



UNITED NATIONS
UNIVERSITY



GEOTHERMAL TRAINING PROGRAMME

Mar. 19, 2014 /IGH-LSG-ÁR-BS-PV-JLH-EdV

**SHORT COURSE ON UTILIZATION OF LOW- AND MEDIUM-
ENTHALPY GEOTHERMAL RESOURCES AND
FINANCIAL ASPECTS OF UTILIZATION**

**Organized by UNU-GTP and LaGeo,
held in El Salvador during March 23rd – March 29th, 2014**

SUNDAY, 23 March

Participants and trainers arrive in El Salvador and register into a hotel.

18:30-22:00 *Opening dinner at Mezzanine of Hilton Hotel*

MONDAY, 24 March

08:30-09:00 **Registration**

09:00-09:20 **Opening ceremony – Ing. Jorge Burgos, General Manager of LaGeo**

09:20-09:30 **Aim of the short course – organization and practical matters**

Ingimar G. Haraldsson, UNU-GTP and Evelyn de Velis, LaGeo

Geothermal energy overview – Chairman: Manuel Monterrosa, LaGeo

09:30-10:15 **Geothermal energy in the world and UNU-GTP capacity building activities**

Lúdvík S. Georgsson, *Ingimar G. Haraldsson*, and Ingvar B. Fridleifsson, UNU-GTP

10:15-10:45 *Coffee break*

10:45-11:30 **Current status of geothermal resources development in Central America**

Francisco Montalvo, LaGeo

11:30-12:00 **Geothermal activity and development in Mexico – Keeping the production going**

Magaly Flores-Armenta, *Miguel Ramírez-Montes*, and Lilibeth Morales-Alcalá, CFE

12:00-12:30 **A Caribbean geothermal success story**

Anelda Maynard-Date and Alexis George, NEVLEC

12:30-14:00 *Lunch*

Session continued – Chairman: Ingimar G. Haraldsson, UNU-GTP

14:00-14:20 **Geothermal development in Bolivia**

Daniel Villarroel, *Danny Rivera and Pedro Ramos*, ENDE

14:20-14:40 **Geothermal development in Chile**

Daniel Almarza, CER

14:40-15:00 **Geothermal development in Colombia**

Elíana Mejía, Lorena Rayo, Javier Méndez, and Julian Echeverri, ISAGEN

15:00-15:20 **Geothermal development in Ecuador: History, current status and future**

Andrés Lloret and Jerko Labus, INER

15:20-15:40 **Development of geothermal energy and factors that affect its utilization in Peru**

Alcides Claros, MEM

15:40-16:10 *Coffee break*

Regional cooperation and capacity building – Chairman: Ingimar G. Haraldsson, UNU-GTP

16:10-16:40 **Regional Geothermal Training Programme at the University of El Salvador**

Evelyn de Velis, LaGeo

- 16:40-17:00 **Regional Geothermal Office for Central America**
Francisco Montalvo, LaGeo
- 17:00-17:30 **Discussion**
Francisco Montalvo, LaGeo and Ingimar G. Haraldsson, UNU-GTP

TUESDAY, 25 March

The principles of medium enthalpy geothermal power plants – Chairman: Miguel Ramírez-Montes, CFE

- 09:00-09:30 **Geothermal power plants**
Einar T. Eliasson, Sverrir Thorhallsson, and Benedikt Steingrímsson, ÍSOR
- 09:30-10:00 **Thermodynamics of power production cycles**
Páll Valdimarsson, Reykjavik University / Atlas Copco
- 10:00-10:30 **Binary power production cycles**
Páll Valdimarsson, Reykjavik University / Atlas Copco
- 10:30-11:00 *Coffee break*

Binary power plants in Latin America – Chairman: Miguel Ramírez-Montes, CFE

- 11:00-11:30 **Geothermal binary cycle power plants – Principles, operation and maintenance: Case study from El Salvador**
Angel Monroy and Godofredo López, LaGeo
- 11:30-12:00 **Geothermal energy: Current situation in Costa Rica**
Jessica Arias, Dione Barahona, and Lizeth Valverde, ICE
- 12:00-12:30 **Experience with low enthalpy geothermal projects in Mexico**
Ignacio Raygadas, CFE
- 12:30-14:00 *Lunch*

Design considerations for medium enthalpy geothermal power plants – Chairman: Thorleikur Jóhannesson, VERKÍS

- 14:00-14:30 **Piping design for geothermal projects**
José Luis Henriquez and Luis Aguirre, LaGeo
- 14:30-15:00 **Design of binary plant components**
Páll Valdimarsson, Reykjavik University / Atlas Copco
- 15:00-15:30 **Exergy and thermoeconomics**
Páll Valdimarsson, Reykjavik University / Atlas Copco
- 15:30-16:00 *Coffee break*
- 16:00-16:30 **Problems in geothermal operation – Scaling and corrosion**
Einar Gunnlaugsson, Reykjavik Energy, Halldór Ármannsson, Sverrir Thorhallsson, and Benedikt Steingrímsson, ÍSOR
- 16:30-17:30 **Practical examples and discussion**
Páll Valdimarsson, Reykjavik University / Atlas Copco and José Luis Henriquez, LaGeo

WEDNESDAY, 26 March

Direct utilization of low- and medium-enthalpy geothermal resources – Chairman: Benedikt Steingrímsson, ÍSOR

- 09:00-09:20 **Direct use of geothermal resources**
Thorleikur Jóhannesson and Carine Chatenay, VERKÍS
- 09:20-10:10 **Utilization of geothermal resources for space heating**
Carine Chatenay, Halldóra Gudmundsdóttir, and Thorleikur Jóhannesson, VERKÍS
- 10:10-10:30 **Geothermal baths, swimming pools and spas: Examples from Ecuador and Iceland**
Ingimar G. Haraldsson, UNU-GTP and Andrés Lloret, INER
- 10:30-11:00 *Coffee break*

