Center for Renewable Energy Sources and Saving

Greek Ground Source Heat Pump (GSHP) Market (Status – Outlook and Training Needs)

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Geothermal Energy Resources Classification:

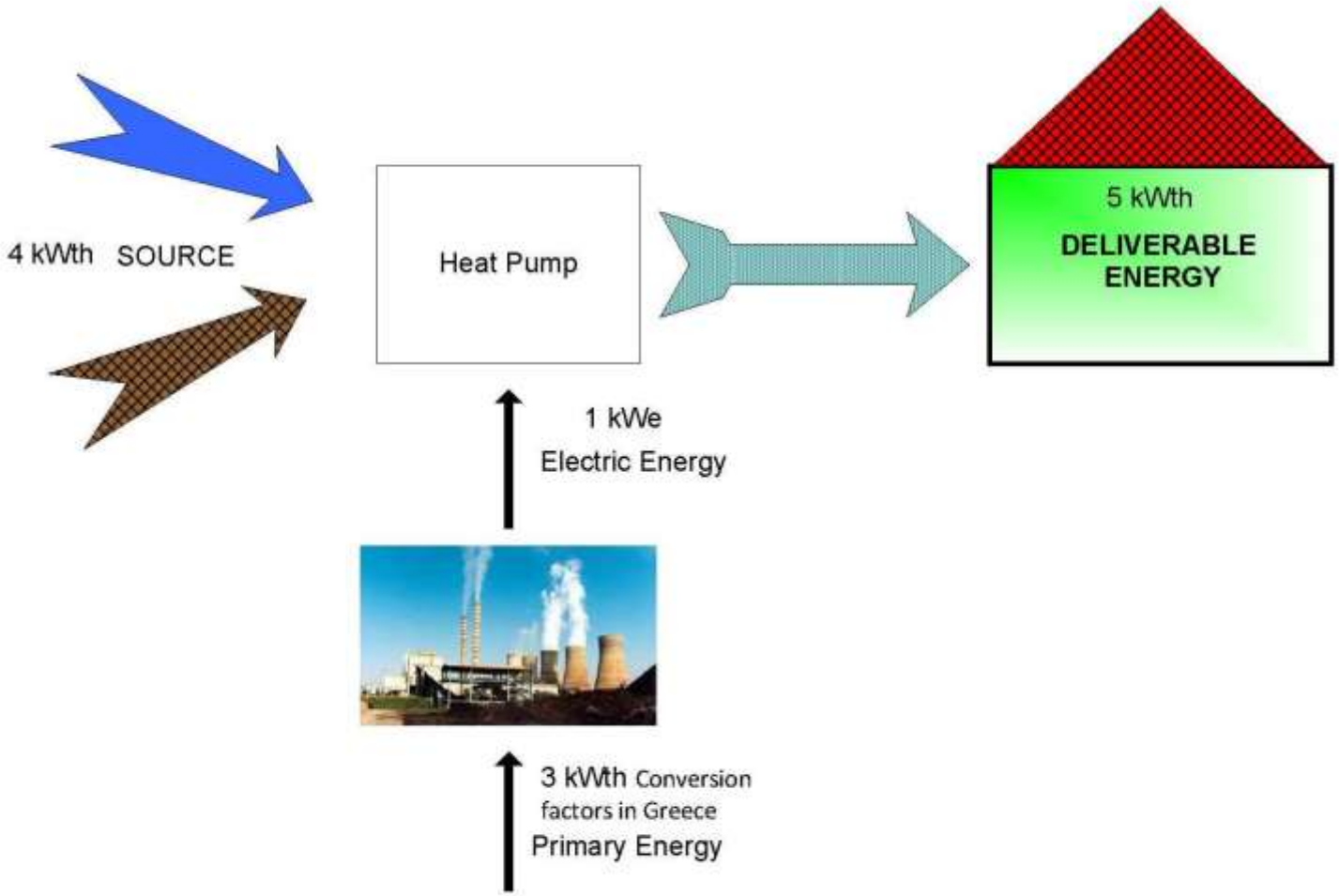
- High Enthalpy:
  - Resources with temperature of subsurface rocks and waters T > 150 ºC
- Low Enthalpy:
  - Resources with temperature of subsurface rocks and waters T from 30 ºC to 150 ºC
- Shallow Geothermal:
  - Resources with temperature of subsurface rocks, waters and surface bodies (sea, lakes, and rivers) T < 30 ºC

