Geothermal Energy Country Update 2020-2022 of Madagascar

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Abstract

Geothermal research in Madagascar has been conducted by for academic or economic purpose. Reconnaissance surveys have focused on geology, geochemistry, hydrology and geophysics with the aim of elucidating subsurface temperatures and the spatial extent of the geothermal systems. The country counts about 120 thermal springs whose emergence temperature varies between 30 and 57°C.

Geothermal systems in Madagascar can be grouped into volcanotectonic and tectonic types. Geothermal Resources of medium temperature exist in the recent volcanic areas, mainly in the north and the central part of the country. Subsurface temperatures were sometimes indirectly determined. Some corrections have been operated, on measured or deducted temperature values from suitable geochemical tools. Subsurface temperatures up to 154 °C have been predicted by geothermometry and mixing models. The estimated generation potential for the country is about 350 MW.

There are many important zones where the geothermal energy could be more interesting for agriculture (greenhouses), aquacultures, heating and refrigeration (heat pumps), etc. Direct uses of geothermal heats, both for drying and cooling, may provide economic gains for local farmers provided that working capital can be made accessible. Available geothermal heats from existing geothermal energy can be used for drying and cooling of tropical fruits and vegetables grown in the Antsirabe and Itasy cities. Steam or hot water available from small geothermal heat pump is combined with active and passive solar utilization methods. A preliminary study is conducted by the University team, to dry jerked banana spike and ananas. The heat pump, a reverse one, is used for heating and cooling houses. Geothermal water of about 46°C is used for this purpose.

Currently, geothermal water is used for bathing, swimming pools, balneology, tourism, potable water bottling and washing with little economic return. Electricity production from geothermal water is also planned. A foreign private company attempts to install the first binary cycle power plant near Antsirabe and Itasy.

Keywords: *Thermal springs, exploration, geothermal potentialities, direct use, Madagascar*

1. INTRODUCTION

The solution to the energy supply problem in Madagascar is the use of alternative energy. We speculate that one of the long term solution is the geothermal development.

Concerning the electricity policy, the Government is represented by the Office de Régulation de l'Electricité (ORE). The project consists in the regulation in mutation of the Electricity Sector, including: the energy transition oriented towards renewable energies, the regulatory framework more attractive and more securing for private investments, and incentive measures to facilitate the development of renewable energy.

This paper represents a summary of the important results of the geothermal development update of Madagascar.

2. RESOURCES AND POTENTIAL OF GEOTHERMAL ENERGY

Madagascar hosts several signs indicating the presence of geothermal resource such as volcanoes (young/dormant), hot springs, geyser, travertine mound and seeps. The country counts about 120 thermal springs (Figures 1, 2 and 3) whose emergence temperature varies between 30 and 57°C.

The distribution of hot springs, heat flow and the nature of the geothermal reservoirs are controlled by the geological structures. Based on the association of geological setting, the geothermal areas can be divided in three sections: volcanic terrain, fault zone, and sedimentary basin. Resources and geothermal systems in Madagascar can be grouped into two main types: volcanotectonic and tectonic. Geothermal potential in the field volcanotectonic generally may have a moderate to medium potential.

Following preliminary reconnaissance studies, three important zones presenting a geothermal potential interest for electricity production can be selected (Andrianaivo, 2008): the northern part geothermal zone (Ramena, Sambirano, Ankaizina), the Itasy geothermal zone and the Antsirabe geothermal zone in the central parts (Figures 2 and 3).

