Urban Sustainability utilising the Subsurface

An example of Geothermal Energy

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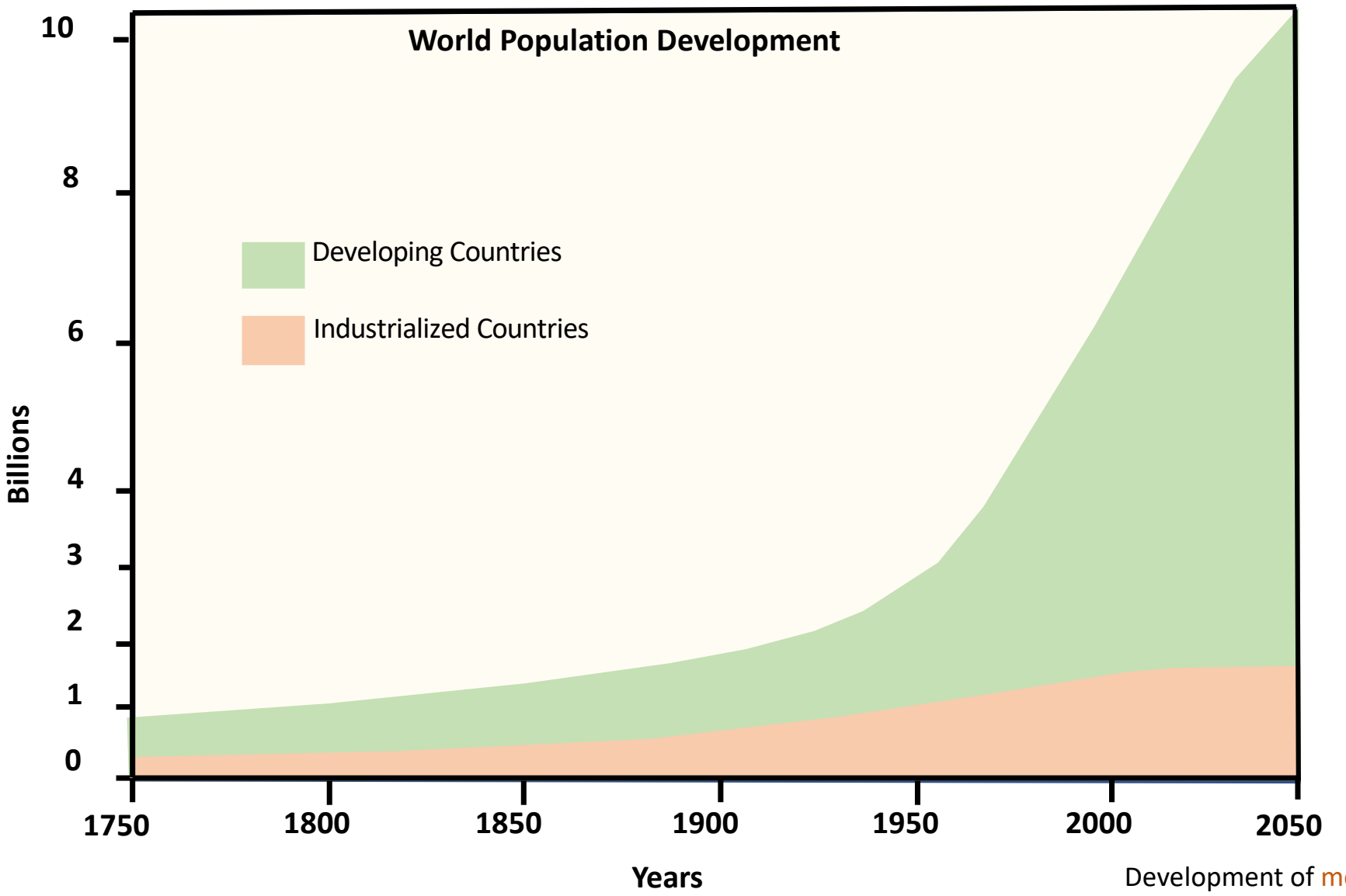


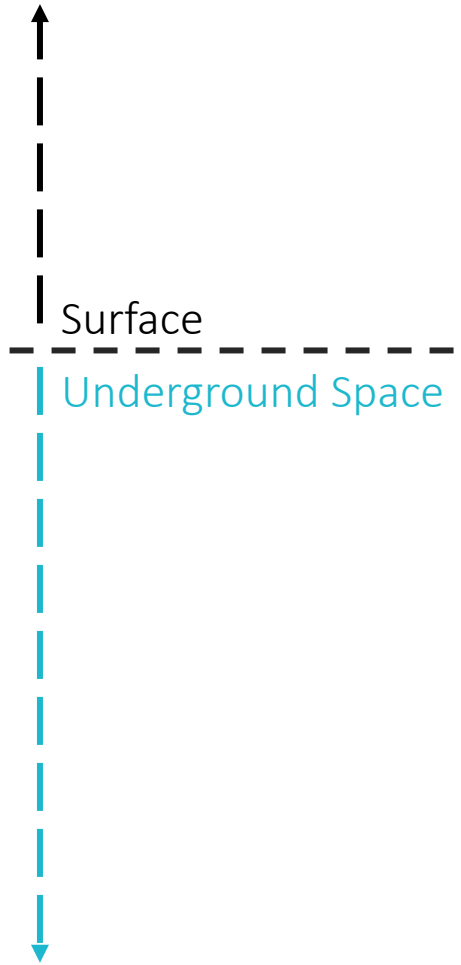
(Modified from; GRID Arendal, 2005)

Development of megalopolies leads to:

- High-rise buildings
- Overcrowded transport networks
- Reduced greenspace and quality of life
- Environmental degradation

Slide Courtesy M. Stables

Underground Space



"The Next Level UP is DOWN" (ITACUS vision, 2020)

Underground Space

Source: C. Paraskevopoulou, Cliffs of Moher, Ireland,03.06.2019

Current Applications

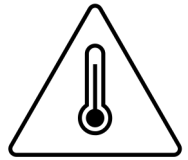
Transportation

Parking

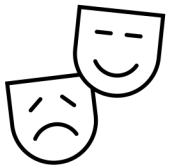
Farming

Storage Facilities

Groundwater Resource



Geothermal energy



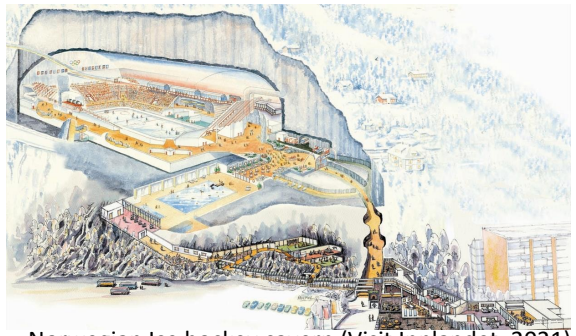
Recreational Facilities

Underground Space Examples

Multiple Uses	Project Title	Benefits and Limitations	
Sports & Recreation	Lowline Development, New York	- Green Space - Multi-use Potential - Controlled climate	- Large investment - Time consuming - Planning permission
Culture & Education	EWHA Woman's University, Seoul	- Minimal visual pollution - Naturally Insulated	- Lacks diverse future uses
Health	Speleotheraphy, Wieliczka saltmines, Poland	- Health Benefits - Multi-use potential - Minimal construction	- Necessary or gimmick?
Transport	London Underground, London	- Faster, safer transport - Less visual and noise pollution	- Large networks that crowd the subsurface
Energy	Kazunogawa Power Station, Tokyo	- Less visual, noise and vibration pollution - Controlled environment	- May require significant decommissioning

