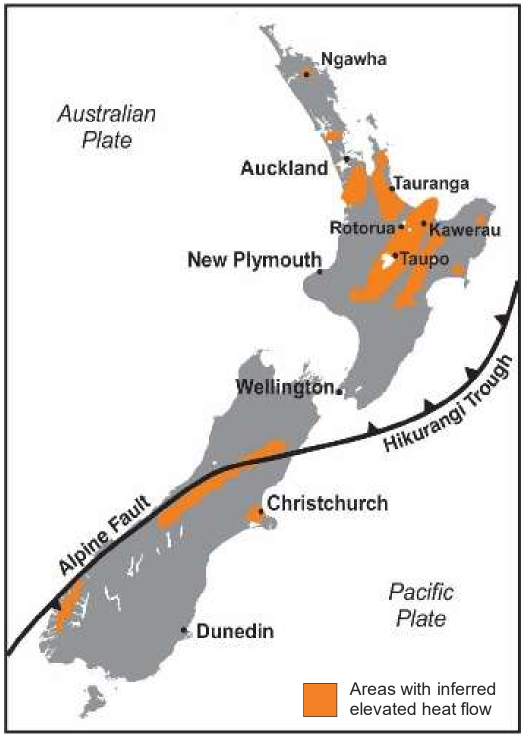
* Enthalpy is a measure of total heat content in a thermodynamic system / 'Low enthalpy' being geothermal resources with subsurface conditions of < 90 - 150 °C

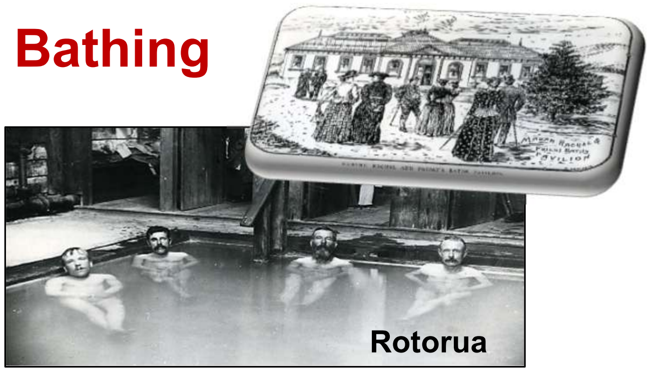
- Many sources not developed.
- Most pervasive is **natural thermal gradient** (i.e., areas with constant temperature throughout the year).
- Globally, direct heat use includes :
  - bathing
  - domestic heat pumps
  - space / greenhouse heating
  - aquaculture
  - industrial processing
  - agricultural drying
  - other (e.g., de-icing, textile drying, desalination, biomedical …)



- Geothermal fluids may contain components, e.g., silica, lithium and gases, with potential extraction for commercial use.
- Applications requiring heat may use low enthalpy sources instead, or supplement non-renewable coal, natural gas or fuel-oil.
- Cost saving can be achieved by adopting an **integrated (cascade) system**, with users connected in series (i.e., utilising fluid from a preceding plant or operation).

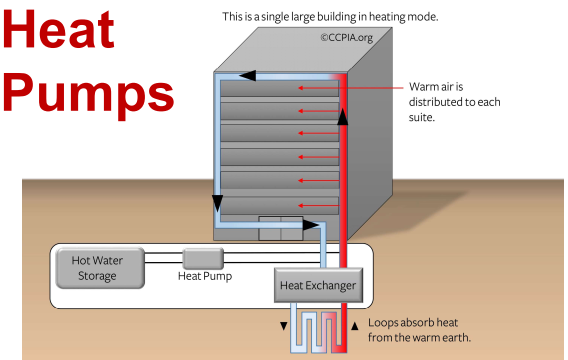
EXAMPLES IN NEW ZEALAND

Bathing



Spas, either town-supply heated by geothermal energy or sourced from thermal bores, utilised for healing & relaxation (i.e., geotourism).

