GEOSUSTAINED

GEOTERMIA SUPERFICIAL

Perspetivas de aplicação em contexto urbano

Opportunities for shallow geothermal energy exploitation

UNIVERSITY OF LEEDS

Professor Fleur Loveridge
University of Leeds

6 DEZEMBRO 2022

PARCEIROS

LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL · LISBOA CÂMARA MUNICIPAL · universidade de aveiro · LISBOA e·nova

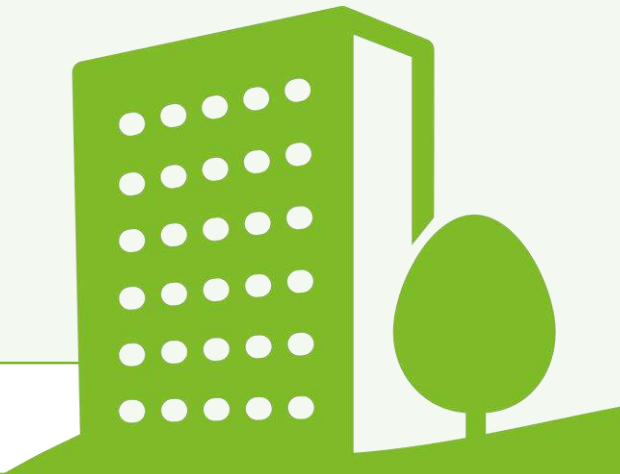
APOIO

Sociedade Portuguesa de Geotecnia · CPGA Comissão Portuguesa de Geotecnia Ambiental

INSTITUIÇÃO

(SUBSTITUIR POR LOGO DO ORADOR)

Contents



Background

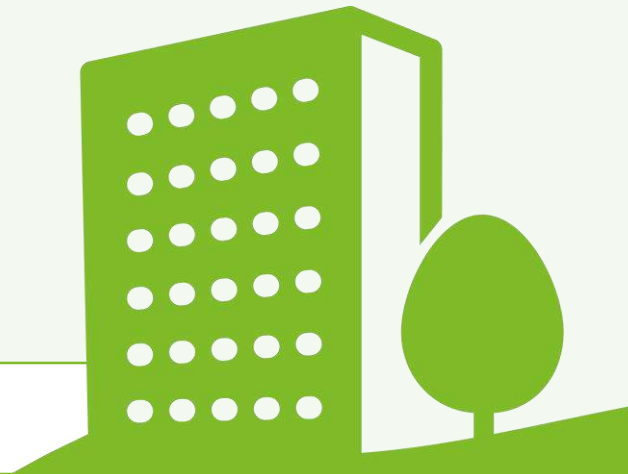


Figure 2: UK emissions in 2019

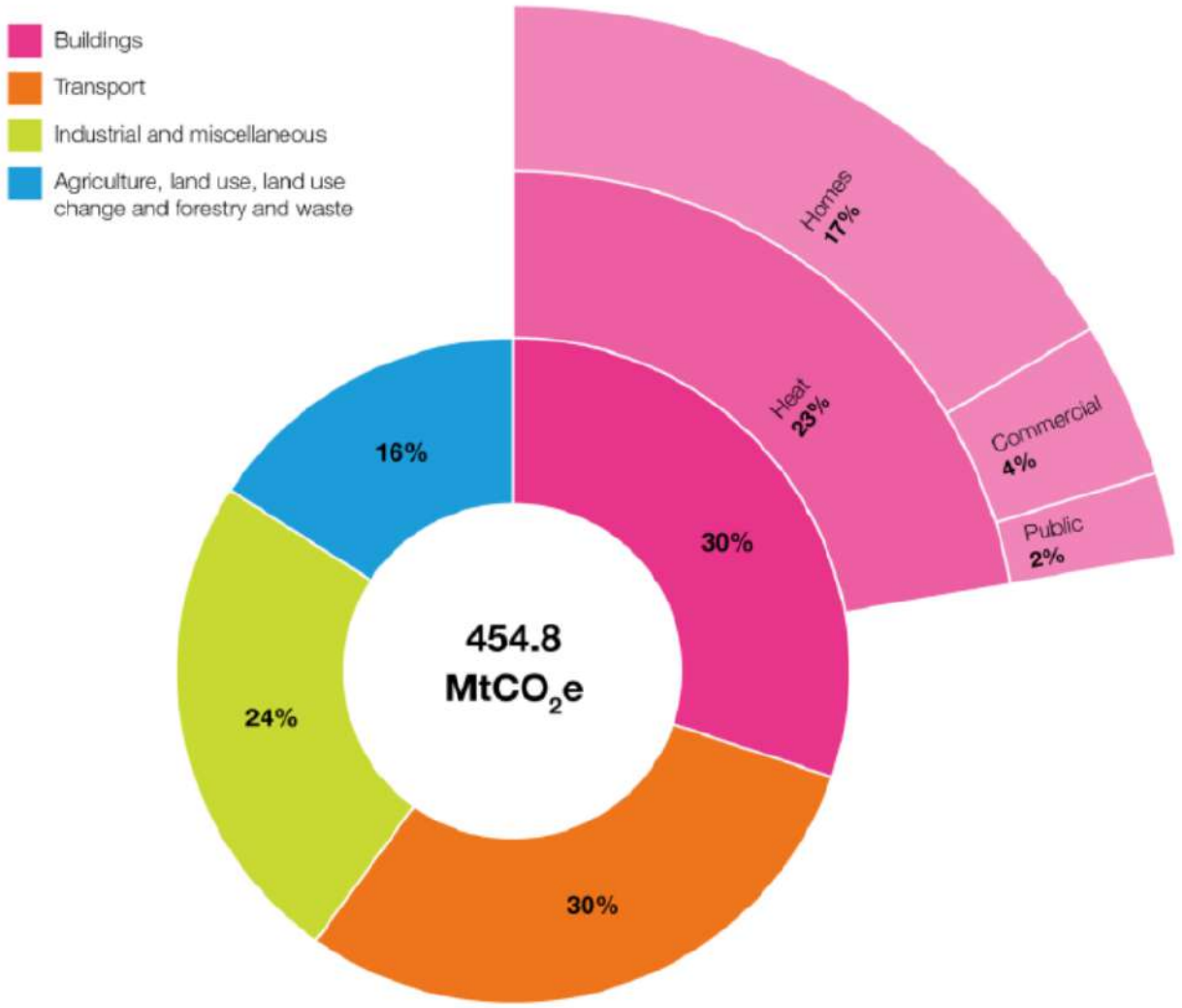
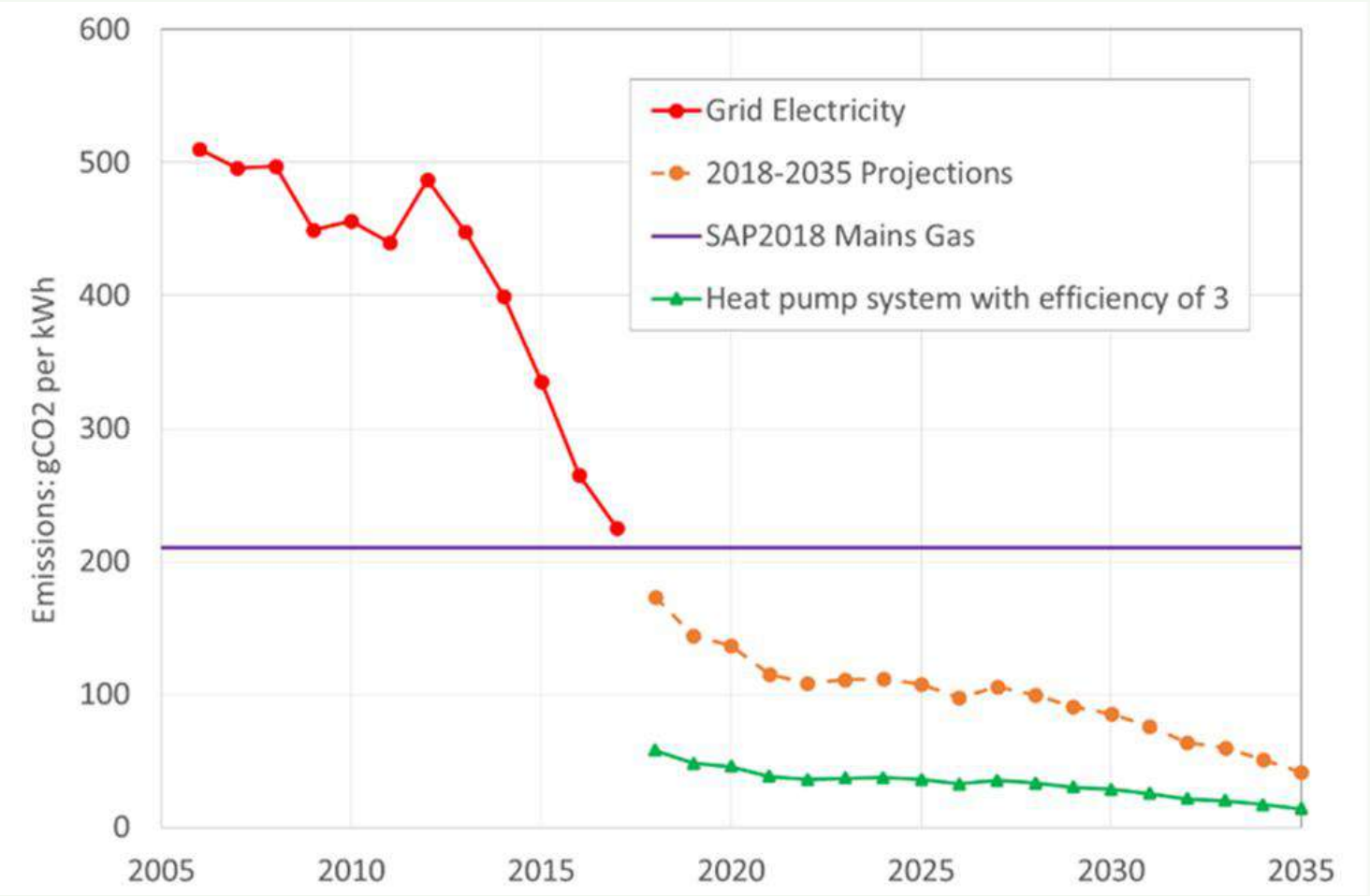


