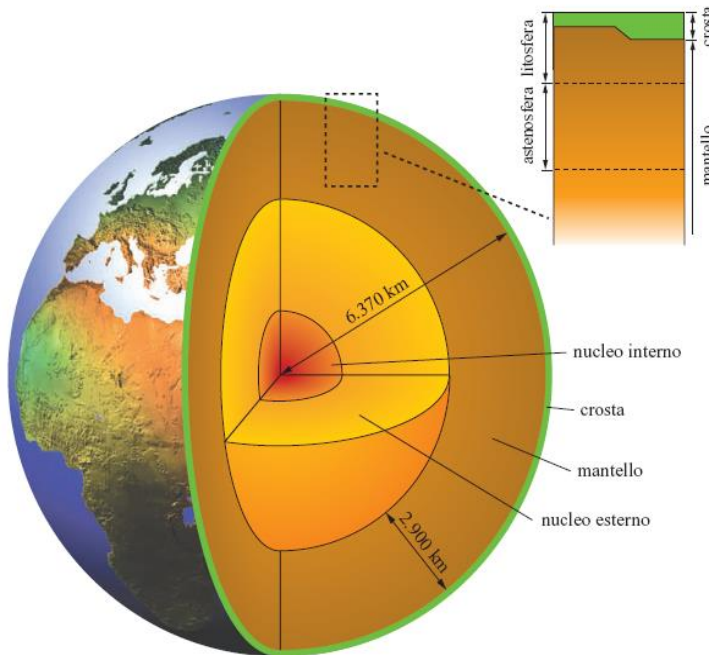




Geothermics: energy under our feet



Prof. Galgaro Antonio
Antonio.galgaro@unipd.it

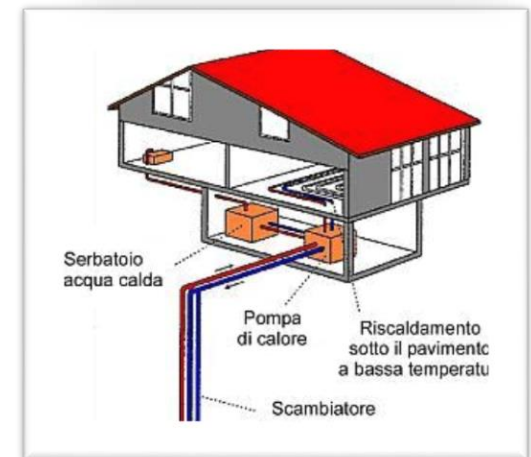
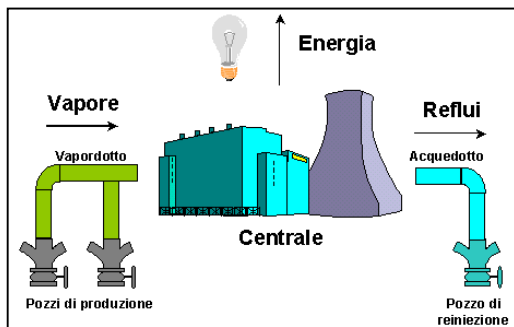
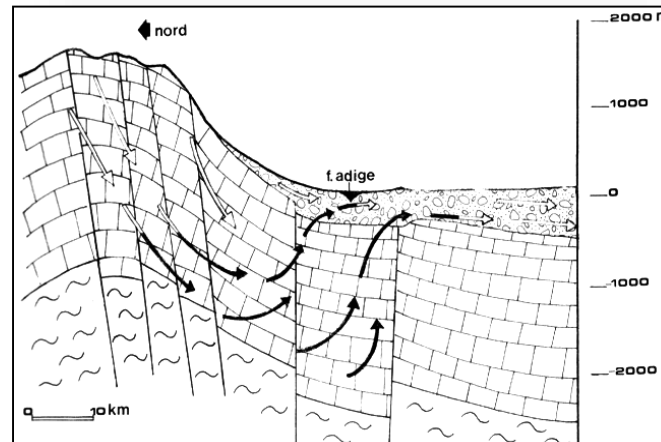
High temperature $> 90^{\circ}\text{C}$
(electricity production)

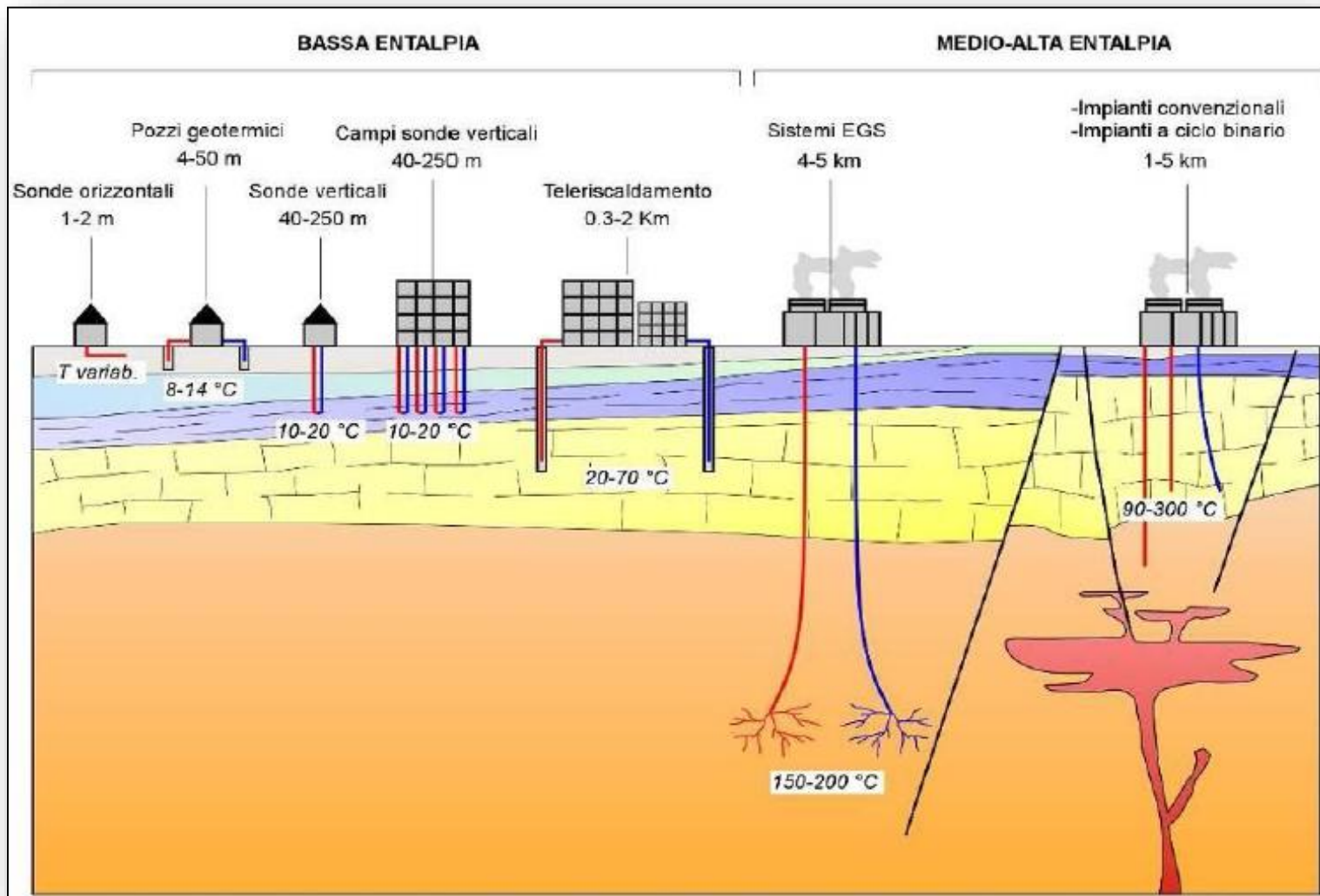
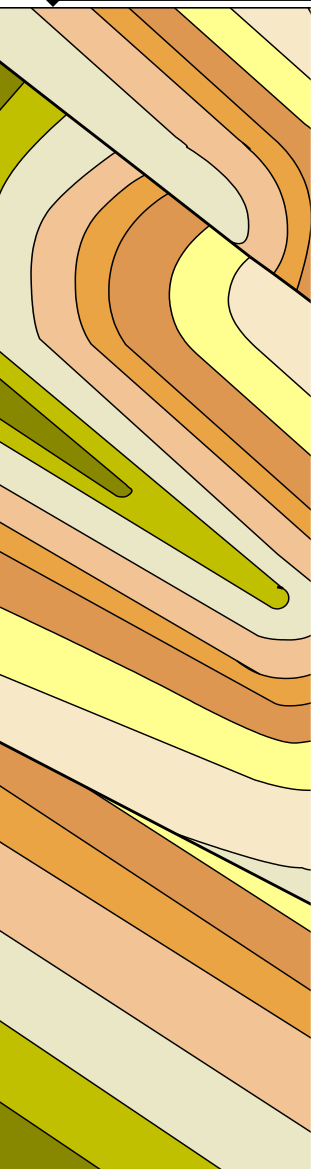


