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Technical Track: PV, Thermal, and Storage

NEW WAYS TO COMBINE SOLAR THERMAL WITH GEOTHERMAL

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Seasonal Storage Technologies

MULTISOURCE HEAT PUMPS

HEAT PUMP CONCEPTS FROM SPAIN, GERMANY, BELGIUM AND ITALY CAN BE COMBINED TO DESIGN A SYSTEM WHICH WILL BE LESS EXPENSIVE TO BUILD AND

MORE EFFICIENT THAN CONVENTIONAL

GROUND SOURCE HEAT PUMPS

MUCH SMALLER GROUND LOOP AND LOWER ELECTRICITY USE

International Journal of Low-Carbon Technologies 2018, 1–16

Dual source heat pump, a high efficiency and cost-effective alternative for heating, cooling and DHW production

José M. Corberán, Antonio Cazorla-Marín*, Javier Marchante-Avellaneda and Carla Montagud

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Abstract

This article presents the characteristics and performance of an innovative dual source heat pump (DSHP) for heating, cooling and domestic hot water (DHW) production. The research work was carried out in the framework of the H2020 European project: Geot€ch 'GEOthermal Technology for economic Cooling and Heating'. The DSHP is able to choose the most favourable source/sink in such a way that it can work as an air-to-water heat pump using the air as a source/sink, or as a brine-to-water heat pump coupled to the ground. The DSHP is manufactured as an outdoor 'plug & play' unit, working with R32 refrigerant and including a variable speed compressor, which gives full capabilities for an efficient modulating operation. The DSHP was fully characterized in steady state conditions at the IUIIE laboratory. In order to assess its dynamic performance and to identify key control strategies to optimize its annual operation, a complete integrated model of the DSHP system in TRNSYS including the DSHP and all the other system components was developed. A first energy assessment, carried out for an office building located in the Netherlands, proves that the DSHP system would be able to reach a similar efficiency than a pure ground source heat pump (GSHP) system with half the ground source heat exchanger area needed. Therefore, the DSHP system could become a cost-effective alternative solution for heating, cooling and DHW production in buildings, as the initial investment would be significantly reduced compared to GSHPs, with similar or even higher energy efficiency.

Keywords: dual source heat pump; geothermal energy; energy efficiency

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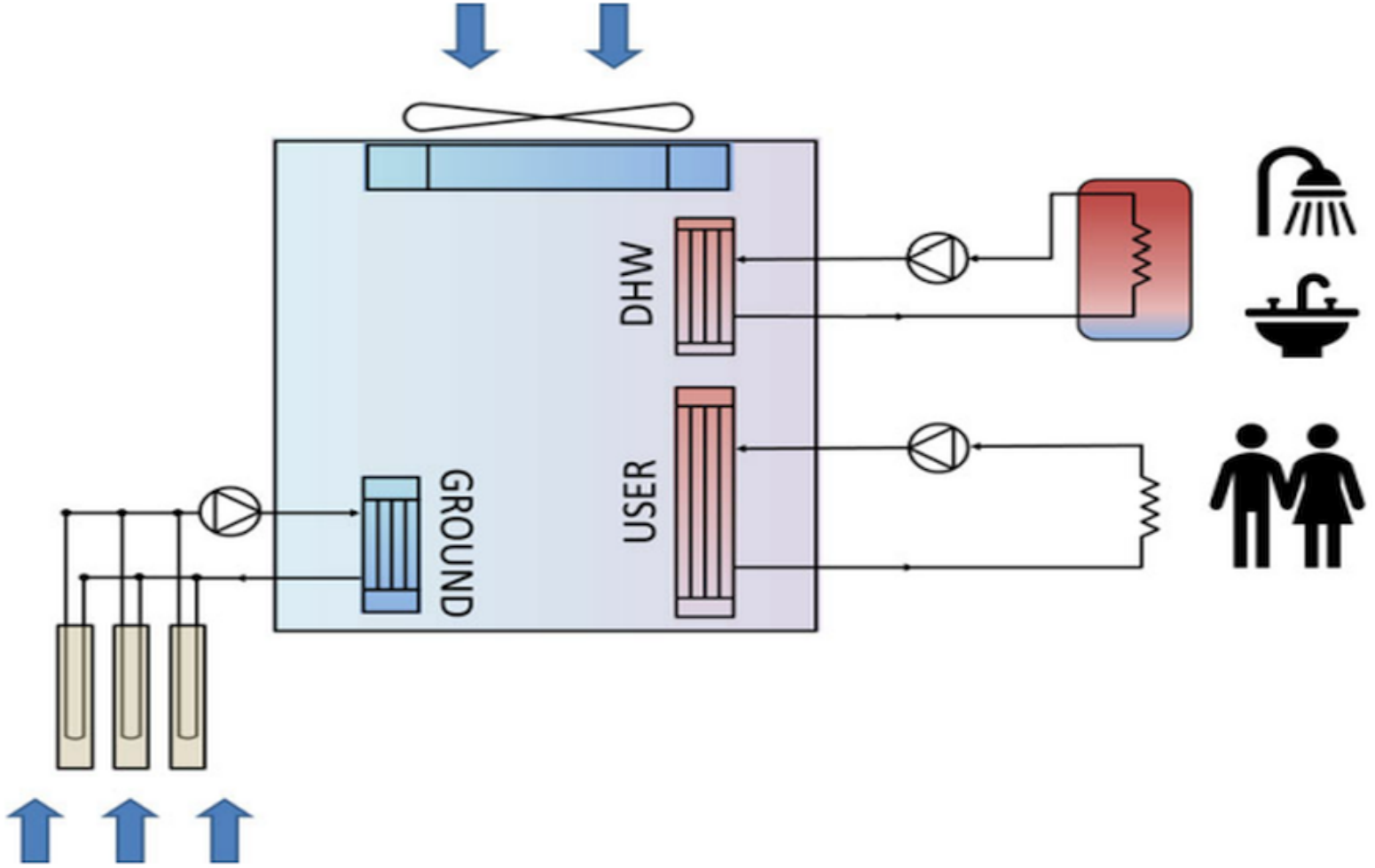