- 11:00-11:30 **Geothermal energy in horticulture**
 Árni Ragnarsson, ÍSOR, Magnús Ágústsson, Icelandic Agricultural Advisory Center,
 Martha Mburu and *Paul K. Ngugi*, GDC, *Thorleikur Jóhannesson*, VERKÍS
- 11:30-12:00 **Geothermal energy in aquaculture**
 Árni Ragnarsson, ÍSOR and *Thorleikur Jóhannesson*, VERKÍS
- 12:00-12:30 **Industrial applications of geothermal resources**
Thorleikur Jóhannesson and Carine Chatenay, VERKÍS
- 12:30-14:00 *Lunch*

Session continued – Chairman: Paul K. Ngugi, GDC

- 14:00-14:30 **District heat distribution networks**
Páll Valdimarsson, Reykjavik University / Atlas Copco
- 14:30-15:00 **Heat pumps and geothermal space cooling**
Thorleikur Jóhannesson and Carine Chatenay, VERKÍS
- 15:00-15:30 **Hybrid power plant using three energy resources at the San Vicente geothermal field, El Salvador**
 Caleb Nájera, *Álvaro Flamenco*, and Salvador Handal, LaGeo
- 15:30-16:00 *Coffee break*
- 16:00-16:30 **Geothermal direct applications in Central America and Mexico**
René Recinos, LaGEO
- 16:30-17:30 **Discussion**
Thorleikur Jóhannesson, VERKÍS

THURSDAY, 27 March

Field trip to Berlin binary cycle power plant and direct utilization sites.

FRIDAY, 28 March

Financial aspects of geothermal development – Chairman: José Luis Henríquez, LaGeo

- 09:00-09:45 **Phases of geothermal development in Iceland: From a hot spring to utilization**
Benedikt Steingrímsson, ÍSOR
- 09:45-10:15 **Geothermal exploration and associated cost in Iceland**
 Bjarni Richter, *Benedikt Steingrímsson*, Magnús Ólafsson, and Ragna Karlsdóttir, ÍSOR
- 10:15-10:45 **EIA and permitting: Time and cost considerations**
Ana Silvia de Arévalo, LaGeo
- 10:45-11:15 *Coffee break*
- 11:15-11:45 **Geothermal drilling: The price of reaching the resource**
Miguel Ramírez-Montes and Magaly Flores-Armenta, CFE
- 11:45-12:15 **Geothermal power plants: Procurement and construction**
Páll Valdimarsson, Reykjavik University / Atlas Copco
- 12:15-12:45 **Operation, maintenance and monitoring: Manpower and material needs of Ahuachapan power plant, El Salvador**
Godofredo López, LaGeo
- 12:45-14:00 *Lunch*

Session continued – Chairman: Páll Valdimarsson, Reykjavik University / Atlas Copco

- 14:00-14:20 **Electricity markets**
Carlos Guzmán, LaGeo
- 14:20-14:40 **Government incentives and international support for geothermal project development**
Ingimar G. Haraldsson, UNU-GTP
- 14:40-15:00 **From carbon financing in the context of geothermal development towards adaptation to climate change**
Luis Franco, LaGeo

- 15:00-15:20 **Cost and revenues of direct use applications**
Carine Chatenay and Thorleikur Jóhannesson, VERKÍŚ
- 15:20-15:50 *Coffee break*

Financial modelling of geothermal projects – Chairman: Páll Valdimarsson Reykjavik University / Atlas Copco

- 15:50-16:50 **Financial modelling of geothermal power projects**
Paul K. Ngugi, GDC
- 16:50-17:30 **Discussion**
Paul K. Ngugi, GDC, José Luis Henríquez, LaGeo, and Benedikt Steingrímsson, ÍSOR

SATURDAY, 29 March

Financing geothermal projects – Chairman: Anelda Maynard-Date, NEVLEC

- 09:00-09:30 **Risks and risk mitigation in geothermal development**
Paul K. Ngugi, GDC
- 09:30-10:00 **Feasibility study: Cost estimation for geothermal development**
José Roberto Estévez, LaGeo
- 10:00-10:20 **Financing geothermal projects**
Migara Jayawardena, World Bank
- 10:20-10:40 **Bankable geothermal project documents**
Paul K. Ngugi, GDC
- 10:40-11:10 *Coffee break*

Comparisons and large scale considerations – Chairman: Ana Silvia de Arévalo, LaGeo

- 11:10-11:30 **How do financial aspects of geothermal compare with other energy sources?**
Carine Chatenay and Thorleikur Jóhannesson, VERKÍŚ
- 11:30-11:50 **Economic benefits of geothermal space heating from the perspective of Icelandic consumers**
Ingimar G. Haraldsson, UNU-GTP
- 11:50-13:00 *Lunch*

Review and discussion – Chairman: Ana Silvia de Arévalo, LaGeo

- 13:00-13:30 **Review** (Instructors and Trainees)
- 13:30-14:00 **Discussion and recommendations**
- 14:00-14:30 *Coffee break*

Conclusions and closing remarks – Chairman: Ingimar G. Haraldsson, UNU-GTP

- 14:30-15:00 **Summary of the discussion, conclusions, and recommendations**
- 15:00-16:00 **Final closing ceremony**
- 16:00-16:30 *Course assessment and next steps in training courses for Central America Meeting and review by instructors*
- 19:00-21:00 *Closing cocktail hosted by LaGeo at Hilton Hotel.*

SUNDAY, 30 March

All guests depart from San Salvador for their home countries.