Costa Rica:
Geothermal Energy

Its own sustainability model

GRUPO ICE

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Content

A Visionary Model

Science, technique, and experience allow natural resources exploitation to meet development demands. However, these resources must be rationally used to guarantee quality of life for the next generations.

The Costa Rican Institute of Electricity (ICE) was born in 1949 thanks to this philosophy. As a public institution, ICE was required by Law to guarantee the provision of energy for the country while keeping the sources.

The route was traced from that moment, creating a particular model with a national vision. Today, Costa Rica stands out in Latin America as a leader on clean energies, thanks to its energy matrix based mainly on hydropower.

The first works took advantage of water from river basins. Later on, some projects based on other clean energies such as Earth heat, wind force, and biomass joined the matrix.

This publication highlights one of these distinctive features of our energy matrix: Geothermal energy.

It reviews how, starting in the 60s, ICE developed a continuous research, analysis, human resources training, and construction work that today, places Costa Rica on the Geothermal energy production global elite.

All ICE achievements have respected the ethical principle in our founding charter of keeping nature balance. ICE's current geothermal projects and the ones in the future will maintain this principle.

As the world continuous, here, in Costa Rica, we have forged a road over more than 70 years building a forefront company in power generation; all this in harmony with the environment.

Power Development Based on Clean Energies

- After seven decades of tireless work from ICE, the national power coverage reached from 14% in 1949 to almost 100% in the present. Ninety three percent of the power provided for the country comes from clean sources.

Costa Rica stands out thanks to its electric development based on renewable sources. It has been the engine of progress, boosting protection and conservation of natural resources in the country.

The Electrical Development Planning in Costa Rica is in the hands of the Costa Rican Institute of Electricity (ICE), a government company created in 1949.

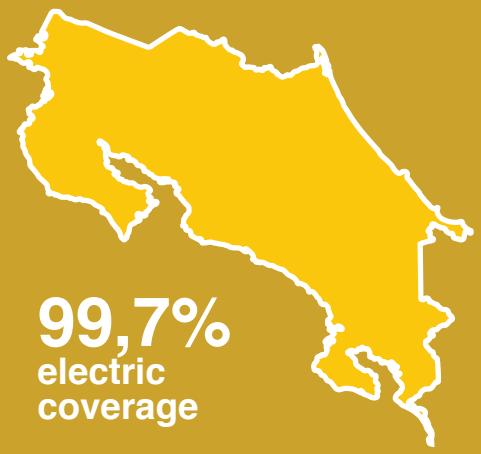
Sound planning and project successful development has allowed high quality and confident power supply.

Electric coverage reaches 99.7%, and 93% of the power generation comes from clean sources.

The main contribution in power generation comes from hydropower plants, followed by geothermal, wind, biomass, and solar plants.

Thermal power (fossil fuels) backs up the grid and imports substitute thermal generation when they are cheaper for the electric grid.

The environmental dimension is an important part in the process of planning, assessing, and selecting the best option for power project development in the country. Besides, the relationship with all stakeholders is permanent and close from the early stages of work conceptualization.



99,7%
electric coverage

ICE is responsible by law of ensuring power supply for the Costa Rican population. ICE also generates 74.6% of the power in the country. The Compañía Nacional de Fuerza y Luz (a company that belongs to ICE group), produces 3.4 %; the power cooperatives and public service companies generate 5.8%, and the private generators 16.2 %.

Leading clean energy

According to the "Clean energies leadership" report that analyzed 26 nations performance on clean energies, Costa Rica has an energy matrix based mainly on hydropower and seeks to depend only on renewable sources.

On this study, Costa Rica was ranked on the first place thanks to its efforts to diversify its sources of energy and bet for other renewable sources besides hydropower.

