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Education and Research in the Field of Geothermal Heat Pumps in the Centre of Sustainable Development and Energy Savings WGGIOS AGH in Poland

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ABSTRACT

The Centre of Sustainable Development and Energy Savings of the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology in Miekinia conducts educational activities in the field of renewable sources of energy; geothermal heat pumps especially. The growing interest in using renewable energy sources (RES) is reflected upon the interest in such a discipline of studies. More and more people have declared the intention of studying RES. RES is a modern discipline that was opened at AGH University of Science and Technology in 2003 as the first one in Poland. Since 2012, when the Centre was open ca. eight thousand people were educated there.

The Centre is heated by heat pumps with ground sources which are simultaneously used by students for their practice and measurements. Heat pumps work in three different heating systems: borehole heat exchangers (83, 87 and 100 m depth) and horizontal ground source (600 m^2 of the area). Moreover, in the Centre, there are didactic heat pumps with temperature and pressure sensors and electric meters. It is possible to compare Seasonal Performance Factor (SPF) depending on different temperatures of energy source and heating system as well as showing how the four-way valve works and the ability of heat pumps of cooling the building actively using the compressor.

In the Centre of Sustainable Development and Energy Savings of the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology in Miekinia, Poland research on the efficiency of compressor heat pumps was launched. Within the national funds, a stand for testing ground-source brine heat pumps for central heating and hot domestic water preparation was built. In the stand, research is conducted on the COP heat pump efficiency in accordance with the PN-EN 14511 standard. Within the research, it is possible to determine the heat pump's operating parameters, such as heating power, electrical power and cooling power. The stand also allows testing the parameters of the cooling system of the tested heat pump.

In the Centre, work relating to the prototyping of new and innovative heat pumps have been started. This includes heat pumps of the scroll compressor with liquid refrigerant injection. Research works carried out in the Centre regard also to thermal parameters of the soil using a Thermal Response Test device. The device was self-made by the team of the employees of the Centre.

1. INTRODUCTION

The Centre of Sustainable Development and Energy Savings of the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology in Miekinia is research and educational centre for activities in the field of renewable sources of energy, geothermal heat pumps especially (Figure 1). The Centre serves as an educational base for all stakeholders, especially for students, pupils, local governments, renewable energy sources specialists among others. Moreover, the Centre cooperates with business while being an R&D place for geothermal, heat pumps and other RES technologies.

The Centre is located in a ca. 30 km distance from Krakow, Poland and AGH University headquarter. It is placed in a former administration building of porphyry mine, which was rearranged and rebuilt to be a laboratory and educational building along with fulfilling modern energy efficiency standards. Now the building is ten times more energy-efficient than the former one. It is shown as a good practice of how to modernise a building and upgrade the site of mine and land reclamation by converting a building into a modern and energy-efficient building supplied with renewable energy sources. The Centre is in the disposal of bed places, which helps, for example, students to have classes for several days without having to drive or commute for long hours.

Construction of the Laboratory was co-financed by the European Regional Development Fund of the European Union under the Malopolska Regional Operational Programme 2007 – 2013. The Centre was established in 2012, and since then many people were successfully educated there.

Figure 1: The main building of the Centre of Sustainable Development and Energy Savings of the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology in Miekinia, Poland

2. EDUCATION

The educational and scientific activity of the Faculty of Geology, Geophysics and Environment Protection, AGH University of Science and Technology (AGH-UST), Krakow, Poland, is closely related to the subject-matter of renewable energy sources (RES). As interest of this field of science increased firmly, there were the speciality "Renewable energy sources" established in the AGH University of Science and Technology in 2003. And it was the first that speciality in Poland. In 2012 there was launched the "Ecological Energy Sources" speciality, both for first (engineering) and second (Masters) degree.

Having a fully equipped laboratory creates greater educational possibilities result in increasing number of students interested in acquiring knowledge in this discipline, improving the educational quality by growing number of practical courses, and conducting the scientific-research work for the engineer's theses, master's theses and doctoral dissertations, which significantly facilitate the students' research activity and improve the quality of the theses.

The laboratory represents a site of practical courses for students from different faculties of AGH-UST and other universities and schools in Malopolska, syllabuses of which concern problems of environmental protection. The activity of the laboratory allows the increasing number of exchanges of students from AGH-UST and other universities from Europe. Practical use of up-to-date technologies in RES causes an improvement of conditions for professional study, allowing to improve professional qualifications through supplying with modern technical and didactic equipment.

The education in the Centre is provided in the several RES technologies like solar energy (both thermal and photovoltaics), biomass, wind energy among other forms of renewable energy, but the emphasis is given to geothermal energy and heat pumps. The primary heat source for the building is based on four ground heat pumps, which supply heat to the building and are an expanded research station (Figure 2). It creates the opportunity for students to have their observation and measurements on the working system.