Figure 2 shows the proportion of emissions in 2019 from buildings to the nearest whole number; of the 454.8 mega tonnes of carbon dioxide equivalent ($MtCO_2e$) total emissions, 23% were due to heating buildings, with the largest proportion of this stemming from homes.[35]

HM Government, Heat and Buildings Strategy, 2021



- >28 million homes to be decarbonised
- Electrification is key route to heat decarbonisation of heat
- GSHP > ASHP; important nationally for green elec demand
- Needs to reduce capex
- Rising energy prices will hasten transition

Carbon intensity of UK grid electricity from 2006 to 2017 with projections to 2035. Data: grid electricity data from the Digest of United Kingdom Energy Statistics (DUKES); projections from BEIS (2018); mains gas from BRE (2018)

GEOSUSTAINED

Gas Prices: Forward Delivery Contracts - Weekly Average (GB)

More information

Electricity Prices: Forward Delivery Contracts - Weekly Average (GB)

More information

Wholesale prices:

- More than tripled in last year

@ 24 Jan 2022

- Gas 7 p/kWh
- Elec 20 p/kWh
- Ratio ~ 2.75

https://www.ofgem.gov.uk/energy-data-and-research/data-portal/wholesale-market-indicators

Types of ground energy system

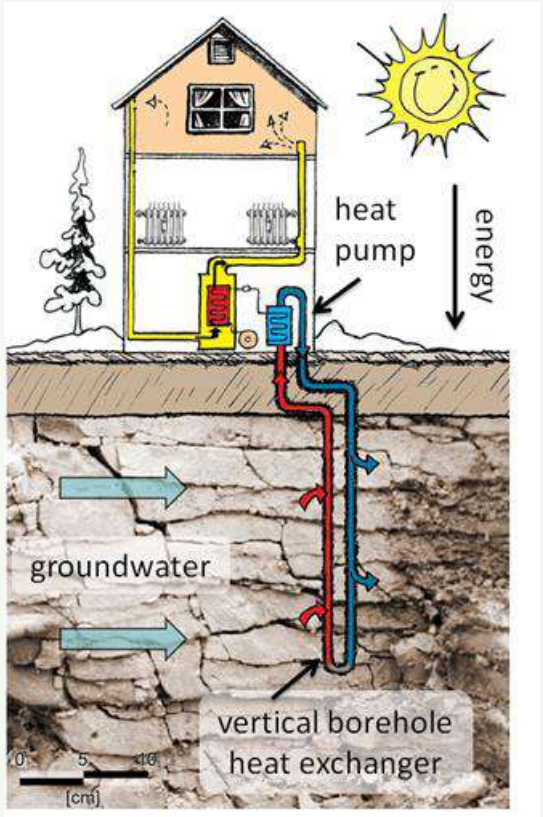
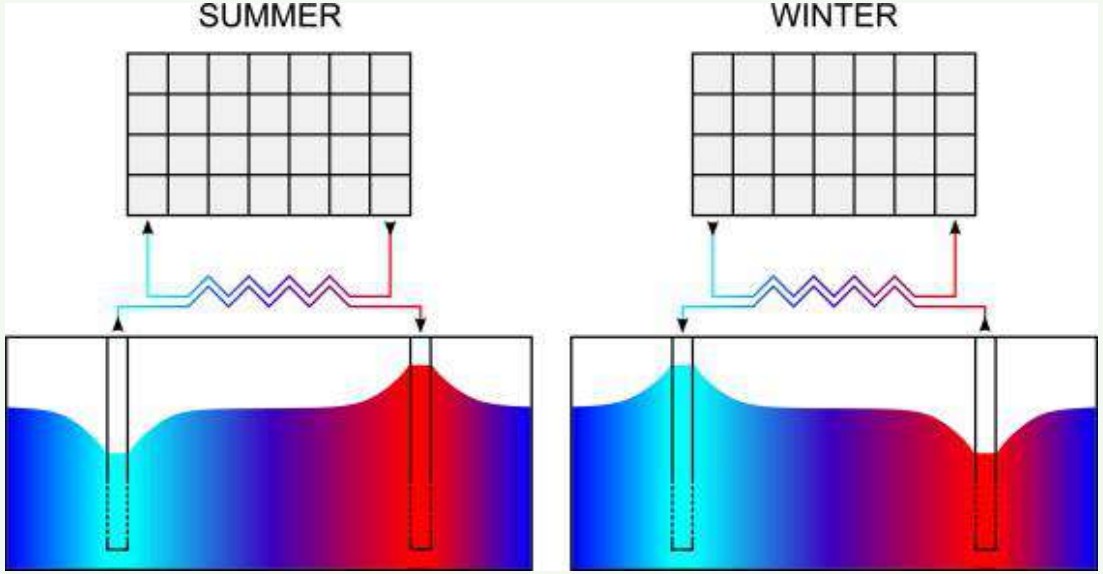