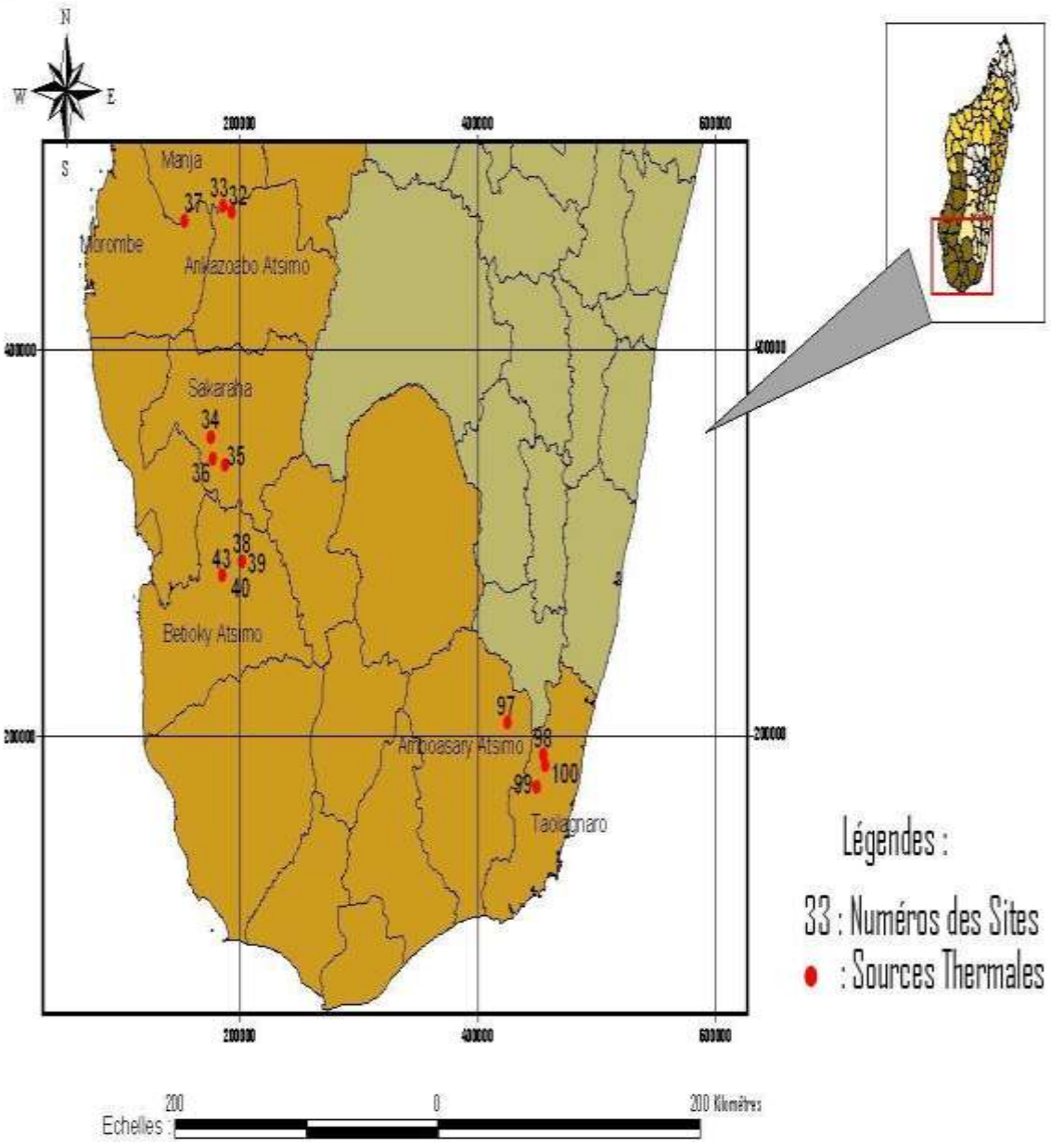

Fig 1: Thermal springs in the southern part of Madagascar (Virkir, 1981; modified after Lala Andrianaivo et al, 2010)

