EUBILD-UNAKLIM

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Education and Training

Briefing for lecturers and participants

"Clima-, Environment-, Nature- Protection and Renewable Energy - Professional"

Module M5 – 07
Geothermal Energy,
District Heating and Cooling

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Overview

Curriculum

Module No./Code	M3 - 27
Module Designation	Introduction to Geothermal Energy, District Heating and Cooling
Units of the Module (if applicable)	1: Introduction to Geothermal Energy 2: Introduction to Power Generation and District Heating with geothermal sources 3: Best-Practice and Environmental Impact of Geothermal use in the energy system
Module Content	This module and lectures introduce the participants in the fundamentals and potential of geothermal resources and systems in the energy sectors and systems. By built a general understanding of the resources use and technology approach participants are able to understand the economic and environmental impact of geothermal resources usage in projects with district heating and cooling (small, medium and big scale) and potential for electrical power generation. **Specific topics:** 1: Introduction to Geothermal Energy ● Geology and Earth heat ● Basics of geothermal systems ● Energy reservoirs and energy network ● Investments, operating costs, costs of current production, efficiency ● Case studies and reference installations ● National and international utilisation potentials 2: Introduction to Electrical Power Generation, District Heating and Cooling with geothermal sources Challenges for Electrical Power generation from geothermal sources Concept and Components of District Heating and Cooling Systems Calculation of energy prices and cost effectiveness Case studies and reference installations Local and regional utilisation potentials 3: Best-Practice and Environmental Impact of Geothermal use in the energy system ● Best Practice in the World experiences of geothermal water end energy utilization ● Ecological and life cycle analysis ● Environmental Impact of geothermal exploration ● Environmental Impact of Geothermal energy utilisation ● Environmental Impact of District Heating and Cooling Projects ● Environmental Impact of Geothermal water utilisation

Qualification Goals	The learning goal is to train the participants to understand and implement current technical concepts of the geothermal use in energy concepts and solution. They are able to achieve commerciality while meeting legal, social and environmental challenges from the aspect of geothermal resources and use it in the local and regional matter. The lectures want to build an understanding of: • Basic concepts of exploration and use of geothermal resources, the characterisation of geothermal reservoirs and the production of heat and power; • Integrated management techniques to deliver a geothermal energy project; • Present and future potential of geothermal energy in the global and regional energy resource portfolio. • Electricity generation, district heating and cooling concepts, projects and best-practise • Environmental aspects of geothermal water and energy utilisation.
Planning period	5th month
Module Duration	4 day`s
Module Frequency	On Requirement
Number of Assigned ECTS Credits	1
Total Workload and Type (individual studies + contact hours)	32 hours (Contact hours 16 h = 50%)
Type of Lecture (compulsory, elective, etc.)	Compulsory
Usability of the Module for Other Study Programs	none
Enrolment Prerequisites	lecture in M1 and M3 – 21 Introduction to Energy Distribution and M3 - 23 Introduction to Solarthermal Energy and Storage must have been completed and passed
Responsible Coordinator	Program Director
Name of the Lecturer	NN
Teaching Language	English/German/Hungarian/Polish/ Romanian
Testing Category / Requirements for Credit Award	Participation and study report
Contribution to Final Grade	2,1%
Teaching and Learning Methods of the Module	• Practice-oriented lecturer input • Active participation by the participants through discussion and contributions • Completing exercises and writing an study report
Special Features (e.g. share of distance learning, field trips, guest lectures, etc.)	Field trip to an geothermal electrical power plant and/or district heating systems and/or balneothermal

	center with geothermal water use in the region
Literature (compulsory reading/additional literature)	Relevant articles and cases will be handed out by the lecturer during the lectures. Recommended literature: Mary H. Dickson and Mario Fanelli; Geothermal energy: utilization and technology; UNESCO Publishing by John Wiley & Sons; 1995 William E. Glassley; Geothermal Energy: Renewable Energy and the Environment, Second Edition; 2014, CRC Press; ISBN-13: 9781482221749 Ingrid Stober, Kurt Bucher; Geothermal Energy: From Theoretical Models to Exploration and Development; 2013; Springer Verlag Colin Harvey, Graeme Beardsmore. Inga Moeck and Horst Rüter; Geothermal Exploration - Global Strategies and Applications; 2016; IGA Academy Books; ISBN: 978-3-9818045-0-8 Billy C. Langley; Heat Pump Technology 3rd Edition; 2001, Pearson; ISBN: 978-0130339652 Keith E. Herold; Absorption Chillers and Heat Pumps; 2016, Productivity Press; ISBN: 9781498714341 Jay Egg; Geothermal HVAC: Green Heating and Cooling; 2010, McGraw-Hill Education ISBN: 9780071746106 Marc A. Rosen, Seama Koohi-Fayegh; Geothermal Energy: Sustainable Heating and Cooling Using the Ground; 2017; John Wiley & Sons Inc.; ISBN: 9781119180982 Sven Werner; International review of district heating and cooling; Science direct https://www.sciencedirect.com/science/article/pii/S0360544421730614X Dietrich Schmidt, Anna Kallert, Markus Blesl; Sven Svendsen, Hongwei Li, Natasa Nord, Kari Sipilä; Low Temperature District Heating for Future Energy Systems; https://www.sciencedirect.com/science/article/pii/S1876610217322592 Dietrich Schmidt, Anna Kallert, Janybek Orozaliev, Isabelle Best, Klaus Vajen, Oliver Reul, Jochen Bennewitz, Petra Gerhold; Development of an Innovative Low Temperature Heat Supply Concept for a New Housing Area; Energy Procedia, Volume 116, 2017, pp. 39-47 District Energy in Cities: Unlocking the Potential of Energy Efficiency and Renewable Energy;