Image by Pedchenko

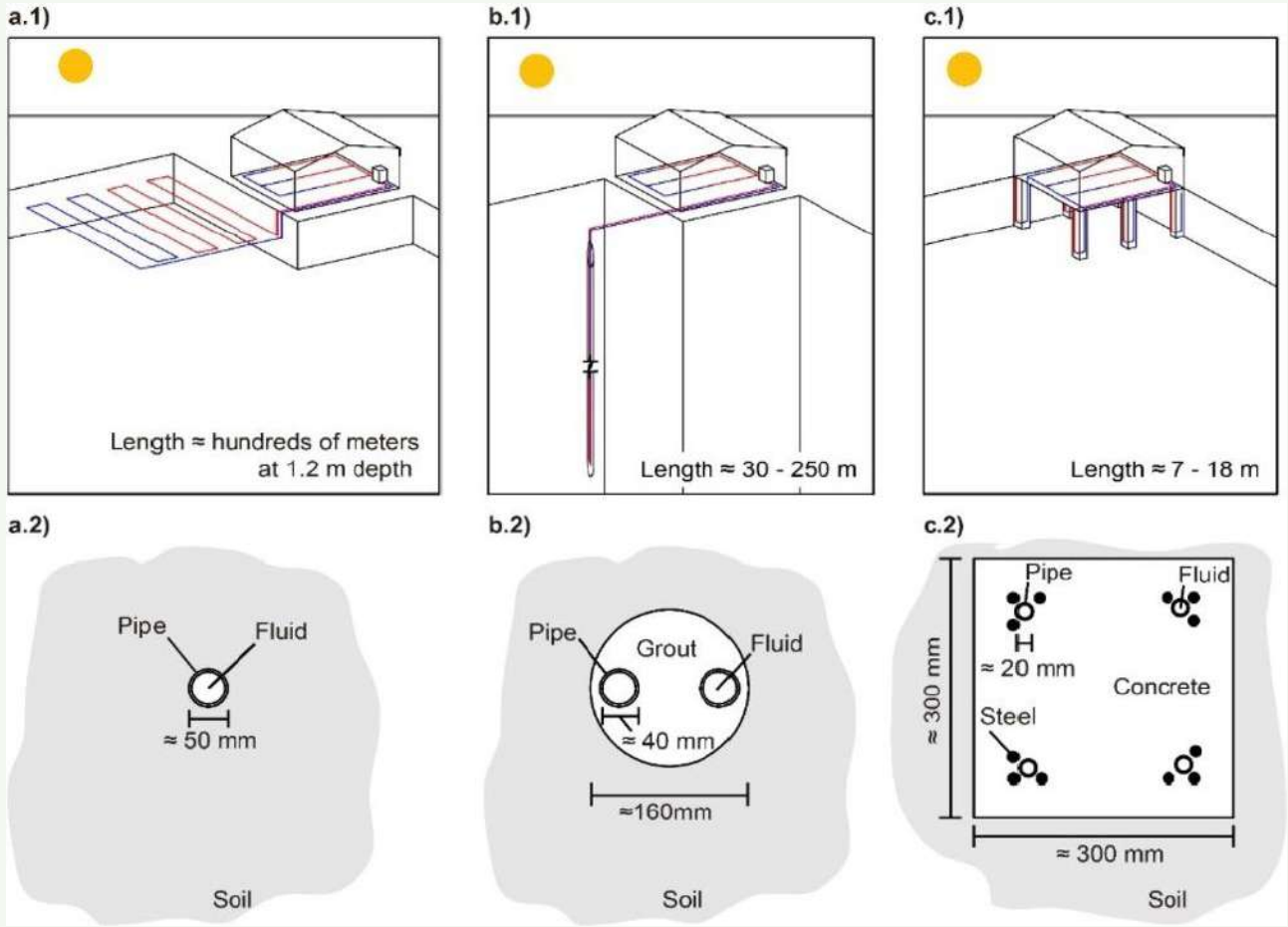
Open loop or ATES (aquifer thermal energy storage)

- Use groundwater direct as heat transfer fluid or via heat exchanger
- Commonly reject waste water back to aquifer
- High energy availability per well
- Well design; pumping tests; permitting (abstraction & recharge); thermal feedback