Figure 1. *Basic structure and components of the dual source heat pump.*

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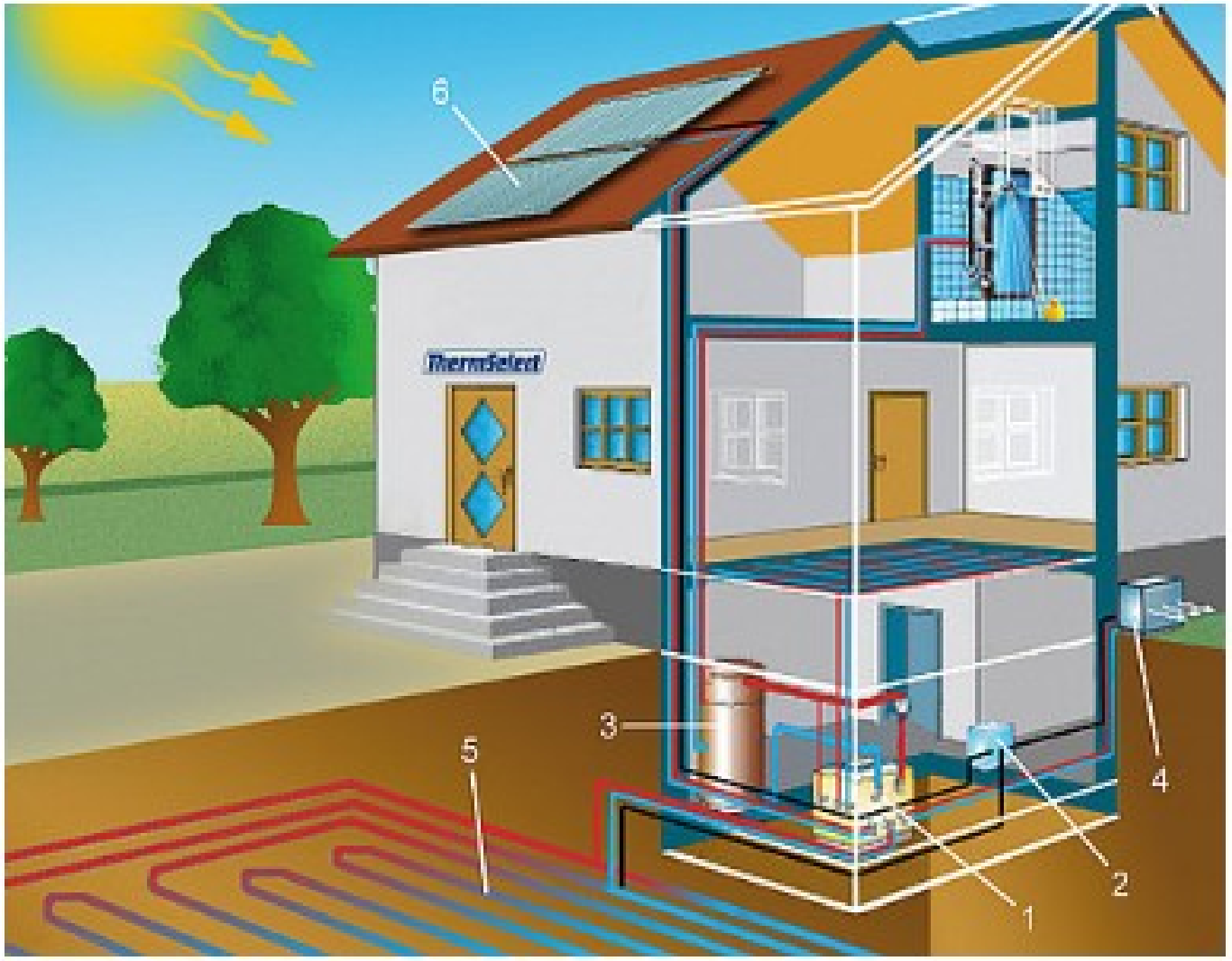
6
ThermSelect
3
5
4
1
2

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An analysis of solar assisted ground source heat pumps in cold climates

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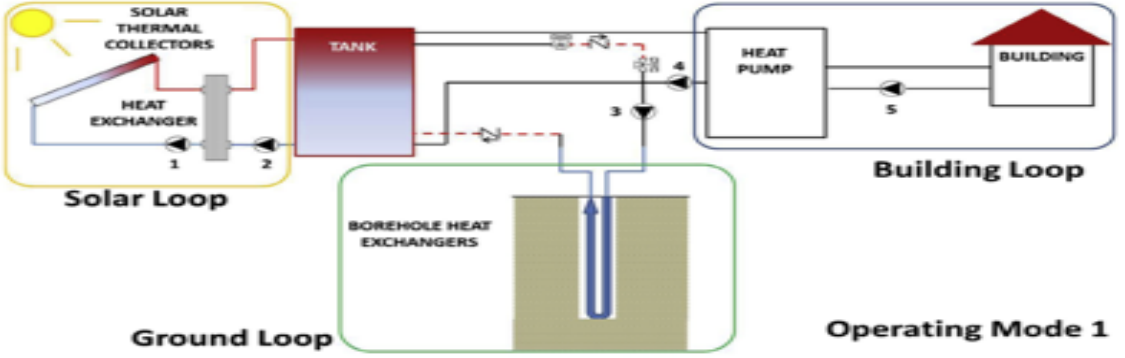
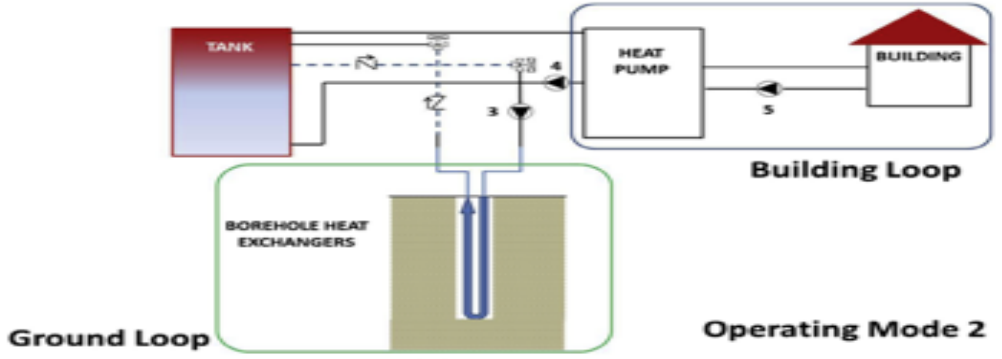
ABSTRACT

Exploiting renewable energy sources for air-conditioning has been extensively investigated over recent years, and many countries have been working to promote the use of renewable energy to decrease energy consumption and CO_2 emissions. Electrical heat pumps currently represent the most promising technology to reduce fossil fuel usage. While ground source heat pumps, which use free heat sources, have been taking significant steps forward and despite the fact that their energy performance is better than that of air source heat pumps, their development has been limited by their high initial investment cost. An alternative solution is one that uses solar thermal collectors coupled with a ground source heat pump in a so-called solar assisted ground source heat pump.

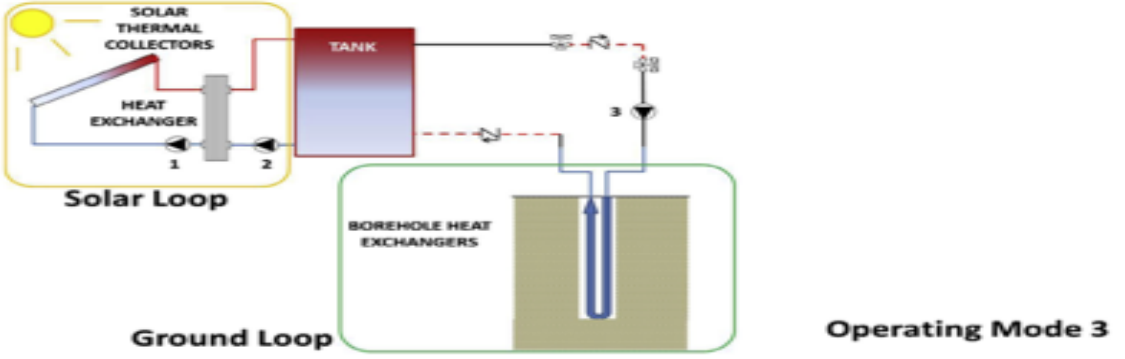
A ground source heat pump system, used to heat environments located in a cold climate, was investigated in this study. The solar assisted ground source heat pump extracted heat from the ground by means of borehole heat exchangers and it injected excess solar thermal energy into the ground. Building load profiles are usually heating dominated in cold climates, but when common ground source heat pump systems are used only for heating, their performance decreases due to an unbalanced ground load. Solar thermal collectors can help to ensure that systems installed in cold zones perform more efficiently. Computer simulations using a Transient System Simulation (TRNSYS) tool were carried out in six cold locations in order to investigate solar assisted ground source heat pumps. The effect of the borehole length on the energy efficiency of the heat pump was, in particular, analyzed. Finally, a suitable control strategy was implemented to manage both the solar thermal collectors and the borehole heat exchangers.