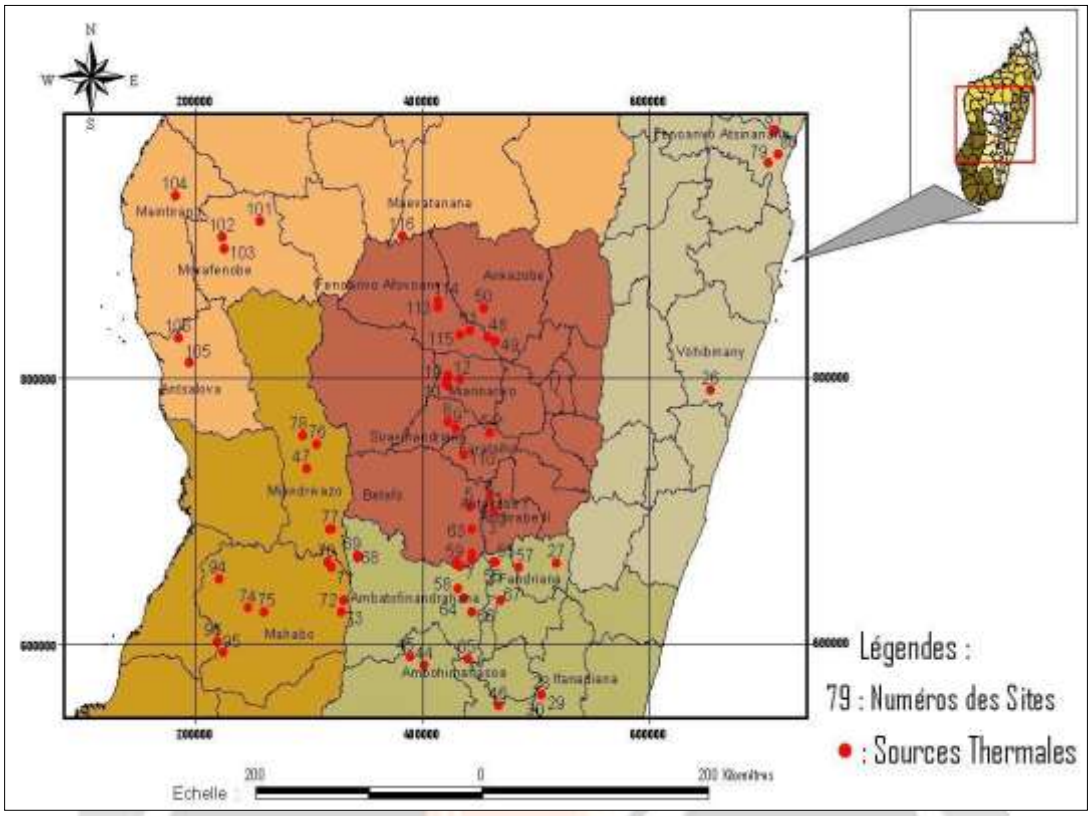

Fig 2: Thermal springs in the central part of Madagascar (Virkir, 1981; modified after Lala Andrianaivo et al, 2010)

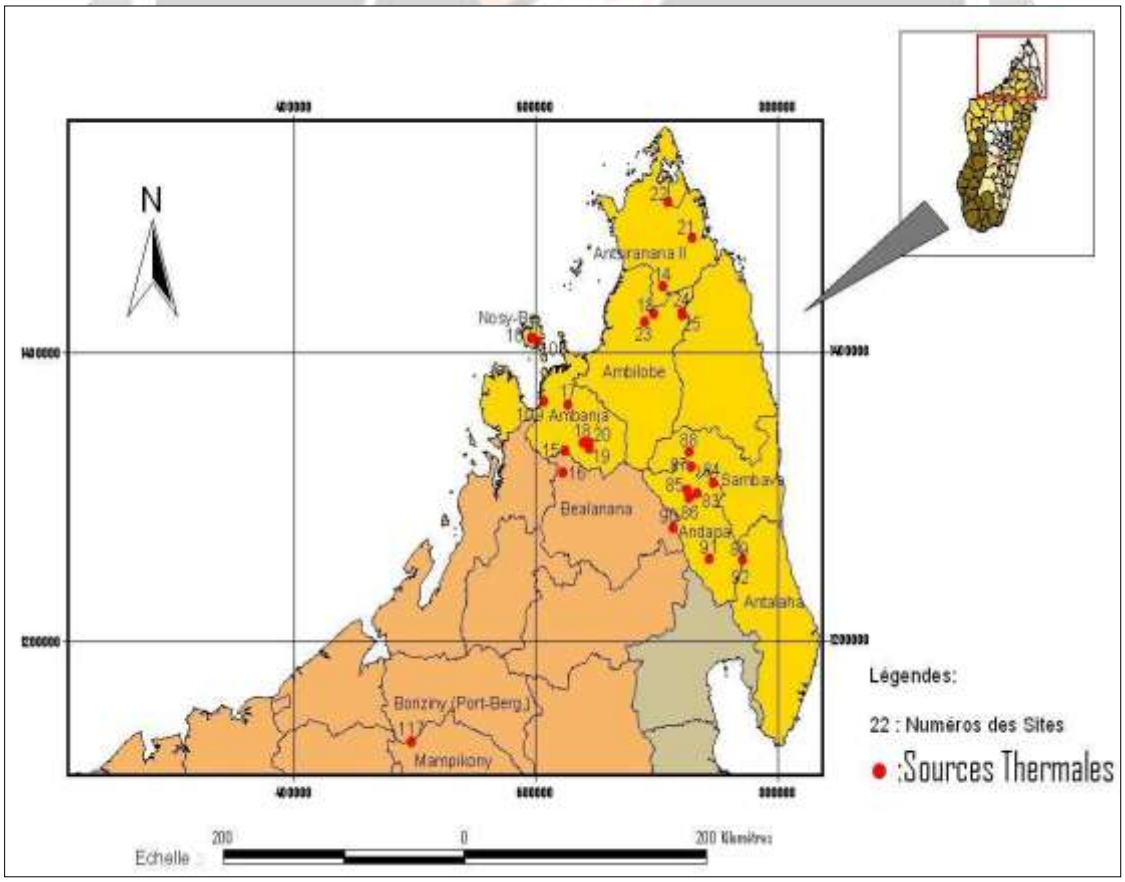

Fig 3: Thermal springs in the northern part of Madagascar (Virkir, 1981; modified after Lala Andrianaivo et al, 2010)