https://doi.org/10.1016/j.ejrh.2014.08.001

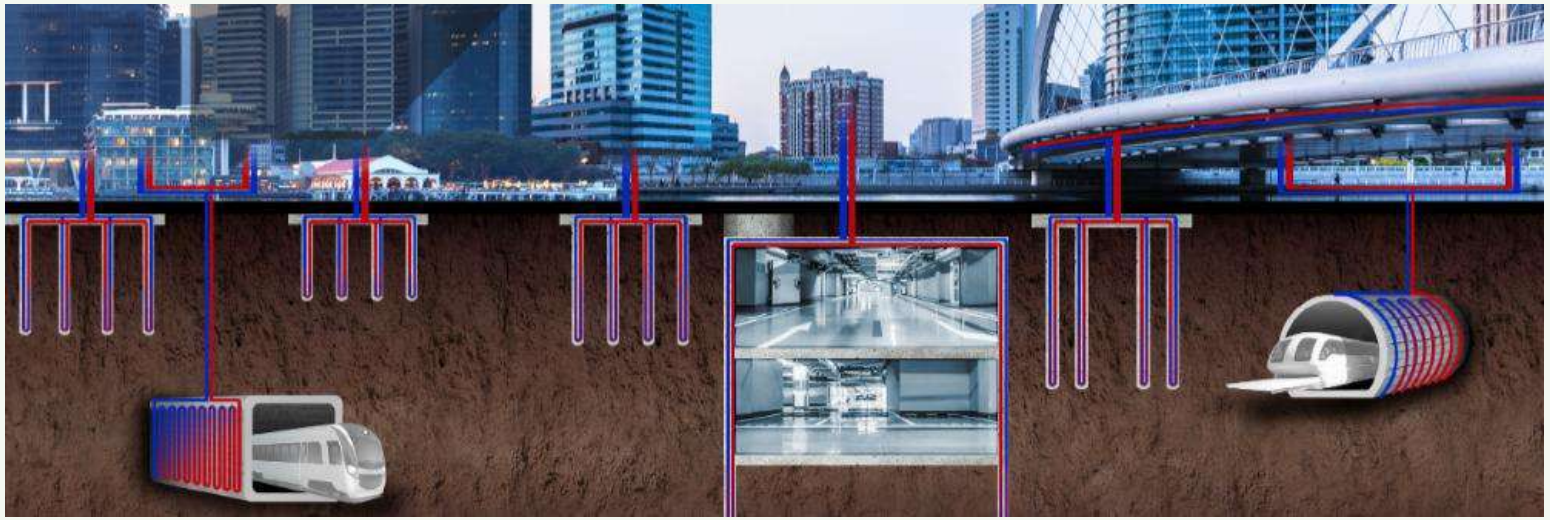
Closed Loop Ground Heat exchangers



https://doi.org/10.1016/j.energy.2017.12.104

- Dedicated heat transfer fluid
  - Water and anti-freeze
- Horizontal
- Vertical
  - Boreholes
  - Energy piles

Energy Geostructures



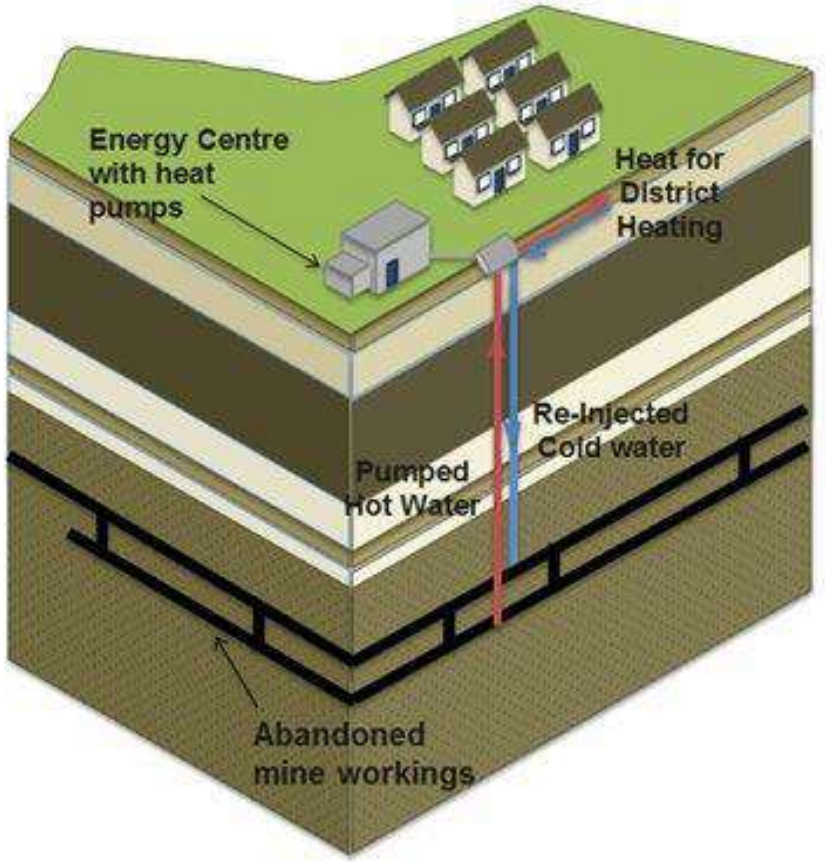
- Piles or other sub-structures used for closed loop ground source
- Proven technology
- Check for structural impacts

Image from Geoeg, an energy geostructures start up company in Switzerland: https://geoeg.net/en/