Heat Pumps

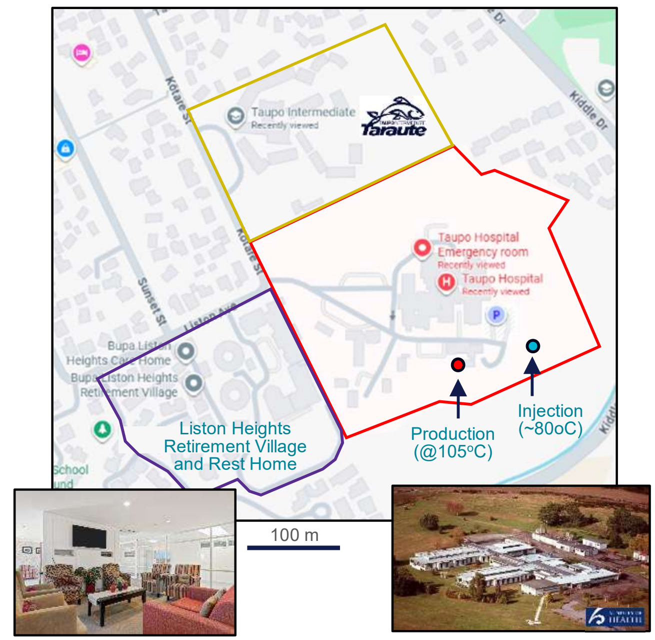


Heat pumps force heat from low-grade (natural) environments to high-grade energy.


Photo: Ingramswaterandair.com

Water Heating / Supply

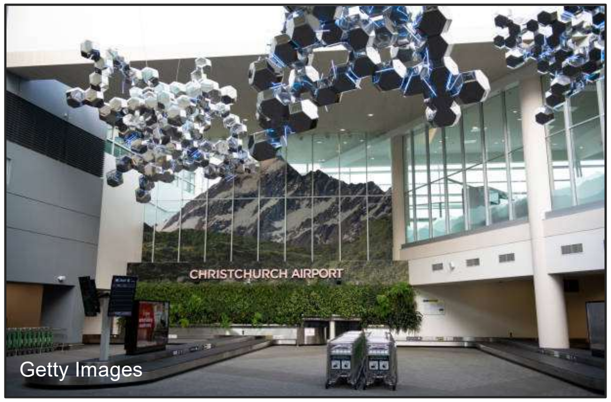
Integrated supply to Taupō Hospital, Taupō Intermediate and Liston Heights Retirement Village.



EXAMPLES IN NEW ZEALAND

Christchurch International Airport

Upgrade to Christchurch International Airport provided an opportunity to install a modern heating & cooling system utilising low temperature geothermal energy.



- 3.6 MW of water-cooled chillers and variable speed pumps used to heat and cool water for use throughout the airport.

Home Water Heating

On the edge of the Wairakei-Tauhara Geothermal Field, a local resident uses an earth-loop system, with heated town-supply water pumped through the family home.

EXAMPLES IN NEW ZEALAND

Agriculture

Use geothermal fluid to heat, irrigate or sterilize soil, & create a microclimate in a greenhouse.

Heating accomplished by forced circulation of warm air and / or hot water circulating in pipes or ducts.

Gourmet Mokai Limited, Mokai

Flower growing

Most gerbera glasshouses in New Zealand use waste oil for heating.

At Horohoro, shallow bores deliver fluid to a heat exchanger, with hot water circulation and overhead air heating keeping 14°C conditions.

Aquiculture

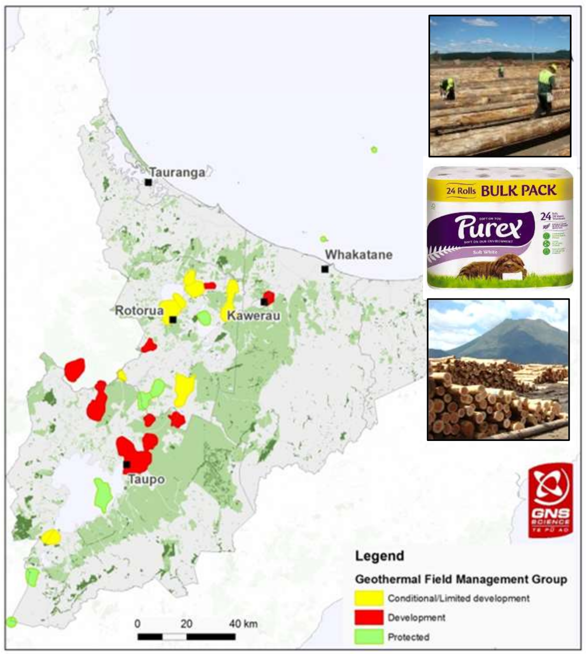
Focus of geothermal aquaculture is to heat water for aquatic animal (e.g., catfish, eels, shrimp, other shellfish) and aquacultural crops (incl. algae species, kelp and spirulina).

