

Geothermal Energy: Development Opportunities for the Miravalles Area, Costa Rica

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ABSTRACT

The exploitation of the Miravalles Geothermal Field has brought a great development to the nearby areas to the field. The beautiful gift that the nature gave to this area, the Miravalles Volcano, is the main character of this history. The geothermal field that lies under its impressive view has given development to the nearby towns, thanks to the necessary improvement in infrastructure for the production of the geothermal energy, being this project a pillar in the energy structure in the country. The Instituto Costarricense de Electricidad (ICE), in charge of the development of the geothermal projects in the country and as a public entity with a command of social responsibility, has cooperated with the development of the towns of the area.

The area of Miravalles in its beginnings was invaded by farmers, and thanks to the effort and those first residents' courage that fought to get something of land to sow, the skirts of the Miravalles Volcano began to be colonized. The development of the geothermal energy in Miravalles was taken as an opportunity and it was well seen for the residents of this area, when it brought infrastructure development, study opportunities, employment generation as much for these inhabitants as for others of the country that were attracted to migrate to this area. Other non traditional development possibilities of the area were also created, as it is the tourism.

Thanks to this situation it is observed the benefits that an appropriate development with a socially responsible vision can bring to the near populations to a geothermal development.

1. INTRODUCTION

The Miravalles Geothermal Field is located in the northwestern part of Costa Rica, in the Guanacaste Province (Figure 1). The field is developed to the south and southwestern of the Miravalles Volcano, the highest volcano of the Guanacaste Mountain Range. It is extended between the 400 and 800 m.a.s.l. with an average gradient of 5%. The geothermal reservoir is 800-1000 m thick of the high-temperature liquid-dominated type, located at about 700 m depth with reservoir temperatures naturally declining to the south and west. The nearest commercial airport (domestic and international flights) is located at a 60 km distance by car. The nearest commercial port is at a distance of 120 km by car. The field is located at a 150 km of San José (the capital of Costa Rica). This is about 225 km by car.

The Miravalles Complex comprises five power units in three different power houses, seven separations stations, the pipeline network, 53 wells (production, injection and observation) and a series of artificial ponds intended for cold injection, maintenance operations and emergencies.



Figure 1: The Miravalles Geothermal Field.

The main features (wells, power plants and other) can be seen in Figure 1. The main facilities of the Centro de Servicios Recursos Geotérmicos (CSRG), which is the ICE's department in charge of the exploration, evaluation and exploitation of the geothermal resources in the country, is also located in Miravalles. The installed generation of the Miravalles Complex reaches 163 MWe and comprises the 8% of the total installed capacity of Costa Rica and generates about 14-16% of the total electrical generation of the country (Vallejos, 2006).

Fortuna and Guayabo are the main towns of the Fortuna and Mogote districts, located in the Bagaces County. Both communities constitute the main influencing population centers of the Geothermal Project, because in their territory is settled the main infrastructure: wells, pipelines, offices, power plants and campsite for the ICE's workers.

This territory can be defined as a Tropical dry Forest in transition to Tropical Humid Forest area, with an annual precipitation of around 1600 mm and a temperature average of 25 °C. The zone is affected by the climatic conditions characteristic of both slopes of the Pacific and of the Atlantic coasts of Costa Rica. The climate is characterized by a dry season running from December to April, and a rainy season from May to November. The depression found

between the Miravalles and Rincón de la Vieja volcanoes allow the step of the humid flow coming from the Caribbean, reaching there an annual total of precipitation of about 3400 mm. The precipitation is progressively reduced as descends toward the plains of the Pacific where an annual precipitation of 1000 mm in the coast is found. The pH values of the rain ranges from 4.0 to 8.0, indicating the presence of acid rains. This phenomenon is associated to natural causes, such as the presence of fumaroles and the activity of the nearby Rincón de la Vieja volcano. These values have been constant before and after the commissioning of the different power plants at Miravalles, showing that the environmental impact these plants cause is minimal.

The wind direction in the area is predominantly NW and an important NE component exists. The maximum speeds measures in the monitoring station at the Unit I and II Power Plants reach values of 70-100 Km/h in the first months of the year and they stay in general around 30-50 Km/h during the rainy season (ICE, 1996). This situation has recently brought the building of a 49 MWe wind power plant which is expected to be commissioned by the 2010.

The hydrographical network is very developed in the area, with a permanent régime and a preferential flow pattern in direction N-S, in conformity with the main neotectonic trend. The most important rivers are respectively the White River and the Cuipilapa River. There is a wide readiness of water for domestic and agricultural purposes, as well as for the activities of the Geothermal Project, so much from the superficial aquifers as from big springs that sprout in the northern portion of the area and supply of fresh water the two towns and the geothermal project (ICE, 1996).

2. HISTORICAL ASPECTS

Is it believed that the Miravalles Volcano was named by the Spaniards conquerers; in fact the indigenous name of the volcano is Cuipilapa. The first cattle ranches marked the colonial era, and the cutting of the forest land was developed in order to devote the lands to this activity.