Image courtesy of Josh Turner

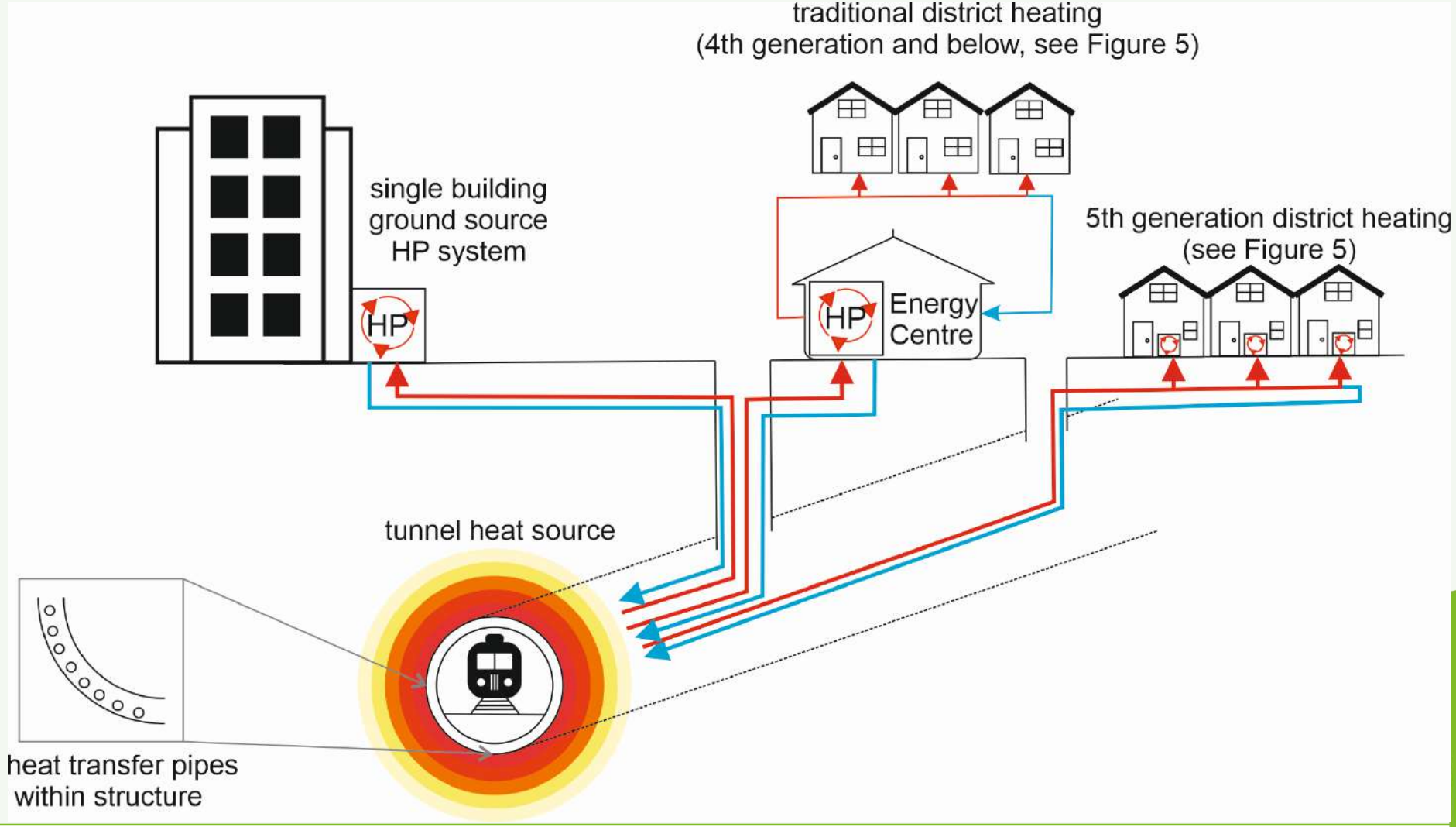
Mine Water Heat

- Huge reservoir of warmer water
- Some water already pumped for treatment
- Closed loop – low risk, lower return
- Open loop – higher risk, higher return
- Understand underground environment, geochemistry, thermal feedback

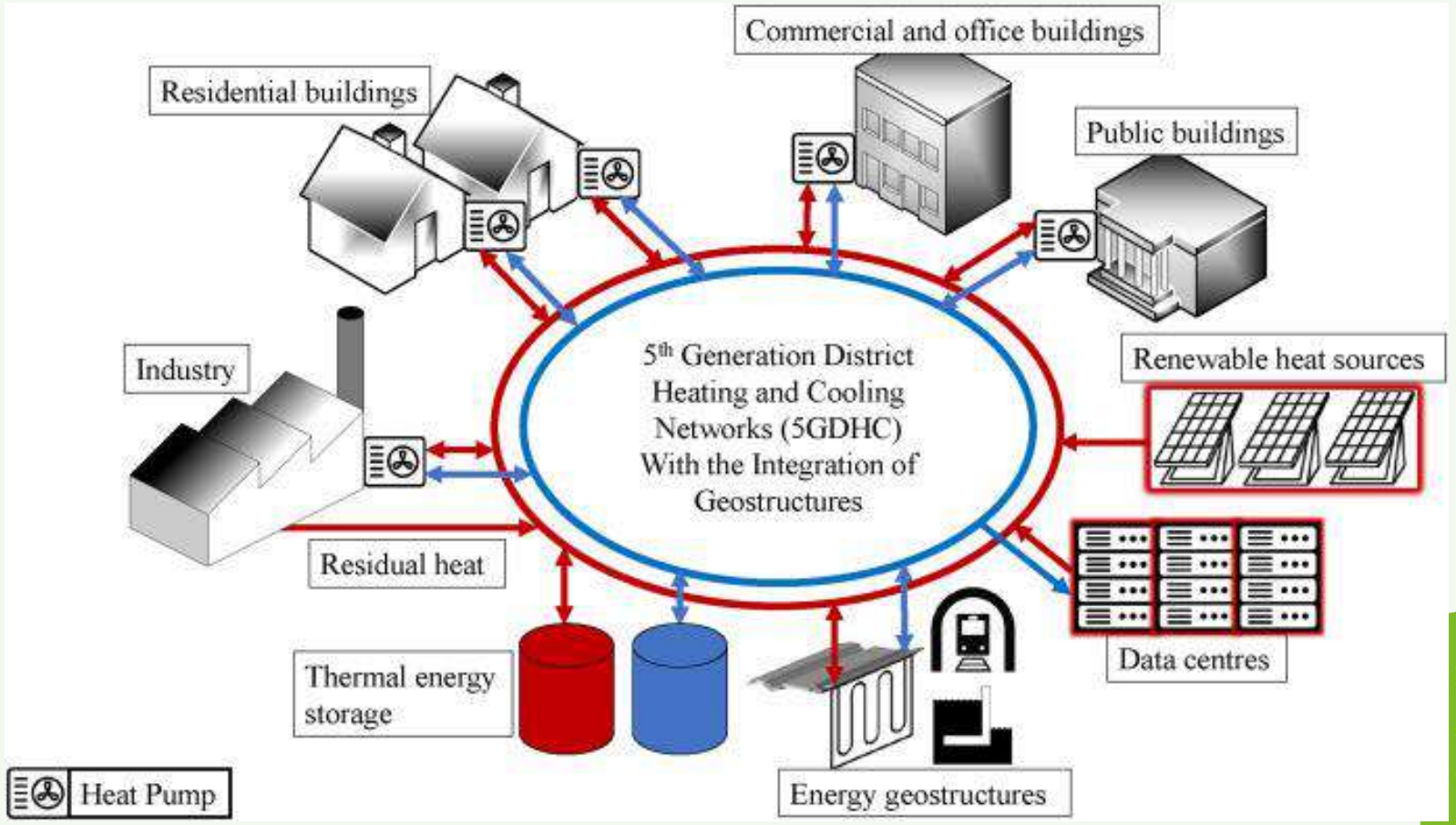


https://www.durham.ac.uk/research/institutes-and-centres/durham-energy-institute/about-us/news/mine-water-energy-paper-published/

Heat Delivery Options

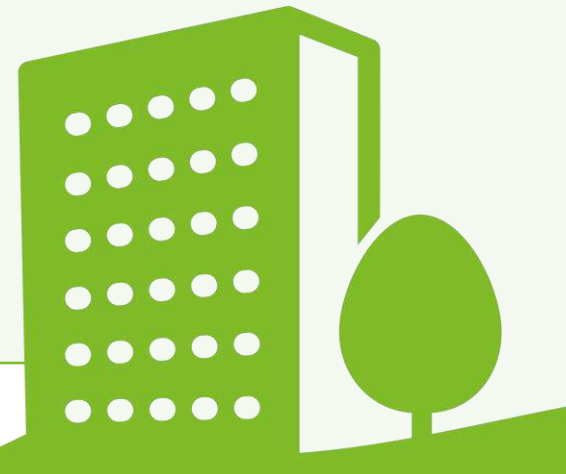


A note about district heating



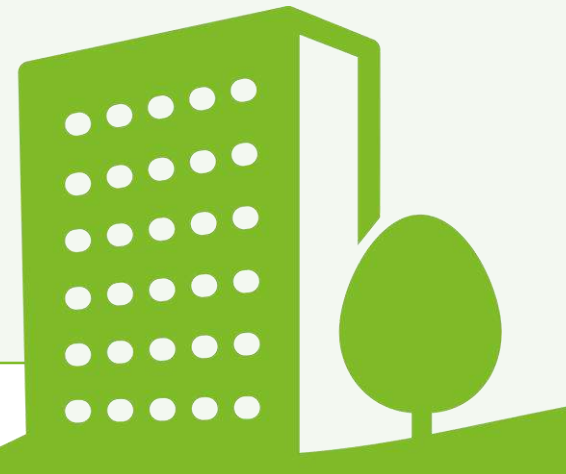
Meibodi & Loveridge (2021) https://doi.org/10.1016/j.energy.2021.122481