Huka Prawn Park, Wairakei

EXAMPLES IN NEW ZEALAND

Timber Processing

Co-location geothermal / forestry.



- Asaleo Tissue
- Sequel Lumber
- CHH Wood Products
- Natures Flame

Natural air-drying of timber is slow and expensive. Plantation Radiata Pine can have uneven product quality due to moisture content, low density / strength and proneness to fungal / insect attack

Geothermal steam can be used to process woody products.

Kiln Drying

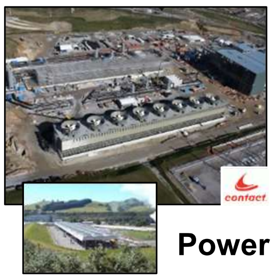
Kiln drying adds value to timber.

A timber-drying kiln is a large oven in which geothermally heated air can be used to draw moisture from the timber.

INTEGRATED / CASCADE USE

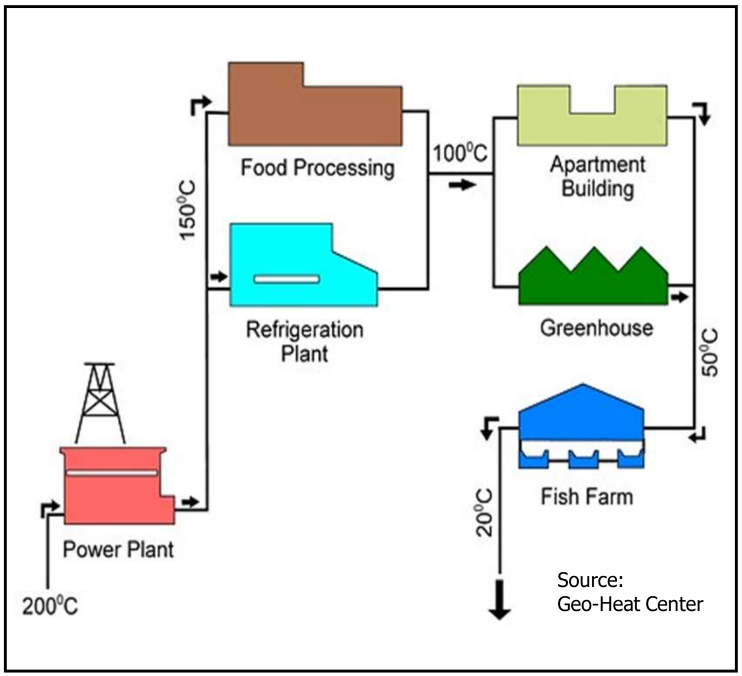
CASCADE USE

Wairakei



Power

Pine mouldings, building boards



Prawn Farm

Wairakei Terraces

Brewing

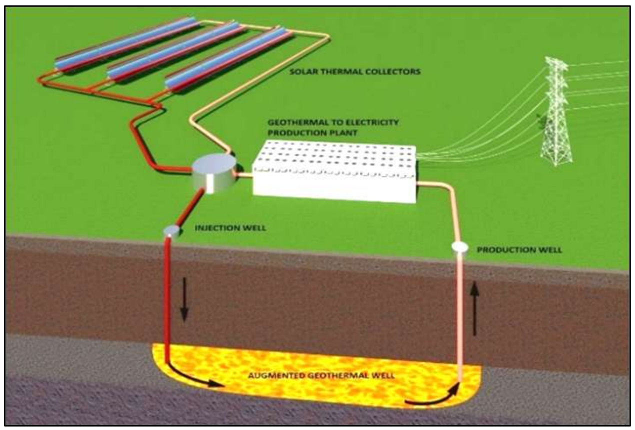
He Ahi Eco-Business Park

Joint development between Te Pae o Waimihia Trust & Contact Energy.

It offers access to a low-carbon, renewable energy source for heat-intensive industries – e.g., **TNUE** (Total Nutrient Use Efficiency), slow-release urea fertilizer factory)

INNOVATIVE TECHNOLOGIES

Geothermal + Solar



Innovative technologies to collect solar energy (in the form of heat), in order to create a 'synthetic' / engineered geo-system

Mineral extraction

Eliminate silica scale in pipes / heat exchangers, capturing high-grade colloidal silica (i.e., **Geo40**) for paper, coatings, manufacturing etc; and nanostructured calcium silicate (i.e., **CaSil Technology**), with applications for agricultural and horticulture industries.

