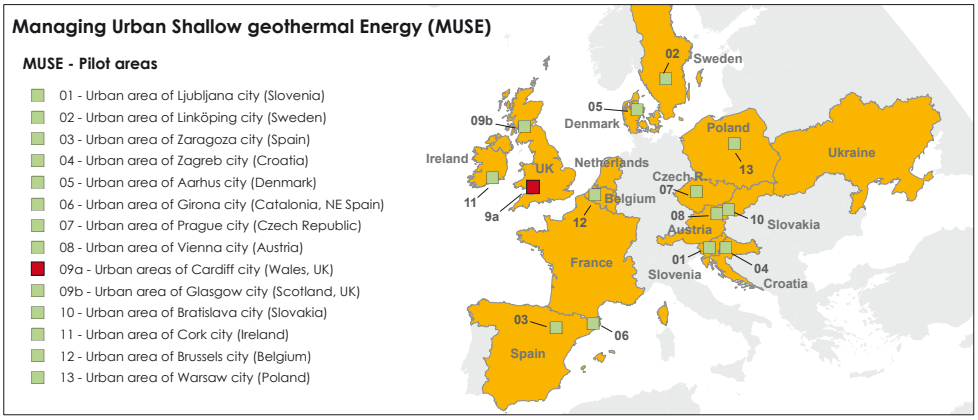
# CARDIFF FACTSHEET



## Pilot area information




Cardiff is the Capital city of Wales and an important administrative, business and residential center. The urban area of Cardiff, UK is a medium-sized low-lying coastal city with an area of 140 km$^2$.

Topographically Cardiff is fairly flat ground and rises from sea level to low hills in the north, east and west to around +30 m asl. It has an average annual air temperature of 10.8 °C and is affected by Urban heat island effect. It is intersected by two rivers that drain into an impounded man made freshwater lake called 'Cardiff Bay'.

Much of the city is underlain by thin deposits of glacial sand and gravel and alluvium which offer a shallow aquifer for open loop geothermal use, in addition to conventional vertical and horizontal closed loop systems in the bedrock and till. There are several deep (>100m) closed loop systems into the underlying Triassic, mainly mudstone, bedrock. There is one known operational shallow (<20m) open loop heat pump system in the south of the city, which abstracts from the shallow aquifer.

The groundwater level in the superficial gravels is shallow, typically no more than 5 m below ground level. Seasonal temperatures in the shallow sand and gravel aquifer (0-20m depth) range between 9.1 and 16.1°C (Farr et al 2017). The shallow aquifer makes shallow open loop systems technically feasible, making Cardiff an idea place to investigate shallow urban heat recovery. For use in low carbon district heat networks.

| | |
|---|---|
| Pilot Area | Cardiff |
| Task (MUSE) | 4.10a |
| Country | Wales, United Kingdom |
| Area (km²) | 140 km$^2$ |
| Total number of inhabitants (date) | 346,000 (2012) |
| Inhabitants per km² | 2,471 |
| Level of urbanization | Approx. 70% |
| Elevation range (m a.s.l.) | 0-30 masl average 10masl |

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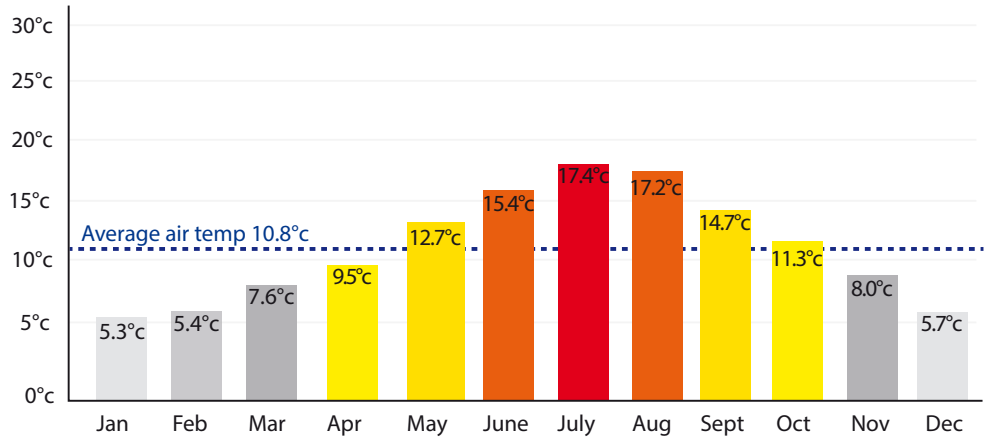
## Climatological settings

| HDD/CDD data according to EUROSTAT method | |
|---|---|
| Heating degree days (HDD); [baseline reference values]; (period for data calculations) | 2275 [15/18] (2017) |
| Cooling degree days (CDD); [baseline reference values]; (period for data calculations) | 5 [21/24] (2017) |
| Length of the heating season (days) | October – May (8 months, 240 days) |
| Length of the cooling season (days) | July – August (2 months, 60 days) |

