European Union Energy Day

Clean energy solutions for the buildings of the future

Astana EXPO, 24 July 2017

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Geothermal resources for HVAC loads in ELI-NP Facility
Analysis of energy behavior and consumption

12:00-12:15

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Facility Manager

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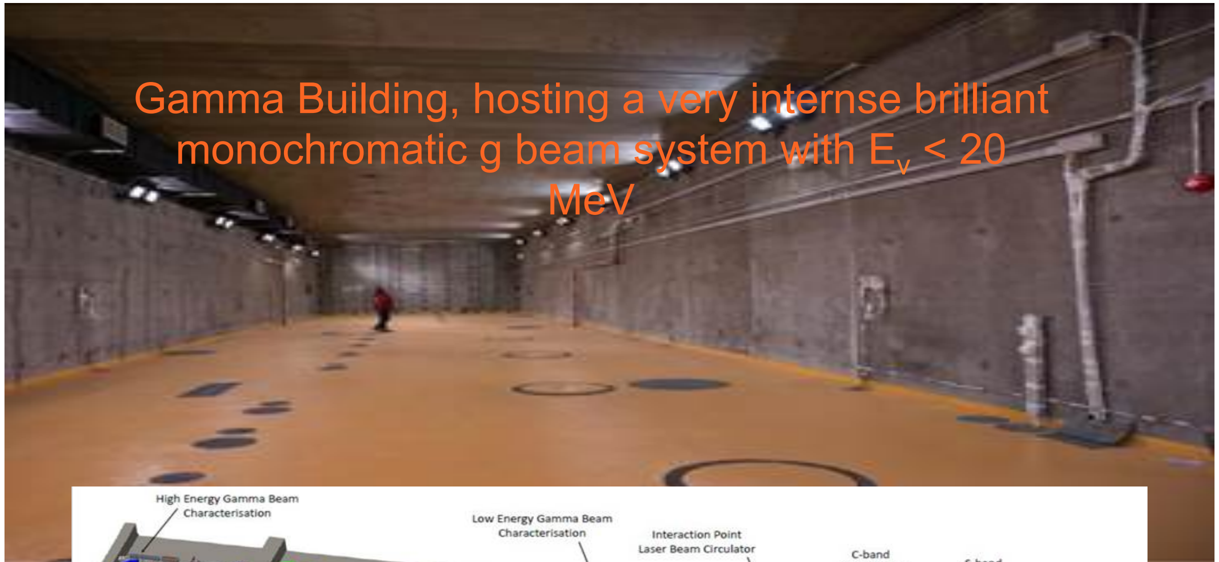
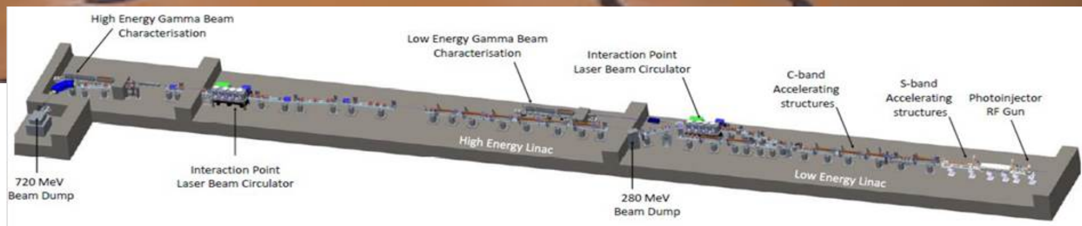


Gamma Building, hosting a very internse brilliant monochromatic g beam system with $E_v < 20$ MeV




