1. PUBLISHABLE SUMMARY

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

The main goal of GEO4CIVHIC (Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings) is to develop and demonstrate easier to install and more efficient Ground Source Heat Exchangers. This is done by using innovative compact drilling machines tailored for the built environment and by developing or adapting Heat Pumps for retrofits in combination with other Renewable Energy Sources through a holistic engineering and controls approach improving the return on investments.
GEO4CIVHIC's target is to accelerate the deployment of shallow geothermal systems for heating and cooling in retrofitted existing and historical buildings. It is based on innovative solutions developed by an international expert group of companies and research centres, experts in the complete value chain of shallow geothermal installations.

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)

The different barriers (technical, social, cultural, economic and legislative) for shallow geothermal heating and cooling in the renovation of existing civil and historical buildings were analyzed and classified, with particular focus on the urban environment.
The concept of "Drillability", intended as prediction of the most suitable drilling methods and related Borehole Heat Exchanger (BHE) types for a given underground, was utilized to develop maps at European scale (Fig. 1) Later on, these maps will be developed at local scale, with particular reference to the demonstration sites within the project.
Such maps are expected to help designers and technicians in the selection of the most suitable drilling technique and BHE type in function of the underground.
The drilling technologies and BHE were developed taking into account the constraints of drilling in built environment and the machines were built to increase accessability, reduce mud, noise, space requirements as well as drilling time and cost.
A compact, versatile drilling machine (Fig. 2) able to operate in built environment was designed and manufactured and coupled with a novel vibrating-rotating drilling head.
A novel semi-automatic feeder strongly reduces the non-productive times of loading the drill rods and co-axial borehole heat exchanger tubes. At the same time such equipment increases the operators' safety.
An extended research was carried out in order to develop grouting and sealing materials to be applied to the BHE installation methodologies identified in the work plan.
First tests showed very good and promising results both in hard and soft undergrounds.
An analysis of the European geothermal heat pump marketwas made covering available configurations, associated costs and heat pump components' selection rules, as well as heat pump solutions for further development.
An in depthanalysis on the state-of-the-art of refrigerants was performed in order to select an environmental friendly refrigerant to be used in the novel plug play geothermal heat pump (Fig 3).
The mechanical and electrical designs of the plug and play heat pump were made and 3 prototypes were produced.

For each of the real demonstration cases, a different type of heat pump solution will be implemented. The solutions range from dual (air and ground) source heat pumps for respectively low and high temperature terminals and geothermal heat pumps for high temperature terminals. The size of these pumps is based on the energy load calculations for each of the sites. Detailed design of the pumps is ongoing.
Several applications and tools to optimise the installation and operation of GSHP technologies are under development: a Decision Support System (DSS) that performs a feasibility assessment for decision makers to understand the benefits of investing in geothermy; an application to select in situ the drilling method and heat exchanger type; a management system for the integration fo GSHPs with other renewable energy sources; and, finally, a user-friendly Application for easy management of energy which allows end-users to identify and reduce their consumptions.
The drilling and BHE methodologies as well as Ground Source Heat Pumps will be implemented in three pilot sites and four demonstration sites with different undergrounds and climates.
The design, the planning and the requests for quotation of the installations in the demo siteare in progress
Moreover GEO4CIVHIC technologies will be applied to 13 virtual sites.
A legislative and regulatory analysis for the case study sites was completed. An Environmental Impact Analysis for the real case study sites and a Life Cycle Analysis comparing the project technologies with other heating and cooling solutions are ongoing. A risk assessment methodology to facilitate the decision support and implementation of the DSS has been developed. A detailed list of EN and national Standards relevant to the project technologies has been compiled for the future development of recommendations.
In anticipation of the exploitation and business planning lateron in the project, the methodology to follow was worked out.
The approach to identify the key exploitable results (KERs) and to protect the Intellectual Property (IPR) was explained in a workshop
So far the Training, Education, Dissemination (TED) plan was composed and is being implemented by all partners with several project presentations, partgicipations in fairs and the publication of several scientific articles

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)

After the first 18 months of work in the project, progress towards cost efficient installation of shallow geothermal systems in retrofitted buildings in urban environment is encouraging
Drillability maps recommend to stakeholders the drilling technology to use based on the available technologies whilst the updated technical and non-technical barriers provide a roadmap for the future work.Several elements of the piling methodology, developed within the Cheap-GSHPs project, were improved in GEO4CIVHIC project bringing the technology very close to market and reducing further the costs. The methodology requires low torque and small amounts of water in unconsolidated soils, reducing machine size and nuisance. This facilitates substantially the use in built environment.
The newly developed roto-vibrating drill head was mounted on a small drilling machine with a dismountable power pack and a telescopic support of the mast. Such a machine facilitates access in narrow roads or can be lifted in confined spaces at reasonable costs due to a reduced weight. The telescopic mast support permits to drill several boreholes, also inclined, without having to displace the machine. Finally, the machine is equipped with a diesel engine of the latest generation, the first in kind from the engine supplier achieving very low emission levels.

The new plug and play geothermal heat pumps of small size allow the replacement of the heating and cooling systems in individual apartments of condominiums with minimum installation costs. Connecting such pumps to a shared set of borehole heat exchangers allows apartment owners to maintain their independent heating and cooling plants while taking advantage of a common geothermal energy source.

The work done on respectively the barriers, the state of art, the drillability assessment, the regulatory aspects, the Decision Support System and the respective tools is designed to facilitate the implementation of shallow geothermal systems in built environment.

Address (URL) of the project's public website

https://geo4civhic.eu

Figure 2 - Drilling Machine

Figure 3 - Heat Pump prototype

Figure 1 - Drillability Map