SOLAR THERMAL COLLECTORS
HEAT EXCHANGER
1
2
TANK
3
4
HEAT PUMP
5
BUILDING
Solar Loop
Building Loop
BOREHOLE HEAT EXCHANGERS
Ground Loop
Operating Mode 1

(a)


TANK
3
4
HEAT PUMP
5
BUILDING
Building Loop
BOREHOLE HEAT EXCHANGERS
Ground Loop
Operating Mode 2

(b)


SOLAR THERMAL COLLECTORS
HEAT EXCHANGER
1
2
TANK
3
Solar Loop
BOREHOLE HEAT EXCHANGERS
Ground Loop
Operating Mode 3

(c)

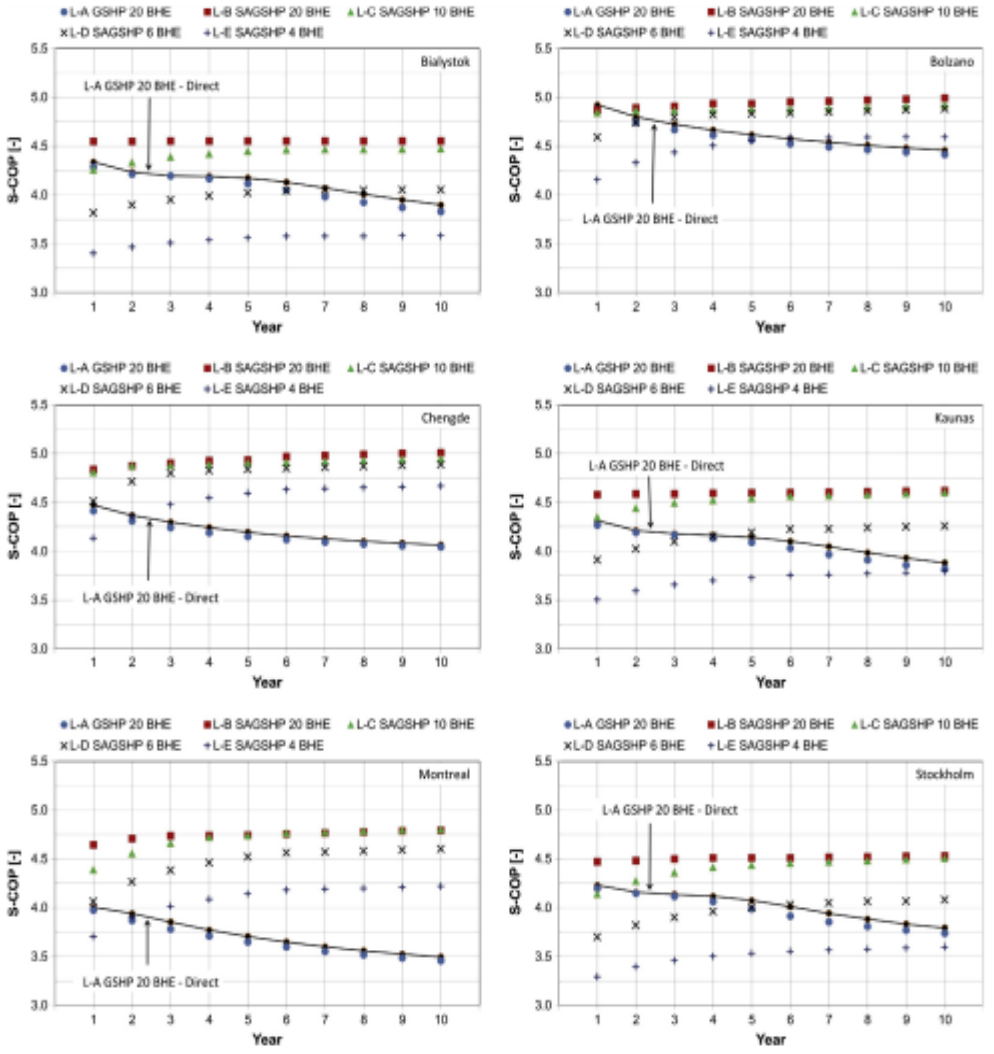
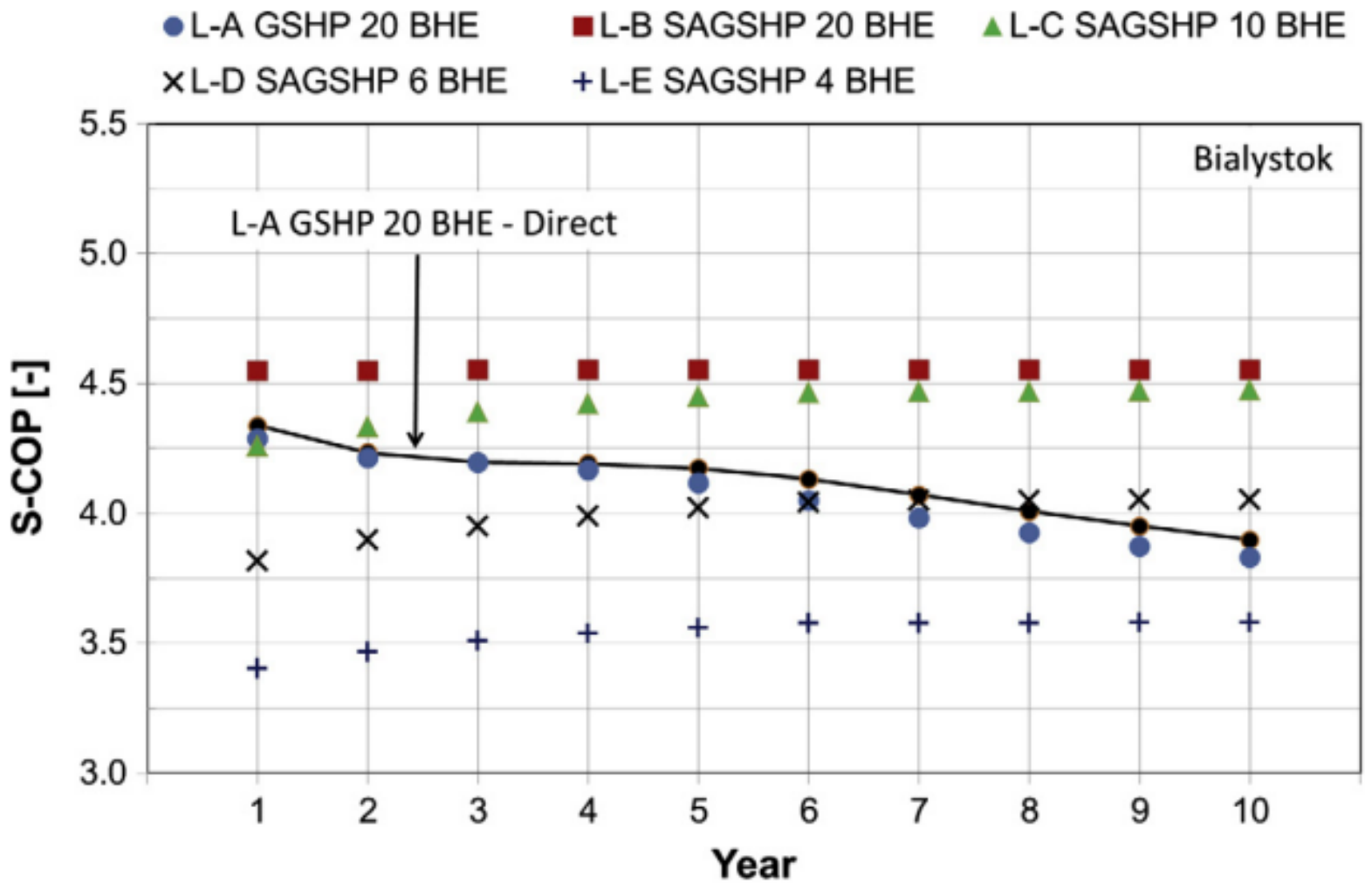


