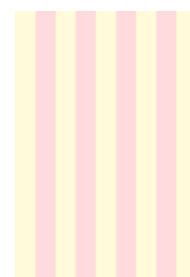
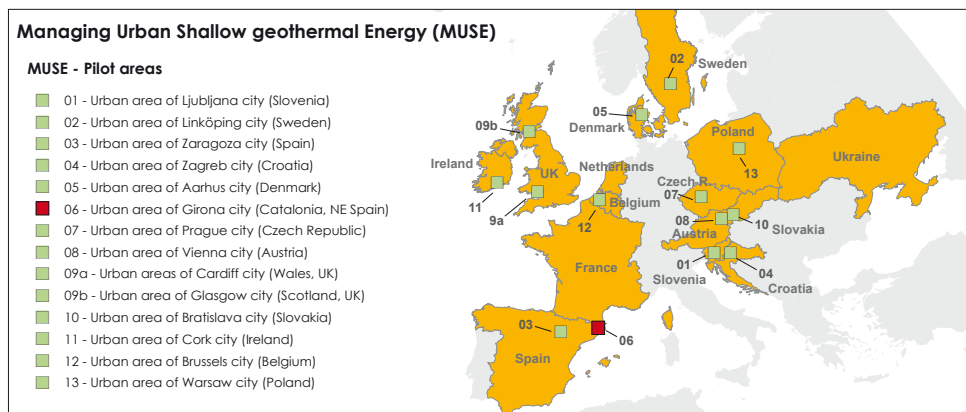


## Pilot area information



The metropolitan urban area of Girona city (Girona and Salt cities, and surroundings) is a model for urban areas with a poorly-developed shallow geothermal energy (SGA) market. Until recently, only a few closed-loop systems existed in the whole area. Utilization of shallow geothermal energy for heating and cooling is increasing in Catalonia, from 2016 to 2018 the overall installed thermal power has increased more than 140%. Despite this increase, geothermal energy still covers just a minor part of the heating market. The topographical level of the study area varies from 65 to 186 m a.s.l., temperature ranges from 8.2°C to 22.3°C, with a mean value of 14.7°C, maximum of 37.5°C and minimum values of -6.8°C. Urban area of Girona stands on Cambro-Ordovician, Carboniferous-Permian and Paleogene bedrock, configuring a basin filled with Neogene continental alluvial deposits and quaternary fluvial sediments, which aquifers will be utilized for geothermal development. Groundwater is rather shallow, i.e. 3 – 26 m below surface [1], and water temperature varies between 16oC and 17oC. Hydraulic conductivity of surface deposits varies between 0,1 to 1 m/d for the Neogene aquifer and from 4 to 80 m/d for the alluvium quaternary deposits (Ter and Onyar rivers).

|                                    |   |
|------------------------------------|---|
| Pilot Area                         | Girona  |
| Task (MUSE)                        | T-4.7   |
| Country                            | (Catalonia); Spain  |
| Area (km <sup>2</sup> )            | 48 km <sup>2</sup> (39,1 km <sup>2</sup> from Girona city)  |
| Total number of inhabitants (date) | 138.702 inhabitants (2016)<br>(98.255 from Girona city)   |
| Inhabitants per km <sup>2</sup>    | 2.889 hab./km <sup>2</sup> (2016)<br>(2512 hab./km <sup>2</sup> from Girona city)   |
| Level of urbanization              | 16 km <sup>2</sup> /48 km <sup>2</sup> = 33% (2016)<br>(12 km <sup>2</sup> /39 km <sup>2</sup> = 30% from consolidated urban area of Girona city) |
| Elevation range (m a.s.l.)         | 65 – 186  |

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## Climatological settings

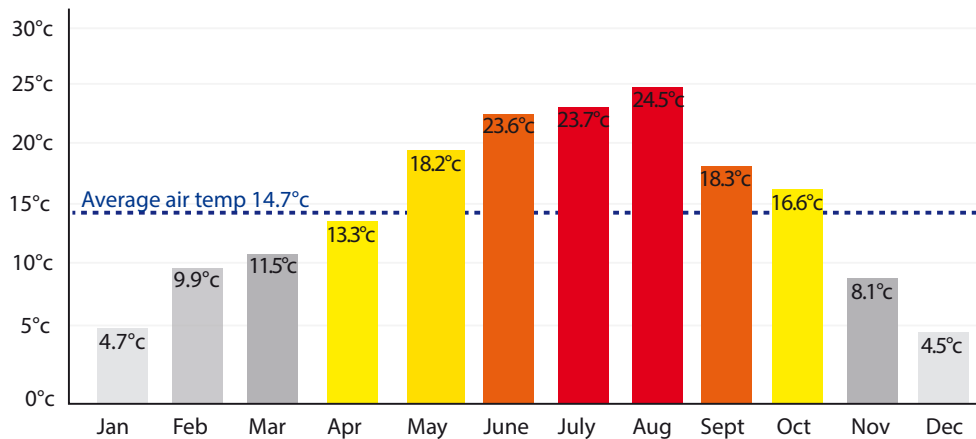
HDD/CDD data according to EUROSTAT method