Source of data: Eurostat. https://ec.europa.eu/eurostat/data/database

## Average monthly and annual air temperature




## Economic boundary conditions

| Estimated average installation costs for shallow geothermal systems (€/kW output) [1] | |
|---|---|
| Open loop systems | 800 |
| Closed loop systems | 1600 (ground source install cost ~10,000 – ~22,000, depending on size (excluding RHI) |
| Estimated average heating costs (€/kWh) | |
| Open loop systems | 25? |
| Closed loop systems | 25? |
| Drilling cost range per meter (€/m) for Open Loop | 50 - 100 |
| Drilling cost range per meter (€/m) for Borehole Closed Loop | 50 -100 |



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## Market situation

| | | |
|---|---|---|
| Number of SGE installations in pilot area | OLS<br>V-CLS<br>H-CLS | 1 (OD)<br>2 (EST)<br>0 (EST) |
| OLS = 1 - 'Grangetown Nursery School' installed by BGS 20kw installed in 2015<br>VCLS = 1 - 'Senedd Building, Cardiff Bay' 100kW installed in 1999<br>2 - 'Unknown location, Cardiff' 120 kW installed 2016?<br>HCLS = no known systems | | |
| Current growth rate | No. of Installations<br>- UK saw an 18% increase in heat pump installations in 2017 compared with 2016 (BSRIA, May 2018)<br>- Around 22,000 heat pumps (air and ground source) were installed in UK in 2017 (BSRIA, May 2018)<br>- Only 1 in 10 of the UK's ~20,000 installed heat pumps in 2016 were GSHP (BSRIA, 2016)<br>- UK Governments' Renewable Heat Incentive (RHI) scheme has been extended to 2021 for domestic and non-domestic and have to be installed by Microgeneration Certification Scheme (MCS) certified installers.<br>- The UK's 4th Carbon budget is calling for 4 Million domestic and 600 000 commercial heat pumps to be installed by 2030. 8000 heat pumps installations per week from 2025 are required to meet 2050 CO2 targets. | |
| Estimated share of open loop systems | | 10% |
| Estimated share of closed loop systems | | 90% |
| Estimated total share of shallow geothermal methods in the heating market | V-CLS | <1% |
| Other SGE technologies:<br>Eg. inter-seasonal heat storage schemes or energy piles | It's unknown (there are probably some energy piles) | Unknown |
| Estimated total share of RES in the heating energy market (%) (specify local or national values) | | National |

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## Regional geological and hydrogeological characteristics

***Quaternary Sand and Gravel Aquifer: 'Target Aquifer'***

The Glacial Sand and Gravel is the target aquifer for shallow open loop geothermal development in the city. In the north of the city it is unconfined and towards the south becomes confined under Tidal, Alluvial sediments (Devensian and Holocene). Groundwater in the sand and gravel aquifer, which can be up to 30m thick, is frequently < 5 m below ground level. Groundwater flows towards the rivers and the coast. Pumping tests and dewatering operations show that the sand and gravel aquifer can sustain yields of up to 10 l/s however further testing may prove higher yields are achievable, though re-injection rates may be lower.

Groundwater chemistry can range from 'fresh' groundwater to brackish and even saline, a reflection of the proximity of the city to the coast but perhaps also due to the legacy of heavy industrial pollution. Groundwater is naturally elevated in iron and manganese – both of which pose challenges for heat pump infrastructure.

There is a 3D Geological Model (built in GSI3D software) of the superficial deposits recently developed using data from 3000 boreholes.

