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Costa Rica Country Update Report

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ABSTRACT

Since the last country update report for Costa Rica presented in 2020, geothermal exploration and development in the country has continued its development. The past few years, geothermal exploitation and development in Costa Rica for electrical generation purposes have had an important impulse. Since the country's energetic policies are mainly based on renewable energy sources in order to decrease the CO2 emissions, and face climate change effects, geothermal energy continues to be a important part of the base load of the electrical system in Costa Rica, which nowadays contribute producing around 16 % of the total electrical generation of the country.

The Dr. Alfredo Mainieri Protti Geothermal Field (formerly Miravalles, 154.5 MWe) continued its productivity rate in stable conditions and the first unit of Las Pailas Geothermal Field (42.5 MWe) completed eleven years producing continuously since year 2011. The second unit in Las Pailas of 55 MWe started its commercial operation in July 2019 with very stable production during this period. A drilling program of 17 wells for the development of Borinquen I (first of two 55 MWe units) is underway with very good results to date.

Considering the important investment for geothermal development, the main challenge has been the sustainability of the reservoir, not only during the initial planned development period, but also for any possible future expansion. Continuous strategies have been developed, in order to secure the commercial exploitation of the Dr. Alfredo Mainieri Protti field in order to extend the useful life of the reservoir for other 30 years.

The geothermal projects portfolio was has been updated, considering proposals at different project maturity stages, aimed to satisfy the electrical expansion requirements until 2040. In 2022, ICE presented the Costa Rica ′s geothermal potential update study report. This study, in addition to the traditional geoscientific disciplines, included the United Nations Framework Classification for Resources (UNFC), geophysical, remote sensing and socio-environmental evaluations as well.

1. INTRODUCTION

As a total commitment environmental friendly country, electrical generation in Costa Rica relies almost completely in renewal energy sources. By December 2022, just 7.00% of the total electrical installed capacity was geothermal (Figure 1), but representing 13.00% of the total energy delivered to the national electricity grid (Figure 2). 98% of the electricity generated between January and December 2022 was produced from renewable sources like hydro, geothermal, solar and wind.

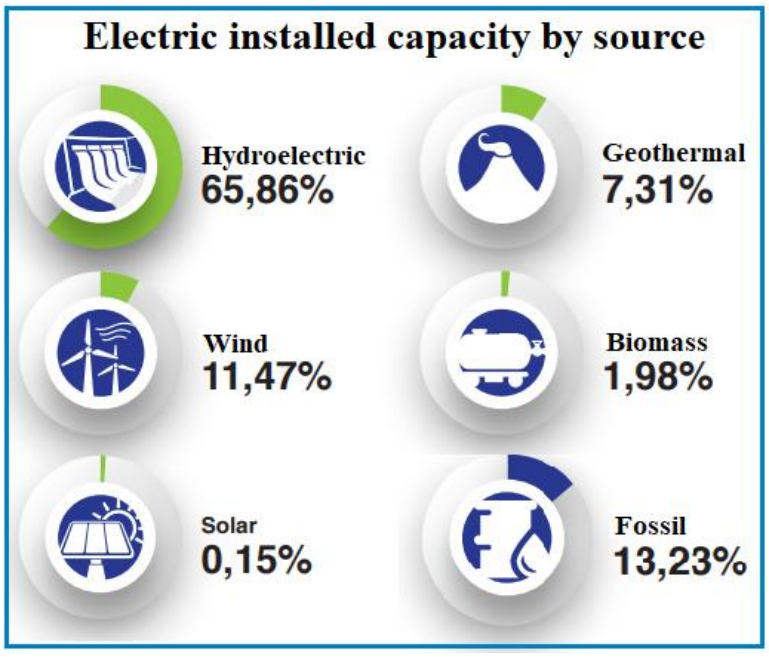

Figure 1 Installed electric generation by source in Costa Rica by December 2021. Modified after ICE (2021)

