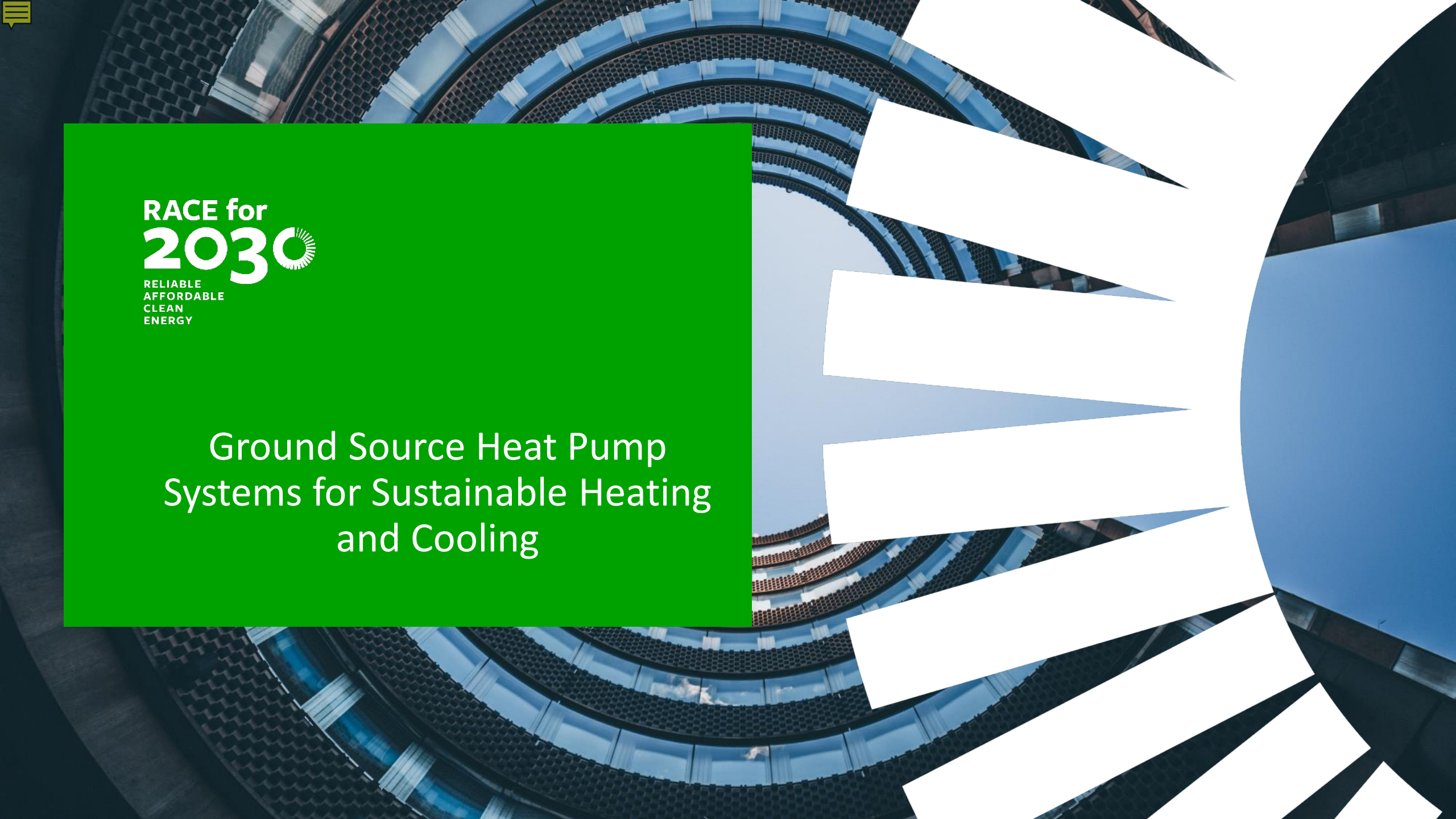


Ground Source Heat Pump Systems for Sustainable Heating and Cooling

Ground source heat pumps > peak electricity demand, urban heat island, embodied carbon

- Background in Australia
  - Fairwater Living Laboratory – residential
  - Commercial building air source heat pump retrofits – plant room space constraints
- Background from overseas
  - USA
  - Europe
- Subsurface Urban heat Island and Underground Climate Change

Fairwater Living Lab - residential heating/cooling

- $1.7M over 3 years (completed Jun22)
- Residential precinct in Western Sydney (Endeavour Energy network area), former Ashlar Golf Course, Blacktown, 38 hectares
- 6 Star Green Star rating for 800 homes
- 40 study homes, detached and semi-detached dwellings
- GeoAir Geothermal HVAC Ducted A/C from QPS Geothermal / ActronAir, 80 m deep boreholes
- 51 dB operating noise (no external condenser units)
- Deep hole direct exchange (DHDX), R410A refrigerant, GWP of 2,088

Air conditioning – 37-42% of annual electricity use

With GSHP

Peak demand	↓3 kW/home
Electricity use	↓ 21% > $238/year saving
GHG saving	↓0.9 t CO_2-e/home/year