Laser and Laboratory Building, hosting
➢ a High Power Laser System (10 PW, 1 PW, 100 TW)
➢ Workshops and Laboratories
THALES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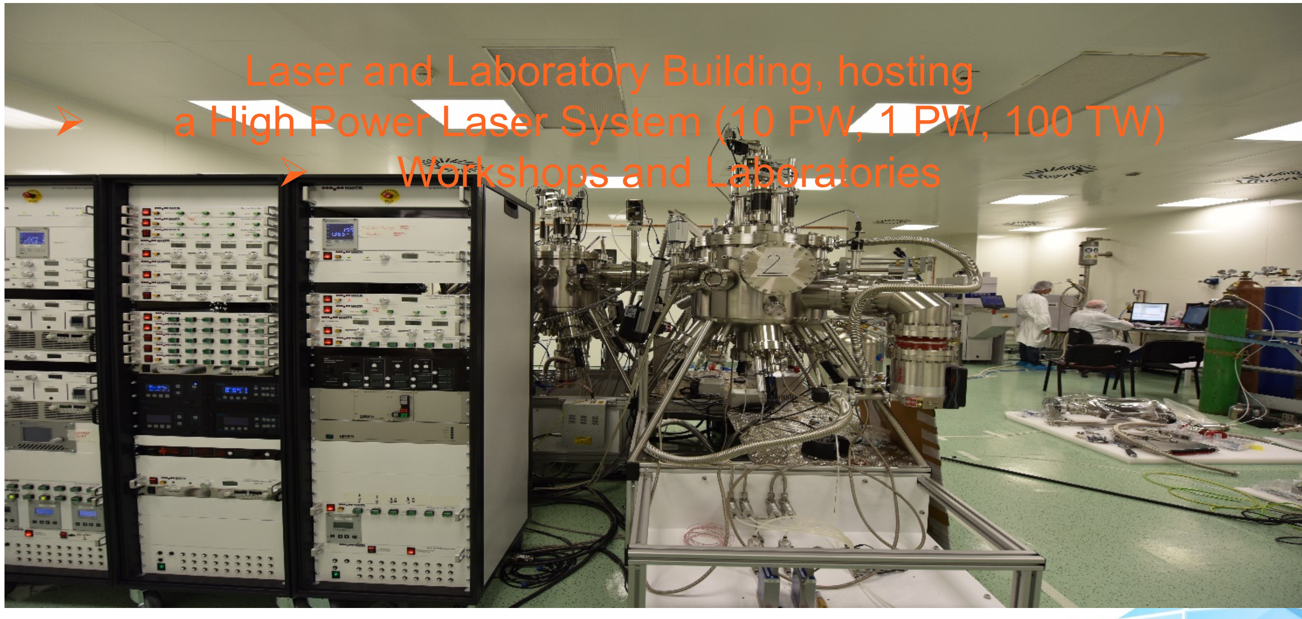
Laser and Laboratory Building, hosting

- a High Power Laser System (10 PW, 1 PW, 100 TW)
- Workshops and Laboratories

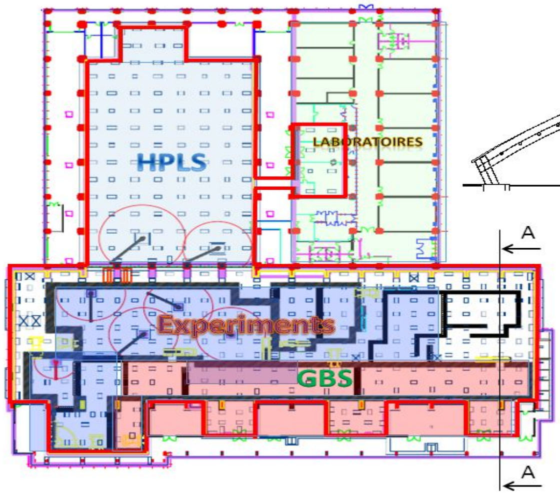


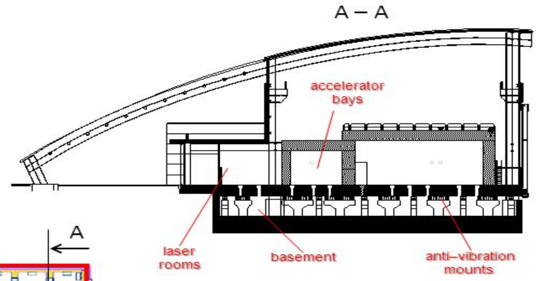
Brief overview over ELI-NP Project

Over 32.000 sqm of built-up area and 270.000 cubic metre of air to condition

BUILDINGS	Ground floor area sqm	Built-up area sqm
RESEARCH DUTY BUILDINGS		
GAMMA BUILDING (basement and ground floor)	7,130.25	12,738.70
LASER BUILDING (basement, ground floor, first floor)	4,448.10	8,659.00
LABORATORY BUILDING (ground floor)	2,593.60	2,884.40
TOTAL	14,643.73	24,753.88
DOMESTIC BUILDINGS		
OFFICE BUILDINGS (basement, ground floor + five floors)	738.94	4,528.33
GUEST HOUSE (basement, ground floor + two floors)	735.51	2,290.78
CANTEEN (ground floor)	277.62 123.70	277.62 123.70
TOTAL	1,875.77	7,220.43

