A new innovative Ground Heat Exchanger for heating, cooling and energy storage

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Uponor has developed a new innovate ground heat exchanger in conjunction with the MESSIB project co-financed by the European Commission under the Seventh Framework Programme (FP7).

The overall objective of MESSIB project is the development, evaluation and demonstration of an affordable multi-source energy storage system (MESS) integrated in building, based on new materials, technologies and control systems, for significant reduction of its energy consumption and active management of the building energy demand.

Among the innovative elements in MESSIB is Advance ground storage (GS) technology combined with radiant systems and ground thermal contact improvement by the development of a conductive fluid material (CFM). The basic idea behind energy storage in buildings is to provide a buffer to balance fluctuations in supply and demand.

The need for energy storage

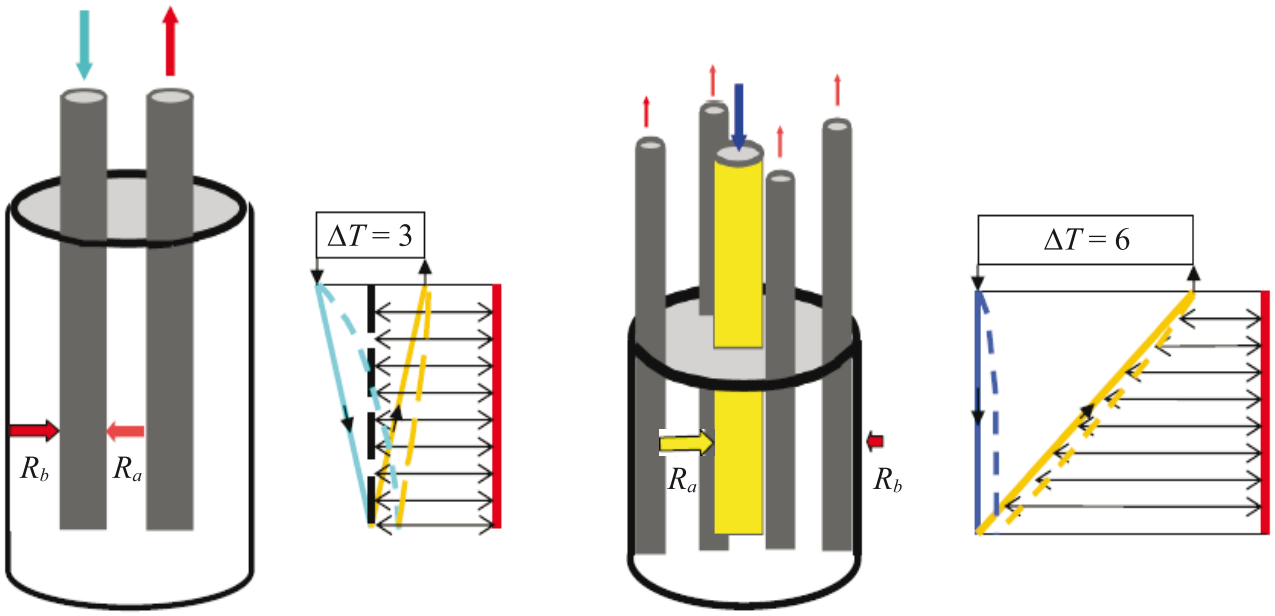
One of the challenges of today's energy systems is to way to match the demand and the supply. Reliable storage systems for short as well as long term are hence essential for efficient energy systems and further integration of renewable sources.

State of the art storage technologies for thermal energy include: Underground thermal energy storage (UTES), water tanks above ground, rock filled storage with air circulation, phase change materials (PCM) and thermo-chemical storage. The scope of the MESSIB development on thermal storage is to increase of the energy efficiency and indoor comfort in buildings by the reduction of the energy demand and the decrease of thermal gradients and temperature variations.

The Uponor development TIL-GHEX

The Uponor development under MESSIB is a so-called TIL-GHEX (Thermal Insulated Leg – Ground Heat Exchanger). It consists of a central thermally insulated pipe (40 mm) and a number of (between 6 and 12) outer active pipes (16 mm) acting as heat exchangers connected through a manifold at the bottom and at the top of the borehole.

The high number and small diameter of the outer pipes will increase the efficiency of the heat exchange and hence increase the thermal performance simply because the surface area between the collector and the surrounding ground is higher. Using a laminar flow the pressure drop in the outer small dimensioned pipes is minimized and there is no increased pressure drop over the circulation pump compared to the larger pipe dimension in traditional collectors. Since the Uponor TIL-GHEX ground energy collector is able to maintain a low borehole thermal resistance even at low flow rates, one can also take advantage of utilizing variable speed pumps and hence save energy without a negative influence on the heat transfer coefficient. The idea behind the thermally insulated central pipe is also to be able to keep a high temperature drop over the heat exchanger which is beneficial for cooling purposes.



Design principle of the TIL-GHEX compared with a traditional U-collector design.

Comparison with traditional U-pipe storage and collectors

The efficiency of a ground energy borehole is influenced by two factors. Firstly, the temperature difference between the inlet and the outlet flow of the collector. Secondly, the heat transfer coefficient between the collector and the surrounding ground which is normally referred to as the inverted value of the thermal heat resistance. The second factor is also influenced by the total surface area between the collector and the surrounding ground. Two main parameters influence the thermal heat resistance: The thermal resistance between the upward and the downward going flow (R_a) and the borehole thermal resistance (R_b).

One of the drawbacks with conventional collectors is that there is an undesired heat transfer between the upward and downward going flow. The thermal resistance between the upward and downward going flow is mostly denoted Ra and should be as high as possible. With Uponor TIL-GHEX ground energy collectors that undesired heat transfer is minimized through the insulated central pipe causing a higher R_a. The other drawback with conventional collectors is that the desired heat transfer to and from the surrounding ground is low compared to what can be obtained from a physical point of view. To obtain a high heat transfer between the fluid in the pipes and to the surrounding ground, the borehole thermal resistance denoted R_b has to be low.

