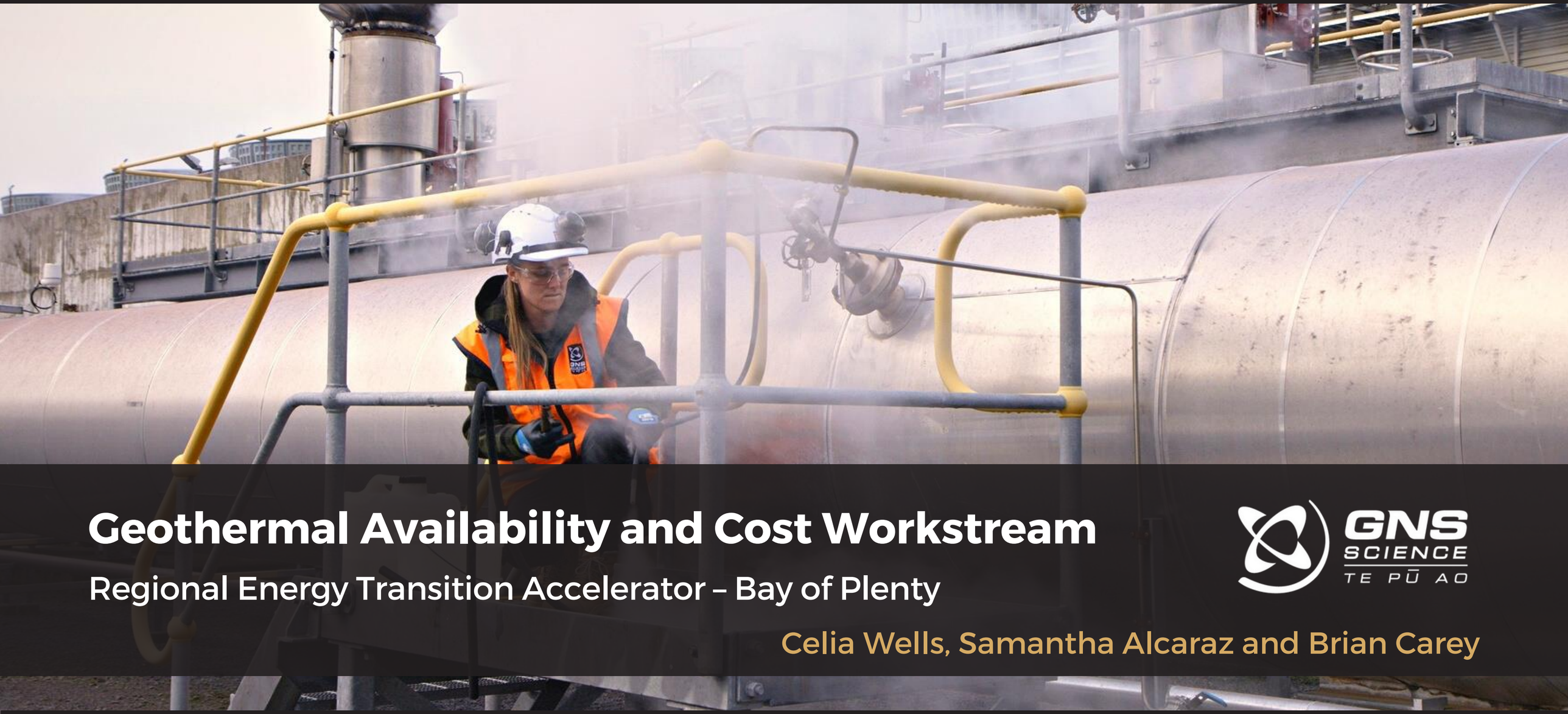


Geothermal Availability and Cost Workstream

Regional Energy Transition Accelerator – Bay of Plenty

Celia Wells, Samantha Alcaraz and Brian Carey

GNS SCIENCE TE PŪ AO

Background to work with EECA

GNS Science Team

- GNS research history and resources

Brian Carey

Celia Wells

Samantha Alcaraz

- Our Collaborators

Greg Moore
Dobbie Engineers

Yale Carden
GeoExchange Ltd

Geothermal Impact – significant carbon reductions

"That operational emissions reduction of between 80 and 100% (compared to natural gas providing heat for the same duty) are achieved using geothermal and ground source heat pump (GSHP) technologies."

