DIRECT GEOTHERMAL ENERGY

Professor Ian Johnston
Golder Associates Chair of Geotechnical Engineering
Department of Infrastructure Engineering University of Melbourne

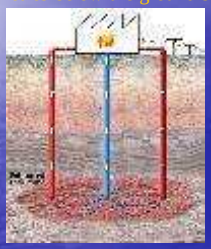
DIRECT GEOTHERMAL ENERGY

What is direct geothermal energy?
Volcanoes, boiling mud and geysers; Rotorua and Iceland?
(Hydrothermal)


It has nothing to do with this!

DIRECT GEOTHERMAL ENERGY

"Hot rocks" using super-hot water and steam from several kilometres below the ground surface to generate electricity?




It has nothing to do with this!

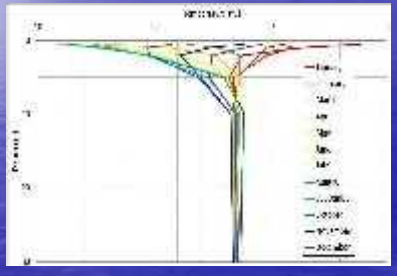
DIRECT GEOTHERMAL ENERGY

Hot or warm water obtained from springs for spas?


It has nothing to do with this!

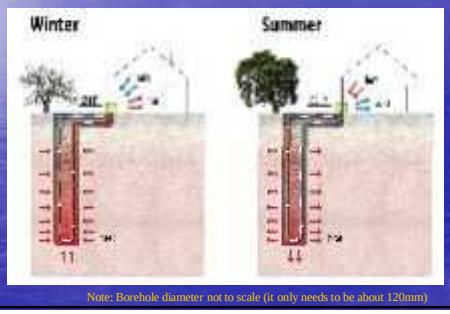
DIRECT GEOTHERMAL ENERGY

Ground temperatures in Melbourne



DIRECT GEOTHERMAL ENERGY

This is what it is



Note: Borehole diameter not to scale (it only needs to be about 120mm)

DIRECT GEOTHERMAL ENERGY

Key elements of a Direct Geothermal Energy system:

- Ground Heat Exchanger
  - Closed Loop
    - Vertical loops
    - Horizontal loops
    - Pond and lake loops
    - Foundation loops
  - Open Loop
    - Abstraction of groundwater
- Ground Source Heat Pump
- Building Heat and Cooling Demand

7

DIRECT GEOTHERMAL ENERGY

Ground loops

8

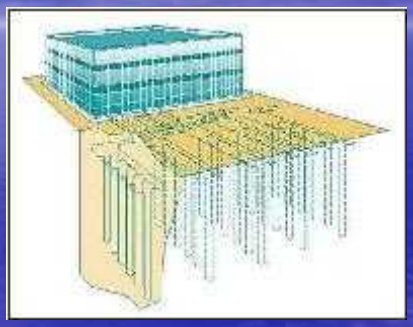
DIRECT GEOTHERMAL ENERGY

Ground loops

9

DIRECT GEOTHERMAL ENERGY

Ground loops



10

DIRECT GEOTHERMAL ENERGY

Ground loops

11

DIRECT GEOTHERMAL ENERGY

Ground loops

12

DIRECT GEOTHERMAL ENERGY

Ground loops

13

DIRECT GEOTHERMAL ENERGY

Ground loops

14

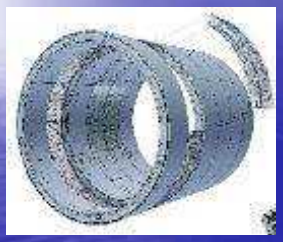
DIRECT GEOTHERMAL ENERGY

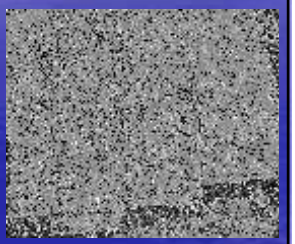
Ground loops

15

DIRECT GEOTHERMAL ENERGY

Ground loops

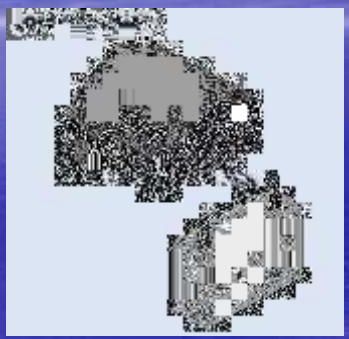




16

DIRECT GEOTHERMAL ENERGY

Ground loops



17

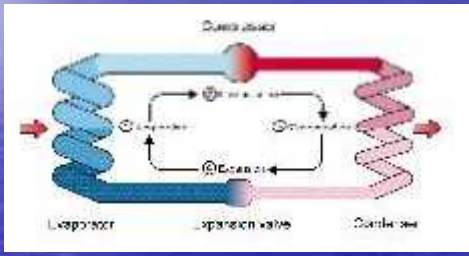
DIRECT GEOTHERMAL ENERGY

Not just for heating and cooling for people

Crop drying
Timber drying
Food processing
Chemical extraction
Paper production
Greenhouses
Cool/cold stores
Specialist uses