Fig. 9. The seasonal energy efficiency of the heat pump (S-COP) over the ten years period.


L-A GSHP 20 BHE
L-B SAGSHP 20 BHE
L-C SAGSHP 10 BHE
L-D SAGSHP 6 BHE
L-E SAGSHP 4 BHE
Bialystok
L-A GSHP 20 BHE - Direct
S-COP [-]
5.5
5.0
4.5
4.0
3.5
3.0
1
2
3
4
5
6
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9
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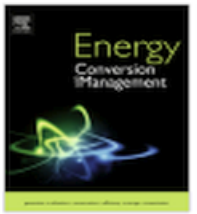

Hybrid ground-source heat pump system with active air source regeneration

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Geothermal
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Modeling

ABSTRACT

Ground-source heat pump systems (GSHP) offer great advantages over traditional heating and cooling installations. However, their applications are limited due to the high initial costs of borehole drilling. One way to avoid these costs is by reducing the size of the borefield, e.g. by combining the system with other renewable energy sources or by using active regeneration to increase the system efficiency. In this paper a hybrid ground-source heat pump system (HGSHP) is analyzed. The borefield is split into a warm part and a cold part, which allows for seasonal thermal-energy storage. Additionally, supplementary dry-coolers capture heat during summer and cold during winter. The relationship between the underground storage size and temperature and the drycooler capacity is described, using an office building in Flanders (Belgium) as reference case. Results show that with a HGSHP system a significant borefield size reduction can be achieved without compromising system performance; i.e. for the reference case a reduction of 47% was achieved in the cost-optimal configuration. It is also shown that the cooling seasonal performance factor decreases significantly with underground storage capacity. In addition, the HGSHP can be used to maintain or restore thermal balance in the geothermal source when heating and cooling loads do not match.

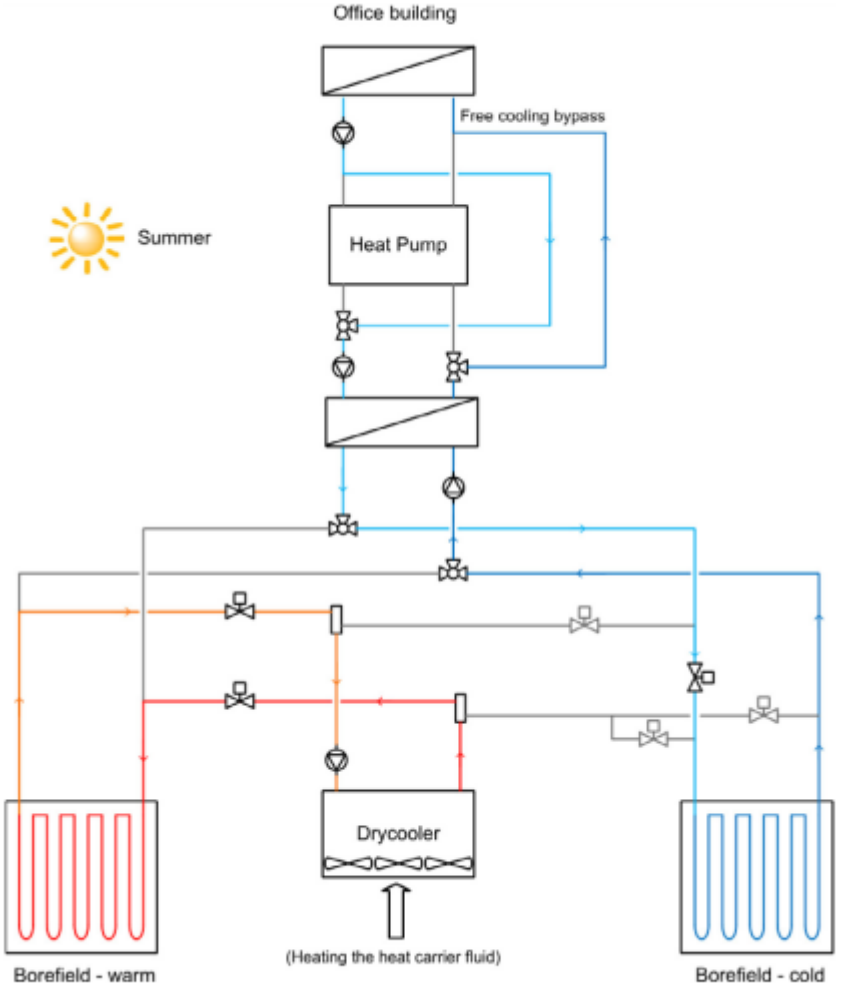


Fig. 1. Configuration diagram of the HGSHP system in cooling mode.