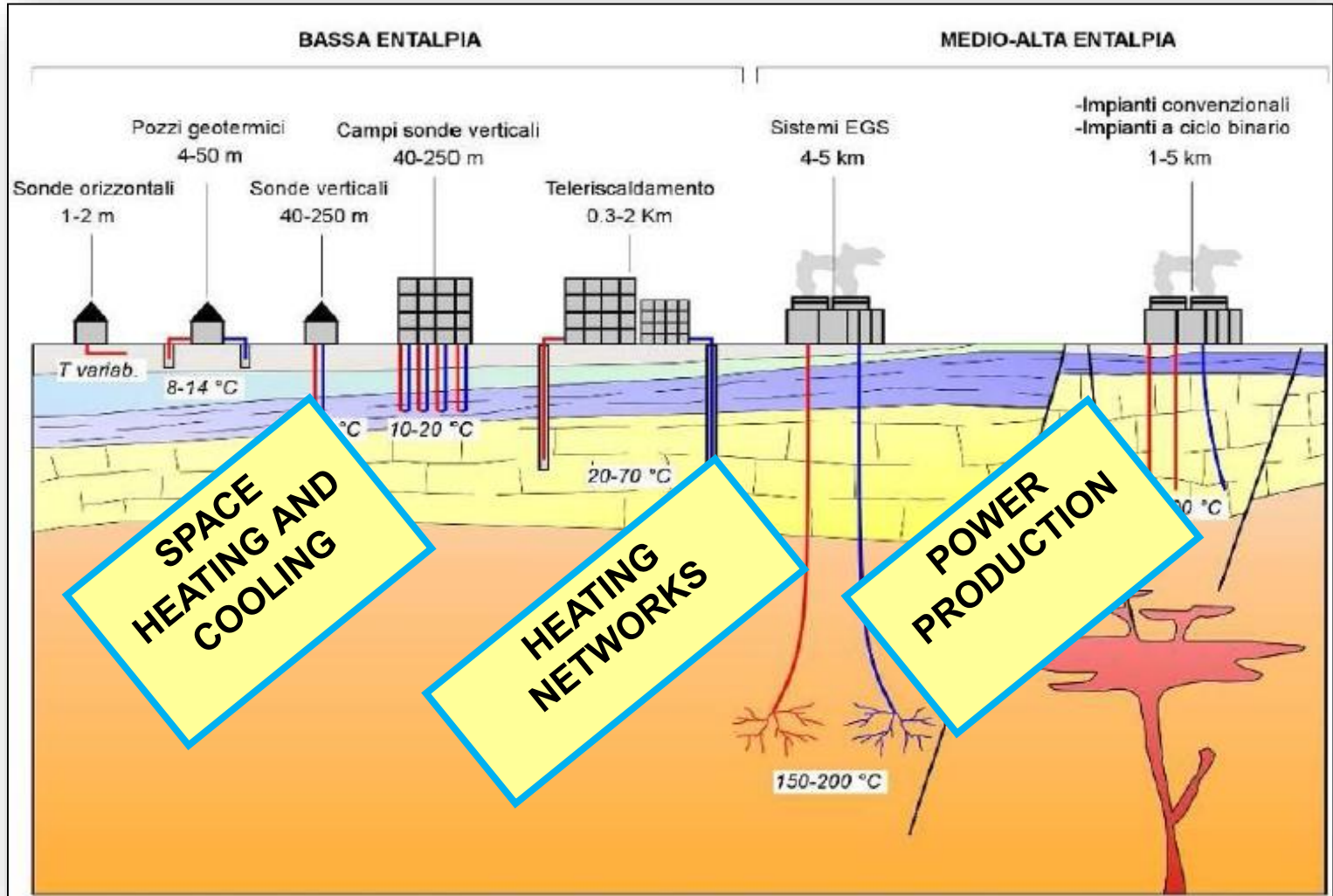
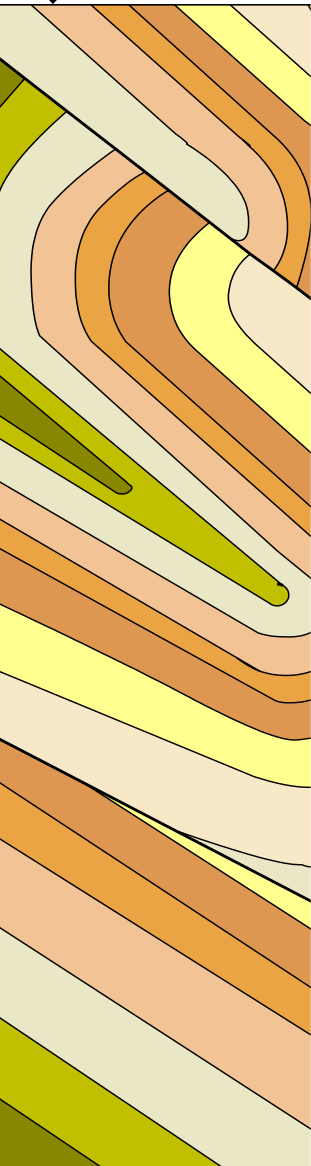
Average temperature $25-90^{\circ}\text{C}$
(thermal energy production)