Solar PV
- ↑ electricity use
- ↓ self sufficiency
- ↓ self-consumption

COVID later morning peak + increased 10am-3pm use

Remaining questions
- GSHP ducted system > over-reliance?
- Solar PV owners
- User behaviour + occupant preferences

Source: https://arena.gov.au/knowledge-bank/fairwater-living-lab-residential-heat-pump-study-annual-public-report/

Direct geothermal – aquatic centres

Photo - Gippsland Regional Aquatic Centre (GRAC) in Traralgon, Victoria

Other -

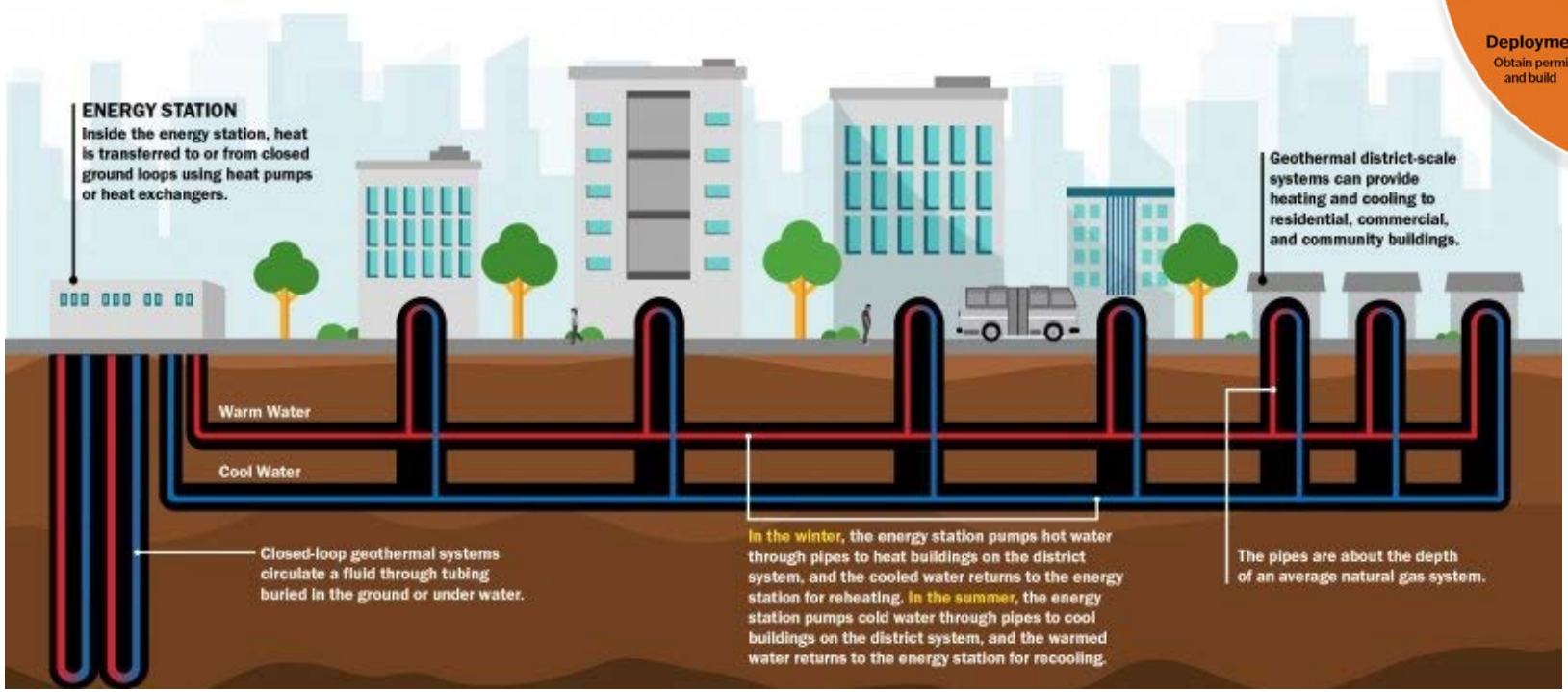
Other projects

- Metro Tunnel Project, Melbourne
- Yanderra Shallow Geothermal Systems Demonstration (ARENA) – poultry farm
- Arthur Boyd National Gallery and Plumbing Industry Climate Action Centre
- Parliament of Victoria
- Rivergum Residential Treatment Centre (Victoria)
- Sydney Light Rail Electrical Substation Cooling
- Australian War Memorial
- Jan 2023 capacity
  - 36 MW_t direct use geothermal
  - 71 MW_t GSHP

Source: Beardsmore et al, 2023, Country Update – Australia, Proceedings World Geothermal Congress 2023, Beijing, China, October 8-13, 2023

RACE for 2030

USA - Geothermal District Heat & Cooling



Main benefit – 33% ↓ grid cost and total emissions reduction - https://www.osti.gov/biblio/2224191
Source: US DOE https://www.energy.gov/eere/geothermal/geothermal-heat-pumps