DIRECT GEOTHERMAL ENERGY

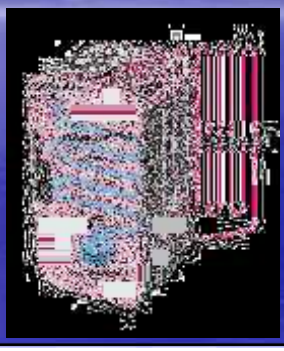
Heat pumps



19

DIRECT GEOTHERMAL ENERGY

Heat pumps



20

DIRECT GEOTHERMAL ENERGY

Heat pumps

21

DIRECT GEOTHERMAL ENERGY

Heat pumps

22

DIRECT GEOTHERMAL ENERGY

Building heating and cooling demand, key variables:

- Climate
- Roof, wall, floor construction
- Effect of sun and shade
- Ventilation
- Lights and appliances
- People
- Building use
- Distribution system

23

DIRECT GEOTHERMAL ENERGY

Advantages:

- A sustainable and renewable energy source
- Available 24/7
- Provides a major reduction in carbon footprint
- Coefficient of performance ≈ 4+
- Well established technology
  - About 3 million installations in Europe and North America
  - Rapidly growing in China, Korea and Japan
- Heat pump and HVAC technology well established
- Can be used in conjunction with traditional HVAC systems
- Can be used anywhere
- Costs are competitive internationally
- Victorian conditions are ideal for direct geothermal

24

DIRECT GEOTHERMAL ENERGY

Disadvantages:

- Largely overlooked in Australia so far
- Few people have heard of it
- Costs are a little high at present but will become highly competitive
  - As industry matures
  - As competition develops
  - As a carbon tax bites
  - If/when subsidies are introduced
- Currently ground loop systems are designed conservatively but more economic systems will result from
  - Ongoing research
  - Use of hybrid systems
    - (use of existing/auxiliary systems for peak, combination with solar, buffer tanks, passive systems, zoning, etc, etc)

25

DIRECT GEOTHERMAL ENERGY

House renovation, Surrey Hills

- 14.7 kW heat pump
- 4 x 30m boreholes

Source: Direct Energy

26

DIRECT GEOTHERMAL ENERGY

Brush Ski Club, Mt Hotham

- 2 x 21 kW heat pumps for heating & hot water
- 16 x 30 m boreholes
- Fossil-fuel consumption down 80%
- Payback period estimated at 6 years

DIRECT GEOTHERMAL ENERGY

City of Melbourne Bowls Club
Flagstaff Gardens

- System capacity 66.5 kW
- 4,900 m of "slinky" pipe
- 24 x 1.8 m deep trenches
- Installed beneath bowling green

Source: Meinhardt

8

DIRECT GEOTHERMAL ENERGY

Skyper Building, Frankfurt

- 154 m tall, 38 storeys
- Heating capacity 300 kW, cooling 160 kW
- 35 m deep concrete piles (0.9 – 1.2 m diameter)
- 30 km of HDPE pipe
- Annual CO_2 savings of 90 tonnes

Sources:
Markiewicz, Enercret

DIRECT GEOTHERMAL ENERGY

STRABAG Headquarters, Vienna

- Total conditioned area 21,000 m²
- Heating cap. 1.7 MW, annual output 840 MWh, cooling cap. 2 MW, annual output 1450 MWh
- 220 x 15 m deep concrete piles (650mm diameter), 6000 m² ground slab, 68 km of HDPE pipe
- Payback period 3.4 years

Sources:Enercret,
Arsenal Research

30

DIRECT GEOTHERMAL ENERGY

Jungwon University, Korea

- Total area 96000m², Heating and cooling load 6.23MW
- 245 x 150m boreholes, double U-tubes
- 60 x 122kW heat pumps

Source:
Dr Yoonho Song, KIGAM

31

DIRECT GEOTHERMAL ENERGY

Research at the University of Melbourne:

Aims:

- To better understand factors which influence performance.
- To develop improved guidelines for design and installation.
- To improve the economics by optimising geometry, hybrid systems, baseload/peak combinations, passive systems, etc, etc.
- To make direct geothermal energy a system of choice by raising its visibility to the community.
- To provide education and training for the trades, professions, regulators and politicians so that these systems can be rolled out.

32

DIRECT GEOTHERMAL ENERGY

Development of a test facility on campus

Comprising ground loops of between 100mm and 600mm diameter to 30m, with much instrumentation to assess performance

33

DIRECT GEOTHERMAL ENERGY

Design and installation of full scale systems

Such as the 85kW system just installed at Main Ridge, again with much instrumentation to assess performance.