LAYOUT





Platform supported on dampers

Anti–vibration platform

±1 μm @ < 10 Hz

6

Parameters, Utilities and Special Requirements

➢ Laser and Laboratories Building

Temperature in the HPLS room:	**22±0.5°C**
Relative humidity of the HPLS room:	**35-50 %**
Over-pressure ventilation in HPLS room:	**40 Pa**
Clean room requirements of HPLS room:	**class 7 - ISO 14644**
Protection against floor vibration:	≤1 x 10^{-10} g^2/Hz at less **than 200 Hz.**
Temperature in Laboratories:	**20±0.5°C**
Relative humidity of Laboratories:	**30±10 %**
Over-pressure ventilation in Laboratories:	**40 Pa**
Clean room requirements of Laboratories:	**class 6 - ISO 14644)**

➢ Gamma Building

Temperature in the Accelerator Bay:	**22 ± 0,5°C**
Relative humidity of the Accelarator Bay: condensation free	**35-50 %**
Depression in the Accelarator Bay:	**14 Pa**
Protection against floor vibration:	**±1 mm at less than 10 Hz.**

➢ Electrical Power

- 5 electrical transformer substations
- 2 separated distribution lines
- busbar power distribution system

Absorbed Power: 5.625 kW
(at a simultaneity factor of 0.7)
Installed power: 10.016 kW (100% load)
8.013 kW (80% load)

➢ Thermal Capacity

Heating power requirements:
Over 3.2 MW (HVAC)
Cooling power requirements: 6.0 MW
Technological Cooling Water : 2.2 MW
Installed thermal capacity:
higher than 6.10 MW

ELI-NP Ground Source Heat Pump System

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Generaly a GSHP system consist of a:

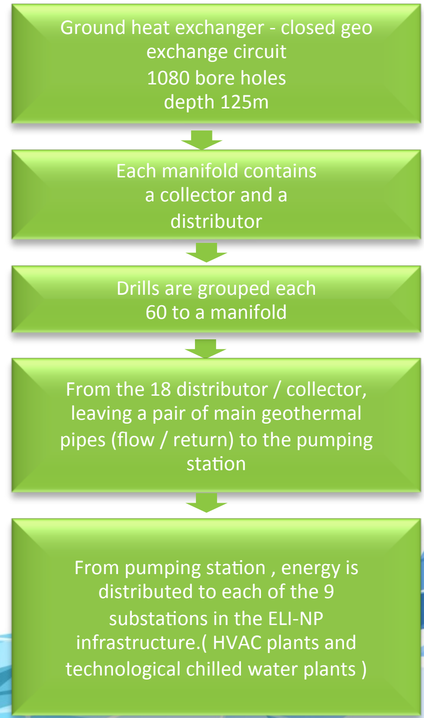
- heat exchange component called a ground heat exchanger (GHX);
- and one or more ground source heat pump (GSHP).

The heat exchange component passively heats or cools water by circulating water through pipes installed in the ground.

