



Outline of Local Training schemes
in Geothermal Technologies – Capacity Building



September 2018

Title	Geothermal Energy – Capacity Building
Long Title	Geothermal Energy Exploration/Utilisation – Capacity Building

Level	Intermediate
Field of Study	Geothermal Energy Exploration/Utilisation

Training Program Author	Dr. Sreto Boljevic
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Duration of Training Delivery	24 Weeks
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Training Program Description	<p>Geothermal energy, form of energy conversion in which heat energy from within Earth is captured and harnessed for cooking, bathing, space heating, electrical power generation and other uses. Heat from Earth's is produced mainly by the radioactive decay of potassium, thorium and uranium in Earth's crust and mantle and also by friction generated along the margins of continental plates. The subsequent annual low-grade flow to the surface averages between 50 and 70 milliwatts per square metre worldwide. Geothermal heat energy can be recovered and exploited for human use, and it is available anywhere on the Earth's surface. The estimated energy that can be recovered and utilised on the surface is 45×10^6 exajoules, or about 1.4×10^6 terawatt per years, which equates to roughly three times the world's annual consumption of all types of energy. The amount of usable energy from geothermal sources varies with depth and by extraction method. Geothermal energy use can be divided into three categories: direct use applications, geothermal heat pumps (GHPs) and electric power generations.</p>
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Learning Outcomes:

LO1	Describe the Geothermal Energy Exploration/Utilisation and the resource characterisation.
LO2	Describe the Geothermal Energy Resources and Resources Assessment.
LO3	Describe the Borehole Heat Exchanger operational principles and application regarding the Geothermal Energy Exploration.
LO4	Describe the Ground Heat Exchanger operational principles and application regarding the Geothermal Energy Exploration.
LO5	Horizontal Ground Heat Exchanger operational principles and application regarding the Geothermal Energy Exploration.
LO6	Describe Surface Water Heat Exchanger Systems operational principles and application regarding the Geothermal Energy Exploration.
LO7	Describe Opportunistic Heat Source and Sinks regarding the Geothermal Energy Exploration/Utilisation.
LO8	Describe Geothermal Energy Conversion - Heat Pumps and Heat Engines: A Thermodynamic Overview'
LO9	Describe Direct Use of Geothermal Resources.
L10	Describe Low Temperature Geothermal Resources – Ground Source Heat Pumps.
L11	Describe Generating Power Using Geothermal Resources.
L12	Describe Environmental Impact of Geothermal Energy Exploration/Utilisation.
L13	Describe Environmental Impact of Geothermal Energy Exploration/Utilisation.
L14	Visualise Possibilities and Issues associated with the Geothermal Energy Future Exploration/Utilisation.

Indicative Content:

LO1	General understanding of Geothermal Energy Exploration/Utilisation technology and Geothermal Energy Resources Characterisation regarding the thermal capacity and accessibility to harvest the thermal energy.
LO2	Geothermal resources classification; define resources from systematic perspective with inherent thermal, hydrological and geological features that span the full spectrum of resources types and utilisation practice. Define geophysical, geological and geochemical surveys for evaluation of undiscovered Geothermal resources; possible economics & environmental impact regarding the exploration/utilisation of the geothermal resources.
LO3	Define installation/Operational consideration parameters such as the soil/rock thermal conductivity; borehole thermal resistance; the undistributed earth temperature; the heat extraction (and rejection) rates ; the mass flow rate of the heat carrier fluid; environmental & economic impact.
LO4	Ground Heat Exchanger consideration such as energy density; water well drilling technology; ground water flow rate; ground water quality; water disposal; large/medium/small commercial heat pump system ground heat exchanger system; environmental & economic impact.
LO5	Horizontal heat exchanger orientation; heat transfer of shallow ground heat exchanger coupled to buildings; estimated operational parameters required to adequately size a horizontal ground heat exchanger for a building; sizing ground heat exchanger; large/medium/small commercial heat pump system horizontal ground heat exchanger system ground thermal properties; environmental & economic impact.
LO6	Seasonal Dynamics in Thermal Process on Surface Water Heat Transfer Low-thermal geothermal energy; open loop system; closed loop system; large/medium/small commercial heat pump system; surface water heat exchanger system; environmental & economic impact.
LO7	Heat exchange with building foundations. Utilisation from other energy section; abandon oil and gas wells; Integrated loads and loads sharing with Combined heat & power, solar energy system, district energy system, sewer heat recovery system, Heat Pump energy system; environmental & economic impact of utilisation of opportunistic heat and sinks.
LO8	Heat Pumps and Heat Engines: A Thermodynamic Overview; Carnot Cycle (first/second law efficiency); Entropy and Exergy; Ranking and Brayton cycle; Heat Pump; Heat pump cycles; Refrigeration.
LO9	Direct use of Low-enthalpy resources; Space heating and cooling including district heating; agriculture application; industrial application; aquafarming application; horticulture application; indirect use of geothermal energy; environmental & economic impact.

