2015

CHEAP AND EFFICIENT APPLICATION OF RELIABLE GROUND SOURCE HEAT EXCHANGERS AND PUMPS

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Coordinator	CNR-ISAC
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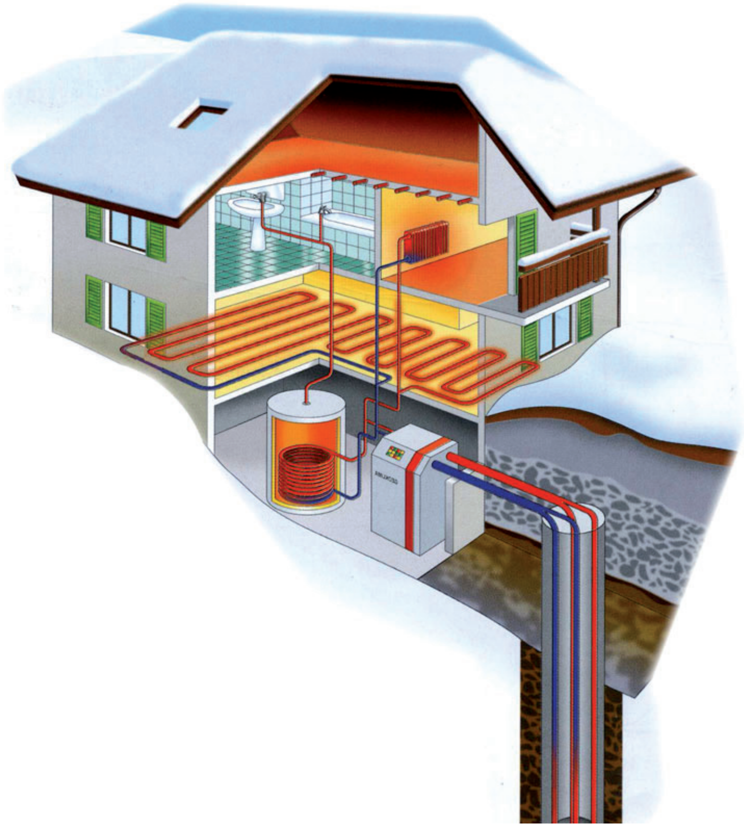

www.cheap-gshp.eu

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GENERAL INFORMATION

In order to achieve the objectives of Cheap-GSHPs, a multidisciplinary and complementary consortium has been built, composed by specialists in different disciplines involved (physics, climatology, chemistry, mechanics, engineering, architecture, drilling and GSHE technology). The majority of them have a large and comprehensive experience in the framework of the European Commission (EU) Research Programs and particularly in shallow geothermal systems.

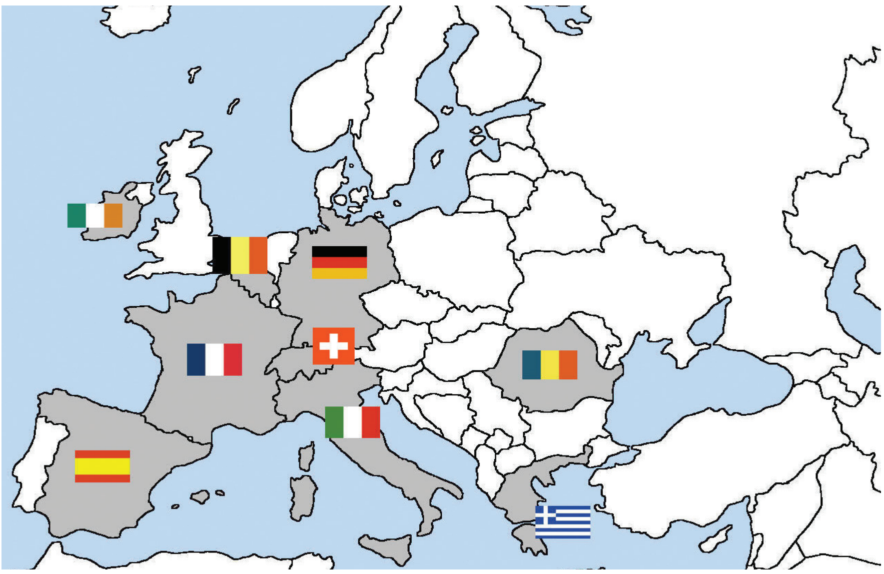
The proposal will focus on one hand on the development of more efficient and safe shallow geothermal systems and the reduction of the installation costs. This will be realized first by improving drastically an existing, innovative vertical borehole installation technology and the design of coaxial steel GSHE and second, newly designed basket type GSHE's with novel installation methodologies will be developed. **With a view to improve safety and reduce permitting requirements the improved coaxial GSHE's will be installed respectively to depths of 40 – 50 meters and the basket type GSHE's to 15 – 20 meters. This doesn't prevent however the coaxial GSHE's to be installed up to depths of 100 – 120 meters**.