Between 1850 and 1855 a small colony of Germans settled down the region. However, they abandoned this area because they didn't adapt to the prevailing conditions. In 1890 it was attempted the introduction the coffee grown in the Guanacaste province, trying to take advantage of the volcanic lands of the Guanacaste Mountain Range. It was projected to establish a railroad in order to transform the extensive livestock area in one of intense commercial agriculture. In 1894 was announced the establishment of the Santa Rosa Coffee Estates Company. The intention was to establish a property of canes in the region of Cañas County. The plan of transformation of the landscape fails for lack of penetration roads to take out the product. At that time, the Miravalles Farm located in the Miravalles slopes was property of the former Costa Rica president Bernardo Soto. The first introductory attempts in forming small coffee plantations didn't give the expected results due to the aforementioned problems and for the strong winds presents in the region. Then a Soto's relative sells it to the Wilson Salazar Company. The boundaries of the farm extended from the dividing line of waters of the Nicoya Gulf, including the actual area of the Palo Verde National Park.

With the sale of this property to Mr. Wilson Steward (a railroad engineer), a new period of invigoration of the livestock began in the region. This situation promoted the displacement of the few small owners that still existed in the region. It monopolized the use of land, resulting in

migration to other parts of the country. This settled the weakening of the socio-economic development of the region, stepping back to be owned by one family where the jobs were fairly low. This reactivated deforestation and settled the conditions for a social movement by the end of the 1940's decade.

In the years 1947-1948, a group of landless peasants invaded the Miravalles region, causing a change of life in the area. This invasion leads to a struggle between squatters and the land owners of the Hacienda. Squatters cleared forests in the mountains to plant near the pasture, and the owners ordered the Liberia guard to evict them. The owners in their first foray burned ranches and drove the peasants into the mountains, who returned after a while forced by the difficulties they spent in the higher areas (ICE, 1988).

This situation was solved in December 1953 when the government in that moment decided to intervene. The land was expropriated and a fair price was paid to their owners and it was distributed among the peasants who lived there. This initiates a renewal of progress in agriculture. In addition, livestock was booming, small villages were built and also penetration roads and schools. Finally, there was a big change in the region that resulted in the emergence of several villages: Fortuna, Guayabo, San Bernardo, Sagrada Familia, Santa Cecilia, San Isidro, Nuevo Pueblo, etc. Later on, the first two towns became as the centers of the district. Parallel to this, accelerated deforestation and thus part of the disappearance of the wildlife.

Among the works carried out were the construction of the drinking water pipeline and the construction of the bridge over the Blanco River, which made easier the communication with Bagaces and marketing potential of its producers (ICE, 1988). This formed the basis landscape scenario found by Instituto Costarricense de Electricidad (ICE) in the 70s, corresponding to the phase of exploring the potential of geothermal energy in the region.

3. SOCIAL DEVELOPMENT IN THE AREA BEFORE ICE'S ARRIVAL

When ICE started to develop the intensive geothermal exploration activities in 1975, Fortuna was the more developed community of the area and where the principal infrastructure of the geothermal complex would be located. However, there were some problems in obtaining suitable land for installing the headquarters of the project. Finally after many negotiations, land purchase and expropriation, ICE acquired the land necessary for developing the geothermal project. The headquarters were set up in Guayabo instead (Figure 2).



Figure 2: Construction of ICE's headquarters in Miravalles in late 1970's.

By the beginning of the activities Guayabo had no road and had a single street which crossed the center of the town with no infrastructure (Figure 3 and 4).

The socio-economic reality that ICE found in that decade characterizes a farming economy, where the small and medium farms dominated and only a few large farms existed. There were produced grains such as rice, beans and corn, plus fresh tomatoes and chile and others. It also had meat and milk livestock. There were larger areas of land occupied by the livestock. Much of the production was of subsistence kind and the surplus was sold to Bagaces, and especially Liberia and Cañas cities. The roads were bad (Figure 5), the public transport service also bad and other services in general almost nonexistent. La Fortuna, although it was more developed community, had no electricity and therefore no phone service (Figure 6).

Guayabo had a small oil fueled electrical plant and few lights. Production was moved in carts pulled by oxen or horses. All these factors were a serious obstacle to the development of this region.

The arrival of ICE in the middle 1970's signified the first installation of telephone services (5 lines, two for the geothermal project and the other 3 for public telephony: **one in Fortuna and two in Guayabo**), the construction of the electrical distribution lines, the improvement of the roads, etc. The first five deep geothermal wells were drilled in Miravalles between the years 1978-1980 (Figure 7), and they were so successful that it led to the drilling of eight more deep wells by 1985. All these wells were also



Figure 3: Guayabo Main Street at the end of the 1970's.



Figure 4: Guayabo Main Street in the 1980's.

successful and the feasibility studies proved the existence of a geothermal reservoir. ICE got loans from the International Development Bank and the Japanese Overseas Economic Cooperation Fund (OECF) for developing the Miravalles Geothermal Project. This was a decisive impulse to the development of the zone because it was secure the presence of ICE for many years.