The electrical generation system of Costa Rica is organized as a regulated utility, where *Instituto Costarricense de Electricidad* (ICE – stands for "Costarican Electricity Institute") is legally mandated to fulfill the country's electricity needs. ICE is an autonomous institution of the government of Costa Rica, vertically integrated into generation, transmission and distribution divisions. Besides having the largest capacity in generation plants, its transmission network manages and distributes part of the total electrical energy generated. In the generation business, there are other companies involved. Private or independent generation through long-term contracts provides electricity to the ICE's generation system, while five of the other seven distributors in the country have their own generation plants to supply part of the demands of their customers. ICE participates for Costa Rica as the single agent in the Regional Electricity Market (Central America joined market). The *Autoridad Reguladora de los Servicios Públicos* (ARESEP – stands for "The Regulatory Authority for Public Services") ensures the quality and price of public services provided by ICE and the other electric companies.

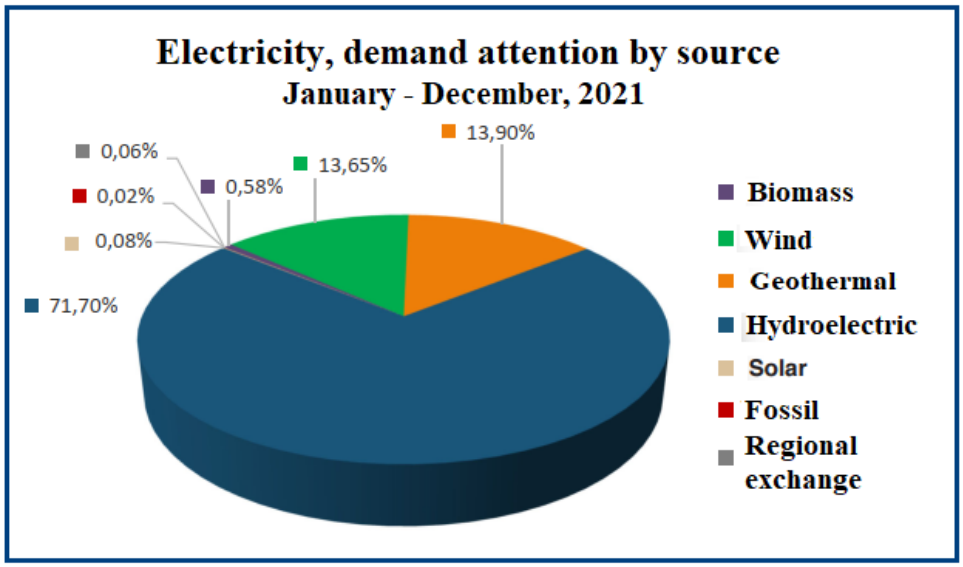

Figure 2 Electricity production by source. January – December 2021. Modified after CENCE (2022)

The system is organized under the *Sistema Eléctrico Nacional* (SEN – stands for "National Electricity System"). It consists of the Generation, Transmission and Distribution subsystems. All elements of the SEN are fully interconnected in a single transmission system. The electric power generation in Costa Rica is carried out by 6 public companies and 32 private companies (Figure 3).

