Low enthalpy geothermal economics

Presentation to the

2011 NZ Geothermal Association Seminar

By

Mike Suggate

East Harbour Energy

East Harbour Energy

- An energy-focussed consulting business
- Providing strategic advice, planning and project management services to business and government
- With strong commercial and economic capability
- And a particular focus on energy and infrastructure projects, new technology introduction:
  - In recent times geothermal and biomass.

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Talking about today

"To foster the development of NZ's low enthalpy geothermal resources'

Will be talking to:

- The July report "Technological economics review" by:
  - CRL Energy
  - East harbour Energy
- And some East Harbour work in this area

i.e. the economics of geothermal resource development and technology application

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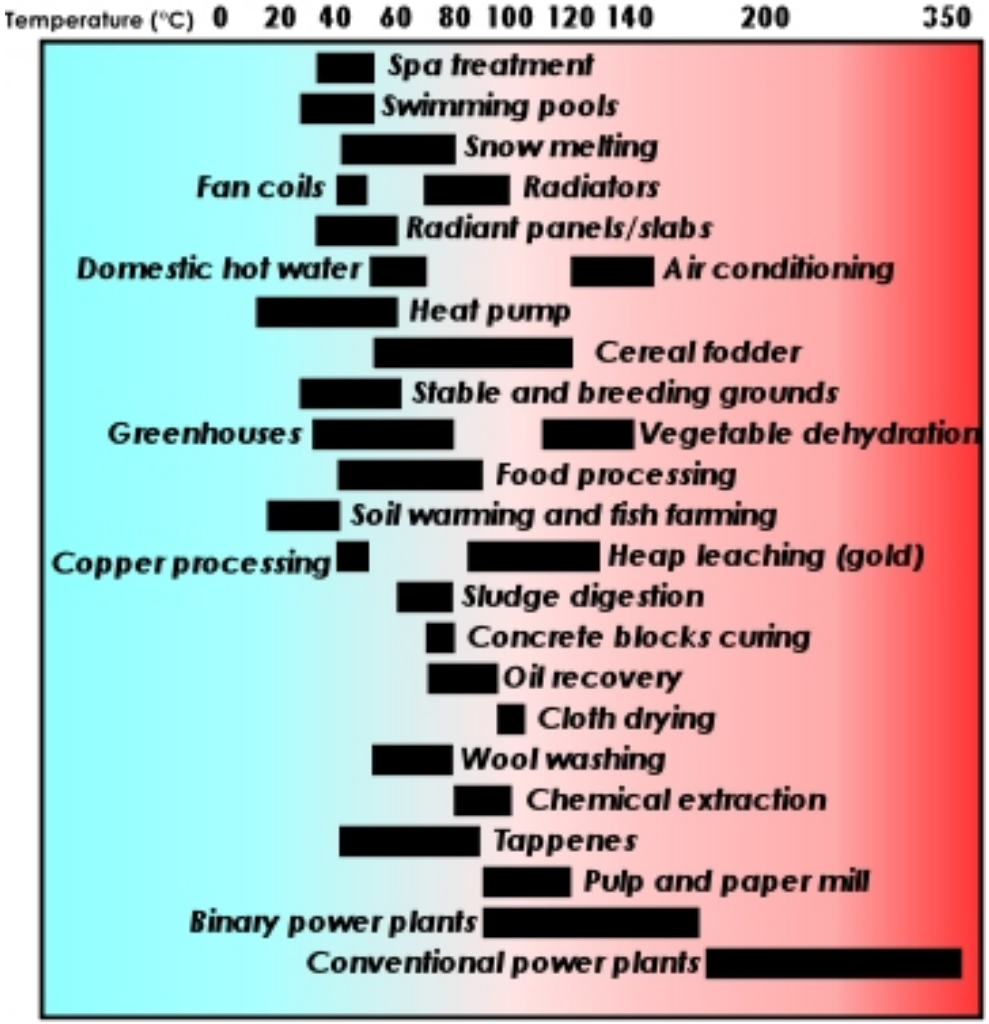
Direct heat uses



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Commercial drivers

Geothermal resource development is driven by two factors:

- The cost of extracting energy and delivering it to a point of use, and
- The (commercial) opportunities for its use.