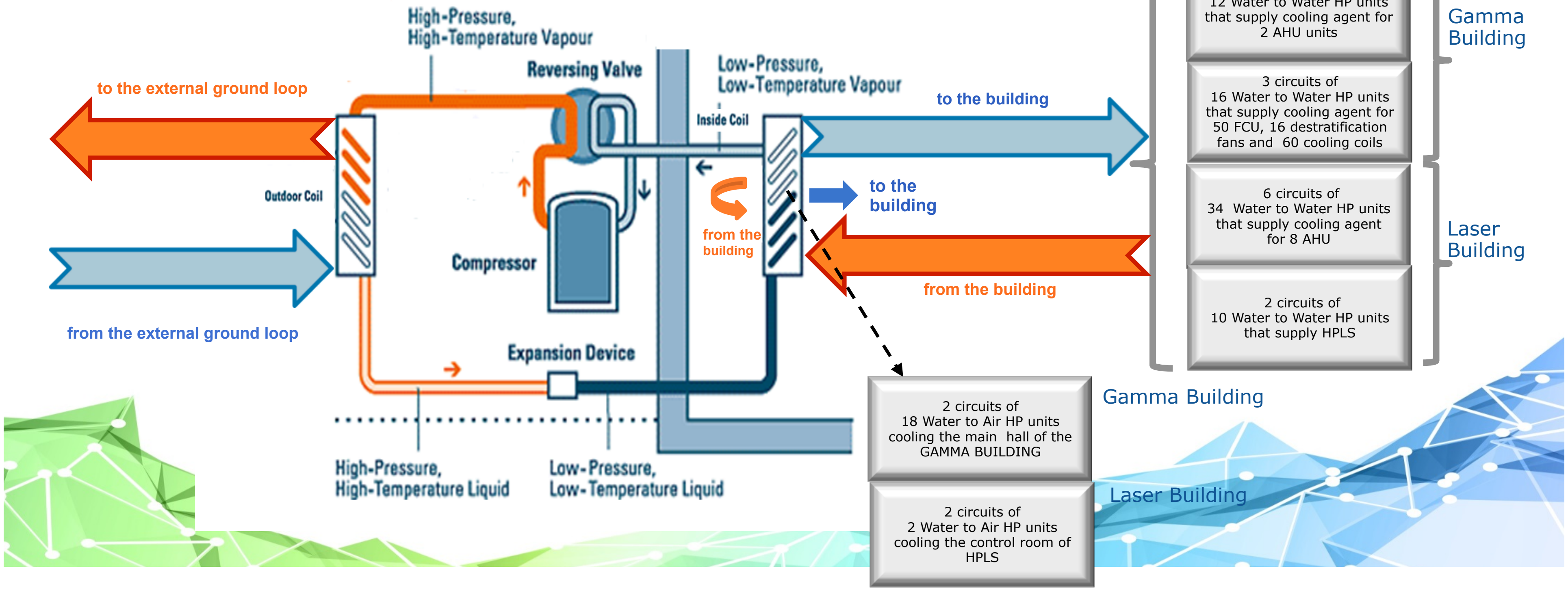
The heat exchange process uses solar radiation stored in the ground and provides stable temperatures that are the approximate equivalent of average annual air temperature for that location (approximatively 12°C for Romania)

For the ELI-NP a closed loop installed in vertical boreholes solution was chosen considering the following benefits:

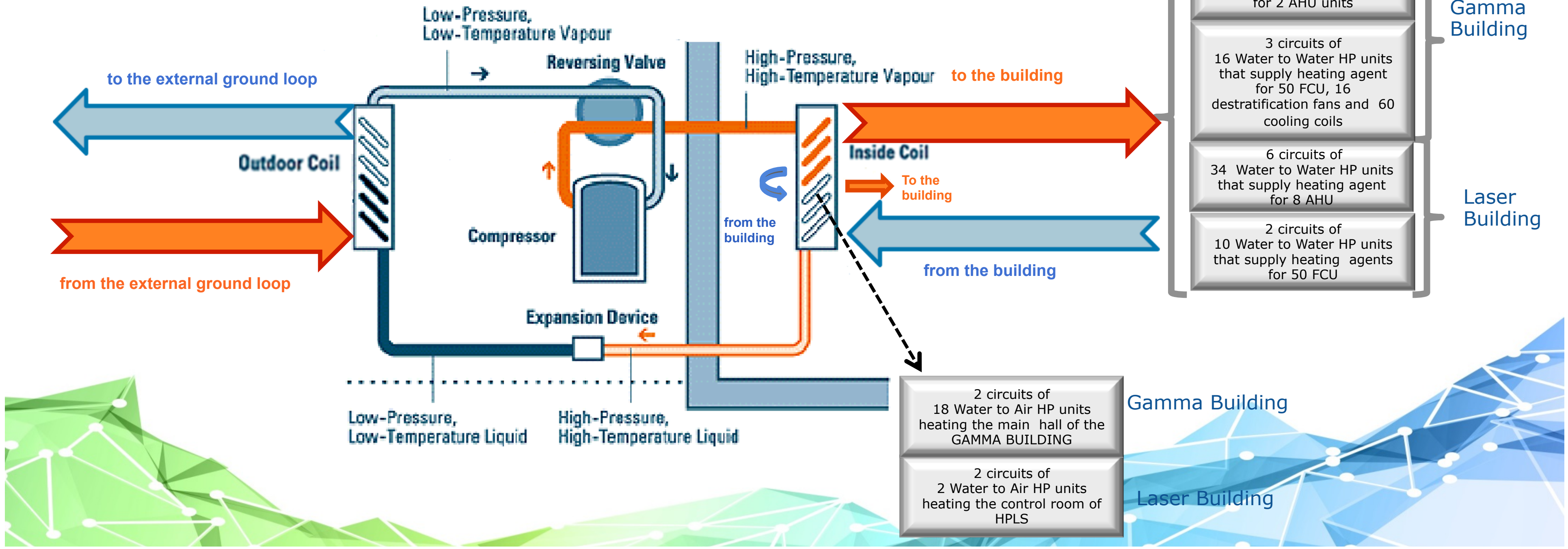
- The system circulates the same water continuously;
- Closed loop systems are environmentally benign. They are sealed so that no fluid is exchanged with the environment;
- The vertical bore configuration is a popular choice for systems of all sizes because of its efficient use of space;
- Leaks are rare, generally occurring because of a contractor latter cutting a buried pipe.