Small Power Initiatives

Technologies for greenfield / low temperature power in community-driven initiatives, or with brownfield development partners.

Baseload Power Japan, 50 kWe units at Midori, Japan.
Midori #1: 307 l/min, 87 °C water, from ~45 - 50 m depth

UTILISE GEOSCIENCE INSIGHT

- Investment in geoscience has value beyond the initial exploration .... with clear goals, robust survey design and **best industry practice** at every stage of prospect evaluation, exploration & resource utilisation

- Application of geoscience is **ongoing** - look critically at resource data, meld findings from past / diverse studies, and insight from new surveys (including field monitoring / response to utilisation)

- Promote frank conversations with stakeholders and partners concerned with sustainable use of the resource and how **effects** are best managed – which is less clear if not driven by **good science**.

- Challenge the data, but do not “over-interpret” or cherry-pick data to advocate pre-determined wishes (e.g. overly optimistic resource capacity)

WHAT MORE COULD WE DO?

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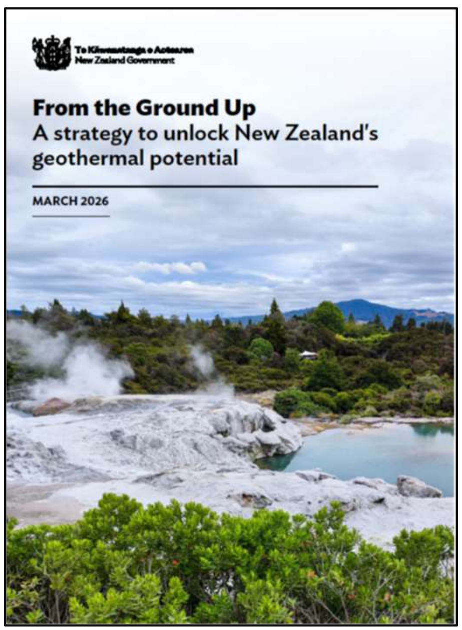
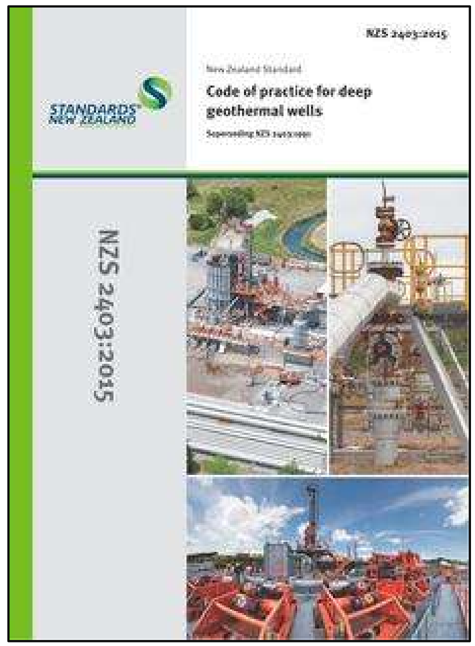
Access to Government and industry-acquired data, regulatory support & funding to **expediate** initiatives





Promote **best industry practice**, for conventional & innovative applications

- **Make it easier** to fund initiatives that enhance field characterisation, achieve exploration objectives and positive development outcomes
- Initiate collaborative surveys that **directly address** resource uncertainty in New Zealand
- Invest more in local capability and skills training, e.g., via **Centre of Excellence,** whilst integrating international expertise (and new technologies) where appropriate.

CONCLUSIONS

- **Every geothermal system is different**, and require **unique geoscience solutions** to resolve system dynamics, optimally target wells and de-risk exploration / development
- Geoscientists should provide **clear, unambiguous advice** – clarify uncertainties, whilst being conscious of financial limitations
- **Benefits of low-enthalpy use** : (a) High thermal efficiency; (b) Minimum start-up time; (c) Low carbon footprint / Reduction in imported fuel; (d) Low environmental footprint; (e) Sustainable resource utilisation / reliable energy supply; (f) Positive impact on regional development
- It is for New Zealand to continue working towards easy access and sharing of geoscience data, and support human capacity building in geothermal science and technical areas.

- I appreciate the invitation from NZ Māori Council to share my insights.

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