Shallow Geothermal (T<30°C)

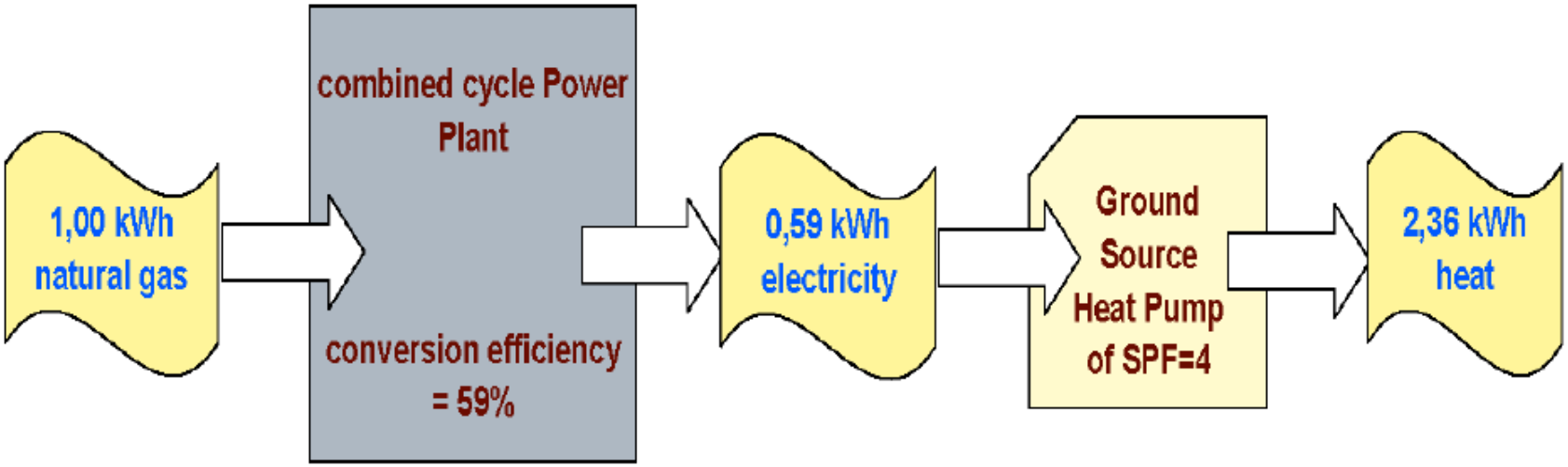
- **Ground Sources Heat Pumps (GSHP)**
  - Heating, Cooling and Domestic Hot Water
  - Houses, hotels, office buildings, schools, shopping centers, stadiums, greenhouses etc.

DIRECTIVE 2009/28/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC

- Aerothermal, geothermal and hydrothermal heat energy captured by heat pumps shall be taken into account for the purposes of gross final consumption of energy from renewable sources for heating and cooling; provided that the final energy output significantly exceeds the primary energy input required to drive the heat pumps.
- Heat pumps enabling the use of aerothermal, geothermal or hydrothermal heat at a useful temperature level need electricity or other auxiliary energy to function. The energy used to drive heat pumps should therefore be deducted from the total usable heat. Only heat pumps with an output that significantly exceeds the primary energy needed to drive it should be taken into account.
- The quantity of heat to be considered as energy from renewable sources for the purposes of this Directive shall be calculated in accordance with the methodology laid down in Annex VII (as defined in the directive of 1st March 2013)


4 kWth SOURCE
Heat Pump
5 kWth
DELIVERABLE ENERGY
1 kWe
Electric Energy
3 kWth Conversion factors in Greece
Primary Energy

Primary Energy Gains



The value of SPF for HP's in Greece

- According to Greek legislative framework (Common Ministerial Decree No. D6/oik.5825/09.04.2010 and Law 3851/04.06.2010) the official solution for the calculation of Eres in Greece for heating and/or cooling is given by the Eq: $E_{RES} = Q_{usable}\,(1\text{-}SPF)$.

