University of Southampton

Energy Geo-Structures:
Principles, Barriers, Opportunities

Dr Fleur Loveridge
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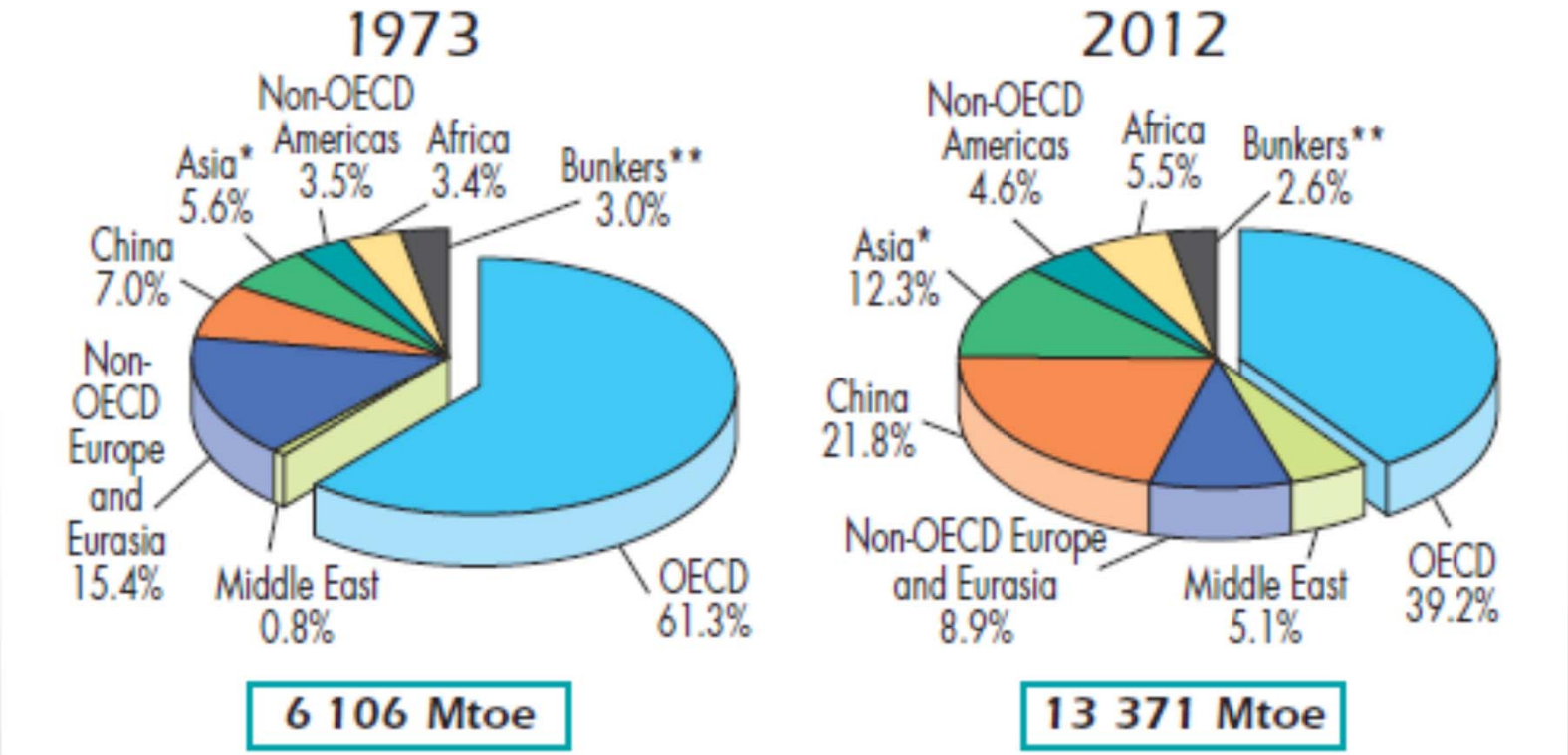
Outline

- Background
- Principles of Operation
- Types of energy Geo-Structure
  - Examples
- Barriers to uptake:
  - Cost; Construction challenges; Design issues
- Opportunities
- Summary