New York Lowline (Seo & Koo, 2020)

Speleotheraphy, Wieliczka (Wiszniewski, 2015)



Norwegian Ice hockey cavern (Visit Innlandet, 2021)

(Modified from; Seo & Koo, 2020; Barton et al., 1994; Ivy, 2004; Tezuka & seoka, 2003)

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1987 (World Commission on Environment and Development)

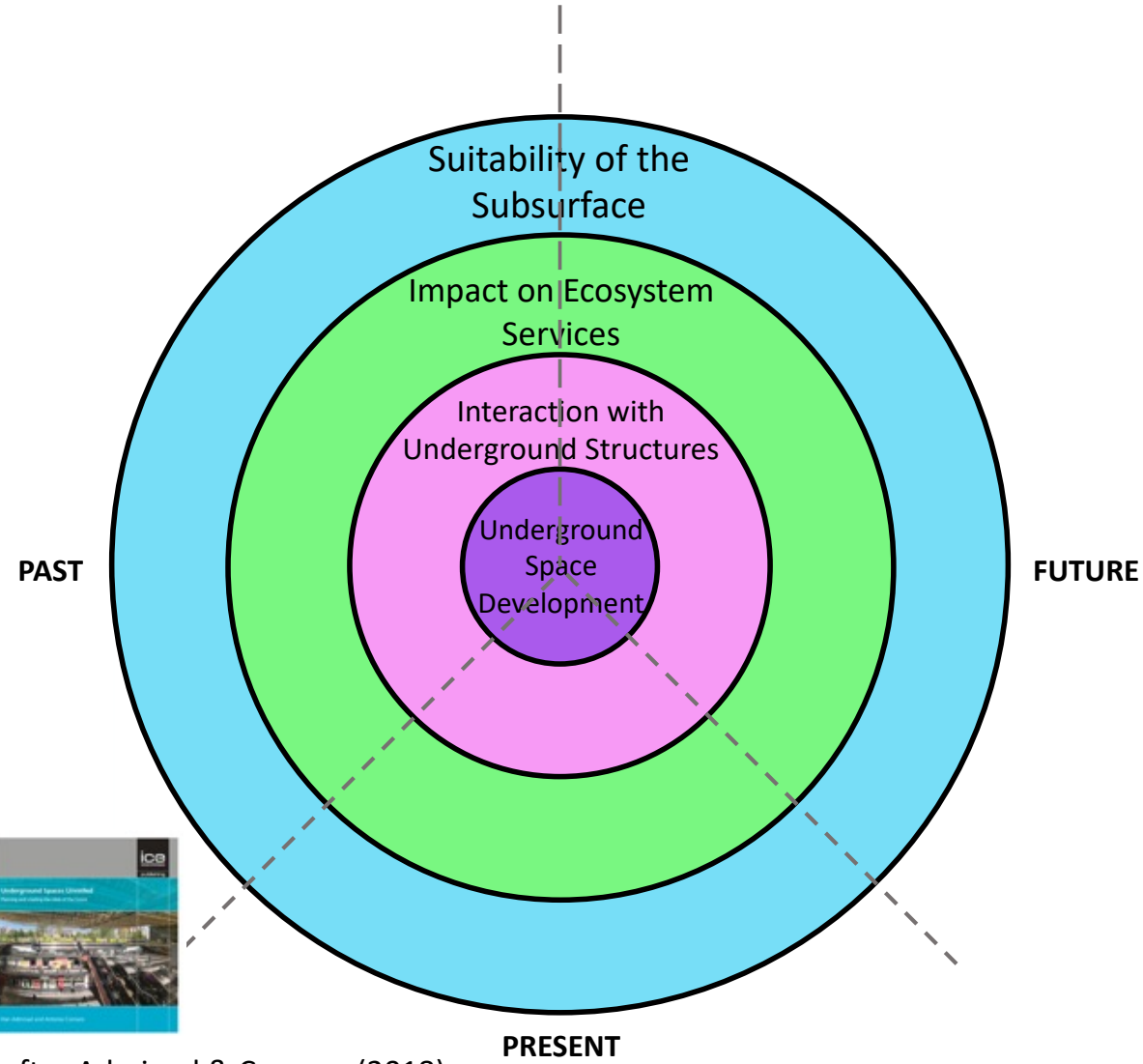
“the development that meets the need of the present generation without compromising the ability of future generations to meet their own needs”

Underground Space and Sustainability

Simple Sustainability Matrix

	Present	Future
External	Does the use of underground space contribute in a sustainable way ie. material use, less noise pollution?	Is the space reusable for other functions?
Internal	Is the development itself sustainable i.e., it uses less energy, has lower carbon footprint?	Does the use of underground space still allow future development?

(Modified from; Cornaro & Admiraal, 2012)



