

**Ground and Hydro-Thermal** Energy System



**Deep-coil 300<sup>®</sup>**

**GeoSSum<sup>®</sup>**

**GeoSSum<sup>®</sup> – Hybrid**

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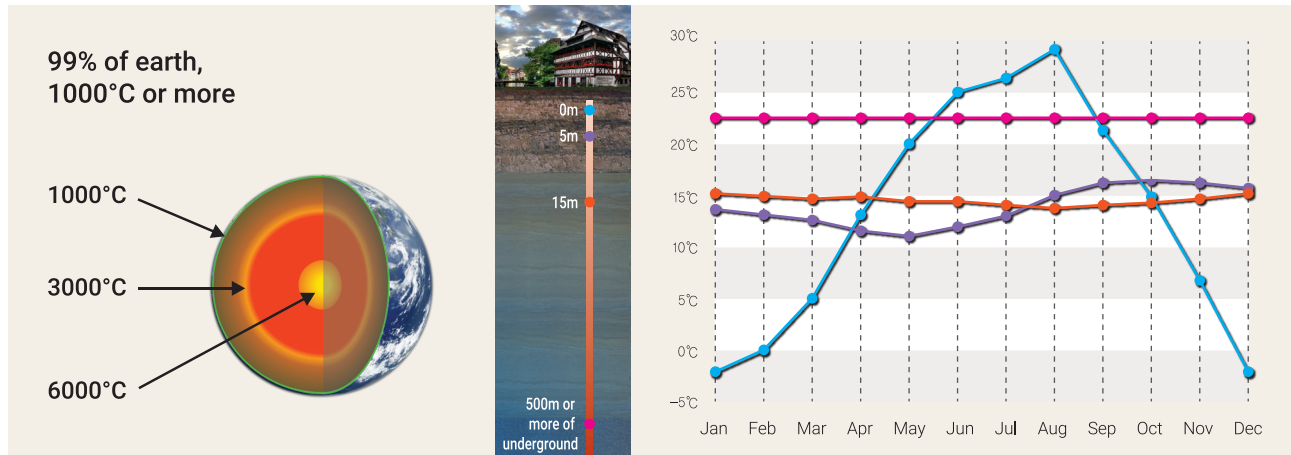
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# Ground and hydro-thermal energy

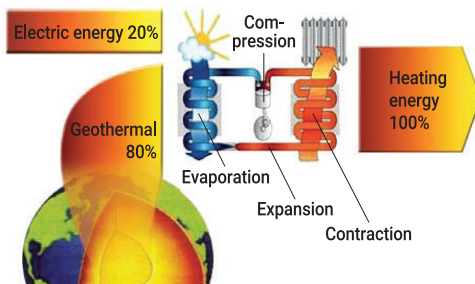
Definitions and characteristics of ground and hydro-thermal (hereinafter, the “geothermal”) energy

**Thermal energy held in soil, rock and ground water that consist underground**

No impact on the shift in atmospheric temperature / Unlimited energy source and environment-friendly / Affordable operation expense



## Geothermal heat pump and system efficiency

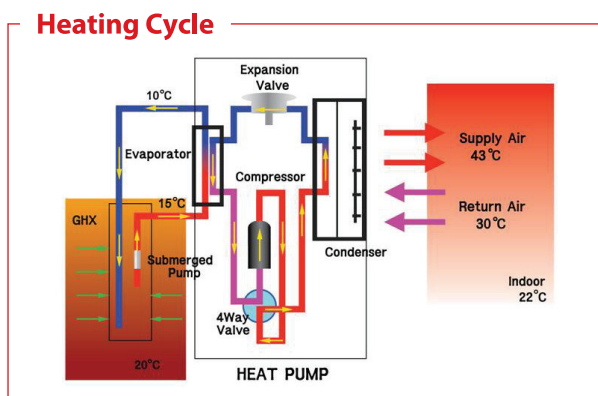


The geothermal energy system has the highest efficiency from the existing cooling and heating systems, and is environment-friendly system.

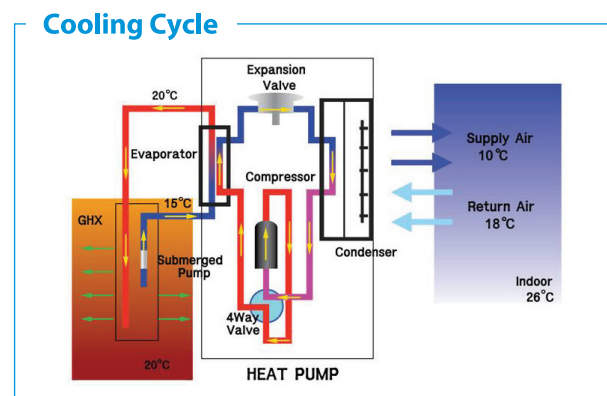
- US EPA-Environmental Protection Agency

## Principle of the geothermal energy system

This is an environment-friendly system with high efficiency that uses the geothermal source to solve heating and cooling issues by a system.



**Heating** is afforded by discharging indoor thermal energy to ground by using the heat pump.



**Cooling** is afforded by discharging indoor thermal energy to ground by using the heat pump.

# Deep-coil 300<sup>®</sup>

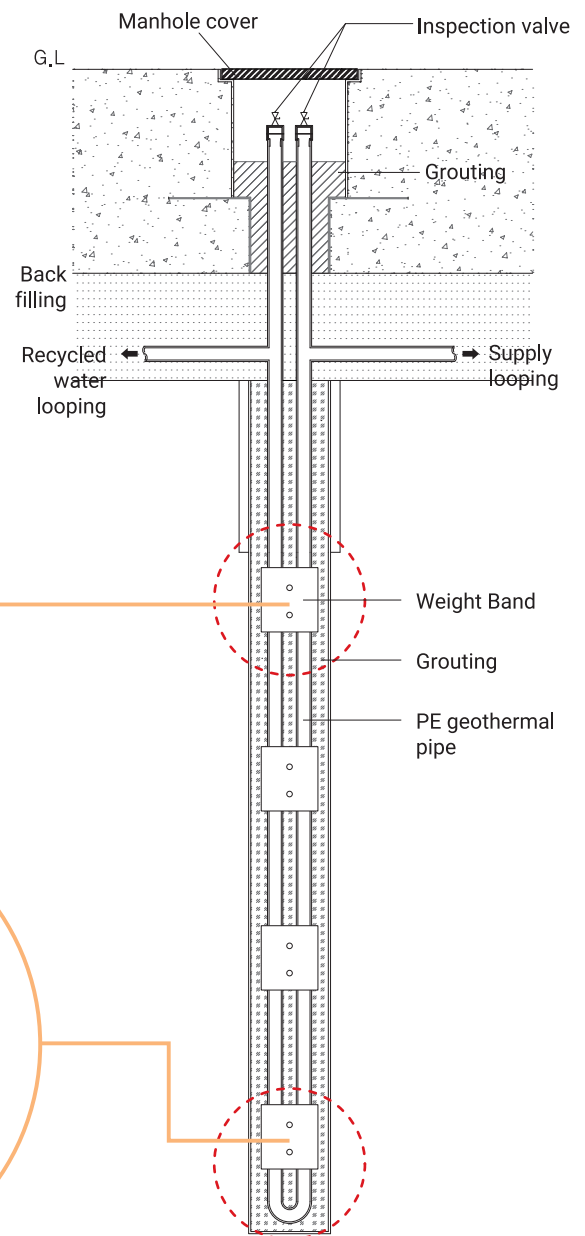
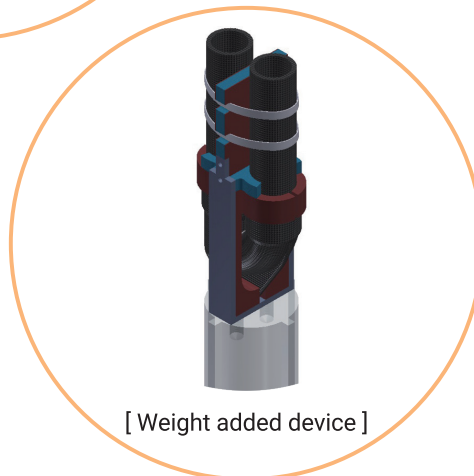
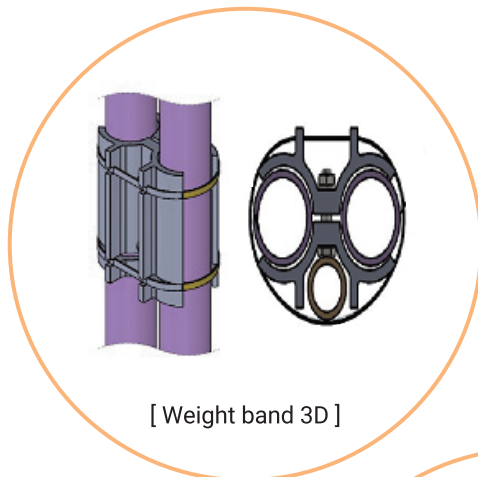
## Deep vertical closed-loop geothermal system