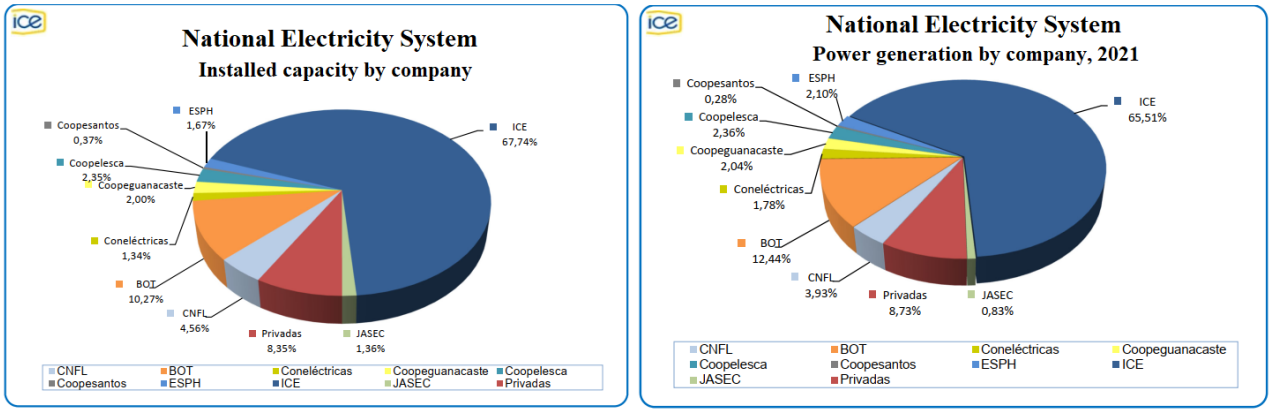

Figure 3. Installed capacity and electricity generation by company, 2021. Modified after CENCE (2022)

Taking into account the possible energy needs of the country in the coming years, ICE develops a electricity generation expansion plan for generation and distribution. This plan is updated every two years. The latest expansion plan (2018 - 2034) included the construction, modernization and decommissioning of several plants for a total of 546 MWe (up to a capacity of 4076 MWe at the end of 2034). This plan corresponds to the master plan necessary to meet the forecast average demand scenario. The present value of the Plan for the period 2018-2034 is 2184 million USD, of which 1916 million USD correspond to the investment costs, 260 million USD to the operating costs and 7 million USD to the energy costs not supplied (ICE, 2019).

2. GEOTHERMAL RESOURCES AND POTENTIAL IN COSTA RICA

The Costa Rica geothermal potential update study report (ICE, 2022), shows a possible distribution of high, and moderate temperature resources for electric generation. The study indicates an accessible possible potential of around 1000 MWe for Costa Rica, based on the available information and subsequent interpretations (

Table 1).

Table 1 Geothermoelectric estimated capacity in Costa Rica.

High Temperature Systems		
Geothermal Area	**Total estimated capacity (MWe)**	**Estimated capacity without restricted sectors (MWe)**
Estimated potential up to 2500 meters deep	**1331**	**614**
Estimated potential up to 3000 meters deep	**2277**	**1019**

In this study, the geothermoelectric potential estimations were carried out under two scenarios: one considering all the areas of interest, according to geological variables and the second, excluding from the analysis the sectors with access restrictions (national parks and reserves, wetlands and areas with extensive urban development). Figure 4 shows the obtained geothermal interest areas and restricted sectors.