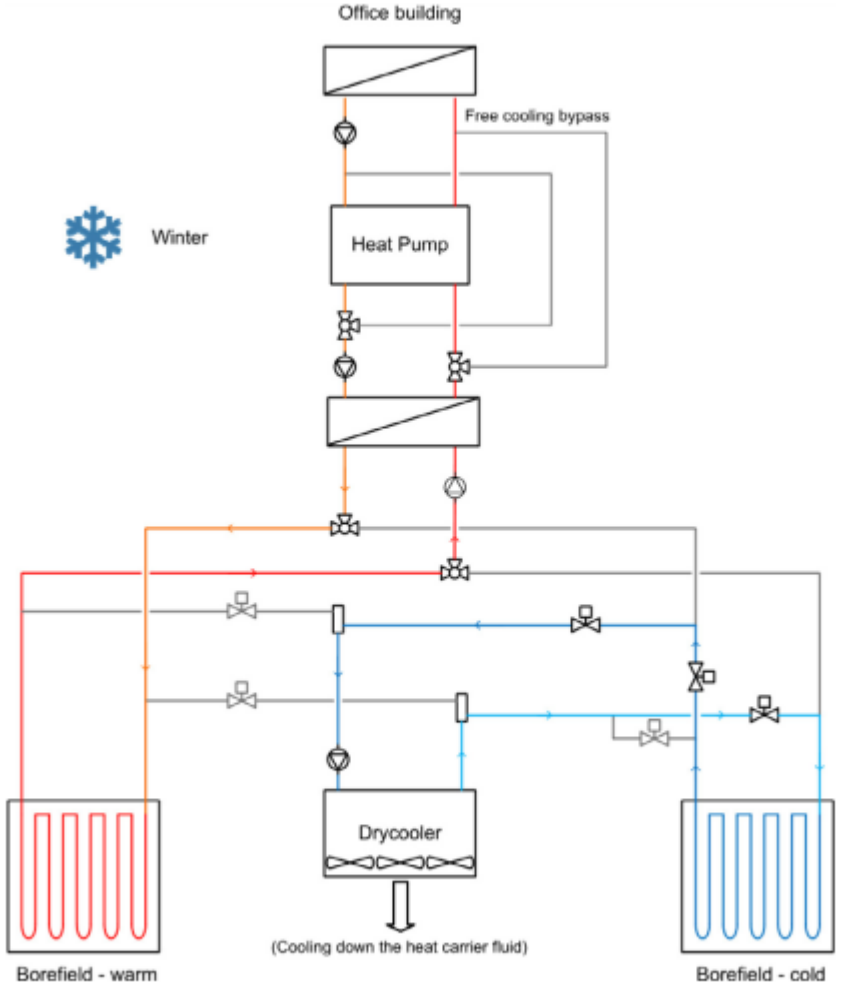
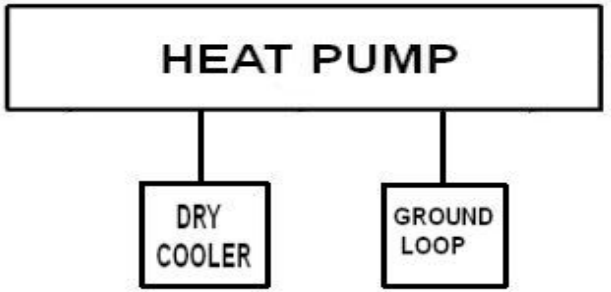


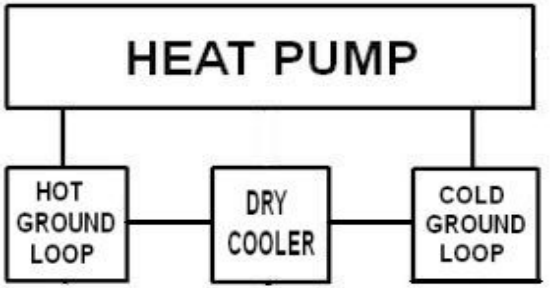
Fig. 2. Configuration diagram of the HGSHP system in heating mode.



