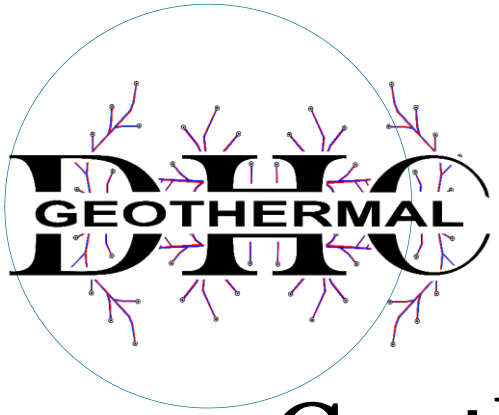

NTNU
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Geothermal Energy Pile for Heating/Cooling Buildings

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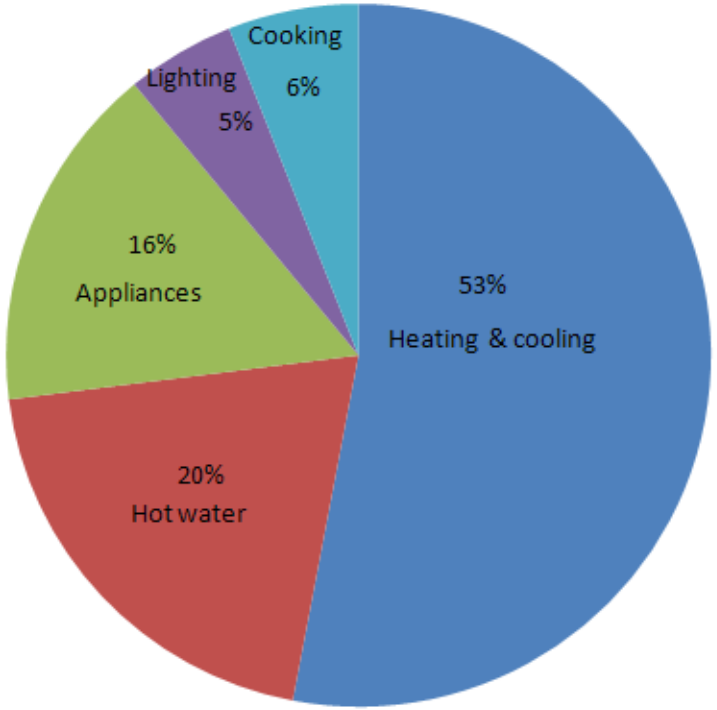
cost
EUROPEAN COOPERATION IN SCIENCE & TECHNOLOGY

Presentation overview

- Ground energy
- Ground source heat pump
- Geothermal Energy Pile
- Case studies
- Conclusions

Energy usage

- **73% energy is being used for heating/cooling and hot water**
- **Every house is responsible for 20,000 kg (20 tonnes) of greenhouse gas emissions (GHG) per year**
- **Conventional heating/cooling system efficiency 50% to 80%**
- **Carbon tax, energy is getting more expensive**
- **Reduce energy use and GHG emission save the world**