(Technology of priming water project of the Korea Institute of Energy Technology Evaluation and Planning)

New Environment Technology (NET) Certification No. 549 / Patent No. 10-0981527 /  
Patent No. 10-1299826 / Patent No. 10-1425632 Patent No. 10-1425632,  
Patent No. 10-1550057 / Patent No. 10-2018-00789 / Patent No. 10-1415299

## Characteristics of Deep-coil 300<sup>®</sup> technology

- By attaching the weight band and weight added device to the exterior and lower part of the geothermal coil pipe to diminish the buoyancy of the geothermal coil pipe to structure the vertical closed-loop ground heat exchanger with deep depth (300m)
- Apply the narrowness prevention technology in grouting
- Reduce the entire length of the ground heat exchanger and decrease the boring quantity compared to existing technology
- The site area savings effect following the decrease in boring quantity



[ Shop drawing of Deep-coil 300 ]

※ The weight band and weight added device are subject to change the design for quality improvement.



# The work depth increasing technology by using the weight band

Installation depth of geothermal coil pipe accomplishes from existing 150~200m → 300m

## Limitations in field application

- > The weight of the geothermal coil pipe (HDPE) is  $0.93 \sim 0.97 \text{ mg/cm}^3$  that is lighter than water to have the buoyance.
- > For the buoyancy diminution, there is a limitation of installation up to 200m even if the weight pendulum is placed.

## Solution

- > Combine the weight band and weight added device on the exterior of HDPE to increase the weight per unit length.
- > The straight line equipment is attached to the inserter to minimize the friction resistance of the HDPE pipe and improve the workability

## Effect

- > Improve the installation depth of the geothermal coil pipe
- > With the increase of HDPE weight, the diameter of the geothermal coil pipe is expanded
- > The weight band maintains the gap of the coil pipe (role of spacer)
- > Improve the heat exchange by expanding the diameter of the geothermal coil pipe



- » Reduce the installation length of the ground heat exchanger
- » Decrease the quantity of the geothermal boreholes (1/2 or more)
- » Reduce the excavation area of the geothermal boreholes (1/2 or more)

## Photo of Korea Institute of Energy Technology Evaluation and Planning test-bed field work



[ Excavation ]



[ Installation of the ground heat exchanger ]



[ Installation of the weight band ]



[ Installation of the mechanics' room ]

## Applying the grouting narrowness prevention technology

### Deep-coil prevents the grouting coil pipe narrowness.

- > During the grouting inside the geothermal boreholes, it applies the coil pipe narrowness prevention patent method (Patent No. 10-M15299)
- > The geothermal pipe closure can be prevented even for the case of installing the ground heat exchanger up to the deep depth
- > During the grouting work, the water pressure of the high pressure is maintained until the cure inside the coil pipe is completed and prevent the coil pipe narrowness.

## This technology is applicable even in a narrow construction site

### Comparing to existing technology, the site area can be reduced up to 1/2

- > Number of excavation hole: Comparing to existing technology, 52% is saved (result of the GLD simulation)
- > Building site: Comparing to existing technology, 54% is reduced.
- > In the narrow site of a city, it has the effect of applying the maximum load of geothermal
- > Securing the exclusive green space following the boring site decline
- > Minimizing the impact of intervention in civil and construction processing due to excavation

## GLD program simulation (Example)

### GLD simulation conditions

| Category   | Condition  |
|--|--|
| Existing building  | 15-story office building   |
| Designed temperature   | EWT : Cooling for 35°C, heating for 7°C                                  |
| Flux   | 10.0L/min  |
| anti-freeze liquid   | Ethanol of 16.5%   |
| Initial ground temperature                                     | 17.28°C  |
| Ground heat conductivity                                       | 3.27 W/mk  |
| Ground heat exchanger<br>(external diameter/internal diameter) | U-tube, SDR-11<br>- 150m : 40mm(42.2/34.5)<br>- 300m : 50mm(48.26/39.50) |
| Circumference of boring hole                                   | 150mm  |
| Pipe interval  | Average  |
| Grout  | Volclay Grout(water for 70%, bentonite for 30%)                          |
| Ground heat exchanger arrangement                              | 5X5 square type arrangement  |

※ For the load interpretation condition, a study of building energy consumption sample study by Korea Energy Economics Institute (Choi Do-young, et al, 2015)

※ Ground heat conductivity: House Filled with Happiness, Baksa-ro, Seo-myeon, Chuncheon-si Test-bed 300m TRT applied

## GLD simulation result

불력당 평균 부하 - 수직 지열 프로젝트...

월별 부하 데이터

| 업데이트 | 냉방       |         | 난방       |         |
|------|----------|---------|----------|---------|
|      | 최소 (kWh) | 피크 (kW) | 최소 (kWh) | 피크 (kW) |
| 1월   | 0        | 0       | 16533    | 1837    |
| 2월   | 0        | 0       | 9000     | 1000    |
| 3월   | 0        | 0       | 7200     | 800     |
| 4월   | 0        | 0       | 0        | 0       |
| 5월   | 0        | 0       | 0        | 0       |
| 6월   | 9000     | 1000    | 0        | 0       |
| 7월   | 16533    | 1837    | 0        | 0       |
| 8월   | 7200     | 800     | 0        | 0       |
| 9월   | 8550     | 950     | 0        | 0       |
| 10월  | 0        | 0       | 0        | 0       |
| 11월  | 0        | 0       | 0        | 0       |
| 12월  | 0        | 0       | 8550     | 950     |
| 총:   | 41283    | 3.0     | 41283    | 3.0     |

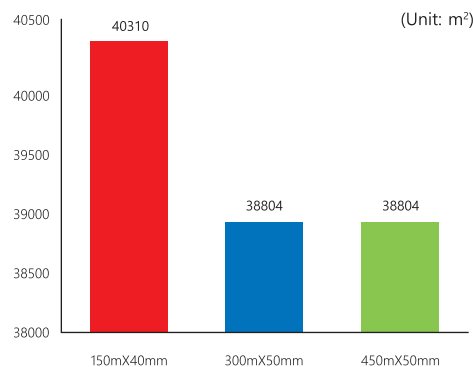
유형: 10.0 (L/min)/3.5kW 인입 온도 (°C): 35.0 7.0

| Classification                 | Deep-coil           | Existing technology (PE40) |
|--------------------------------|---------------------|----------------------------|
| Excavation depth               | 300m                | 150m                       |
| Existing gross load volume     | 1,837kw             | 1,837kw                    |
| Total heat exchanger length    | 38,804m             | 40,310m                    |
| Number of geothermal boreholes | 129 boreholes       | 269 boreholes              |
| Area requiring excavation      | 2,750m <sup>2</sup> | 6,000m <sup>2</sup>        |

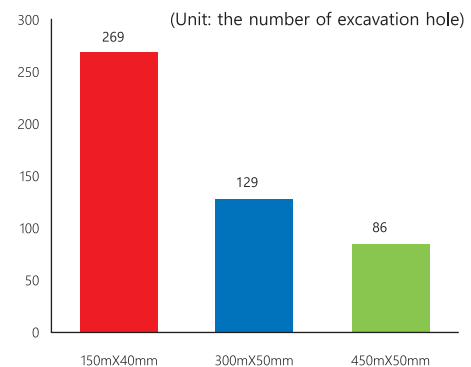
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수직 지열 프로젝트 - 수직 지열 프로젝트 300m-02

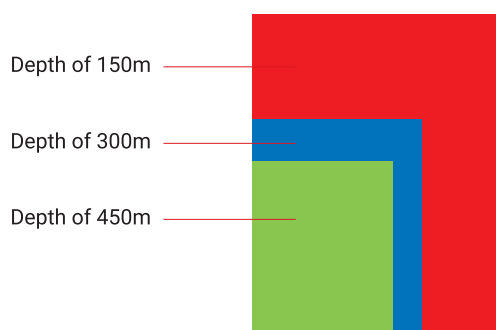
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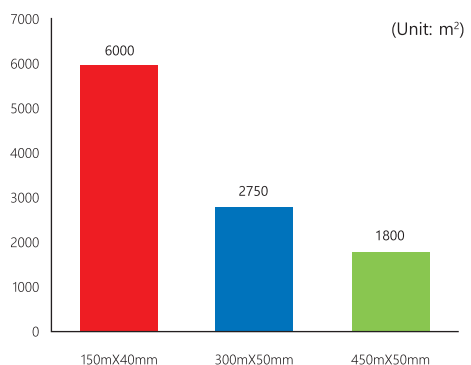
[ Change of length for the ground heat exchanger following the pipe size ]