The increasing installment of new power plants in Miravalles resulted in a great source of jobs for many years (1994 Unit 1, 1998 Unit 2, 2000 Unit 3 and 2003 Unit 5). The main facilities of the Centro de Servicios Recursos Geotérmicos (CSRG), which is the ICE's department charge of the exploration, evaluation and exploitation of the geothermal resources in the country, is also located in Miravalles.

4. SOCIAL DEVELOPMENT IN THE AREA AFTER ICE'S ARRIVAL

A survey conducted in both communities by 1988 showed the good perception the project had between the residents at that time. The 85.5% of residents of the Fortuna and Guayabo towns argued that the project had caused socioeconomic changes in the nearby communities, and felt that the most important change was that ICE had become a source of work in the area (Figure 9). 95.7% of residents surveyed said the project would benefit the country due to increase in electricity production, employment and tourism development. Even though the project showed a high degree of acceptance, there were an atmosphere of uncertainty and some concerns in regard to the dimensions and consequences of the project (Saborío et al, 2010).



Figure 5: Road between Fortuna and Bagaces, 1960's.



Figure 6: Fortuna Main Street in the 1960's.



Figure 7: Site for Well PGM-01, Miravalles Volcano to the End - 1975.



Figure 8: Construction of roads for deep wells and communal roads, middle of 1970's.

When the strong phase of the construction of the power plant started in 2001, Fortuna and Guayabo greatly developed because of the hiring of inhabitants of both towns, the arrival of workers who demanded other services and the much needed repairing of the roads and the improvements of other public services.

Further development of the geothermal field was a key factor in improving the quality of life of the residents. The reasons were the opportunity for employment and job stability; because many of the staff required developing the project was hired in the populations surrounding the area. ICE employed personnel like professionals, laboratory technicians, field operators, power plant workers, drillers, welders, electricians, plumbers, accountants and clerks, among many others. Recruitment of the staff varied depending on the different stages of the project development. Since the geothermal activity was new in the country, ICE prepared a skilled workforce. The appointment of new staff has brought a high immigration of people from different parts of the country in search of employment, professional and technical personnel who eventually adopted the area as a place of permanent residence (Figures 10 to 14, Barquero, 2003).

The trade and services sector has increased because of the population increase in recent years. (Quesada, 1998). This increases the demand for restaurants, lodging, recreation centers and other services that encourage the people economically (Figure 15, Barquero, 2003), since the new activities have become an alternative source of employment for the people. Towns in general and especially Guayabo were changing: increased business or shops, professionals as doctors, lawyers, teachers settled in the town and offering their services, and began to develop other activities in the area. Therefore, it also encourages the establishment of services in general, as the Red Cross, schools and colleges, the Social Security Clinic, banks, the telecommunications office, utilities, Internet cafes, transportation, public safety associations and committees that monitor the different needs of the people. The increase

in the commercial activity led to some land owners to sell properties for the construction of habitational developments and even the government institutions started to develop habitation projects.

In regards to the education, ICE has projected itself in the area by way of training for communities, both in terms of employee training as to the community. Another indirect contribution to education is the access to the Internet as well as road construction and improvement of neighborhood roads. The possibility of having stable jobs has enabled the mobilization of students to different schools, colleges and universities, including those outside the canton of Bagaces like the ones located in Liberia and Cañas (main population centers of the Guanacaste province).

Other benefits that ICE brought through the development of the Miravalles field was the development of social work with the community, as cooperation with aqueducts, repairs and improvements to schools and the Fortuna and Guayabo Colleges among others. It has also benefited the tourism sector: the residents agree that the Miravalles Geothermal Complex gave them a name and put them on the map. In fact, the complex itself is an attraction pole because of the atypical of the infrastructure and the lack of knowledge of the people regarding this source of electricity. The geothermal resources in the area have encouraged landowners near the Miravalles Volcano to build Hot Springs resorts (Figure 16).

This growth and development is reflected in the increase of population. In 1988, the population between both Fortuna and Guayabo towns were 1832 inhabitants, 56% of which belonged to Fortuna and 44% to Guayabo. According to the latest population census, conducted by the Statistics and Census National Institute (INEC, 2000) in 2000 Guayabo had a population of 3011 and Fortuna 2932, by 2001 Guayabo had 3060 inhabitants and Fortuna 2959 (INEC, 2001) (Figure 17, Barquero, 2003).

4.1 Social Activities

Some of the identified actions ICE has done in supporting the quality of life of the surrounding populations are mentioned as follows (Barquero, 2003):

- Repair and maintenance of roads and bridges (Guayabo, Fortuna, Pueblo Nuevo, Cuipilapa, etc.) (Figure 18).
- Repair and maintenance of other infrastructure as schools, churches, gyms, communal centers, etc. (Guayabo, Fortuna, Pueblo Nuevo, Cuipilapa, etc.) (Figure 19).
- Consultancy activities in various professional and technical fields.
- Coordination of activities concerning education graduate programs (ICE workers and people of surrounding towns).
- Support with staff of the institution to carry out training programs in different areas in the community. (Secretarial, Basic Mechanics, Electricity, English, Computers, Safety. Etc)
- Training the workforce of community which has directly resulted in the availability of skilled manpower in the area.