A project cannot proceed with only one of these drivers being attractive.

Geothermal energy can be used for the direct supply of energy, electricity generation, or if the temperature is high enough a cascade of both uses is possible.

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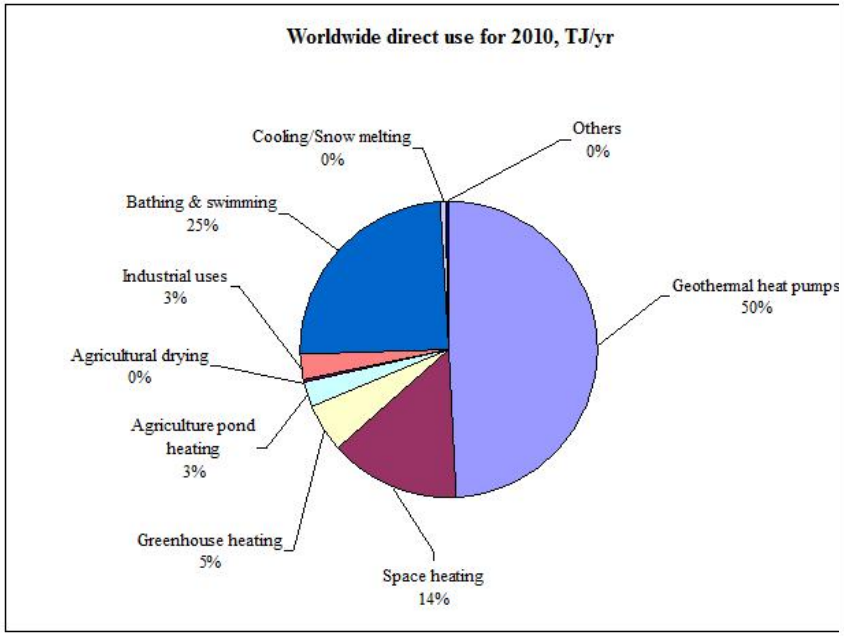
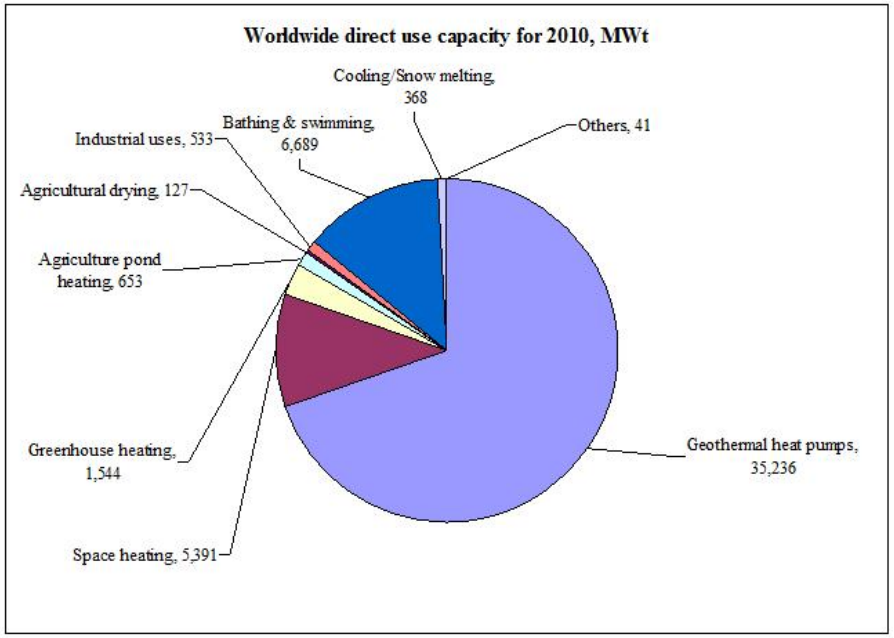
Direct use worldwide





- Total TJ circa 440,000 (NZ 9,500, mainly Kawerau)
- Dominated by ground-source heat pumps (GSHP), followed by bathing and swimming
- Heat pumps are the growth area - 15,000 to 215,000 TJ in 15-years

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And in New Zealand?