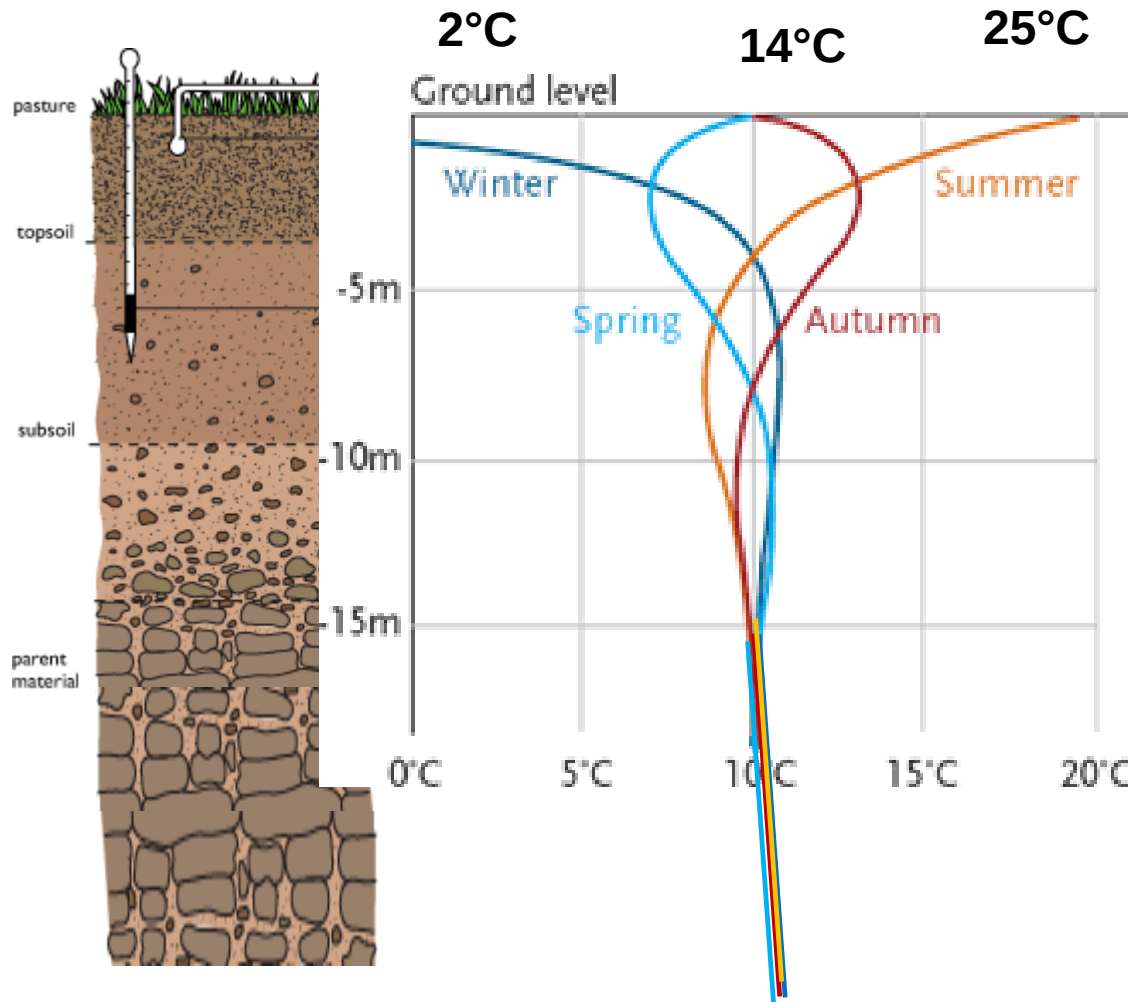
Low temperature $> 90^{\circ}\text{C}$
(thermal energy production)