On the other hand, the proposal will develop a decision support system (DSS) and other design tools covering the geological and drillability aspects, feasibility and economic evaluations based on different plant set-up options, selection, design, installation, commissioning and operation of low enthalpy geothermal systems. These tools will be made publicly available on the web at different levels for respectively non-expert and expert users, including comprehensive training to lower the market entry threshold.

Given that drilling and GSHE technologies are mature but costly, this holistic approach is included in the proposal to bring the overall cost of the total project down, i.e. not just the cost of the GSHE itself but the avoidance of ground response tests, the reduction of the engineering costs for the design of the GSHE and the integration of heat pumps with building heating and cooling systems. Also the use of the novel heat pumps for higher temperatures developed within the project will reduce the costs in the market for retrofitting buildings, in particular for historical ones, when replacement of the high temperature terminals can be avoided. The developments will be demonstrated in six sites with different undergrounds and climate conditions, whilst the tools will be applied to several virtual demo cases

PARTNERS WITHIN THE CONSORTIUM

The Consortium is composed by 17 partners (Italy, Belgium, Greece, Germany, France, Ireland, Romania, Spain and Switzerland). Northern, Southern, Western, Eastern and Central EU countries are well balanced so that Europe is geographically well represented.



GENERAL OBJECTIVES

The basic idea of Cheap-GSHPs project is to substantially reduce the total cost of ownership, composed out of investment and operating costs, increase the safety of shallow geothermal systems during installation and operation and increase the awareness of this technology throughout Europe.

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CHEAP GSHPs

aims at reducing the installation costs of the GSHE's up to 25-30% and contributing to the environment with a reduction of CO2 emissions of 1.800 T/y.

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Cheap-GSHPs will address these barriers with particular focus on capital cost reduction and increased awareness whilst improving safety as well.

Cheap-GSHPs will address first of all the improvement of the installation and operating efficiency of shallow geothermal systems, reducing the installation costs of the GSHE's, with 25 to 30 %, increasing the deployment of this technology by at least 10% versus current estimates and contribute to the environment with an additional reduction rate of CO2 emissions of 1.800T/y.

The proposal will focus on improving the yield and reducing the cost of two types of vertical BHE's by developing drilling machines and improving the BHE design. The two types of GSHE's are respectively the coaxial steel BHE and the heat basket type GSHE.

The first type is installed using either the 'vibrasond' or the 'easy drill' technique of partner HYDRA. The vibrasond technique is patented in Italy (patent number 0001398341). Several installations have been installed in Northern Italy over the last 5 years.

Drilling machine

In Belgium the technology has been awarded an innovation prize and more than 18000 m of BHE's were installed in the period 2011 – 2015 . This fairly new technology, cost competitive with the conventional single and double U BHE's, still has a lot of potential. This potential will be developed in this project by realizing a purpose built drilling machine, improving and combining both before mentioned techniques on one machine basis. Several improvements to the coaxial BHE will be made as well.

