1. PUBLISHABLE SUMMARY

Summary of the context and overall objectives of the project (For the final period, include the conclusions of the action)

Shallow geothermal energy, despite its huge potential as renewable energy source in the heating and cooling of buildings, is underutilized in Europe. The main problems are the high investment cost and the lack of knowledge or confidence.
The European Commission plans to substantially increase the use of renewable energy in the heating and cooling of buildings, today 50 % of the total energy usage. This will lead to less dependency on oil and gas from outside Europe, a reduction of CO2 emissions and new jobs. Shallow geothermal is one of the technologies to realize this transition.
Cheap-GSHPs is addressing the high upfront investment costs, the safety as well as the raising of the awareness and expertise level.
The objectives are to reduce the total cost of ownership by 25 – 30 %, to increase the safety by developing drilling machines, redesigning heat exchangers and installation methods. 6 real and 10 virtual demonstration cases where the technological innovations and tools are installed provide learnings and data for future exploitation. Once the innovations from this project make their way to the market, the deployment of shallow geothermal should accelerate with 10 % and CO2 emissions decrease accordingly. In addition, the developed software and modelling tools, including the sizing of ground source heat exchangers and the selection of heat pumps feed into the "Decision support system" (DSS). This tool suite is the cornerstone of a large dissemination campaign to promote awareness. The DSS is freely available enabling the end-users to assess technical and economic feasibility as well as design support to installers.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far (For the final period please include an overview of the results and their exploitation and dissemination)

Geological maps (Fig.1) and building energy load profile were developed as databases. Thermal and physical properties on rocks and unconsolidated materials from the test sites have been measured complementing literature data and previous analysis. A new method to measure these parameters on gravel has been developed. A methodology to create €/kW maps (Fig.2) compares the innovative borehole heat exchangers to the traditional ones at municipal level.
Helix type ground source heat exchangers (GSHE) (Fig.3) were developed with diameters in the range of 350-400 mm, i.e. smaller than the state of art, typically around 500 mm. The purpose is to facilitate drilling at larger depths which are today 3-5 meters. In combination with an evolved auger based dry drilling method these were installed in 4 demonstration sites at depths ranging from 8 to 14 meters.
Co-axial heat exchangers (Fig.4) out of stainless steel with an enlarged diameter and an insulated internal tube were developed. A drilling machine was built to pile these GSHE's faster and deeper into the soil. Different design improvements of these co-axial GSHE's were simulated. The most optimal GSHE's have been installed with the new drilling machine in record time in the pilot test field. In the demonstration cases, basic feasibility of the methodology was proven in certain types of soil and the speed of installation confirmed. Important learnings were made during the drilling in these sites for future large scale exploitation. All demonstration sites demonstrated important gains of thermal energy exchange when compared to the state of art. These factors combined lead to the targeted cost

reduction in unconsolidated soils where borehole stabilization is needed. A patent request has been submitted.
A new HP with CO2 as refrigerant for high temperature terminals (Fig.5) has been designed and installed in the Technical Museum Nicola Tesla in Zagreb. This two-stage heat pump avoids the replacement of the terminals at high temperature in building refurbishments, in particular in historical ones. A patent request is pending.
The development of software and modelling tools, including the sizing of ground source heat exchangers and the selection of heat pumps, has been completed and is feeding into the "Decision support system" (Figs. 6&7).
This DSS enables the end-users to choose the best geothermal technology for their case. The DSS, with an engine that estimates the building's energy consumption, characterizes the different shallow geothermal plant combinations taking also into account the climatic and soil conditions. This tool, freely usable on the web site, is to be an accelerator for technical offices, architects, ESCO's, building owners and investors to introduce the novel technologies. Also non-expert users can use a simplified version to assess the feasibility and economic returns.
6 real and 10 virtual demonstration cases where the technological innovations and tools were installed and applied provided learnings and data for future exploitations.
A detailed legislative and regulatory analysis of each case study site (Fig.8) was made and a comparative study of the current regulatory conditions for GSHP system completed. An environmental impact assessment demonstrated the low impact of the new technologies. A LCA for each site compared the project technologies against other GSHP technologies. The co-axial heat exchanger design was introduced in the European Standard (CEN-TC 451-WG2) currently being drafted.
An action plan supporting the market introduction of Cheap-GSHPs technologies and exploiting the project results has been developed.
Project website flyer, brochure, 2 videos, newsletters, fact sheets were realised. Social media, congresses, conferences, etc., and fairs were used for dissemination. A technical brochure and a technical training manual in 8 languages, and a technical handbook in 3 languages focused on historical buildings, were realised as basic material for the national workshops. They are freely available in the web site.

