ELI-NP MAGURELE ROMANIA – THE LARGEST SHALLOW GEOTHERMAL SYSTEM IN EUROPE OPERATION DATA FROM 2017

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The Extreme Light Infrastructure – Nuclear Physics Laboratory – acronym ELI-NP – located in Magurele (near Bucharest, Romania) is the most advanced research facility in the world focusing on the study of photonuclear physics and its applications, comprising a very high intensity laser of two 10PW ultra-short pulse lasers and the most brilliant tunable gamma-ray beam. It may cover a wide range of research topics in fundamental physics, nuclear physics and astrophysics, materials science, management of nuclear materials and life sciences.

The investment – comprising both the research facilities and the energy supply systems - was funded by the European Union and by the Government of Romania, and was finalized in September 2016. It covers an area of approx. 33,000 m^2 of new, high quality, energy efficient buildings. The cooling and heating loads of the research and civil buildings - in value of 6 MW and 4.5 MW, respectively - are fully covered by means of shallow geothermal energy. The GSHP system – which was designed and constructed by Romanian specialists - consists of 1080 boreholes, 125 m deep, feeding 43 water-to-air heat pumps, 123 water-to-water heat pumps and 10 air handling units.

The paper presents the results of monitoring the operation of the GSHP system during the time period January 1st, 2017 until February 2nd, 2018, covering also the response of the shallow geothermal system at partial loads.

Keywords: ***Geothermal, Ground Source Heat Pump, Borehole Heat Exchangers, Geothermal HVAC, ELI-NP***

1. **Brief overview of the ELI-NP Project**

BUILDINGS	Ground floor area sqm	Built-up area sqm
RESEARCH 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
CAFETERIA (ground floor)	277.62 123.70	277.62 123.70
TOTAL	1,875.77	7,220.43

Table 1. Buildings within the ELI-NP Project

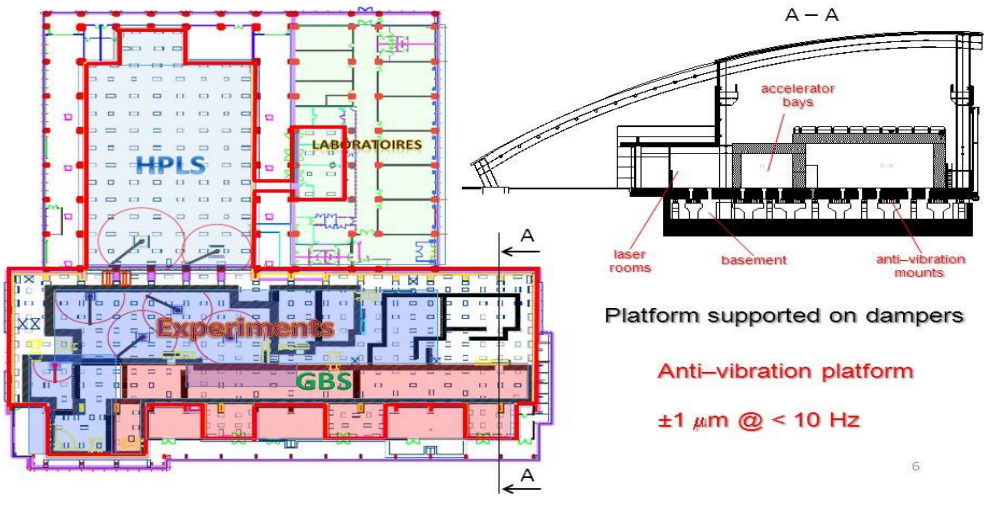

Figure 1. General layout of the ELI-NP research building

2. 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: $\leq 1 \times 10^{-10}$ 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 and class 7 - ISO 14644

Gamma Building

- Temperature in the Accelerator Bay: 22 ± 0,5 ^{o}C
- Relative humidity of the Accelerator Bay: 35-50 % condensation free
- Under-pressure in the Accelerator Bay: 14 Pa
- Protection against floor vibration: ±1 mm at less than **10 Hz**