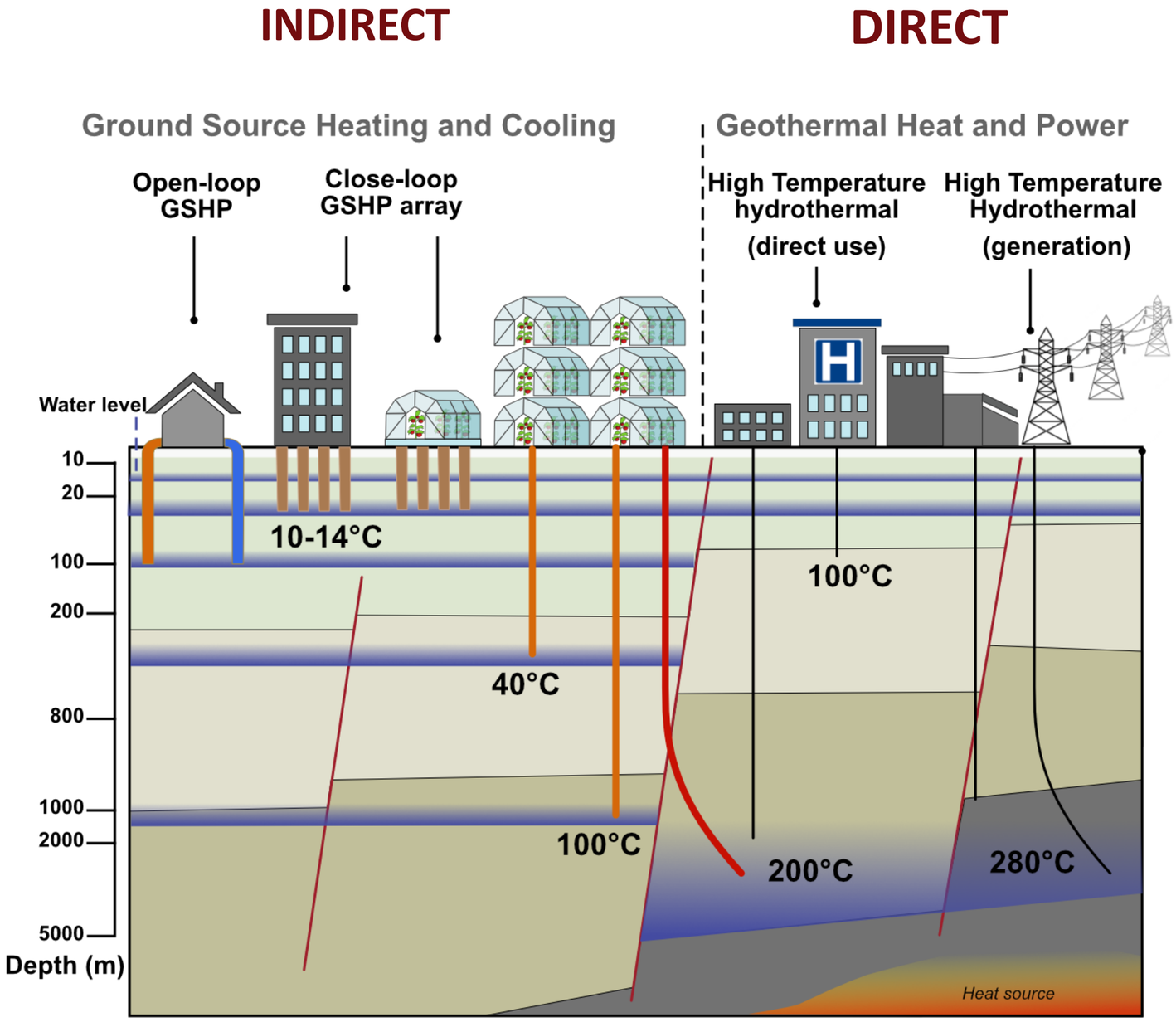
GNS Science report, 2023

Geothermal water used to supply energy (provided it is kept in the liquid state) is not included under the ETS as there are no emissions associated with its use.

CO2e emissions factors and reduction potential (as of 2023)

Fuel Type	tCO_2e/GJ	% Emissions reduction per GJ compared to natural gas
Coal (Sub-bituminous)	0.09043	
Natural Gas (National Average)	0.05573	
Any Geothermal Steam (default)	0.01079	81%
Kawerau - Steam	0.00727	87%
Kawerau – NTGA 2020 UEF	0.00381	93%
Mokai – two-phase	0.00056	99%
Mokai Greenhouse – two-phase	0	100%
Any geothermal Water	0	100%
Water for GSHP	0	100%

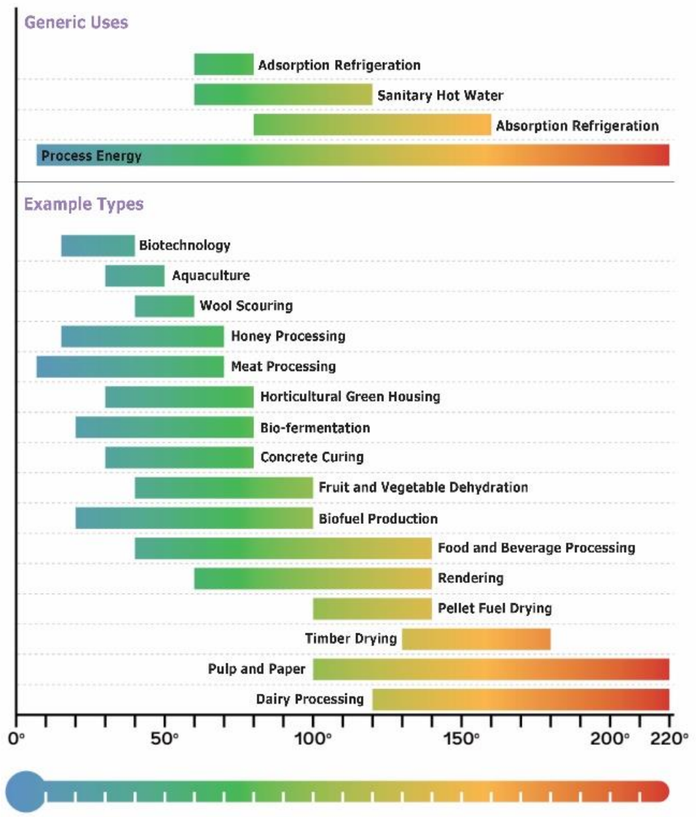
Many technologies to access subsurface heat



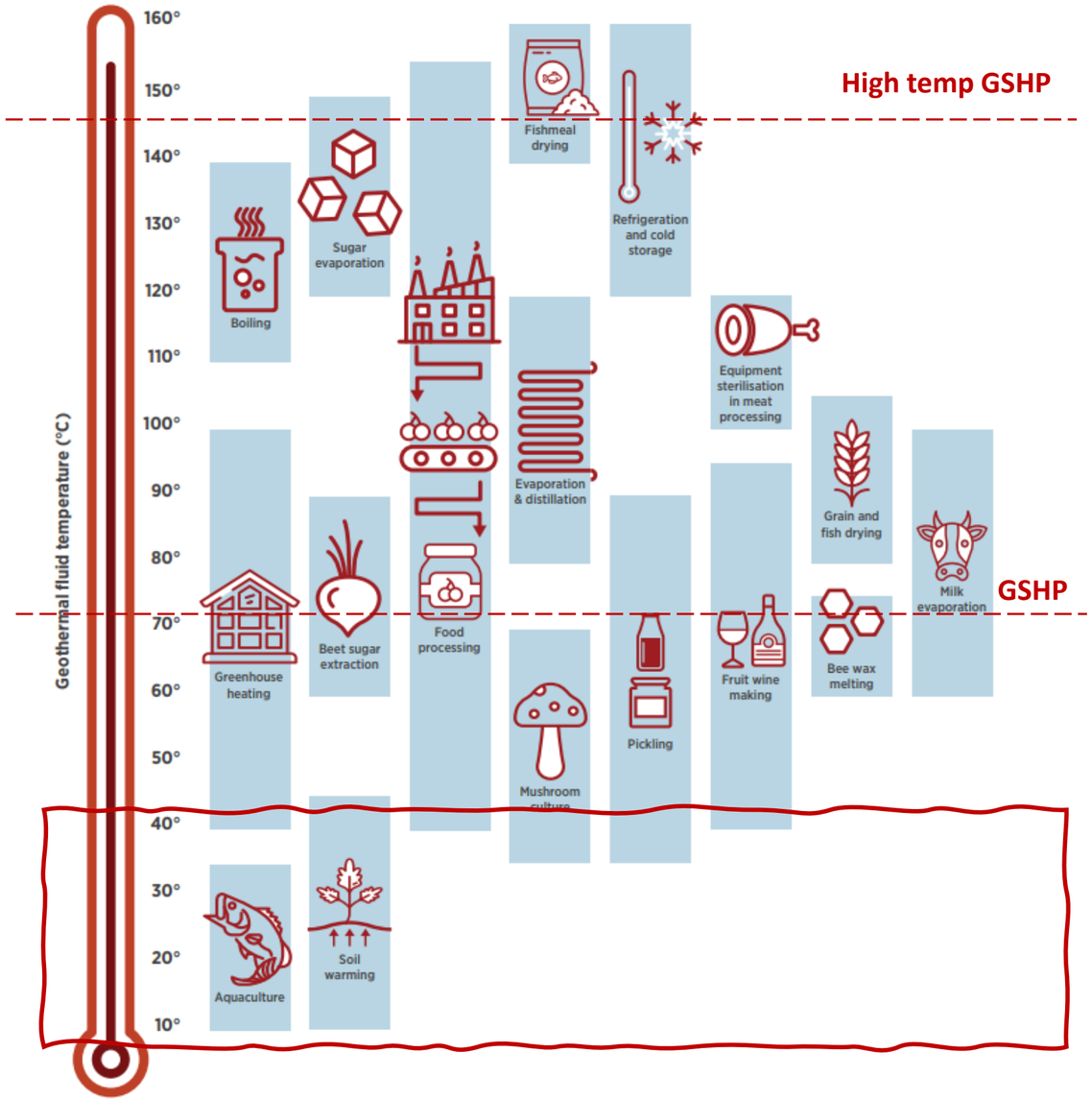
Your energy requirements and site location will dictate if and how you can access geothermal energy and what technology is right for your facility and applications.