Background

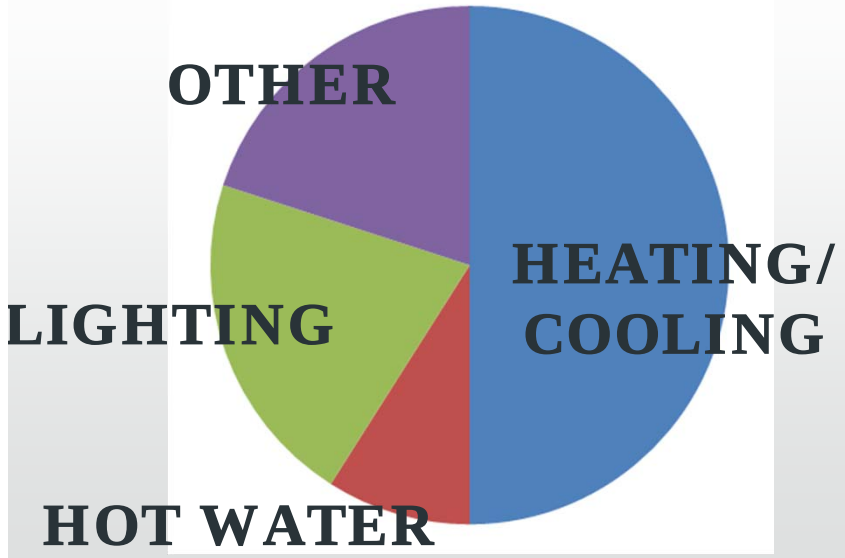


- IEA outlook for 2035:
  - 15,000 Mtoe best case (2°C limit achieved);
  - >17,000 Mtoe (new policies scenario)

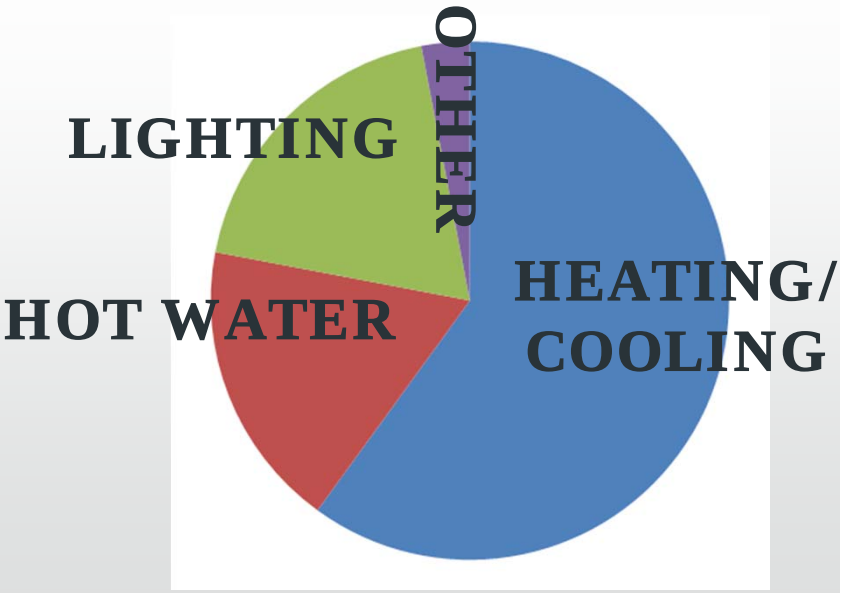
Background

In Europe & North America typical over 50% of energy consumption is heating (or cooling)

