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Geothermal Development in East Africa, Republic of Djibouti

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ABSTRACT

Since 1970, the Republic of Djibouti has investigated their geothermal potential. In the country, there is steady increase in demand for electricity, with a favorable institutional framework in place, along with clear objectives for development.

This presentation will present the favorable geologic condition found in the area of concern, and outline potential development obstacles, including hypersaline reservoir chemistry and an arid environment.

Several prospective sites of interest will be discussed regarding their priority and initial feasibility. Also, the organization of the entities in charge of developing this potential will be outline and discussed in detail.

1. INTRODUCTION: SOCIO-ECONOMIC BACKGROUND

1.1. The Republic of Djibouti

Republic of Djibouti is presently a low income country, located in one of the most arid climatic environment. It is also located at the intersection of several major economic routes of the planet, linking the Red and Mediterranean seas with the Indian Ocean, as well as large African countries with the outside world. This original position represents a major advantage in a world-open economy, and offers a real opportunity for the country if it is able to answer the needs of the growing regional economic development.

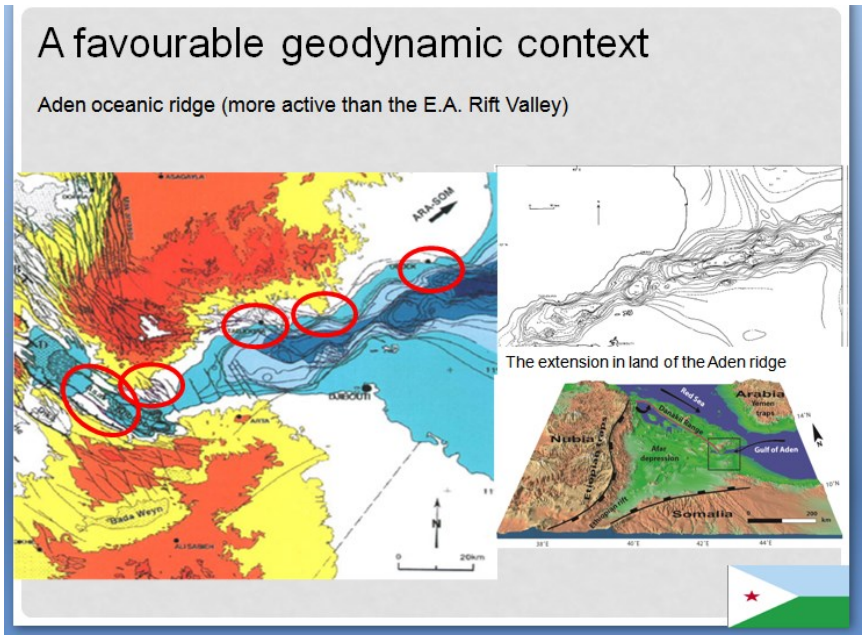

Figure 1: The Gulf of Aden

2. GEOTHERMAL POTENTIAL:

2.1 Favorable Geodynamic Context

Wide open on the Gulf of Aden at the southern end of the red sea, Djibouti is a geostrategic position touching Ethiopia (80 million inhabitants), Eritrea (4 million) and Somalia (10 million), and in great proximity with Yemen (15 million) through the narrow Bab-El-Mandeb straight. The current population of Djibouti is estimated to be about 850 000, of which about 600 000 live in the main town of Djibouti-Ville, 95 000 in secondary towns and the remainder, 155 000, in a rural setting, including a substantial nomadic population. The country's electrification rate is about 50 per cent. Demand in Djibouti-Ville area is currently supplied from two main power stations operating on fuel oil with an installed capacity of 100.3 MW.

The availability of and access to clean, adequate and low cost energy is expected to significantly contribute to economic growth, the re-enforcement of the competitiveness of the country, the improvement of the quality of daily life of the population and

consequently to the reduction of poverty. At the present time, the lack of distribution network or even of isolated generators, and the high cost of electricity in Djibouti-City and other towns makes it unaffordable to many citizens, small scale commerce and light industry. Access in the rural areas is very limited and electricity is unknown to the pastoralist population.

The unavailability of a reliable and adequate supply of low cost energy is viewed as the main constraint on industrial development, economic growth and social well-being of citizens. The increasing cost of importation of petroleum products not only by far surpasses the level of the negative trade balance, but import dependency subjects the country to uncertainties which arise from tensions in oil producing regions. The risk of social instability arises from the constraint that the high cost and inadequate availability of energy imposes on the effort at sufficiently rapidly reducing poverty.