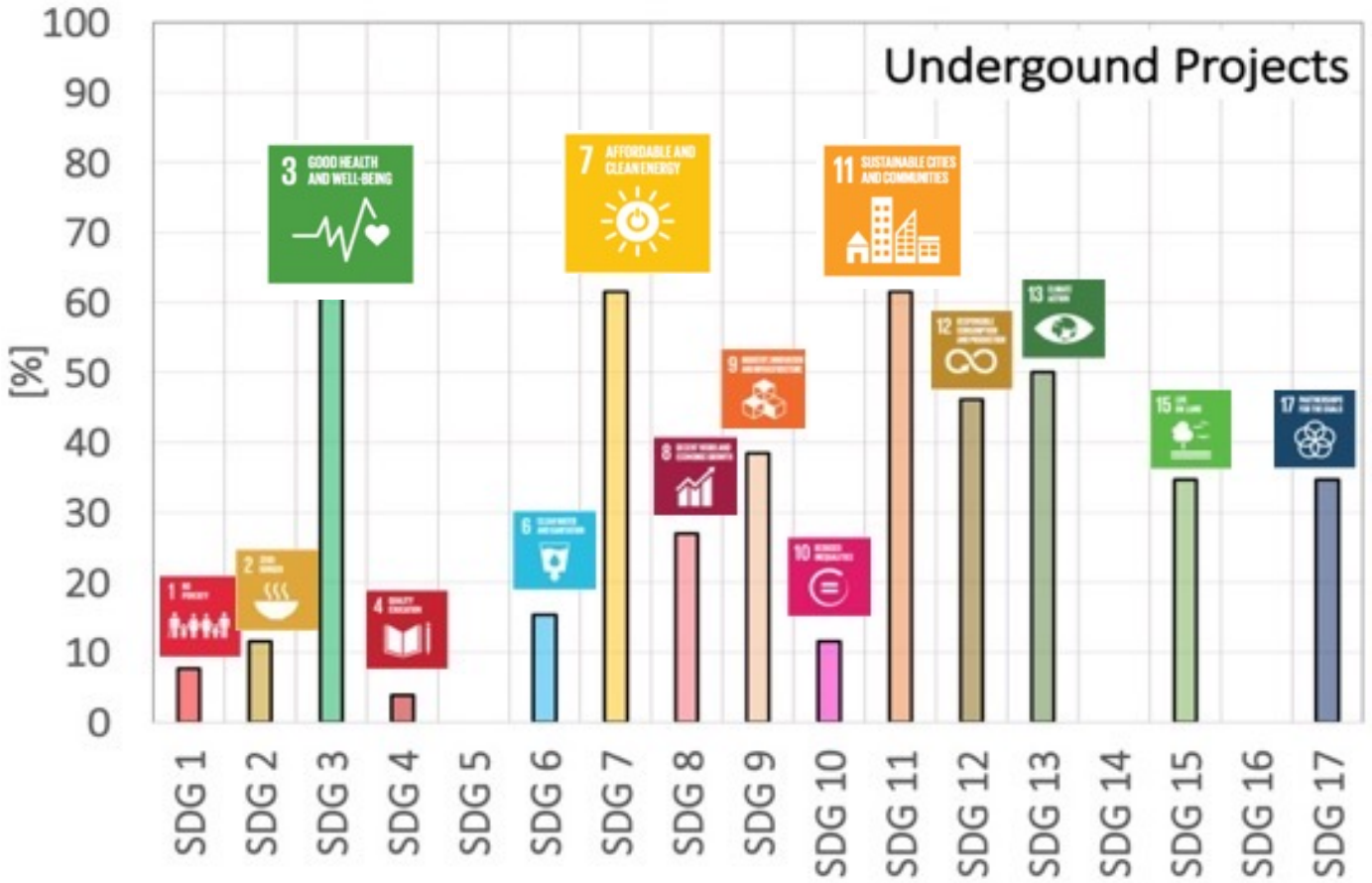
after Admiraal & Cornaro (2018)

SDGs (U.N., 2015)


Atlas of Sustainable Development Goals
2020
From World Development Indicators


1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

Underground Space and Sustainability



Generating a database of underground structures/projects

30 projects examined

- Transport & Commuting
- Energy (geothermal, hydro-power etc.)
- Storage (waste)
- Recreational
- Housing
- Food & Beverage

Paraskevopoulou, C., 2021. **Underground Space and Sustainability**, presented during ACUUS 2020 on Deep Inspirations (virtual).

Underground Space and Sustainability

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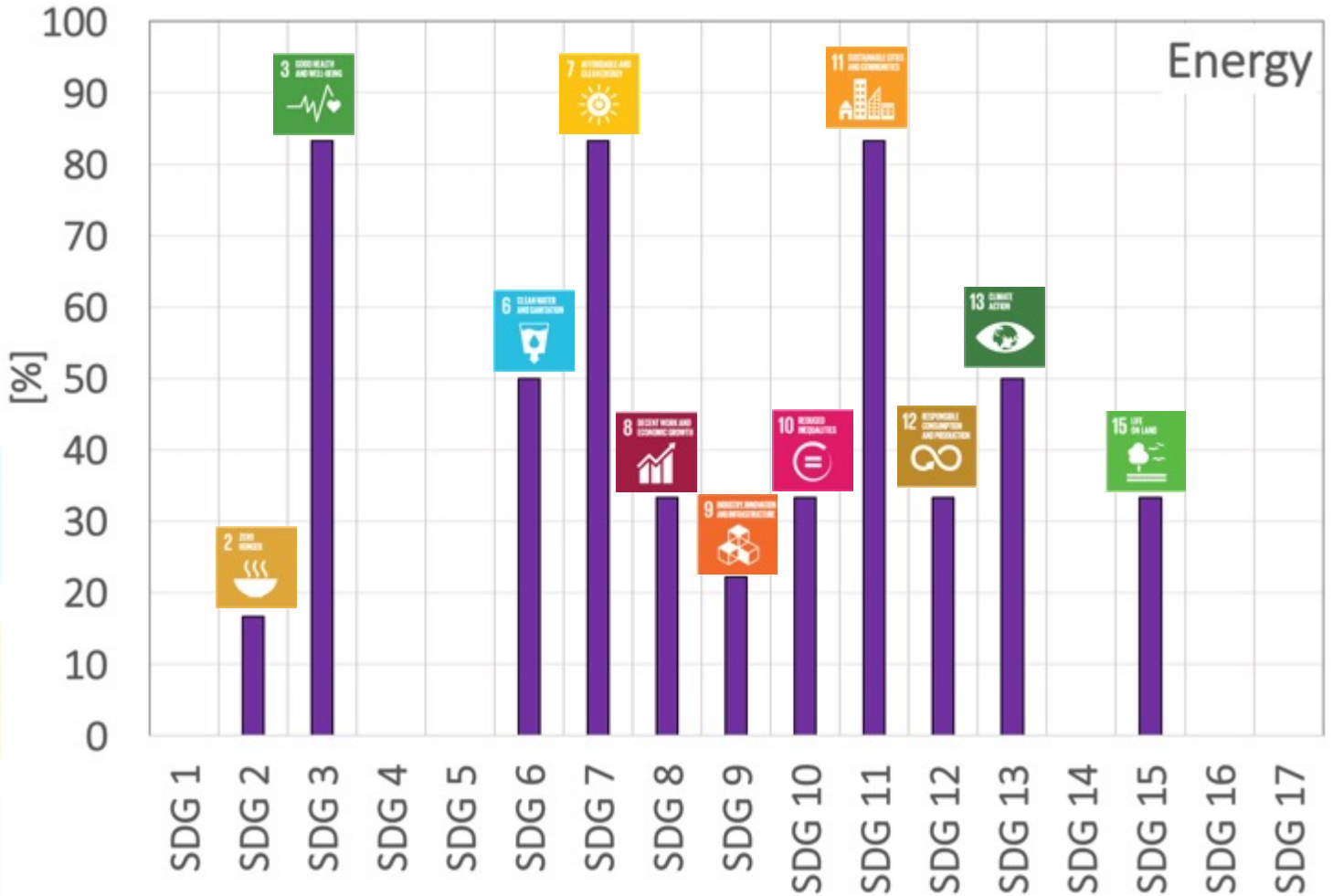
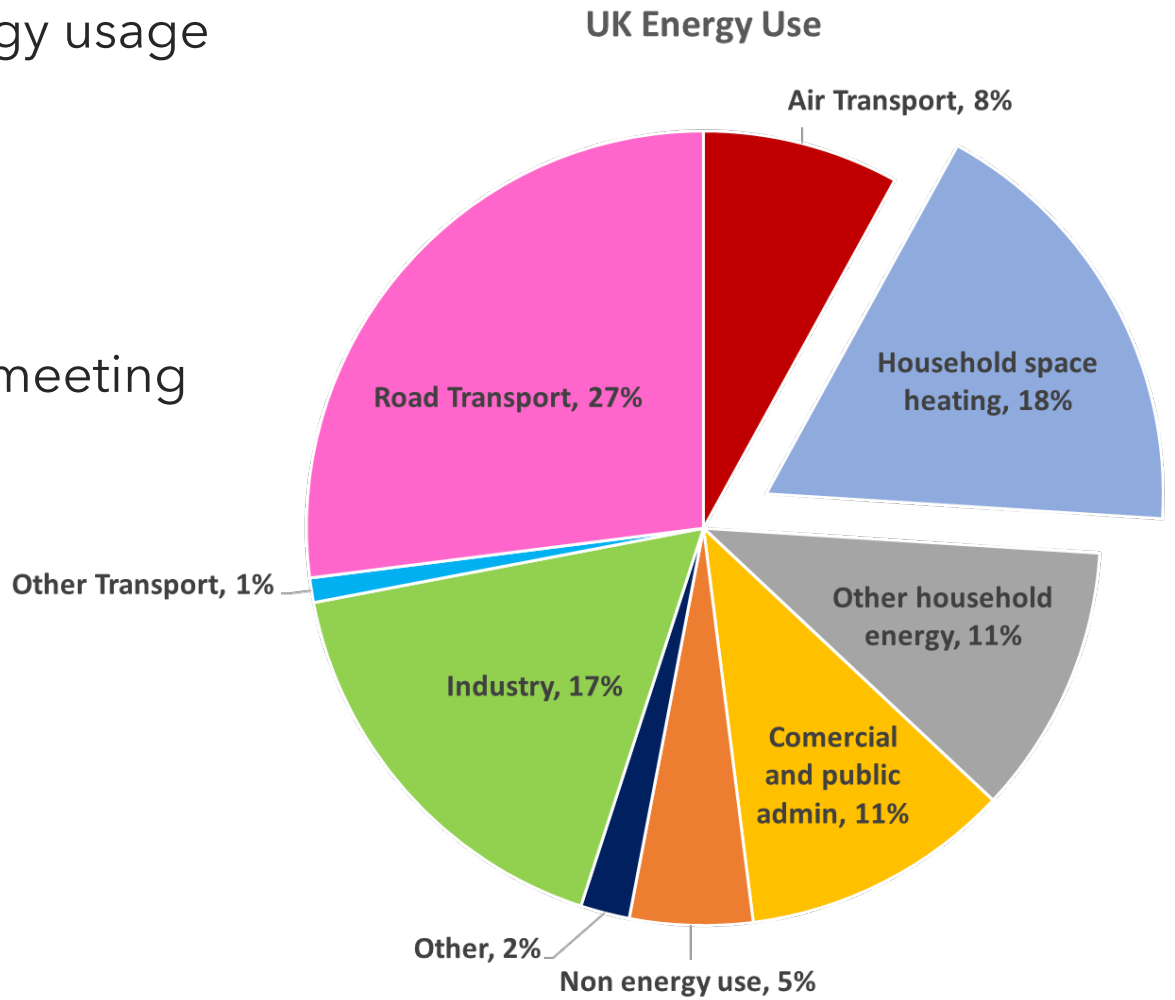