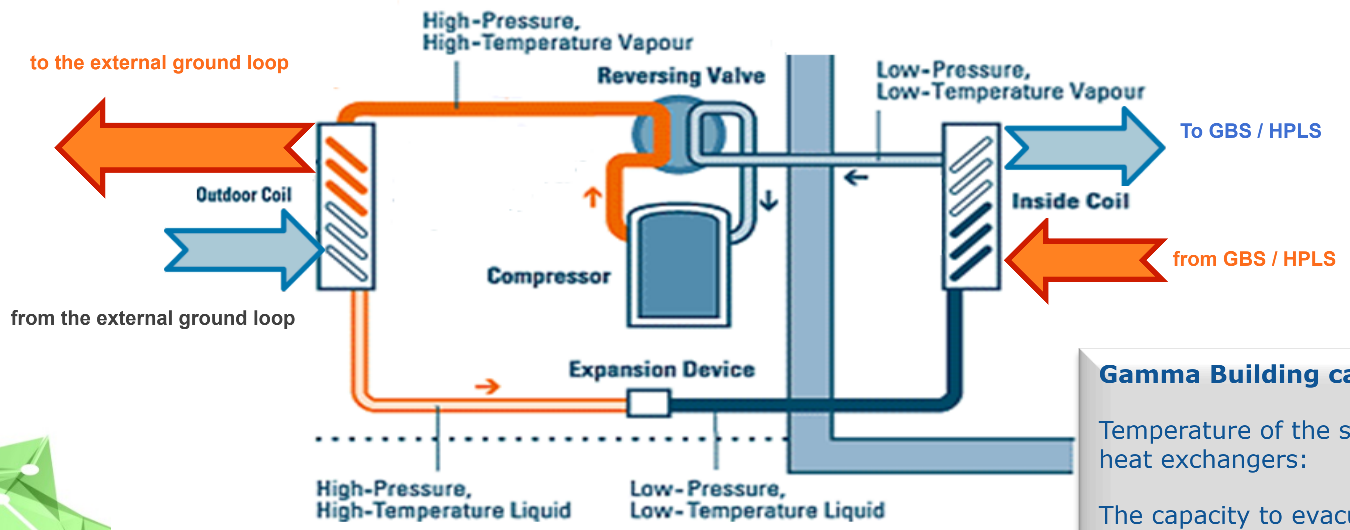
The Heat Exchange Process in the ELI-NP Ground Source Heat Pump System
COOLING CYCLE



The Heat Exchange Process in the ELI-NP Ground Source Heat Pump System
HEATING CYCLE



The Heat Exchange Process in the ELI-NP Ground Source Heat Pump System
COOLING WATER FOR THE GBS AND HPLS



2 circuits of
20 Water to Water HP units
that supply cooling water for
the GBS

2 circuits of
20 Water to Water HP units
that supply cooling watwr
for the HPLS

Gamma Building capacity to evacuate heat

Temperature of the supplied technological water in the heat exchangers: 7ºC on the input, 11ºC on the output