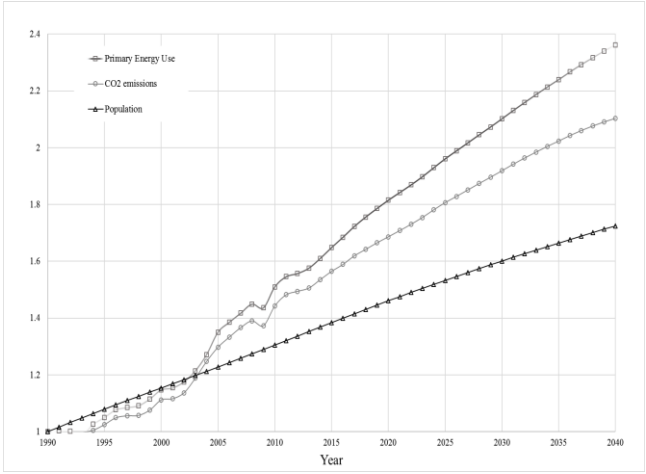


Average home energy use

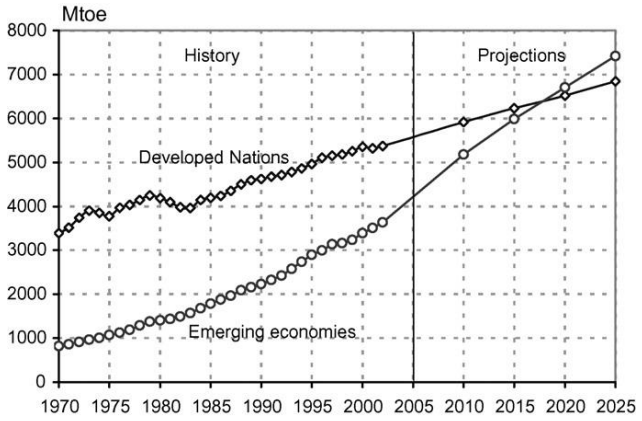
Energy usage

- **According to the International Energy Agency between 1990 and 2020**
  - Energy consumption increased by almost 80%
  - GHG emission increased by 70%
  - Population increased by 48%

- **Energy use of emerging nations such as China, India, South Africa, Brazil will exceed by 2020 that for developed nations**



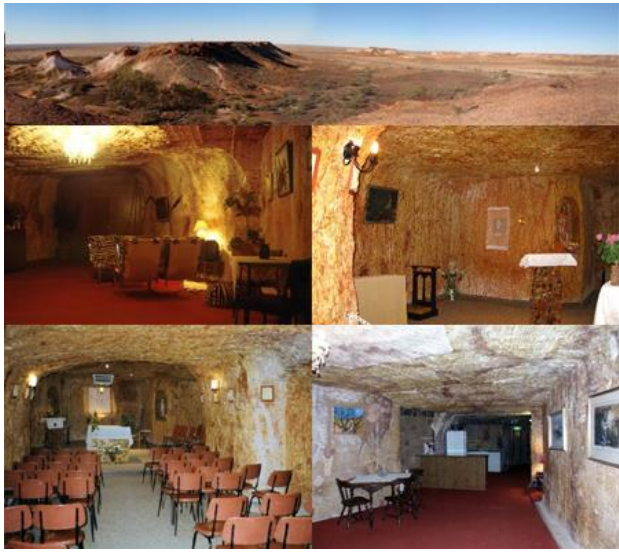
Energy consumption, CO2 emissions and world population (Energy Information Administration, USA 2006)



Developed and emerging nations energy usage (Energy Information Administration, USA 2006)

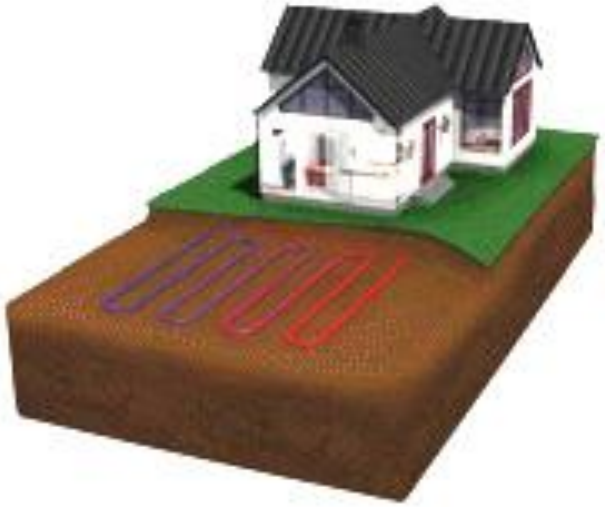
What is ground energy

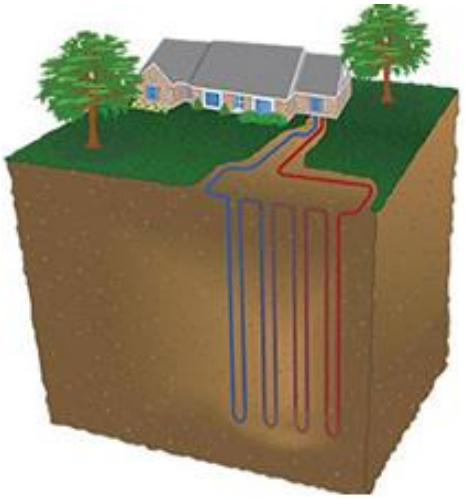
- **Ancient concept: caves, underground houses, wine cellar**
- **Ground has stable temperature throughout the year and it is equal to the average annual temperature**
- **Ground is warmer than air in winter and cooler than air in summer**



How does it work?