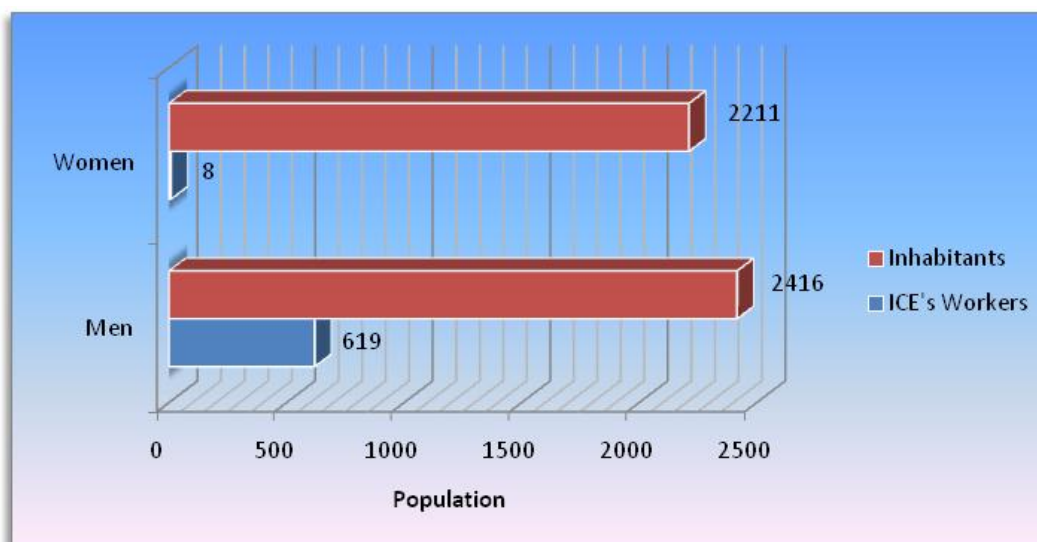


Figure 9: Population working for ICE – 1997.

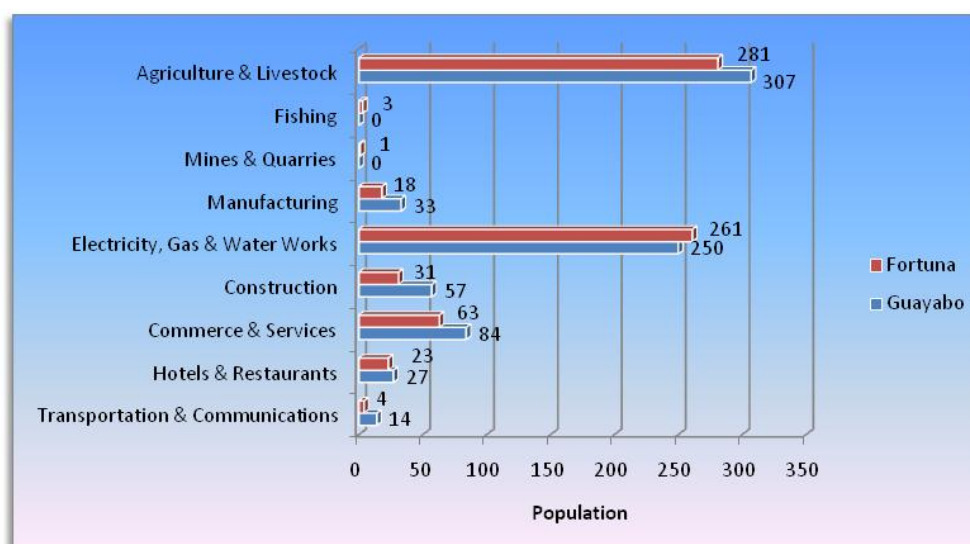


Figure 10: Working activities – 2000.

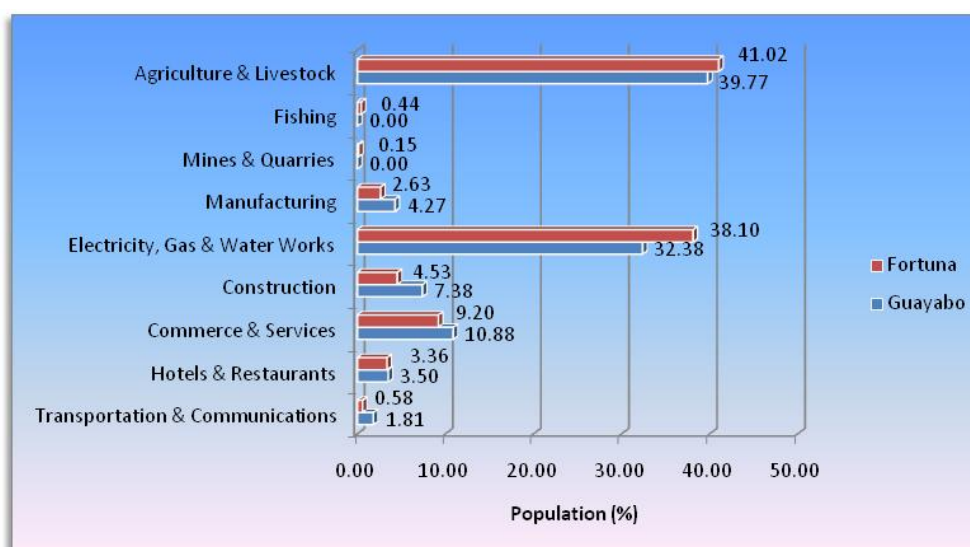


Figure 11: Working activities (%) – 2000.