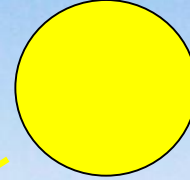




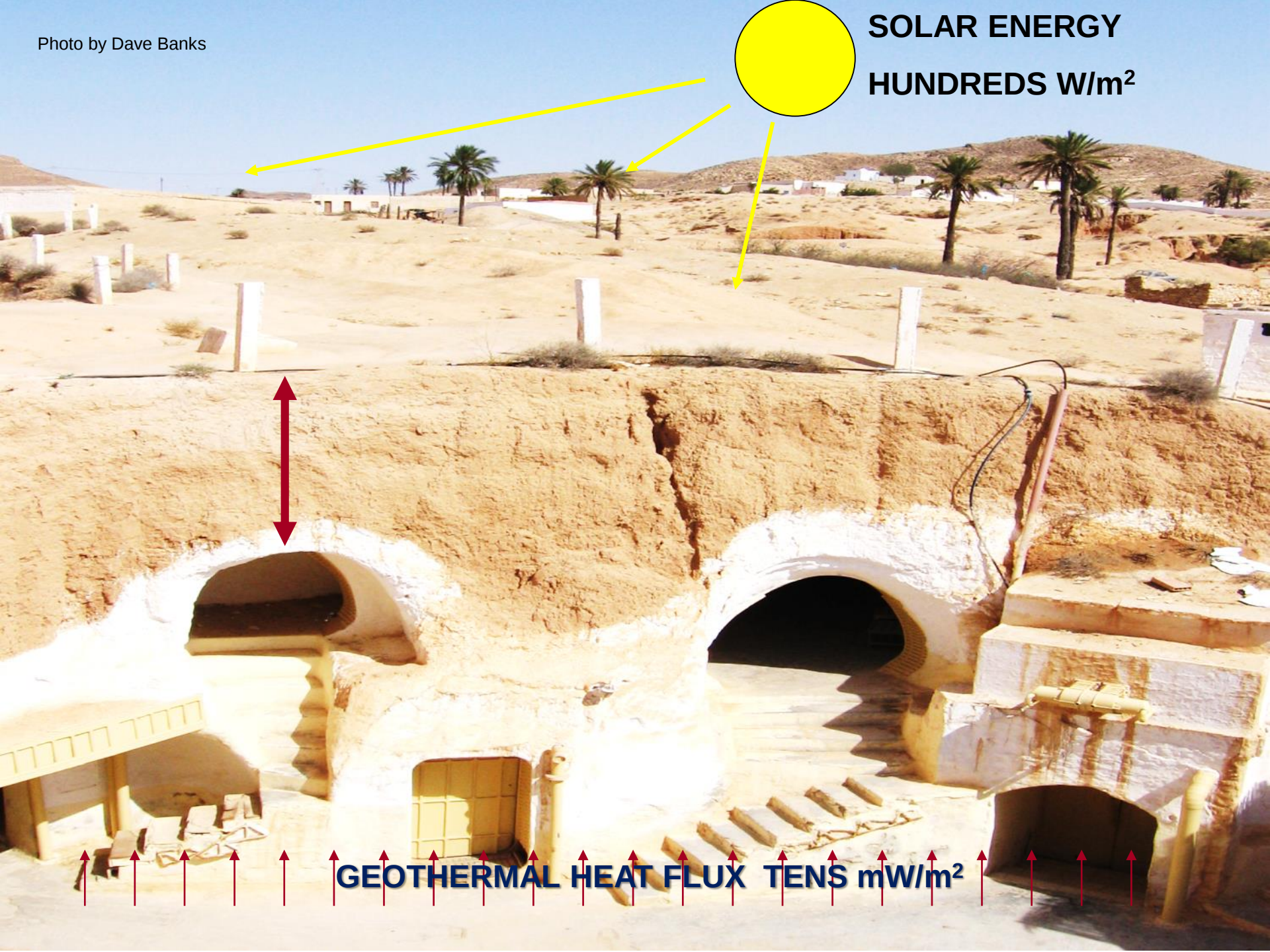
$$grad = 0,03 \frac{K}{m}$$

$$heat\ flux \left[\frac{W}{m^2} \right] = grad \times \lambda$$

Photo by Dave Banks



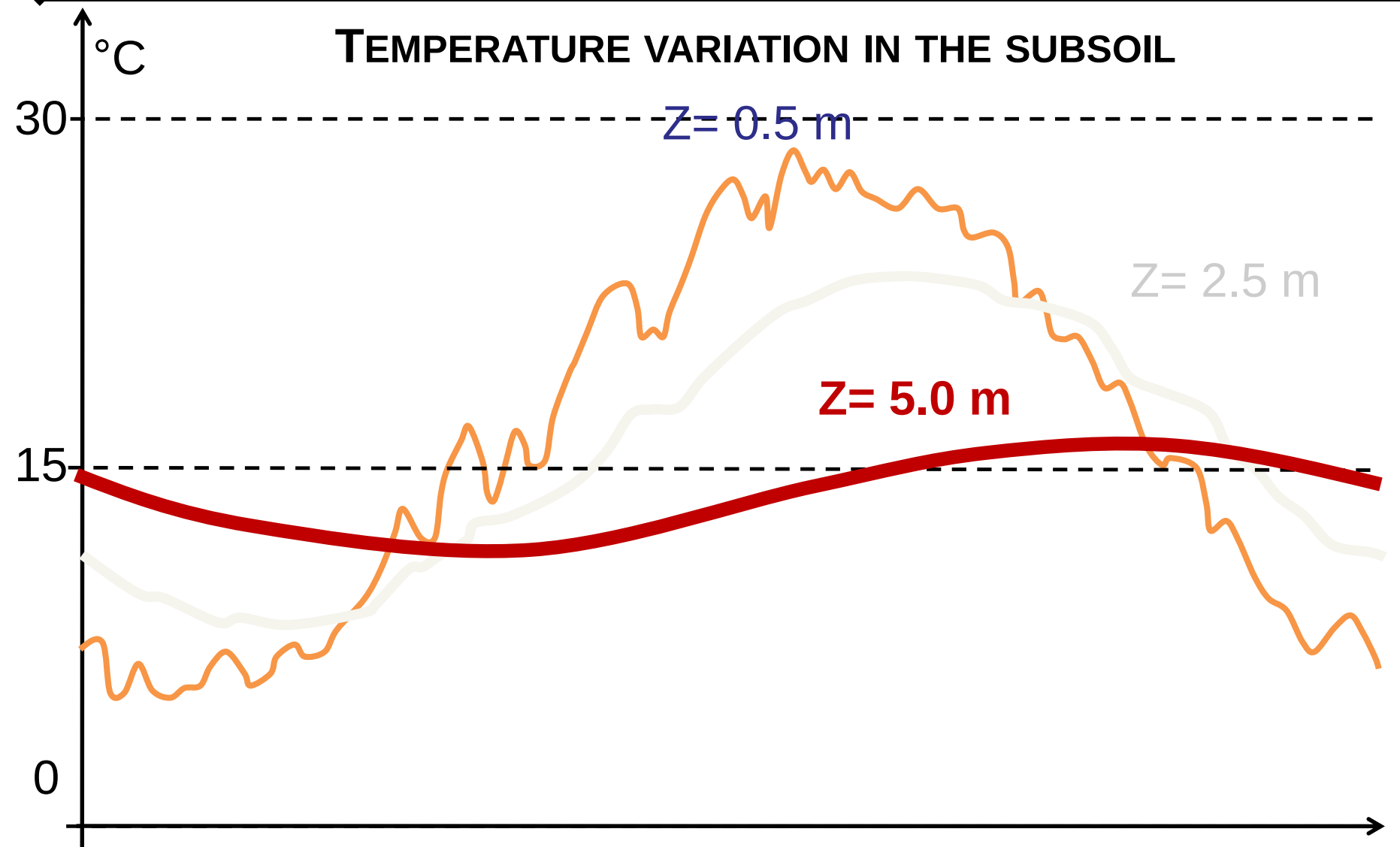
SOLAR ENERGY
HUNDREDS W/m²



GEO THERMAL HEAT FLUX TENS mW/m²



TEMPERATURE VARIATION IN THE SUBSOIL



UNDERGROUND LIVING

➤ IN THE UNESCO SITES

Petra, Giordania



Cappadocia, Turchia



Norimberga, Germania



quando il frigorifero non esisteva

Derinkuyu, Turchia



UNDERGROUND LIVING

➤ CURRENT and PAST



Matera



- prehistoric neolithic settlement
- the ancient city, "I Sassi", has been a UNESCO heritage site since 1993
- Constant T throughout the year

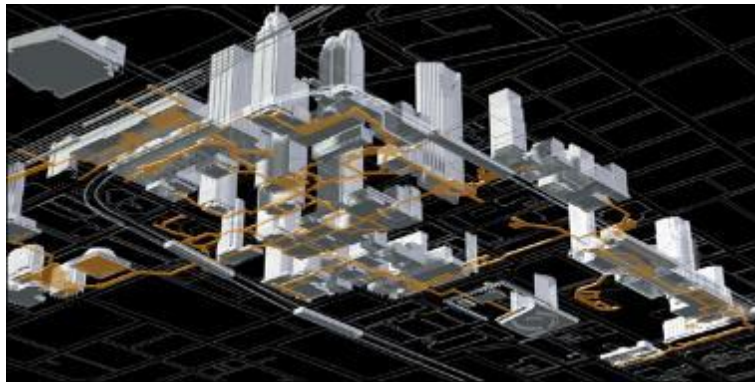
UNDERGROUND LIVING

➤ CRITICAL CLIMATE CONDITIONS

Toronto



Montreal



UNDERGROUND LIVING

➤ ONLY MOVIES OR REAL LIFE?