- In New Zealand domestic scale growth has been inhibited by:
  - High capital costs
  - Better economics of alternatives such as air sourced systems
  - Shorter heating seasons, lower energy requirements
- For larger commercial scale development:
  - risks are high and rewards not guaranteed
  - Returns can be high
  - NZ temperature gradients are comparatively high
    - Often in our view circa 60^{o}C/km north of the TVZ,
    - 30^{o}C/km elsewhere
- For electricity abundant conventional resources and low demand growth has slowed development

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Low temperature economics

- Direct use geothermal heating (and cooling)
  - Economics depend on the resource temperature and application
  - Economic in some applications
- Electricity generation:
  - Typically binary plants
  - The hotter the better - efficiency drops with temperature
  - As low as 98^{o}C is feasible
  - May be economic at moderate scale?

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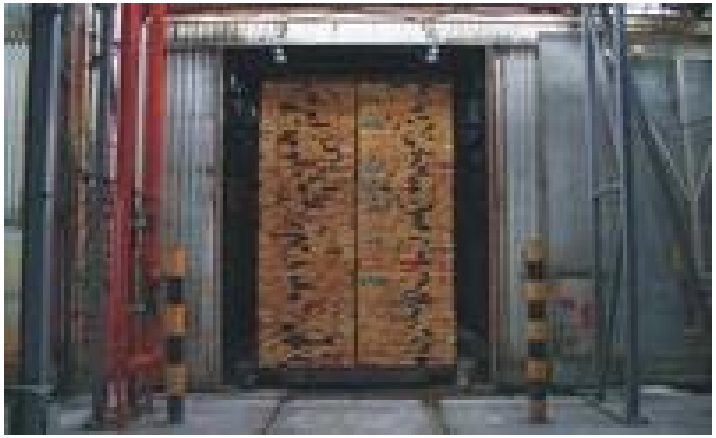
Direct Use Examples



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Ground source heat pumps

- Potential applications over much of NZ
- With closed ground loops the potential varies with soil conditions from 8 – 12 W/m^2 up to 35 – 40 W/m^2
- Ground/surface waters have higher potential capacities than ground loops
- COP up to 5
- Capital costs mean GSHPs need higher loads/load factors to be economic
  - Much of NZ has short residential heating seasons which favours air source heat pumps
  - Cost premium 2 – 5 times over other forms
- So really doesn't work economically for residential use, but can for commercial (with high duration curves)

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Spa development study

- Owners wanted “attributes” of a natural spa
- Investigated using heat from groundwater to supply
  - 60kW for heating hot tubs
  - Temperature circa 60^{o}C (for showers), 30^{o}C for tubs
- Of the options (direct electric, air source heat pump, gas) it had the lowest running (energy) cost – but highest capital cost
- Payback 2.5-years c.f. simple electric heating system
- But high capital costs made gas the most economic overall option

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Geothermal resource outside the TVZ

- Even outside recognised geothermal areas, sedimentary basins have notional thermal gradients between 27ºC/km and 33ºC/km
- Permeability, and depth to basement can be issues
- EHE Feasibility studies for greenhouses and dairy plants indicate the technique is likely to be economic but
- A first well is needed to prove this

Option	Capital cost ($000s)	Annual operations cost ($000s)	Annualised energy cost 5% WACC ($000s)	Annualised energy cost 10% WACC ($000s)
45ºC supply, 27ºC/km, 1.2km deep well	600	15	64	98
45ºC supply, 33ºC/km, 1.0km deep well	500	13	53	82
60ºC supply, 27ºC/km, 1.8km deep well	900	23	95	147
60ºC supply, 33ºC/km, 1.5km deep well	750	19	79	123