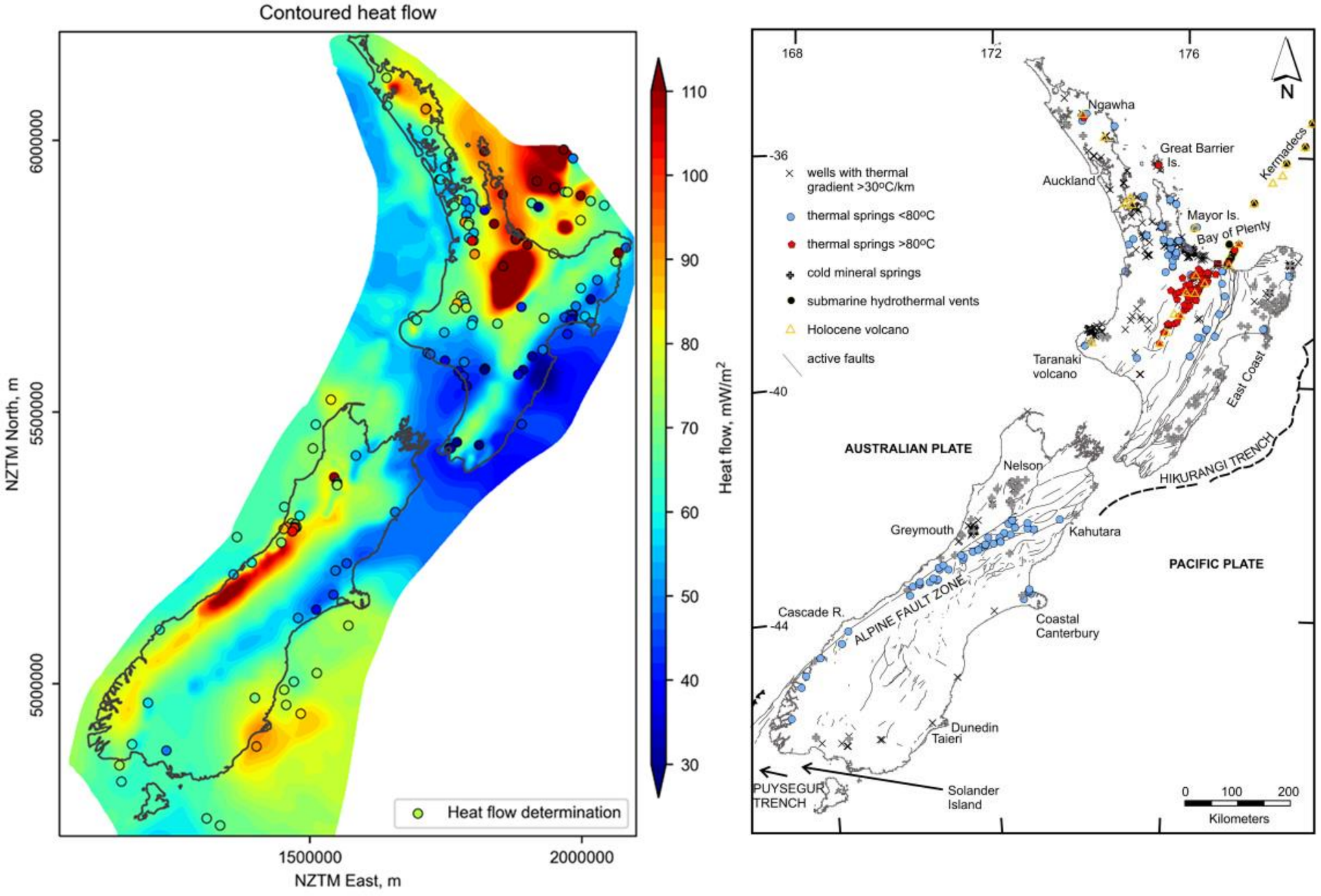
Geothermal Heat Use

HEAT CAN BE USED FOR MANY PURPOSES



Lower temperature geothermal applications have broad application across the Bay of Plenty Region




Contoured heat flow
NZTM North, m
6000000
5500000
5000000
1500000
2000000
NZTM East, m
Heat flow determination
Heat flow, mW/m2
110
100
90
80
70
60
50
40
30
168
172
176
N
-36
-40
-44
wells with thermal gradient >30ºC/km
thermal springs <80ºC
thermal springs >80ºC
cold mineral springs
submarine hydrothermal vents
Holocene volcano
active faults
Ngawha
Great Barrier Is.
Kermadecs
Auckland
Mayor Is.
Bay of Plenty
Taranaki volcano
East Coast
AUSTRALIAN PLATE
Nelson
HIKURANGI TRENCH
Greymouth
Kahutara
PACIFIC PLATE
Cascade R.
ALPINE FAULT ZONE
Coastal Canterbury
Dunedin
Taieri
PUYSEGUR TRENCH
Solander Island
0
100
200
Kilometers