The heat basket type GSHE is today mainly used in horizontal applications. This type of GSHE has a large heat exchange surface leading to high extraction rates but due to the larger diameters of 400 to 500 mm, actual drilling machines and costs are limiting the vertical applications to depths of 10 m. The project will advance the drilling machines and techniques to exploit these heat basket type BHE's at higher depths with smaller diameters following cost/benefit optimization of the different machine options.

With respect to safety, the heat basket type of GSHE's will most likely remain at depths higher than 40 – 50 m potentially reducing interactions with shallow aquifers used as potable water supplies. The coaxial steel BHE's do not need grouting when the piling installation technique is used. In other words, the safety is built in.

The project will also develop decision support and other design tools covering the hydro-geological data bases and drillability; the feasibility and economic evaluation of different plant set-ups; the selection and design of low enthalpy geothermal systems. These tools will not only include GSHE's but also heat pumps which in the end are an integral part of such systems next to plant configurations with other renewable energy sources like solar thermal which create synergies. These tools will be made publicly available via web-portal at the end of the project.

Helicoidal Ground Source Heat Exchangers

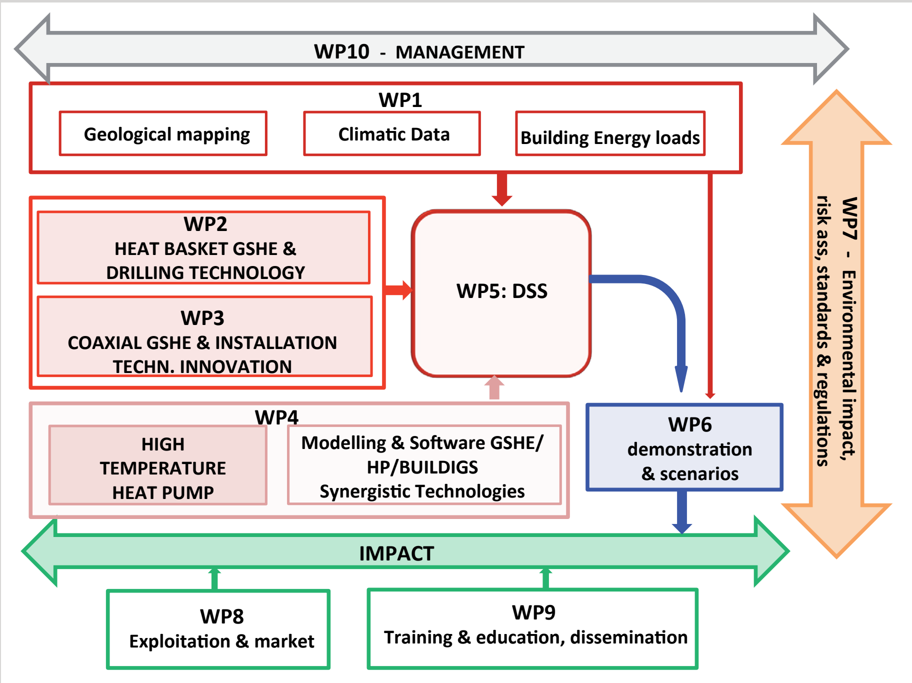
In addition, the safety, regulatory and environmental aspects are being addressed across all the components of the system going from the geological aspects over the GSHE's and their installation to the heat pumps and the integration within historical, existing and new buildings and districts.

To summarize, the project aims at building innovative drilling machines, at substantially improving GSHE's in several of its aspects and at expanding the field of applications. In addition, an end to end approach will be developed to select and deliver from a cost and safety perspective the optimum system including heat pumps and plant configurations including the integration of other synergy creating Renewable Energy systems.