[ Change in the number of excavation hole following the depth ]



[ Comparison of excavation area for each depth ]



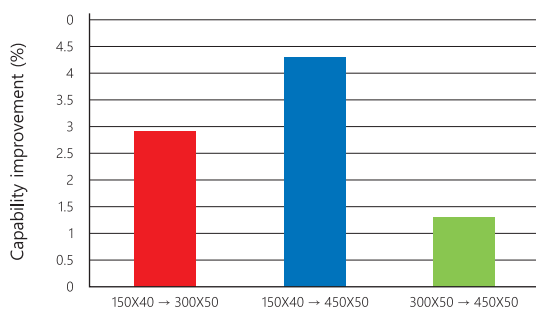
## Shortening of investment recovery period with savings of work expenses

### Comparison of capability per unit length of the ground heat exchanger for each depth

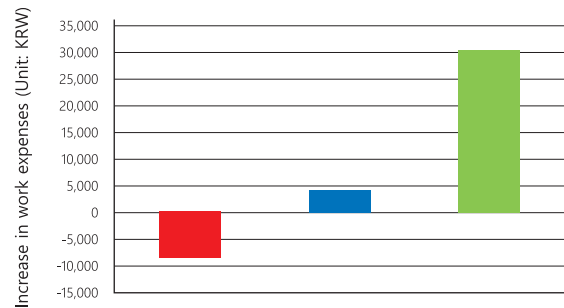
| Classification of comparison group | Peak load | External diameter of pipe | Number of hole/total required length (m) | Investment cost per m | Capability per unit length |
|------------------------------------|-----------|---------------------------|--|-----------------------|----------------------------|
| 150m                               | 1,837     | 40                        | 269/40,310                               | 146,130               | 45.57                      |
| 300m                               | 1,837     | 50                        | 129/38,804                               | 122,999               | 47.34                      |

※ Reflection of GLD program simulation result that applied 15F building model

※ Calculating the investment costs by reflecting the cost analysis report of Korea Economic Administration Institute



[ Comparison of capability improvement per unit length compared to the existing technology ]

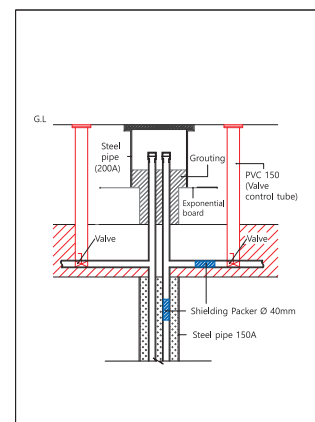
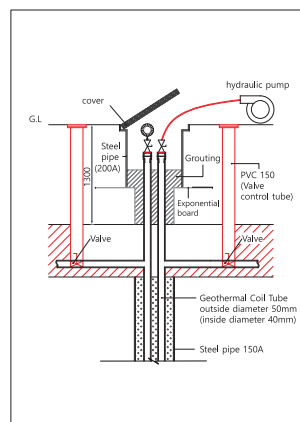
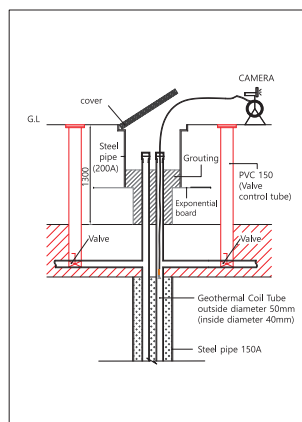
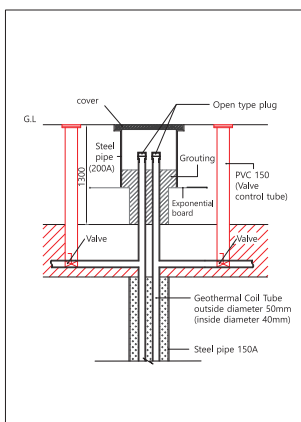


[ Comparison of increase in work expenses per unit length for improving 1% of capability ]

## Technology possible for maintenance and inspection of the geothermal coil pipe

### Installation and operation of manhole and trench pipe manhole

- > Confirmation of leakage on the heat exchanger by installing the heat exchange coil pipe manhole
- > Effect of disconnecting the soil ground water contamination accident of leaking the looping anti-freeze liquid in advance
- > Through the manhole and trench pipe manhole, submersible filming survey after the water pressure test for exposure and water flushing, it is possible to maintain repairing of leakage area
- > Open and inspect the simulation trench pipe manhole in the front and back for reverse return and supply pipe



## Comparison of characteristics for low and deep ground heat exchanger

| Classification                              | Deep-coil  | Existing technology   |
|---|--|---|
| Installation depth                          | 300m or more   | 150m ~ 200m   |
| Coil pipe diameter                          | 50A  | 40A   |
| Principle of technology                     | Install the weight band calculating the weight per unit length on the exterior of the coil type HDPE pipe in certain interval and it makes it easy to have the geothermal coil pipe up to the deep depth.  | By using the coil pipe inserter, the PE pipe interior is filled with water to reduce the buoyancy to install  |
| Heat capacity per unit geothermal boreholes | 4.5 ~ 5.5RT  | 2.0 ~ 3.0RT   |
| Existing building structure application     | Possible   | Impossible  |
| Repairing when a brine leakage occurs       | Possible   | Impossible  |
| Power cost for looping pump                 | Not much (reduce the losses comparing to the existing technology by expanding the diameter of the geothermal coil pipe)  | It is slightly higher comparing to Deep-coil 300  |
| Strengths                                   | <ul style="list-style-type: none"> <li>&gt; It deepens the excavation depth to expand the heat capacity per unit construction site</li> <li>&gt; Reduction in a number of excavation hole for 50% or more per unit area</li> <li>&gt; Savings of initial investment costs for 20% comparing to the existing technology</li> <li>&gt; Saving construction site for 50%</li> <li>&gt; Internal maintenance available for the ground heat exchanger</li> <li>&gt; Easy to apply to the downtown buildings and single large building structures</li> </ul> | <ul style="list-style-type: none"> <li>&gt; Shallow excavation depth for easy work</li> <li>&gt; General supply technology</li> </ul>   |
| Weaknesses                                  | <ul style="list-style-type: none"> <li>&gt; Requiring technology in work</li> </ul>  | <ul style="list-style-type: none"> <li>&gt; Massive needs for excavation holes</li> <li>&gt; High concern for possible inept foundation for intensive excavation on the foundation part of building structure</li> <li>&gt; Need for broad facility site area</li> <li>&gt; Limits in securing the natural green space in cities</li> </ul> |

※ The unit geothermal boreholes for heat capacity (RT) is subject to change depending on the measured value of heat conductivity rate (w/m.k) and load safety ratio