Hobbit Hole, Lord of the Rings



by D. Banks

Traditional house shelter Selkup-Siberia

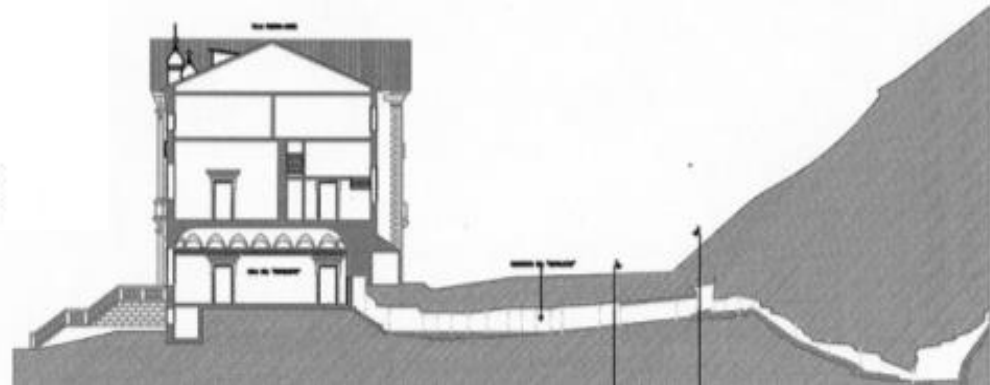
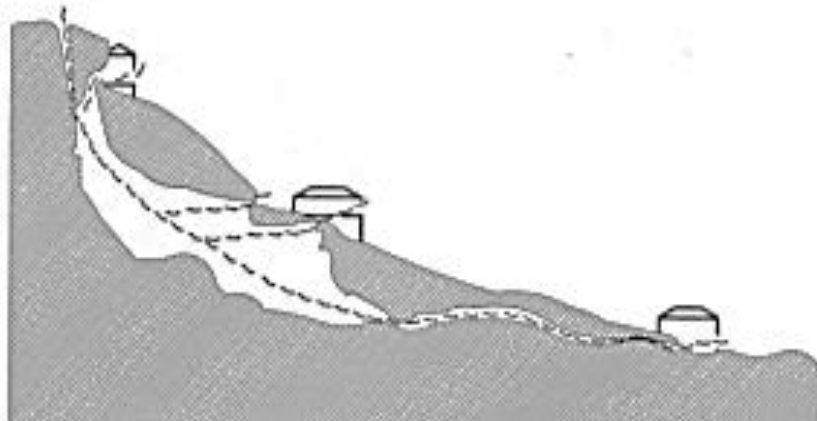
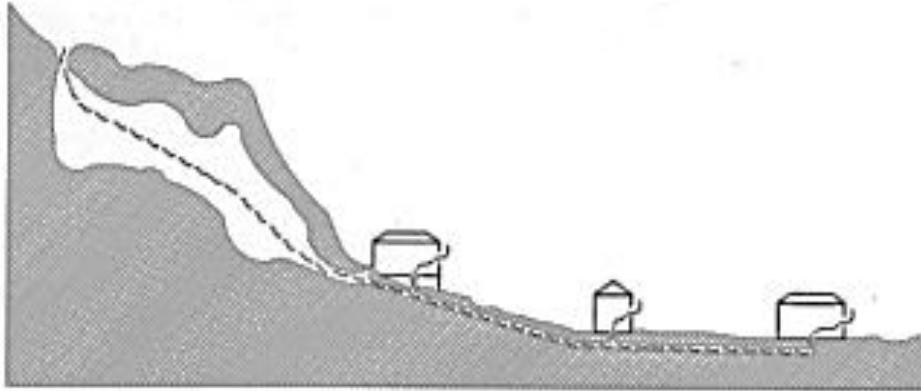


Tatooine, Star wars



Tataouine, Tunisia

Villa Aeolia (VI): AN EXAMPLE FROM THE PAST (1560)



WHY LIVES UNDERGROUND?

advantages of underground houses:

weather resistance (hot and cold T)

quiet living space

discreet presence in the surrounding landscape,

almost constant internal temperature due to the natural

insulating properties of the surrounding soil

energy efficiency

environmental compatibility

natural materials

disadvantages

possibility of flooding

possible falls or rock slips

insufficient internal lighting

creation of craters, sinkholes

cracks in buildings

air exchange

FREE ENERGY SOURCES

AIR



Advantages:
 Unlimited availability
 Easy installation
 Low cost

Disadvantages:
 Noise
 Efficiencies
 Aesthetics

WATER

grounwater



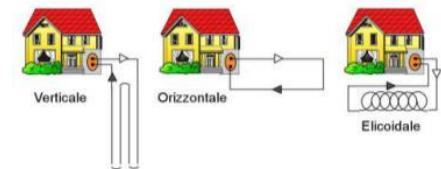
Advantages:
 High efficiency
 Easy installation
 Zero local emissions
 Intermediate costs

Disadvantages:
 Limited availability
 Licensing difficulties

river, lake, sea



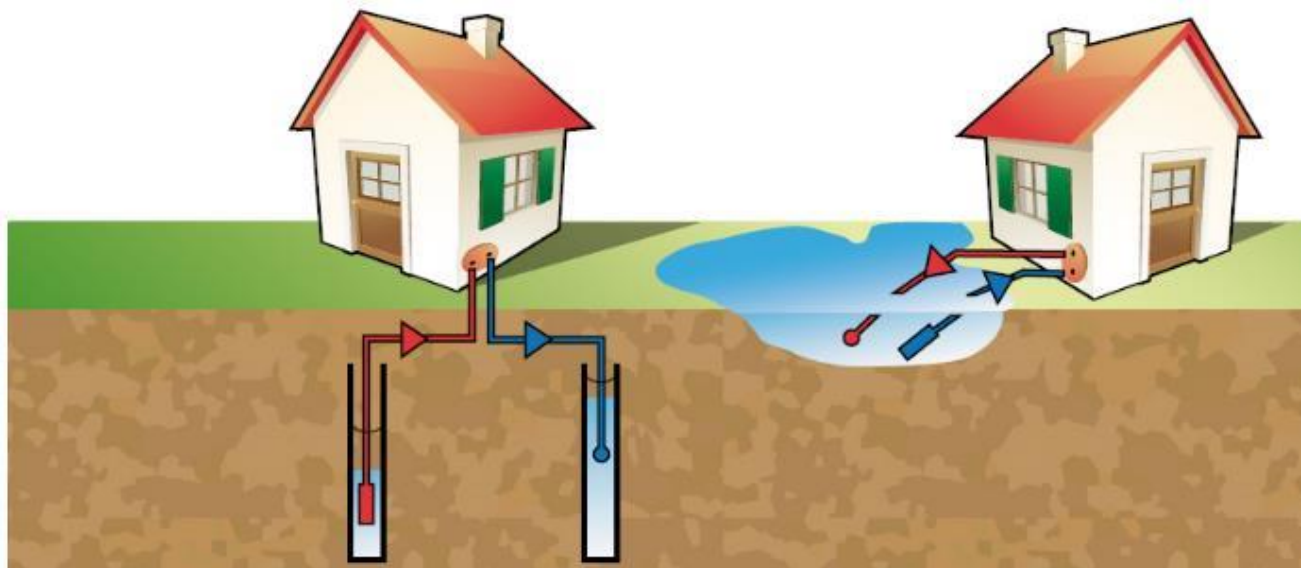
GROUND



Advantages:
 Ubiquitous availability
 Significant efficiencies
 Low thermal impact
 Zero local emissions