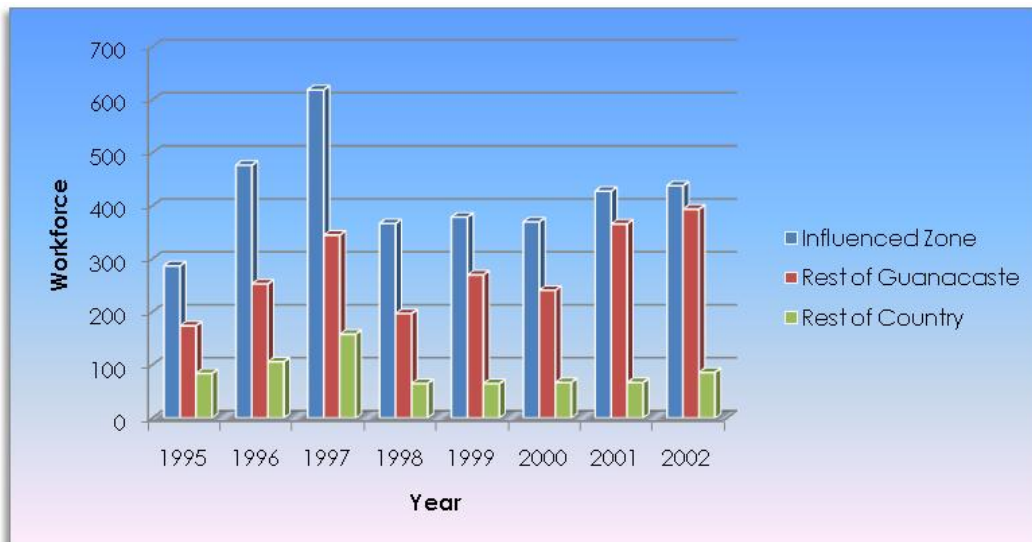


Figure 12: ICE's Workforce by region 1995 – 2002.

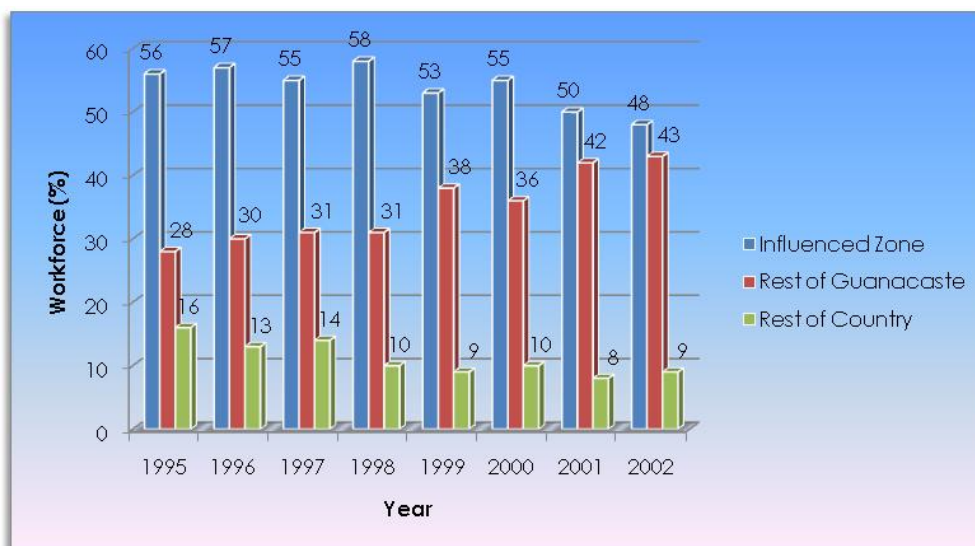


Figure 13: ICE's Workforce by region (%) 1995 - 2002.

