

## Geothermal education at the AGH University of Science and Technology in Kraków, Poland

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### ABSTRACT

The article presents the activity carried out at AGH University of Science and Technology, Faculty of Geology, Geophysics and Environmental Protection, in the field of education of students on the subject of renewable energy sources, including geothermal energy. As the first one in Poland at the Faculty a specialization for students of renewable energy sources was created. A few years later, the direction of the Ecological Energy Sources was also established. A great opportunity to educate students is provided by the Laboratory of Renewable Sources and Energy Saving located in Miękinia (several dozen kilometers from Krakow). In the laboratory, students have the opportunity to carry out research work on the installation of renewable energy sources, including various types of heat pumps

### 1. INTRODUCTION

The AGH University of Science and Technology in Krakow is a modern technical university that takes active part in building a society based on knowledge while taking advantage of technologies for the purpose of economic growth and development. The university was established in 1913, and opened in 1919. The university's priority is the accomplishment of tasks and projects that are part of the knowledge triangle: education – scientific research – innovations ([www.agh.edu.pl](http://www.agh.edu.pl)). One of the 16 faculties in the structure of AGH- UST is Faculty of Geology, Geophysics and Environmental Protection. At present, the faculty has the most environmental profile among the technical faculties of AGH UST. Education program integrates knowledge from both the applied and basic (university-type) Earth sciences with the elements of various technical sciences and basic sciences ([www.wggios.agh.edu.pl](http://www.wggios.agh.edu.pl)). One of the important field of education is Ecological Sources of Energy. The topic of geothermal energy utilization as one of the ecological energy sources, is an important element of this field of study. Faculty offers classes in modern laboratory Laboratory of Renewable Sources and Energy Saving located in Miękinia near Kraków, so students are able to receive high professional qualifications. Along with the necessity of the

continuous development of green energy sources and their increment in the total energy balance of the Poland and the European Union, Department of Fossil Fuels faces the need of students education ([galaxy.agh.edu.pl/~k-se](http://galaxy.agh.edu.pl/~k-se)). The effective use of geothermal energy is associated with the need to constantly improve qualifications and exchange experience. For this purpose, we implement students and staff exchange programs – FSS (the Scholarship and Training Fund Mobility Projects in Higher Education) and Erasmus+ Programme, creating opportunities for our students to learn from more experienced scientists in the field of geothermal energy.

### 2. ECOLOGICAL ENERGY SOURCES FOR STUDENTS

In 2003, at the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology, specialty called *Renewable energy sources*, for students of *Environmental Engineering* was introduced as the first one of this kind in Poland.

In 2012, 1st degree engineering studies in the field of *Ecological Energy Sources* were launched. From 2016, in order to allow students continuing education, second degree of studies has been running. A graduate of the course of Ecological Energy Sources receives a master's degree in the field of Earth Sciences, a discipline in geology.

These courses concern the implementation and exploitation of renewable energy sources, with particular attention to geothermal energy such as: geothermal resource assessment, identification of prospective area for geothermal water and energy utilizations.

### 3. FSS AND ERAZMUS+ PROGRAMMES

For many years the Department of Fossil Fuels of the AGH University of Science and Technology in Cracow collaborates with various academic and research centres from Iceland.

In the years 2013-2016, the FSS Program - the Scholarship and Training Fund Mobility Projects in Higher Education has been realized, providing the possibility of running students and employees

exchange programs with Keilir Institute of Technology (Reykjanesbær, Iceland).

Scholarship and Training Fund was created on the basis of Memorandum of Understanding of implementing of Financial Mechanism EEA 2009-2014 between Iceland, Liechtenstein, Kingdom of Norway and Poland, as well as on the basis of Memorandum of Understanding of implementing of Norwegian Financial Mechanism 2009-2014 between Kingdom of Norway and Poland. The main purpose of the Fund will be to reduce the social and economic disparities within the European Economic Area and to strengthen bilateral relations between Poland, Iceland, Liechtenstein and the Kingdom of Norway in the area of education ([www.fss.org.pl](http://www.fss.org.pl)).

Partner Institutional Agreement between AGH University of Science and Technology (Poland, Kraków) and Keilir Institute of Technology (Reykjanesbær, Iceland) allowed the cooperation in form of the provision of mobility of university students and staff.

Keilir is an educational institution founded in 2007 based in Ásbrú Enterprise Park in Reykjanesbær on the Reykjanes Peninsula in South-West Iceland. At Ásbrú, Keilir plays a big part in shaping a new community build on the premises of a former United States NATO military base, focusing on developing educational possibilities and support for start-up companies in the area. The school has become a frontrunner in reinventing educational practices and possibilities within the Icelandic educational system through innovative educational approaches and bringing together business, industry, academia and entrepreneurs. The purpose of Keilir is to create and disseminate knowledge in an active partnership with domestic and international schools, companies and other economic partners ([www.keillir.net](http://www.keillir.net)).