Disadvantages:
 High cost of probing field

Open loop



Closed loop



SONDE GEOTERMICHE VERTICALI

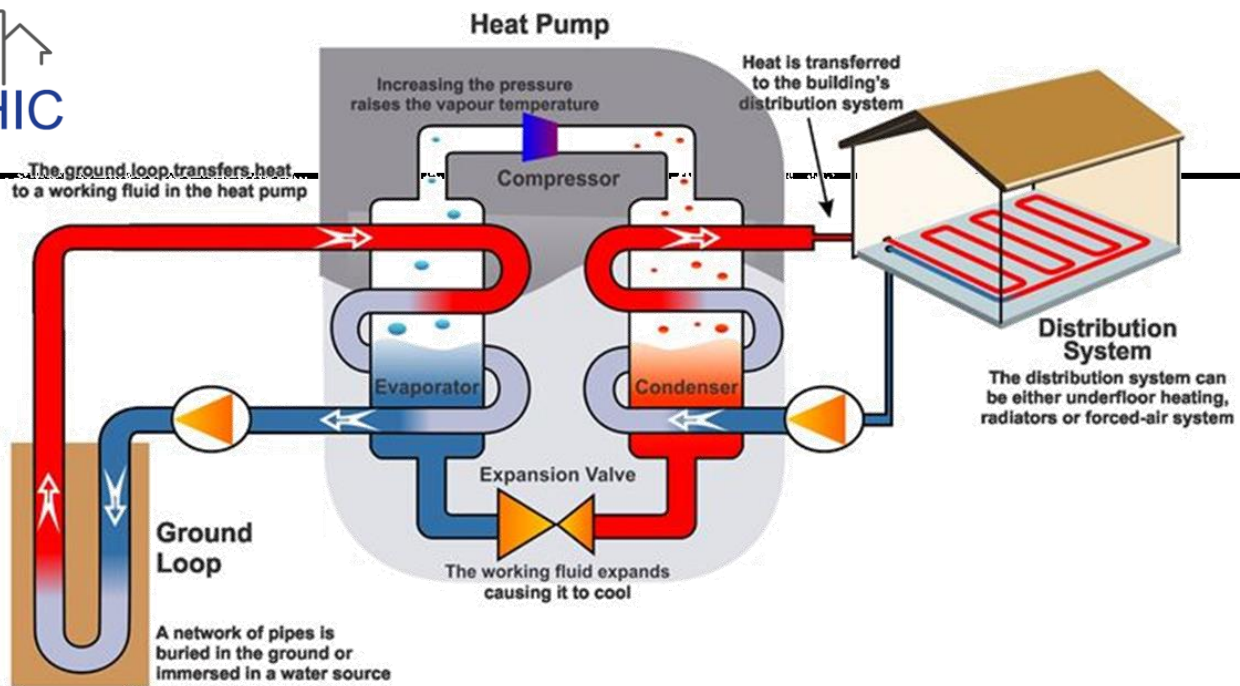
Vertical borehole heat exchangers 100÷130 m



