

SHORT COURSE ON GEOTHERMAL EXPLORATION AND DEVELOPMENT

**Organized by OAS and UNU-GTP in cooperation with LaGeo S.V. de C.V.
in El Salvador, 7th-12th November, 2011, at LaGeo's headquarters in San Salvador**

International lecturers: *Ingimar G. Haraldsson, UNU-GTP, Benedikt Steingrímsson and Árni Ragnarsson, ÍSOR – Iceland GeoSurvey, and Páll Valdimarsson, UI - University of Iceland*

Local lecturers from LaGeo: *Francisco E. Montalvo, Jorge Burgos, Pedro Santos, Manuel Monterrosa, José Luis Henriquez, Godofredo López, Ana Silvia de Arevalo, Arturo Quezada, Luz Barrios, Ruben Loy, Luis Franco, and Carlos Guzman*

SUNDAY, 6 NOVEMBER

Participants and trainers arrive in El Salvador and register into the Holiday Inn Hotel.

20:30-22:00 *Opening dinner hosted by LaGeo.*

MONDAY, 7 NOVEMBER

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

08:30-09:00 **Welcome ceremony – aim of the short course, organization and practical matters**

Dr. Ronalth Ocaheta, Representative of OAS in El Salvador

Ms. Mari Carmen Aponte, Ambassador of United States to El Salvador

Mr. Ingimar G. Haraldsson, UNU-GTP

Geothermal energy overview – Chairman: Árni Ragnarsson, ÍSOR

09:00-10:00 **Geothermal energy in the world with special reference to Latin America**

Ingimar G. Haraldsson, UNU-GTP

10:00-11:00 **Geothermal systems in global perspective**

Benedikt Steingrímsson, ÍSOR

11:00-11:15 *Coffee break*

11:15-12:00 **Geothermal activity and development in S-America**

Ingimar G. Haraldsson, UNU-GTP

12:00-13:00 **Current status of geothermal resources development in Central America**

Francisco E. Montalvo, LaGeo

13:00-14:00 *Lunch*

Session continued – Chairman: Árni Ragnarsson, ÍSOR

14:00-15:00 **Short presentations by the S-American participating nations on the status of geothermal development in their countries and future plans**

Participants from Colombia, Ecuador and Peru

Geothermal project planning – Chairman: Ingimar Gudni Haraldsson, UNU-GTP

15:00-16:00 **Phases of geothermal development in Iceland**

Benedikt Steingrímsson, ÍSOR

16:00-16:15 *Coffee break*

16:15-17:00 **Geothermal project planning in El Salvador**

Jorge Burgos, LaGeo

TUESDAY, 8 NOVEMBER**Geoscientific geothermal exploration and drilling – Chairman: Páll Valdimarsson, UI**

- 08:30-09:30 **Geothermal exploration and development – from a hot spring to utilization**
Benedikt Steingrímsson, ÍSOR
- 09:30-10:15 **Introduction to geothermal surface exploration methods**
Benedikt Steingrímsson, ÍSOR
- 10:15-10:30 *Coffee break*
- 10:30-11:15 **Geothermal drilling and well design**
Benedikt Steingrímsson, ÍSOR
- 11:15-12:00 **Introduction to subsurface geothermal exploration**
Benedikt Steingrímsson, UNU-GTP
- 12:00-13:00 **Case example – Exploration of the Berlin geothermal field, El Salvador**
Pedro Santos, LaGeo
- 13:00-14:00 *Lunch*

Session Continued – Chairman: Ingimar Haraldsson, UNU-GTP

- 14:00-14:30 **Introduction to field monitoring and management**
Benedikt Steingrímsson, ÍSOR
- 14:30-15:00 **Field monitoring and management, the Berlin geothermal case**
Anibal Rodríguez, LaGeo
- 15:00-16:00 **Introduction to resource assessment – volumetric assessment, computer modelling and simulations**
Benedikt Steingrímsson, ÍSOR
- 16:00-16:15 *Coffee break*
- 16:15-17:30 **Case examples and practical session**
Benedikt Steingrímsson, ÍSOR, and Manuel Monterrosa, LaGeo

WEDNESDAY, 9 NOVEMBER**Power generation and direct use of geothermal energy –
Chairman: Benedikt Steingrímsson, ÍSOR**

- 08:30-09:00 **Introduction to geothermal power plants**
Benedikt Steingrímsson, ÍSOR
- 09:00-10:00 **Thermodynamics of geothermal power production**
Páll Valdimarsson, UI
- 10:00-11:00 **Steam cycles and main components for geothermal power production**
Páll Valdimarsson, UI
- 11:00-11:15 *Coffee break*
- 11:15-11:45 **Piping design: the fundamentals**
José Luis Henriquez, LaGeo
- 11:45-12:30 **Binary cycles and main components for geothermal power production**
Páll Valdimarsson, UI
- 12:30-13:00 **Operation and maintenance of a geothermal power plant, the Ahuachapan power plant, El Salvador**
Godofredo López, LaGeo
- 13:00-14:00 *Lunch*