In 2014 student realized two very interesting projects related to geothermal energy utilization, which ended writing of diploma thesis:

- *H<sub>2</sub>S removal from geothermal gases based on Icelandic experience* - The project being the basis of the thesis was made entirely in Iceland during a student exchange at the last semester of the master program. In cooperation with the Blue Lagoon spa (BL) has been selected (among many available methods) the best way of purification H<sub>2</sub>S from geothermal gas from HS Orka. Then was created the on-site installation, at the BL Research and Development Center, allowing filtration of the gas and the measurement of efficiency in the real conditions. Removal of H<sub>2</sub>S helps to avoid corrosion of the other elements, through which the gas flows, and allows to obtain a practically uncontaminated CO<sub>2</sub> (which is being used in the algae bioreactor). It is also an important aspect

for reducing emission of this toxic gasses (CO<sub>2</sub> and H<sub>2</sub>S) to the atmosphere (Wija, 2014).

- *Proposal for utilization of surplus heat at Reykjanes Power station in Iceland* - The focus of this thesis was to perform an in-depth analysis of geothermal conditions in Iceland, with main focus on Reykjanes geothermal field utilized by power station of the same name. As currently large amounts of heat stored in the effluent from the plant are dumped into the ocean as a waste water, an attempt to evaluate possible ways of utilization this effluent will be undertaken. Chemical analysis of silica content in effluent is a starting point for discussion on possible utilization of this surplus heat stored in discharge water. Specific local circumstances are taken into account. (Piecza, 2015).

In 2016, two students taking a degree in the field of renewable energy resources at the Faculty of Geology, Geophysics and Environmental Protection of the AGH-UST, have accomplished their M. Sc. diploma semester in Keilir Institute of Technology (KIT) working at the project: *Feasibility study of Enhanced Geothermal System (EGS) in low-temperature areas of Iceland with Hot Dry Rock (HDR)*, in the cooperation with one student and employees from KIT. Within this unique project, the case study of low-temperature resources utilisation in Hólmavík town area (NW Iceland) with the implementation of the Enhanced Geothermal System (EGS) was performed. The main target was to verify the possibility of using the energy stored in HDR within the analysed area for providing heat for a small district heating network (Sowizdzal, Drabik, 2016). The participation in projects implemented by Icelanders allows to transfer the valuable geothermal experience over Polish circumstances. Despite different geological conditions in both countries, determining possibilities of geothermal resources utilisation, this project fits perfectly into Polish reality. It concerns the possibility of using low-temperature geothermal resources with the EGS systems implementation, which is also a novelty in Iceland due to the occurrence of large areas of high-temperature hydrogeothermal resources that are utilised in a large scale for various purposes (Drabik et al. 2016). As a result of the project two master's theses were created:

- *The analysis of possibilities of using Enhanced Geothermal System (EGS) in low-temperature areas in Iceland for providing heat for small district heating networks* - The project section concerns the case study of Hólmavík town in Westfjords region. Mainly the geological aspect as well as tectonics is taken into consideration and static resources of petrogeothermal energy are determined for two different scenarios. As the effect, it is shown that from geological point of view, implementation of EGS technology in such town as Hólmavík in Iceland might be plausible. Nevertheless, both technological and economic aspects need to be determined for the

complete feasibility study of EGS within low-temperature areas in Iceland (Drabik, 2016)

- *The concept of the geothermal district heating system for dispersed settlement on the example of the town of Holmavik in Iceland* - This dissertation is to provide generalized guidelines, basing on specified casus of Holmavik town in NW Iceland and using them, to compare two available sources of geothermal power – Enhanced Geothermal System and vertical heat exchanger heat systems. Both providing power for municipal heating system, that is not existing yet, hence is desired among the Holmavik citizens (Ciapała, 2016).

In 2016, in order to continue Polish-Icelandic student exchanges in the field of geothermal energy, AGH-UST joined the Erasmus + program. According to the international agreement between AGH-UST and the University of Iceland for 2016-2021, subsequent students had the opportunity to gain valuable experience in Iceland. In the academic year 2017/2018, three students went on a student exchange, which resulted participation in research work carried out in Iceland and in following master's theses:

- *Feasibility of vertical heat exchangers in low-temperature areas in Iceland with Hólavík as a use case* – The following master's thesis is a continuation of the project, with the same name, conducted during the Erasmus+ Programme in Iceland at University of Iceland, at Faculty of Electrical and Computer Engineering (School of Engineering and Natural Sciences). The main purpose of this project was to determine the feasibility of vertical heat exchangers in low-temperature areas in Iceland with Hólavík as a was that only residential buildings will be covered by this design. This work shows that it is technically possible to use vertical heat exchangers for ground source of heat pump in both for create district heating or individual space heat-ing of residential buildings in climate of West Fjords in Iceland (Mandera, Kubik, 2018)
- *Study of surplus energy utilization generated in intermittent power plants for energy storage in district heating system in the Westfjords, Iceland* - In this study the system combining wind turbines, district heating network and thermal energy storage was proposed and examined for the instance of the Westfjords, Iceland. This approach is set to mitigate the negative impact of unstable renewable energy sources and manage the generated surpluses. The short review of the current state of energy sector in Iceland was provided to present local conditions. Wind potential in the described area was estimated as high and compared with average wind turbine generation in European Union. In addition, long term correlation between power production and demand in district heating network was proven. It is

assessed that roughly 60% of consumed energy could be supplied by introducing wind turbines to existing electric and oil district heating system. Moreover, this share can be increased by adding thermal energy storage. Some recommendations basing on this project were given to Polish energy market (Mathews, 2018)

The cooperation with Iceland, which remains one out of the World's leading countries in the utilisation of renewable energy resources, provides possibility of development in the field of geothermal energy, enriching with the theoretical knowledge as well as practical skills. Since Iceland owned the enormous experience with the broad utilisation of geothermal resources for different purposes, it remains an excellent example for the countries such as Poland that are developing their geothermal energy sectors. The numerous exchanges that has been organised within the FSS and Erasmus+ Programmes contribute to the extendedness of Polish-Icelandic cooperation. Many projects such as the one realised by Polish students in the cooperation with employees of Keilir Institute of Technology (Iceland), improve their qualifications and might bring several benefits for the domestic economy.

#### **4. THE AGH-UST EDUCATIONAL AND RESEARCH LABORATORY OF RENEWABLE ENERGY SOURCES AND ENERGY SAVING IN MIĘKINIA**

The educational and scientific activity of the Faculty of Geology, Geophysics and Environment Protection, AGH University of Science and Technology (AGH-UST) created the need for establishment of educational and research infrastructure that would enable practical courses and laboratory studies, which would enrich the educational offer of the University and improve the quality of the research work.

One of the former didactic buildings of AGH University of Science and Technology in Miękinia was rebuilt and modernized in energy saving standards thanks to funding from the EU and adapted to a laboratory (Fig.1). The laboratory is located on the grounds of the old quarry. Housed in the former administrative building of the mine porphyry in Miękinia. Within the project, the building has been completely redesigned, achieving energy-efficient building characteristics and the needs for the RES laboratory. Realization of the project will represent the first element of revitalization planned by the Krzeszowice commune and the AGH University of Science and Technology in Kraków

The AGH-UST Educational and Research Laboratory of Renewable Energy Sources and Energy Saving is equipped (Fig.2-4) with didactic and research stands of heat pumps and solar collectors, photovoltaic installations, small wind turbine, biomass and biofuels installations, boreholes heat exchangers, TRT equipment and building management system as well as mobile exposition of RES facilities (BUS OZE).

In the Laboratory 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 in active way - using the compressor. Research on efficiency of compressor heat pumps as well as thermal parameters of the soil using a Thermal Response Test device was launched.

The laboratory represents a site of practical courses for students from different faculties of AGH-UST and other universities and schools, syllabuses of which concern problems of environment protection. Activity of the Laboratory allow to increase exchange rate of students from AGH-UST and other universities from Europe. Practical use of up-to-date technologies in RES causes improvement of conditions for professional study, allowing to improve professional qualifications through supplying with modern technical and didactic equipment.

Apart from the activity directed to students' needs, the laboratory plays informative and consultative role in the fields of renewable energy sources and energy conservation for people interested in this subject.



**Figure 1: The building of the AGH-UST Educational and Research Laboratory of Renewable Energy Sources and Energy Saving in Miękinia.**



**Figure 2: Research installation with heat pumps.**



**Figure 3: A laboratory room of RES with demonstrative models of the devices.**



**Figure 4: Didactic and research stands of heat pumps.**

### 3. CONCLUSIONS

Geothermal energy is one of ecological and renewable energy sources, available and prospective for practical use in many areas of Poland. The growing interest in renewable energy sources in Poland reflected in the interest of young people - students starting university education. Field of study - *Ecological Energy Sources* – created on the Faculty of Geology, Geophysics and Environmental Protection of AGH University of Science and Technology, gives students the opportunity to expand their knowledge in the field of geothermal energy. Students participated in student exchange programs, like FSS and Erasmus+ Programmes, and carried out geothermal projects. All these projects contribute a lot to the education of students and employees and the exchange of experience in the field of geothermal topics.

A unique opportunity to educate students by providing them practical knowledge in the field of renewable energy sources, including geothermal energy, gives also the Laboratory of Renewable Sources and Energy Saving AGH in Miękinia. The laboratory constantly develops the didactic base to meet the requirements of employers, as well as to respond to students' interests.

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