TIL-GHEX benefits

The TIL-GHEX allows a higher energy transfer between the ground and the collector to a low borehole thermal resistance. This means that the depth of the borehole by up to 50% with the same thermal output. While the TIL-GHEX collector is more costly than a conventional collector, the total costs of installation are lower due to the reduced borehole depth.

The TIL-GHEX collector displays a high thermal resistance between the downward and upward going flow regardless of the flow rate. In contrast, the performance of conventional collectors depends on the flow velocity, with high losses at a low flow rate and clearly inferior performance even at high flow rates.

In summary the Uponor TIL-GHEX collector extracts a maximum of thermal energy which is transported up to the ground surface by a number of low diameter outer pipes (between 6 and 12). This applies to the heating mode. For cooling the direction of transportation is the opposite.

Thermal Response Test (TRT)

A thermal response test (TRT) is a procedure that is carried out in order to measure the heat transfer performance between the fluid in the GHEX (Ground Heat Exchanger) and the ground. The TRT is performed to make a cost effective BTES (Borehole Thermal Energy System) design.

The heat transfer performance can be divided in the thermal performance in the ground and the thermal performance in the borehole. Whereas it is difficult to influence ground thermal conductivity it is on the other hand easy to influence the thermal performance for the borehole by the GHEX (Ground Heat Exchangers) design and the material in the borehole.

Typical heat transfer rates in a GSHP (Ground Source Heat Pump) installation differ from 30–50 W/m, but higher rates as 100 W/m can be realized if solar collectors are used to charge the bore hole with heat that is going to be seasonal stored in the ground.

As part of the MESSIB project, a Thermal Response Test has been performed on two prototypes and the measured Rb values compared with a single and double U-loop for different brine flows. The results have proven that the TIL-GHEX offers considerably lower Rb than single and double U-loop. The TIL-GHEX has shown borehole thermal resistance around 0.02 K/Wm (dependant on the flow rate) while traditional U-collectors show thermal resistance in the range of 0.04 K/Wm (turbulent flow) and up to 0.07 K/Wm (laminar flow). The TIL-GHEX performs in particular better at laminar flow rates. The reason to that is that U-loops with large hydraulic diameters have to operate in turbulent flow regime to perform optimally.

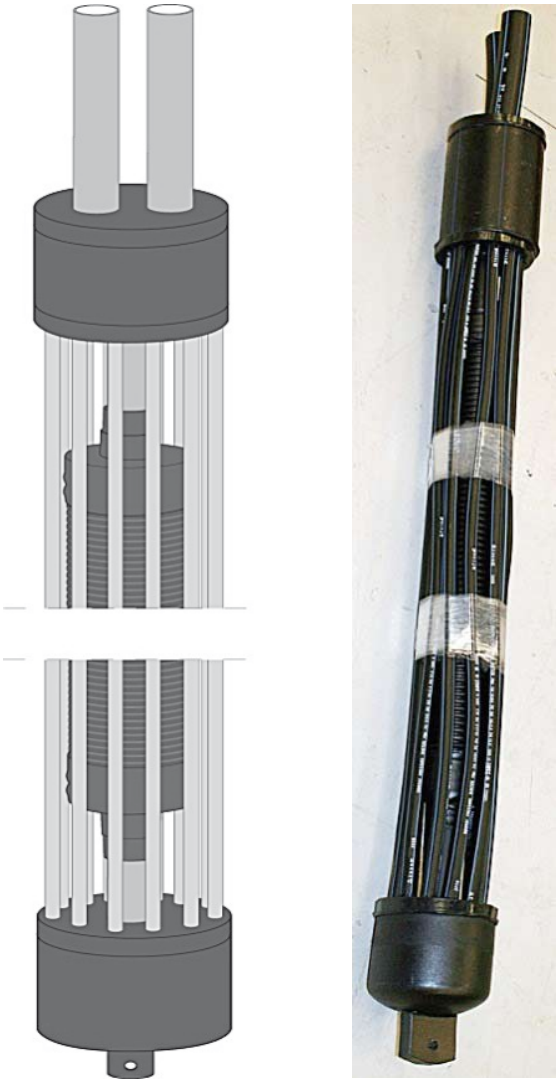
Demonstration Projects

The MESSIB project demonstrates concept and solution of the project at three locations; one is a single-family like house in Greece. The other demonstrators which monitor the performance of the Uponor GHEX as a part of embedded system are located in Freiburg /Germany and Paterna/Spain.

Furthermore, the TIL-GHEX has currently been installed at a number of demonstration projects throughout Europe, including Freiburg in Germany, Virsbo in Sweden and the new office building project Plaza Loiste in Vantaa, Helsinki, Finland. The performance of the installations will be monitored for future improvement and optimization of the TIL-GEX and its interface to the integral building energy system.

Conclusion and Perspectives

Sustainable heating and cooling technologies for buildings is key to reduce the overall energy consumption in the construction sector and further integrate renewable energy sources. Improved thermal energy storage technology plays a vital role for balancing the fluctuations in supply and demand. Reliable storage systems for short as well as long term are hence essential for efficient energy systems that contribute positively to a sustainable construction development.



Uponor TIL-GHEX.

Being part of the MESSIB project has allowed Uponor to develop a co-axial TIL-GHEX ground collector and store system with proven superior thermal performance. The developed products and systems are already being installed within commercial projects which form a good basis for further improvements and commercialisation of efficient ground energy storage systems.

For further information please visit www.messib.eu.