DUAL SOURCE SYSTEM

AIR SOURCE OR GROUND SOURCE

50 PERCENT REDUCTION IN GROUND LOOP SIZE



DUAL SOURCE SYSTEM

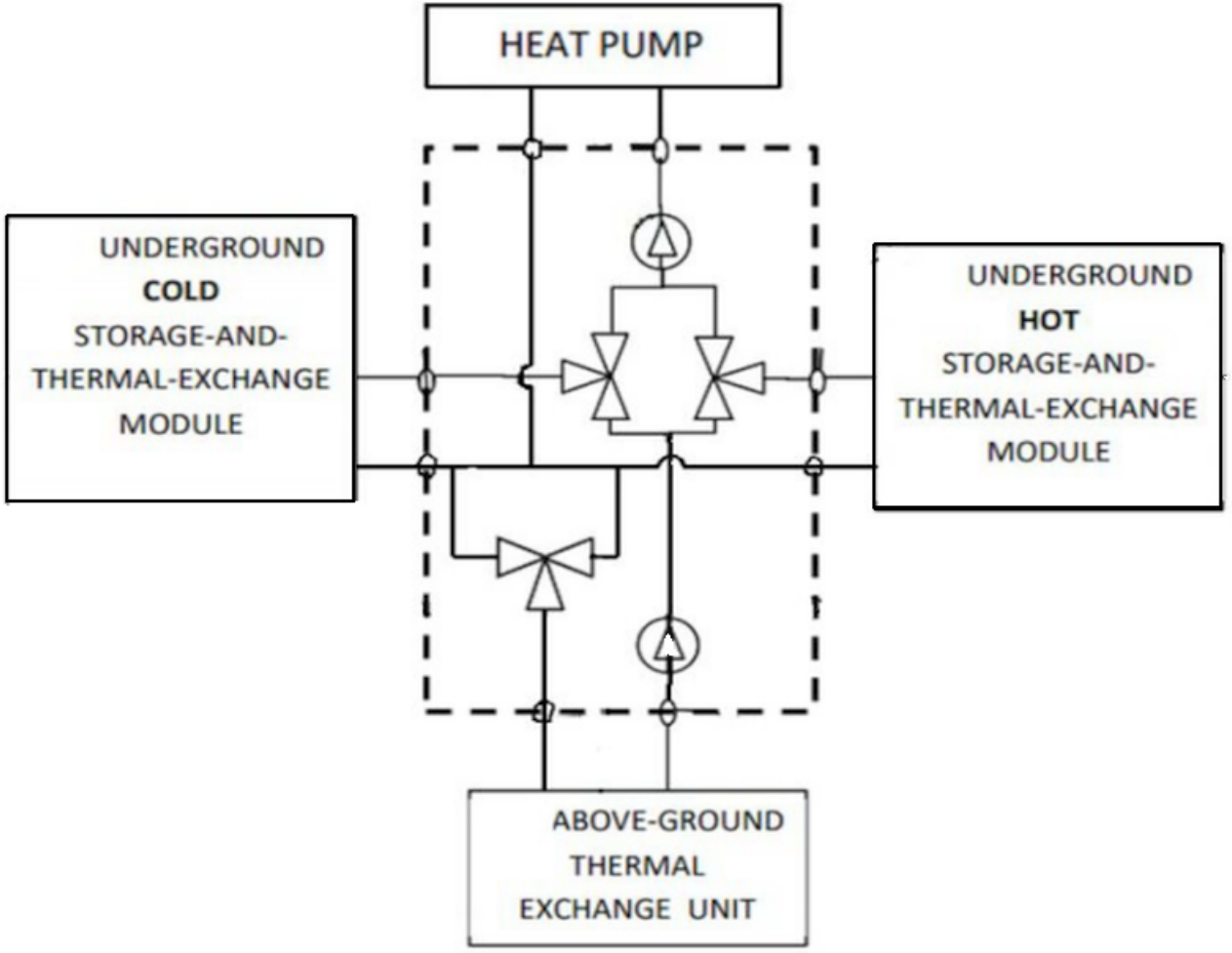
HOT GROUND LOOP OR COLD GROUND LOOP

50 PERCENT REDUCTION IN GROUND LOOP SIZE

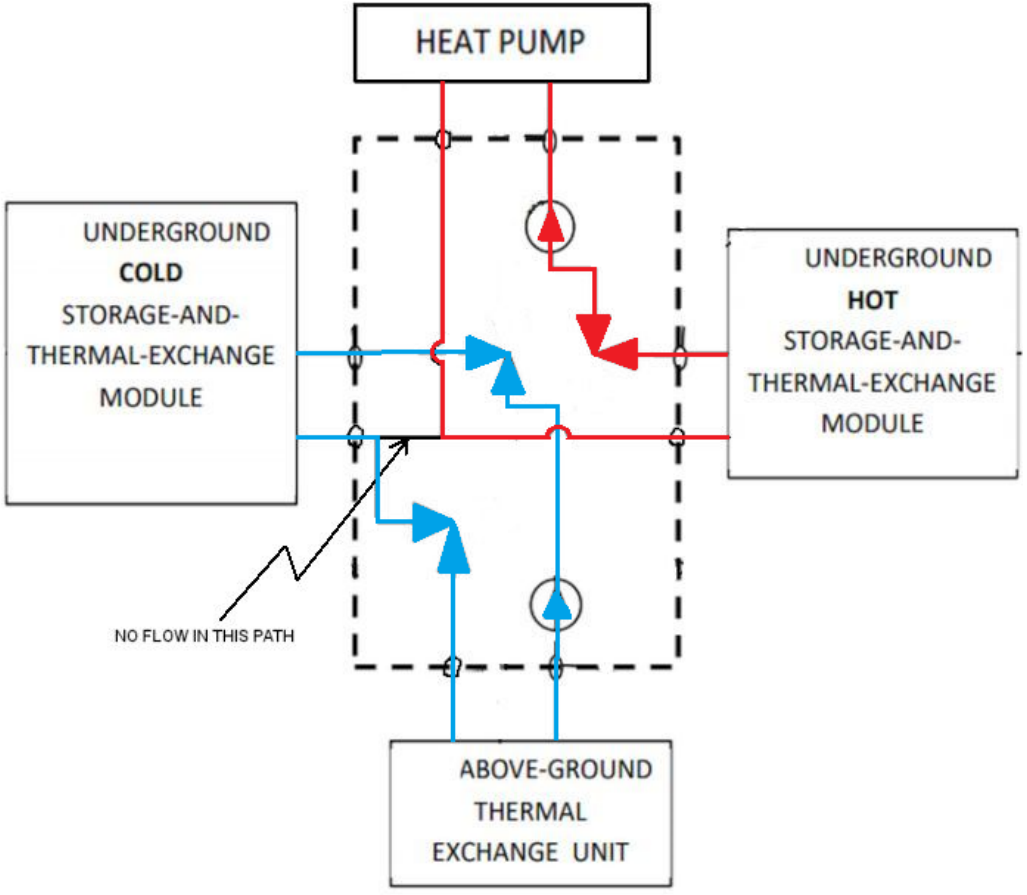
IF A SYSTEM COULD HAVE BOTH OF THESE

INDEPENDENT DUAL SOURCE METHODS IN USE, THE

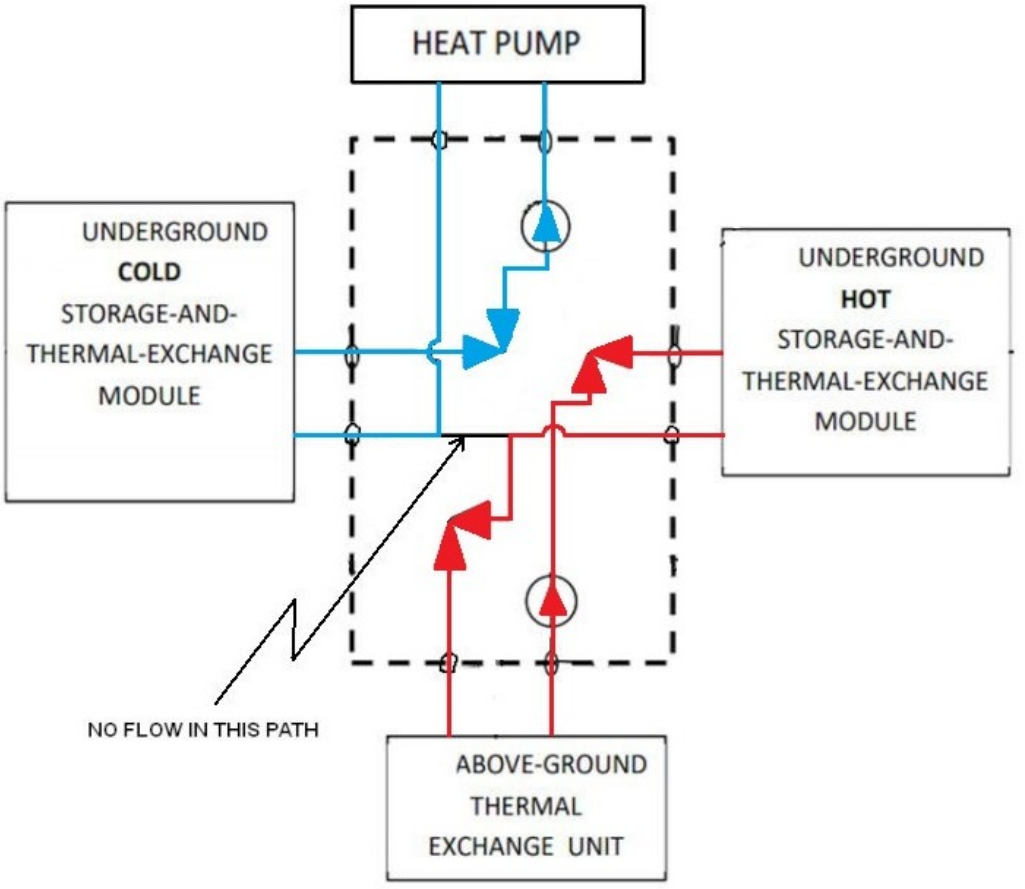
LOOP SIZE REDUCTION WOULD BE MORE THAN 50 PERCENT