SPECIFIC OBJECTIVES

Objective	Description
1	Development of thematic geological maps at municipal level
2	Improvement of drilling and GSHE technologies from a design, material and installation machine perspective
3	Development and availability via web of a combined GSHE and heat pump modeling software
4	Construction of a decision support tool in order to identify the best shallow geothermal system
5	Development and demonstration of a two-stage heat pump for higher temperatures
6	Demonstration of the developments in 6 different real case studies and 10 virtual case studies
7	Provision of a solid and large basis for implementation of low enthalpy geothermal systems in Europe
8	Construction of an exploitation platform with business models, and interaction with the key partners of the winning projects on the other renewable energy technologies inside the topic "LCE 3 – 2014/2015: Demonstration of renewable electricity and heating/cooling technologies".
9	Recommendations for the harmonisation of standardisations, regulations and authorisations

OVERALL STRUCTURE OF THE WORK PLAN



DEMONSTRATION
IN CIVIL AND HISTORICAL BUILDINGS

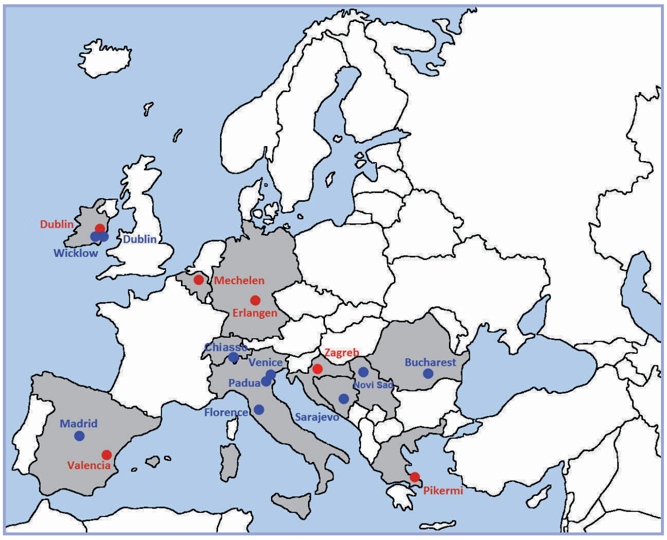
The project case studies are essential for Cheap-GSHPs, as they will highly contribute to validate the new technologies at real scale. On the other side, the selected cities and small districts would become good practice examples to promote the overall use of Cheap-GSHPs technologies all over Europe and beyond. The main criteria for the selection of the cities have been:

- To represent different European areas (North, South, West and East), as well as different climate conditions;
- To belong to different historic periods, different materials and architectural and urban patterns;
- To be strategically placed in Europe so that they could contribute to the widespread use of Cheap-GSHPs technologies in Europe and Associated countries.

Next to real case studies, also virtual demonstration sites will be studied. Instead of real installations, the performance of the innovative solutions will be modeled and simulated to infer their evaluation in other climate zones and different ground conditions. This will allow to have a larger scenario of applicability and efficiency of the new technologies and systems.

All these virtual case studies will also facilitate the comparison in terms of economic feasibility.

In Cheap-GSHPs project, six real and ten virtual demonstration cases, in particularly notable cultural-historical buildings will be provided to test innovative solutions in cooperation with UNESCO. The demonstration sites will be a concrete proof of the ability to integrate these technologies in cultural sites and will highlight how the innovative shallow geothermal heat exchangers applications may successfully overpass conservational constraints and barriers to geothermal power application in cultural sites.



Map of real (in red) and virtual (in blue) demo sites

REAL CASE STUDIES

Belfield House at University College
Dublin, Ireland

The Buildings office on the University College Dublin (UCD) campus, part of is heated with a 120m deep borehole geothermal borehole. The office is part of Belfield House that was built in 1801 by Ambrose Moore and subsequently extended in the 1830s to create a mix of Georgian and Victorian features. The geothermal system was included as part of a recent refurbishment in 2005. The UCD campus has been the focus of several research projects on both the geothermal potential of the site and ground thermal properties. Other conventional collectors are present on the site and provide a good basis for comparison of the heat exchangers developed as part of Cheap-GSHPs.