***Geological: Bedrock***

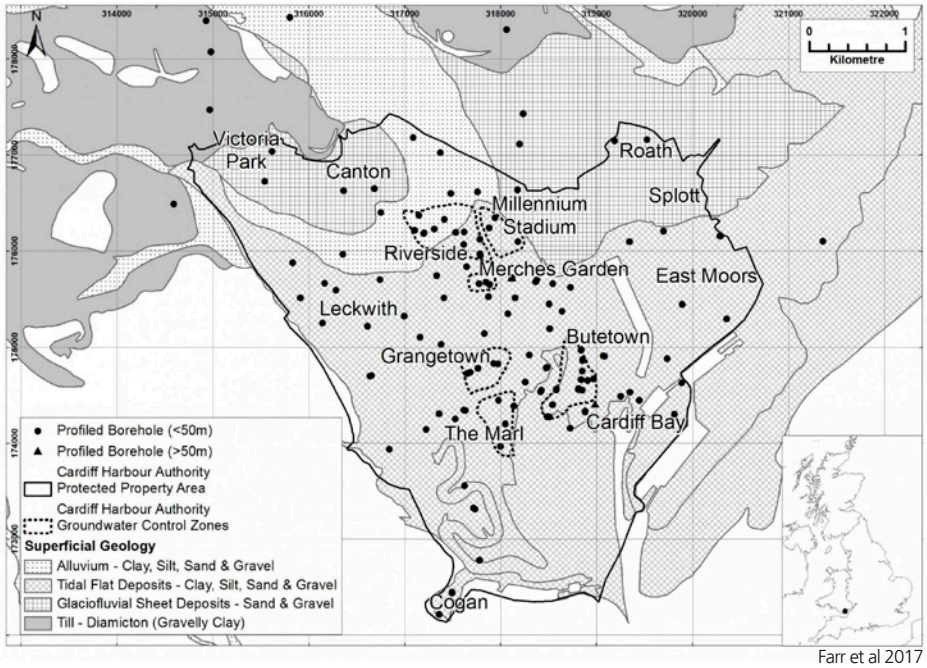
The bedrock is mostly of Triassic Age and was deposited in desert environment associated with player lakes. Lithologies include; Interlayered Mudstone, Sandstone and Limestone with minor Gypsum seams. The bedrock aquifer is considered to be low productivity although some horizons can yield useable quantities of water. At least two deep (100 m) closed loop systems are known to be installed into the bedrock, and one experimental open loop in the shallow aquifer.

***Anthropogenic***

There are extensive and highly heterogeneous made ground deposits, some of which contain perched water tables. They are not considered as potential sources of water in this study area.

***Thermogeology***

Groundwater temperature: 9.1 to 16.1°C average of 12.4°C (within a depth range of 0-20m). The average depth of the 'Zone of Seasonal Fluctuation' is 9.5 mbgl and extends to a maximum of 15.5 mbgl.




Farr et al 2017



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## Summary of works and timeline

| Main Objectives | |
|---|---|
| ✓ | Evaluation and characterization of geology/ hydrogeology / thermal conditions |
| ✓ | SGE assessment resources (for OCS and/or CLS) / and evaluation of UTES-BTES) |
| | Study of conflicts of use (OLS / GWL - OLS/CLS). Hazards/interferences, effects on sub-surface |
| ✓ | Strategies and actions for management and local energy plans |
| **Relation of foreseen tasks** | |
| ✓ | Data collection (TRT, DTRT, rock samples, GWL, T-profile's etc) |
| ✓ | New field works (TRT/geophysics /new samples and lab etc) |
| ✓ | Monitoring existing SGE/GWL/T etc) |
| ✓ | Mapping (in general terms) |
| ✓ | 2D/3D Modelling (in general terms) |

## Detailed summary of works at the Pilot Areas and brief timeline

***March 2019 – March 2020 MUSE monitoring period.***

Investigation of aquifer properties
Baseline temperature monitoring
GSHP pilot monitoring
Mapping installed systems and potential conflicts of use
Geophysical Investigations (BGS-TNO collaborations?)
TRT(BGS-GBA collaborations?)
Pumping test
Thermal conductivity measurements (field and lab/core)
Heat flow or Hydrogeological models
Governance: Review of regulation (WP2 & 3)
Social Science: Stakeholder questionnaires & Public engagement, Installer questionnaires (WP2, 3 and 5)

## Reference


Farr et al. 2017 Mapping shallow urban groundwater temperatures, a case study from Cardiff, UK. Quarterly Journal of Engineering Geology and Hydrogeology, 50 (2). 187-198. https://doi.org/10.1144/qjegh2016-058

Kendall, R.S. 2015 Conceptual cross-sections of superficial deposits in Cardiff. British Geological Survey, pp10. (OR/15/045) http://nora.nerc.ac.uk/id/eprint/511584/

Kendall et al., 2018. Model metadata report for Cardiff Superficial Deposits. British Geological Survey Open Report, OR/16/031. 19pp.


www.ukgeos.ac.uk/Cardiff

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## Contact

Managing Urban Shallow geothermal Energy
Project number GeoE.171.006

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