UK

Decarbonising Space Heating in the UK

- Space heating =18% of the UK's total energy usage (~62% household energy usage)

- Decarbonising this energy is a key part of meeting Net Zero emissions by 2050



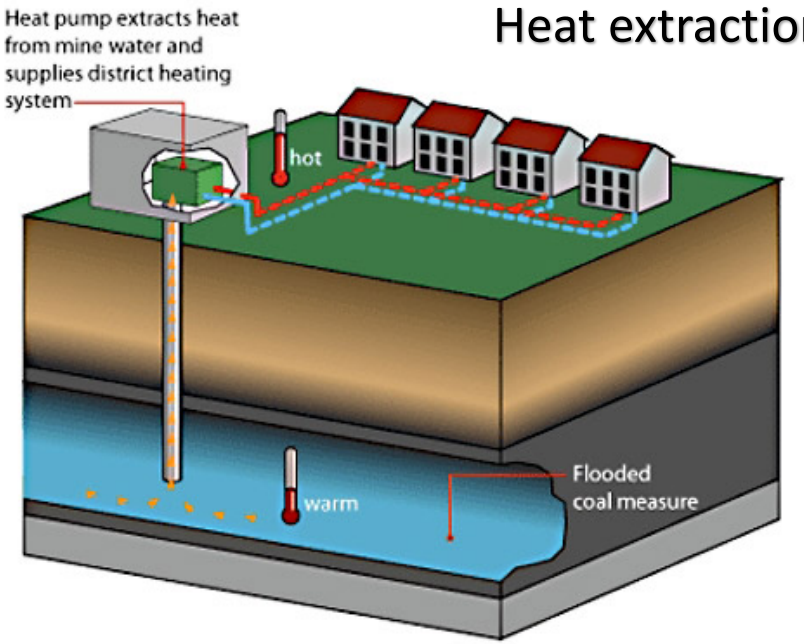
Total UK energy use by sector (Modified from Palmer and Cooper, 2013)

Slide Courtesy S. Connolly

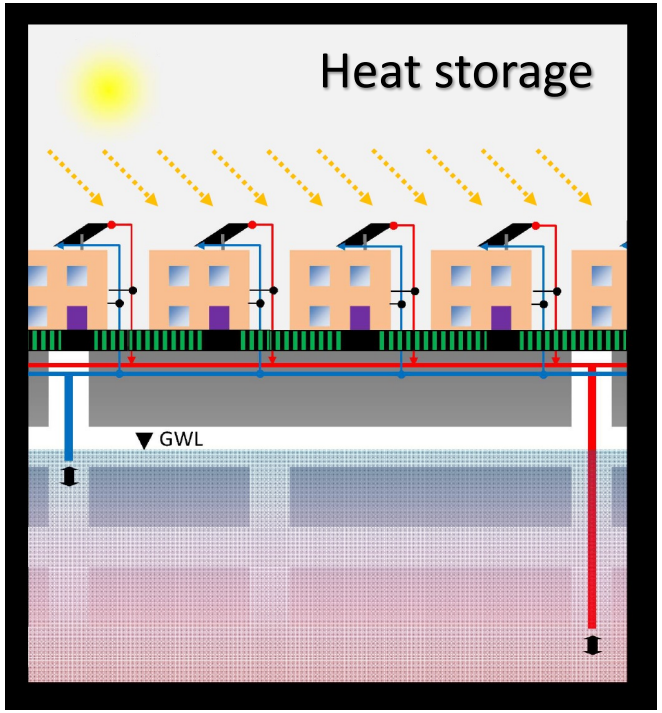
Connolly, S., Paraskevopoulou, C., Kearsey, T., Piazolo, S., Shaw N. Investigation of geothermal heat production and heat storage in abandoned mines of the East Pennine Coalfield. *(in Prep*)