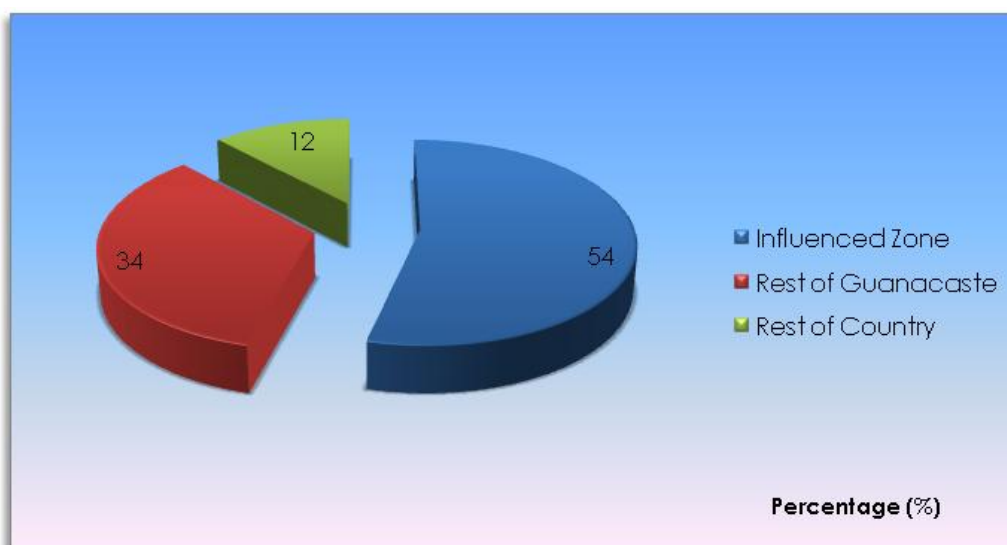


Figure 14: ICE's Workforce by region (Average) 1995 – 2002 (Barquero, 2003).

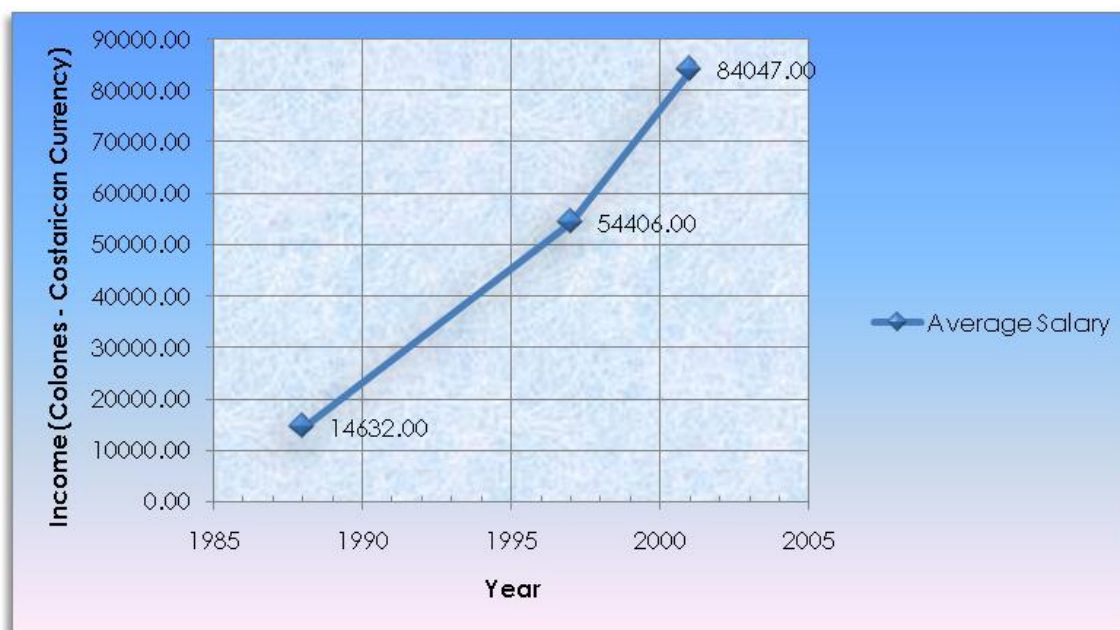


Figure 15: Family Income 1988 – 2001.