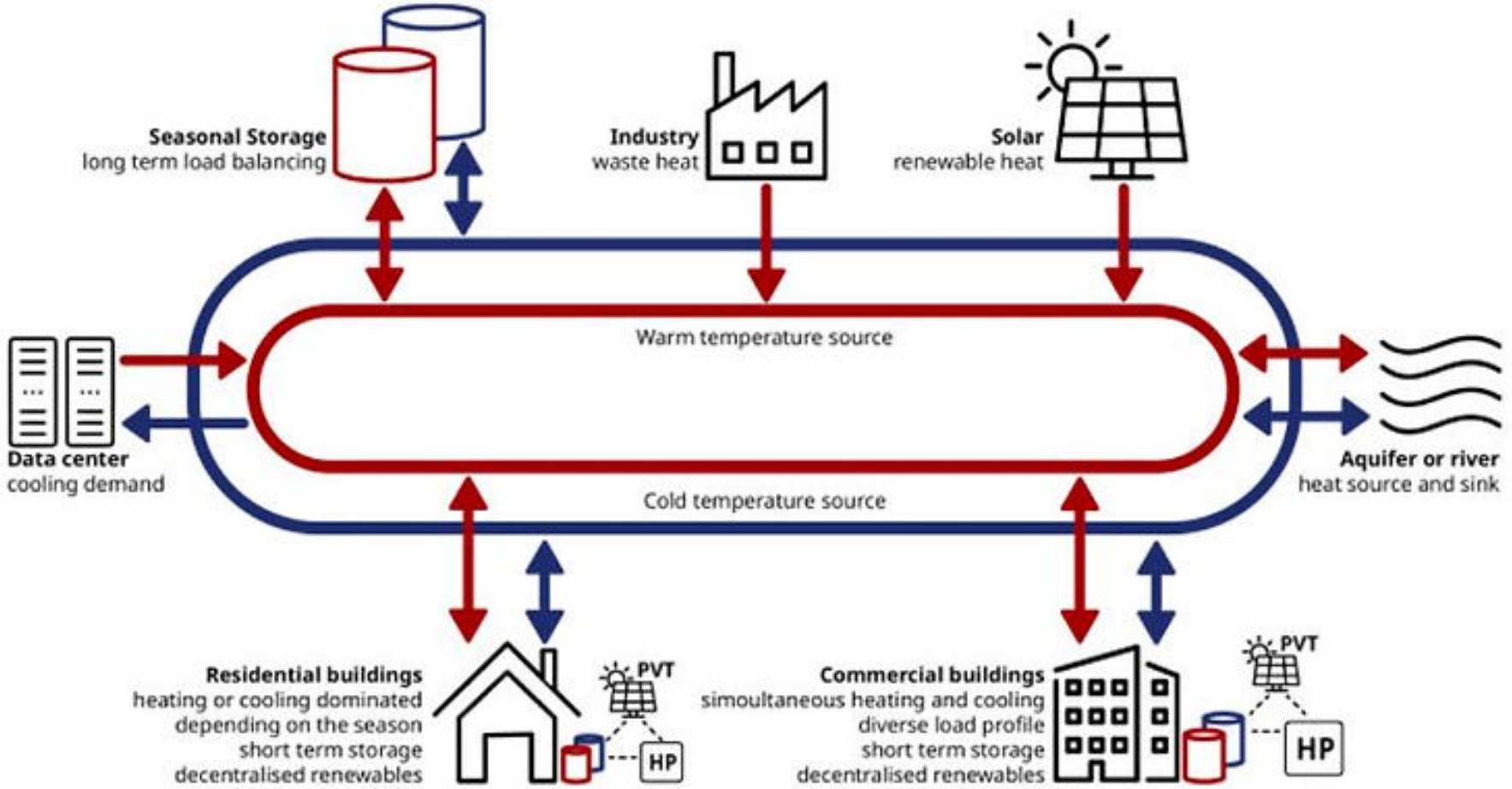
RACE for 2030

Europe - Geothermal District Heat & Cooling

Source: Federation of European Heating, Ventilation and Air Conditioning Associations
https://www.rehva.eu/rehva-journal/chapter/geothermal-energy-use-in-the-nordic-countries