The capacity to evacuate the heat dissipated by the equipment: 2 x 750 kW

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HEAT PUMPS

Air to Water Heat Pumps:	43
Water to water Heat Pumps:	123

AHU

Gamma Building:	2 x 80.000 m3/h
Laser and Laboratories Building:	8 x 54.000 m3/h

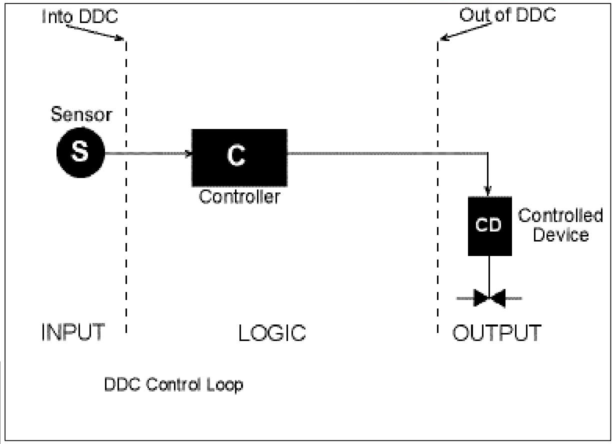
Fan Coil Units:	192
Plate Heat Recovery:	26
Destratification Fans:	16

Direct Digital Control
DDC

The HVAC system control is fully automated

Building Management System
Gathering Data, Monitoring,
Identifying trouble spots regarding:

- Life safety
- Fire protection
- Security
- Energy management
- Lighting schedules
- Equipment monitoring and maintenance



Statictics EUROPE

The number of large BHE installation >10 km total borehole length increased to 171 in 2016, including 24 plants >30 km.
The cumulated BHE length of these 171 plants surpassed 3400 km in 2016

Country	City, Name	No. BHE (pcs)	Depth BHE (m)	Total BHE (m)	Year
RO	Magurele near Bucharest, ELI-NP	1080	125	135000	2015
FI	Sipoo, SOK Logistics Centre	300	300	90,001	
CH	Zurich, ETH-Campus Hönggerberg	435	200	87000	2014/2016
CH	Rotkreuz, Suurstoffi 2	193	280	54040	2015
FI	Espoo, Lippulaiva shopping centre	148	350	51800	under construction
CH	Wallisellen, Richti-Areal	220	225	49500	2012
SE	Karlstad, Campus Karlstad	204	240	48240	2014
NO	Lørenskog, Nye Ahus hospital	228	200	45600	
CH	Zurich, Neues Wohnquartier Freilager	205	220	45100	2013/2014
CH	Zurich, FGZ Friesenberg, BHE-field Grünmatt	179	250	44750	2015

Benefits Associated with the GSHP System

- Reduced annual energy costs by between 30 and 70 per cent;
- Reduced CO_2 emissions;
- Reduced peak electrical loads by 30-40 per cent;
- Regulator / rating friendly – both energy and water points for Green Star, LEED etc;
- Low Operating Cost;
- The distributed nature of the system makes it easy to understand. A heat pump located at each space will provide independent heating and cooling. The operation of one heat pump does not affect any other heat pump;
- Low Maintenance in terms of time and costs by over 50%;

➢The heat pump itself is a packaged unit. Diagnosing issues is easier due to the distributed nature of the system. Any problem is typically closely related to the equipment serving the particular space;

➢In-built redundancy through modular and staged unit installations;

➢No Supplemental Heat Required;

➢Heat pumps can meet all of the space loads, including ventilation loads. Ventilation air can be tempered by separate heat pumps and/or conditioned with heat recovery equipment;

➢No Required Exposed Outdoor Equipment; the ground heat exchanger is buried and the heat pumps are located inside the building;

➢Designers do not have to supply space on the roof for equipment;

➢Low Environmental Impact;

➢No fossil fuels need to be consumed on site. Pollution can be best mitigated at a central power plant where electricity is produced. As the efficiency of electricity production or renewable power generation increase, so does the environmental efficiency of the heat pump system;

➢Longer Life Expectancy;

➢The high density polyethylene piping used in geoexchange systems comes with a fifty year warranty;

➢Both the ASHRAE and the Electric Power Research Institute have concluded, based on independent research studies, that the appropriate service life value for ground source heat pump technology is 20 years or more. This benchmark is the current industry standard. GSHP replacement is anticipated at roughly 20 years and the ground loop more than 50 years;

➢Compatible with Building Management Systems.