Residential ecohouse
Putte bij Mechelen, Belgium

The residential ecohouse in Belgium is a single family home out of two stories and with a total surface area of 170 m2. The house has structural frame out of wood, the walls are out of straw bales of 35 cm

thickness and the windows are three pane windows. Heating and cooling will be provided by a geothermal heat pump through radiant panels. State of art coaxial GSHE's and newly developed coaxial GSHE's will be installed, monitored and confronted to each other. This, to demonstrate the improvements and developments realized within WP3.

Universidad Politécnica de Valencia
Spain

In the context of a project funded by the Spanish Ministry of Science and Innovation, a reference borehole heat exchanger installation was constructed in the Universidad Politécnica de Valencia campus to improve the procedures to characterize thermal properties of Mediterranean area grounds. Borehole depth is 17 meters (two pieces with a length of 8,70 meters each connected by a joint) with polyethylene tubes installed vertically in a pipe located in the center of the pile with a double U-shaped configuration to permit the passage of the heat carrying fluid. The idea is to enlarge the capacity of the installation and in parallel build in a novel helical heat exchanger developed within Cheap-GSHPs. This would allow a very precise comparative study of the thermal performance of both in semipermeable soil conditions, as well as allow very detailed studies of the thermal conditions in a variety of external climate and usage characteristics (heating, cooling, etc...).

Test site Erlangen
Erlangen-Eltersdorf, Germany

Demo room with heat pump and under floor heating systems and lots of testing possibilities. The finally selected GSHE's within WP2 will

be installed here with the selected machine technology. The area will also be as one of the demonstration sites of WP6.

Bioclimatic office building of CRES
Pikermi, Greece

The bioclimatic office building of CRES (total net area 428m2) was designed and constructed as a demonstration building which uses various RES technologies and energy saving techniques. This building was constructed during the years 1999-2001. Among RES technologies used in the building, the geothermal water-to-water heat pump operates in bivalent mode and covers about 21% of heating and 15% of cooling loads of the building. The unit utilizes groundwater from two wells ~80m deep each, located North and South of the building. The heating and cooling capacity of the aforementioned system is Pth=17.5kW and Pc=16kW respectively.

Technical Museum of Zagreb
Croatia

The Museum is in operation since 1954 and it is one of the most visited museum of Croatia. It houses historic aircraft, cars, machinery and equipment. It maintains the oldest preserved and still operational steam engine in the area, dating from the mid-19th century. The implementation of CHEAP geothermal solution in the atelier and expo rooms of the Technical Museum will also display a function of education and awareness on the contribution of science and technology to sustainable energy. A special area has been devised for this important function and devoted to enhance awareness and education of youngsters and broader public on the matter. Cheap installations will therefore be able to provide factual reduction of costs and of CO_2 emission along with an important educational asset for sustainability and climate change mitigation efforts.

VIRTUAL CASE STUDIES

Ballyroan Library
Dublin, Ireland

The building is a community library owned by South Dublin County Council and was built in 2011. The building is A2 rated and has an operating 60kW GHSP system using 6 x150m double-U closed loop collectors. The IGTP project funded by the Sustainable Energy Authority of Ireland is currently monitoring the performance of the building and the collector behavior as part of a project that aims to better understand ground thermal properties. This is an ideal comparative virtual case study example for the coaxial probe.

Residential Retrofit Glencree
Wicklow, Ireland

This is a residential home, part of which is from the 1800s and has recently been retrofitted with a hybrid

9kW heat pump and a 160m double U 32mm collector (in 2 boreholes) along with external insulation and new windows. This will be an ideal example for modelling a virtual case study.