Exploration of geothermal energy is still at early stage. The current study has focused on geology, geochemistry, hydrology and geophysics with the aim of elucidating subsurface temperatures and the spatial extent of the geothermal systems. The results indicate that the geothermal activity in the following three potential areas is related to volcanic and tectonic activities, which has a higher heat flow than the surrounding Precambrian crust. Subsurface temperatures around 155°C for the northern part of the island (Ramena, Sambirano, Ankaizina), 92-176°C for Itasy zone and 88-265°C for Ankaratra-Antsirabe in the central part have been predicted by geothermometry and mixing models (Gunnlaugsun et al, 1981; Sarazin et al, 1986; Manissale et al, 1999; Andrianaivo, 2008; Ramasiarinoro and Andrianaivo, 2010). The estimated generation potential for the country is 350 MW.

A magnetic survey of Itasy geothermal system has been conducted and the data were analyzed to determine the reservoir permeability of the study area. Three dimensional modeling was used to interpret the pseudogravity anomaly. The study shows that the demagnetized rock has good correlation with reservoir permeability (Rajomalahy, 2022).

3. GEOTHERMAL UTILIZATION

The two main utilization categories, power generation and direct use, are already introduced in many countries around the globe; further, expanding distribution is possible and should be increasingly enforced.

Direct heat use is one of the oldest, most versatile and also the most common form of utilization of geothermal energy. The commonest uses of geothermal energy in Madagascar are the traditional ones: balneology and recreation. Bathing, swimming and balneology (therapeutic use) are the best known forms of utilization in Madagascar.

There are today in Madagascar five thermal water spas used for balneology, sports and recreation and as tourist centers. Thermal waters are also bottled by three mineral water bottling companies. Bottling of mineral water is regulated by the Law on Concessions.

A large hotel and rehabilitation center with a swimming pool is heated in Antsirabe Spa. A similar use is practiced in Ranomafana Namorona Spa near the Ranomafana National Park. Thermal springs in Bezaha Spa and in Betafo Spa are used for rehabilitation center and recreation center.

Drinking water out of taps allows massive use for disease prevention. Utilized water for relaxation, sanitary needs and prevention has the highest share in balneology.

In the drying applications, geothermal energy may be used to dry several crops available in some areas such as fruit, vegetable. Design configurations of solar assisted dryers and cooling units developed by our University can be integrated with available heats generated from geothermal heat pumps. Steam or hot water available from geothermal heat pump is combined with active and passive solar utilization methods. A preliminary study is conducted by the University team, using a venturi type hybrid ICDC (Integrated Solar Collector-Drying Chamber) solar dryer (Kamaruddin A. and IBP Gunadnya, 2010) to dry jerked banana spike and ananas.

Table 1 shows performance test results of the dryer when applied to various tropical crops in the country.

Table 2 shows the summary of geothermal heating and cooling installations in the country.

Table 1: Drying temperature and drying time of some crops

Commodity	Drying Temperature (°C)	Drying time (h)	Load (kg)
Ananas	41	32	37
Banana	38	7	11
Zucchini	42	8	5

Table 2. Summary Of Geothermal Heating And Cooling Installations In The Country

2022	Data refer to 2022				
(1) Geothermal Application	(2) Total Installed Capacity (MWt)	(3) Total Energy produced (TJ/year)	(4) Total Energy used (TJ/year)	(5) Number of Installations	Notes
Agriculture and food processing	41	267	267	2	
Industrial process heat					*in progress*
Health, recreation and tourism	2814	75585	75585	4	
Heating and cooling for buildings					*in progress*
Other uses					
Total values	2855	75852	75852		