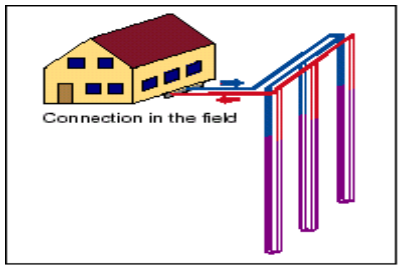
- Furthermore it is mentioned that only heat-pumps with a SPF above 1,15 * 1/η are taken into account. The value of SPF for GSHP's in Greece is considered greater than 3,3, until the value of η be determined in Greek legislative framework.

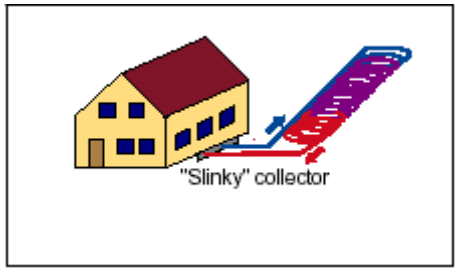
- The conversion factor of primary energy to electricity in Greece is taken as 2.90 (2010).

Configuration of GSHP systems

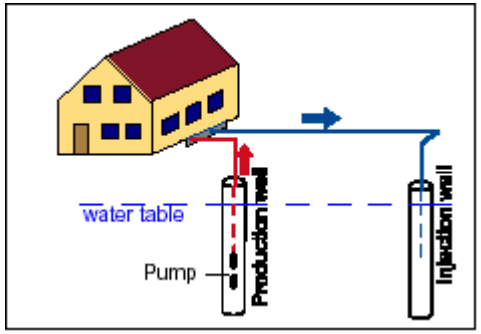
- Ground Heat Exchanger
  - Closed System (horizontal or vertical)
  - Opened System
- Ground Sources Heat Pump
- Heating and Cooling System low temperature