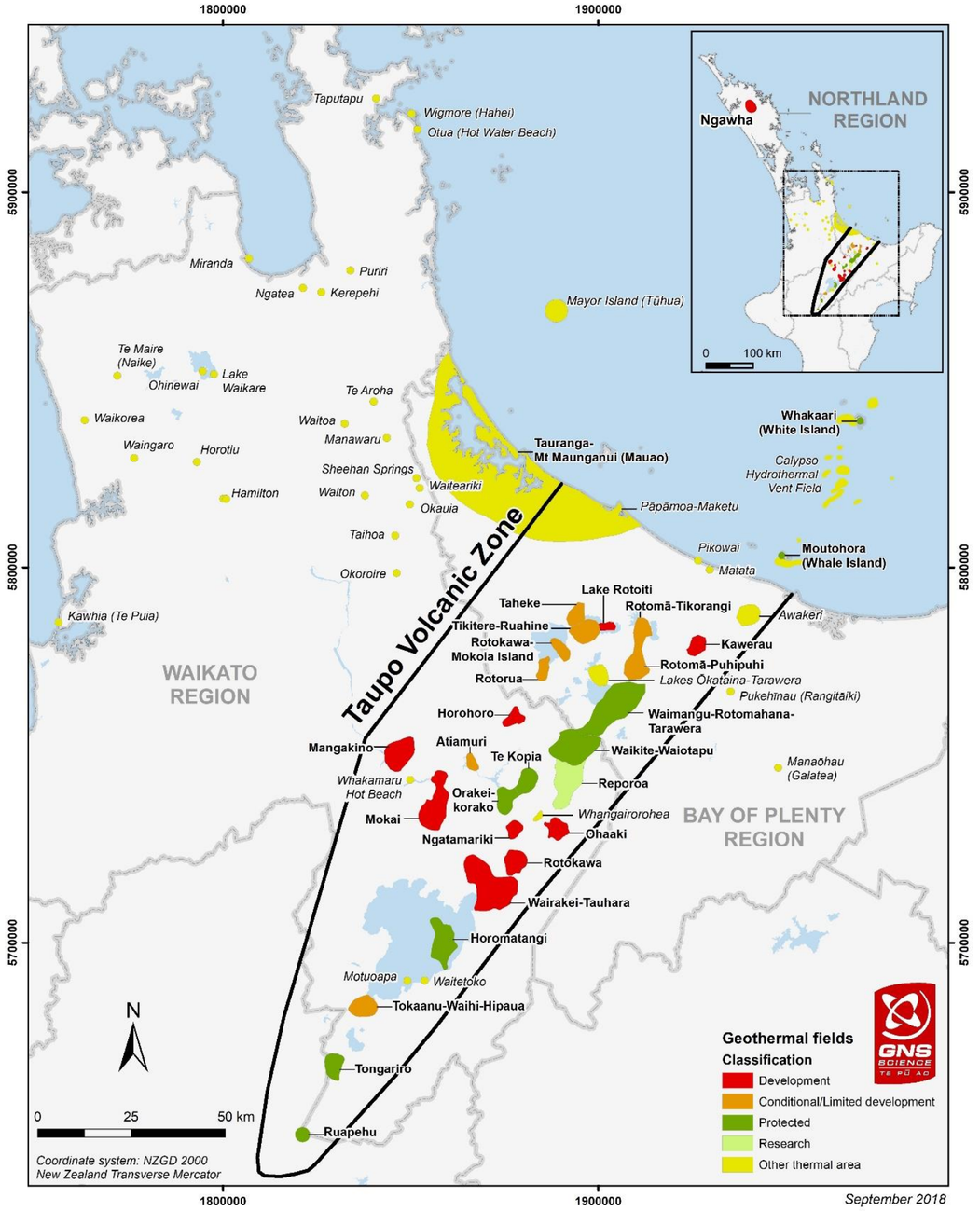
RMA considerations – Policy, Plans, Consents

Geothermal systems management groups by BOPRC

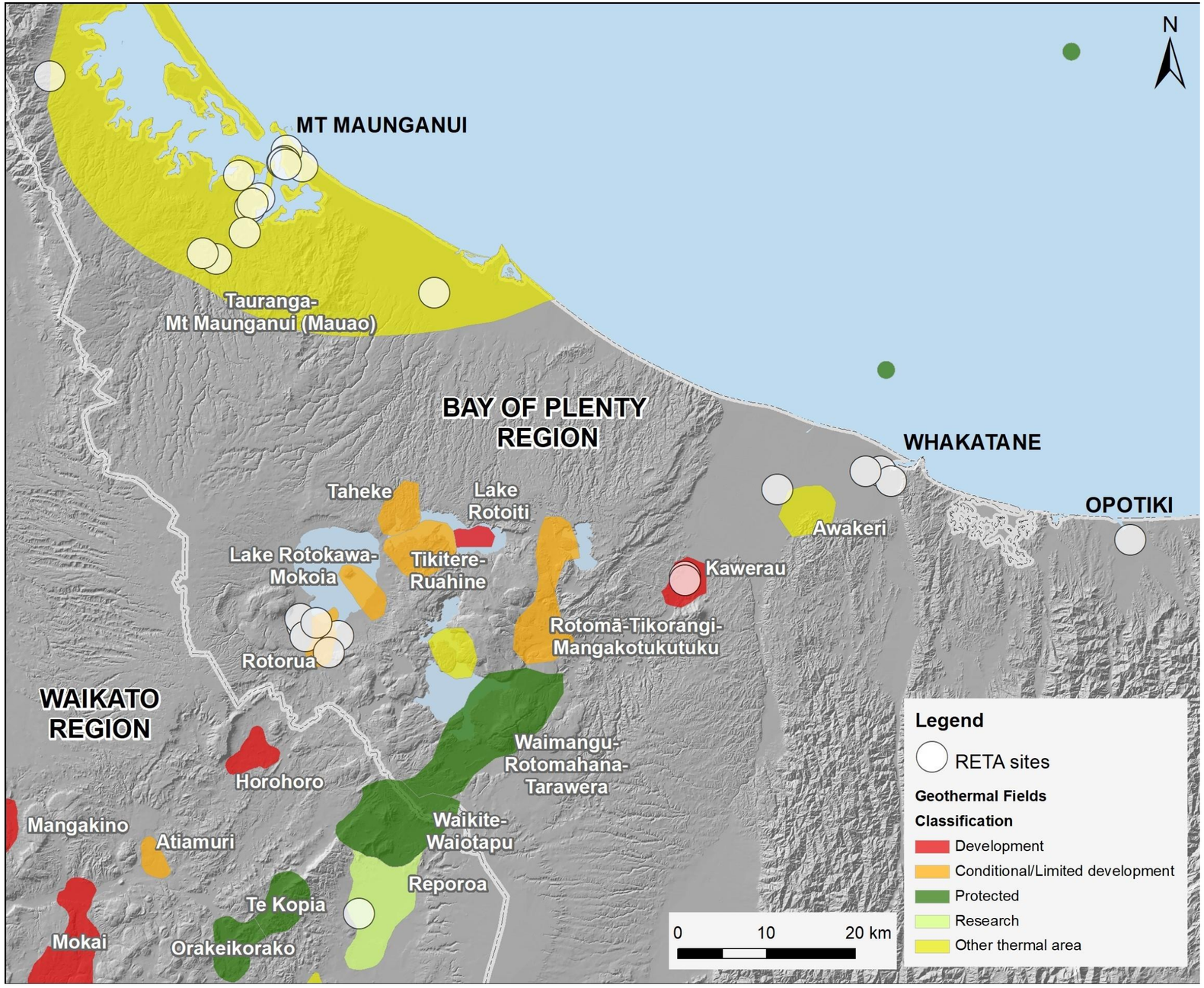
https://www.boprc.govt.nz/environment/geothermal/classifying-geothermal-systems