- **What do we need?**
  - **Ground**
  - **Heat exchanging loop**
  - **Heat Pump**
- **What is heat exchanging loop?**
  - Plastic pipe (HDPE)
  - Fluid (water or water + glycol)
- **Horizontal loop**
  - Lot of space available
  - Trenches
  - Horizontal bore holes
- **Vertical loop**
  - Limited space
  - Vertical Bore hole





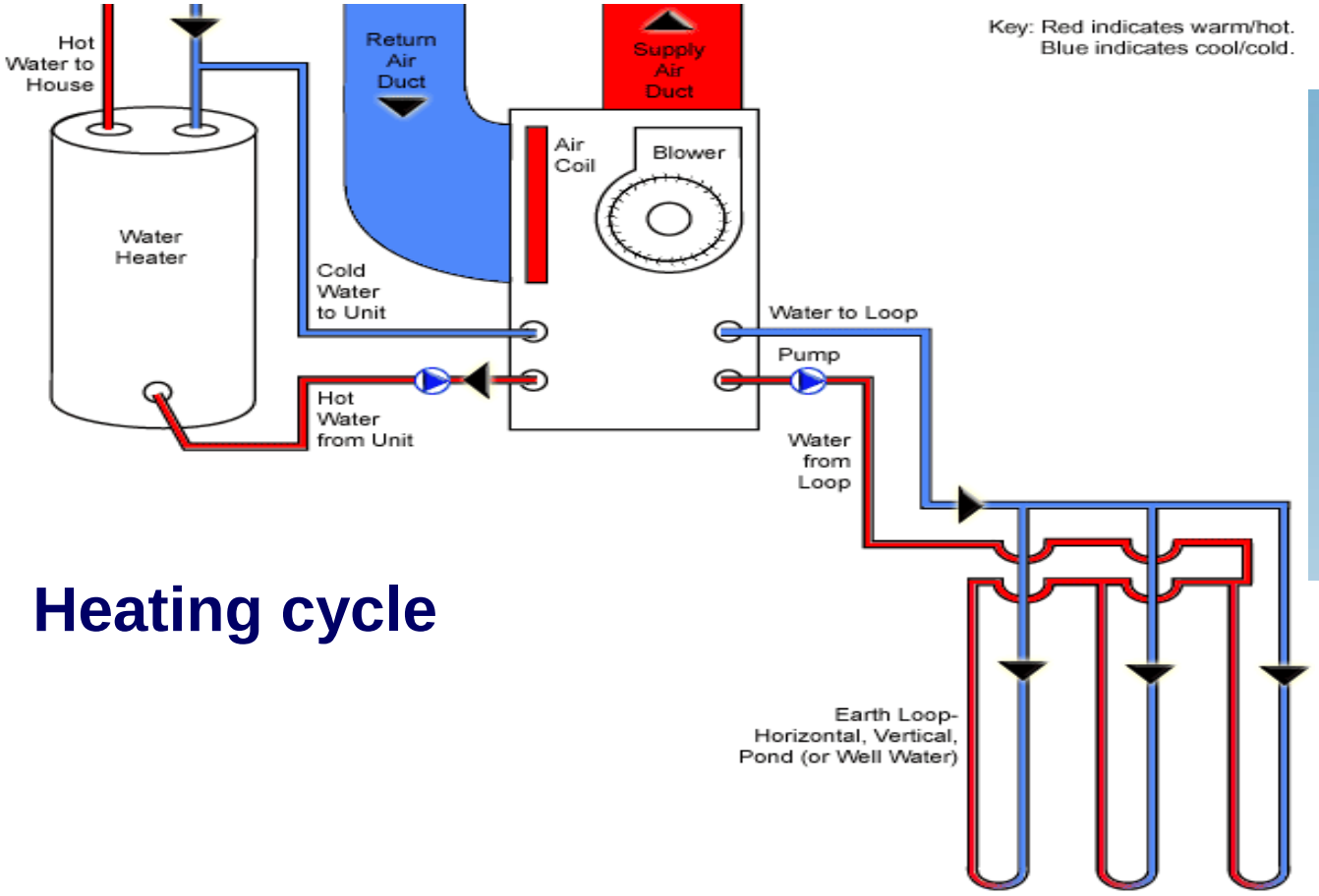
Open loop GSHP

- Aquifer
- if water table is high and stable
- Beware of ground water flow direction
- Low installation cost
- Strict regulations (in some countries it is banned)

Water source heat pump (WSHP)