RACE for 2030

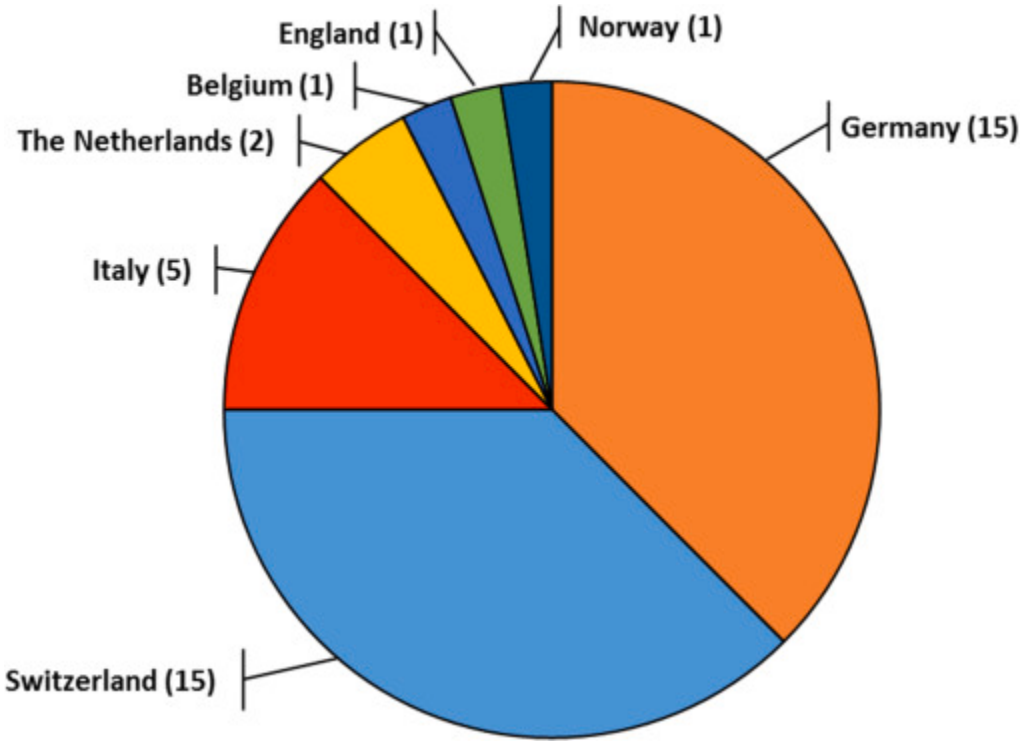
Fifth-generation district heating and cooling systems (5GDHC)

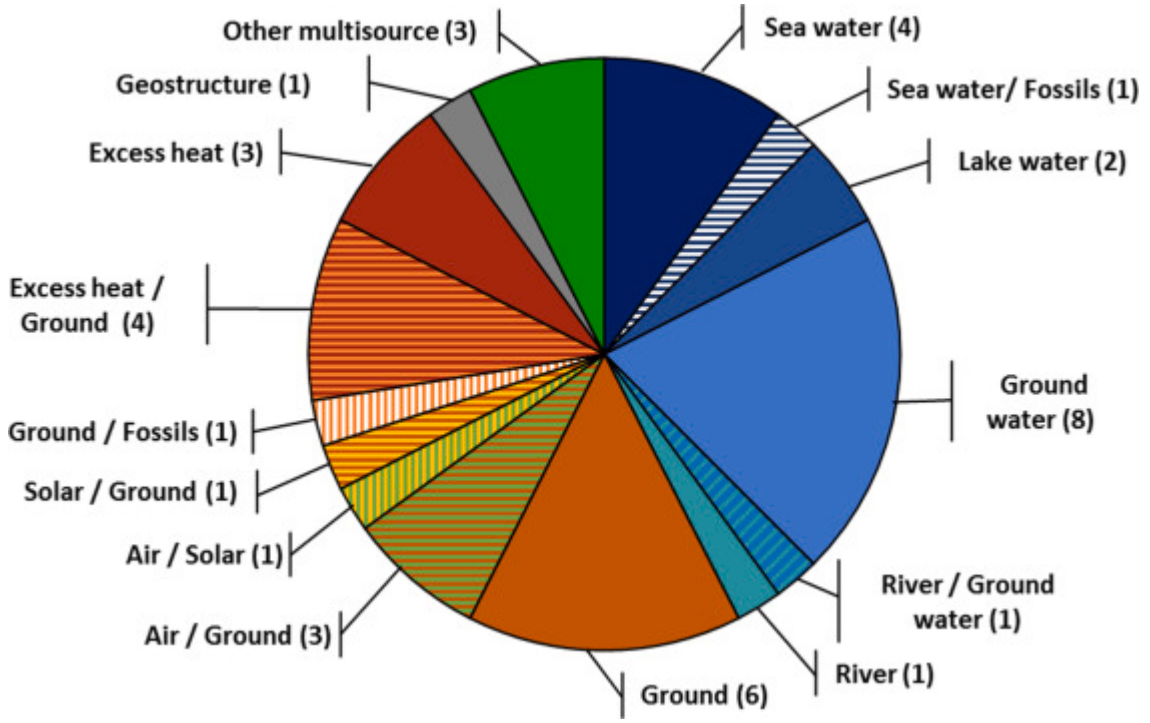


Source: https://thefifthestate.com.au/columns/spinifex/are-district-energy-systems-finally-ready-for-prime-time-in-australia/