Heat pumps work in three different heating systems. The first one has three borehole heat exchangers (83 m depth each of them), and heat or chill is distributed on the building using ventilation ducts. The second heat pump has three borehole heat exchangers (87 m depth each of them), and heat or chill is distributed by underfloor heating. The third and fourth heat pumps work together, and they are producing high-temperature heat (for a heat pump high temperature is 50 to 55˚C) for domestic hot water and to distribute heat to the building by radiators. The third heat pump has three borehole heat exchangers (100 m depth each of them) as a source, and the fourth has the horizontal ground source (600 m^2 of the area). The main aim of heat pumps installed in the laboratory is heating and cooling the building and production of domestic hot water. Cold air is supplied to the building in a passive way, without using the compressor. The installation is measured with temperature sensors, heat meters and electric meters. Temperature sensors give data about brine and boiler water. Heat meters and electric meters give information about the quantity of heat production and quantity of electric consumption by the compressor and other devices like circulation pump, controller etc. All data are saved on the server and accessed by a computer program which can also be monitored in real-time. The software gives opportunities for viewing present and archival parameters of installation as graphs of temperature, energy consumption, the energy produced, etc., or to calculate the efficiency of the heat pump in any period. Using the software, it is possible to control heat pumps from anywhere in the world.

Figure 2: The view on a boiler room with installed heat pumps.

Except for four heat pumps which heat the building, in the laboratory, there are two heat pumps to didactic aims. The first of them is an air-water type heat pump (Figure 3). Modules of energy source and heating system have the ability to set the temperature parameters, which allows comparing among others, Seasonal Performance Factor depending on different temperatures of energy source and heating system. The second didactic heat pump is a small device of water-water with direct evaporating type. This heat pump also has temperature and pressure sensors and electric meter. It is possible to show how the four-way valve works and the ability of heat pumps of cooling the building in an active way, through the use of the compressor.

Figure 3: Heat pump efficiency tests during academic internships.

Apart from the activity directed to students' needs, the laboratory plays an informative and consultative role in the fields of renewable energy sources, energy conservation and smog (which is an important topic in Poland nowadays) for people interested in that subjects. Many people benefited from an education in the field of renewable energy sources (Figure 4). This includes pupils, local governments and local communities, NGOs, specialists from local governments who will serve as energy consultants, foreign guests, etc.

Figure 4: Graduates from primary school educational RES programme financed from ESF

Moreover, ca. 100 different SMEs benefited from energy efficiency consultations during SPIN – Malopolska Knowledge Transfer Centres project in 2016-2018 financed from the European Regional Development Fund.

As more and more communities are interested in renewable energy sources, the Centre also provided mobile education, which means that the Centre is in the disposal of mobile laboratories (Figure 5). They can go almost everywhere and provide a demonstration of RES installations and educate about RES and reduction of smog.

Figure 5: Mobile RES laboratories (“OZE BUS”) waiting for visitors.

Dozens of locations benefited from mobile education on site. In the mobile laboratory, several installations can demonstrate the operating principles of renewable energy sources (i.e. solar collectors, photovoltaic, ground or air heat pumps, etc.). In the second mobile laboratory, three types of heat sources are shown: first, very non-ecological (an old boiler) in which anything can be burn and which can be a source of low emission, second, solid fuel boiler of 5th class (eco-design), which can reduce the low emission slightly from a house, and third, a heat pump which not cause any emission in place of use. In every case, the emissions are measured. This leaves users with the decision on what the best option for heating and for the environment are.

2. RESEARCH

In the Centre, research in the field of geothermal and air heat pumps are carried out. Likewise, in the Centre of Sustainable Development and Energy Savings of the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology in Miekinia research on the efficiency of compressor heat pumps was launched. Within the national fund, a stand for testing ground-source brine heat pumps for central heating and hot domestic water preparation was built. In the stand, research is conducted on the COP heat pump efficiency in accordance with the PN-EN 14511 standard (Figure 6). Within the research, it is possible to determine the heat pump's operating parameters, such as heating power, electrical power and cooling power. The

stand also allows testing the parameters of the cooling system of the tested heat pump. As for now, the tests are mostly held as pre-certification tests, but the stand will also provide an accredited test in the near future.

Figure 6: Heat pump efficiency testing stand.

There is research on the ground source of heat pumps, as the Centre measures thermal parameters in the boreholes, which are monitored (Figure 7). There is also a self-constructed, easy movable Thermal Response Test (TRT) device for thermal parameters measurements (Figure 8), self-constructed and made by the Centre staff.

Figure 7: Drillings for borehole heat exchangers in the Centre

Figure 8: Thermal Response Test device while measurements

The Centre also cooperates with several companies from RES industry (i.e. heat pumps and solid fuel boilers producers and installers) and as R&D place for geothermal and heat pumps technologies. Moreover, the research staff is working on prototyping new, innovative and ecological heat pumps.

3. CONCLUSION

The Centre of Sustainable Development and Energy Savings of the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology in Miekinia conducts research and educational activities in the field of geothermal energy and heat pumps. It is in disposal in great educational and research installations which are used not only for measurements but to show some good practices for interested stakeholders (students, local communities, etc.). It also has great potential for on-going and future R&D projects.