- Pond, lake, river, sea
- Open and close loop
- Low installation cost

Heat pump

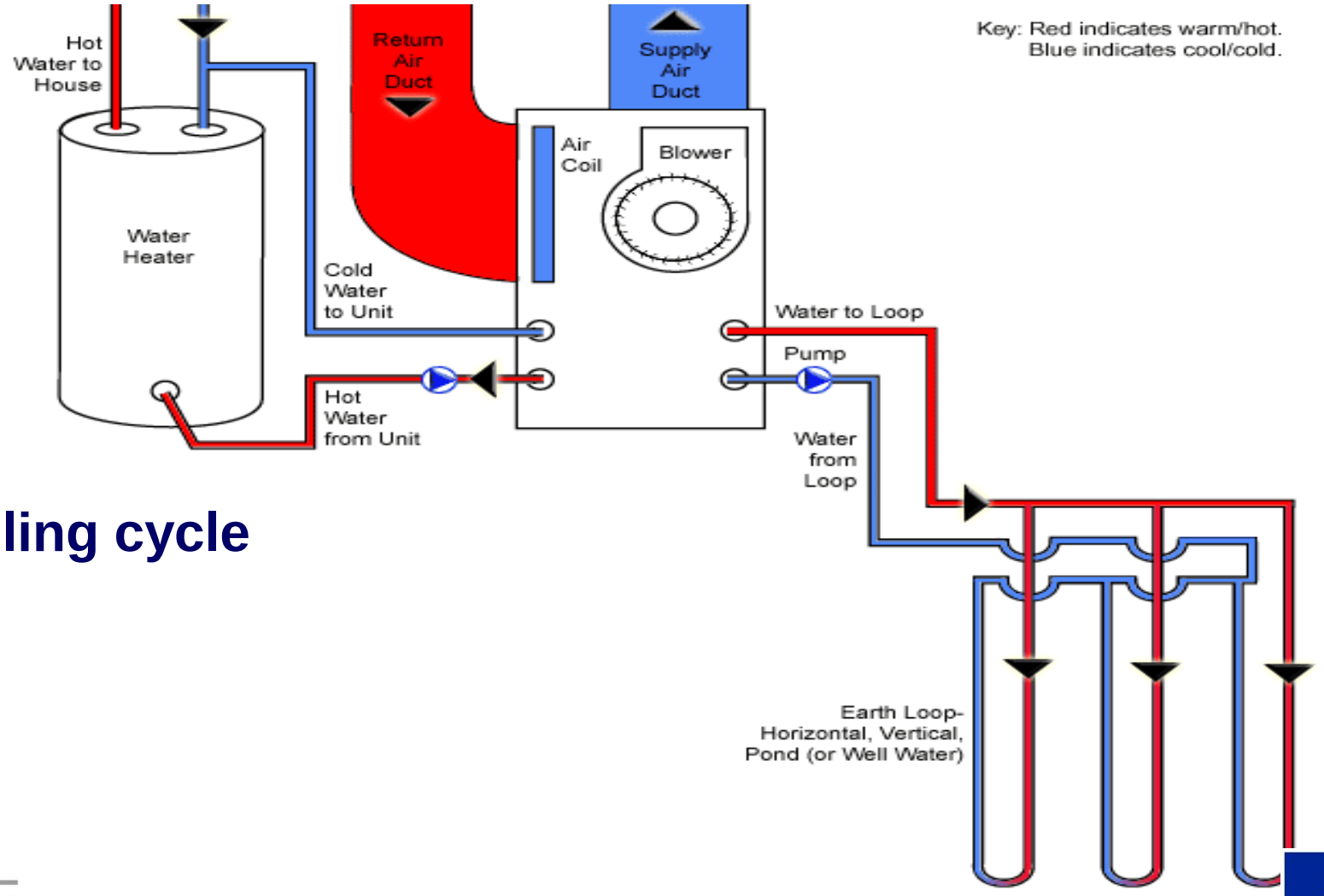


Key: Red indicates warm/hot.
Blue indicates cool/cold.

Heating cycle

Image source: Geoexchange

Heat pump



Cooling cycle

Image source: Geoexchange

Case study

- **Gloucester Police Headquarters, Quedgeley, Gloucester, UK**
  - Three storey building 8500 m^2
  - Vertical closed loop
  - 150 bore holes, 98 m deep
  - 860 kW Cooling and 765 kW Heating
  - 9 Reversible heat pumps
  - Active CO_2 Management
  - Completed October 2005
  - Energy savings of 36%
  - Savings of £60,000 per year running cost

Source: GI Energy

Case study

- **Robert Gordon University, Garthdee Campus, Aberdeen, UK**
  - New campus located next to river Dee
  - Aberdeen known as granite city
  - Granite rock (hard to drill in)
  - Vertical closed loop
  - 66 bore holes, 220 m deep
  - 900kW Cooling and 900 kW Heating
  - CoP of 5 for heating and 6 for cooling
  - Largest commercial GSHP in Scotland
  - Completed October 2013

Source: GI Energy

Case study

- **Kingsmill Hospital, Mansfield, Nottinghamshire, UK**
  - King's Mill reservoir used for water supply and recreation
  - Close loop lake system
  - 140 stainless steel heat exchangers under the surface of the reservoir (hidden by floating reed beds to protect the heat exchangers and new habitat for wildlife)
  - 42 water source heat pump units
  - 5.4 MW cooling and 5 MW heating system, largest in Europe
  - CoP of 6.0 for cooling and 3.8 for heating
  - Completion Jan 2011