European Research

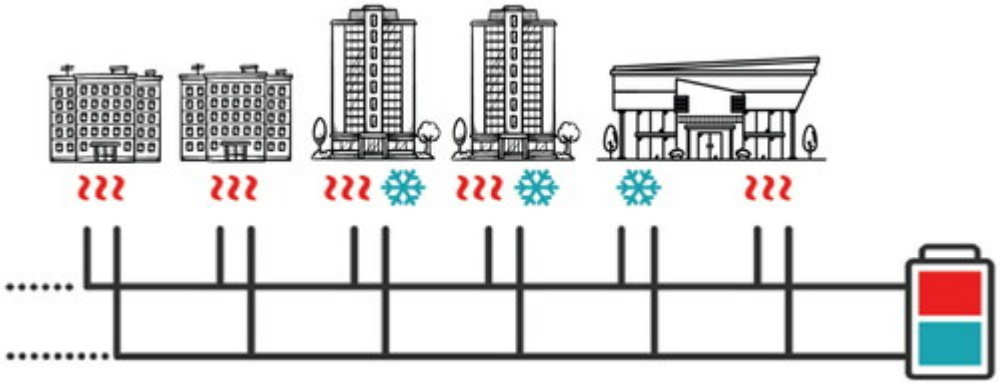
- Simone Buffa, Marco Cozzini, Matteo D'Antoni, Marco Baratieri, Roberto Fedrizzi (2019) 5th generation district heating and cooling systems: A review of existing cases in Europe, Renewable and Sustainable Energy Reviews, Volume 104, 504-522, DOI: 10.1016/j.rser.2018.12.059





European Research

- Jonas Lindhe, Saqib Javed, Dennis Johansson & Hans Bagge (2022) A review of the current status and development of 5GDHC and characterization of a novel shared energy system (SES), Science and Technology for the Built Environment, 28:5, 595-609, DOI: 10.1080/23744731.2022.2057111



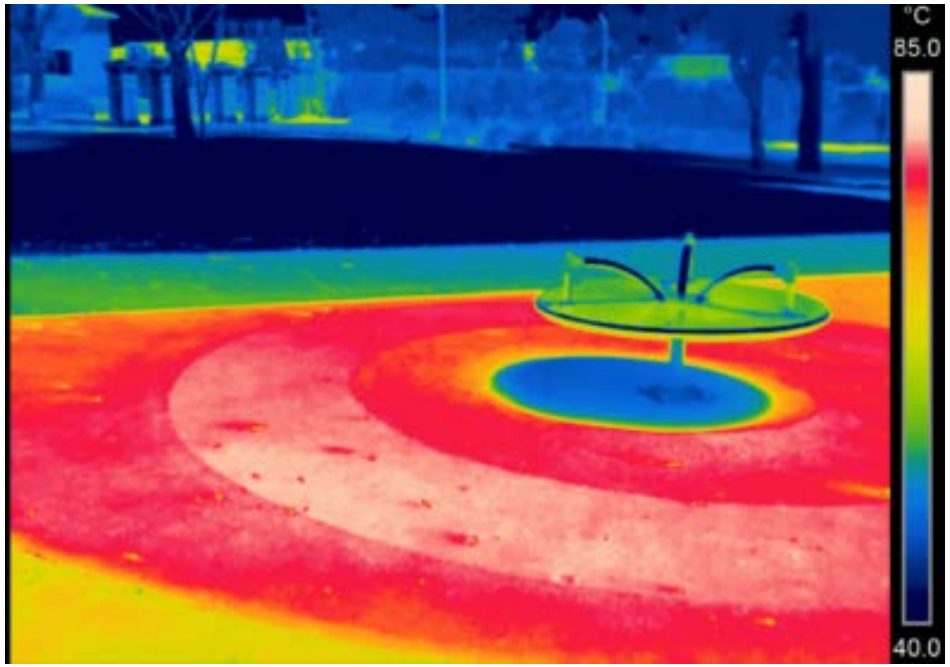
Thermal shared energy system (SES)

ectogrid™ at Medicon Village, Lund, Sweden

Subsurface Urban Heat Island > Underground Climate Change

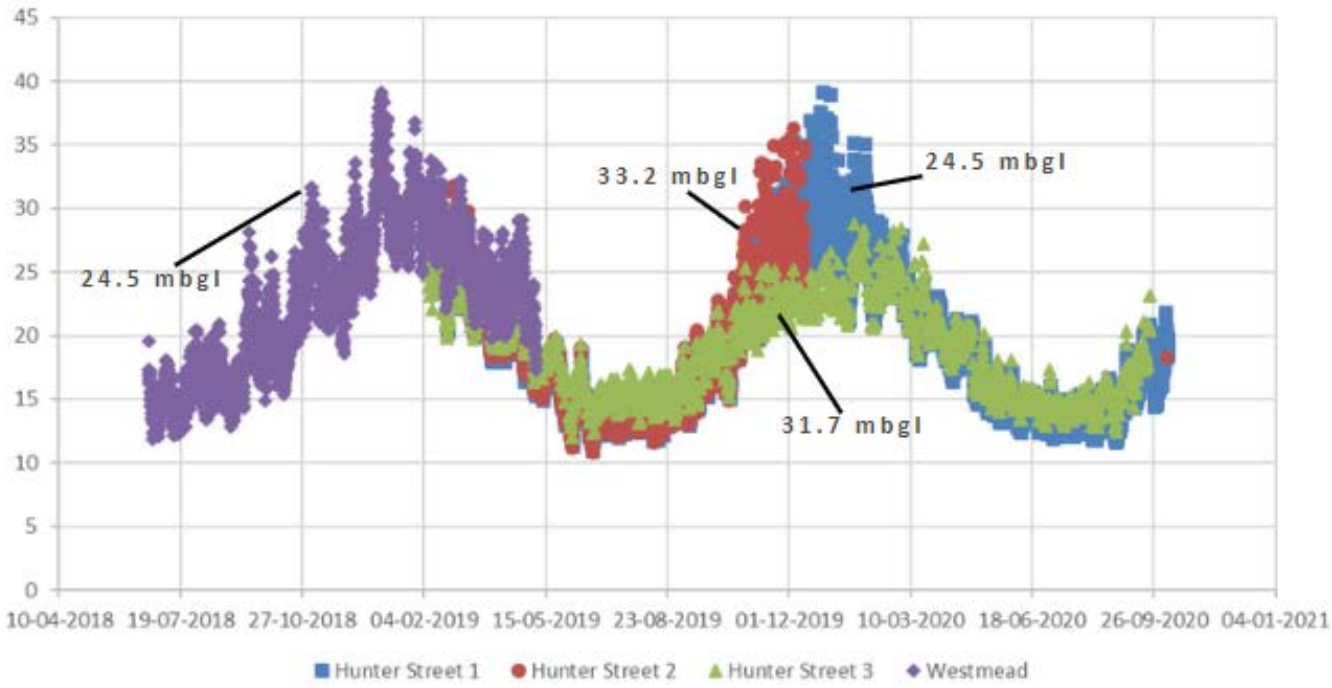
Subsurface Measurements in Western Sydney**.**