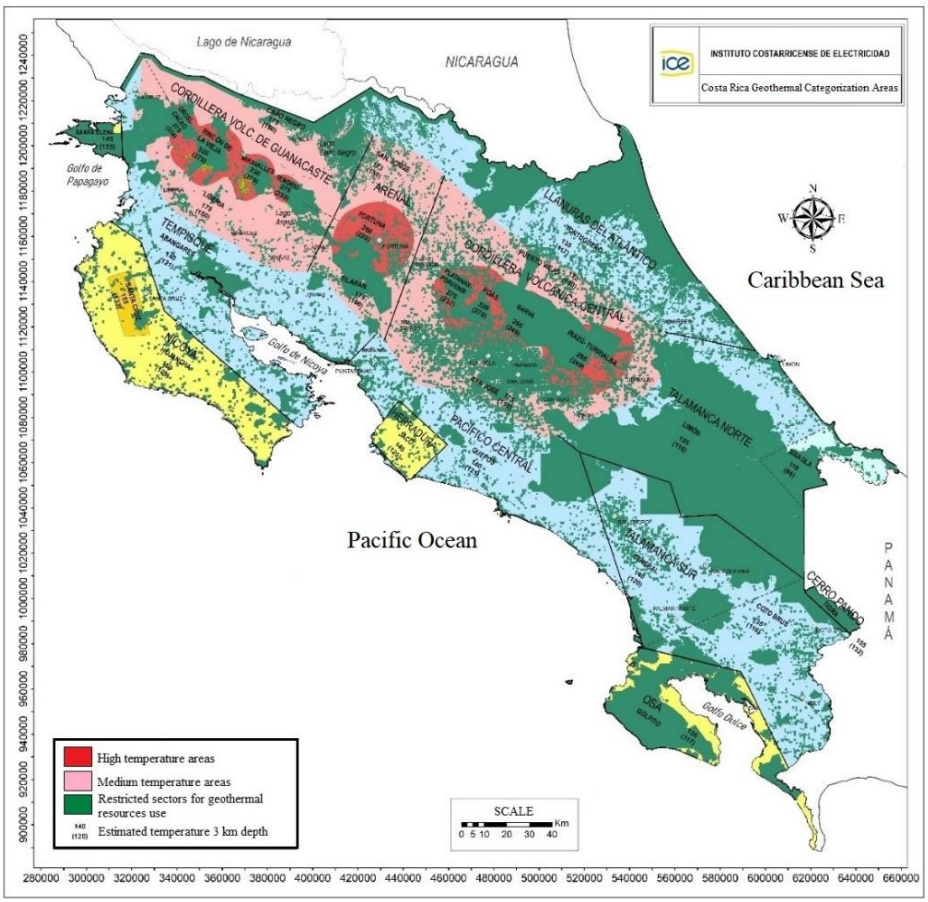

Figure 4. Geothermal categorization map of Costa Rica. high temperature areas are denoted in red, medium temperature areas are shown in pink, while restricted sectors for geothermal use are displayed in green. ICE (2022).

3. ELECTRICAL GENERATION THROUGH GEOTHERMAL ENERGY IN COSTA RICA

Nowadays geothermal energy in the country is mainly used for electrical generation through power plants complexes at the Dr. Alfredo Mainieri and Las Pailas fields (Figure 5). Due to its strategic importance for the country in the present and future energy supply, sustainability of those fields is considered a matter of special relevance.

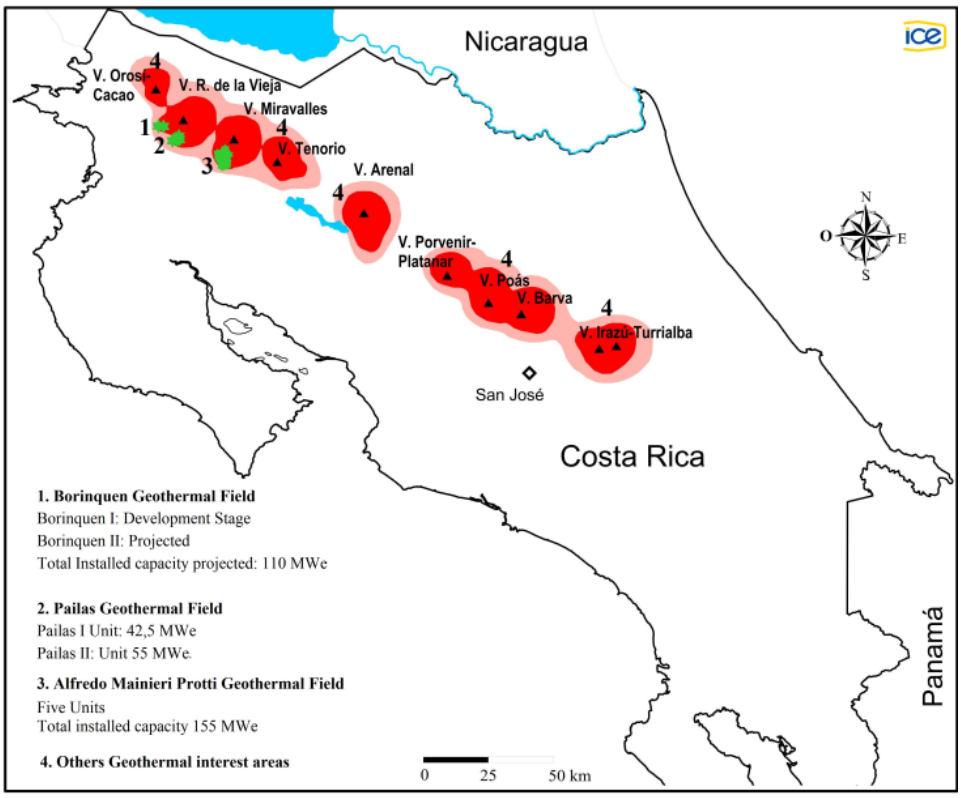

Figure 5 Geothermal developments in Costa Rica.