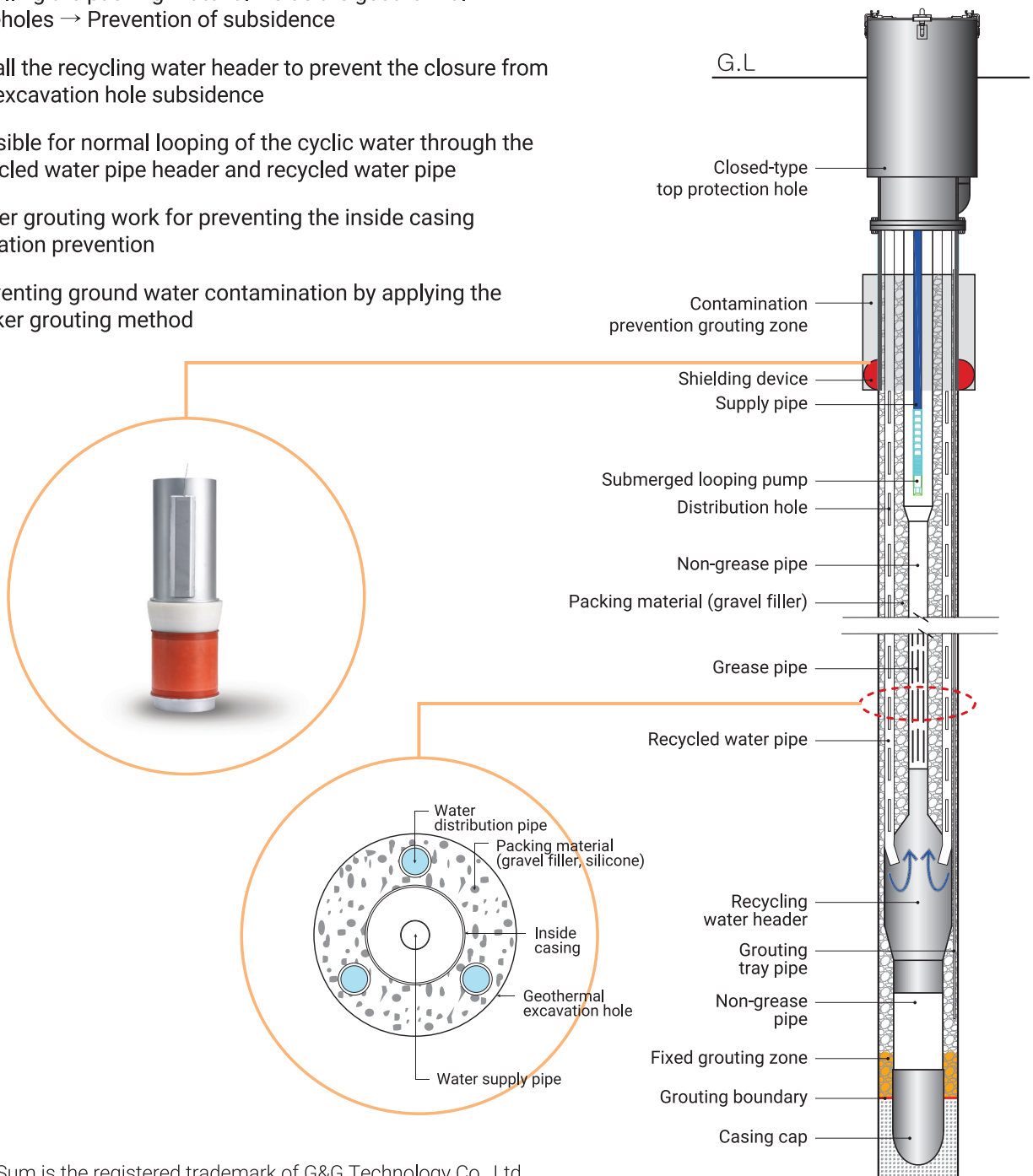
# GeoSSum<sup>®</sup>

## Subsidence prevention SCW geothermal system

New Environment Technology (NET) Certification No. 495 / Patent No. 1554668 /  
Patent No. 10-1605304 Patent No. 10-1403041 / Patent No. 10-1832459 /  
Patent No. 10-1714021

### Characteristics of GeoSSum<sup>®</sup> technology

- Securing the supporting force in the geothermal boreholes by installing the packing material inside the geothermal boreholes → Prevention of subsidence
- Install the recycling water header to prevent the closure from the excavation hole subsidence
- Possible for normal looping of the cyclic water through the recycled water pipe header and recycled water pipe
- Lower grouting work for preventing the inside casing deviation prevention
- Preventing ground water contamination by applying the packer grouting method



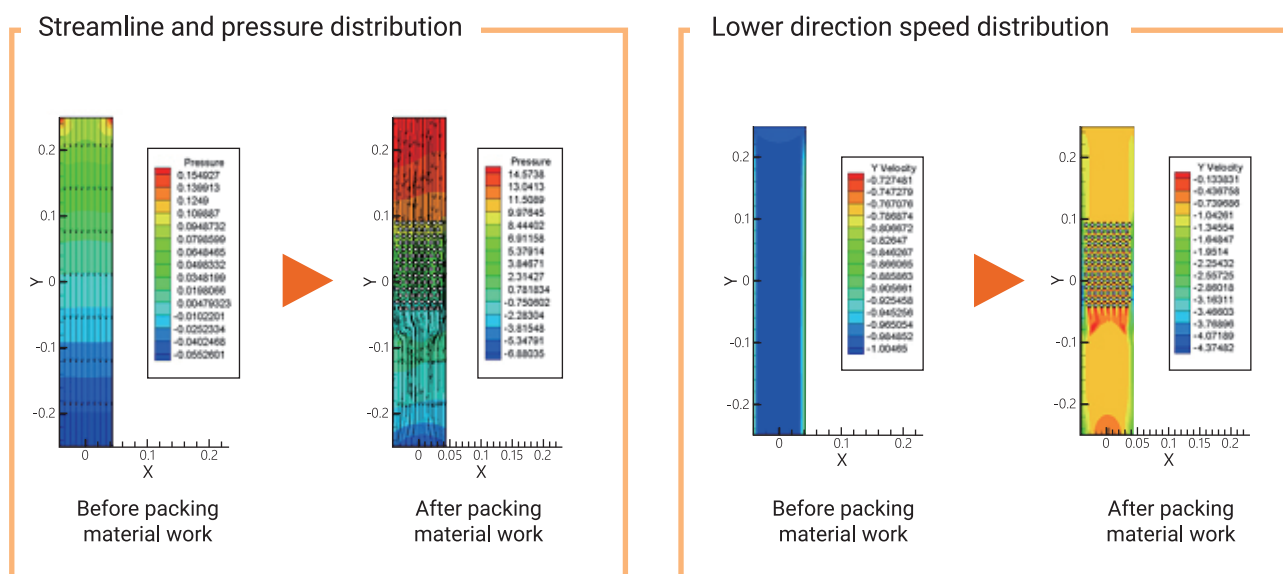
※ GeoSSum is the registered trademark of G&G Technology Co., Ltd.

## Function to prevent the increase of effective heat conductivity rate and ground water subsidence

### Principle of the increase in Effective heat conductivity rate following the use of packing material

- > The recycled water pipe is distributed for 2~4 units to install in the hole wall space of the inside casing and geothermal boreholes
- > The packing material work between the inside casing and excavation hole walls
- > Securing the supporting force by filling with the packing material between the inside casing and water distribution pipe – subsidence prevention
- > Increase of heat conductivity rate by the packing material

| Category                                 | Without packing material | With packing material |
|--|--------------------------|-----------------------|
| Speed vector direction                   | Unilateral direction     | Bending phenomenon    |
| 1m/s water looping differential pressure | 0.2101871Pa              | 21.45415Pa            |
| Fluid speed                              | 1m/s                     | 4m/s                  |



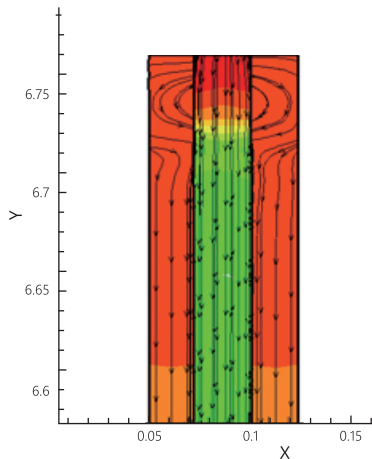
### TRT test before and after injecting the packing material

- > Increase in heat conductivity rate effect from installing the recycled water pipe distribution hole and packing material
- > Fill with packing material (grave;) for the particle size of 3-5mm
- > Prevention of dent in geothermal boreholes and increase in thermal delivery effect
- > Comparing to the existing technology, approximately 11% of heat conductivity is increased

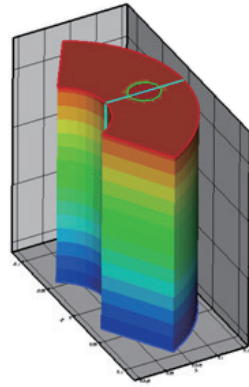
| Category                  | Before packing material work | After packing material work |
|---------------------------|------------------------------|-----------------------------|
| heat conductivity (W/m.k) | 3.29                         | 3.7                         |



## Looping ground water fluid condition following the use of packing material and recycled water pipe



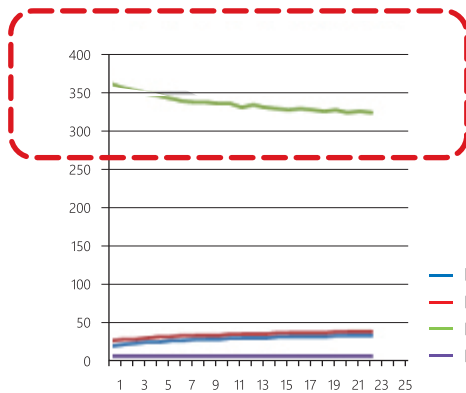
[ 2-D distribution drawing of upper fluid ]



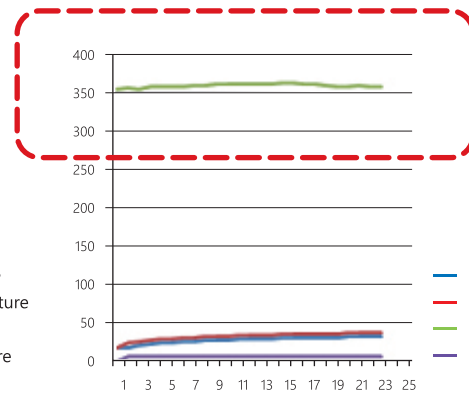
[ Distribution drawing for upper pressure ]

The flux flowing in the packing material territory is at the 15% level comparing to the flux in the water distribution pipe, and when there is a partial closure phenomenon in the packing material territory, this flux is decreased with the flex in the water distribution pipe is increased, but the increase of the pressure is not significant.