Surface – Western Sydney
max of 85°C – playground



Surface temperature (playground) Western Sydney - 2020

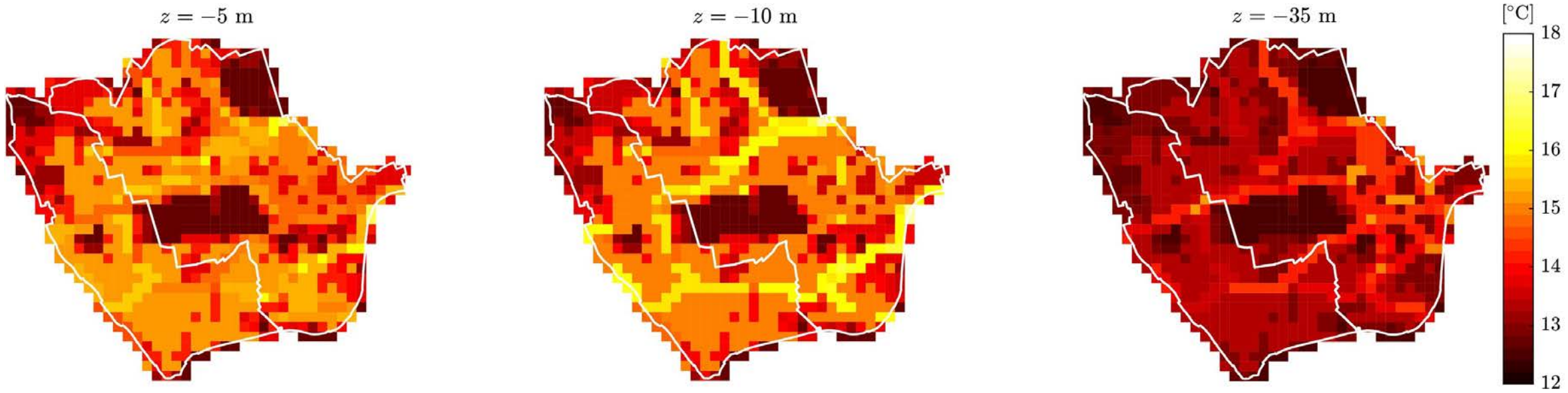
Subsurface – Western Sydney
max of 38°C - 25m below surface



Measured data – from WSP

Subsurface Urban Heat Island > Underground Climate Change

Subsurface Temperature Mapping of Kensington, Chelsea and Westminster, London, UK



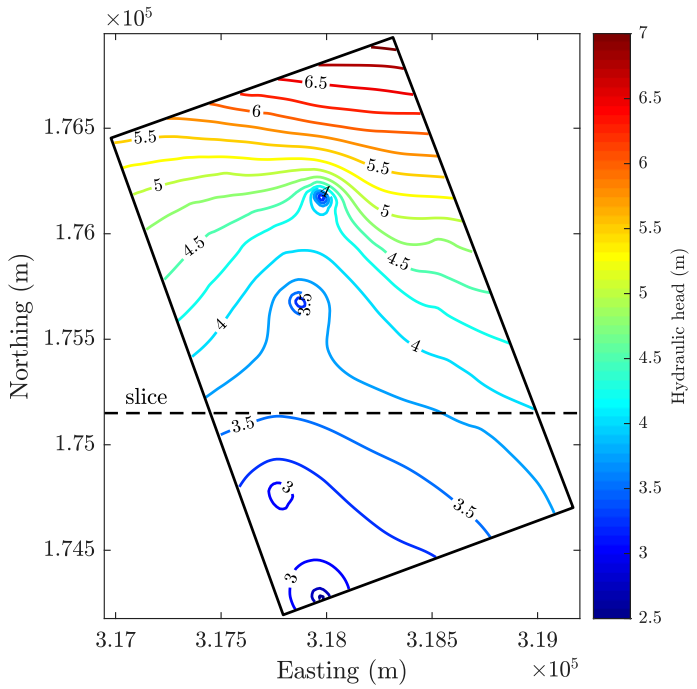
Max of **6°C** temperature **increase in the subsurface**