	www.unep.org/energy/des Bundschuh J. (ed.), Tomaszewska B (ed.); Geothermal Water Management; 2018; CRC Press Taylor&Francis Group https://www.crcpress.com/Geothermal-Water-Management/Bundschuh-Tomaszewska/p/book/9781138749009

Lecture 1: Introduction to Geothermal Energy

The aim of the lecture is to introduce basic information in the field of geothermal energy, with particular emphasis on circulation of geothermal waters in nature and the way of using energy and geothermal waters. Knowledge on the selected methods for identifying, sharing and using geothermal resources will be provided.

1. Geology and Earth heat

Fundamental principles of geology and hydrology, heat flow mechanisms.

2. Basics of geothermal systems

Basic definitions on geothermal energy. Basic geological description of favourable conditions for different types of geothermal deposits occurrence. Basic concepts related to geothermic (a thermal gradient of the Earth, and the geothermal degree, geothermal water and steam deposits). High-temperature and low-temperature geothermal resources and conditions of their occurrence. Sources of heat in the Earth's crust and the processes responsible for the heat flow.

Basic methods of geothermal energy utilization – direct utilization, geothermal heat pumps (GHP), ground source or ground coupled heat pumps (GSHP or GCH) and binary fluid generators for electrical use and electricity production.

Methods of geothermal deposits exploitation.
The technologies performing geothermal wells (vertical, directional, horizontal).
Methods of water production for geothermal using.
The disposal of geothermal fluids.

General characteristic of geothermal systems in the world and in the selected locations (Poland, Germany, Hungary, Romania).

3. Energy reservoirs and energy network

Methods for assessment of geothermal resources and reserves.
Examples of classifications of geothermal resources types.
Methodology of the assessment – Factors affecting aquifers, and geothermal resources.
Review of computer modelling techniques useful in geothermal resources prospecting and assessment.

4. Investments, operating costs, costs of current production, efficiency

Geological and economic aspects of extraction using deep hole drilling (drilling costs, performance, temperature, mineralization, the chemical composition of the waters, etc.).
Economic viability of the construction of geothermal installations.
Regulations, financial incentive measures for geothermal development,
Geothermal Risk and Risk Guarantee Founds – challenges and opportunities.

5. National and international utilisation potentials

Utilisation of geothermal waters in balneotherapy and recreation.
Basic concepts of balneotherapy.
Factors enabling the use of the waters for medicinal and recreational objectives (e.g. temperature, mineralization, chemical composition).
Recreation and balneotheraphy centres in Poland / Hungary / Germany / Romania, other Europa and in the world.

6. Case studies and reference installations

Geothermal waters and energy in Poland or Hungary or Germany or Romania as place of origin by the participants – examples

Poland case studies: Podhale region, Polish Lowlands (Mszczonów, Pyrzyce, Poddębice, Uniejów)

Germany case studies (Neustadt-Glewe, : Waren und andere siehe https://de.wikipedia.org/wiki/Liste_von_Geothermiekraftwerken_in_Deutschland)

Romania case studies: (Oradea)

Hungary case studies: (Miszkolec, Tura)

Duration for lecture 1 – 5 hours

Exercises – 3 hours

Exercises for example could concern the development of case studies for selected regions (point 6)

Lecture 2: Introduction to Electrical Power Generation, District Heating and Cooling with geothermal use

The aim of the lecture is to introduce basic information in the field of electricity production, heat production and cooling from geothermal resources.

1. **Power generation from geothermal sources**
   Worldwide overview of geothermal electrical power generation
   Introduction to electrical power generation with geothermal use
   Review of high and low temperature technology

2. **Concept and Components of District Heating and Cooling Systems**
   Overview of heating systems, components, influences, cooperation
   Geothermal – the characteristics of energy source
   Geothermal as the heating source component
   Optimization of geothermal heating system (hybrid energy sources, cascade energy use, heat pumps)
   Geothermal cooling

3. **Combine heat and electrical power generation, polygeneration**
   Combine heat and electrical power,
   combine heat, electrical power and cooling

4. **Calculation of energy prices and cost effectiveness**
   Wide utilisation of geothermal products (energy, water and others) – overview and case studies

5. **Case studies and reference installations**

   Turawell Project Orka – Hungary
   Podhale Region and Mszczonów Heating Planta – Poland
   Project Oradea - Romania
   Projekt Neustadt-Glewe – Germany

6. **Local and regional utilisation potentials**

   Perspective areas in Poland (local potential, recognition of resources)

Duration for lecture 1 – 6 hours

Exercises – 2 hours

Lecture 3: Best-Practise and Environmental Impact of Geothermal use in our energy system

The first goal of the lecture is to performance the best practices of using geothermal water and energy in different locations over the World. The second aim is to presentation a lot of aspects of geothermal impact on a natural environment and economy. Students will find out about impacts on a natural environment and economy caused by geothermal water exploration and utilisation, geothermal energy utilisation for district heating purposes and for cooling projects.