(1) Geothermal application	*Report of the total amounts for the five major uses of geothermal direct heat*	
	Agriculture and food processing	*Includes:* Greenhouse *(Flowers, plants, mushrooms, algae, hemp, vegetables and fruits);* Aquaculture *(Fish and seafood);* Food Processing *(Food drying, salt and sugar production, canning);* Beverage Processing *(Pasteurization, UHT (ultra-heat treatment), brewing, carbonization, evaporation and distillation);* Others *(Animal husbandry, open field irrigation, cooking, etc.)*
	Industrial process heat	*Includes*: Wood and wood products (*Pulp, paper, fiber, timber drying and processing*); Textile Manufacture (*Dying, refining, and processing of textiles);*Chemicalsandpharmaceuticals *(Industrial processing of chemicals, pharma and beauty products);* Metal & minerals recovery *(Extraction, recovery and TEOR (Thermal Enhanced Oil Recovery);* Other *(Desalination)*
	Health, recreation and tourism	Thermal spas (*Commercial thermal spa centers, ex. Blue Lagoon)*; Swimming and sport centers (*Facilities using geothermal resource for recreational purposes*)
	Heating and cooling for buildings	*This type of application includes the use of air conditioning and hot water for commercial, residential and public buildings. Multiple choice of applications is possible here*
	Other uses	*This type of application includes other uses of direct heat that cannot be attributed to any category above (e.g. snow melting)*
(2) Installed Capacity (MW)	*Total installed capacity (gross) - 2855*	
(3) Total energy produced (TJ/year)	*Total energy (referred only to the geothermal part) supplied to geothermal units' users - 75852*	
(4) Energy used (TJ/year)	*Primary heat supplied by the geothermal resource to the projects - 75852*	

(5) Number of installations	*Total number of units (projects/facilities and single units) in operation - 5*

4. DISCUSSION AND CONCLUSION

Geothermal research in Madagascar has been only ensured by university teams mainly Ecole Supérieure Polytechnique d'Antananarivo. Though limited equipments and after years of research in hydrogeology, geochemistry and geophysics, these published or to be published works allowed to identify the geothermal potentialities of Madagascar. Thus, to go from the phase of resources identification into the phase exploitation or development of geothermal energy, Madagascar must install an adapted institutional framework to encourage the private sector to invest in this field. Also, Madagascar will have to encourage geothermal research, and to mobilize more financing support to work out a development strategy which will have as objectives:

• Geothermal master project;
• Detailed geological mapping, identification of the resources area and geographically associated needs
• Tax incentives
• Public and professionals' information

The primary energy production from domestic sources hasn't changed considerably during last seven years. The highest shares get hydropower (63%) and thermal plant (37%). The contribution of renewable sources is jointly presented with hydropower.
According to the published report by the Ministry of Energy a target of 10% share of RES in 2020 could be achieved mainly by increasing the contribution of hydro power plants.
A National Program promoting development of renewable energy sources for the period 2015-2025 has been approved.
It is focused on the reduction of electricity and liquid fuels as sources for heating and their replacement with renewable.
A State Commission for Energy issues licenses and sets compulsory preferential purchasing prices for electricity generation from renewable. The prices are formed based on the analysis of investment expenditures by technology, expenses for energy generation by technology and the rate of capital repayment. No purchasing prices are available for electricity generation from thermal waters because such activity is still missing in the country.
A substantial problem in RES development in the country is the lack of coordination of this process. Still, no official register for renewable application is available.
Among different types of geothermal application only balneology (sanitary needs, prevention, treatment and rehabilitation), swimming pools, drinking water and relaxation have shown a growth. Some quantities of thermal water have been used to meet the demand of potable and domestic water. The total installed capacity for direct heat use runs up to 2,855 MWt (Table 3).
Major current barriers stated for the previous seven years period for the geothermal development in the country remain the same:

- Lack of preferential status to the use of geothermal energy for heat production.
- Lack of expertise in preparation of exploration and business plan.
- Insufficient commercial financing.

Local taxes and fees are important but very insufficient source of funds for the Municipalities budgets.
Lack of investments and organizational problems are still the major obstacles for the geothermal development in the country.
It is actually possible to establish a strategic route for geothermal energy whose role will be:

- to establish an exhaustive census and an inventory of the national potential;
- to set up a true policy of research in geothermics with the facilities granted to other sectors; and
- to encourage the private sector in the research and development in the geothermic field

Existing Spa centers located in central Madagascar would increase the share of thermal water in their activity and the type of applications as well.
A process of assessment of the existing geothermal resource regarding possibilities for electricity generation by using modern technologies is in progress.
The project of the government, represented by the Office de Régulation de l'Electricité (ORE), consisting in the regulation in mutation of the electricity sector is also is in progress

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