Service Industries



Domestic



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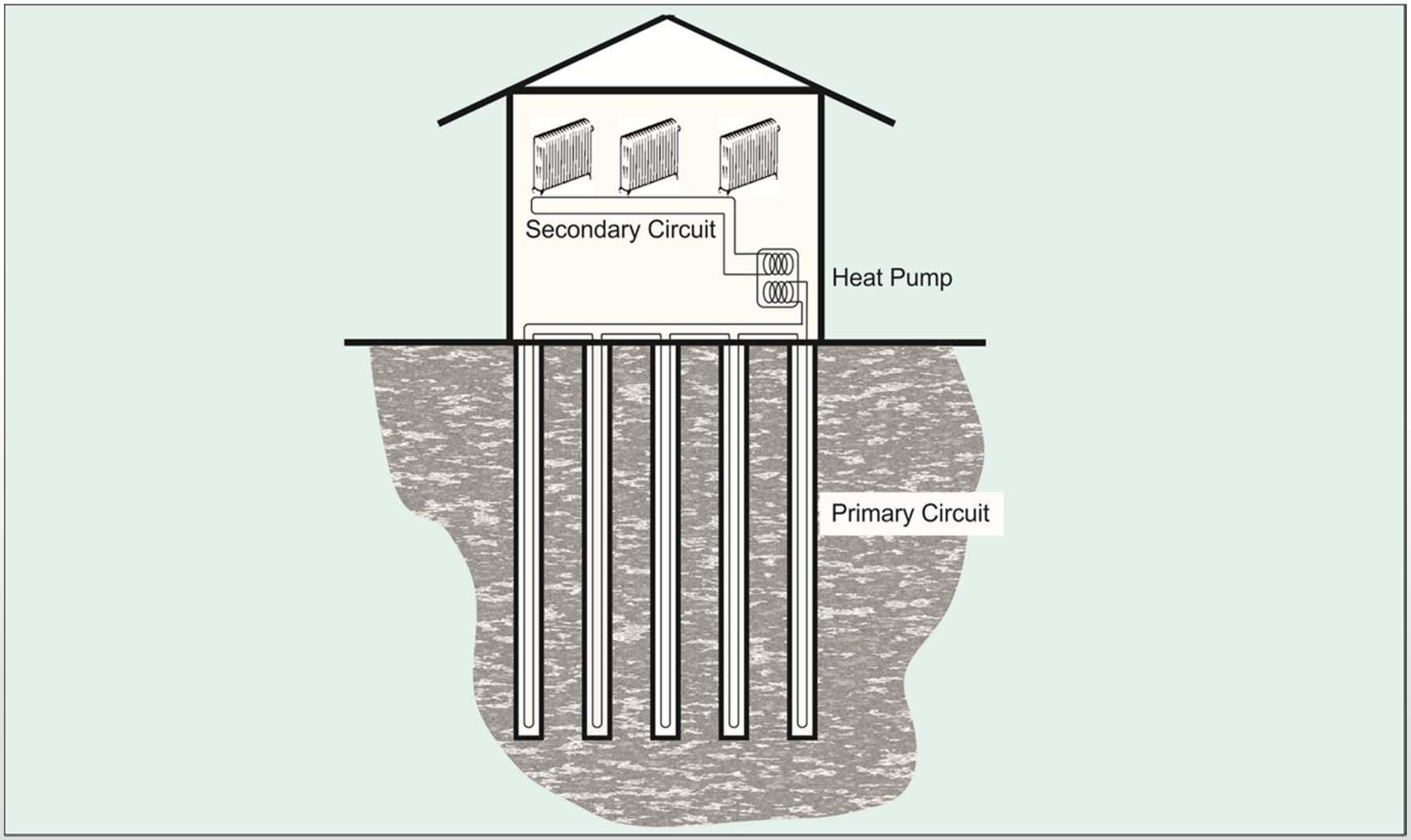
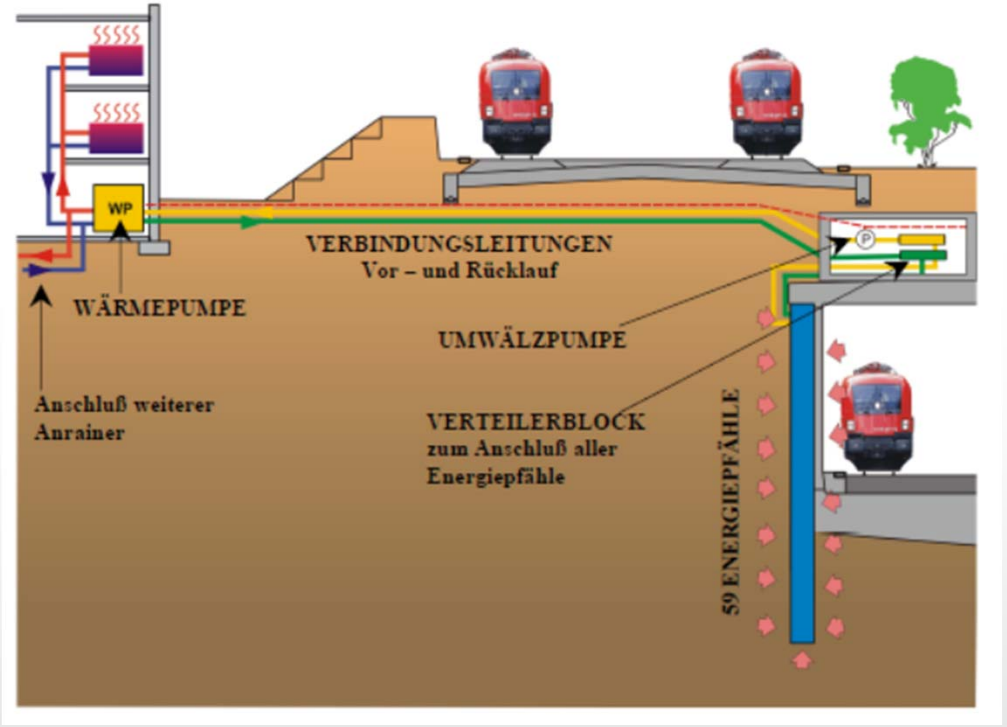
What is an Energy Geo-Structure?