|  |                                     |
|--|-------------------------------------|
| Heating degree days (HDD); [baseline reference values]; (period for data calculations) | 1733 [15/18] (2017)                 |
| Cooling degree days (CDD); [baseline reference values]; (period for data calculations) | 228 [21/24] (2017)                  |
| Length of the heating season (days)  | 106; (18°C/18°C)<br>79; (15°C/15°C) |
| Length of the cooling season (days)  | 74; (20°C/20°C)<br>61; (23°C/23°C)  |

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

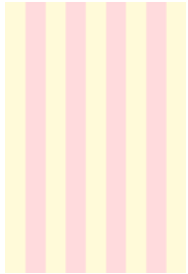


## Average monthly and annual air temperature



## Market situation

|   |                      |  |
|---|----------------------|--|
| Number of SGE installations in pilot area   | V-CLS                | 16 (OD)                                    |
| Current growth rate   | No. of Installations | 140% from 2016 in Cat                      |
| Estimated share of open loop systems  |                      |  |
| Estimated share of closed loop systems  |                      |  |
| Estimated total share of shallow geothermal methods in the heating market   | V-CLS                | 5%   |
| <u>Other SGE technologies:</u><br>Are there inter-seasonal heat storage schemes or energy piles in your pilot area? | Unknown              | No UTES exists<br>Unknown foundation piles |
| Estimated total share of RES in the heating energy market (%) (specify local or national values)                    |                      | 8.5%                                       |



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## Economic boundary conditions

| Estimated average installation costs for shallow geothermal systems (€/kW output) <sup>1</sup> |  |
|--|--|
| Open loop systems  | Unknown  |
| Closed loop systems  | 1700 - 2200€/ kWt  |
| Estimated average heating costs (€/kWh)  |  |
| Open loop systems  | Unknown  |
| Closed loop systems  | 0.025 – 0.05 €/kWh (data: 2012)                                  |
| Drilling cost range per meter (€/m) for Open Loop  | 50-600 €/m.l. (percussion drilling rig – Ø 250/500mm)            |
| Drilling cost range per meter (€/m) for Borehole Closed Loop                                   | 50 -60 €/m.l. (rotary air percussion drilling rig - Ø 115/150mm) |

## Regional geological and hydrogeological characteristics

### **Bedrock:**

Paleozoic (schists, slates and quartzites intruded with quartz and aplite dykes and veins; post-Variscian granodiorites and granites) and Paleogene (lower and middle Eocene: Nummulite limestones and marls). Geological structure: highly controlled by major normal faults in NW-SE direction.

### **Plio-Quaternary:**

Continental alluvial fans and fluvial sediments. Shales and coarse sands with gravel and conglomerate intercalations from Pliocene and alluvial and fluvial coarse sediments in the Quaternary related to the Ter and Onyar rivers. Anthropogenic deposits are observed as well.

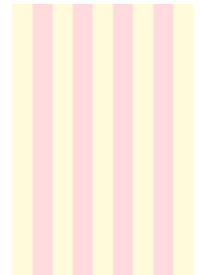
### **Hydrogeology:**

Target aquifers: The alluvial Quaternary aquifers associated to Ter and Onyar rivers, and the semi-confined Pliocene aquifer. Other aquifers are located in the highest parts of the city (karstic limestone aquifer - Eocene) In general, groundwater flows eastwards.