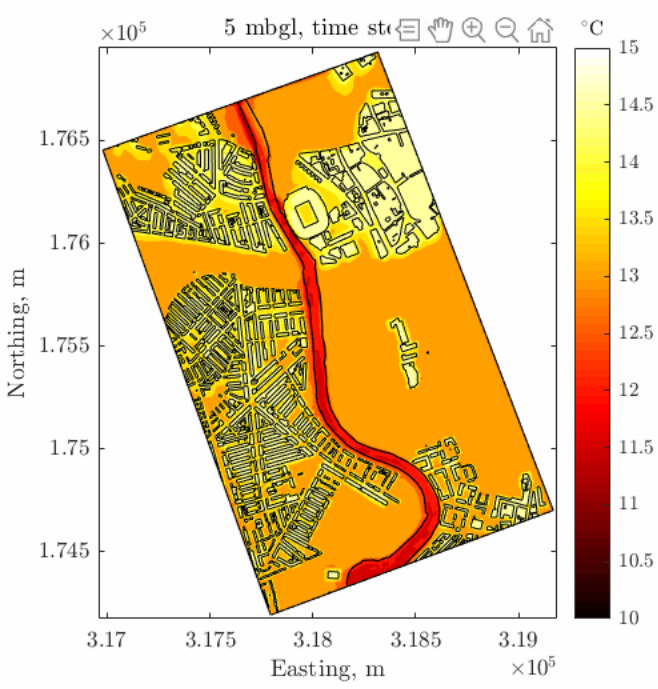
- Supply of **50% to 75%** of total energy (gas) demand in the area.
- Up to **33%** saving in CO_2 emissions

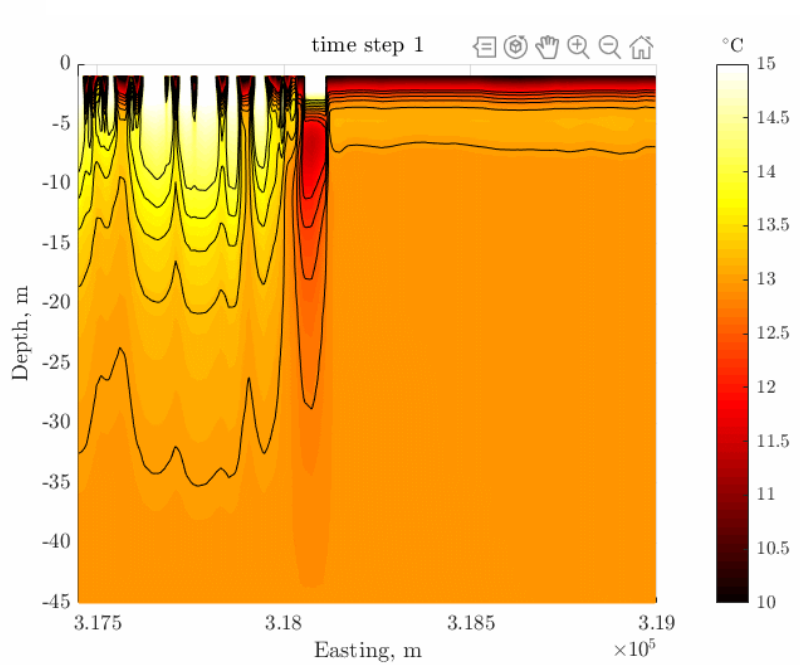
Bidarmaghz et al. (2021)

Subsurface Urban Heat Island > Underground Climate Change

Subsurface Temperature Mapping of Cardiff, Wales.







<u>Similar observations have been reported for:</u>

- **Chicago (Rotta Loria, et.al., (2023)**
- **Several German cities (Menberg, et. al., (2013)**
- **And more**

- Supply of **23% to 100%** of total energy demand in Cardiff, Wales.
- Up to **75%** saving in CO_2 emissions