Complex of Santa Croce
Florence, Italy

The Monumental Complex of Santa Croce includes several architectural spaces: Church, Bell Tower, Cloisters, Pazzi Chapel, museums, Basement. The Gothic church of Santa Croce, the largest Franciscan church in the world, was founded in 1294. With its impressive architecture, its great fresco cycles of Giotto and his school, paintings on wood, stain glass windows and numerous sculptures, the Basilica epitomizes one of the most important pages in the history of Florentine art from the thirteenth century onwards. It preserves the tombs of Michelangelo, Galileo, Rossini, Foscolo, Machiavelli, Alfieri and other famous personalities in the history of Italy.

Ca' Rezzonico and Ca' Lupelli
Venice, Italy

The site is situated in the historical city centre, fronting the Canal Grande and consists of a complex of buildings: the main building is Ca' Rezzonico which is the museum block, a smaller building named Ca' Lupelli Wolf Ferrari which is occupied by the direction offices and a garden open to the public. The main building was built in 1649; the annexed block construction goes up again to before the XIX century. Ca' Rezzonico is one of the most famous palaces in Venice, designed in the middle of the 1600s and completed in the middle of the 1700s. It was decorated by some of the greatest artists of the century, the most outstanding of whom was Giambattista Tiepolo who frescoed two large ceilings on the piano nobile and painted two large canvases that can also be seen on the ceiling. In 1935 it was purchased by the Venice City Council and was transformed into a museum of the Venetian eighteenth

century. Today the building is also renowned for the outdoor area that was discovered in the nineteenth century and was used as a theatre and garden. Ca' Lupelli - Wolf Ferrari is a less important historical building, actually occupied by offices, didactical activities and the offices of a fundraising Association. In the past year the site complex has been interested by a general study aiming at: improving sustainability and installations efficiency.

Manens-Tifs S.p.A. Headquarter
Padua, Italy

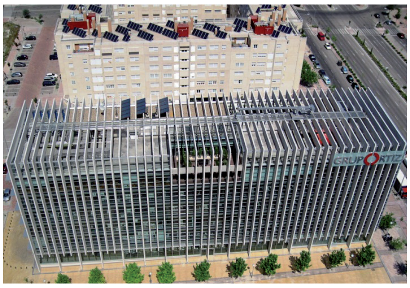
The building is located in the Industrial Zone of Padua. It is the headquarter of an engineering company dealing with the design of HVAC and electrical

plants. The building has a floor area of 1800 m2 and a heating/cooling capacity of 80 kW. A GSHP system with 16 boreholes of 100 m are installed. The system is running since April 2004 and a monitoring system for the indoor conditions and of the GSHP system is recording since then data.

Grupo Ortiz Office Buildings

Vallecas – Madrid, Spain

The site is comprised of three office buildings which incorporate constructive techniques and production methods to achieve a high degree of energy efficiency, including cooling and refrigerating active and passive strategies and renewable energy sources (geothermal interchangers). The three buildings have an identical architecture, are monitored to check their performance and energy efficiency and to carry out studies regarding the efficiency of the different incorporated systems.



Historical building

Bucharest, Romania

The building is included in the list of national historical monuments of Romania and it was constructed between 1918 – 1920 by a French business man in order to develop the commercial activity in the heart of Bucharest. The building had two underground levels (up to 7 meters), an opened ground floor and a mezzanine with commercial purpose.

The other levels were used as offices and residential for the French family owner. The top of the building reveals a statuary group made by one of the most important Romanian sculptors, Mr. Dimitrie Paciurea. Nowadays, the building is in the phase of restoration, according with the authorization of the Romanian Monuments (dated October 2012), which includes a floor heating system for the residential area and traditional radiators for the other spaces of the house.