The geothermal electrical installed capacity achieves around 7.00 % of the country's total electrical installed capacity; however, it represents around a considerable 16.00% of the country's current total generation. The difference is due to geothermal plants capacity factor. Since geothermal power plants produce constantly throughout the year-round, and its production is not vulnerable to the climate change effects, they represent an important percentage of the baseload for the country's electrical generation (Run-of-river hydroelectrical power plants production are sensible to seasonal variations). This can be seen in Figure 6. Geothermal and hydro-electrical power plants are intensively used to generate instead of the thermal power plants, as a decisive commitment with the carbon-neutral international policies implemented by the country. Not less important, since ICE is the biggest seller of the electricity to the end-users, its final price is directly related to the averaged costs of all energy sources. For the latter, the substitution of the most expensive generation sources with autochthonous and clean geothermal energy (and other cheaper sources) is considered as an issue of high importance for the economy of the country.

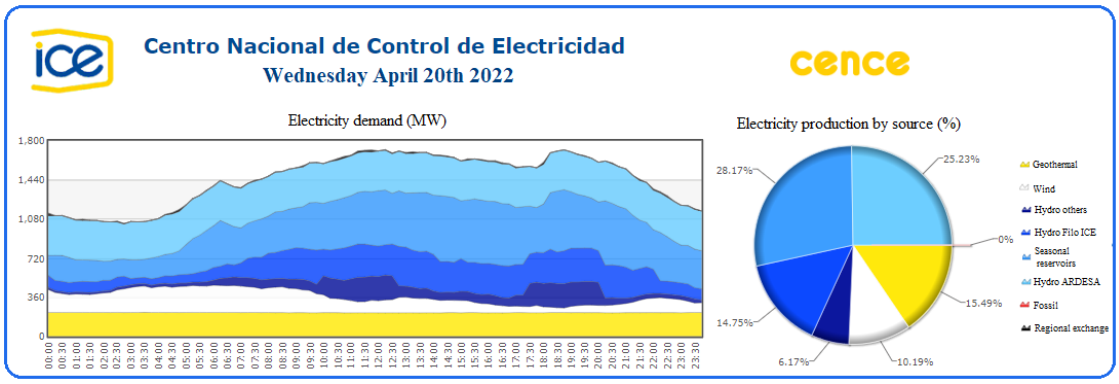

Figure 6 Left: Production by source in MWe by April 20, 2022. Right: Distribution by source by April 20, 2022. CENCE (2022).

3.1. THE DR. ALFREDO MAINIERI GEOTHERMAL FIELD

The Dr.Alfredo Manieri Field is the highest developed and productive of the geothermal fields in Costa Rica. The total installed capacity is of 154.5MWe distributed in five power units (Figure 7).