Design Considerations



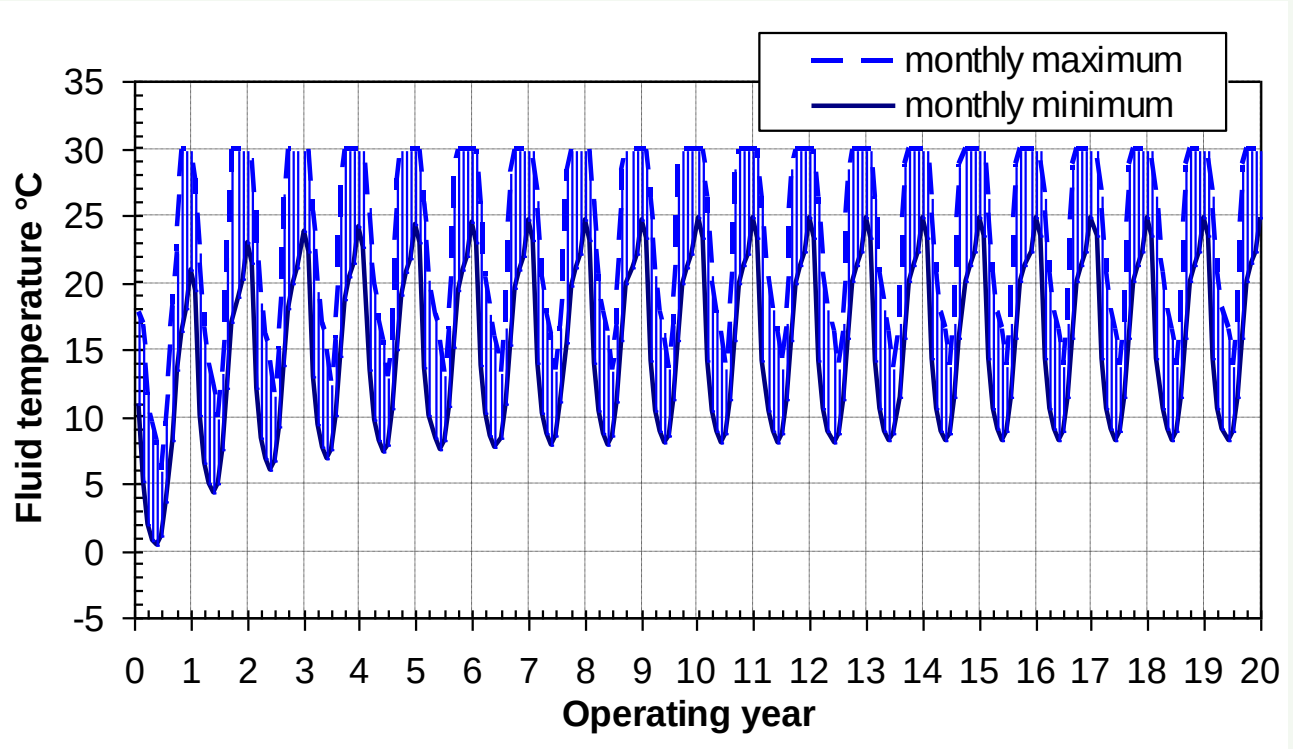
Long term sustainability

- Objectives of design: To maximise thermal transfer (heat/cool availability) within specified temperature limits
- Borehole design: What is the minimum length of borehole required to meet the energy demand, within set temperature limits?
- Pile design: What is the energy availability for the geotechnical pile design length, within set temperature limits?
- Why do we need temperature limits?
  - Prevent fluid and/or ground freezing
  - Environmental impact in ground / ground water
  - Efficient operation of the heat pump & overall system
  - Sustainability of the system
- Balance between heating and cooling

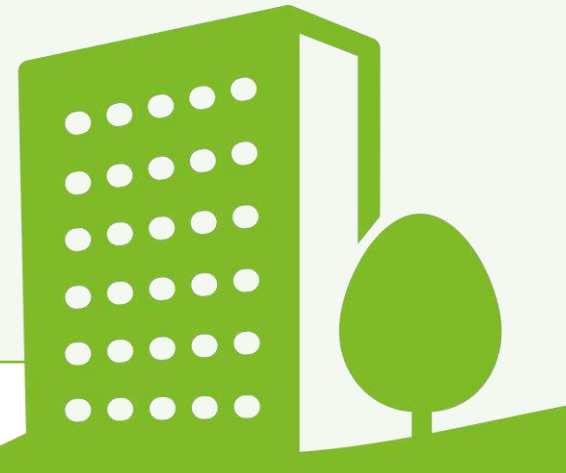


Closed loop design

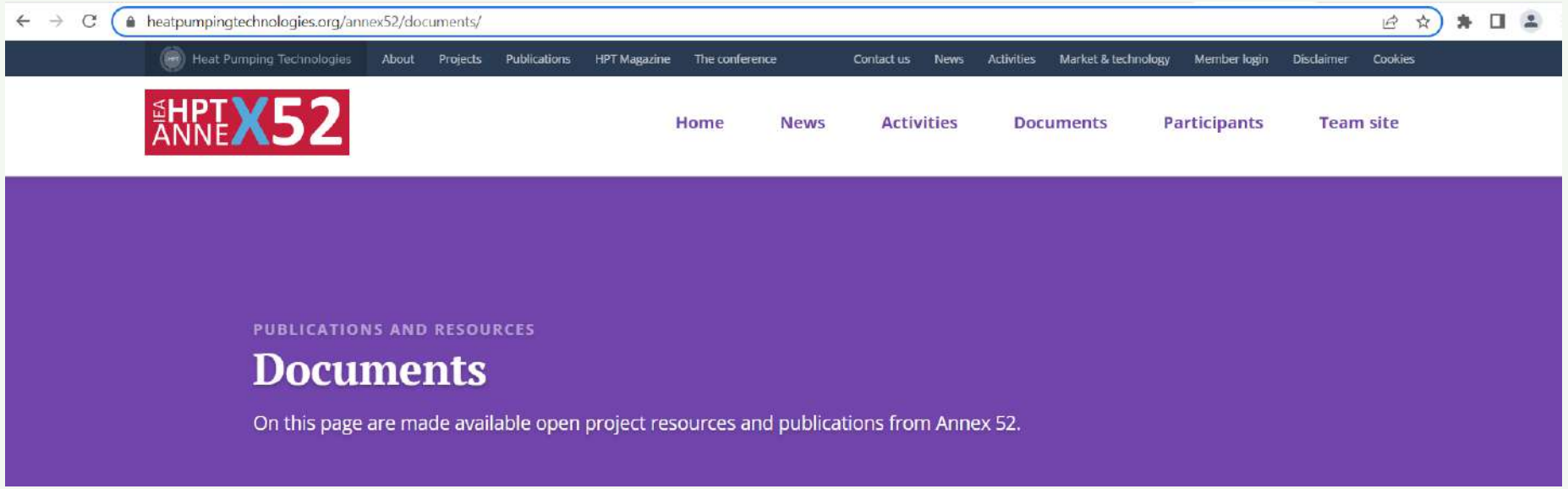
- Relationship between heat transferred and temperature changes is required
  - Rules of thumb (not recommended except pre-feasibility)
  - Analytical models
  - Numerical models
  - Software tools