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Binary cycle generation

- Binary cycles transfer the geothermal heat to working fluids with boiling points lower than water e.g. isopentane (ORC), NH_3 (Kalina)
- Can work with temperatures as low as 90^{o}C
- Thermal efficiency low ~ 10 - 14% typical so costs/kWe increase
- Costs vary depending on the resources specifics, but to be economic projects need some or all of:
  - Scale
  - Embedded electricity sales
  - Direct cooling
  - A relatively low cost geothermal resource

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Two examples

- Ngapuna binary cycle generation plant
  - Circa 1.3 MWe net (scale small)
  - Embedded electricity sales, network connection
  - Free once-through cooling water
  - Shallow, hot (circa 205^{o}C at 250m) geothermal resource
    - But pumping likely
  - Marginally economic at $6,000/kW for whole development

- Waikiti binary cycle plant
  - 98^{o}C spring supply
  - Circa 230kW net (Purecycle ORC plant, low thermal efficiency)
  - Cooling tower required
  - Grid supply
  - Sub economic, but only just

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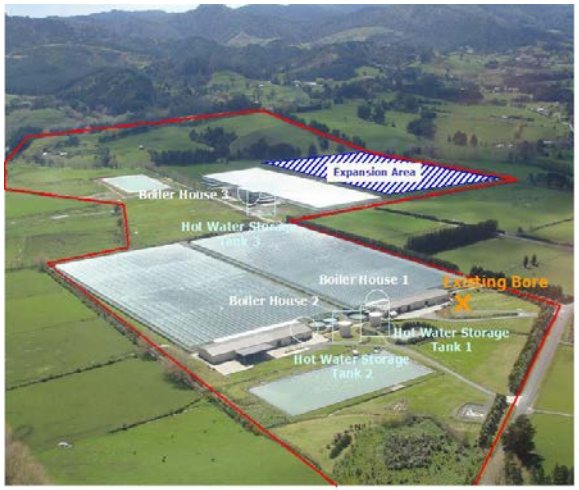
Direct heat supply

East Harbour have recently conducted four direct heat studies covering:

- Geothermal heat supply to process plants
  - With and without associated electricity generation
- Heat supply to a large greenhouse complex

- What have we learnt:

- Greenhouse application
  - With substantial scale - circa 20 Ha
  - Default temp. Gradient 30^{o}C/km, but sedimentary basin too shalow
  - Heat required at circa 70^{o}C (i.e. 2km depth)
  - Displacing gas in area with relatively high tariffs
  - Economics are strongly favourable
  - Applicable – just about anywhere in NZ,
  - North of the TVZ may get > 30^{o}C



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Direct heat supply

Process heat supply – dairy, timber processing

- Applications
  - Process heat at circa 200^{o}C
    - Or say 150^{o}C with a thermal-fuelled top up
  - Timber processing – displacing wood burning with geothermal heat, to leave for higher value use
- The economics can be satisfactory
    - Assuming a conventional geothermal resource, or
    - Even an enhanced geothermal resource
- Can displace majority, but not necessarily all, of the hydrocarbon fuels
- Can generate significant levels of electricity (ORC plant)
- Displace a lot of carbon, driving value from ETS charge

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Take outs

- Heating/cooling applications require scale for conventional economics to work
- Ground loop applications unlikely to be economic at small scale
    - Need other drivers, or to ignore capital charges/returns
    - Use of surface or deeper water clearly economic at scale
- High load factors are important, ideally summer and winter
- Power generation also requires scale, acceptance of (relatively low) utility returns, and full range of favourable attributes
- Industrial scale heat supply can be very attractive
    - To the degree that for new plant it is worth chasing heat sources
    - For low grade heat could be anywhere, but
    - Especially in the TNZ or north where gradients are higher

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Thank you

Any questions

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