Electrical Power provided by:

- 5 electrical transformer substations
- 2 separated distribution lines
- Bus-bar 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: 4.5 MW (HVAC)
- Cooling power requirements: 6.0 MW
- Technological Cooling Water : 2.2 MW
- Installed thermal capacity: higher than 6.10 MW

Ground Source Heat Exchangers System

- Ground heat exchanger - closed circuit, comprising 1080 bore holes, depth 125 m
- Each manifold contains a collector and a distributor
- Boreholes are grouped each 60 to a manifold
- From the 18 distributor / collector, leaving a pair of main geothermal pipes (flow / return) to the pumping station
- From the pumping station, energy is distributed to each of the 9 substations in the ELI-NP infrastructure. (HVAC plants and technological chilled water plants)

Heat pumps equipment

Water to air Heat Pumps:	43 pieces
Water to water Heat Pumps:	123 pieces

Air Handling Units

Gamma Building:	2 x 80.000 m^3/h
Laser and Laboratories Building:	8 x 54.000 m^3/h

Fan Coil Units:	192 pieces
Plate Heat Recovery units:	26 pieces
De-stratification Fans:	16 pieces

The HVAC control system is fully automated through a "Building Management System", which gathers data, monitors the whole HVAC&R system, and identifies trouble spots regarding:

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

2. Present day status of the ELI-NP research investment

- The GSHP system is completed and functional, meaning: boreholes, hydraulics, heat pump units, fan coils, AHUs.
- The "civil" buildings (office building, guest house and cafeteria) are operational.
- The adjacent spaces to lab facilities (access hallways, offices) are completed and functional.
- The lab spaces – equipment are currently under installation, building & HVAC are finished.
- The Building Management System has allowed obtaining functioning data for the GSHP system feeding the civil buildings, during the operational year 2017. The results of this monitoring for the 2017 year are presented in the next section.

3. Results of monitoring the GSHPs system for the year 2017

The Results of monitoring the GSHPs system for the year 2017 are presented synthetically in the following diagrams.

The climatic conditions for which the energy performance indicators were calculated are presented in Figure 2.

The values for the heating, cooling and electric energy consumption represent hourly average values for each specific month – these were obtained by means of the BMS for each of the analyzed buildings.