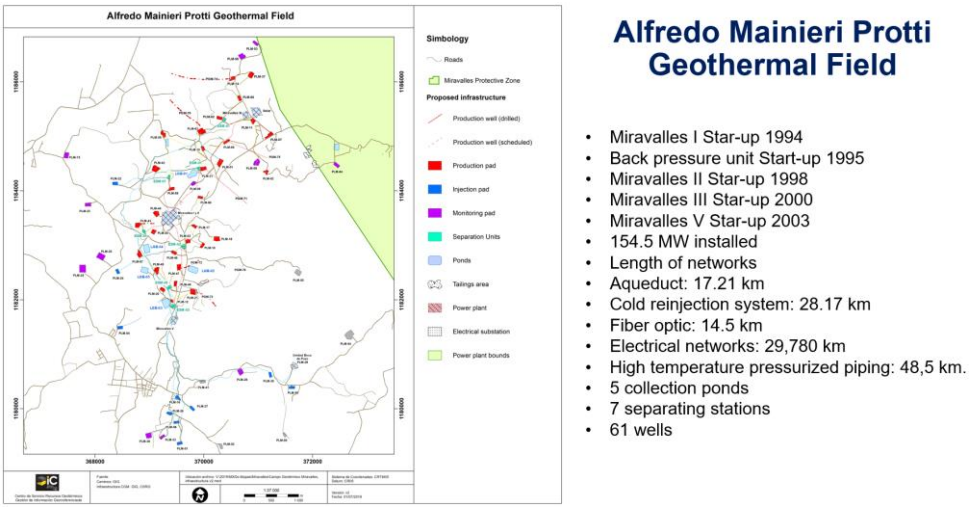

Figure 7 General view of the Dr.Alfredo Mainieri Protti Geothermal Field.

This complex comprises five power units in four different powerhouses, seven separations stations, 48,5km of pipelines, 61 wells (production, injection, and observation) and a series of artificial ponds aimed for cold injection, maintenance operations and containment of emergencies. Continuous monitoring of the geochemical and thermohydraulic parameters of the field and extensive reservoir simulation are important tasks done at this field. The current knowledge of the reservoir and the trend of the evolution observed has headed to conclude that the field has actually reached its maximum extraction rates at the already developed areas. Some actions taken by ICE in order to stabilize the field production and reach the maximum field productive levels are currently implemented or will be done in the near future, such as repowering the Miravalles units on 2028, 2029 and for 2030 (Units I, II and II respectively).

3.2. PAILAS GEOTHERMAL FIELD

With 42.5 MWe gross and 35 MWe net power plant, Las Pailas I unit was officially commissioned on July 24, 2011. To date Unit I comprises seven production wells and four injection wells. Aquifers in the area have a composition of neutral sodium-chloride, high salinity, low non-condensable gases (NCG) and temperatures ranging from 240-255°C.

The project was developed under the “leasing with option to buy” scheme, where the Banco Centroamericano de Integración Económica (BCIE, stands for Central American Bank for Economic Integration) owns the plant and leases to ICE for a 12 years period. After that time, ICE will buy the power plant. The US$160 Million power plant built is a 42.5 MWe Ormat two-module combined cycle binary plant where the steam is sent to the vaporizers and the brine is sent to the preheaters. The power cycle working fluid is N-pentane.

Located to the east of the first power plant of the area, is Pailas II unit, a 55 MWe flash plant. It was officially commissioned on July 23, 2019, and works with 12 production wells and 9 injection wells, located in 6 pads. Aquifers in the area have a composition of neutral sodium-chlorinated, high salinity, and temperatures up to near 270°C.

Las Pailas II unit was design with the newest concept for operational flexibility (each production pad connects directly to a separation unit and its mirror reinjection pad), optimization of the infrastructure to minimize the footprint, in order to preserve the major of the biodiversity of the sector (a single road connects the vast majority of the pads, and is utilized as well to place the hot and cold pipelines). This project accounted for the highest and newest standard in ecological monitoring with a unique technique denoted as "Biomonitoring through DNA" from insects collected from several places in the project.

A map of the geothermal field is shown on Figure 8.