L10	<p>Low –enthalpy geothermal resources; Availability of low temperature geothermal resources; assessment of low temperature geothermal energy resources; property of low temperature geothermal energy resources; open loop/closed loop low temperature geothermal system; geothermal heat pumps utilised for low temperature geothermal resources</p> <p>Environmental/economic impact of power plants using low-enthalpy resources. Power generation from low enthalpy geothermal resources; sustainability of low enthalpy geothermal system. Industrial/commercial application of low temperature geothermal energy resources; environmental & economic impacts associated with utilisation of low temperature geothermal resources.</p>
L11	<p>Temperature – entropy process; flashing process single/double flash steam power plant; Dry-steam power plants; Binary cycle power plants; advance geothermal conversion system.</p>
L12	<p>Describe Environmental Impact of Geothermal Energy</p> <p>Exploration/Utilisation: greenhouse gases generation/reduction from geothermal energy exploration/utilisation, terrain changes, drilling issue, water issue, cooling the earth.</p>
L13	<p>Define economics concerns such as: payback period; rate of return; present value; life-cycle cost, life – cycle savings; return on investment; cost of geothermal energy system, uncertainty in economic analysis of geothermal energy system.</p>
L14	<p>Visualise Possibilities and Issues associated with the Geothermal Energy Future</p> <p>Exploration/Utilisation include: massive potential; generally considered environmentally friendly; great availability; recent technological advancement; high up front cost; location specific; some minor environmental issue</p>

Workload:

Workload Type	Workload Description	Hours	Frequency	Average Weekly Learner Workload
Lecture	Classroom theory + work examples	6.0	Every Week	6.0
Practical	Practical/Lab/Site demonstration	4.0	Every Week	4.0
Independent & Directed Learning (Non-Contact)	Information research	6.0	Every Week	6.0
Total weekly learner workload				16.0
Total weekly workload contact				10.0

Recommended reading resources:

- 1) Geothermal Heat Pump and Heat Engine Systems Theory and Practice; Andrew D. Chiasson, Ph.D., P.E., P.Eng; John Wiley & Sons Ltd, 2016; ISBN: 9781118961971.
- 2) Low – Enthalpy Geothermal Resources for Power Generation; D. Chandrasekhara, Jocher Bundschuh; CRC Press, 2008; ISBN: 978-0-415-40168-5.
- 3) Geothermal Energy Systems – Exploration, Development and Utilisation; Edited by Ernest Huenges, Partick Ledru; Wiley VCH, 2010; ISBN:978-3-527-40831-3
- 4) Sustainable Energy Production and Consumption – Benefits, strategies and environmental costing; Edited by Frano Barbir, Sergio Ulgiati; Springer, 2007; ISBN 978-1-4020-8492-8
- 5) Geotheramal HVAC – Green heating and cooling
Jay Egg, Brian Clark Howard; Mc Graw Hill, 2011;
ISBN: 978-0-07-174611-3.

Supplementary reading resources:

- 1) Geothermal Energy – An Alternative Resources For 21st Century; Harsh Gupta and Sukanta Roy; Elsevier 2007; ISBN-13 978-0-444-52875-9.
- 2) Geothermal Energy resources for Developing Countries; D. Chandrasekharam, J. Bundschuh; Sweets & Zeitlinger Publisher; ISBN:905809 5223

Assessment Breakdown:	%
Continuous Assessment: Learning Outcome Address: 1-14	20.00%
End Training Program Examination: Learning Outcome Address: 1-14	40.00%
Practical assessment Learning Outcomes Address: 3-10	40.00%