Mine Water Geothermal

Heat extraction



Inhabitat, 2008



GeoERA, 2021

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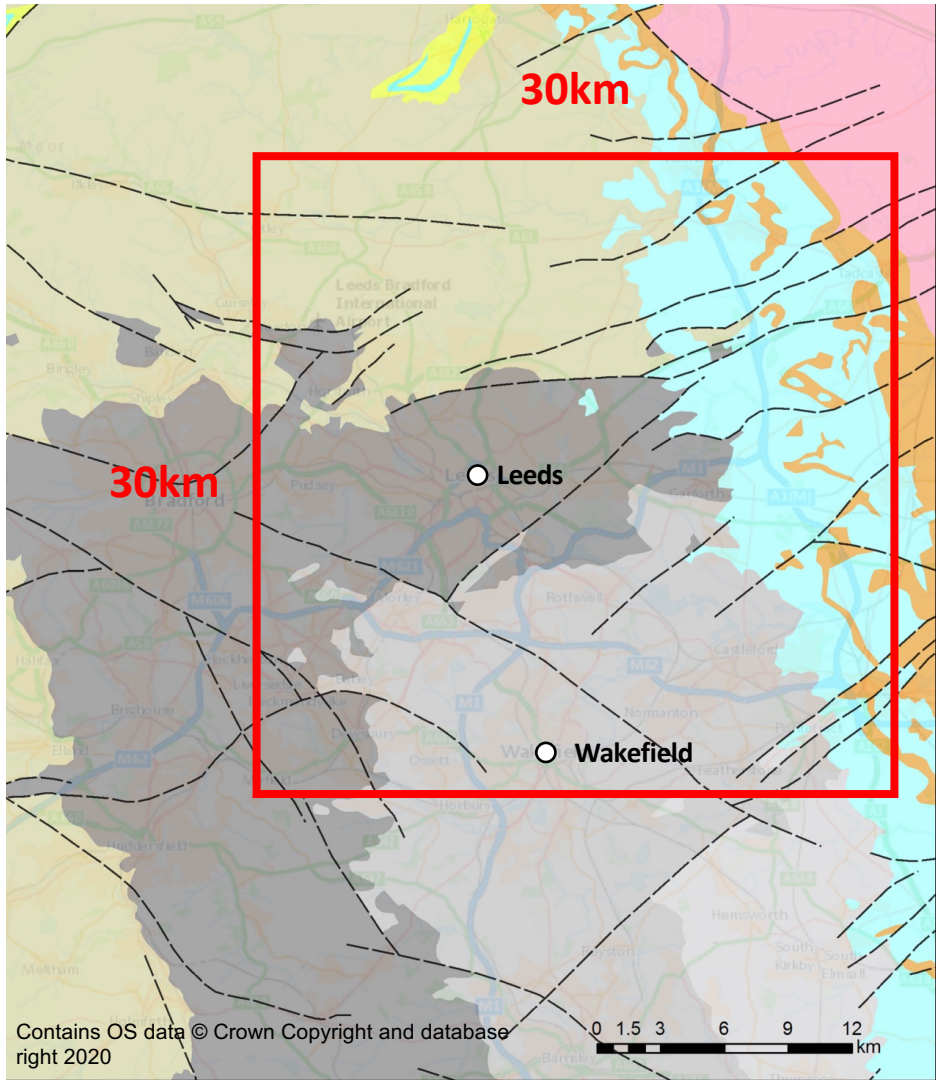
Mine Water Geothermal in Leeds, UK



- Triassic Sandstone & Conglomerate
- Permian Dolomitised Limestone (incl. Cadeby Fm)
- Permian Mudstone, Siltstone, and Sandstone
- Pennine Upper Coal Measures
- **Pennine Middle Coal Measures**
- **Pennine Lower Coal Measures**
- Millstone Grit

Coal Measures = *mudstones, siltstones, sandstones, and coal seams*

Moderately strong sandstones

Weak – moderately strong mudstones and siltstones

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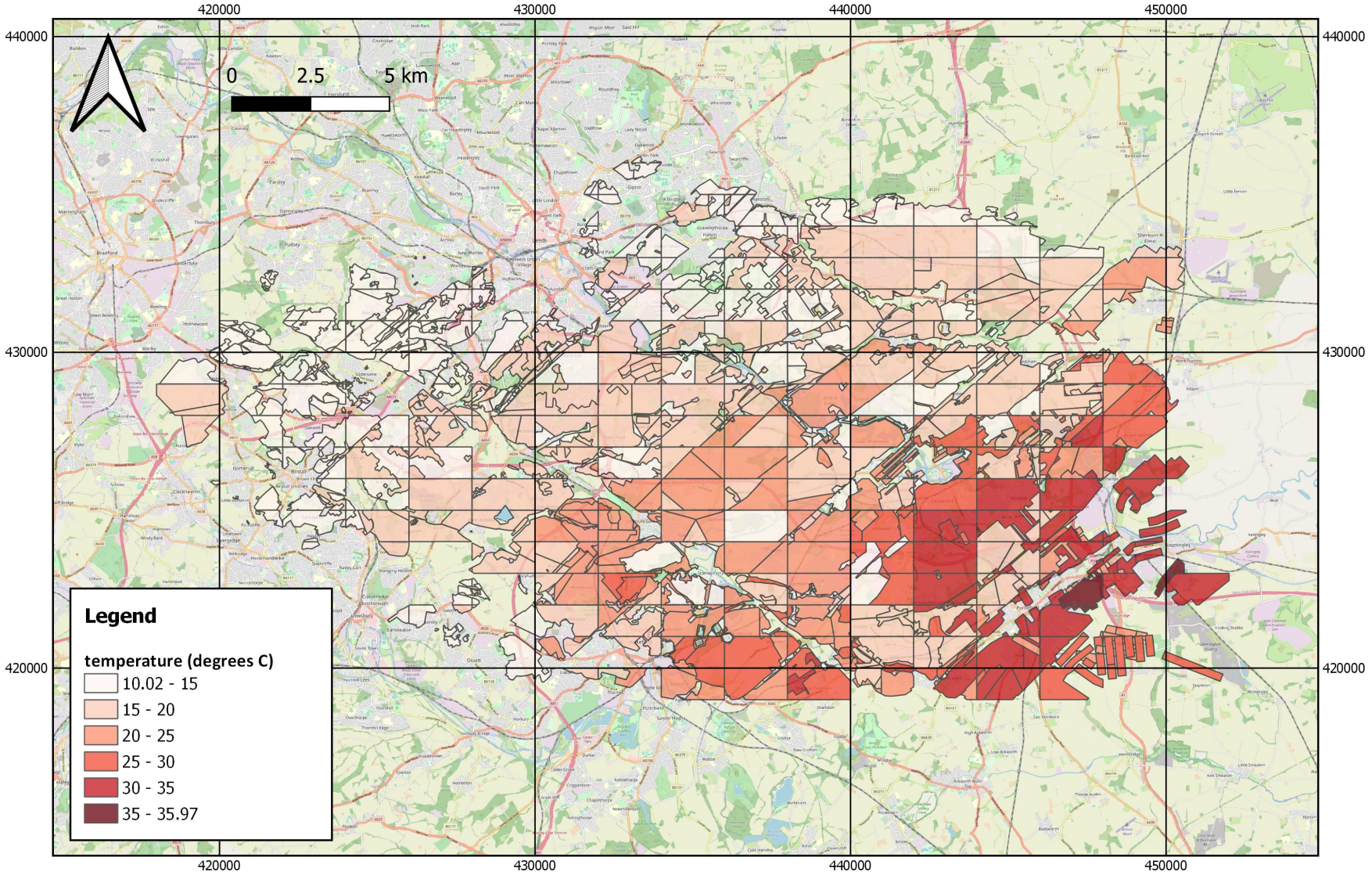
Mine water temperature estimates for seams ≥ 1m thick