Progress beyond the state of the art, expected results until the end of the project and potential impacts (including the socio-economic impact and the wider societal implications of the project so far)

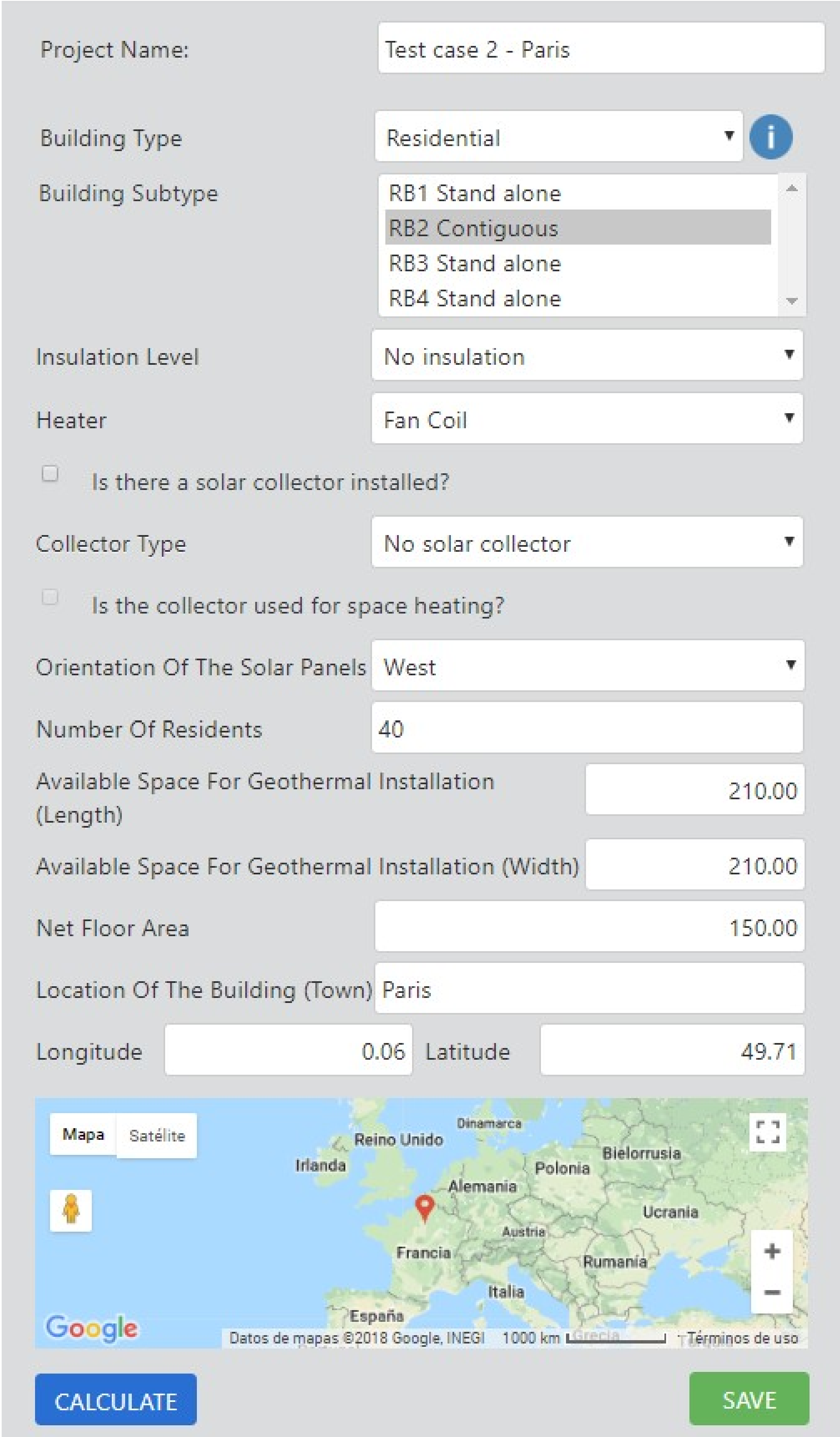
The projected impact of the products, tools and documentation material is achievable over time. The market impact of Cheap-GSHPs will become more visible when the developed products are brought from the actual TRL 7 to TRL 8/9. This is the case for the steel co-axial heat exchangers and its installation method/drilling machine as well as for the high temperature heat pump. The new heat baskets and their installation method/drilling machine have a more limited field of application. The most immediate impact is to be expected from the use the DSS, its related tools and documentation material.
The DSS, the related tools and training material have enhanced the awareness of this technology. Non-expert users can assess in a user friendly way the feasibility of shallow geothermal for their respective buildings, new of refurbished. With the tools stakeholders' work along the value chain is made easier and of higher quality.
The projected acceleration of 10% of the actual market growth will bring the benefits in terms of job growth and CO2 emission reductions. To realize this acceleration, the main innovations need to