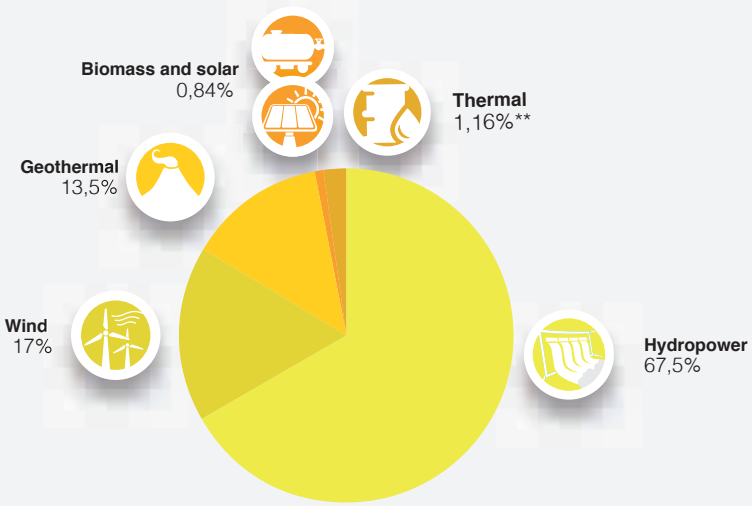
Costa Rica has one of the highest potentials to generate geothermal energy in the region: up to 2,135 MW are available for exploitation.

Thanks to its geographical position, Costa Rica possesses excellent potential for wind power generation with a speed that range between 4.8 and 5.6 m/s.

**** Prepared in November 2014 by the World Wildlife Fund (WWF).***

Our electric grid

Since the 1970's, ICE began a process to diversify the power sources by incorporating geothermal energy. Over the years, other sources have joined the grid. This is how the national electric grid is distributed:



Source: National Center for Energy Control (CENCE), 2019.
Notes: (*) Percentages correspond to the installed capacity in the country.(**) Source of support, that is, used only when the others do not meet the energy demand.

Power from the Bowels of the Earth

- This science studies the thermal state of the Earth, the temperature distribution inside it, and its harnessing as a heat source.

Unlike the rest of renewable energies, which origin, direct or indirect is solar radiation, geothermal energy comes from the Earth's heat that is born in its inner layers and comes up to the earth crust.

This source is located inside the Earth in the form of latent heat and is related to volcanoes, thermal water, fumaroles and geysers.

Even though it represents a huge amount of energy, only a fragment can be used by humanity: this fragment is defined as ***geothermal resources.***

This type of exploitation differs from regular mining because the latter is based on resource extraction and depletion.

Developing countries consider more and more geothermal resources exploitation because of its huge advantages.
How can we use it?

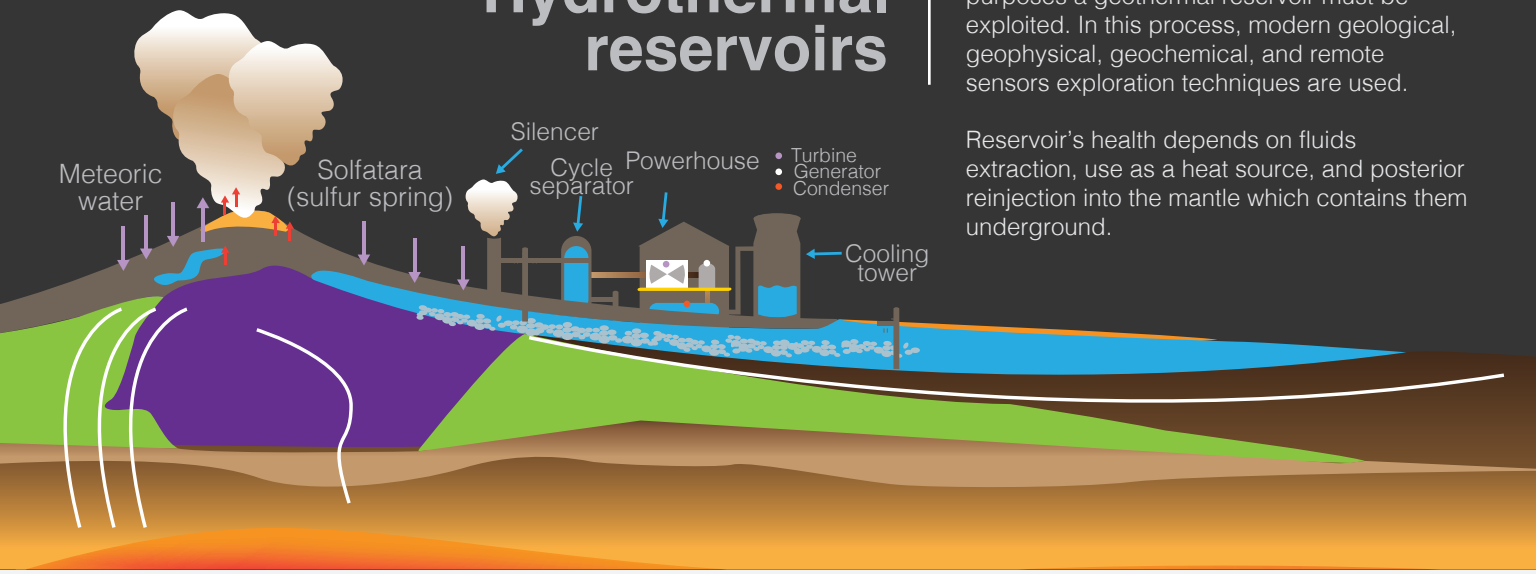
We can harness geothermal resources in:

- Power production when the deposits overpass 150 C.
- Thermal applications for the industry, services, household sectors when the temperature is lower than 100 C.

Hydrothermal reservoirs

To extract heath from the Earth for commercial purposes a geothermal reservoir must be exploited. In this process, modern geological, geophysical, geochemical, and remote sensors exploration techniques are used.

Reservoir's health depends on fluids extraction, use as a heat source, and posterior reinjection into the mantle which contains them underground.



- Use in conditioning and hot water production (resources with temperature under 25 C).

The scientific development on that field give a glimpse of the leading role that this sustainable and environment friendly resource will have because it is not affected by climate conditions and is no solar radiation dependent.

Advantages

Using geothermal energy has numerous advantages such as:

1. It is an almost inexhaustible source of power if it is handle in a sustainable way.
2. It is a clean energy with low levels of sonic and visual pollution.
3. It produces minimal environmental impact. The environmental footprints are punctual and reversible.
4. It has lower generation costs than those of traditional power generation sources, especially thermal.
5. It contributes to the social economic development of nearby communities.
6. It is not climate condition dependent as they are wind, solar and hydropower energies.
7. It contributes to biodiversity enrichment thanks to reforestation and does not pollutes surficial aquifers.
8. It is compatible with other activities such as tourism, livestock, and agriculture and, at the same time, favors forest recovery and preservation.
9. Being an underlying energy, it replaces hydrocarbon energy, which represents important savings for the country.

ICE Proved Expertise in Geothermal Energy

- As part of its continuous efforts to develop renewable sources of energy, in the 70's, ICE began the first studies on geothermal potential for power generation. These studies helped to find nine vast sites in the northern province of Guanacaste.

Aware of the need to find sources of energy alternative to thermal, a highly polluting and oil producing countries dependent, in the 70's, ICE began the first studies to determine if there was geothermal potential in the country.

In the late 70's, expert research was advanced and ICE confirmed that there were resources on the volcano slopes located at the Guanacaste province.