**Vertical borehole 20÷30 m
Vibro-drilling**



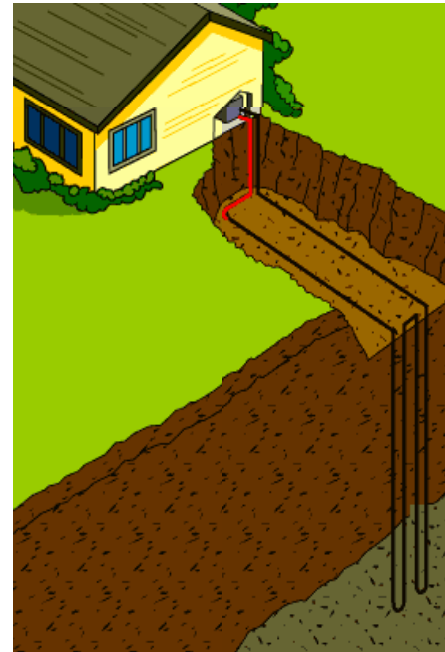




winter



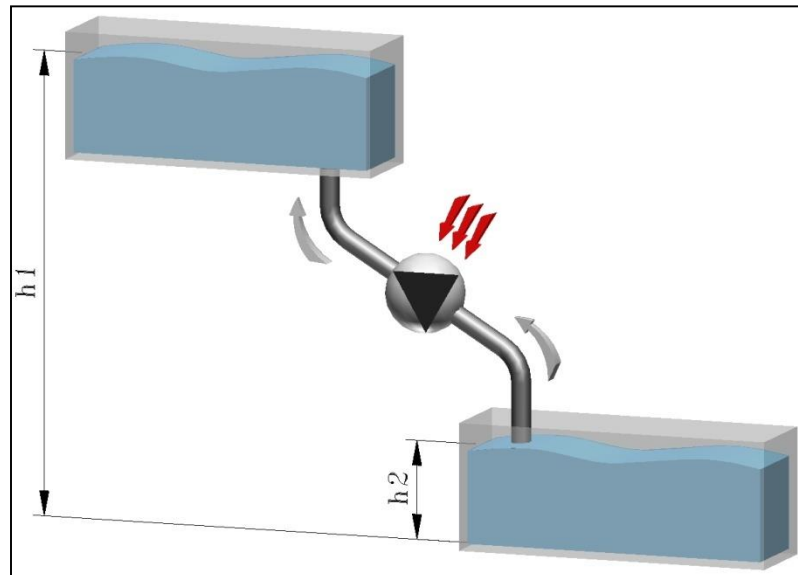
summer



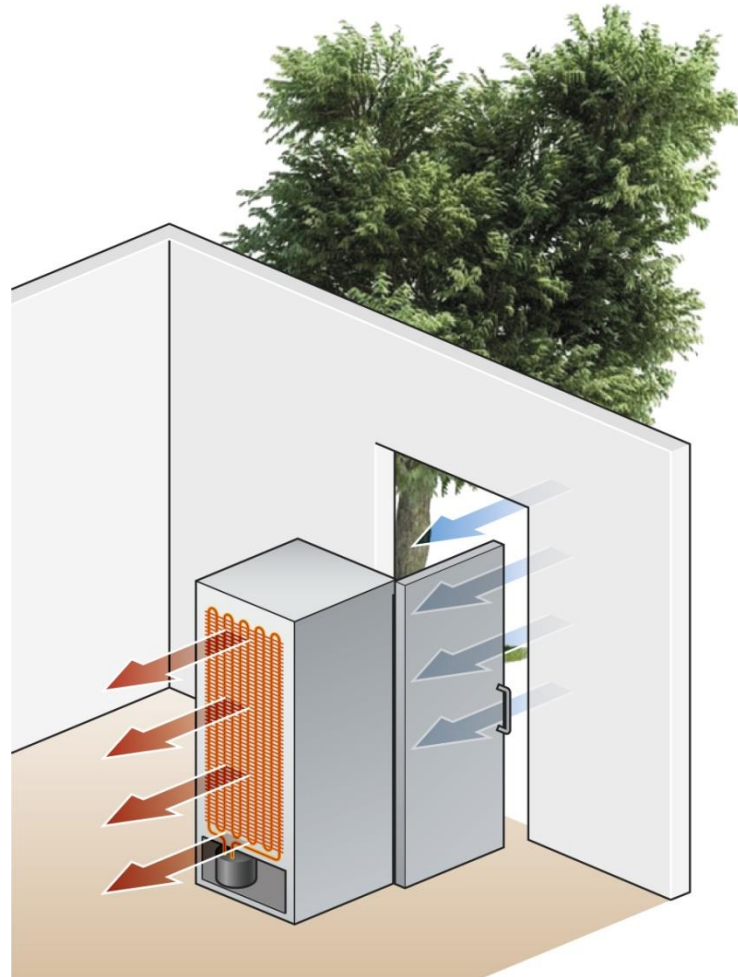
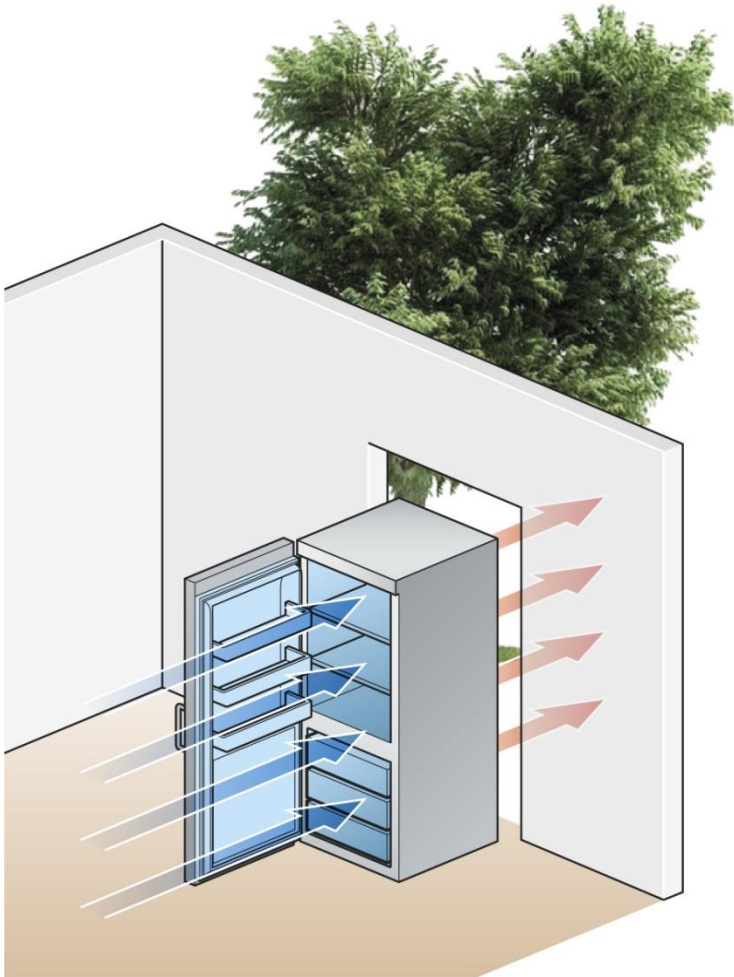
Thermodynamic / Hydraulic analogy in the operation of a Heat Pump:

➤ II^o Principle of Thermodynamics: the transfer of a quantity of heat from a "cold" body to a "hot" one is allowed only through the use of mechanical work In Hydraulics:

➤ the transfer of a quantity of water from a lower basin to an upper one can only take place through the use of a pump, therefore with expenditure of mechanical energy

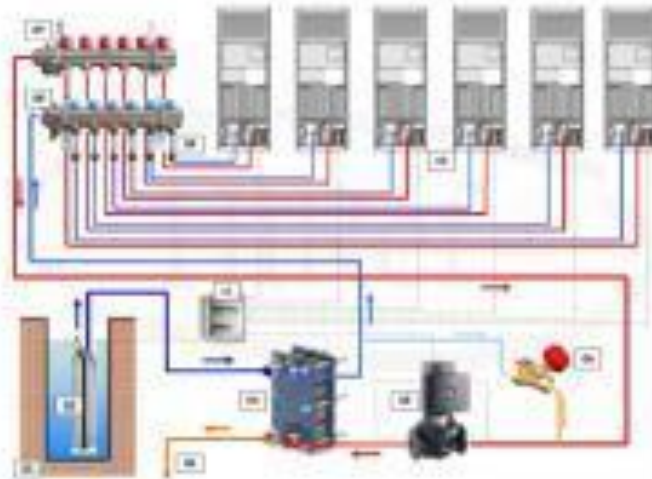


Example at home: refrigerator



Practical examples





(modi) antichi, maufacati con pareti in cartongesso.



Sopra, l'ingresso era molto, sotto la sala dei suoi di alimentazione delle macchine.