be brought to full market readiness. This is within reach with the planned developments based on the learnings from the demonstration cases. Then an important marketing effort is needed from the involved players focused on the above mentioned application fields and on the stakeholders, ESCO's in particular.

Address (URL) of the project's public website

http://cheap-gshp.eu/

DSS Input data form



Project Name: Test case 2 - Paris

Building Type: Residential

Building Subtype: RB1 Stand alone / RB2 Contiguous / RB3 Stand alone / RB4 Stand alone

Insulation Level: No insulation

Heater: Fan Coil

Is there a solar collector installed?

Collector Type: No solar collector

Is the collector used for space heating?

Orientation Of The Solar Panels: West

Number Of Residents: 40

Available Space For Geothermal Installation (Length): 210.00

Available Space For Geothermal Installation (Width): 210.00

Net Floor Area: 150.00

Location Of The Building (Town): Paris

Longitude: 0.06 Latitude: 49.71

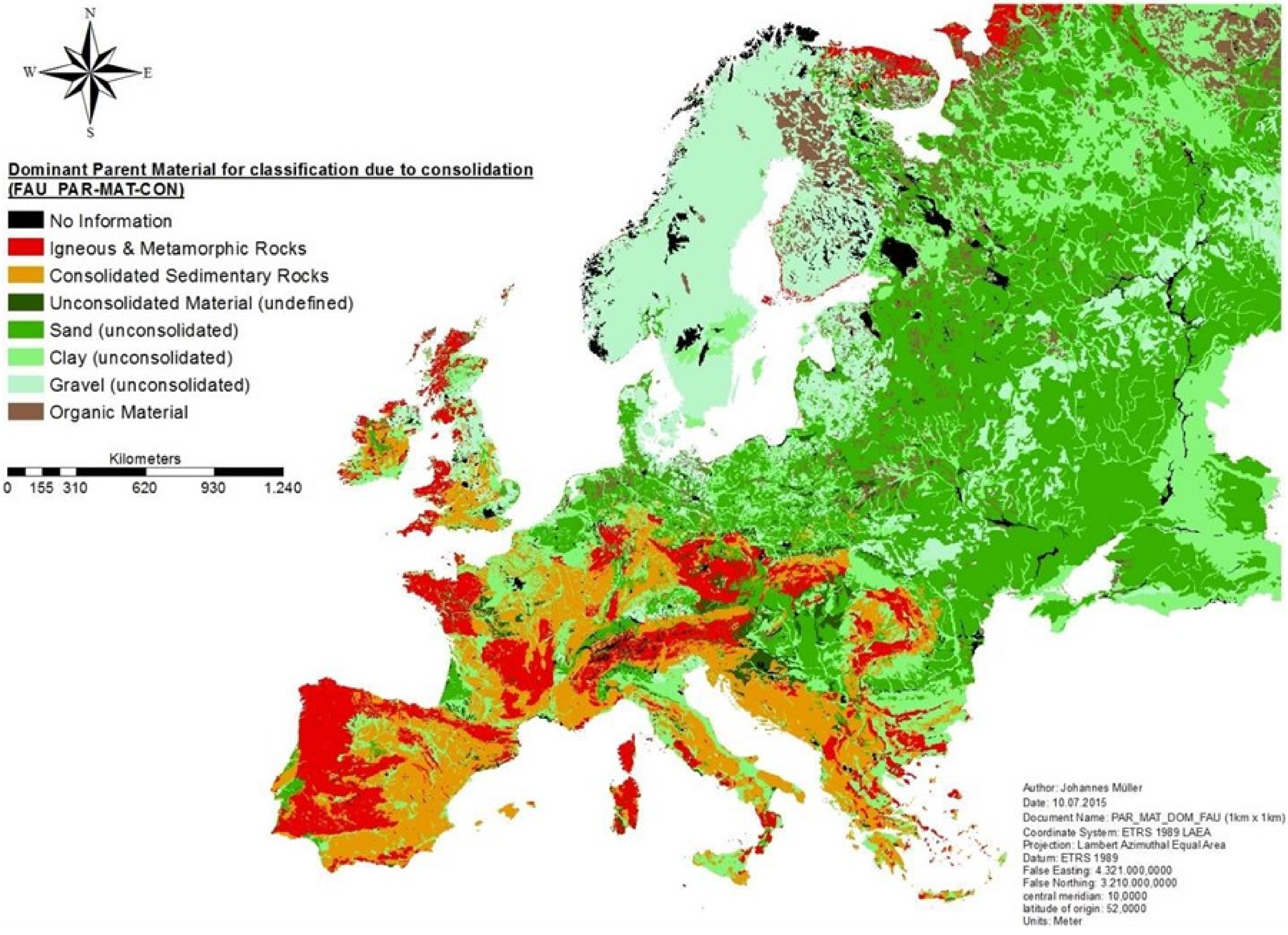
CALCULATE

SAVE

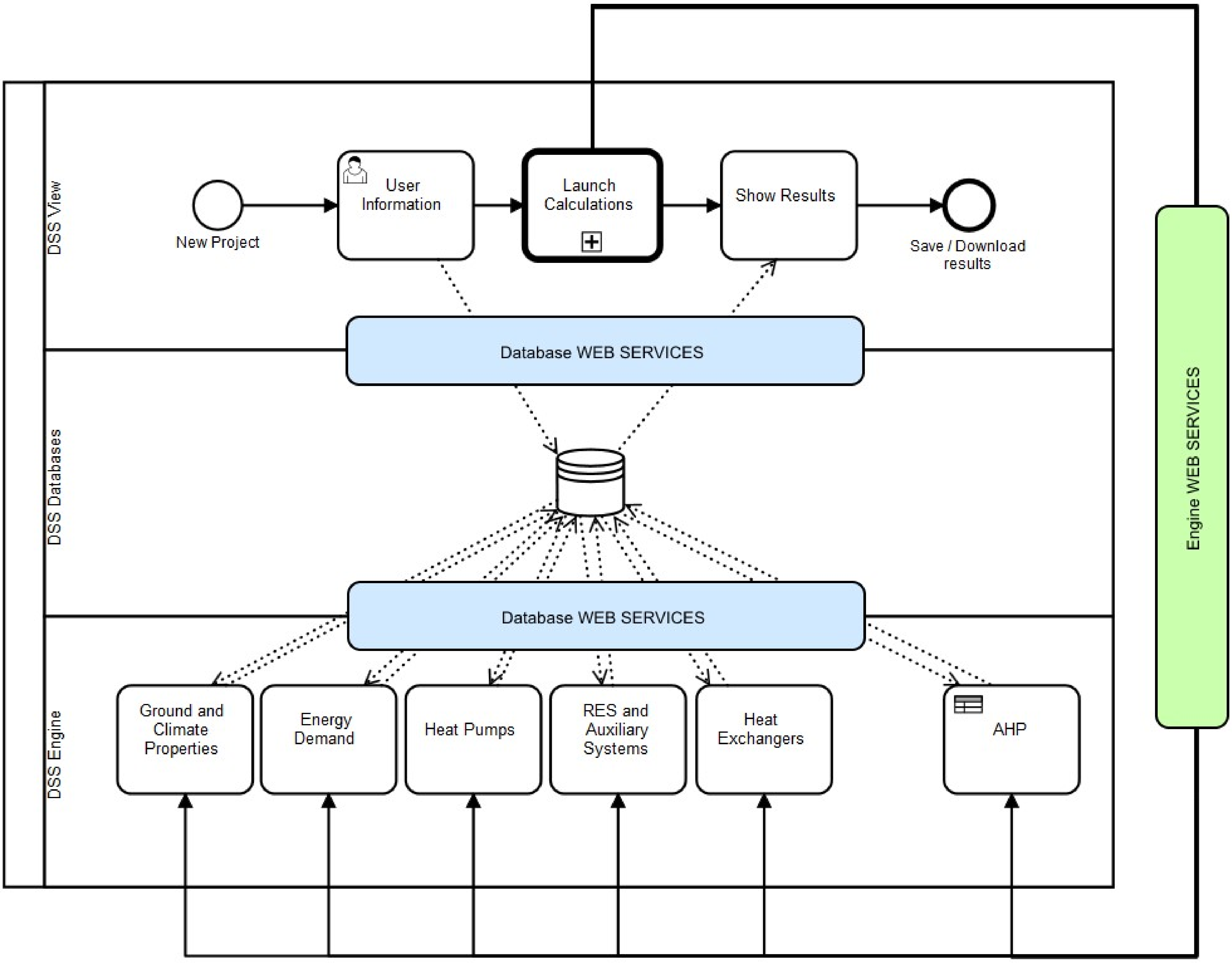
Installation at the drilling machine test site in Molinella (Italy)