The energy policy of the government is to diversify the primary source of energy for conversion to electricity on a commercial basis at affordable prices. At the present time, Djibouti has no indigenous coal, oil or gas. There is very little vegetation for supply biomass energy supply and no rivers for hydro-power generation. The government aim is thus to develop all available alternative and renewable energy resources whereby the priority goes to geothermal resources for which the country is believed to have a good potential. This is intended to be carried out with private sector participation in the development of the resource and the generation of electricity.

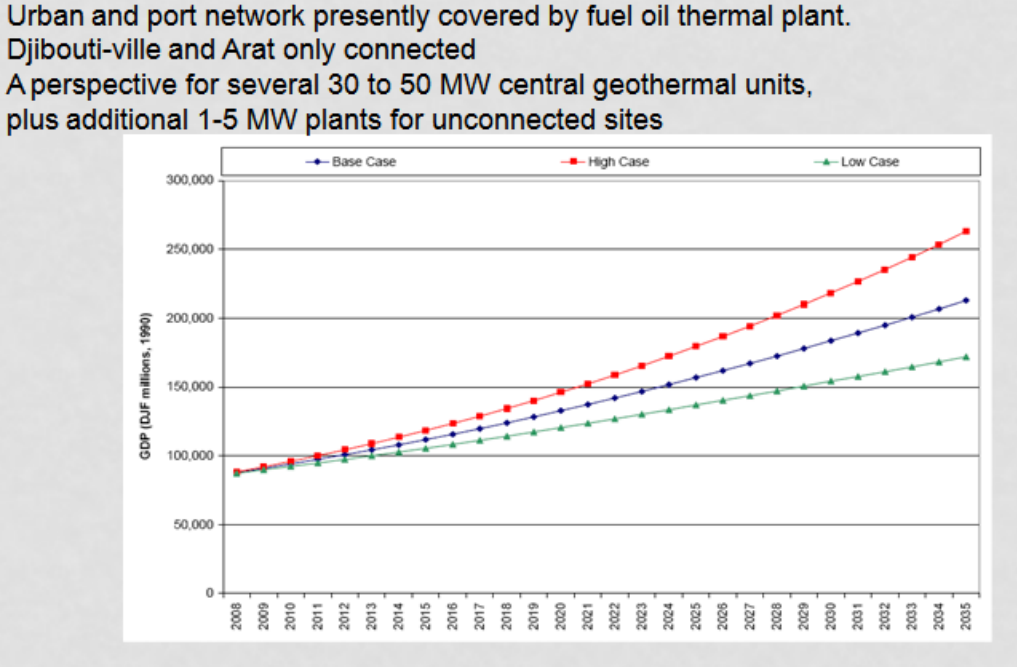

Figure 2: An increasing demand for electricity

3. SYNTHESIS: A FIRST QUALITATIVE HYERARCHY OF GEOTHERMAL SITES

From this logical overview of the potential geothermal resource of the Republic of Djibouti, two contracting types of development can be considered from the resources point of view:

Classic high enthalpy sites located on land and offshore, aimed at serving the present or future electric grid, from eventually large thermal power units; and,

Smaller medium enthalpy development using ORC technologies on non-magmatic hydrothermal sites linked with fracture systems affecting the stratified series.

3.1. Classic High Enthalpy Fields Along Ridge On-land and Offshore, Serving the Present or Future Electric Grid

We have the following sites, from east to west along the ridge axis: Obock, Rouéli, Nord-Ghoubbet, Asal and ManadaInakir.

In terms of magmatic heat source proximity at depth, the order is:

1) Asal
2) Nord-Ghoubbet
3) MandaInakir
4) Rouéli
5) Obock

In terms of water quality in the reservoir, the score is the following:

1) Nord-Ghoubbet
2) MandaInakir

3) Rouéli
4) Obock
5) Asal

In terms of permeability:

1) Nord-Ghoubbet
2) MandaInakir
3) Asal
4) Rouéli
5) Obock

In terms of the potential size of the site (in MWe):

1) Asal
2) Nord-Ghoubbet
3) MandaInakir
4) Obock
5) Rouéli

In terms of proximity and importance of the demand:

1) Asal
2) Nord-Ghoubbet
3) Rouéli
4) Obock
5) MandaInakir

In terms of knowledge of the geothermal field:

1) Asal
2) Nord-Ghoubbet
3) Rouéli
4) Obock
5) MandaInakir

As a whole, Table 1 presents the respective scoring of these sites in light of these various criteria.