1. Best Practice in the World experiences of geothermal water end energy utilization

   World and EU examples.
   Legal acts and regulations for geothermal energy and water utilization.

2. Ecological and life cycle analysis

3. Environmental Impact of geothermal exploration

   Impact of geothermal exploration on the environment – exploration work (e.g. geophysics research), drilling, noise, emissions, isolation of aquifer and reservoir levels.

4. Environmental Impact of Geothermal energy utilisation

   Impact of geothermal energy utilization on the environment - reservoir management, distribution, water discharge, long-term exploitation.

   Ecological effect obtained during the exploitation of geothermal energy. Economic profitability and ecological effect.

5. Environmental Impact of District Heating and Cooling Projects

   Costs, plant construction, long-term operation possibilities, pressure in the hole, injection of water.

6. Environmental Impact of Geothermal water utilisation

   Treatment and purification of geothermal waters (Examples of the use of technology; reverse osmosis, ultrafiltration, aeration, deironing and other applied treatment technologies)

Duration for lecture 1 – 5 hours

Exercises – 3 hours

Educational outcomes

Knowledge

- Student knows and explains the basic definitions, concepts and laws used in geothermal energy and knows selected geological methods and heating technologies used in the diagnosis, access and management of energy and geothermal resources.
- Student has the basic knowledge of geology of various geothermal regions and related to them types of geothermal deposits.
- Student is aware of geothermal resources renewability and has basic information on technology of geothermal drillings.
- The student has a basic knowledge of physics and thermal thermodynamics.
- The student has knowledge about the environmental aspects of the use of energy resources.

Skills

- Student is able to analyze the conditions of geothermal waters occurrence and assess their suitability for specific purposes using the literature and materials.
- Student is able to perform simple resource assessments and interpret the results of hydrogeothermal measurements for simple geological situations.
- Student has the ability to extend his knowledge in the field of geothermal energy.
- The student is able to estimate the cost-effectiveness of the application of geothermal energy technology.
- The student is able to collect and analyze relevant data and on their basis determine the impact of exploitation on the environment

Attitudes/Social competences

- Student is aware and understands economic, social and ecological impact of engineering activity in the field of prospecting and exploitation of geothermal deposits.
- Student is aware of necessity to improve professional and personal competences and extending knowledge through self-learning
- Student understands value of research work and can think critical about information from different sources

Guideline for study-report and template

Each student will select a geothermal resource or region in order to prepare a Case study report, due to at the end of the course.

The study report is required to be about 5 pages long (Times New Roman, 12 point font, 1. 5 line spacing), including figures and tables. All report must have a references list.

List of references:

Mary H. Dickson and Mario Fanelli;
Geothermal energy: utilization and technology; UNESCO Publishing by John Wiley & Sons; 1995

William E. Glassley; Geothermal Energy: Renewable Energy and the Environment, Second Edition; 2014, CRC Press; ISBN-13: 9781482221749

Ingrid Stober, Kurt Bucher; Geothermal Energy: From Theoretical Models to Exploration and Development; 2013; Springer Verlag

Colin Harvey, Graeme Beardsmore. Inga Moeck and Horst Rüter; Geothermal Exploration - Global Strategies and Applications; 2016;
IGA Academy Books; ISBN: 978-3-9818045-0-8

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Dietrich Schmidt, Anna Kallert, Markus Blesl; Sven Svendsen, Hongwei Li, Natasa Nord, Kari Sipilä; Low Temperature District Heating for Future Energy Systems;
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Dietrich Schmidt, Anna Kallert, Janybek Orozaliev, Isabelle Best, Klaus Vajen, Oliver Reul, Jochen Bennewitz, Petra Gerhold; Development of an Innovative Low Temperature Heat Supply Concept for a New Housing Area; Energy Procedia, Volume 116, 2017, pp. 39-47

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Lund J., Boyd T.L., 2016 – Direct utilization of geothermal energy 2015 worldwide review. Geothermics, vol. 60, pp. 66-93. https://doi.org/10.1016/j.geothermics.2015.11.004

DiPippo R., 2015 – Geothermal Power Plants: Principles, Applications, Case Studies and Environmental Impact, Butterworth Heinemann, 4th Ed.

For Polish case studies:

Górecki W. (red.), 2006 – Atlas zasobów geotermalnych formacji mezozoicznych i paleozoicznych na Niżu Polskim

Górecki W. (red.), 2011 – Atlas zasobów wód i energii geotermalnej Karpat Zachodnich

Górecki W. (red.), 2013 – Atlas zasobów wód i energii geotermalnej Karpat Wschodnich