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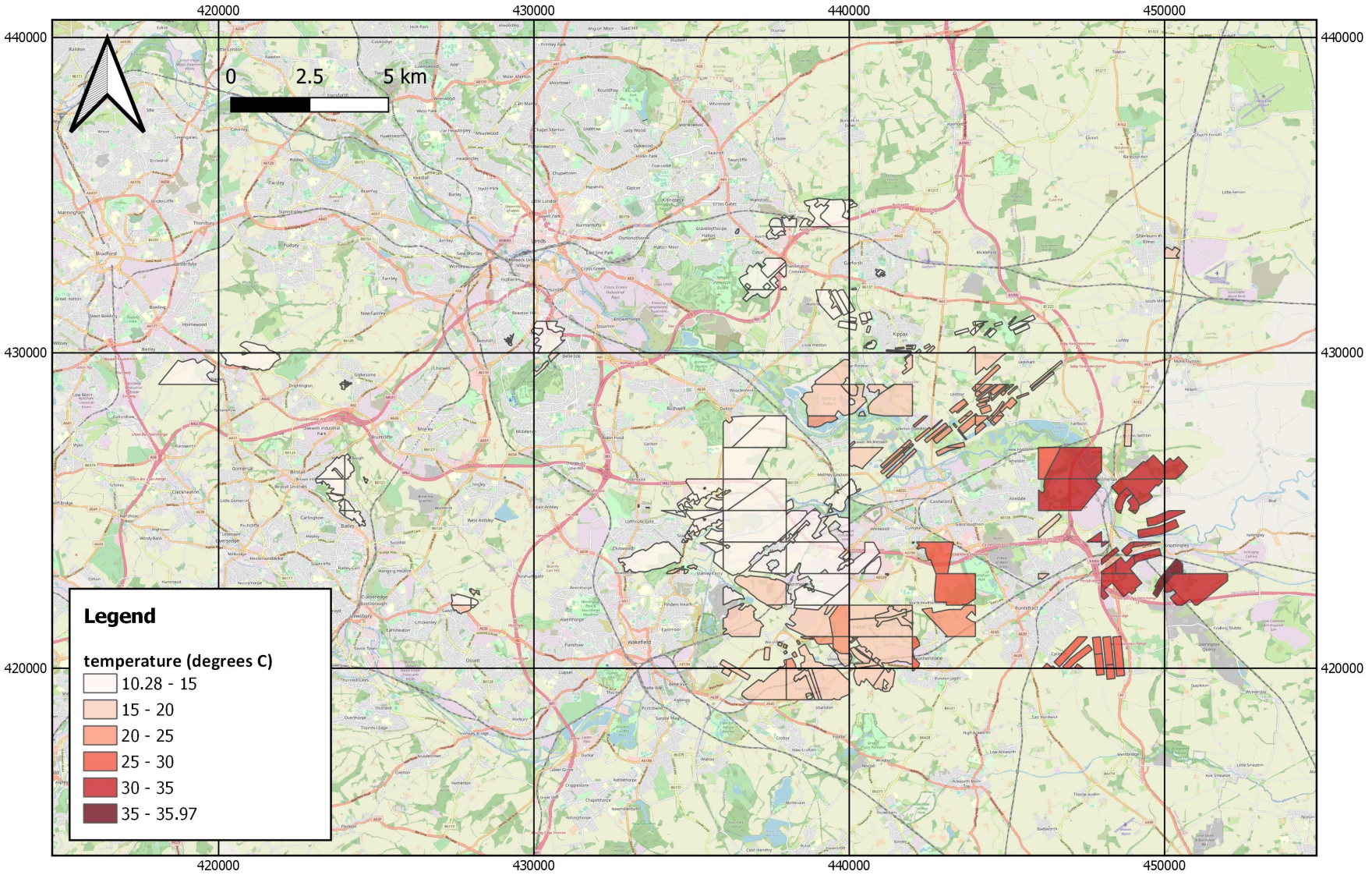
Mine water temperature estimates for seams ≥ 2m thick