Historical Museum of Bosnia and Herzegovina

Sarajevo, Bosnia and Herzegovina

The historic building of the Historyical Museum of Bosnia and Herzegovina is of considerable townscape and historical value in the urban townscape of Sarajevo; designated as a national monument. Its design is the product of the famous Zagreb school, making it one of the most important examples of contemporary design of the latter half of the 20th century in Bosnia and Herzegovina and beyond. The building was erected during the period 1959-1965 characterized by the development of the modern architecture in Bosnia and Herzegovina, a time of rapid economic growth, which in turn had an impact on culture and architectural design. The Historical Museum of Bosnia and Herzegovina performs main duties in the field of history. Researching and collecting work created a fund of about 400,000 museum objects, documents, photographs, and art works of different values for the history

of Bosnia and Herzegovina, of which a large number are rare items. This is one of the most important institutions that treats the history of Bosnia and Herzegovina since its first mention in historical sources until today.

The Serbian Orthodox Bođani Monastery

Bodjani, Serbia

The Serbian Orthodox Bođani Monastery is located in the borders of Bač Cultural landscape, situated on the left bank of the Danube river, characterized by continuity of settlements since prehistoric times and remarcable cultural diversity. The complex consists of a church, residential quarters built in the 'U' shape and the accompanying farm houses. The first monastery was built in 1478; the present monastery church, the fourth one to be built, was built in 1722. It is of a cruciform ground plan, with dome, 5.5 m in diameter, rising above the main nave and transept cross. The present quarters were built after a fire, between 1786 and 1810. The sections at the north and south ends have a storey, while the one at the west end is a ground floor structure. The interior walls are covered with frescoes: the Bodani paintings, dating from 1737, displaying both Byzantine and baroque artistic tendencies, represent a crucial point in Serbian art and some of the most valuable frescoes in the first half of the 18th century in South-East Europe.

Office building of Brogeda-Chiasso

Switzerland

The office building of Brogeda-Chiasso custom has been built to satisfy the Minergie® standard. Low energy requirements for heating and cooling makes it possible to use

active concrete plates for thermal energy emission (TABS). Further, there are ideal conditions for the integration of a geothermal system based on geocooling: a borehole heat exchanger field is coupled with a heat pump in winter and with the cooling distribution through a flat plate heat exchanger in summer.

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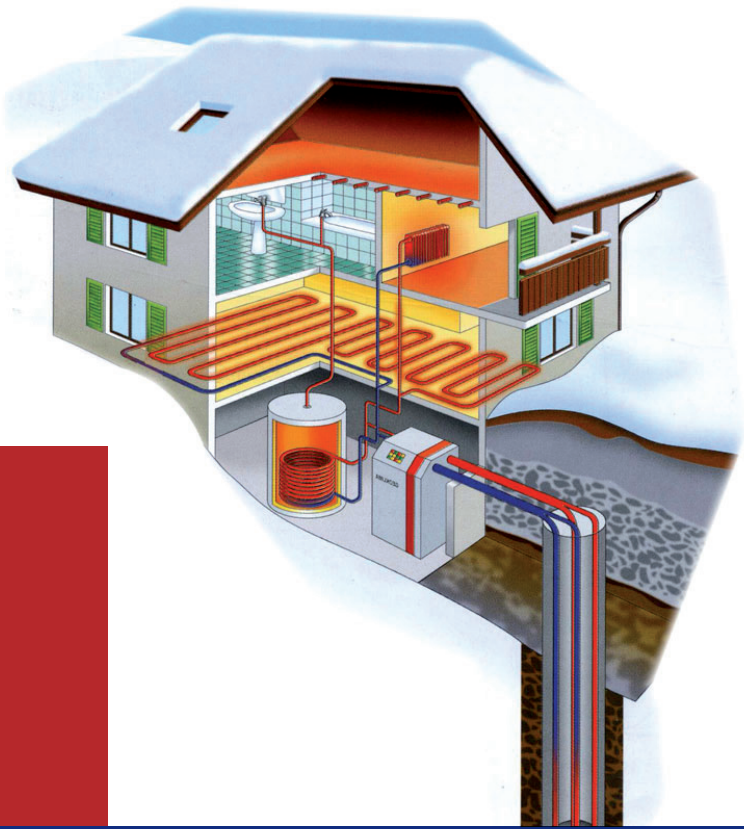

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