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

- 14:00-14:45 **Thermoeconomics – striving for optimum component size, efficiency and economic operation**
Páll Valdimarsson, UI
- 14:45-15:30 **Direct use of geothermal – Lindal diagram, heating systems, heat pumps for heating and cooling, drying, cascaded use**
Árni Ragnarsson, ÍSOR
- 15:30-15:45 *Coffee break*
- 15:45-17:15 **Group work and discussion on selection of geothermal power plants**
Páll Valdimarsson, UI, Árni Ragnarsson, ÍSOR
and *José Luis Henriquez, LaGeo*

THURSDAY, 10 NOVEMBER**Session continued – Chairman: Ingimar G. Haraldsson, UNU-GTP**

- 08:30-09:30 **Direct use of geothermal – greenhouses, fish farming, swimming pools, spas, etc.**
Árni Ragnarsson, ÍSOR

Environmental impact of geothermal activity – Chairman: Árni Ragnarsson

- 09:30-10:30 **Environmental Impact Assessment of geothermal projects in El Salvador**
Ana Silvia de Arevalo, LaGeo
- 10:30-10:45 *Coffee break*
- 10:45-11:30 **EIA – The Hellisheidi geothermal project in Iceland**
Ingimar G. Haraldsson, UNU-GTP
- 11:30-12:15 **Geotechnical aspects and geological hazards in geothermal areas, the El Salvador experience**
Arturo Quezada, LaGeo
- 12:15-13:00 **Environmental aspects of geothermal development in Tecapa – San Miguel Conservation area**
Ana Silvia de Arevalo, LaGeo
- 13:00-14:00 *Lunch*

Session continued – Chairman: Benedikt Steingrímsson, ÍSOR

- 14:00-14:30 **Environmental monitoring of geothermal power plants in operation**
Ingimar G. Haraldsson, UNU-GTP
- 14:30-15:00 **The Clean Development Mechanism from the geothermal perspective**
Ingimar G. Haraldsson, UNU-GTP
- 15:00-15:45 **CDM experience in El Salvador: Case study of two power units in Berlin geothermal field**
Ruben Loy / Luis Franco, LaGeo
- 15:45-16:00 *Coffee break*
- 16:00-17:15 **General discussion on environmental issues associated with geothermal development**
Ana Silvia de Arevalo, LaGeo and Ingimar G. Haraldsson, UNU-GTP

FRIDAY, 11 NOVEMBER

Field trip to Berlin geothermal field and power plant, under the guidance of *Ana Silvia de Arevalo* and *Luz Barrios*, LaGeo. Departure is at 07:00 from the hotel.

SATURDAY, 12 NOVEMBER**Geothermal law and regulatory framework – Chairman: Páll Valdimarsson, UI**

- 08:30-09:15 **Technical aspects to be considered for geothermal law and governmental regulations for geothermal development**
Árni Ragnarsson, ÍSOR
- 09:15-10:00 **Geothermal law and regulations in Iceland**
Árni Ragnarsson, ÍSOR
- 10:00-10:45 **Geothermal law and regulations in El Salvador**
Carlos Guzman, LaGeo
- 10:45-11:00 *Coffee break*
- 11:00-12:00 **Status of geothermal law and regulatory framework in the S-American participating countries**
Participants from Colombia, Ecuador and Peru
- 12:00-13:00 **Discussion on the status in the participating countries**
Árni Ragnarsson, ÍSOR, Ingimar G. Haraldsson, UNU-GTP and Carlos Guzman, LaGeo
- 13:00-14:00 *Lunch*

Session continued – Chairman: Páll Valdimarsson, UI

- 14:00-15:00 **Energy usage and policy of Iceland – the energy master plan**
Árni Ragnarsson and Benedikt Steingrímsson, ÍSOR

Course review and final closing ceremony –**Chairmen: Ingimar G. Haraldsson, UNU-GTP, and Rogelio Sotela, OAS**

- 15:00-16:00 **Review, discussion and recommendations**
Trainers and participants
- 16:00-16:15 *Coffee break*
- 16:15-16:45 **Summary and conclusions**
Ingimar G. Haraldsson, UNU-GTP and Rogelio Sotela, OAS
- 16:45-17:15 **Final closing ceremony**
Ingimar G. Haraldsson, UNU-GTP and Rogelio Sotela, OAS
- 17:30-19:00 *Closing cocktail at LaGeo hosted by LaGeo*

SUNDAY, 13 NOVEMBER

All guests depart from San Salvador for their home countries.