Types of Energy Geo-Structure

- Piled Foundations
- Floor slabs
- Retaining Walls
- Underground Stations
- Infrastructure Tunnels
- Ground Anchors
- Sewer Systems



Advantages

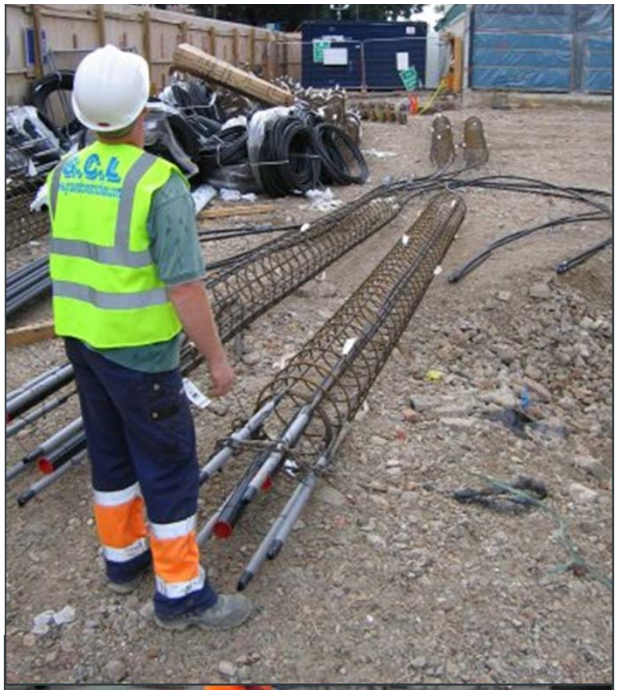
- Higher capital costs offset by
  - Lower operational costs (UK renewable heat incentive)
  - Reduced space requirements
  - Reduced maintenance
  - Reduced energy consumption
- Reduced CO2 emissions
- Almost any geological conditions