Account for demand profiles, specific ground and ground water conditions plus heat exchange design/construction



Examples – UK case studies for IEA Annex 52



https://heatpumpingtechnologies.org/annex52/documents/

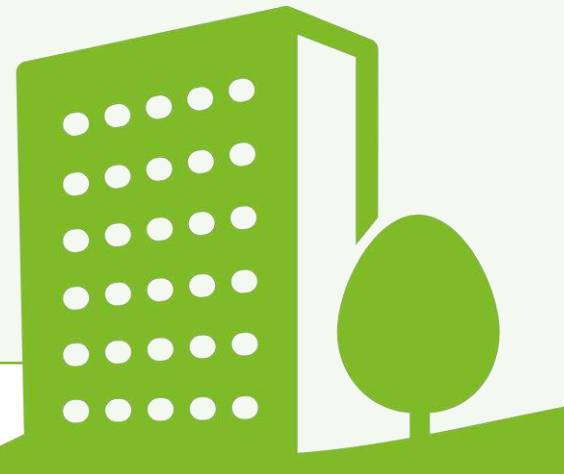
Case Study Comparison

	The Crystal	Hugh Aston Building	Grangetown Nursery
Year (building)/GSHP	(2012)/2012	2010	(1980‘s)/2015
Net floor area	6,920 m²	16,467 m²	280 m²
Heat Pump	X2 Water-to-Water HPs	X4 Water-to-Water HPs	X2 Water-to-Water HPs
Nominal Capacity	2 x 407 kW_h / 2 x 314 kW_c	4 x 110 kW_h / 4 x 120 kW_c	2 x 11 kW_h
Monitoring Period	March 2013 - present	Jan 2010 – Feb 2013	Dec 2015 – Nov 2020

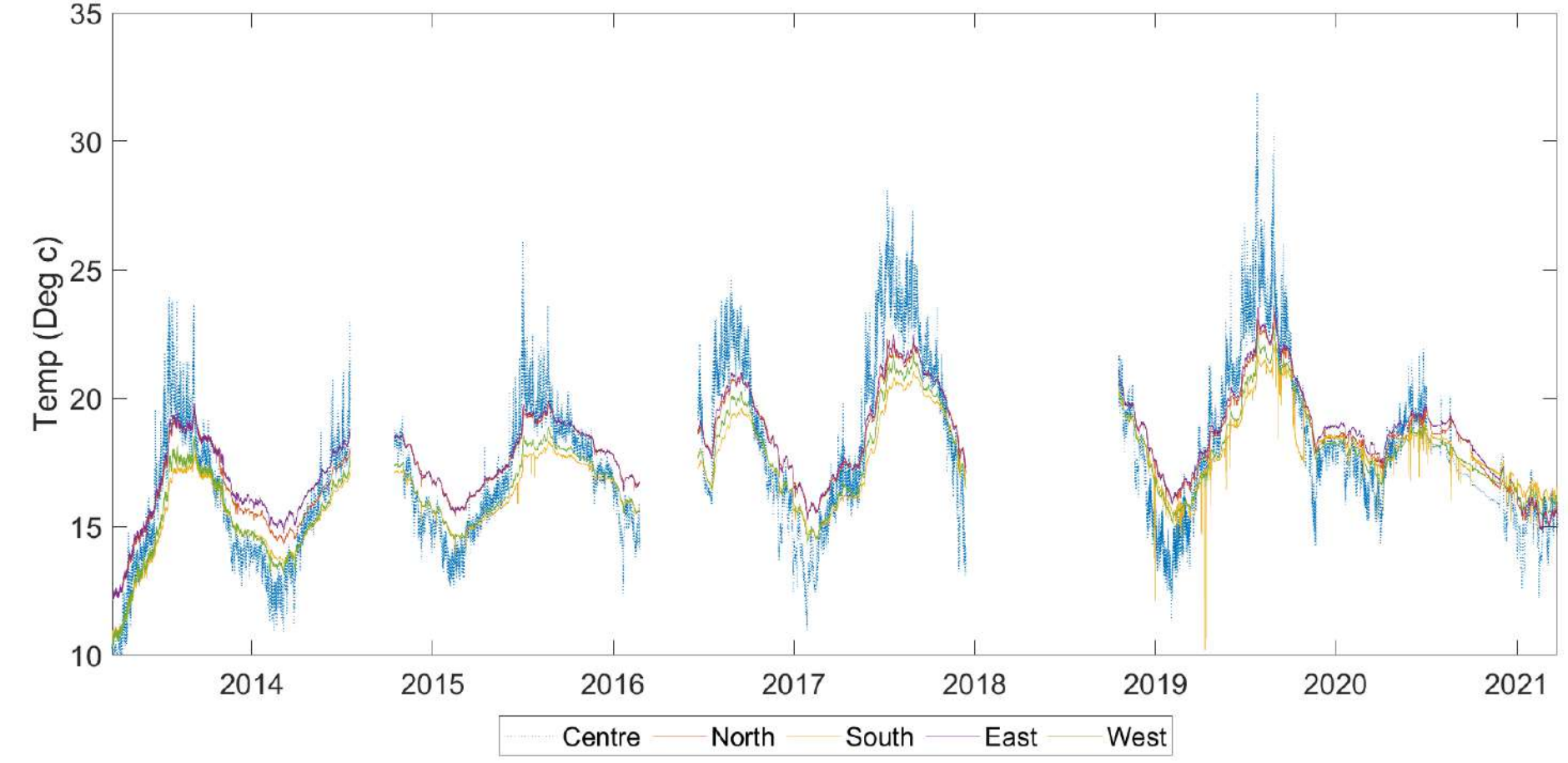
Headline Performance

- SPF1 (heat pump and not any circulation pumps etc):
  - The Crystal – 1.8 to 3.3
  - Hugh Aston Building – 3.3 to 3.6
  - Grangetown Nursery – 4 to 6