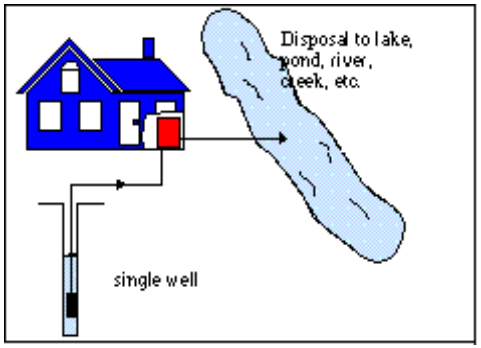
Closed System





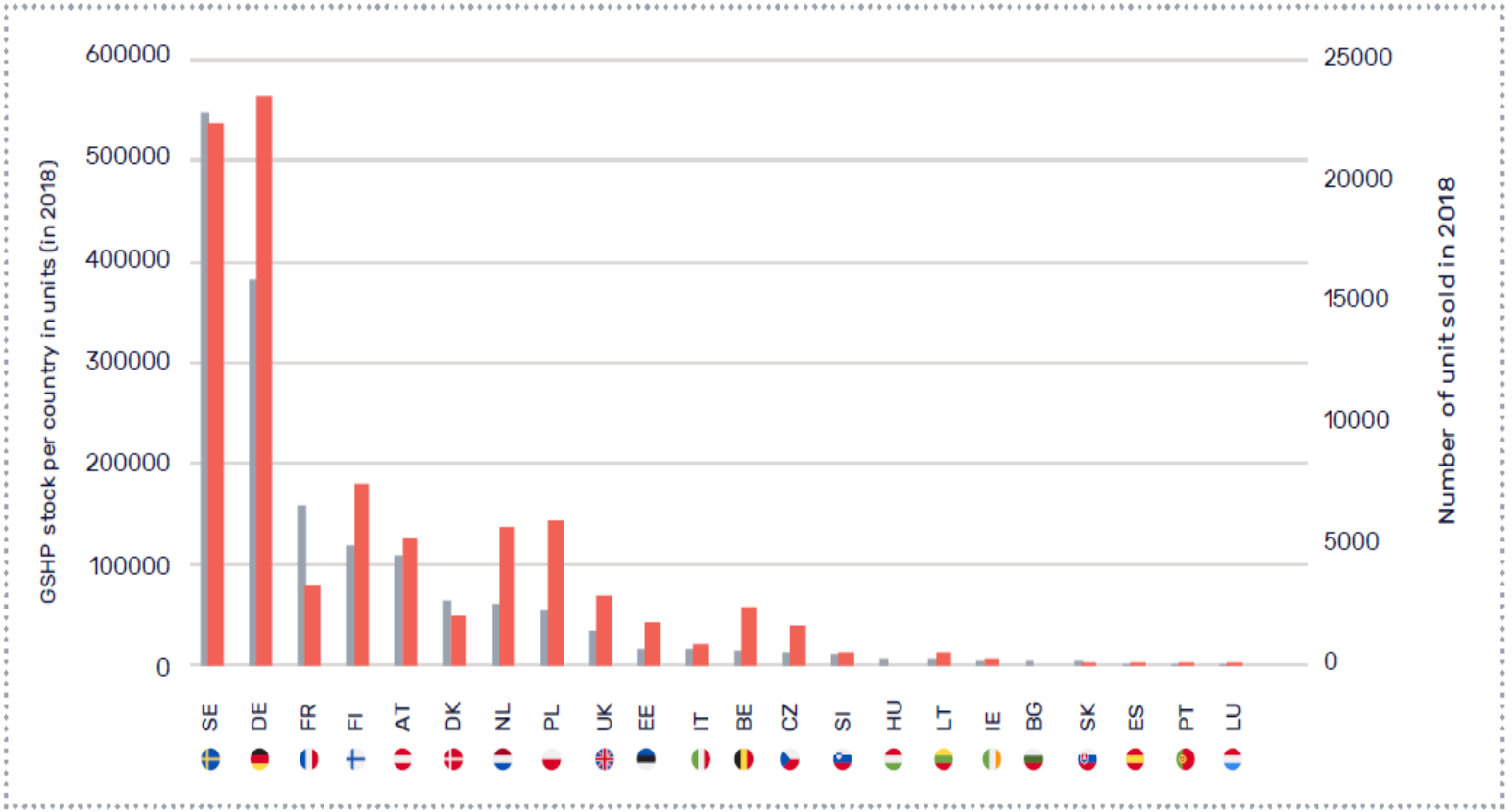
Open System





Stock of GSHP per country, highlighting 2018

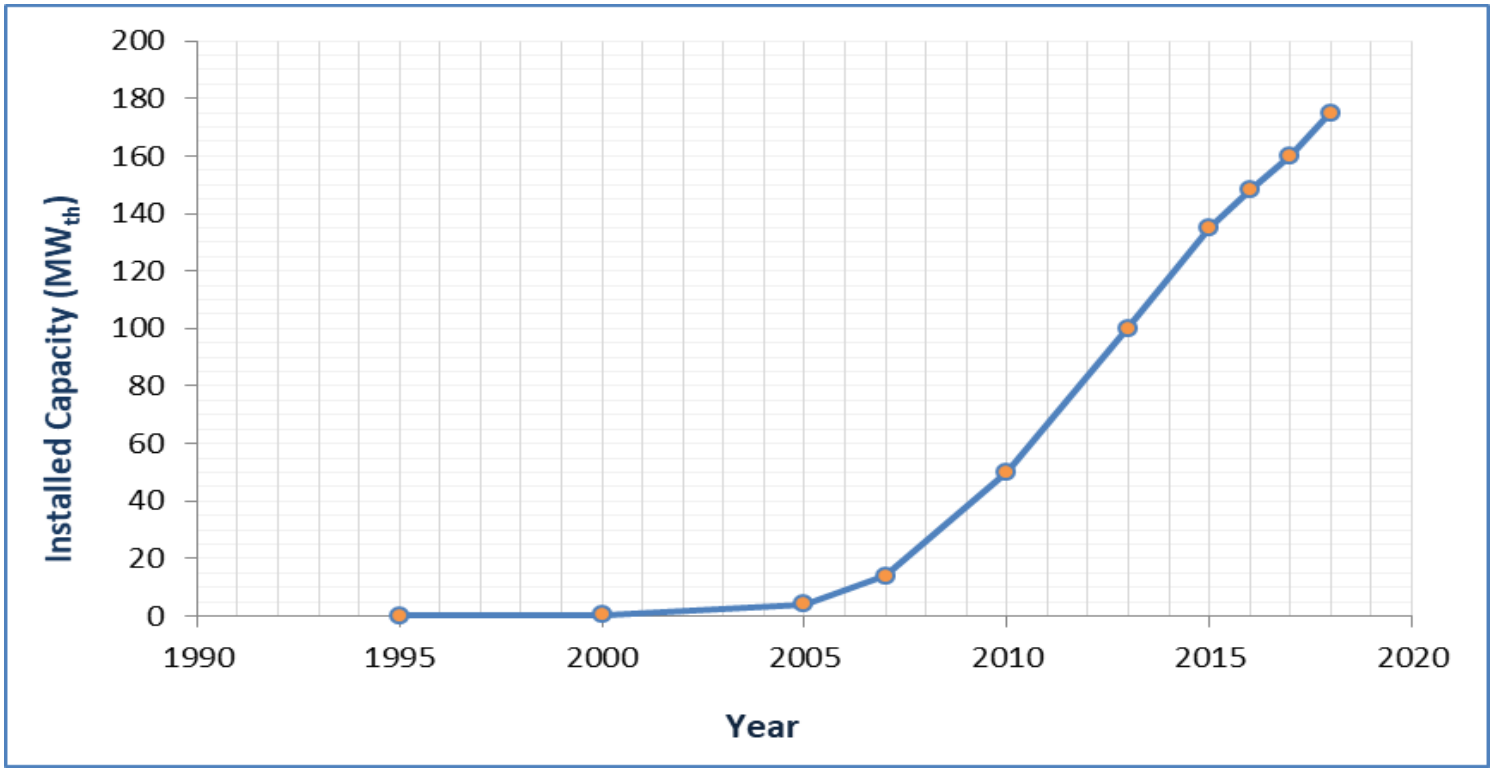
(EGEC GEOTHERMAL MARKET REPORT)



Shallow Geothermal energy, Ground Source Heat Pumps (GSHP) installed in Greece 2019 (EGC Country Update Papachristou et al. 2019)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2018 *		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2018	~3300 (est.)	175	383	300	9	?
Projected total by 2020	**~3500**	**195**	**450**			

Total Installed Capacity of GSHPs in Greece during the last 25 years (1995-2019)



Applications in Greece

Public Swimming Pool of Ilida

- Open System GSHPs total power 800 kWth
- Production Well 70 m^3/h
- Plate Heat Exchanger (titanium)
- 2 GSHPs 400 kWth connected in series
- SPF=5,00
- 44 % Saving Primary Energy pear year
- Reduction of Emissions 256 TCO_2 per year

GSHP in the new building of Central Macedonia Regional Authority (Thessaloniki, N. Greece)

The system consists of two heat pumps (2×425 kW) and three, different type, ground heat exchangers oerating simultaneously:

i) A horizontal (slinky) heat exchanger (total length = 42000m)
ii) Four coaxial BHEs (each 150 m deep)
iii) An open loop system (doublet) that provides the system with 45^3/h of water.