  - Temperature difference of 1°C in the vicinity of heat exchangers (requirement of Environment Agency)
  - Save 9600 MWh of gas and electricity a year
  - Prevent 1,700 tonnes of CO2 entering into atmosphere which is equivalent to removing 600 cars off the road
  - Saving of £120,000 a year

Image source: Skanska

Case study

- **Plas Newydd mansion, Anglesey, Wales, UK**
  - 300 year old 18th century mansion located next to Menai Strait in Anglesey
  - Used oil for heating
  - Used 1500 litres of oil a day during winter (which normal house will use in 10 months)
  - 300 kW sea (marine) source heat pump (basically WSHP)
  - Open loop
  - 200 mm dia pipes run 53 metres to the sea covered by concrete caissons and natural stones
  - Cost £600,000
  - Saving £40,000 per year
  - Operational since May 2014
  - CoP 4.08 and SPF of 2.82

Source: National Trust

Case study

- **Kingston Heights, Kingston upon Thames, Surrey, UK**
  - Kingston Heights development next to river Thames
  - 137 apartments and 145 bedroom hotel.
  - under-floor heating and hot water
  - Open loop
  - Water source heat pump installed 2.5 m under the water surface of river Thames
  - 2.3 MW heating
  - Water is abstracted and passed through stainless steel filter fitted with automated backwash system
  - Two stage filtration system
  - Second filter system cleans up any silt
  - No marine life enter into the system
  - 13 million litres water abstracted per day (equivalent 5 Olympic size swimming pools)
  - Water fed back into the river and will remain within ±3°C of river temperature
  - 500 tonnes CO_2