Makasis, Bidarmaghz et. al., 2022

Subsurface Urban Heat Island and Energy Opportunities

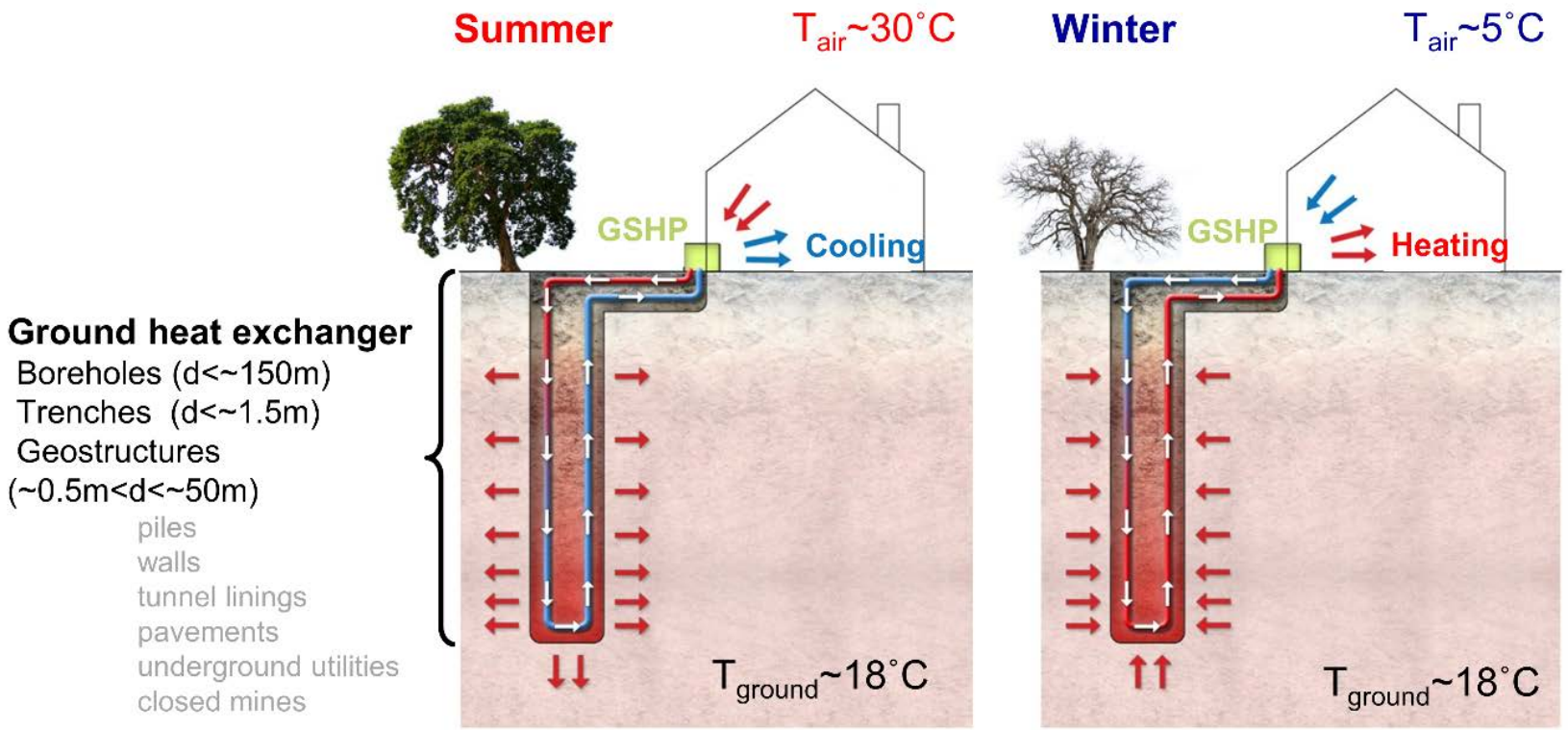
Urban subsurface heat islands will impact the above/underground climate in various ways:

- Temperature **increase** in **pavements** and other urban surfaces
- Above and underground structural **instability**
- Change in **groundwater** quality and quantity
- **Changes in efficiency** to underground **ventilation**/air conditioning
- Thermal **discomfort** in **underground** spaces (passengers, workers, etc)

Urban Subsurface Heat Island and Energy Opportunities

Subsurface heat island can be turned into thermal energy for heating/cooling and the hot water supply of buildings.

This will be achieved via ground source heat pump systems.



Economic, Environmental and Health Benefits – example

Harnessing Subsurface Heat Island via GSHP system will provide:

- Concurrent **heating** and **cooling**.
- Perfect for spaces with **high energy** demand.
  - Schools, hospital, shopping centres, sport centres.
- Proven to effectively **Mitigate** SUHI.
- Improve **stability** and **serviceability** of underground infrastructures.

<u>E.g., 3120 schools in NSW switching from fossil fuel to shallow geothermal energy will save:</u>

- **$343 Mil/year** on energy consumption
- **1.9Mil** tonne CO_2/year
- **400/year** fewer climate related deaths

RACE for 2030 Project Summary:

Project Objectives:

- Enhance confidence in GSHP (Ground Source Heat Pump) design and installation.
- Gain a better understanding of spatio-temporal thermal energy potential in the shallow subsurface.

Environmental Benefits:

- Investigate the resultant environmental benefits of switching to GSHP systems.
- Focus on thermal energy demand and subsurface energy availability.

Matching Energy Demand with Potential:

- Identify areas with the highest energy demand in cities.
- Address locations experiencing energy poverty/ urban heat island (UHI) impacts

RACE for 2030 Project Summary:

Quantify outcomes related to the project, including:

- CO_2 emission reduction.
- Peak electricity demand reduction.
- Urban Heat Island (UHI) effect benefit.
- Health benefits from reduce UHI.

Large-Scale Geothermal Heating and Cooling:

- Explore the feasibility of implementing large-scale geothermal heating and cooling systems.

Focus on Deprived Urban Zones:

- Specifically target deprived urban zones for the implementation of GSHP systems.