## Temperature and flux test → Comparison to existing technology, the stability of the looping flux is high



[ Before packing material work ]



[ After packing material work ]

## Test report

- Before packing material work



- After packing material work



# Preventing the geothermal boreholes subsidence interference by applying the distributed recycled water pipe

## Prevention of looping interference from the original source

- > Prevention of looping interference at the time of subsidence with the installation of the 2-4 WAY water distribution pipe around the internal casing
- > Installation of water distribution pipe header to entice the looping ground water inside the internal casing at the lowest part of the internal casing
- > When closure around the grease pipe due to the subsidence, it prevents the looping ground water drastically decreasing phenomenon.

## Characteristics of the recycled water pipe header

- > The distributed pipe on the lower part of the inside casing is fixed to prevent the bending or push off phenomenon in the process of installing the inside casing.
- > The soil and sand slime clogging phenomenon that has the looping ground water sedimented at the tip of the distributed pipe can be prevented.
- > The fixed header forms the great part to entice the looping ground water to flow inside the inside casing without any interference.

## Technology processing



[ Geothermal borehole excavation ]



[ Installation of earthen block casing ]



[ Contamination prevention (packer grouting) ]



[ Contamination prevention grouting ]



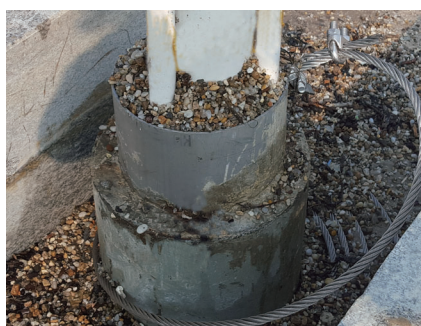
[ Recycled water pipe header installation ]



[ Lower fixing grouting ]



[ Internal material installation ]



[ Filling work ]

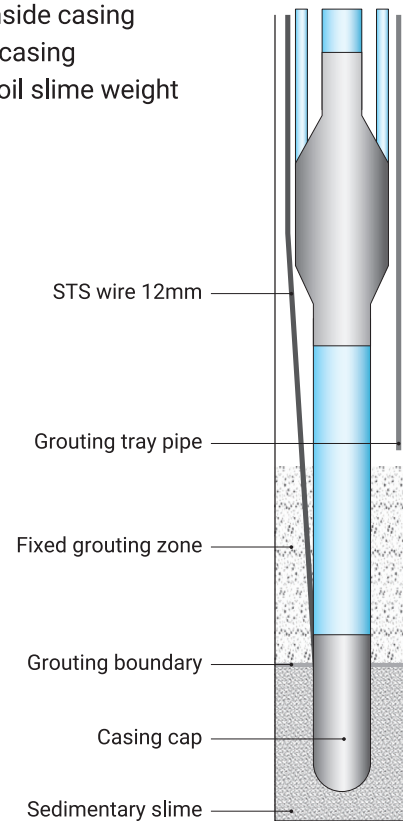
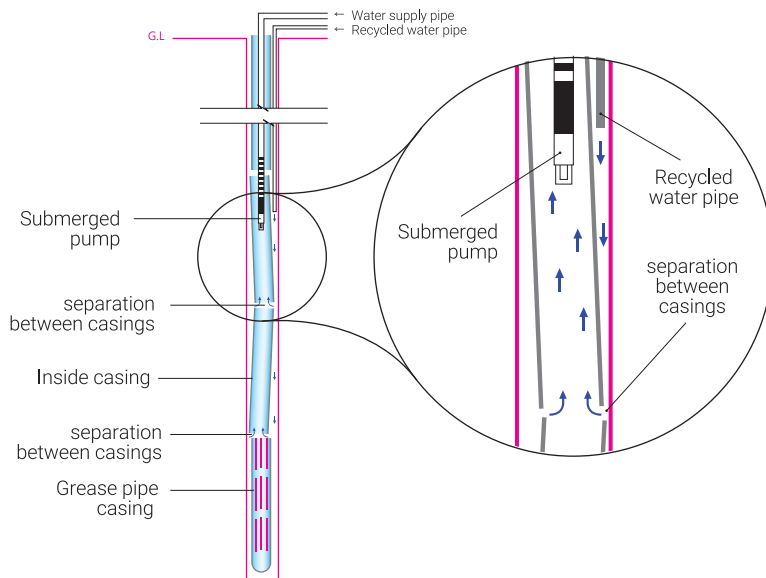


[ Close-type top protection hole installation ]

## Applying the deviation phenomenon prevention system at the joint part of internal casing

- > Prevention of disjoint from the PVC pre-expansion index
- > The stain wire rope is connected on the upper and lower part of the inside casing
- > The lower fixed grouting work for preventing the deviation of internal casing
- > Prevention of inside casing deviation phenomenon by the sand and soil slime weight

### Inside casing joint deviation phenomenon



[Photo of lower fixed grouting work]

## Technology to prevent the subsidence by installing the packing material and recycled water pipe header

### Limitations of existing technology

- > The ground water looping interference occurs in geothermal boreholes subsidence and slime sedimentation
- > The ground water looping interference occurs at the time of slime sedimentation on the lower part of casing even the supporting force is secured by the packing material.

### Solution

- > Structure the recycled water pipe with the distribution hole in between the geothermal excavation hole and internal casing (PVC) installed onto the floor
- > Structure the recycled water pipe header on the lower part of PVC
- > Install the packing material (gravel) on the excavation hole and PVC exterior to secure the supporting force

### Effect

- > Possible to prevent the ground water subsidence by installing the packing material
- > Increase of effective heat conductivity rate with the turbulence formation from the packing material
- > Securing the stability of the ground water looping even in the case where the gap in the inside casing and hole walls is closed due to the hole subsidence by the installation of the recycled water pipe header.
- > Securing the looping stability of the geothermal boreholes by the installation of the distributed recycled water pipe
- > Securing the economic feasibility with advance prevention of closed hole occurrence following the geothermal boreholes subsidence during excavation



## Comparison of characteristics of open-type (SCW) ground heat exchanger

| Classification            |  | GeoSSum<br>(subsidence prevention-type)  | General open-type  | Filling-type Open-type  |
|---------------------------|--|--|--|---|
| Work-ability              | Work depth                                   | 300~500m   | 300~500m   | 300~500m  |
|                           | Technology level of personnel                | Level of intermediary engineer   | Level of intermediary engineer   | Level of intermediary engineer  |
| Safety                    | Hole subsidence prevention                   | Hole subsidence prevention with the packing material work  | No prevention function of hole subsidence  | No prevention of hole subsidence with the packing material work   |
| Environment-friendliness  | Hole subsidence (when collapsing)            | When the hole is collapsed, the recycled water header work does not cause any ground water looping problem that the geothermal boreholes can be used | When the hole is collapsed, the looping interference is inflicted<br>The geothermal boreholes efficiency is declined due to the clogging of internal pipes | When there is any accumulation or closure of packing material hole with fine articles (clay, etc.), the looping interference is inflicted<br>A separate reverse washing device is required. |
|                           | Prevention of internal material to deviation | Geothermal boreholes for lower grouting  | The internal material joint is used with the adhesive that there is high likelihood of deviation   | Not applicable  |
|                           | Prevention of ground water contamination     | Packer grouting (patent method) work (disconnection of contaminated water from flowing in)   | General grouting work (Highly likely to have the contaminated water to flow in)  | General grouting work (Highly likely to have the contaminated water to flow in)   |
| Efficiency and capability | Capacity<br>(1RT=3,024kcal)                  | Around 25 RT/hole<br>(based on 500m)   | Around 25 RT/hole  | Around 25 RT/hole   |
| Technology certification  | NET, NEP                                     | New Environment Technology (NET) Certification No. 495   | Not applicable   | Not applicable  |
| Type for each zone        |  |  |  |   |

※ The heat capacity per hole is subject to change following the measured value and safety of heat conductivity rate (w/m.k).