The Environmental Benefits of Geoexchange

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- The market for GSHPs in Europe has reached a state where the technology can no longer be labeled as unimportant, unavailable or negligible.
- The European Union (EU) heads of state adopted new energy savings and climate protection goals to reduce GHG emissions from all sources (not just buildings) 20 percent compared to 1990 levels by 2020.
- The subsequent proposed European Commission Directive on the use of renewable energy sources includes GSHPs as a contributor to reach the goals.
- A scenario analysis that foresees 20, 30, and 100 percent of the EU building stock being heated by GSHPs in 2020 has concluded that GSHPs could potentially account for 5, 7.1, and 20 percent of the goal, respectively, assuming the EU-25 (meaning 25 countries) average electricity generation fuel mix.
- The basis for these policy events in Europe appears to be the strong GHP market development in central Europe over recent years.

➢The cooling, refrigeration, and other systems in the vast majority of buildings transfer more heat to the building's outdoor environment on an annual basis than is required to satisfy heat loads within the building;

➢GHP systems compete with these wasteful conventional systems by storing and recycling some of the wasted heat and making up the difference from the ground near the building;

➢Equipment using the ground as a heat (energy) source and heat sink consumes less nonrenewable energy (electricity and fossil fuels) because the earth is cooler than outdoor air in summer and warmer in winter;

➢Heat pumps are always used in GHP systems. They efficiently move heat from ground energy sources or to ground heat sinks as needed. Although heat pumps consume electrical energy, they move 3 – 5 times as much energy between the building and the ground than they consume while doing so;

➢Geoexchange systems can help facilities qualify as Green Buildings, increase the efficient use of energy and environmental resources; it can also be a major contributor toward LEED certification for buildings. Industry estimates are the systems can provide up to 34 potential LEED points towards certification. It only takes 40 to get basic certification.

➢Every million square feet of space conditioned with geoexchange technology results in a combined savings of:

- *more than 7.6 million kWh*

and

- *38,207 MMBtu's of fossil fuel*

➢That savings will obviate the need of:

- *20,490 barrels of crude oil per year*

and result

- *in an annual emissions reduction of about 1,525 metric tons of carbon equivalents;*

➢Most significantly, utilities will see a 2.5 megawatt demand reduction for each of the 20 years that the geoexchange system is in operation.

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Geoexchange HVAC Myths Busted

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Geoexchange HVAC systems are not considered a renewable technology because they use electricity.

FACT

Geoexchange HVAC systems use only one unit of electricity to move up to five units of cooling or heating from the earth to a building.

Photovoltaic and wind power are more favorable renewable technologies when compared to geothermal HVAC systems.

FACT

Geoexchange HVAC systems remove four times more kilowatt-hours of consumption from the electrical grid per dollar spent than photovoltaic and wind power add to the electrical grid. Those other technologies can certainly play an important role, but geothermal HVAC is often the most cost effective way to reduce environmental impact of conditioning spaces.

Geoexchange HVAC heat pumps are noisy.

FACT

The systems run very quiet and there is no equipment outside, to bother the environment.

Geothermal systems eventually “wear out.”

FACT

Earth loops can last for generations. The heat-exchange equipment typically lasts decades, since it is protected indoors. When it does need to be replaced, the expense is much less than putting in an entire new geothermal system, since the loop or well is the most pricey to install.

Geothermal HVAC systems only work in heating mode.

FACT

They work just as effectively in cooling and can be engineered to require no additional backup heat source if desired.

Geothermal HVAC systems cannot cool and heat at the same time.

FACT

Systems can be designed to handle multiple loads simultaneously.

Geothermal HVAC systems put refrigerant lines into the ground.

FACT

Most systems use only water in the loops or lines.

Geothermal HVAC systems use lots of water.

FACT

Geothermal systems actually consume no water. Systems work in a closed loop or if an aquifer is used to exchange heat with the earth, all the water is returned to that same aquifer. When applied commercially, geothermal HVAC systems actually eliminate millions of gallons of water that would otherwise have been evaporated in cooling towers in traditional systems.

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