- Group 1 – Protected Systems
- Group 2 – Rotorua System
- Group 3 – Conditional development systems
- Group 4 – Development systems
- Group 5 – Low temperature systems
- Group 6 – Research systems

RMA defines geothermal water as >30°C



The EECA Sites and Geothermal Field Classification



Geothermal – the characteristics

- Geothermal is well suited for baseload as the installations are upfront capital intensive.
  - Peak loads are able to be met, usually at a cost premium relative to combination solutions.
- To work up a geothermal energy solution need a location and an application load.
- Meaningful cost generalisations are usually unable to be made.
  - Fundamentally underground conditions vary location to location.
  - Site to site energy requirements are usually different.
- Geothermal = a bespoke solution
  - Simple like for like comparisons may be able to be made.
- Case studies covered in following slides.

Considered in the GNS report

Existing field with operator –Kawerau

Undeveloped field –Reporoa

Ground source heat pump

- Ambient groundwater
- Low temperature geothermal
- High-temperature heat pump application

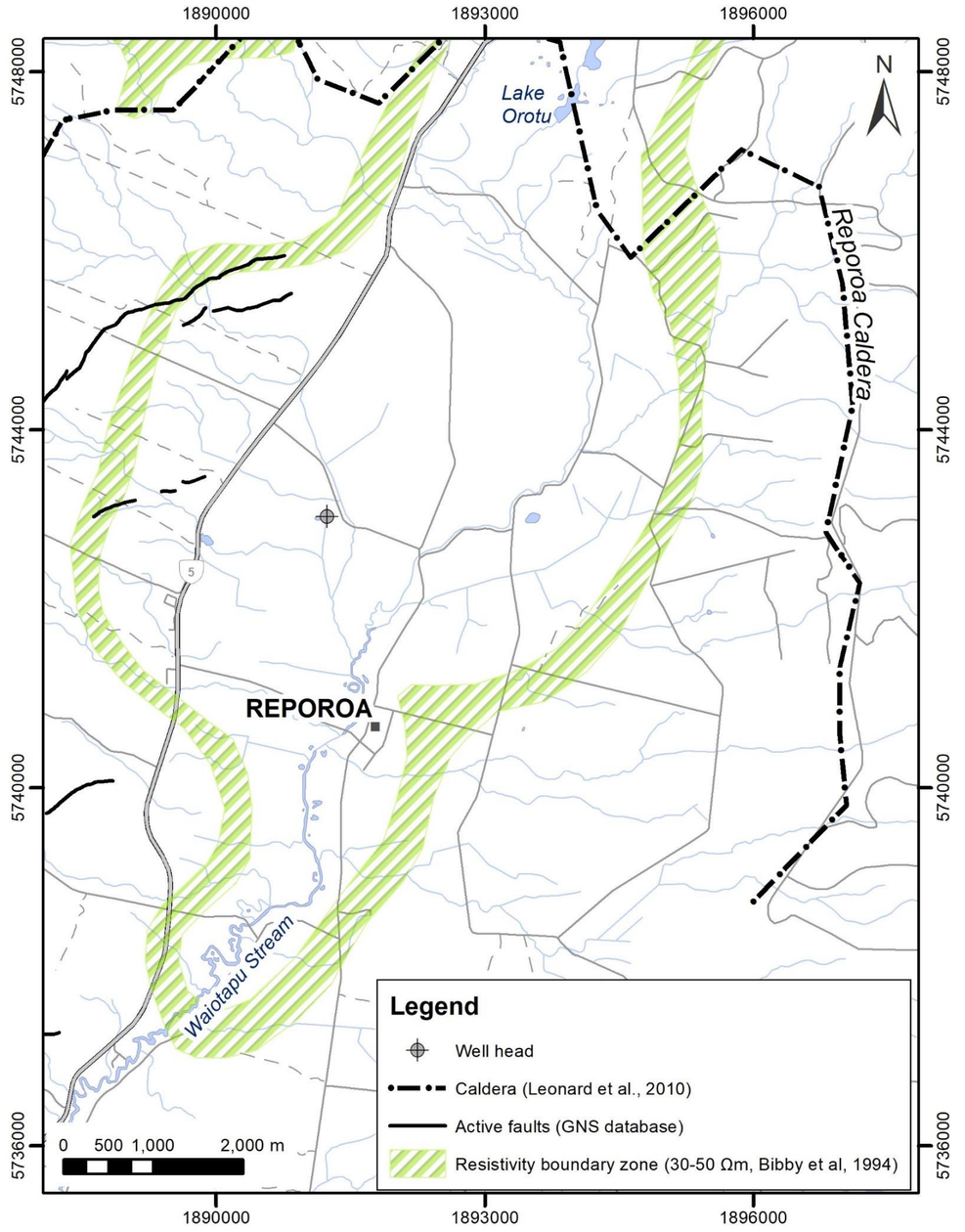
Conservative assessments / highest price estimates.

Kawerau

- Large productive geothermal resource
- Geothermal process heat is a key contributor to industry at Kawerau now
  - Oji, Essity, Sequal, Waiu, Carter Holt Harvey……
- And there is plenty more available right now
  - 6PJ per a of steam at ~170°C
    - < $8 / GJ
- Great carbon emissions profile ….
  - Since 1957 the use of geothermal at Kawerau has reduced carbon emissions (relative to natural gas) by 13,000,000 tonnes!