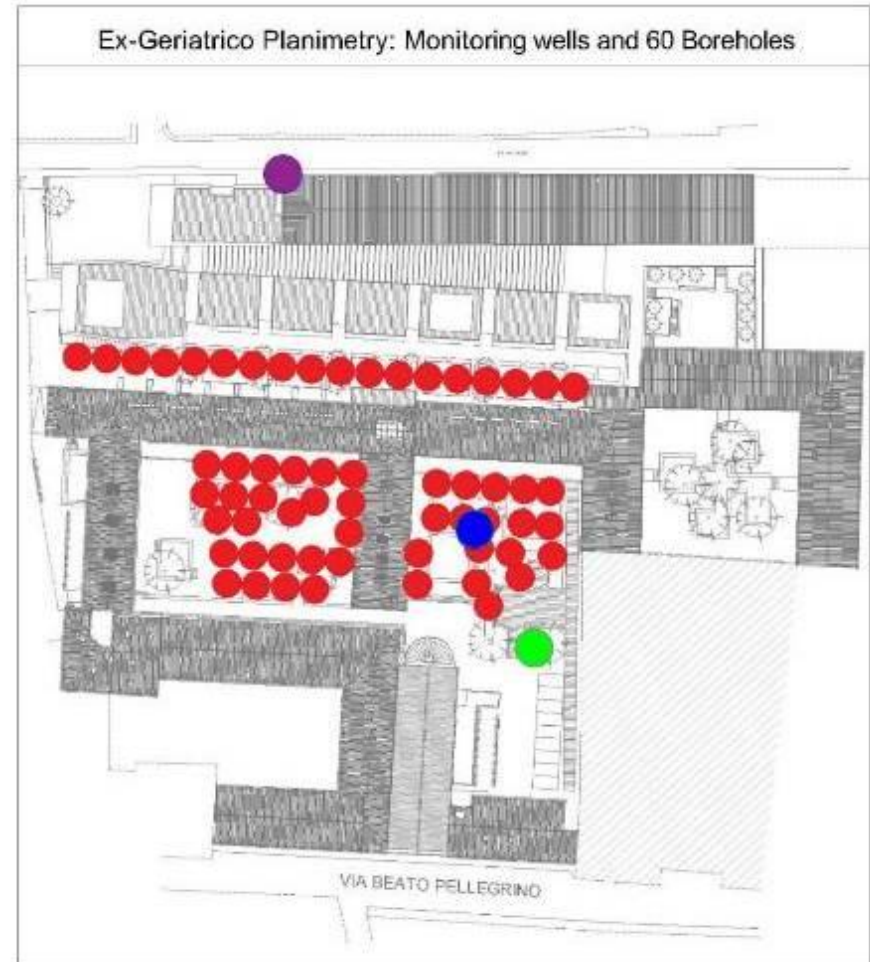
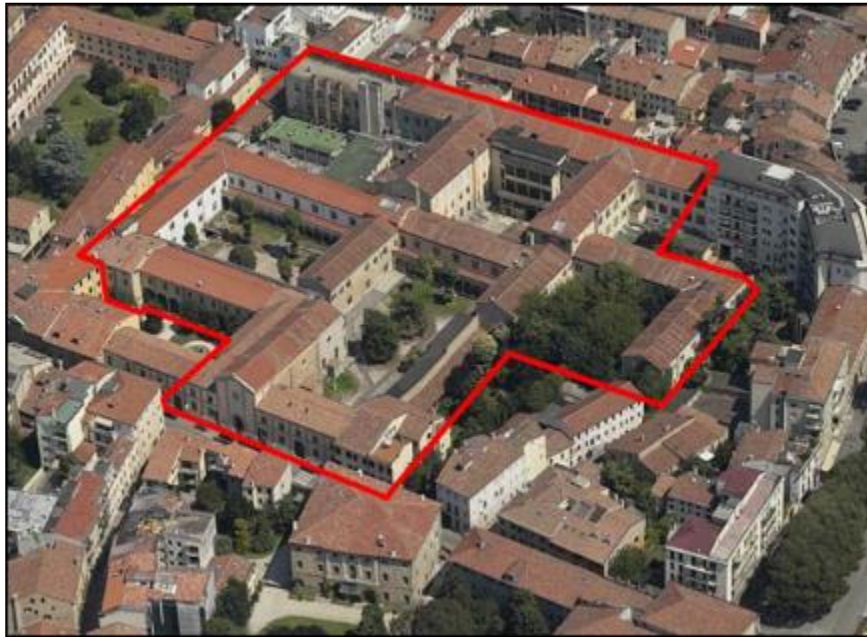
HYDROTHERMAL = exploitation of surface water (lagoon, lake, marine, river) as a thermal source for the air conditioning of buildings, coupled with heat pump systems, in both summer and winter operation.

Italian examples: Ancona (Mole Vanvitelliana), Genova (Acquario e Accademia Navale)

International examples: Oslo (cittadella universitaria), Stoccolma, Helsinky, Zurigo, Parigi (quartiere ex Renault), Atene (aeroporto), Cina (Xinghai), Hong Kong





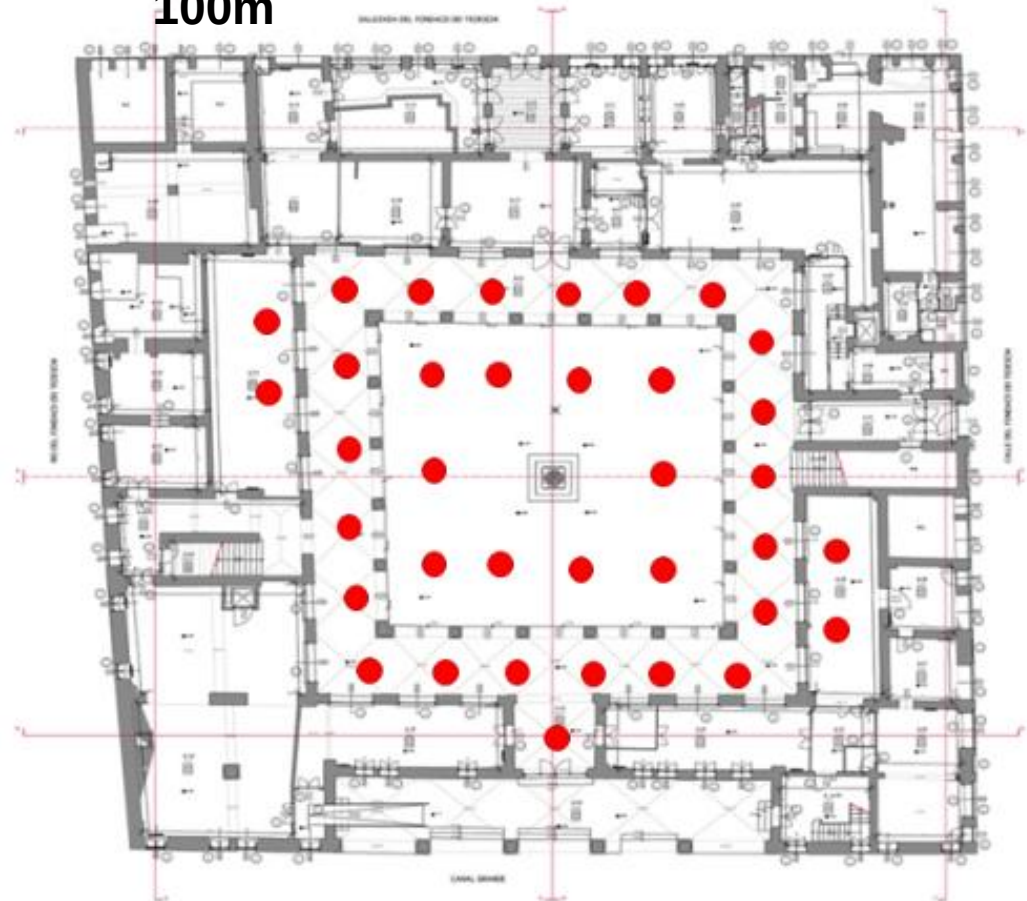


- geothermal system 60 BHEs, depth 120m
- 2 reversible HP (192.6 / 168.4 kWt)
- auxiliary systems radiant panel heating/cooling system (60 W/m²)



potenza riscaldamento: 364,8 KW
potenza raffreddamento: 298,2 KW

46 sonde
doppia U
100m





esempio – fondaco dei tedeschi a Venezia







What Iggy means is,
during the summer when
it's hot outside, it's cool in
his underground home...



And in the winter when it gets very cold,
Iggy's home stays warm and cozy.