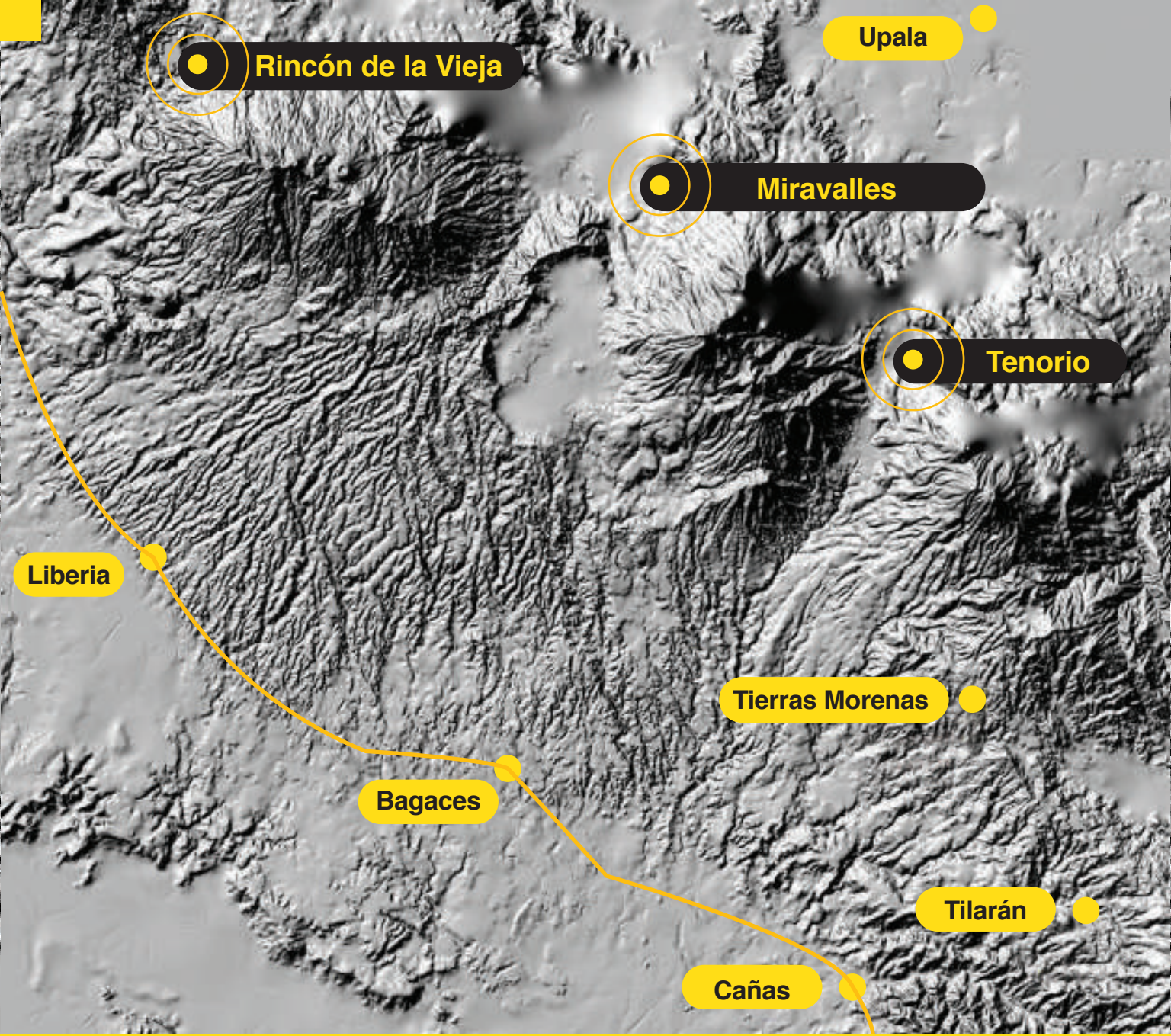
Based on these results, in the mid 80's, the Italian Government and the UN provided support to conduct two research projects:

- Geothermal Identification and Pre-feasibility in the Republic of Costa Rica.
- Geothermal Potential Assessment in Costa Rica. The research conducted determined the existence of nine sites with the capacity of hosting a profitable geothermal project.

Miravalles is born

After a series of analysis, La Fortuna de Bagaces was the place in which the first development was built.

In 1988, the construction of Miravalles Geothermal Project initiated on the southern slope of the Miravalles volcano.



The first studies in Costa Rica initiated in the 70's, and, as a result, the Miravalles Geothermal Camp was discovered and started operations in 1994.

After seven years, on March 25th , 1994, the first unit started operations with a capacity of 55 MW.

During the next ten years, four more units started operations and all together comprise the Miravalles Geothermal Camp, known since 2017 as Alfredo Mainieri Protti after the geologist that prompted geothermal energy in Costa Rica.

This geothermal camp has an installed capacity of 155 MW.

Las Pailas

There is a second geothermal camp in Costa Rica called Las Pailas, located on the slopes of Rincón de la Vieja volcano in Guanacaste.

Its first plant, Las Pailas I, started operation in 2011 and the second, Las Pailas II, in July 2019. Both together total a capacity of 107 MW.