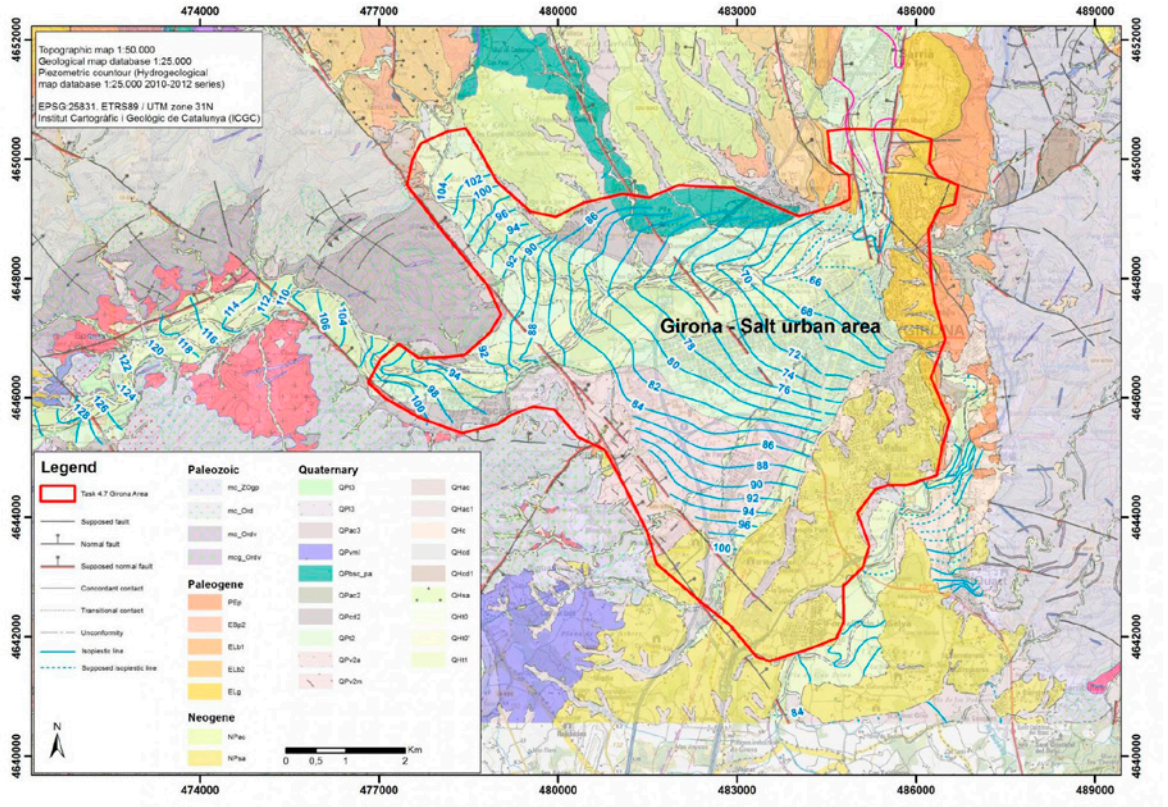
- Alluvial aquifers: show medium-high permeability (gravels) to lower permeability (clays). Intergranular porosity. GWL situated from 3 to 8 m deep [01]. Permeability ranges from 4 to 80 m/d.
- Pliocene aquifer: low permeability (gravel and conglomerate) to very low permeability (silt and clays). Intergranular porosity. GWL situated from 10 to 26 m deep [01]. Permeability ranges from 0,1 to 1 m/d.
- Limestone aquifer: Fractured and karstic dual porosity, unconfined/confined. GWL: from artesian conditions to 70 m deep. Highly variable permeability.

### **Thermogeology:**

Measured groundwater temperature: 16 - 17°C (from 50 to 100m deep) (nov18).



# GIRONA FACTSHEET



## 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.**

Field works - Data collection

Borehole construction (foreseen 3 to 10 wells) (Nov 2018 – March 2019)

Geophysical well logging: Gamma ray and temperature profiles

Environmental baseline monitoring: GWL and T° (data sensors)

TRT (expected 3 to 4 new TRT)

Characterization, analyses and assessment:

Characterization of geology/ hydrogeology / thermal conditions

Baseline temperature monitoring - mapping

3D Geological, hydrogeological and thermal modelling (LeapFrog3D and Feflow)

Assessment and mapping of shallow geothermal potential of open and closed loop systems

Development of guides for deployment and integration SGE in energy plans

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### Contact

Managing Urban Shallow geothermal Energy

Project number GeoE.171.006

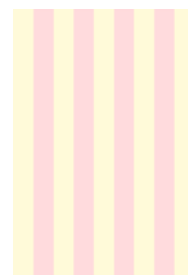
Website - [www.geoera.eu/projects/muse](http://www.geoera.eu/projects/muse)

MUSE Project office: [MUSE@geologie.ac.at](mailto:MUSE@geologie.ac.at)

Pilot area contact person: Ignasi Herms Canellas [ignasi.herms@icgc.cat](mailto:ignasi.herms@icgc.cat)



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