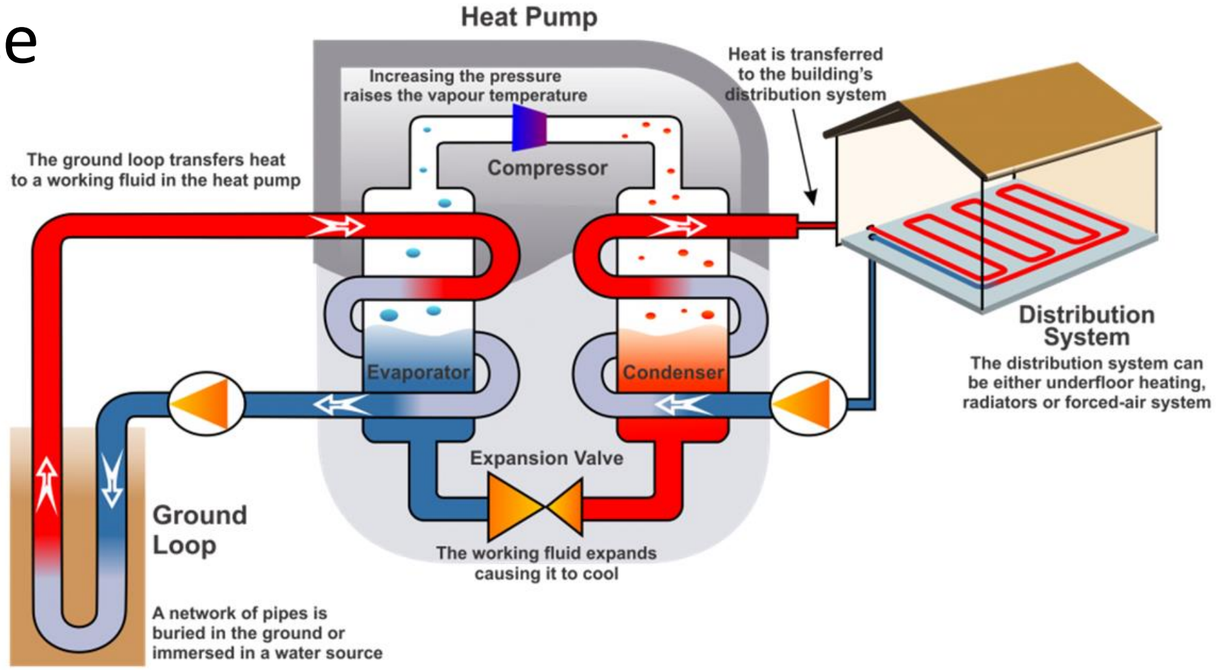
Reporoa

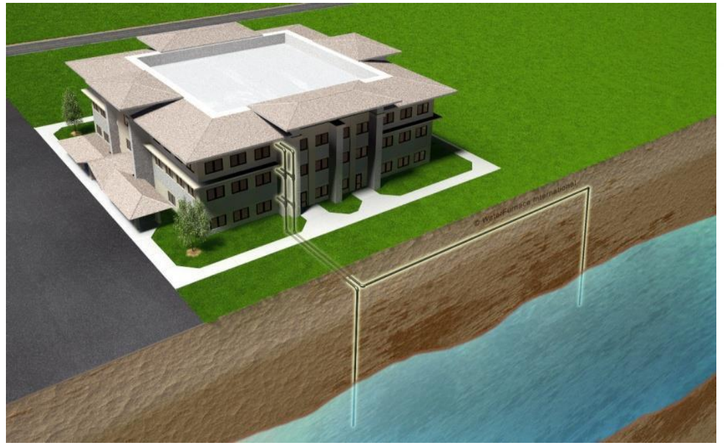
- Geothermal potential exists
  - **260°C or more**
- Exploratory activity required for development
  - **~$18.5m**
- Plan change to facilitate energy extraction is required
  - **~$750k**
- Production and injection wells
  - **~$24m**
- Cost from wellhead to end user(s) is additional and significant capex that requires bespoke design
- Economical with several end users



Ground Source Heat Pump

- Air source heat pump vs ground source
- Geothermal?
- Higher upfront costs
- Higher COP/ lower opex
- Less load on supply infrastructure
- Heating and cooling
- Quiet
- Free up roof space
- Less maintenance in lifetime
- Possibility of district schemes





Public facility with GSHP

Existing steam boiler (gas)

- 24/7 heating and cooling demand
- Heating requirement 1800kW

Aquifer resource 15°C

- 200m deeper aquifer
- Aquifer yield is expected to be able to satisfy the entire estimated site heating and cooling demand

Ground heat exchanger for heating + cooling

- GSHPs can provide a direct replacement in the existing plant room for both the gas boilers
- Site existing electrical demand can satisfy the requirements of the proposed GSHPs.

Modelled Outcome - Public facility with GSHP

- Eliminate 207 tonnes of annual carbon emissions

- GSHP compared to air source HP (ASHP)
  - Reduced electrical peak load between 35 to 50%
  - Reduced energy use by >40%
  - $1.2m additional capital investment
  - Simple payback of 2.6 years

Covered Crop with GSHP

Existing coal and gas boiler system

- 3.2ha facility
- Heating demand ~ 70°c
- Total capacity 5,800 kW

Aquifer resource 15°C

- 270m deeper aquifer
- Testing of groundwater conditions is required to confirm whether 100% of site heating needs can be achieved

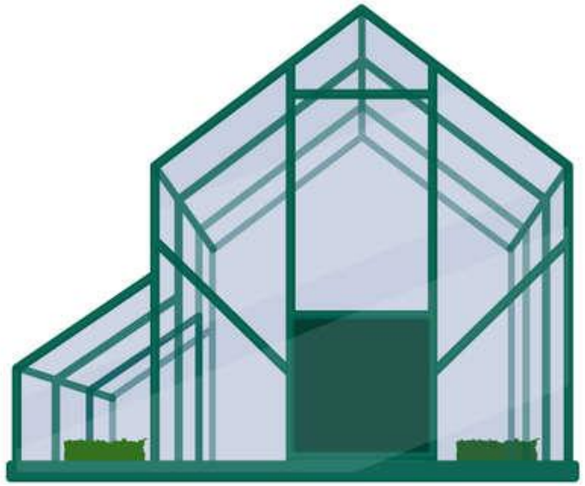
4 x 1200 kW GSHPs

- Capable of 65°C output temperatures
- The GSHPs would be located in the existing boiler room
- Three (3) abstraction wells and four (4) injection wells

Modelled Outcome - Covered Crop with GSHP

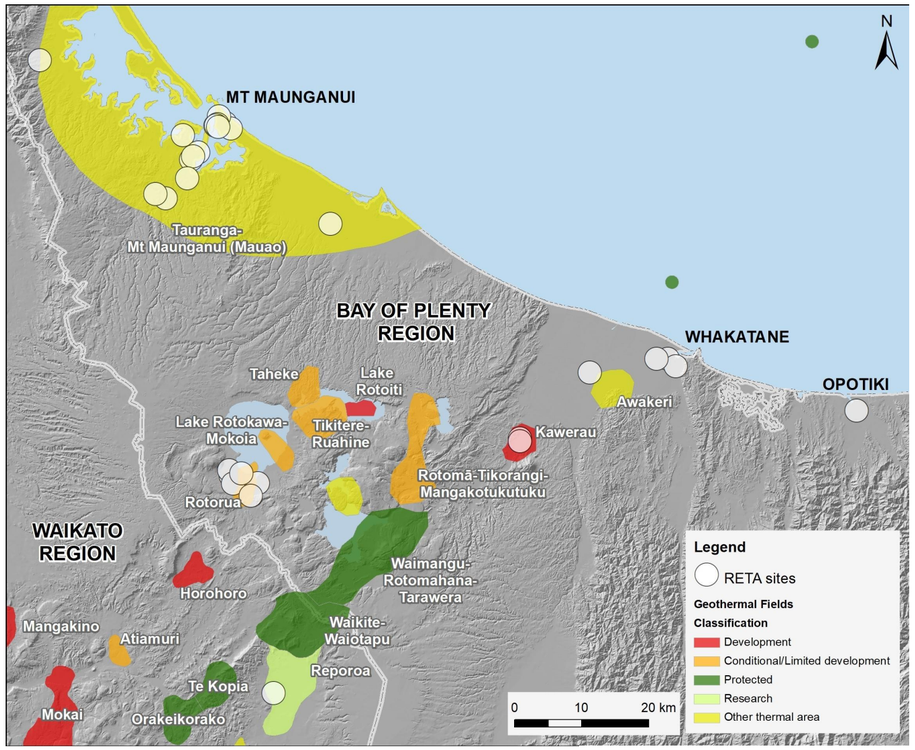
- Eliminate 3,693 tonnes of annual carbon emissions