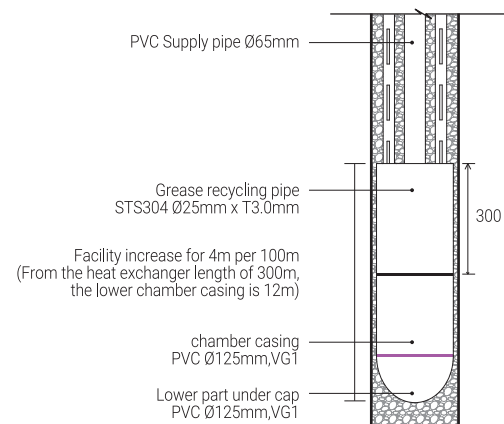
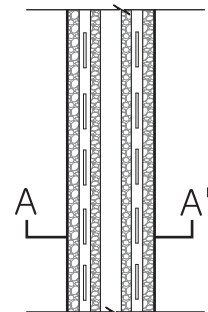
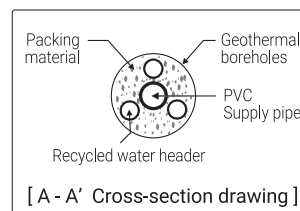
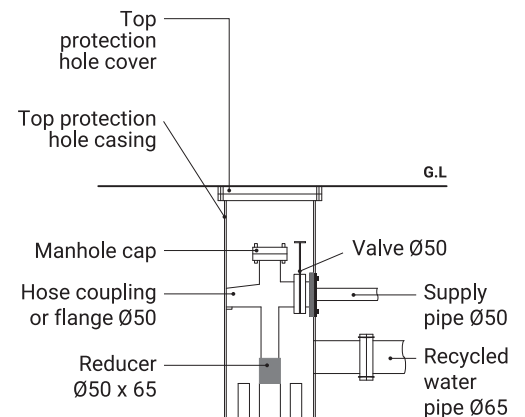
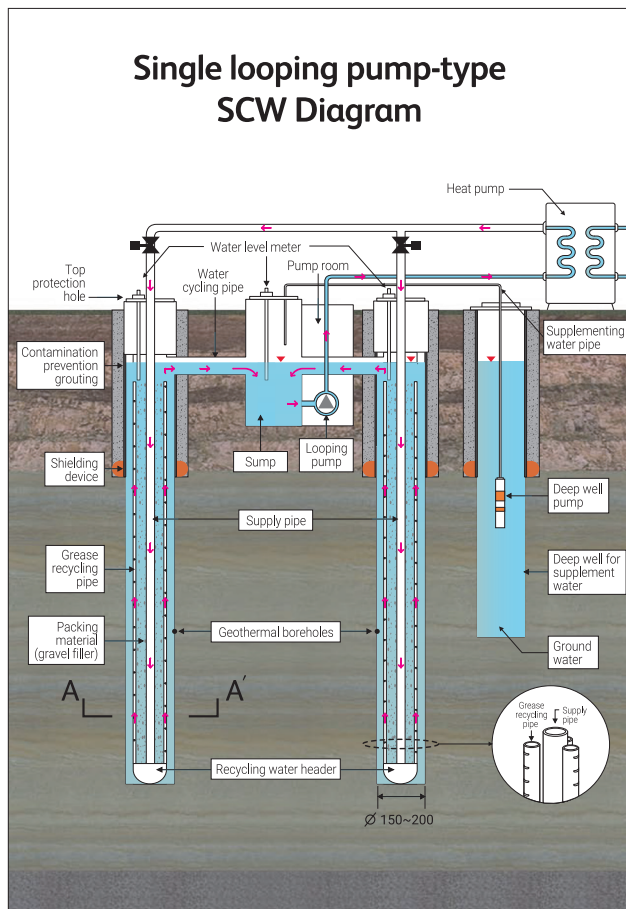
# GeoSSum<sup>®</sup> Hybrid

## SCW geothermal system without the submersible motor pump

New Environment Technology (NET) Certification No. 495 / Patent No. 10-1554668 /  
Patent No. 10-1605304 / Patent No. 10-1403041 / Patent No. 10-1832459 /  
Patent No. 10-1714021

### Characteristics of GeoSSum<sup>®</sup> Hybrid technology

- There is no submerged motor pump in the geothermal boreholes that it can be installed and operated without any interference for the underground building structure.
- Comparing to the same heat capacity, it saves up to 50% of the geothermal boreholes work (when applying smart palm)
- Prevention of inflow of pollutant with the semi-closed type system
- With the installation of the recycled water pipe, it prevents the leakage of ground water and conserving the ground water quality
- Maintenance and management with the single looping pump structure



### SCW geothermal system without the submersible motor pump

- > The geothermal boreholes is not installed with the submersible motor pump.
- > The Supply pipe and grease recycled water pipe are inserted and installed inside the geothermal boreholes
- > For the subsidence (hole collapse) prevention, the packing material (gravel filler) is filled.

### It can be installed and operated without interference on the underground building structure

- > Installation in the underground of building structure for there is no need to install the submersible motor pump

### Geothermal system available for operation

- > The large-capacity geothermal facility can be installed in the narrow site as well

### Comparing to the same heat capacity, the geothermal boreholes work expenses can be saved up to 50%

- > For saving the excavation price, the facility is built around 200m
- > The heat capacity per unit geothermal boreholes and consistent to the SCW is secured
- > Comparing to the vertical closed-loop , it has the effect of reducing around 1/3 of excavation hole quantity (decrease of work area)
- > Comparing to other methods, it has the effect of saving up to 50% of the geothermal boreholes excavation expense (when applying smart palm)

[ Based on 500 RT ]

| Classification                       | GeoSSum Hybrid  | SCW  | vertical closed-loop |
|--------------------------------------|---|--|----------------------|
| Excavation depth                     | Ø200X200  | Ø200X500<br>(contamination prevention zone Ø300)   | Ø150X200             |
| Gross length of geothermal boreholes | 10,000  | 10,000   | 34,000               |
| Quantity of excavation hole          | 50  | 20   | 170                  |
| Number of looping pump units         | 1 set<br>(possible to select 1 set of heat exchanger) | 1 set of heat exchanger,<br>20 units of submersible motor pump inside the geothermal boreholes | 1 set                |
| Power costs of operation             | Small   | Large  | Small                |
| facility expenses                    | Small (saving up to 50%)                              | Large  | Large                |

### Prevention of inflow of pollutant with the semi-closed system

- > The upper part of the geothermal boreholes is comprised with the closed type top protection hole and closed looping pipe to cut off the inflow of contamination source in advance.

### With the reclamation and installation of the recycled water pipe, it prevents the ground water leakage and conserves the ground water quality.

- > The ground water supplied through the Supply pipe is ascended from the interior part of the geothermal boreholes through the recycled water pipe to have the heat exchange.
- > Through the recycled water pipe connected to the Top protection hole, it enters into the sump to fundamentally prevent the external ground water leakage

### Maintenance and management with the single looping pump structure

- > With the installation and operation of the single looping pump that is connected to the sump tank, maintenance and conservation is convenient.
- > Through the looping pump operation and inverter operation of a set, the operation power expense is saved.

[ Heat Capacity (R/T) Table for each depth ]

| Ground heat exchanger model | Excavation diameter(mm) | Excavation depth(m) | Heat capacity per hole(R/T) |
|-----------------------------|-------------------------|---------------------|-----------------------------|
| GH - 150                    | 200                     | 150                 | 7.5                         |
| GH - 200                    | 200                     | 200                 | 10.0                        |
| GH - 300                    | 200                     | 300                 | 15.0                        |
| GH - 500                    | 200                     | 500                 | 25.0                        |

※ The heat capacity is subject to change following the measured value of heat conductivity rate (w/m.k).

# SCW geothermal boreholes

## Post maintenance service

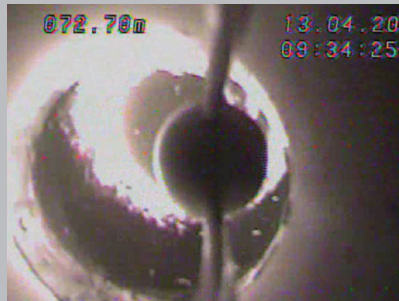
When there is any break down and interference in the SCW geothermal boreholes, the problem will promptly be solved by placing specialized engineering staff and equipment.