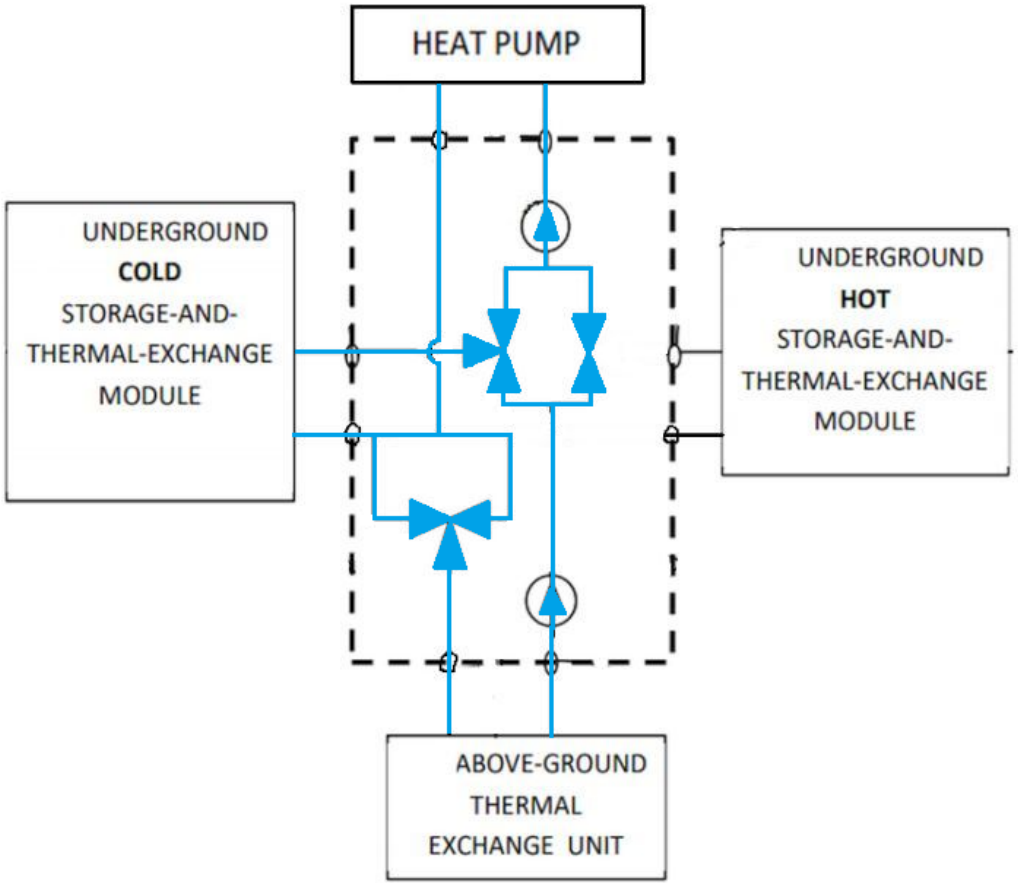
REVISED MULTI-SOURCE DESIGN



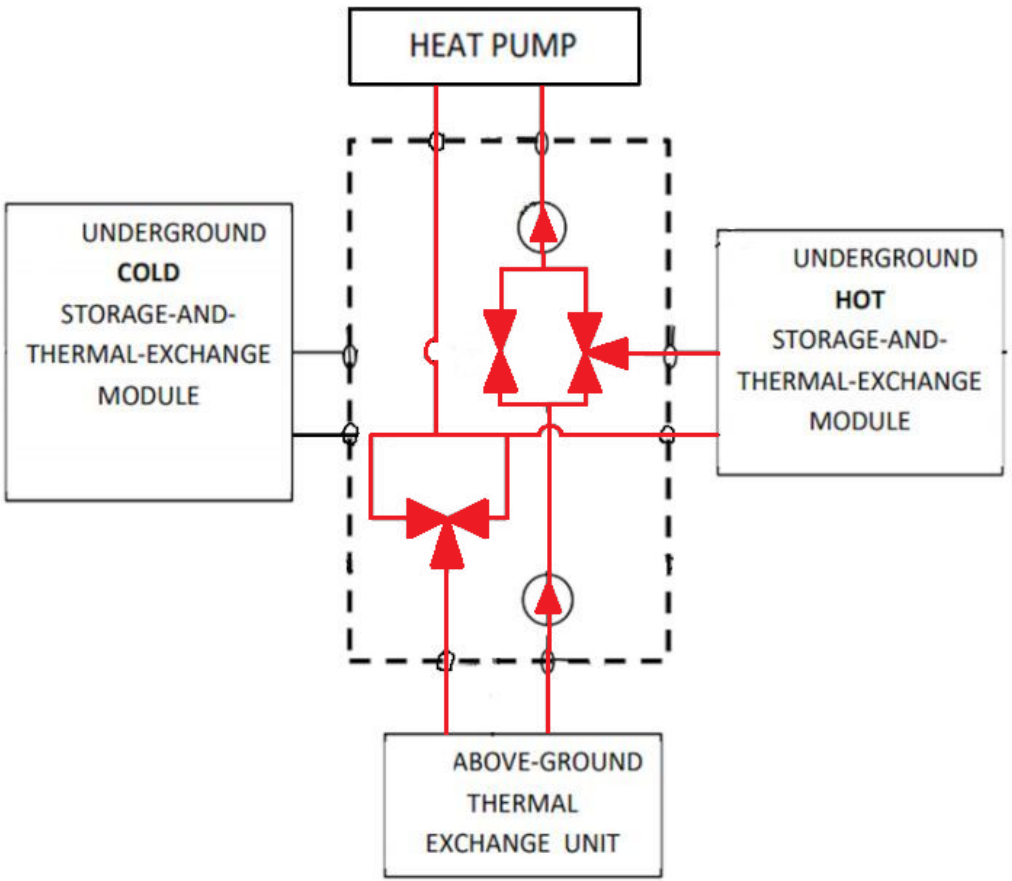
FLOW PATHS DURING THE COLDEST WINTER NIGHT



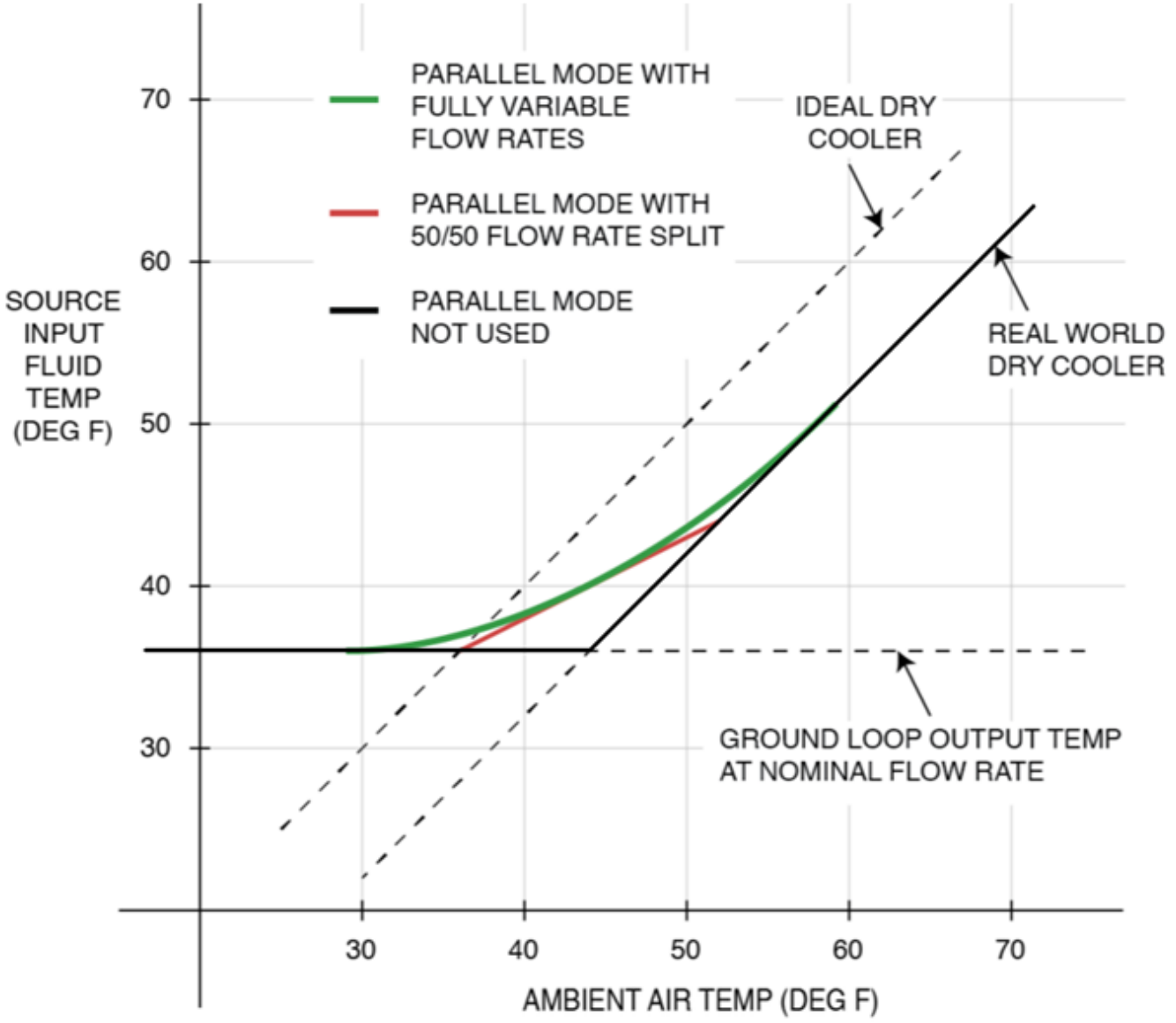
FLOW PATHS DURING THE HOTTEST SUMMER DAY