Exterior of the technical room with the geothermal facility at its opening (29 June 2018)

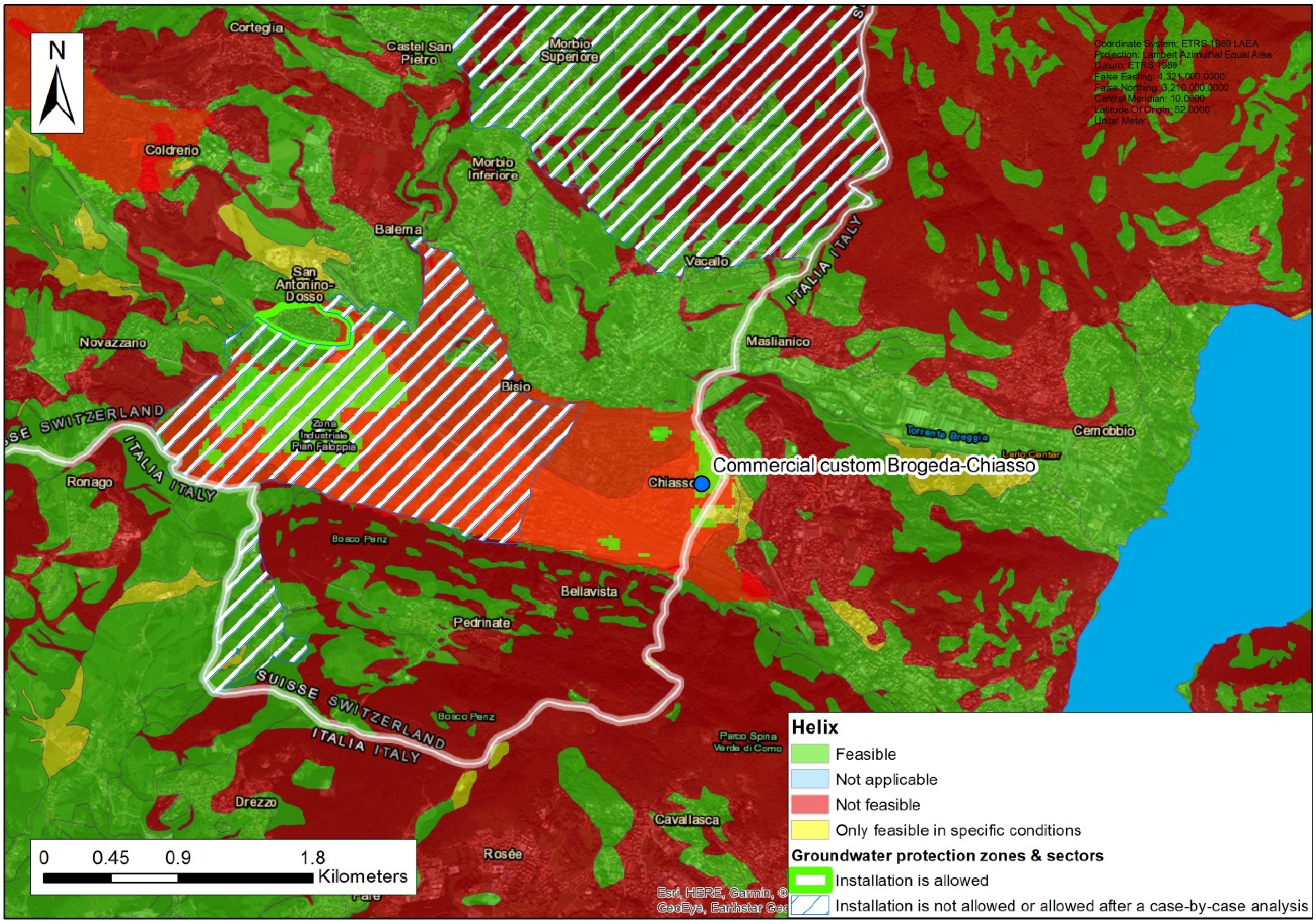
The surface European geological Map called FAU_PAR-MAT-COM



DSS Engine Structure



Example of the Helicoidal feasibility map in Chiasso



Installation of GHEs at demo site in Belgium

Contry brochures on legislation and regulation analysis