## Type of flaws in SCW geothermal boreholes

- Welding flaw of inside casing and joint part deviation by contraction and expansion of materials
- Looping route closure by sedimented materials
- Ground water contamination caused by defect in contamination prevention and Top protection hole



[ Welding defect ]



[ PVC joint deviation ]



[ Contraction and expansion of materials ]



[Contamination of ground water quality]



[ Looping route closure by sedimented materials ]

## Solution and effect

- Inside casing deviation part drawing or joint repairing to restore flawless ground water looping
- With the injection pressurizing cleaning method, cleaning of 500m depth sedimented soil slurry
- Installation of geothermal exclusive close-type top protection hole
- Install the shield device between the geothermal boreholes and casing to cut off the inflow of contamination ground water (applying New Environment Technology No. 275)



# Auto control & Monitoring system

## Structuring long distance and local communication network

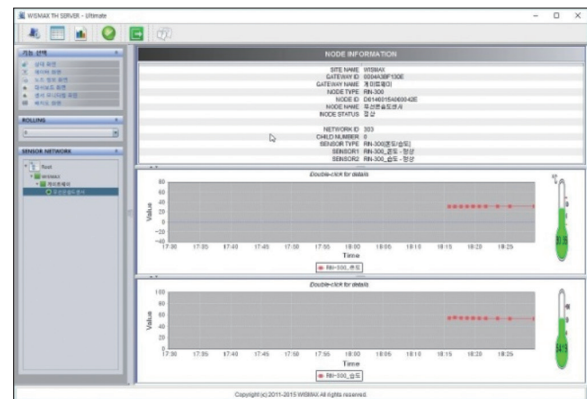
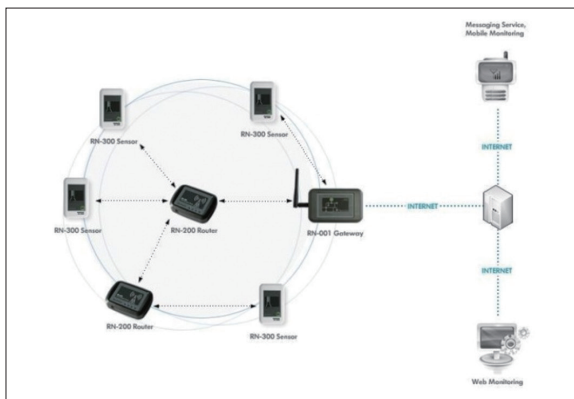
Patent No. 10-1425631, Patent No. 10-2014-0135601, Patent No. 10-2014-0084389

## Composition of geothermal auto control

### Composition of remote distance communication network

- > Geothermal boreholes condition can be monitored in real time
- > Mobile monitoring is available by structuring the LTE communication network
- > With real time monitoring, the condition of geothermal boreholes and system operation can be confirmed

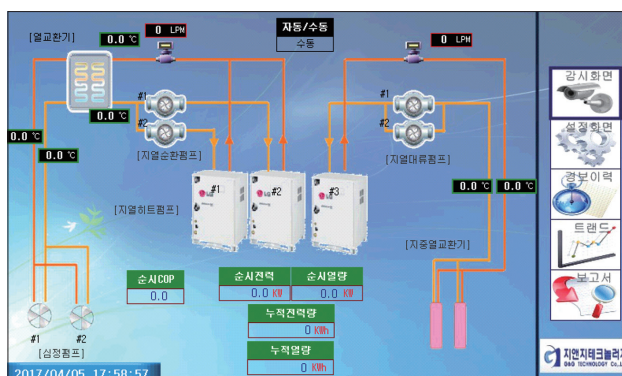
### Flow chart for long distance communication network control



### Local communication network structure

- > Geothermal boreholes condition can be monitored in real time
- > Operating status of heat pump, looping pump and deep well pump can be confirmed
- > For abnormal operation, the alarm function is available to maintain the system

### Flow chart for local communication network control



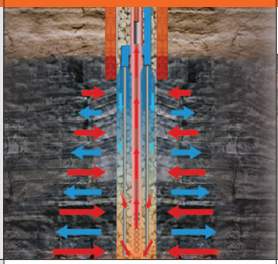
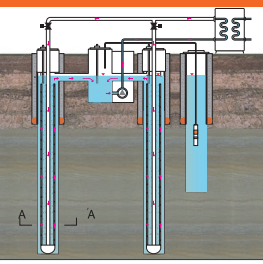
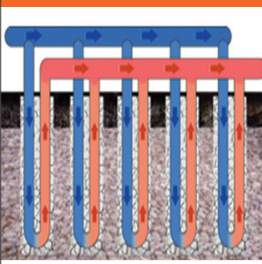
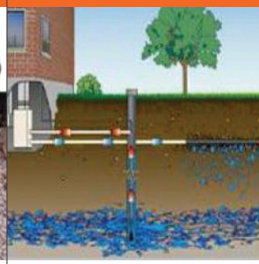
# Comparison of new and recycled energy

**Solar heat and sunlight time standard: Domestically, 3.5~4 hours of use per day**

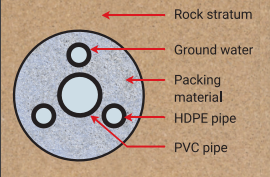
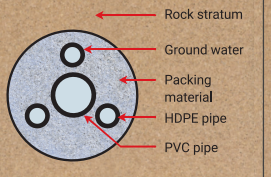
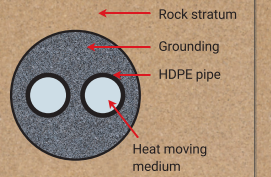
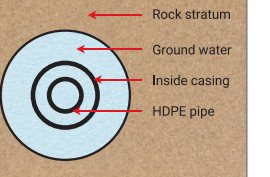
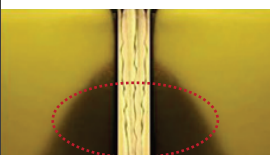
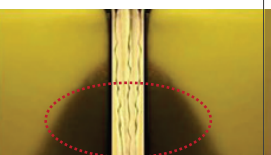
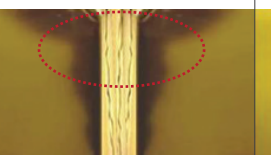
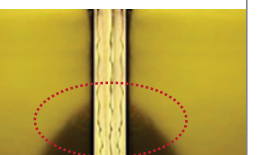
1 RT (tone of refrigeration): Refrigeration capacity required to make 1 tone of pure water at 0°C to an ice of 0°C in 24 hours of time →  $1RT = 3.024\text{kcal/hr} \approx 3.52\text{kW}$

| Recycled energy part       |  |  |  |     |
|----------------------------|---|---|--|--|
| Energy source              | Geothermal  | Sunlight  | Solar energy   | Wind power   |
| Relative expense           | 100   | 400   | 400  | 600  |
| Operation efficiency       | All year  | Less than 40%   | Less than 20%  | Less than 20%  |
| System use                 | Cooling & heating, hot water supply   | Power generation  | hot water  | Power generation   |
| Environmental restrictions | None  | Winter season, effect of cloudy day   | Winter season, effect of cloudy day  | Maintain wind speed of 40m/s or more   |
| Recommended area           | Nationally available  | Area with significant daytime sunlight  | Area with significant daytime sunlight   | Area with significant wind   |
| Domestic conditions        | Actively processing the distribution business                                     | Use of significant number of solar battery with low energy density                | Use of significant number of solar battery with low energy density                 | The charging technology is required for saving the energy when the wind is not blowing |
| Maintenance                | Simple maintenance  | Need for periodic cleaning and replacement of concentrator                        | Need for periodic cleaning and replacement of concentrator                         | Need to make periodic maintenance  |
| Service period             | Over 50 years   | Around 20 years   | Around 20 years  | Around 20 years  |

# Comparison of geothermal energy system method

| Classification                        | Geossum  | Geossum Hybrid  | Vertical closed-loop type  | Open type(SCW)  |
|---------------------------------------|--|---|--|---|
| Geothermal exchanger diagram          |   |                                      |  |  |
| Original technology                   | Europe + Independently developed   | Independently developed   | USA  | USA   |
| Components                            | Ground heat exchanger, packer grouting, water distribution pipe, inside casing, submerged pump   | Ground heat exchanger, packer grouting, water distribution pipe, inside casing, submerged pump, Sump tank, looping pump | Ground heat exchanger, PE pipe, Grout material, anti-freeze liquid                   | Ground heat exchanger, inside casing, submerged pump                                  |
| Application                           | Apartment, school, hotel, commercial building and others   | Apartment, school, hotel, commercial building and others  | Residence, school  | School, commercial building   |
| Certification                         | New Environment Technology Certification No. 495 Certificate of Basel, Switzerland Certificate (annual efficiency 4.0, environment-friendliness) | New Environment Technology Certification No. 495  | None   | None  |
| Boring depth                          | 400~500M or more, interval distance of 10M or more   | 150~500M or more, interval distance of 10M or more  | 150M~200M, interval distance of 5M   | 400M~500M, interval distance of 10M   |
| Heat capacity per geothermal borehole | 20RT~25RT or more  | 7.5RT~25RT  | 7.5RT~25RT   | 20RT~25RT or more   |