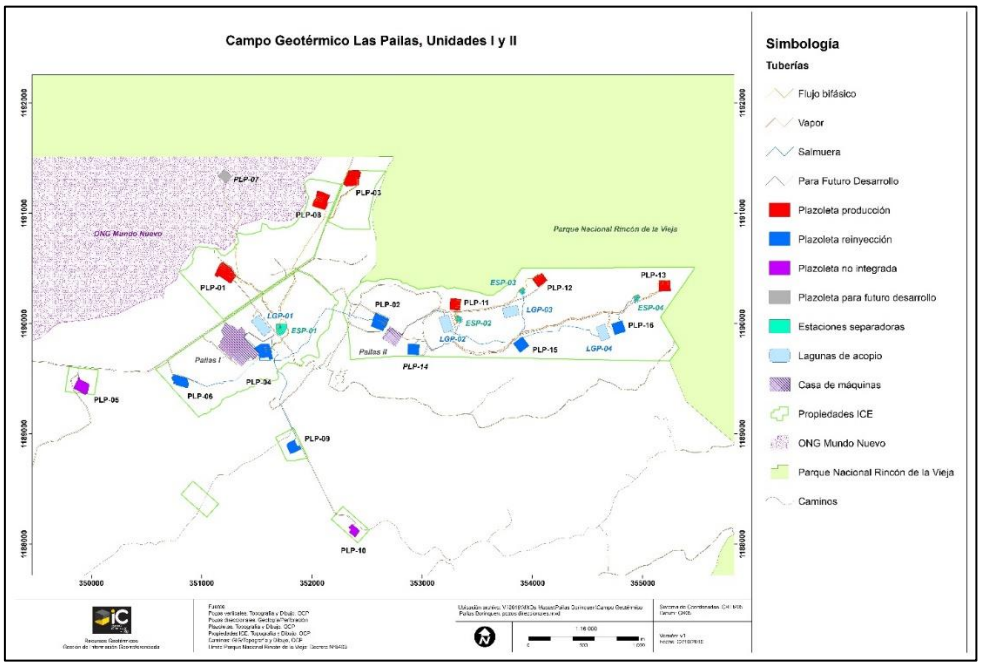

Figure 8. Las Pailas I and las Pailas II Units, 42 Mwe and 55 MWe flash plant installed by 2011 and 2019 respectively. A total of 41 directional wells drilled in 13 pads (production pads are shown in red, while reinjection pads are denoted in blue).

3.3. BORINQUEN GEOTHERMAL FIELD

Located on the west flank of the Rincon de la Vieja volcano, this field is projected to generate 110 MWe gross. Intensive development started by 2018 (Figure 9) with funds from JICA (Japan International Cooperation Agency). The final commissioning of Borinquen I unit (55 MWe flash plant) is expected by 2027, and by 2030 Borinquen II unit. The already identified aquifer is neutral sodium-chlorinated with high salinity content, and temperatures ranging from 240-273 °C. At this moment 13 wells have been drilled of which six wells are producers and five are reinjectors (one is an observation well). These wells are currently been evaluated to monitor the thermal-hydraulic conditions and possible production conditions.