- GSHP compared to ASHP
  - Reduced electrical peak load by 30%
  - Reduced energy use by >28%
  - $1.4m additional capital investment
  - Simple payback of 2.1 years



Same facility but warmer ground temperatures

Influence of Geothermally Enhanced Groundwaters on System Performance				
Heat Pump Type (Source Temperature)	**System COP**	**Electrical Input (kWe)**	**Energy Cost[1] ($)**	**Savings**
ASHP (0 'C)	2.0	2460	$1,215,320	--
GSHP (10 'C)	2.4	2000	$1,012,767	$202,554 (17%)
GSHP (15'C) **X**	2.77	1733	$877,488	$337,833 (28%)
GSHP (20 'C)	3.2	1500	$759,575	$455,745 (38%)
GSHP (25 'C)	3.6	1333	$675,178	$540,142 (44%)
GSHP (30 'C)	4.0	1200	$607,660	$607,660 (50%)
Note 1: Energy cost at 26c/kWh and excludes maintenance etc				



Port of Tauranga industrial site

- High temperature GSHP utilising a geothermally enhanced aquifer
  - 45-55°C at 300m
- Facility currently uses gas for electricity generation and industrial heating (co-generation)
- Distinct operation to analyse –
  - Two Fluid Bed Dryers that receive steam directly from the boiler and require a combined total of 900kg/h steam at 120°C

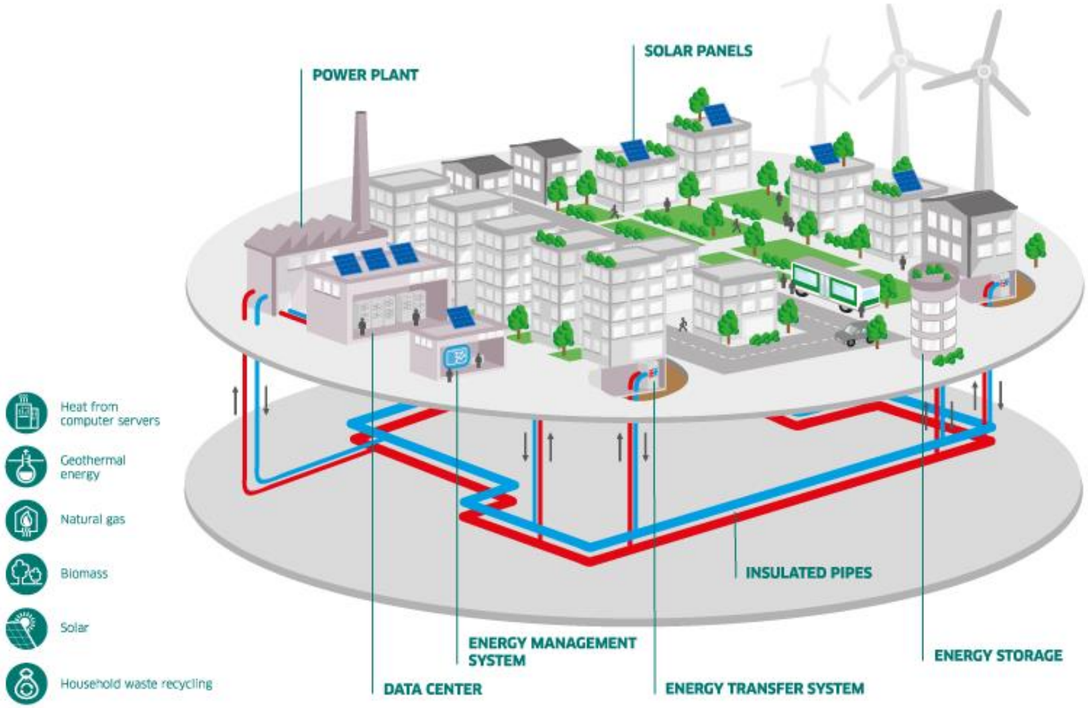
Modelled Outcome - Port of Tauranga industrial site

- Eliminate 1,542 tonnes of annual carbon emissions
- High-temp GSHP opex was similar to existing gas costs

- High-temp GSHP compared with electric boiler
  - Reduced energy use by > 64%
  - $4.5m additional capital investment
  - Simple payback of 4.1 years