Table 1: Scoring of sites for high enthalpy development in Djibouti Republic

Geothermal site along the ridge	Heat source	Permeability	Water recharge quality	Potential size of the site	Geothermal knowledge	Demand size grid proximity
Asal	+++	+	-	++	+++	+++
N-Ghoubbet	++	+++	+++	+++	++	++
Rouéli	++	+	+	+	+	+
Obock	++	+	+	+	-	-
Manda-Inakir	++	++	++	++	-	-

3.2. Local Opportunities for Medium Enthalpy ORC Plants Answering Local Needs

ORC plants can be developed in several sites, the size of which will depend on:

- The quality of the site, and

- The importance of the local demand

In this respect, some of the sites placed in the first category, i.e. suitable for eventual important high enthalpy development could justify the installation in a first step of a small-size medium enthalpy plant only due to the limited demand at present. In a few cases, the local demand may just be fed by the binary plant, due to the limitation of the resource parameters.

In the places located outside the above mentioned set, we have described in this paper one interesting site, due to the local demand, and its limited but still attractive potential: that is Garabbayis answering the need of development axis of Dikhil-Yoboki.

The Abhé site could be a significant site in size, but limited in terms of temperature to ORC technologies. However, due to the agricultural potential of the area, other direct applications of the geothermal fluid could develop (drying, fish farming, cooling).

Besides those two places, several other sites are certainly suitable for small-size ORC medium enthalpy units exploiting local hydrothermal manifestations in response to local demand. We have seen several such sites during our first exploration work

developed in this respect in the north-western part of the Republic. Such potential sites are notably encountered north-east of Asal along the major fault lines crossing transverse faults.

We mentioned the case of Karapti San, where a water well already met such conditions, but several other sites certainly exist in the area as well as in the populated Allol and Sakalol sites to the North and Gaggadé to the East. There is a need for further exploration specifically for this purpose, combining the location of the villages and population concentrations in comparison to the fumaroles and thermal emergences related to transverse faulting systems. It may well be that up to 10 such sites could be identified. Table 2 tries to synthetize these present views by combining all site characteristics.

4. CONCLUSION: TOWARDS A LONG TERM NATIONAL STRATEGY FOR GEOTHERMAL DEVELOPMENT

From the methodology proposed in this paper, it would be possible, after consultation with other experts, and complementary field works, to develop a sound strategy for geothermal development in the country. This should of course, in addition to the improvement of the knowledge of the sites, also rely on a better approach of the appropriate technologies, adapting the costs of the exploration and drillings to the targeted size of the site.

Moreover, the study should be carried with a prospective view of the evolution of the demand, not only resulting from standards figures already available concerning the Djibouti capital and port.

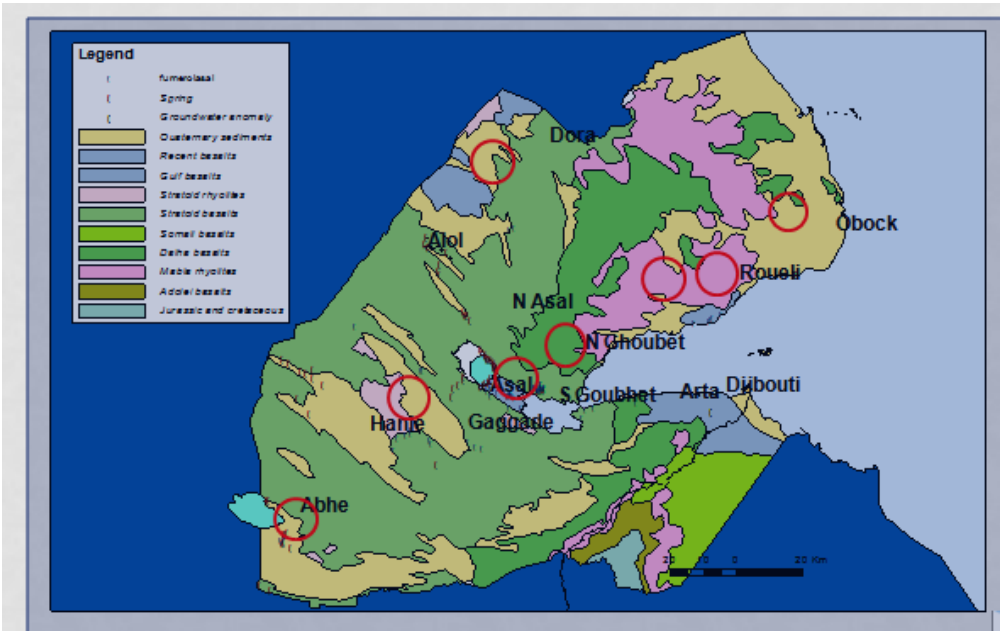

Figure 3: The organisation in charge under construction: information system on all resources including data from geothermal exploration

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