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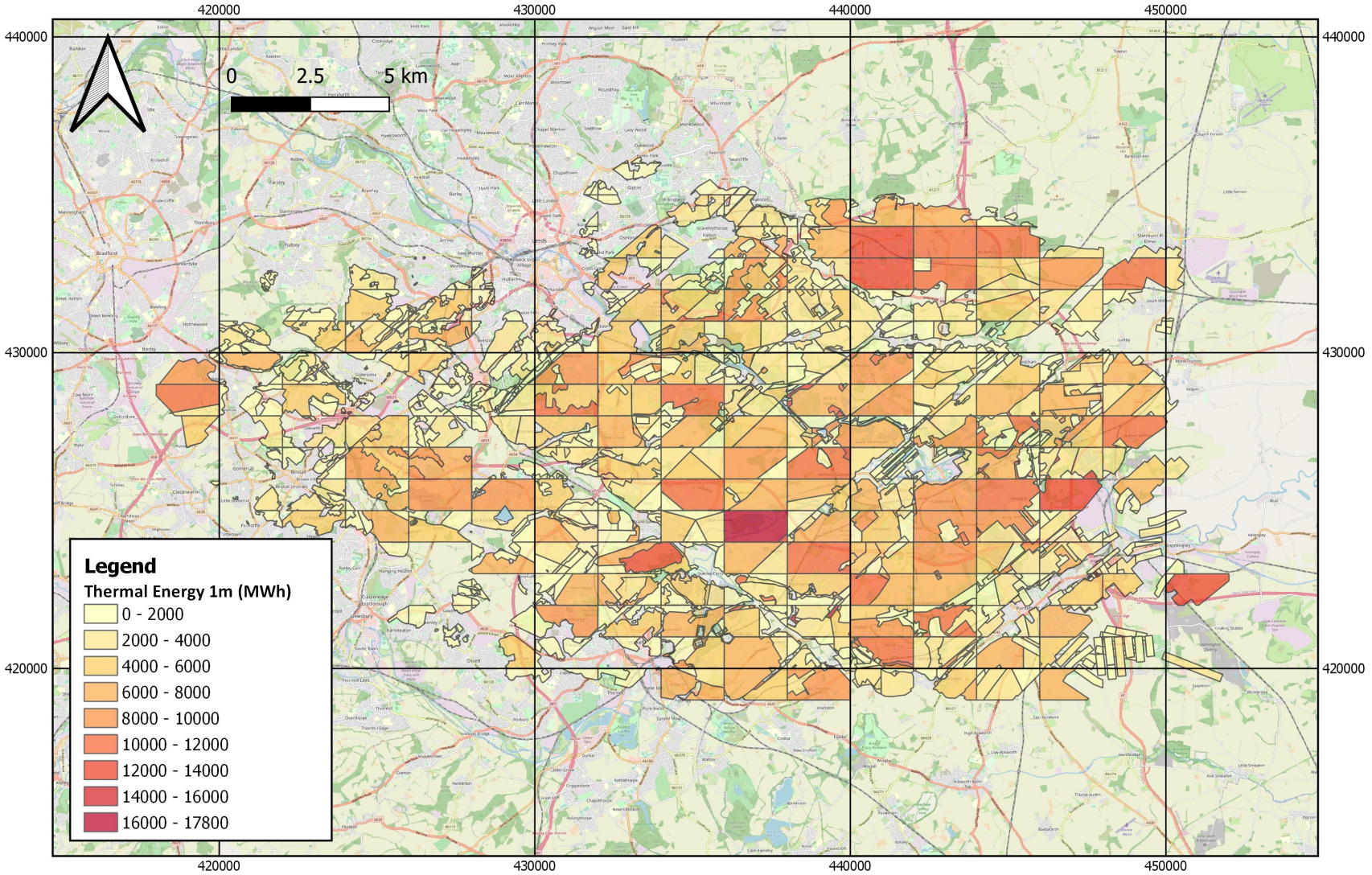
Available thermal energy from seams ≥ 1m thick (70% voids)



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$\Delta T = 5°$

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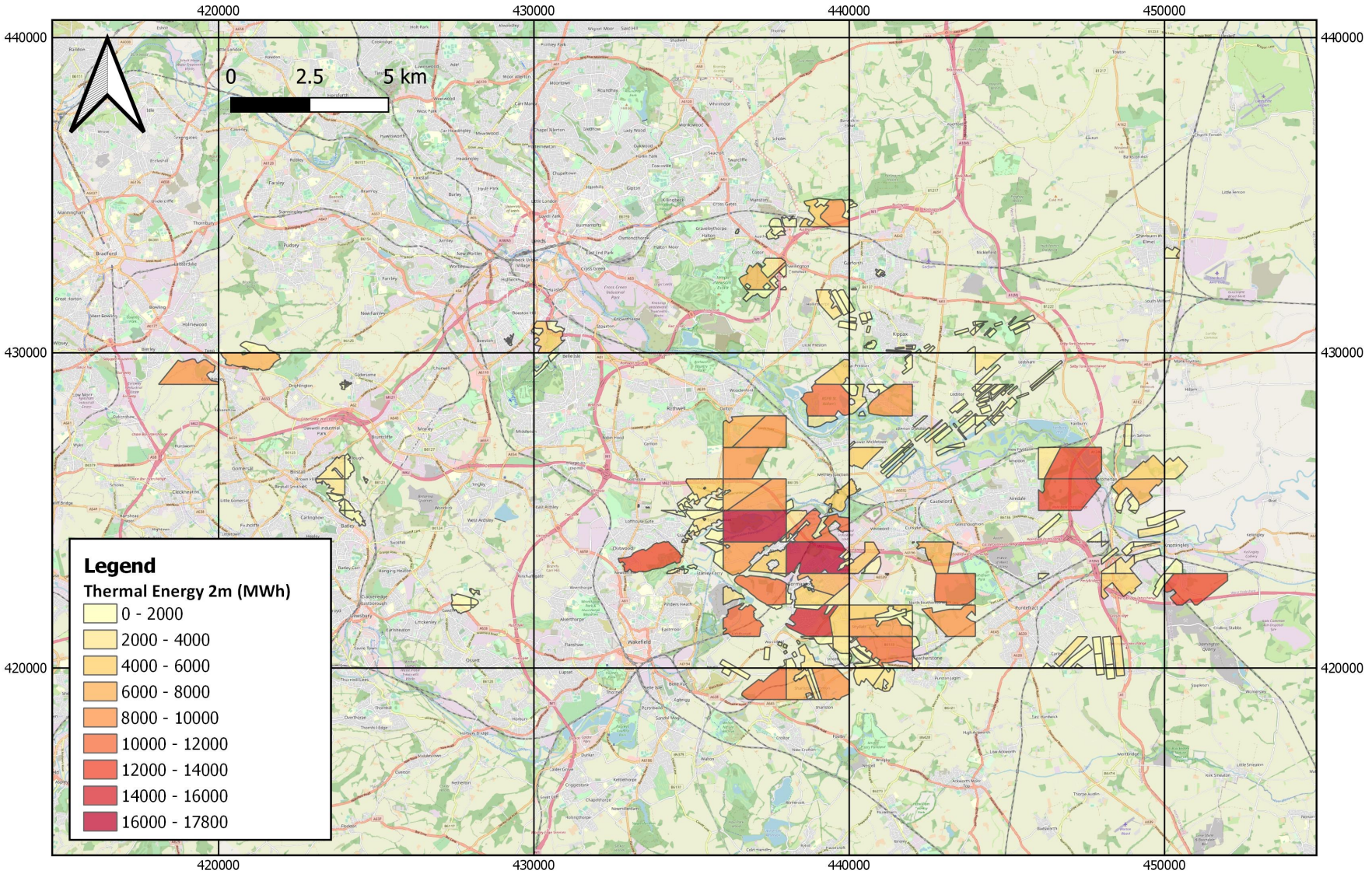