- Promising result for considering 100% facility transition

Recommendation 1 - District energy transition solution

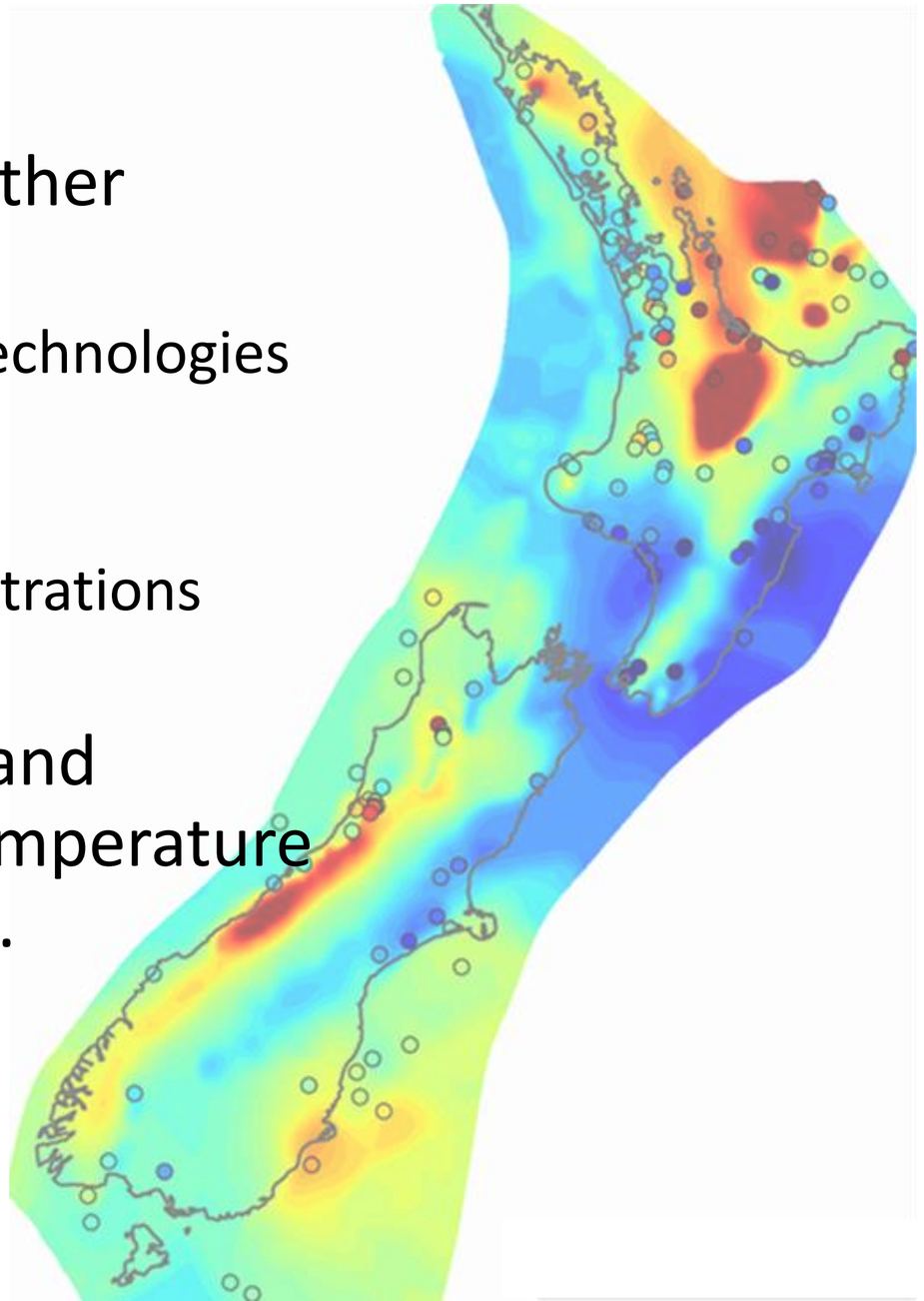


Recommendation 2. Innovation

- **Longer distance piping of high temperature geothermal**
  - France - 20 MW_{th} of geothermal is transported >15 km now
  - What opens up if NZ innovates in this space?
    - How far can we move our geothermal
- **Economics of clustering of business**
  - Shared energy / energy system
  - Variety of management models
- **High Temperature heat pumps**
  - Already capable of ~150 ^{o}C
  - Fund demonstration case study

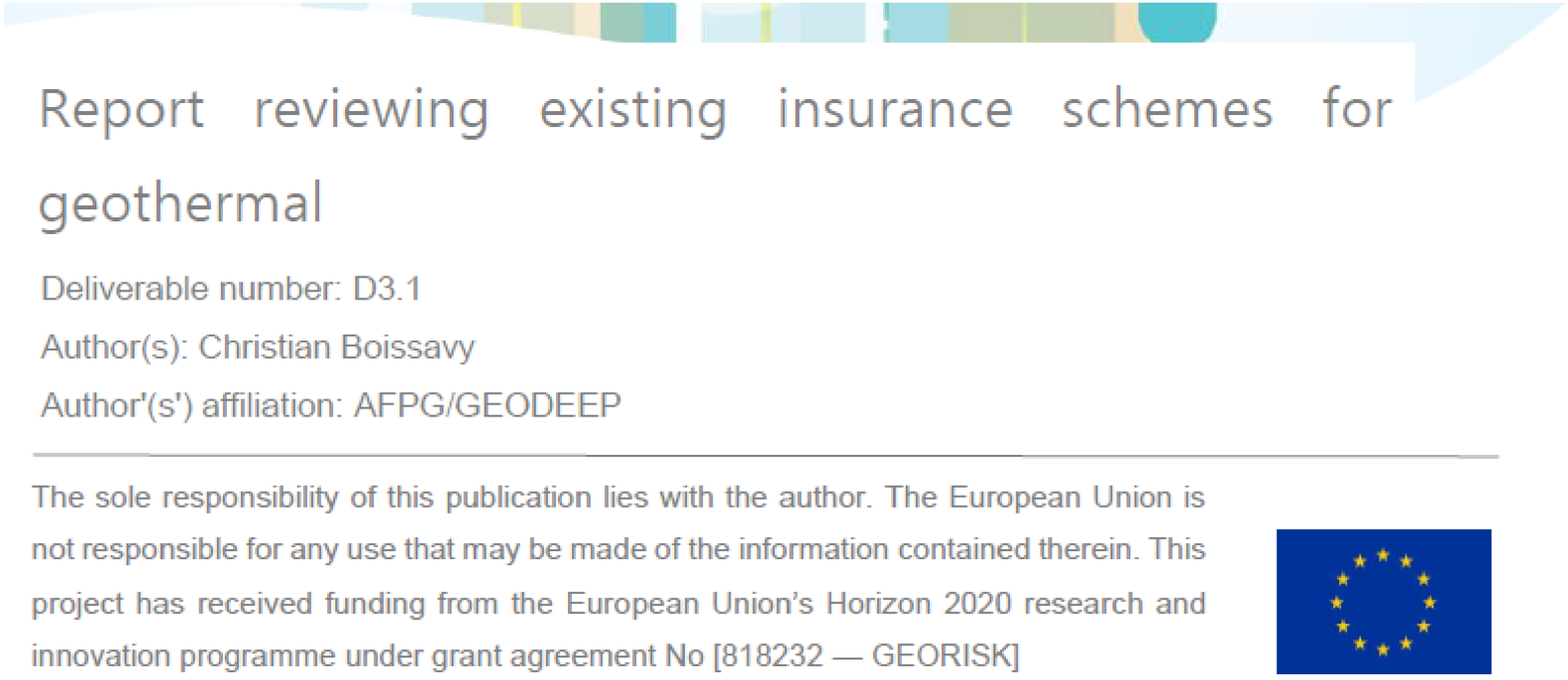
Recommendation 3. National Opportunity

- This type of analysis could be done in all other regions
  - Showcasing lower temperature geothermal technologies across NZ
  - Include in other regional assessments
  - All use established technologies with demonstrations from overseas
- National guidance on consenting process and subsurface management for GSHP/ low temperature geothermal technologies is commissioned.



Recommendation 4. De-risking

- A drilling insurance scheme, similar to the French model, is tailored for New Zealand conditions to de-risk geothermal applications and accelerate decarbonisation targets.



Report reviewing existing insurance schemes for geothermal

Deliverable number: D3.1

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