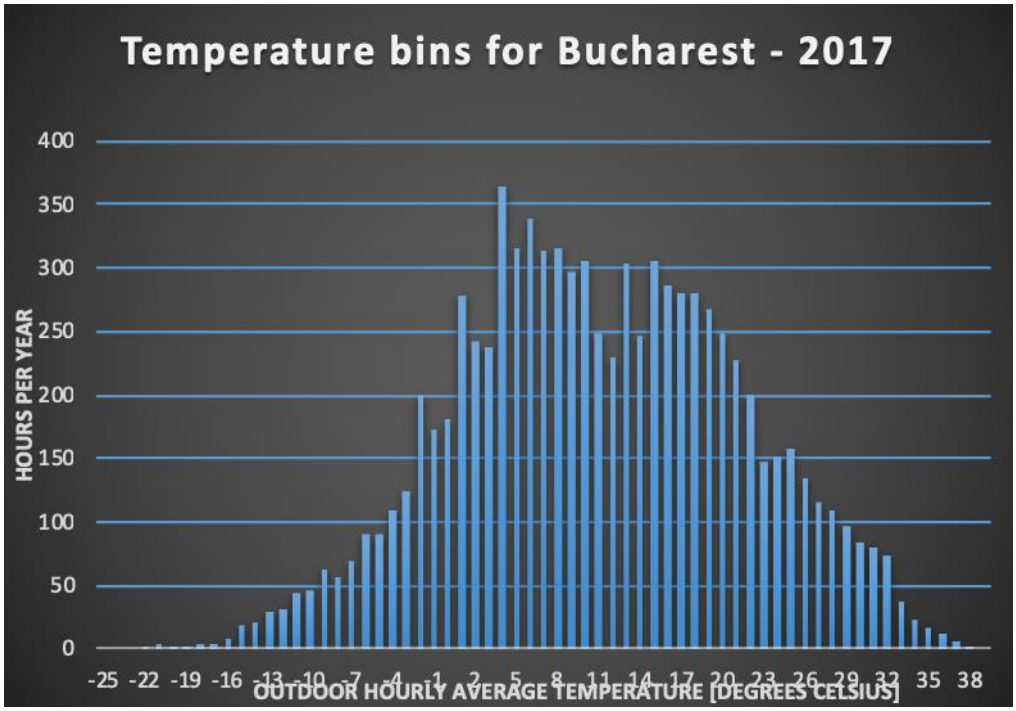

Figure 2. Temperature bins for Bucharest in 2017

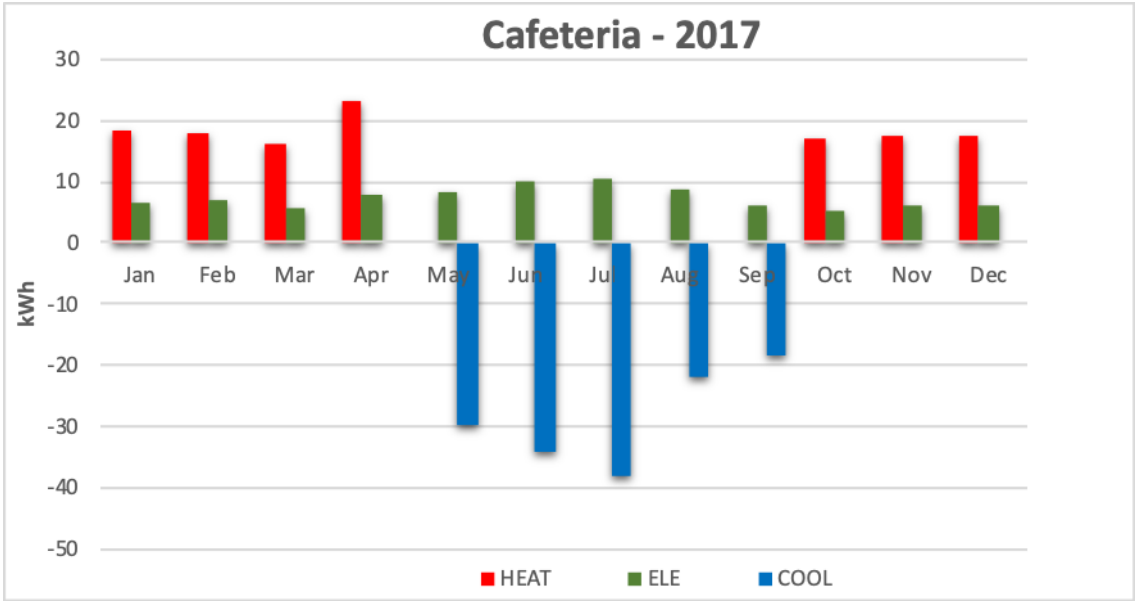

Figure 3. Average energy consumptions for the cafeteria

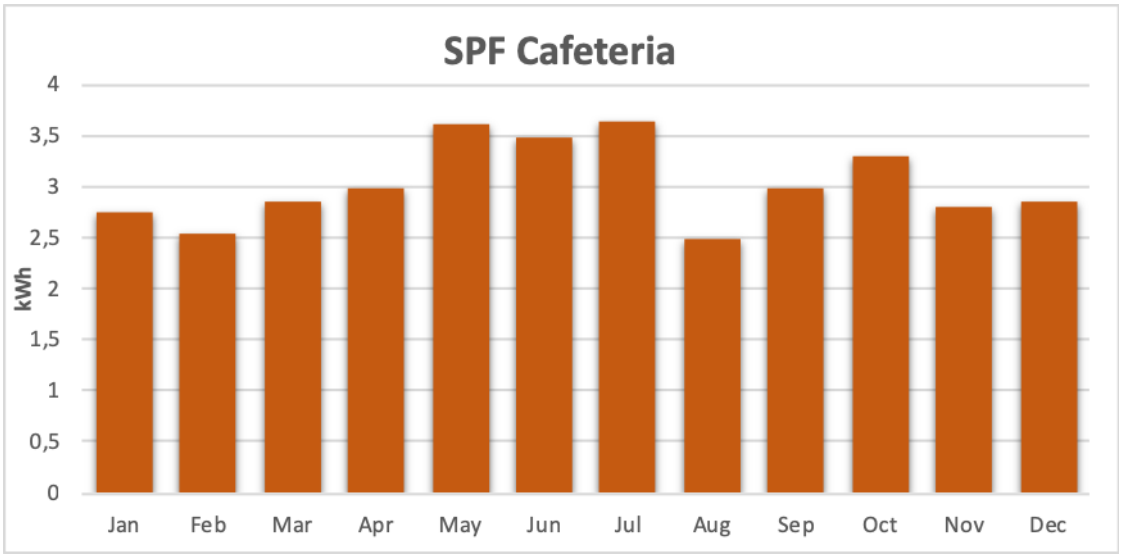

Figure 4. Average SPFs for the cafeteria

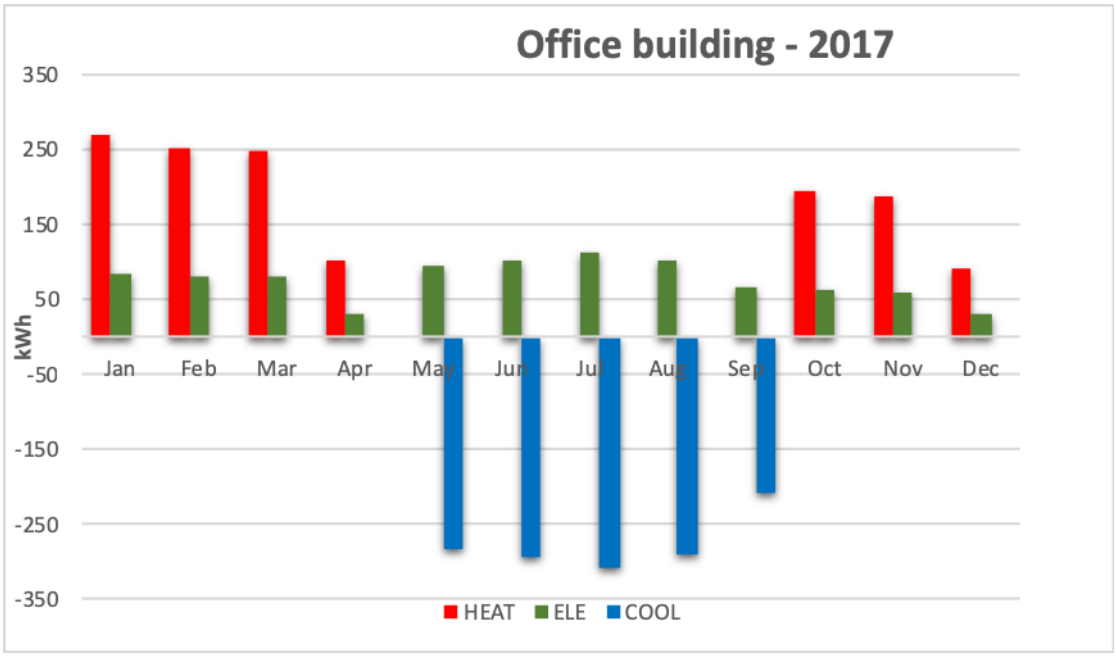

Figure 5. Average energy consumptions for the office building

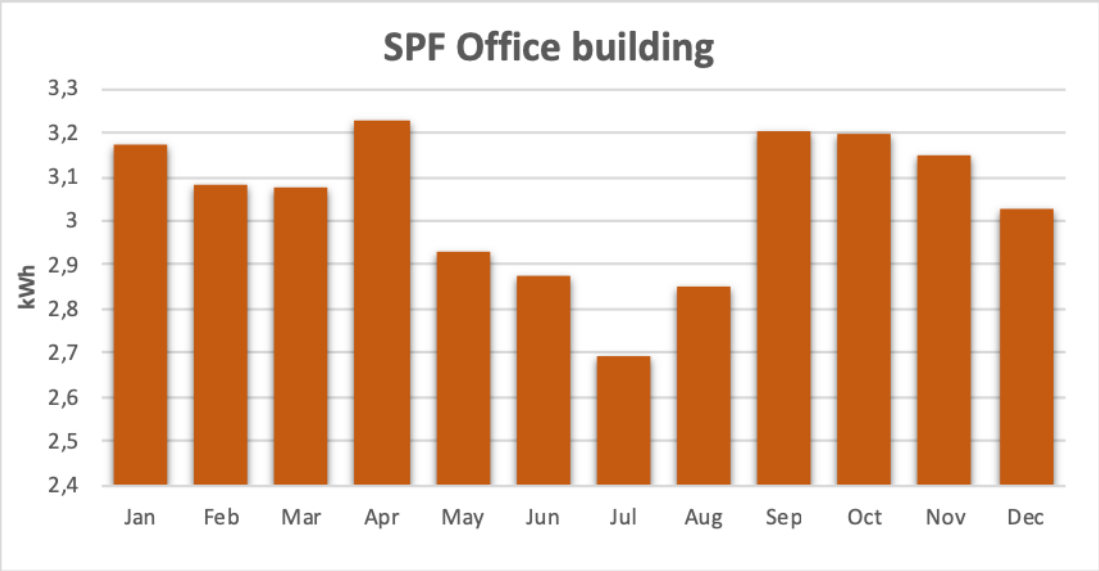

Figure 6. Average SPFs for the office building

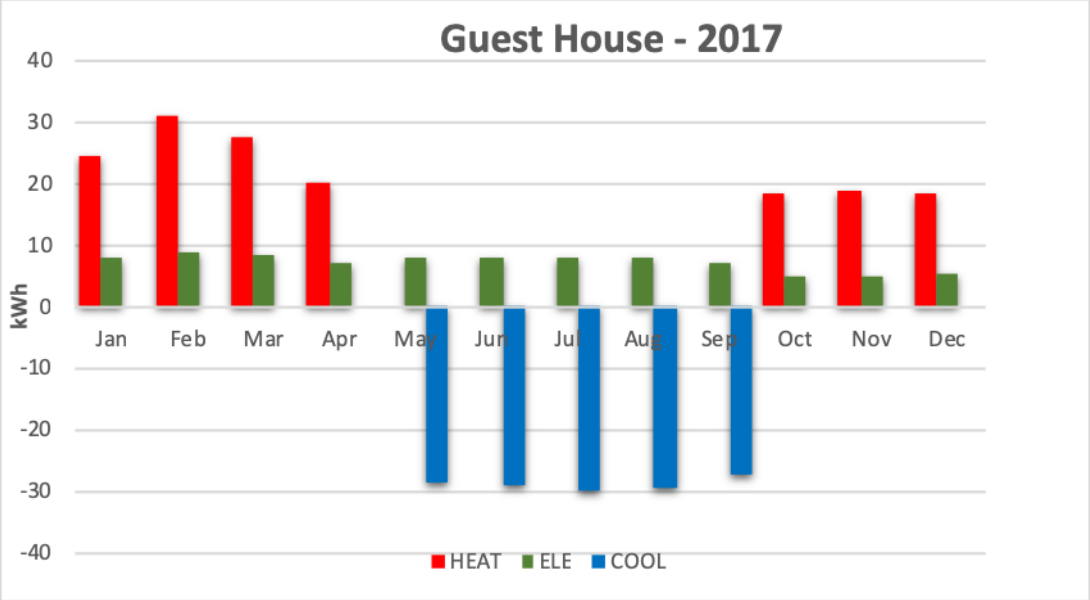

Figure 9. Average energy consumptions for the guest house

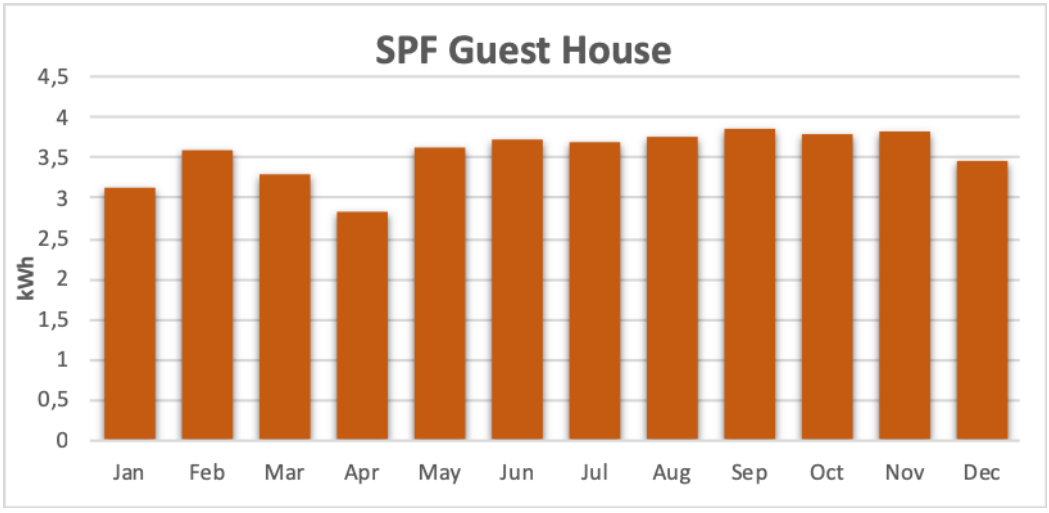

Figure 10. Average SPF for the guest house

4. Conclusions