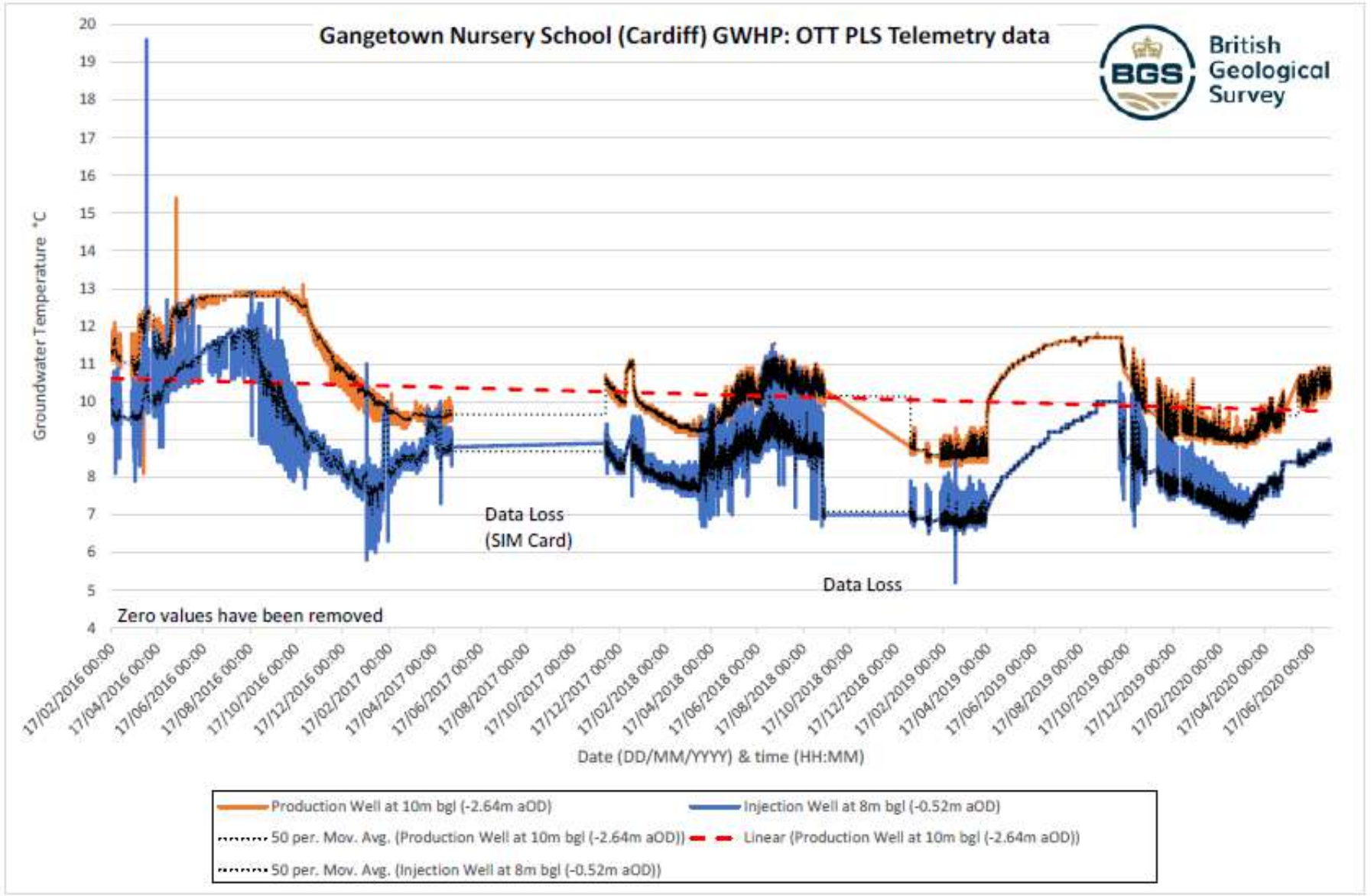
- Challenges
  - Thermal load prediction
  - Bedding in
  - Covid
  - Heat pump cycling
  - Parasitic loads



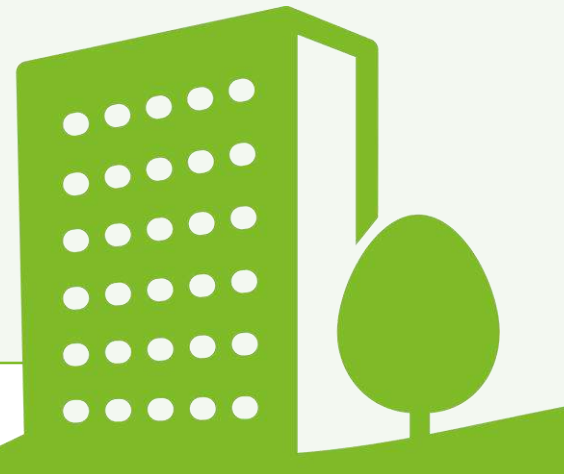
Pile Temperature at the Crystal



Fluid Temperatures (Grangetown)



Perspectives



The Whole System

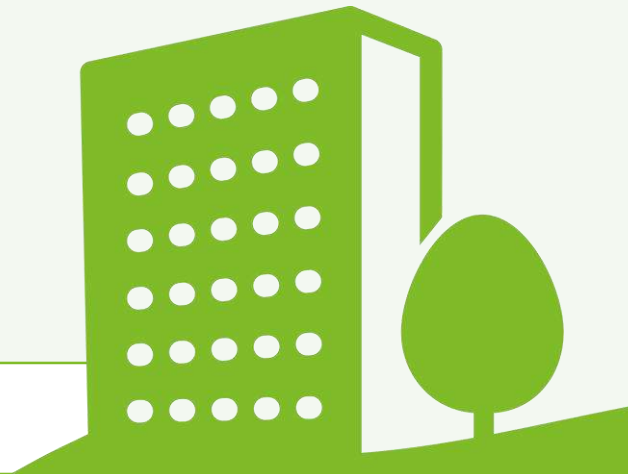
- From the ground to building fit out and operation – many components
- Sources of uncertainty
- The ground
- Design & construction
  - Groundworks
  - Mechanical/HVAC works
  - Building quality
- Humans
  - Design or usage change
  - Operation
  - Monitoring and feedback

Image courtesy of Kensa

The Future

- “The price of doing the same old thing is far higher than the price of change”
- We have to change our heating and cooling approaches
- This community should be leading the way

- Challenges
- Interdisciplinary: geoscience, civil, mech, building services
- Monitoring and feedback
- Policy
- Education & training



Thank you!

- Royal Academy of Engineering
- Engineering and Physical Sciences Research Council

- Also to: Sasha Pedchenko, Maria Alberdi, Saleh Meibodi, Josh Turner, Ida Shafagh & David Boon (British Geological Survey) whose images I have borrowed.