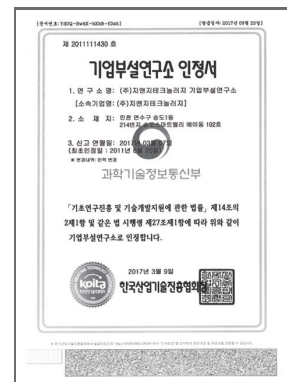
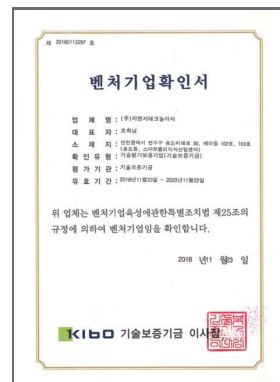
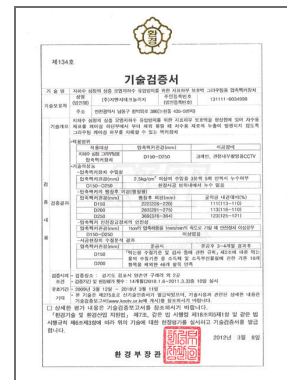
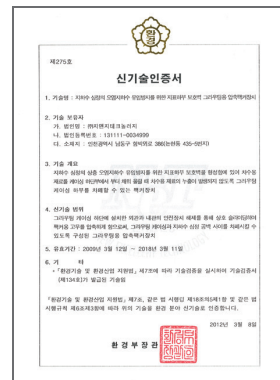
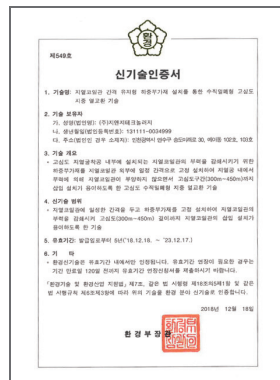
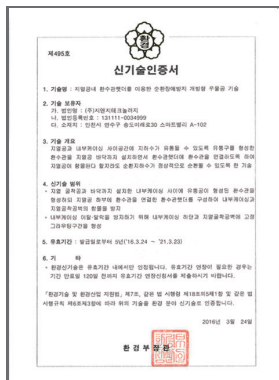
※ The heat capacity (RT) per geothermal boreholes is subject to change depending on the measured value of heat conductivity rate (w/m.k) and load safety rate.

| Classification                       |                      | Geossum  | Geossum Hybrid   | Vertical closed-loop type  | Open type(SCW)  |
|--------------------------------------|----------------------|--|--|--|---|
| No. of boring (based on 100RT)       |                      | 4 holes  | 4~10 holes   | 29~40 holes  | 4~5 holes   |
| Boring area                          |                      | 150 ~200m <sup>2</sup>   | 150 ~200m <sup>2</sup>   | 675m <sup>2</sup>  | 110m <sup>2</sup>   |
| Temperature for geothermal boreholes |                      | Cooling 35°C<br>Heating 7°C  | Cooling 35°C<br>Heating 7°C  | Cooling 35°C<br>Heating 5°C  | Cooling 37°C<br>Heating 7°C   |
| Indoor hole temperature              |                      | Cooling 7°C<br>Heating 50°C  | Cooling 7°C<br>Heating 50°C  | Cooling 7°C<br>Heating 50°C  | Cooling 7°C<br>Heating 50°C   |
| System efficiency (COP)              |                      | Cooling 4.5<br>Heating 4.0   | Cooling 4.5<br>Heating 4.0   | Cooling 3.5<br>Heating 3.0   | Cooling 4.0<br>Heating 4.5  |
| Considerations                       |                      | <ul style="list-style-type: none"> <li>- Depth of tube well</li> <li>- Types of rock</li> <li>- Work may be done in limestone and clay stratum</li> <li>- Freedom of installation space</li> </ul>   | <ul style="list-style-type: none"> <li>- Depth of tube well</li> <li>- Types of rock</li> <li>- Work may be done in limestone and clay stratum</li> <li>- Freedom of installation space</li> </ul>   | <ul style="list-style-type: none"> <li>- Depth of tube well</li> <li>- Grout material</li> <li>- Types of rock</li> <li>- Addition ratio of anti-freeze liquid</li> <li>- Securing of boring site</li> </ul>   | <ul style="list-style-type: none"> <li>- Depth of tube well</li> <li>- Types of rock</li> <li>- Impossible to work in limestone or clay stratum</li> <li>- Flexibly encounter in the installation space</li> </ul>  |
| Ground heat exchanger structure      |                      |    |    |   |   |
| Simulation result                    |                      |  <p>Absorb the heat source of the ground from the depth side</p>  |  <p>Absorb the heat source of the ground from the depth side</p>  |  <p>Absorb the heat source of the ground from the surface side</p>   |  <p>Absorb the heat source of the ground from the depth side</p>   |
| heat exchange process                |                      | Heat conduction of rock stratum and ground water → Heat conduction of ground water and packing material, or heat delivery efficiency improvement by the vortex → Heat flux inside ground water conveys the heat by convection from the upper and lower parts   | Heat conduction of rock stratum and ground water → Heat conduction of ground water and packing material, or heat delivery efficiency improvement by the vortex → Heat flux inside ground water conveys the heat by convection from the upper and lower parts   | Heat conduction of rock stratum and grout material → Heat conduction of grout material and HDPE pipe → HDPE pipe and heat moving medium (anti-freeze liquid) convey the heat by the Heat conduction  | Heat conduction of rock stratum and ground water → Heat conduction of ground water and inside casing → Heat flux inside of ground water has the upper and lower part to convey the heat by the convection   |
| Looping pump                         | Ground looping pump  | 1  | 1  | 1  | 1   |
|                                      | Submerged motor pump | 4  | -  | -  | 4 ~ 5   |
| Characteristics                      |                      | <ul style="list-style-type: none"> <li>- Apply packer grouting to prevent the ground water contamination</li> <li>- High heat conveyance efficiency by direct use of ground water</li> <li>- Expanding the heat conveyance area by using the packing material</li> <li>- May be applicable for limestone and sedimented layer</li> <li>- Inconvenience of maintenance for installation of the submerged looping pump on each geothermal boreholes</li> </ul> | <ul style="list-style-type: none"> <li>- No submersible motor pump in the geothermal boreholes</li> <li>- Geothermal boreholes with the same composition with the subsidence prevention-type SCW GeoSsum</li> <li>- Sump tank composition and installation of single structure looping pump</li> <li>- Convenient maintenance with the ground looping pump maintenance</li> <li>- Effect of saving operation power expenses</li> </ul> | <ul style="list-style-type: none"> <li>- Difficulty in securing the boring site</li> <li>- It depends only on the Heat conduction to have low heat conveyance efficiency</li> <li>- Requiring significant amount of anti-freeze liquid, and if anti-freeze fluid is leaked, it causes contamination of ground water environment</li> <li>- Maintenance and management of 1 set of ground looping pump is convenient</li> <li>- Effect of saving operation power costs</li> </ul> | <ul style="list-style-type: none"> <li>- High heat conveyance efficiency by the direct use of ground water</li> <li>- Heat conveyance in the soil by the convection of ground water</li> <li>- Application not possible in the limestone and sedimented layer area</li> </ul> |

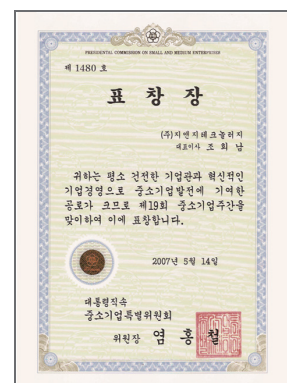
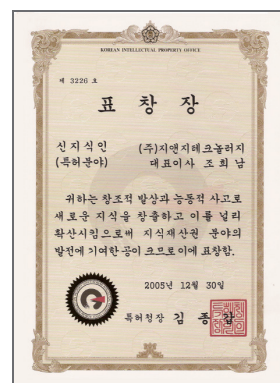
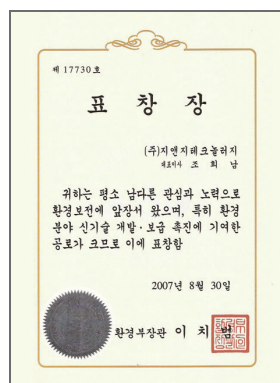
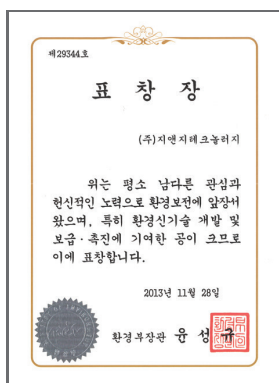


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