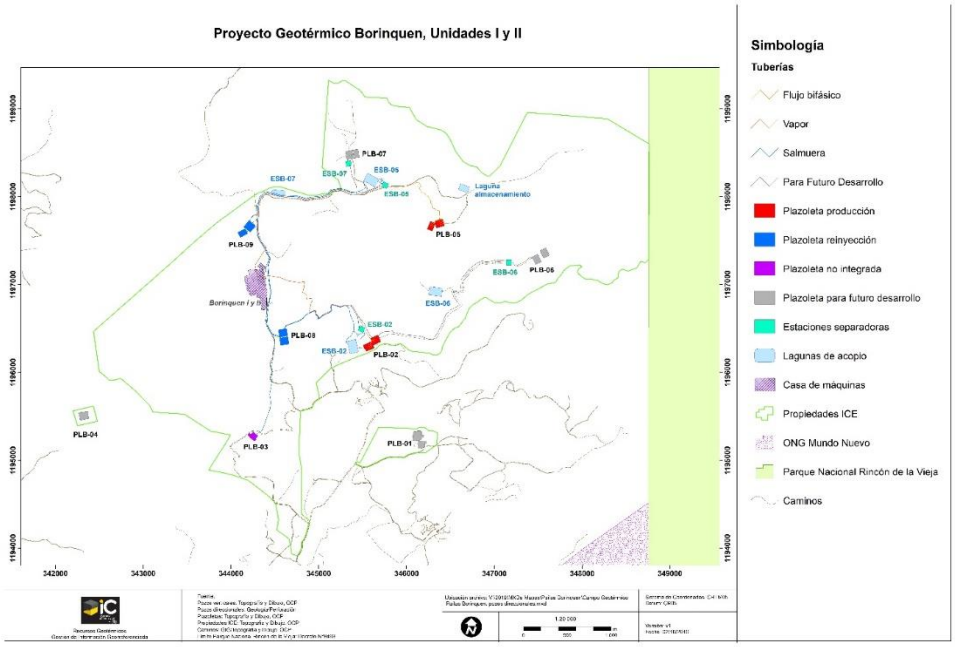

Figure 9 General view of the projected Borinquen Geothermal Field with units I and II.

3.4. OTHER GEOTHERMAL SITES OF INTEREST

Currently further efforts are being carry on in geothermal exploration in other promising geothermal areas around the country such as Turrialba, Vara Blanca, Tenorio, Arenal-Pocosol, Platanar, Rincon de las Vieja (north sector), and other areas as seen in Figure 10. Inclusion of geophysical techniques like magnetotelluric and implementation of thermal images captured (as shown in Figure 11) by drones (the latter thanks to international cooperation between Institute for Geosciences and Natural Resources (BGR from

Germany and ICE) have not just improved notoriously speed but the quality of the investigations in search for the best geothermal development targets.

Figure 10. Drone images taken of some of the recently explored areas. ICE (2022)

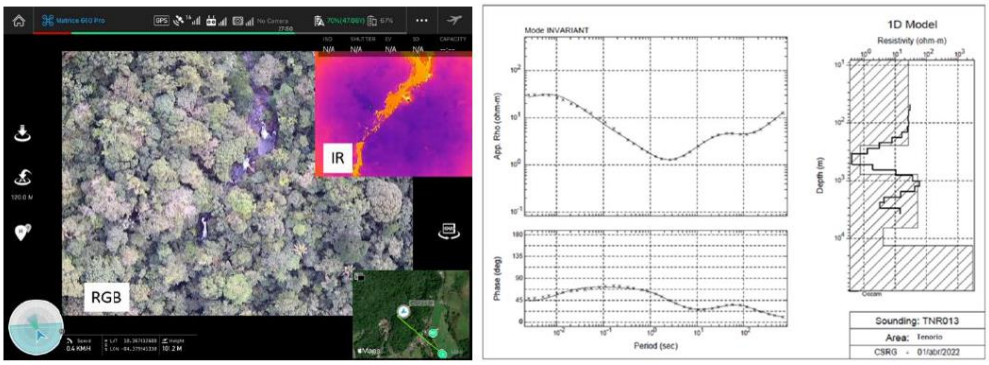

Figure 11. Left picture displays RGB image and its corresponding thermal image of a river in the area of La Marina de San Carlos taken by drones. Right picture shows one of the magnetotelluric soundings curves in the Tenorio area with its corresponding 1D model.

3.5. GEOTHERMAL DEVELOPMENT PLANS

According to the latest country demand of electricity and the forecast scenarios, ICE′s Planning and Sustainability Department is analyzing the inclusion of some (at least 3) strategic geothermal projects, focused on short time availability and reliability by the implementation of modern modular small scale flash type power plants. The results of the integral analysis will be published in the next Electricity Generation Expansion Plan.

4. DIRECT USE

Since 2018, ICE in coordination with other national entities and through international cooperation with GIZ (German Agency for International cooperation), has been working in the design, logistic and finance of the first experimental grain dryer for Costa Rica

Through multilateral effort with SICA (Sistema de Integracion Centroamericana), BGR and countries within the Centralamerican region, ICE as the Costa Rican counterpart is being cooperating for the elaboration of a water geochemical guide for geothermal direct use focused in enhance capabilities of the local authorities such as the Bagaces municipality.

Finally, major advances have been done aiming to design a specific law to encourage the implementation of geothermal direct use projects in the country, through the Costa Rican Environmental and Energy Ministry.

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