Image source: Mitsubishi

Low system maintenance

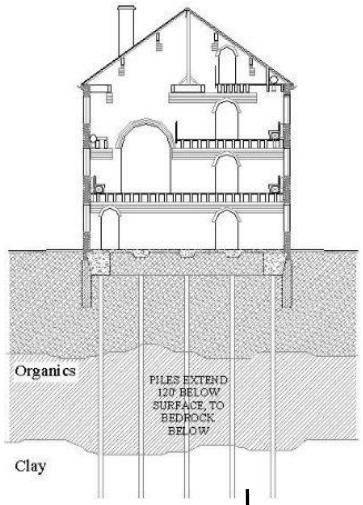
- **Lochiel Detention Centre, Adelaide, Australia**
  - 12 heat pumps installed in March 1995
  - 3 pump kits at ~£400 each
- **Bureau of Meteorology, Adelaide, Australia**
  - 3 units installed in September 2002
  - 1 Printed Circuit Board and 1 loop flush at ~£375
- **Bandiana Army Headquarters, Wodonga, Victoria, Australia**
  - 15 units installed in March 1999
  - 1 blower electronics at ~£225
- **Mt Barker TAFE, Mt Barker, SA, Australia**
  - 29 units installed in May 1997
  - 1 blower motor at ~£125
- **Geoscience Australia, Jerrabomberra, Canberra, Australia**
  - 229 units installed in December 1997
  - 3 compressors and 5 high pressure switch kits at ~£2000

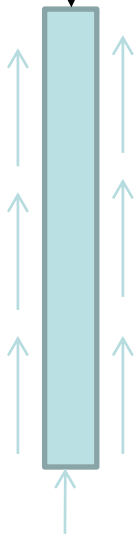
Source: Geo Exchange

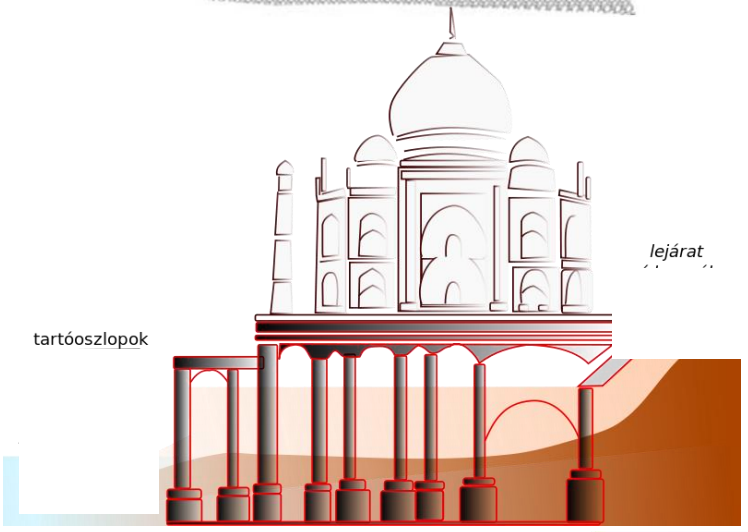
Geothermal Energy Pile

- **What is a Pile?**

- **Deep foundation**
- **Soft ground**
- **High-rise buildings**







- **Skin friction and end bearing**

Geothermal Energy Pile

- Vertical loop
- Cost effective
- Land

Case study

- **The Crystal, Docklands, London, UK**
  - Siemens
  - Permanent exhibition on sustainability
  - Most sustainable building in London
  - Vertical close loop
  - Geothermal energy piles
  - 614 kW cooling
  - 614 kW heating
  - Completed 2012

Source: GI Energy

Case study

- **NEO, Bankside, London, UK**
  - Three apartment towers
  - Vertical closed loop
  - 130 geothermal energy piles, 52 m deep
  - 650 kW cooling
  - 760 kW heating
  - 7 heat pumps of 130 kW capacity each
  - Completed 2011