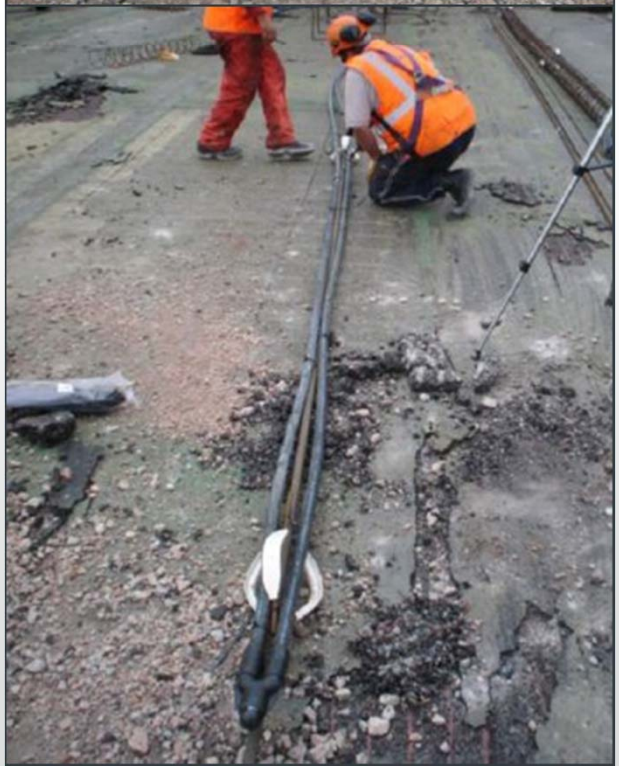
Design Objectives

- Relate temperature changes to applied thermal load (heating and cooling demand)
- Determine thermal energy capacity within temperature limits
  - Avoid freezing
  - Avoid over heating heat pump
- Confirm absence of detrimental effects on the structure

Energy Piles

- Since 1984 in Austria
- Most common energy geo-structure
- Zurich Airport
  - 406 no 0.9m to 1.5m dia piles
  - 2210 MWh of heating and 1500 MWh of cooling per year
- One New Change, London
  - over 2 MW heating and cooling
  - €90,000 annual savings

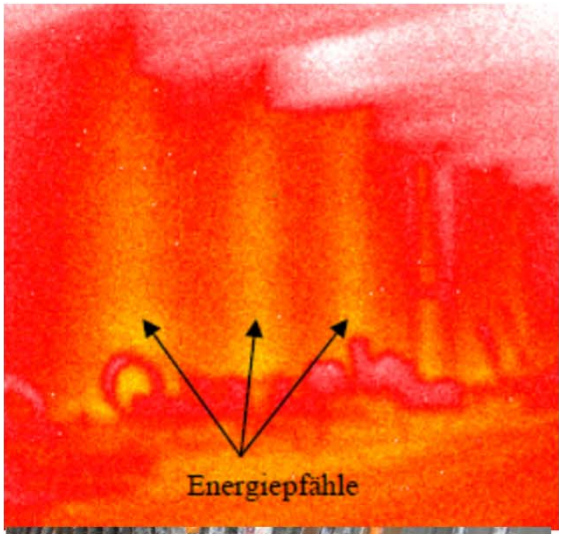




Images courtesy of Cementation Skanska

Energy Walls

- Bored piled wall or diaphragm wall
- Keble College, Oxford
  - 61 no 450mm dia energy piles
  - 74 and ~100 MWhr/yr heating & cooling respectively
- U2 Metro, Vienna
  - 1865m^2 of diaphragm wall and 1640m^2 of base slab thermally activated at Taborstrasse Station



Energy Tunnels

- Energy geotextile between linings (SCL) or embedded in precast segments
- Lainzer Tunnel, Austria
  - Trial section
- Jenbach Tunnel, Austria
  - 27 tunnel rings
  - 15 kW thermal energy supply to a building yard in Jenbach

Barriers to Uptake

- Cost
  - Efficiency needs to be greater than energy cost ratio
- Carbon Issues
  - Efficiency needs to be greater than carbon density ratio
- Construction challenges
  - Can increase costs depending on pile type & labour force skills
  - Avoid damage to installed pipes
- Design issues & lack of design guidance
- Political / institutional barriers

Payback Times

- Measured in years
- Depend on
  - Capital cost (size of system)
  - Electricity cost
  - Efficiency (COP & SPF)
  - Availability of incentive schemes
- Coefficient of Performance, ratio of useable heat energy to electricity supplied to heat pump
- Seasonal performance Factor, ratio of useable heat energy to all electricity for system (i.e. including pumps)

Summary

- Energy geo-structures offer a sustainable way to store renewable heat energy in the ground
- Operated in conjunction with a heat pump which should give >300% efficacy (COP > 3)
- Almost any geological conditions are appropriate
- Any civil engineering structure in contact with the ground may be used
- The limits are only your imagination