34

DIRECT GEOTHERMAL ENERGY

Design and installation of full scale systems

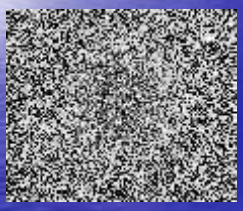
Walter Boas Building on Campus - retrofit system for 25kW, fully instrumented.

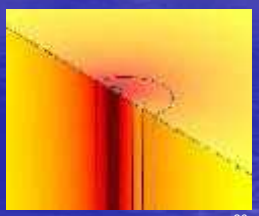
35

DIRECT GEOTHERMAL ENERGY

Numerical modelling of systems

Allows the assessment of various factors on performance (e.g. geometry, geology, climate, materials). Calibrated against field data.





36

DIRECT GEOTHERMAL ENERGY

Direct Geothermal Energy Pilot Demonstration Project for Victoria

- Funded by the Victorian Department of Primary Industries (total value ≈ $3.8m).
- To be completed in 2016.
- Partners: Direct Energy Pty Ltd and Geotechnical Engineering Pty Ltd
- Involves the installation of direct geothermal systems in buildings around the state and monitoring their performance.
- Systems to represent variations in geology, climate, function, new/retrofit, vertical/horiz,
- Buildings:
  - Bio21 building at the University in Parkville (1200m²)
  - Office building in Port Melbourne (1500m²)
  - Large building in Toorak (1600m²)
  - Large house in Main Ridge (Mornington Peninsula) (700²)
  - Area within PICAC
  - Up to about 40 other buildings in Victoria (≈8000m²)

37

DIRECT GEOTHERMAL ENERGY

Thank you

38

DIRECT GEOTHERMAL ENERGY

There are many factors affecting performance including

- How well building is designed
- Tolerance to less than the perfect temperature
- Zoning

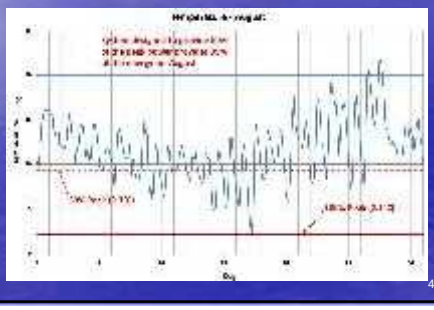
One of the most critical factors that affects capital and running costs is the design capacity of the geothermal system and the extent to which other systems can be used to complement the geothermal system.

i.e. are we designing to peak load or something smaller?

39

DIRECT GEOTHERMAL ENERGY

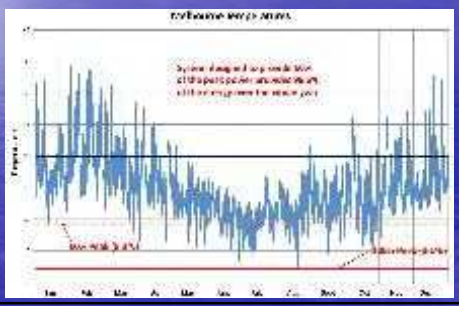
Base-load energy



40

DIRECT GEOTHERMAL ENERGY

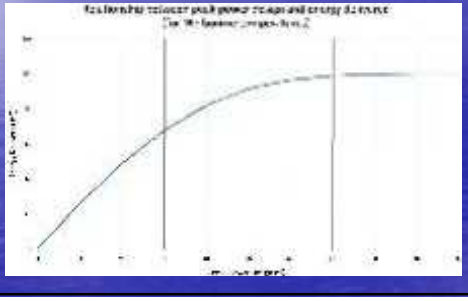
Base-load energy



41

DIRECT GEOTHERMAL ENERGY

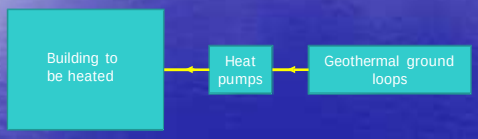
Base-load energy



42

DIRECT GEOTHERMAL ENERGY

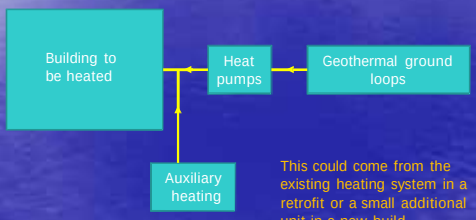
Designing geothermal system to cover 60% of peak, this base-load heating provides 96.5% of the energy required



43

DIRECT GEOTHERMAL ENERGY

For the relatively few days the heating demand exceeds 60% of peak, the additional 3.5% of energy is provided by an auxiliary system



This could come from the existing heating system in a retrofit or a small additional unit in a new-build

44