The construction of Las Pailas I and II was made using directional drilling (the first one partially and the second completely). This technique allows drilling several pits from a single platform, which represents significant savings and a lower impact at surface level.

ICE plans to expand its geothermal resources by building a third camp on the Rincón de La Vieja volcano slopes called Borinquen, which will have two plants: Borinquen I and II, each one with an installed capacity of 55 MW.

The seven Geothermal
Plants in the country

The biggest geothermal development of Costa Rica is located on the slopes of Miravalles, Rincón de la Vieja, and Tenorio volcanoes in the province of Guanacaste.

ICE successfully operates a wide network of seven geothermal plants that total an installed capacity of 262 MW, an average of 13% of the power generation in the country.

These are the plants:

Alfredo Mainieri Protti Geothermal Camp

Miravalles I

It was inaugurated in 1994, with an installed capacity of 55 MW. It uses condensing technology, it means, the steam obtained moves the turbines and then is condensed and reinjected into the site. In 2019 this plant accomplished 25 years of continuous generation thank to the resource sustainable management.

Miravalles II

It started operations in 1998. It has the same installed capacity of Miravalles I (55MW) and uses the same condensing technology.

Miravalles III

It started operations in March 2000 as a BOT project; then, ICE took it over in 2015. It has an installed capacity of 29.5 MW.

Miravalles V

First simple binary cycle plant in the country. It started operations in 2003. Its current installed capacity is 10.5 MW.

Boca de Pozo

Mobile or temporary plant. It uses backpressure technology in which the steam extracted is used for generation and then it is released. It works since 1994 and has an installed capacity of 5 MW.

Las Pailas Geothermal Camp

Las Pailas I

It started commercial operations in 2011. It is made up of two units that total 51.75 MW of installed capacity. It uses the same binary cycle generation technology as Miravalles V does.

Las Pailas II

It was integrated to the National Grid in July 2019. Its installed capacity is 55 MW and, by the moment it was inaugurated, it was considered the most up-to-date geothermal plant in the region. This plant was awarded with the Geolac 2019 prize to the Best Geothermal Project in Latin America and the Caribbean.

Power with social and environmental benefits

- One of the most remarkable features of Grupo ICE geothermal projects: Miravalles and Las Pailas is the importance given to protect the environment and to promote community development.

Evidence shows that, through a comprehensive and inclusive management, it is possible to improve life quality in rural communities, natural environment recovery, and economic benefits for the country by using native, permanent, and cheap energy.

Each project executed was made following a quality plan focused on activity assessment and environmental control in order to prevent, minimize and mitigate negative environmental impact and to enhance the positive impact.

In that way, the building and operation phase impacts were submitted to the measures and actions established on the Environmental Impact Assessment (EIA) and to creative environmental practices.

Miravalles.Thanks to tree planting and natural regeneration enhancement, it was possible to restore 1350 hectares located on the project area.

This zone suffered for decades due to a change pattern in the land use. The forest became livestock and farming lands; this change was supported by State policies without any planning or environmental sustainability awareness.

Today, the natural scenario has changed again thanks to wild life recovery. Some of the efforts made to achieve this goal were the installation of silencers in noise sources, the waterproofing of lagoons, and temporary water and residual solids storage pits, the establishment of coverage or natural boundaries to buffer or minimize visual impact, and the implementation of environmental education or training programs for stakeholders.

Parallel to this, community improvement works have developed on the project's area of influence.

To give a follow-up to the environmental impact, the project includes a permanent monitoring plan that measures the gas content level of the air, soil and foliage pollution, temperature, wind, water, relative corrosion and humidity, and seismic monitoring.

The result of this environment quality follow-up proves that there is no problem registered related to the workers or community members' health, nor any damage or adverse effects on the biocenosis of the influence area.

Las Pailas.This project implemented new working practices according to the agreements made with the communities, such as:

- Job creation.
- Education and training programs.
- Remarkable improvement in road and services infrastructure, schools, and community buildings.
- Protection of archeologic and natural resources.
- Tree planting and forest recovery programs.

- Slope re-greening and stabilization.
- Protection of wild animals and their habitat.
- Building of Infrastructure in order to manage rainwater and avoid erosion and sedimentation.
- Solid and liquid waste management program.
- Wildfire prevention program.