Source: GI Energy

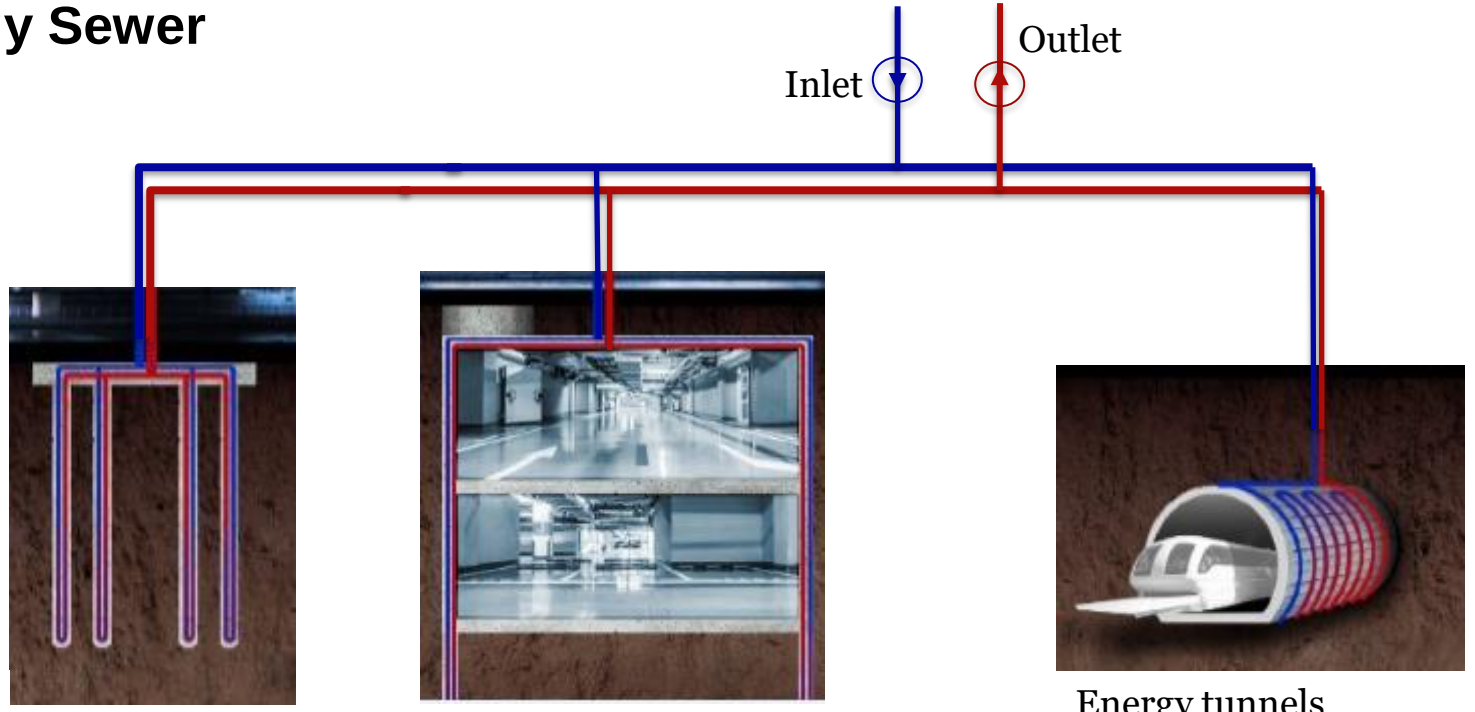
Case study

- **Bvlgari hotel, Knightsbridge, London, UK**
  - Vertical closed loop
  - Geothermal energy piles
  - Diaphragm walls
  - 2000 kW cooling
  - 2000 kW heating
  - Completed 2013

Source: GI Energy

Energy Structures

- Underground structures
- Energy Piles – very popular, most common
- Energy Tunnels
- Energy Diaphragm Walls
- Energy Sewer



Energy piles

Energy diaphragm walls

Energy tunnels

Conclusions

- It is the most energy efficient, environmental friendly and cost effective way of heating or cooling a building (International Energy Agency)
- It is renewable, sustainable and reduces green house gas (GHG) emission
- 300% to 600% efficient
- One system for both heating and cooling and hot water supply
- Swimming pool can be heated as well.
- No maintenance, small space required for heat pump
- No noise
- Ground source systems are saving the equivalent of 13 million barrels of oil a year
- An average home fitted with ground source system reduces CO_2 emissions by the same amount as planting an acre of trees

Thanks for listening

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