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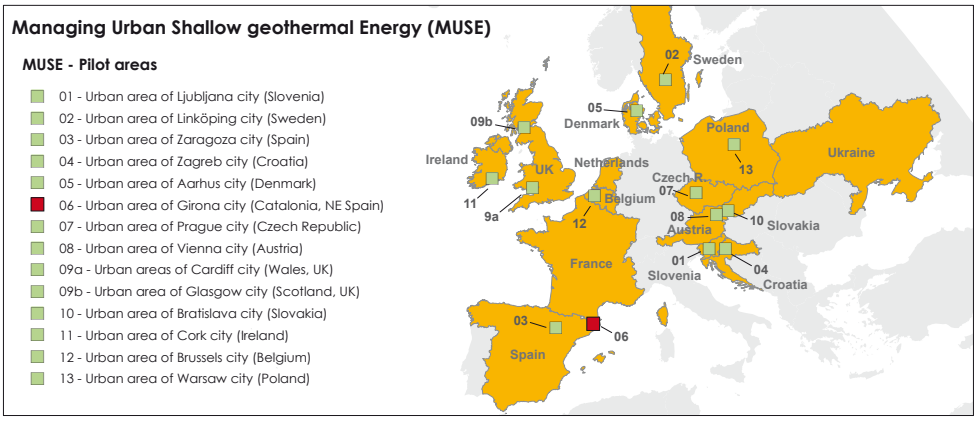
Pilot area information



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 8.2ºC to 22.3ºC, with a mean value of 14.7ºC, maximum of 37.5ºC and minimum values of -6.8ºC. 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 (km²)	48 km2 (39,1 km2 from Girona city)
Total number of inhabitants (date)	138.702 inhabitants (2016) (98.255 from Girona city)
Inhabitants per km²	2.889 hab./km² (2016) (2512 hab./km² from Girona city)
Level of urbanization	16 km² /48 km² = 33% (2016) (12 km² /39 km² = 30% from consolidated urban area of Girona city)
Elevation range (m a.s.l.)	65 – 186

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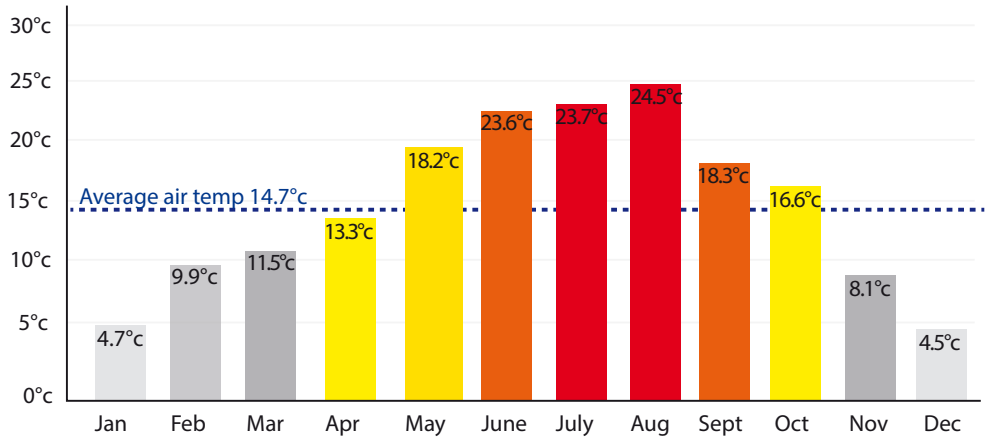
Climatological settings

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) 79; (15°C/15°C)
Length of the cooling season (days)	74; (20°C/20°C) 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%
Other SGE technologies: Are there inter-seasonal heat storage schemes or energy piles in your pilot area?	Unknown	No UTES exists 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) [1]	
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 - 17oC (from 50 to 100m deep) (nov18).

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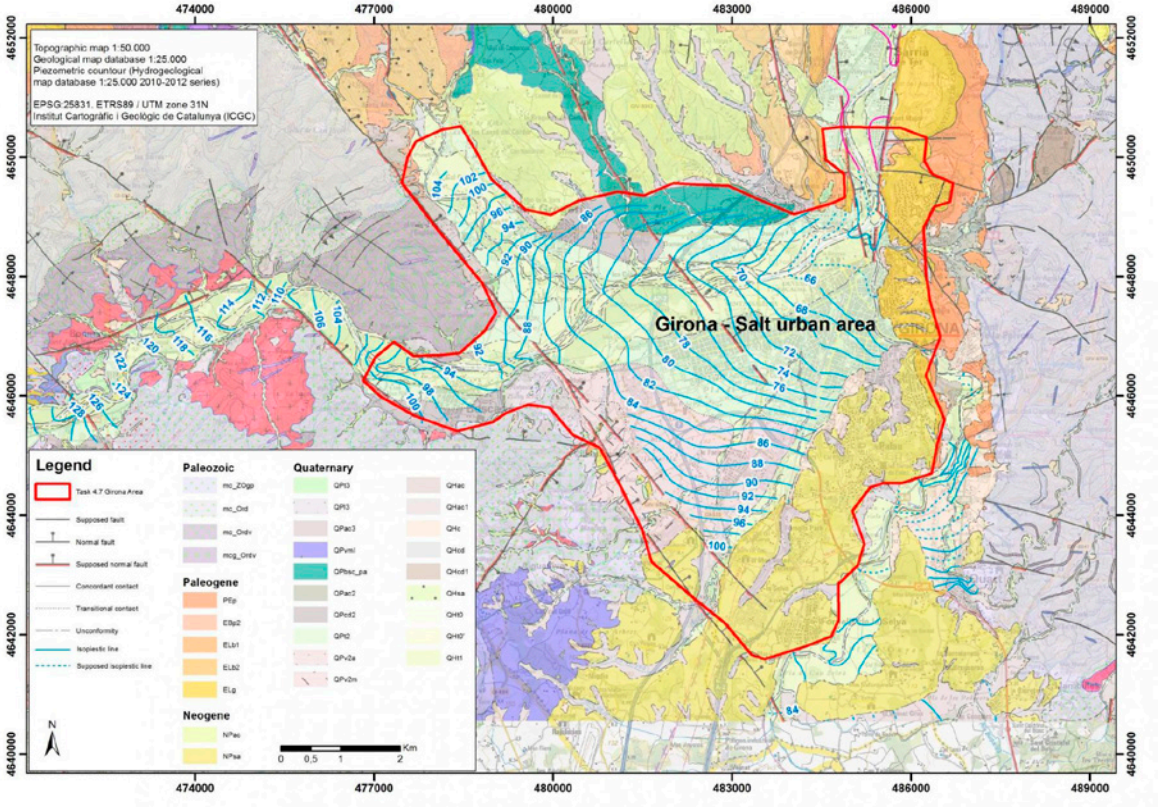

Summary of works and timeline

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)

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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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Managing Urban Shallow geothermal Energy
Project number GeoE.171.006

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