MOST EASY, EFFICIENT AND LOW COST GEOTHERMAL SYSTEMS FOR RETROFITTING CIVIL AND HISTORICAL BUILDINGS

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GEO4CIVHIC Historical Building Brochure

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www.geo4civhic.eu

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The aim of the **"Most Easy, Efficient and Low Cost Geothermal Systems for Retrofitting Civil and Historical Buildings" (GEO4CIVHIC)** European project, is to foster the retrofitting of both civil and historical buildings. Preliminary studies in a previous European project: **"Cheap and Efficient Application of Reliable Ground Source Heat Exchangers and Pumps" (Cheap-GSHPs)**, demonstrated the applicability of geothermal systems in buildings never previously considered for refurbishment using renewable energy sources, in particular geothermal.

The Angel's Gate building

GEO4CIVHIC has given special attention to the application of Ground Source Heat Pumps (GSHPs) in historical buildings in order to overcome the constraints and very stringent regulations associated with the application of renewable technologies in historical buildings. This represents a major breakthrough in the topic of heating, cooling and energy savings in these buildings.

The research performed in the GEO4CIVHIC project had different objectives, some of which were specifically targeted at historical buildings. These included addressing the energy needs and technical solutions to increase energy efficiency, the geological aspects of European soils, the use of innovative high efficiency heat exchangers, the use of new drilling equipment, the innovations on heat pumps and addressing legislative, environmental and economic aspects.

Greystones case study site, showing front aspect of the building and location of the ground heat exchangers in the driveway to the left of the house

The systems developed in GEO4CIVHIC are focused on minimizing the invasive nature of retrofit measures by providing low visual impact heating and cooling solutions by removing any additional risks to historical buildings fabric or architectural elements. The solutions deployed provide very limited environmental impact, improved operational efficiency, low noise emissions and a reduction of operating costs. This was achieved by considering basic design principles, overcoming barriers, defining project specific methodologies as well as assessing the regulations at the base of the application of geothermal solutions to historical buildings.

The GEO4CIVHIC and Cheap-GSHP projects have demonstrated the integration of GSHP technologies to meet the heating and cooling demand of historical buildings. The integration of these solutions delivers clear benefits in terms of CO_2 emission reductions when compared with the conventional fossil fuel heating technologies being replaced. These solutions also provide a unique strategy to deliver temperature-controlled conditions and ambient temperature control in buildings that are traditionally hard to renovate.

In many cases, the refurbishment technologies need to respect the historical nature of the buildings, allowing the preservation of the character of the building with minimal interventions. The advantage of the GEO4CIVHIC GSHP solutions over other renewable energy technologies on the market is the extremely low visual impact that the GSHP and hybrid heat pump solutions installed can offer.

These solutions offer long term sustainable and energy efficient options for improving the fabric of historical building and the implementation of appropriate conservation measures that can have a positive impact to preserving their heritage.

The work of both the GEO4CIVHIC and Cheap-GSHP projects has demonstrated how the integration of GSHPs in historical buildings can be successfully completed. However, critical strategies during the project design and at the implementation stages need to be adopted in order to successfully integrate such solutions. A detailed design process that considers the fabric of historical buildings as well as the specific energy demand and temperature requirement to determine heating and cooling loads of such systems needs to be implemented in advance of proposing a possible solution.

Installation of the heat exchanger

As recommended in the CEN FprEN 16883 in a more general approach, the design needs to adopt a holistic methodology that considers not only the energy demand, but also the location of these buildings (often in historical town centers). The space available determines the potential for installing a ground source collector that requires an integrated, site specific risk assessment design approach. The space constraints are associated with nearby buildings or other archaeological and heritage artefacts in close proximity to project site or in the underground. A detailed assessment to size and install a ground heat exchanger (GHE) is required to ensure minimal impact to these heritage features and the surrounding landscape. The delivery of heating and cooling to historical buildings requires the upgrade of internal terminals and to the existing pipework to maximize efficiency. The location of both the heat exchanger field and the plant equipment (heat pumps, buffer and hot water vessels) needs to be integrated in such a way as to preserve the historical character of the buildings in line with the space available to integrate these technologies.

In some cases, the use of hybrid air and ground source heat pump solutions provides a more appropriate solution that reduces the level of intervention needed whilst maximizing the operational efficiency of the system. Project stakeholders, therefore, need to be carefully consulted to ensure that projects can be delivered in a successful manner.

The installation and completion phases of GSHP projects are temporary, but have the potential to cause disruption during their execution. The selection of the drilling methodology to complete the geothermal field as well as the design and completion of the surface connections needs to consider the physical site (available working area) and the subsurface (soils, geology and groundwater) characteristics in the context of their proximity of other users such as neighboring buildings or subsurface infrastructure in dense urban environments. The selection of the completion methods needs to minimize disruption and maximize operational efficiency. These interventions were successfully demonstrated by the both the GEO4CIVHIC and Cheap-GSHP projects, where GSHP technologies have been integrated and have resulted in an improvement in building comfort levels whilst sustainably preserving their historical character.

"Ca' Rezzonico" building in Venice (Italy)

The heat pumps, together with the GHEs are the core technology innovations for historical buildings implemented in GEO4CIVHIC. These represent an advancement compared to other ground source heat pumps technologies on the market. The project has demonstrated how the development and installation of innovative GSHPs can be easily and efficiently integrated not

only in new, but also in historical buildings. This was achieved by adapting the system configuration, selecting specific refrigerants and by using high efficiency heat exchangers on a case by case basis in line with the requirements of the individual sites selected. Five different heat pumps were developed, some of these dedicated to delivering high temperatures to existing terminals typically present in historical buildings.

The application of the ground source heat pump installed, provides significant benefits in the decarbonisation of heating and cooling in the built environment, delivering very low visual impact solutions in historical centres. Considering the number of historical buildings present in cities and how these buildings are typically excluded from building retrofit targets due to their heritage nature, the possible environmental benefits from the application of the GEO4CIVHIC project technologies could be very significant if these could be applied to a large number of historical buildings.

The design and installation process of shallow geothermal systems in the context of current national and European standards and regulations specific to the various system elements and to historical buildings was reviewed.

Numerous historical buildings (also included in the UNESCO Heritage listing) were selected as relevant real or virtual demonstrators. Recommendations were developed to inspire both professionals and the general public in considering use of GSHPs in historically, architecturally or culturally-valuable buildings where special provisions are necessary to achieve indoor comfort, energy performance and fulfill their conservation requirements.

The University complex "Ex Ospedale Geriatrico" in Padova (Italy)

The successful demonstration of the technologies inspires the use of GHSPs in other historical and UNESCO designated sites, both in Europe and globally by balancing efforts between heritage significance and conservation. GSHPs are the best solution for matching energy sustainability requirements with the preservation of the integrity and authenticity of Cultural Heritage buildings. The low visual impact of the underground elements compares more favourably than other technologies such as air source heat pumps, chillers and fossil fuel boilers. The GSHP alternatives include external elements (external units or chimneys), which alter the appearance of the building envelope compared to the GHSP solution.

GEO4CIVHIC provided strategies for building owners, authorities and professionals involved in the conservation and refurbishment of historical buildings, to facilitate long term, sustainable management by integrating energy improvement measures, increasing energy efficiency and reducing greenhouse gas emissions, whilst allowing the implementation of adequate conservation measures.

A more detailed description of the work performed is presented in Volume 7 of the project Manual, which is dedicated to the application of shallow geothermal technologies in historical and world heritage buildings. Volume 7 is freely available to download from the GEO4CIVHIC project website.

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