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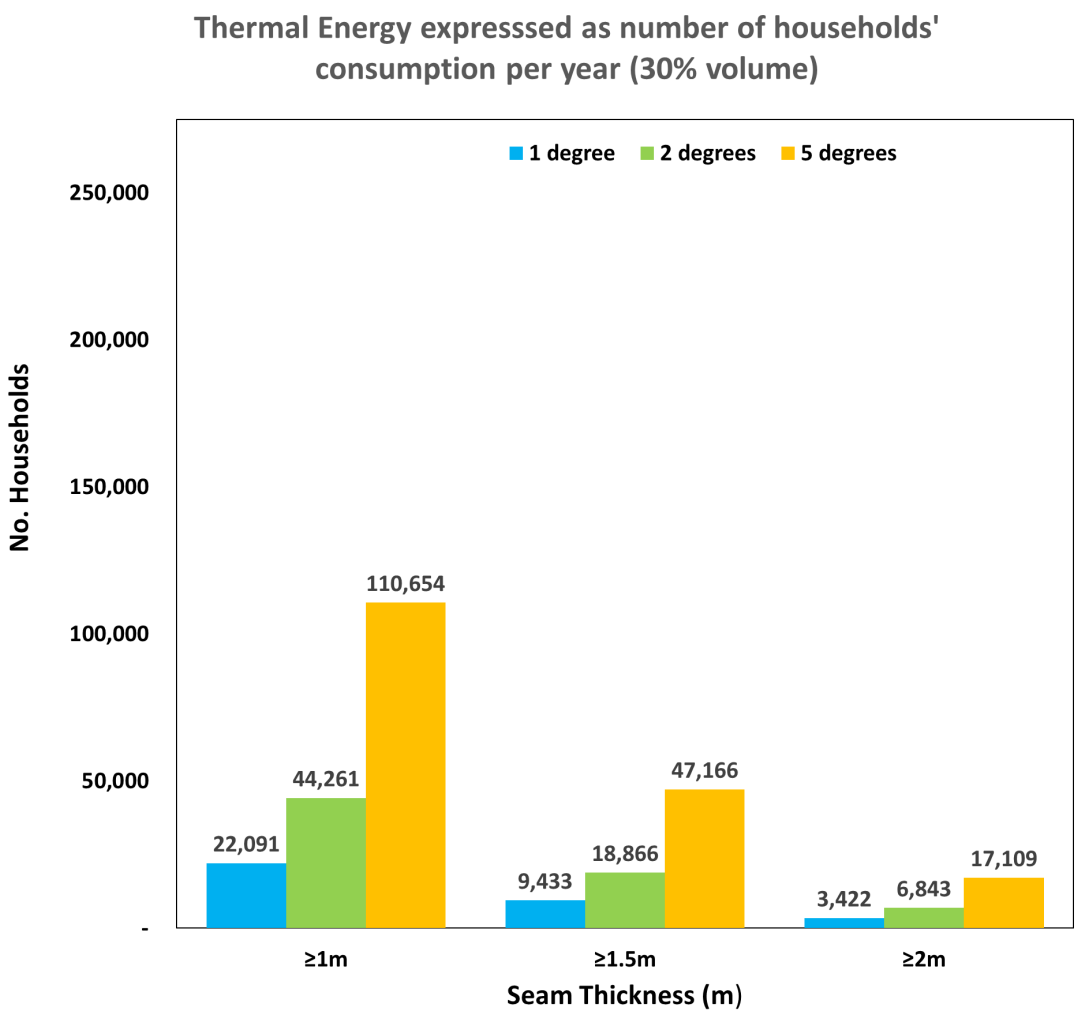
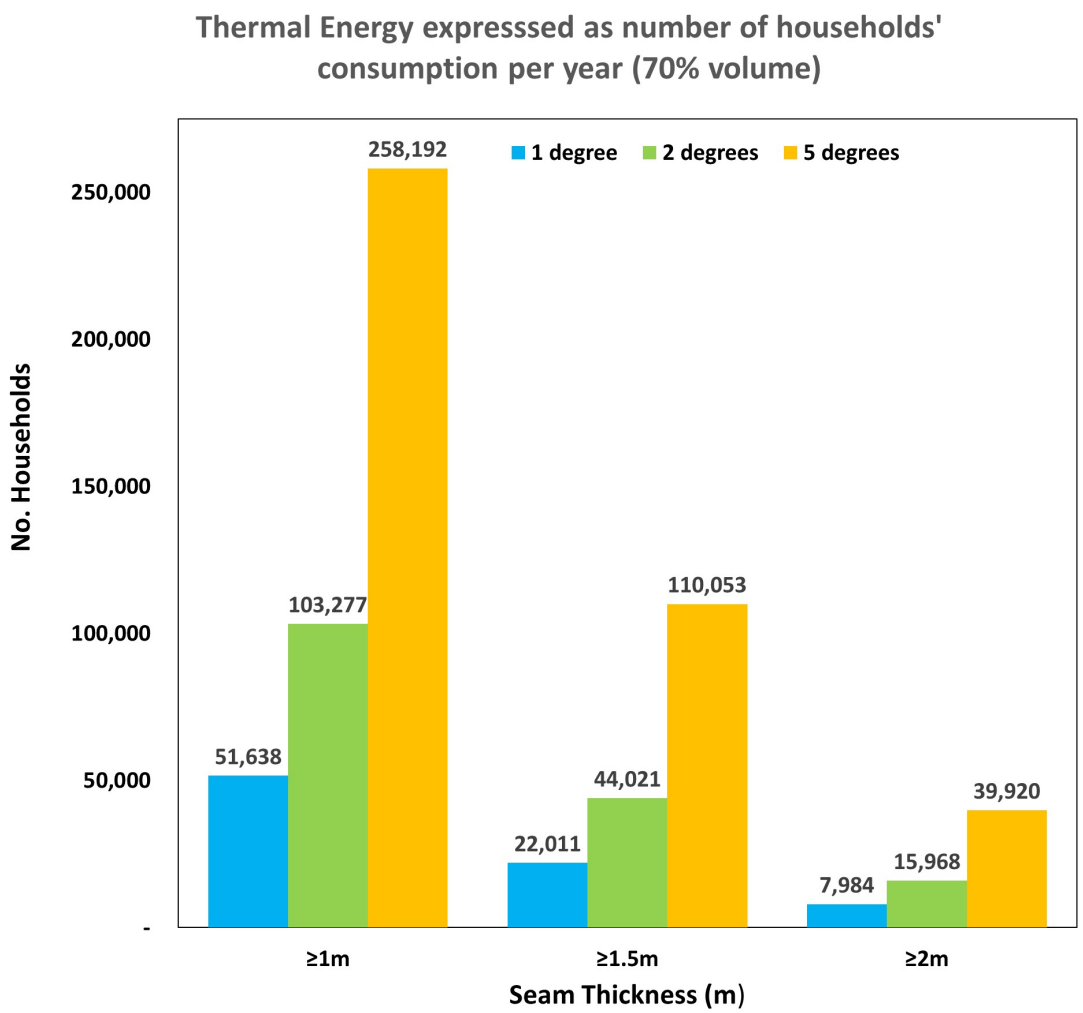
Mine Water Geothermal in Leeds, UK

UNIVERSITY OF LEEDS





Currently: Total number of households in Leeds = 320,217

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Key Take Aways

- **Underground space** is a **major strategic asset** of cities worldwide, and when perceived and encountered holistically in the urban eco-system can contribute towards securing long-term sustainability and resilience of cities.

- **Underground space** can contribute in achieving the **SDGs**.

- Minewater in abandoned mines can contribute in Geothermal Heat production and storage. In the case of Leeds area, it could supply heat to around 250,000 households.

Get involved with ITACUS and our Activity Groups!

Activity Group 2: Sustainability & Underground Space

Email: c.paraskevopoulou@leeds.ac.uk