Hotel Amalia in Nafplion

- Open System GSHPs total power 704 kWth
- Production Well 60 m^3/h
- Plate Heat Exchanger (titanium)
- SPF=4,55 / SEER=3,85
- 46 % Saving Primary Energy pear year
- Reduction of Emissions 323 TCO_2 per year

Applications in Greece

Typical House at Pikermi

- Open System GSHPs total power 8,70 kWth
- Production Well 1,40 m^3/h
- Plate Heat Exchanger (titanium)
- SPF=5,80 / SEER=6,10
- 78 % Saving Primary Energy per year
- Reduction of Emissions 4,10 TCO_2 per year

GSHP design, construction and operation training needs

- A. Training needs for system designers
- B. Training needs for drillers
- C. Training needs for installers
- D. Training needs during maintenance

Most Important European standards and Guidelines (Sanner, 2008)

EN378-1:2008	Refrigerating systems and heat pumps – Safety and environmental requirements–Part1: Basic requirements, definitions, classification and selection criteria
EN255-3	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors –Heating mode-Testing and requirements for marking for domestic hot water units
EN14511-1:2004	Air conditioners, liquid chilling packages and heat pumps with electrically driven compressors for space heating and cooling–Parts1-4
ISO13256-1:1998	Water-source heat pumps—Testing and rating for performance-Part1:Water-to-air and brine-to-air heat pumps
ISO13256-2:1998	Water-source heat pumps—Testing and rating for performance-Part2: Water-to-water and brine-to-water heat pumps
EN12828:2003	Heating systems in buildings–Design for water based heating systems
EN12831:2003	Heatingsystemsinbuildings-Methodforcalculationofthedesignheatload
EN15316/4/2:2008	Heating systems in buildings-Method for calculation of system energy requirements and system efficiencies-Part4-2: Space heating generation systems, heat pump systems
EN15450:2007	Heating systems in buildings. Design of heat pump heating systems

Drillers and Designers Specific Training Needs for GSHP

Unit/Equipment	Actions needed	Parameters to consider
Borehole Heat Exchangers	Perform ground thermal response test	Number of boreholes (#)
	Know Borehole Thermal Resistance	Boreholes depth (m)
	Know specific heat extraction rate	Soil temperature (ºC)
	Know PCM properties (for ground)	PCM quantity (#)
Heat Pump (HP)	Know Heating needs	Heating capacity (kW)
	Know Cooling needs	Cooling capacity (kW)
	Select Heat Pump	COP
		EER Inverter or on-off
Pump (HP to boreholes)	Calculate piping circuit (HP to BH)	Water flow rate (m^3/s)
	Select pump	Pressure drop (Pa)

Installers Training Needs for GSHPs final Operation

Water piping	Verify water piping and accessories state Verify water piping and accessories for water leaks Verify insolation (if applied)
House terminal units - fan-coils (not included in the system))	Verify general state Verify the inlet/outlet water temperature Verify water flow rate Verify/clean air filter Inspect state of coil Verify running mode of air ventilator Verify motor ventilator consumption (V and Amp) Verify thermostats

Pump (House Load)	Verify water flow rate Verify inlet/outlet water pressure Verify general state Verify power supply (V) Verify electric consumption (V) Measure noise level (dB)
Smart control system	Check all functionalities (heating, cooling, DHW, etc)

Maintenance Providers Training Needs for GSHP systems

Equipment	Maintenance operations
Borehole Heat Exchangers	Verify general state Verify the inlet/outlet water temperature Verify the heat of extraction/rejection Verify water flow rate
Heat Pump (HP)	Verify general state Verify power supply (V) Verify electric consumption (V) Measure noise level (dB) Check refrigeration charge Check low and high pressure (cycle) Verify/clean heat exchangers and check for damage Verify water flow rate (low side and high side)
Pump (HP to boreholes)	Verify water flow rate Verify inlet/outlet water pressure Verify general state Verify power supply (V) Verify electric consumption (V) Measure noise level (dB)

Thank you for your attention!!!