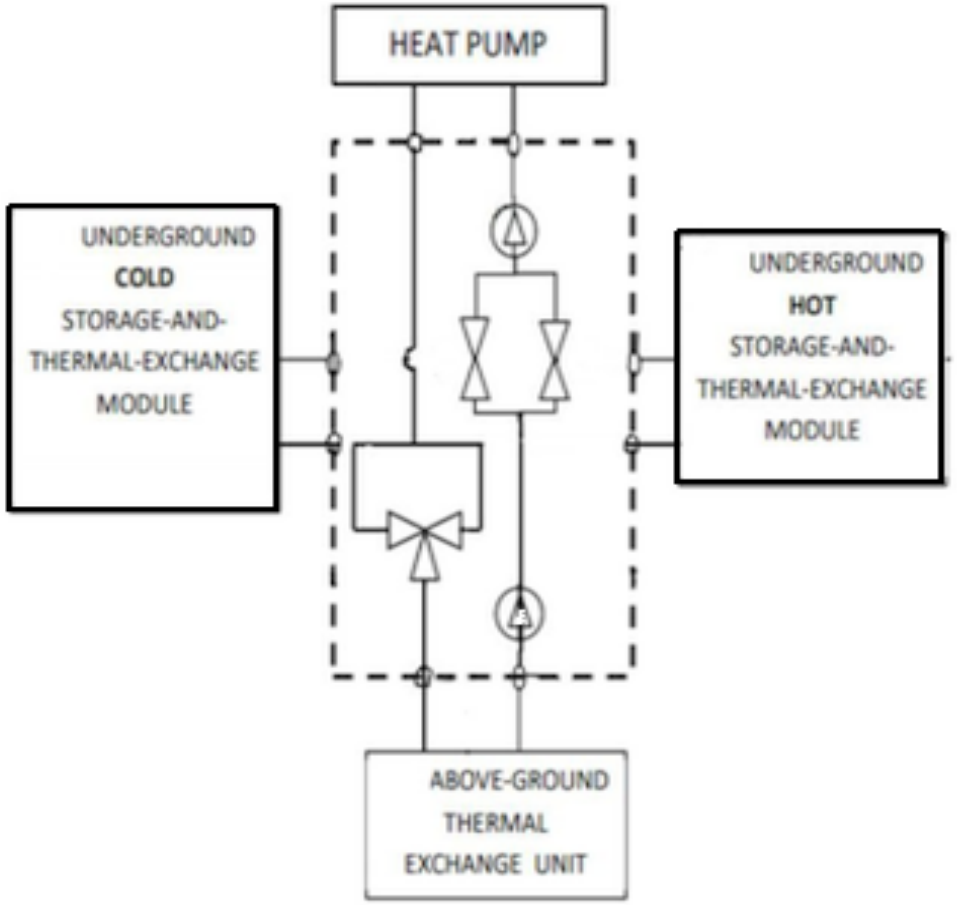


PARALLEL MODE USING COLD MODULE

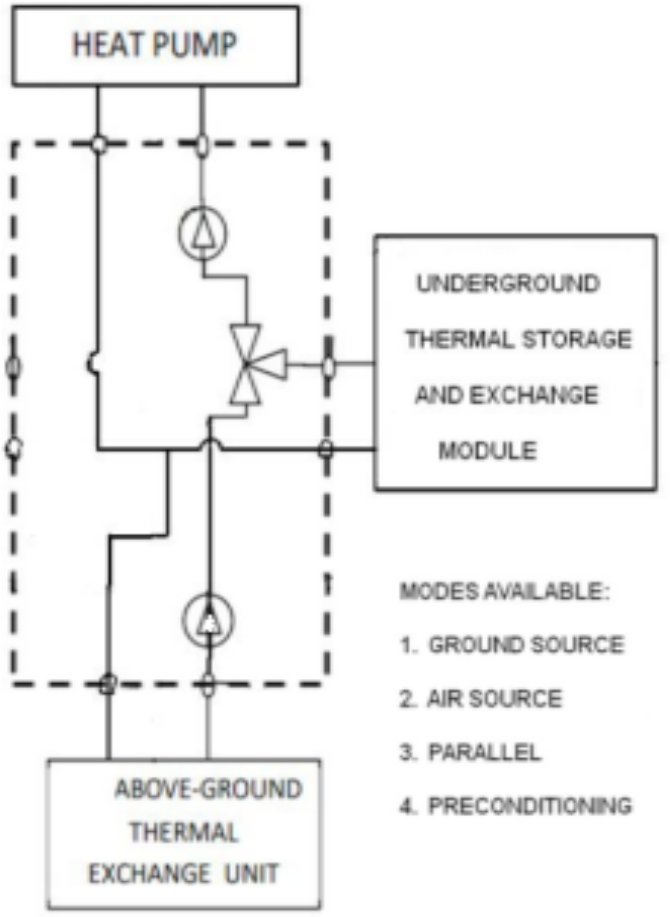


PARALLEL MODE USING HOT MODULE


PARALLEL MODE WITH FULLY VARIABLE FLOW RATES
PARALLEL MODE WITH 50/50 FLOW RATE SPLIT
PARALLEL MODE NOT USED
IDEAL DRY COOLER
REAL WORLD DRY COOLER
GROUND LOOP OUTPUT TEMP AT NOMINAL FLOW RATE
SOURCE INPUT FLUID TEMP (DEG F)
70
60
50
40
30
30
40
50
60
70
AMBIENT AIR TEMP (DEG F)



AIR SOURCE MODE FLOW PATHS



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Size:

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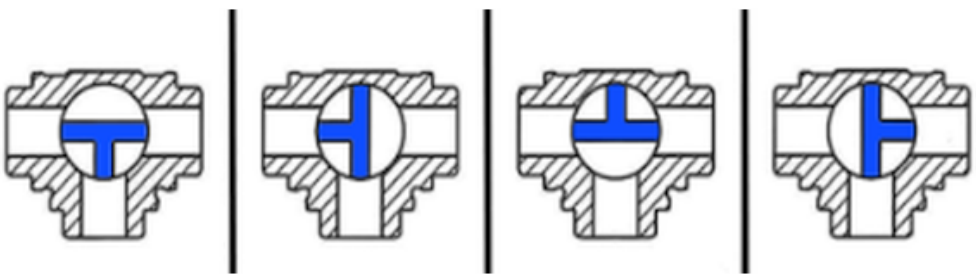

THANK YOU FOR YOUR ATTENTION

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Some concepts presented herein
are currently patent pending