ICE Group projects have brought real growth in its broadest sense for the communities, landowners, and tourist businesses located on the influence area.

They have the best schools, excellent roads, more job opportunities, and a remarkable urban development, which has also, helped to duplicate the population.

The property value continues increasing and local economies have flourished and remain stable.

Site comprehensive development

- Thanks to the exploration, building, and exploitation of geothermal camps, ICE has built experience shown with its successful model developed.

Costa Rica's geothermal projects have developed comprehensively. Among the services that these projects include are:

- Drilling of deep wells for production and reinjection.
- Well cleanout and fixing.
- Productive well maintenance.
- Field pipeline design and construction:
  - Pipeline design by process considering the handling system operation.
  - Hydraulic design, diameter and flow pattern selection, and route tracing.
  - Pipeline design by flexibility under ASME B31.1 "Power Piping" code, for geothermal generation pipelines.

- Surface equipment design:
  - System operation.
  - Equipment Parameter definition.
  - Definition of dimension.
  - Structural design of pressure vessels based on the ASME VIII code.
  - Use of specialized software for finite elements designing.
  - Developing of technical specifications and selection of material and equipment.
  - Internal pipeline cleanout.
  - Hydrostatic testing.
  - Implementation procedure.
- Steam hauling systems maintenance.
- Training.
- Advisory in geothermal camp prefeasibility, feasibility, exploring and exploitation.
- Project Management:
  - Consulting services on any knowledge area related to project management.
  - Specific advisory and training.
  - Comprehensive participation in project management.
  - Contract administration and turnkey contract management, outsource work, and BOT.

Shared experience

- 2002. Training on geochemical analysis techniques and sampling for staff from Panama, Nicaragua, Honduras, Guatemala, and El Salvador.
- 2003. Agreement with NEDO (New Energy and Industrial Technology Development Organization, Japan) for profound neutralization of fluids, to be developed at the Miravalles Geothermal Camp.
- 2004. Training on calcium carbonate inhibition systems for geothermal wells functioning on the LAGEO. SA. De C.V development in El Salvador.
- 2005. Training on treatment and systems for pH modification in geothermal fluids for LAGEO S.A. de C. V from El Salvador.
- 2008. Training for the staff at the Los Humeros and Cerro Prieto Geothermal Camps in Mexico on acid well neutralization.
- 2008 and 2013. Reconnaissance visits to the geothermal camps Miravalles and Las Pailas with delegations from Medellin, Colombia.
- 2011. Polaris Energy, Nicaragua staff: training on chemical treatment for geothermal wells, data interpretation and steam quality.
- 2012. Training on chemical treatment technology for geothermal wells for Leyte Geothermal Production Field Energy Development Corporation Philippines.
- 2012. Agreement with LaGeo S.A de C.V, El Salvador to provide technology for chemical cleanout of geothermal wells.
- 2014. Cooperation agreement with Corporación Eléctrica del Ecuador (CELEC EP) Ecuador Power Corporation. 2015. Technical support for staff.
- 2014. Agreement with Enel Green Power, Italy to provide directional drilling technology.
- 2015. Agreement with Nippon Steel & Sumikin Engineering Co. LTD. Geothermal Power Business Dept. Japan, for capillary tube testing.

The best geothermal plant in America and the Caribbean

- Las Pailas II was awarded in July 2019, during the Geothermal Congress for Latin America and the Caribbean (GEOLAC).

On July 17th, 2019, during the Geothermal Congress for Latin America and the Caribbean (GEOLAC), in Santiago, Chile, Las Pailas II was awarded the prize for “The best geothermal project in the region”.

This organism awarded this project from the Costa Rican Institute of Electricity (ICE) for the use of directional drilling and the social environmental management in Curubandé, Liberia, in the province of Guanacaste, Costa Rica.

Since the 70’s, ICE has refined its capacity and its knowledge on geothermal power; today, ICE is self-sufficient in every stage of the whole process while respecting nature.

Las Pailas II is the most modern plant in Central America and the Caribbean. It has an installed capacity of 55 MW that has the power to serve 137000 households.

This is a production of the Direction of Communication
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