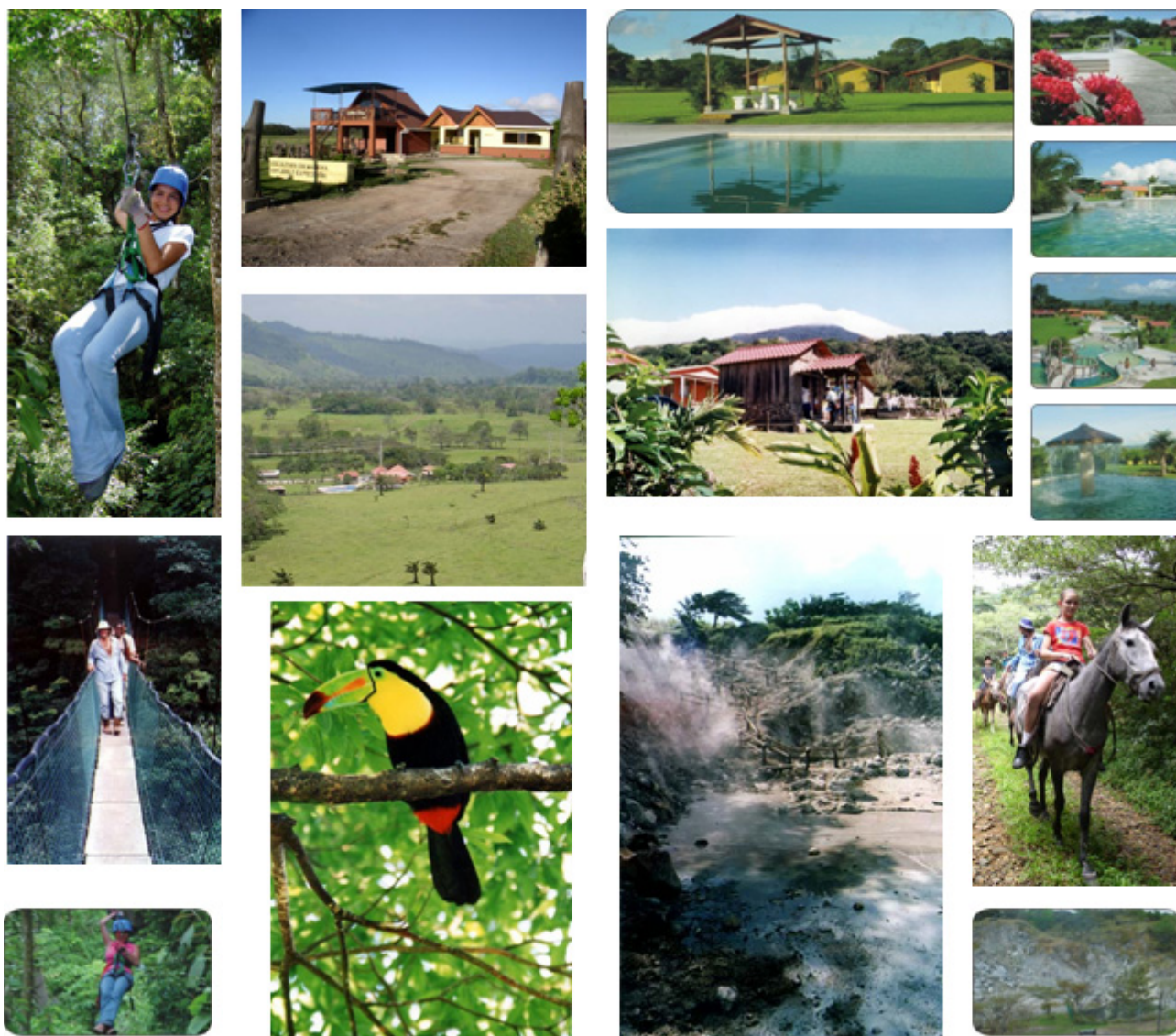


Figure 16: Touristic Activities in Miravalles.

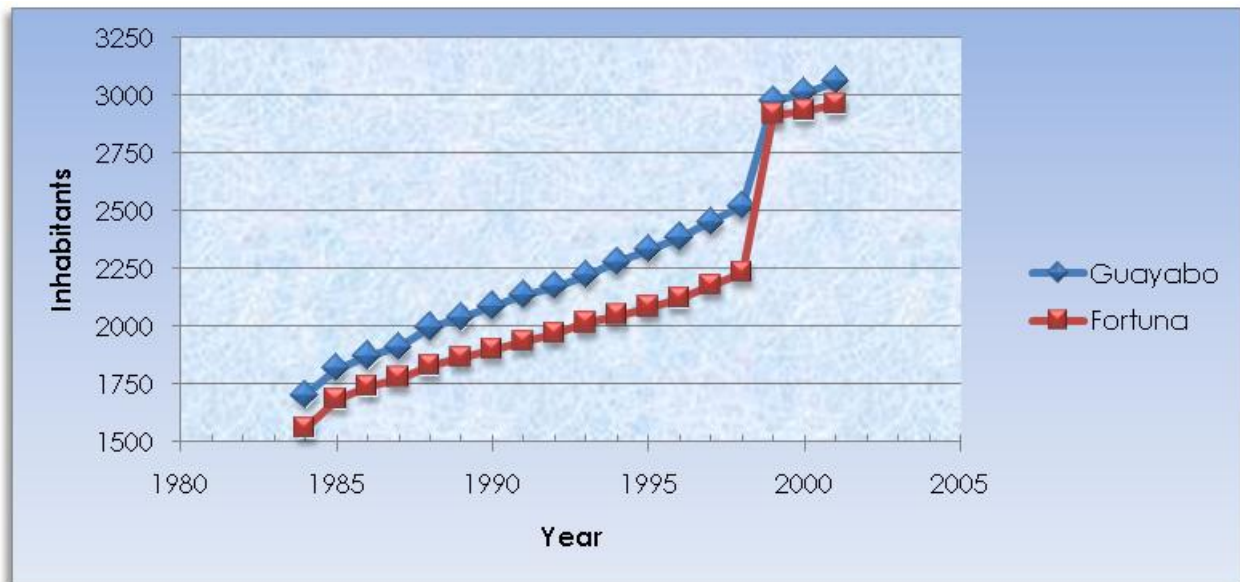


Figure 17: Population Growth in the nearby main towns 1984-2001.