The monitoring results are preliminary results for the "civil" buildings only, before the actual start-up and functioning of the high power laser and gamma laboratories.

The electric energy consumptions are considered altogether for the heat pumps and for the circulating pumps.

The average SPF values are in the range of 3 – values which certainly can be improved after a thorough analysis of the hydraulic system.

Further monitoring will be performed, in order to:

- Differentiate among the electricity consumption for the actual heat pumps equipment and the electricity consumption of the circulating pumps, thus enabling to optimize the performance of the hydraulic network;
- Highlight the energy performance of the GSHP system dedicated specifically to the research equipment – laser and gamma laboratories.
- Given the fact that consumptions are evaluated for the "civil" buildings, the GSHP system is 40% loaded. All the performance values are computed for this situation.
- In order to obtain a full chart of the energy performance for the whole system, a specific monitoring resource should be installed in order to differentiate among the performance of the sources and that of the transport loop. In order to obtain these values, specific electrical energy measurement units should be installed at the source level.
- Currently, there are certain setpoints for temperature for the guest house and the cafeteria but, in order to optimize the loads, different set-points values will be implemented for occupied/not occupied status of the rooms. Now, at ELI-NP, a strategy for different thermal loads is implemented.

5. References

[1] R.S. Stefan, European Union Energy Day – Clean energy solutions for the buildings of the future, Astana World Exhibition, July 24th, 2017

[2] J.D. Spitler, L.E. Southard, Xiaobing Liu, Performance of the HVAC systems at the ASHRAE Headquarters building – Final report, ASHRAE 2014

[3] GEOTRAINET Training manual for designers of shallow geothermal systems, 2011

[4] GEOTRAINET Training manual for drillers of shallow geothermal systems, 2011

[5] Cheap-GSHPs Project Training manual, 2019