4.2 Environmental Activities

Costa Rica has a long tradition in environmental protection activities. In this sense, it is not strange the actions made in the Miravalles Geothermal Project in regards to the environmental protection of its surroundings. Long before the Miravalles reservoir were exploited its first single MWe a monitoring action plan was set up and since then it has been monitored the air and water quality around the power plant and different populations in the area (Guido, 2010).

The Commitment of ICE with the environment and in order to improve the quality of the area for its inhabitants can be illustrated with the following activities, just to say a few (ICE, 2003):

- Planting 394,600.00 trees, equivalent to an area of about 500 hectares.
- Monitoring and recovery of restored or recovered areas in a natural way, approximately 800 hectares.
- Training courses in environmental education and environmental-friendly-tourism development.
- Improving the landscape through the mitigation of visual impacts on structures, pipes and esplanades.
- Prevention and control of forest fires: from 21 fires in 2001 which meant the burning of 160 hectares, only 5 fires occurred in the 2002 fires, which affected an area of 14.5 hectares.
- Controls on illegal logging
- Construction of watching/monitoring towers and the purchase of surveillance equipment.

The visual impact in the area is noticeable, especially for the inhabitants of the surrounding towns (Figures 20 to 23).



Figure 18: Bridge Build by ICE in Guayabo.



Figure 19: Guayabo Gym (ICE's Cooperation).

5. FINAL REMARKS

The access of electricity for the people is a source of progress to any country. Added to this the condition of the geothermal energy itself as a clean, reliable and environmental-friendly source of energy, the Miravalles

Geothermal Project has brought great benefits not only to the nearby population centers but to the whole country.

The main beneficiaries have been the surrounding areas and population centers close to the Miravalles Project. The improvement of quality of life is noticeable; the improvement in infrastructure is also noticeable (Figures 24 to 27).

The geothermal project has not only given a permanent and stable source of jobs but also has let the development of other job opportunities: agriculture, tourism, professional services, etc.

Thanks to this situation it is observed the benefits that an appropriate development with a socially responsible vision can bring to the near populations to a geothermal development.

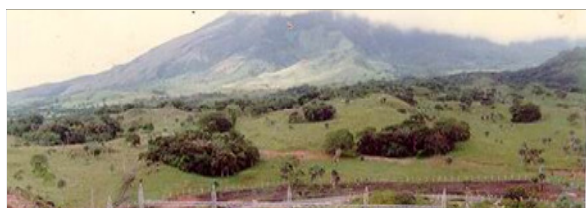


Figure 20: View from Miravalles Power Plant, Miravalles Volcano at the End - 1994.



Figure 21: View from Miravalles Power Plant, Miravalles Volcano at the End - 2004.



Figure 22: ICE Properties in Miravalles - 1994.



Figure 23: ICE Properties in Miravalles - 2004.



Figure 24: ICE's headquarters in Miravalles in late 2008.



Figure 25: Guayabo main street 2009.



Figure 26: Guayabo main street 2009.



Figure 27: Communication Infrastructure for Nearby Towns (Telephone, Cellular, High Speed Internet).

REFERENCES

- Guido, Hartman: (2010). Environmental Management in Geothermal Development: Case History for Costa Rica. . *Proceedings World Geothermal Congress 2010*. Bali, Indonesia. (2010).
- ICE: Estudio de Impacto Ambiental, Unidades 1 y 2, Proyecto Geotérmico Miravalles, Costa Rica. Instituto Costarricense de Electricidad. Costa Rica (In Spanish). (1988).
- ICE: Declaración de Impacto ambiental, 3era y 4ta unidad. Proyecto Geotérmico Miravalles. Instituto Costarricense de Electricidad. Costa Rica (In Spanish). (1996).
- Barquero, Gustavo: Datos Estadísticos de la Influencia del ICE en la zona. UEN de Proyectos y Servicios Asociados, Instituto Costarricense de Electricidad, Costa Rica (In Spanish). (2003).
- Instituto Nacional de Estadísticas y Censos (INEC): Censo Nacional 2000. INEC, Ministerio de Economía, Costa Rica (In Spanish). (2000).
- Instituto Nacional de Estadísticas y Censos (INEC): Encuesta de Hogares 2001. INEC, Ministerio de Economía, Costa Rica (In Spanish). (2001).
- Quesada, Renato: Desarrollo y Promoción turística de Miravalles, Fase II, Diagnóstico y Plan de Acción. Instituto Costarricense de Electricidad, San José, Costa Rica (In Spanish). (1998).
- Saborío, Carlos; Rodríguez, Jeannette; López, Leda; Marín, Yessy: Complejo Geotérmico Miravalles: Historia y Aporte al Desarrollo Socioeconómico y Ambiental de las Comunidades. Costa Rica (Unpublished work in progress). (2010).
- Vallejos, Osvaldo: A Conceptual Reservoir Model and Numerical Simulation Studies for the Miravalles Geothermal Field, Costa Rica, *Geothermal Training in Iceland 1996*, Report 18, UNU G.T.P., Iceland. (1996).