

## STUDY ON THE SOZIO- ECONOMIC FRAMEWORK FOR THE USE OF GEOTHERMAL ENERGY IN VIETNAM

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### ABSTRACT

FUGRO CONSULT GmbH and the Transfer Office for Efficient and Renewable Energy Use was commissioned by the Federal Institute for Geosciences and Natural Resources, Hannover, Germany to work on the study concerning the socio-economic framework for use of geothermal energy in Vietnam in cooperation with the project partner CEVIHEGEO, Vietnam. During the project 6 locations in southern central Vietnam were investigated: Tu Bong, Phu Sen, Thach Tru (Mo Duc), Nghia Thuan, Hoi Van and Kon Du.

The study provides a link between economic analysis and geological conditions. The economic analysis shall estimate actual costs of a geothermal power plant at the sites Hoi Van and Thach Tru taking into consideration local geological conditions and existing geoscientific investigations. The interviews and the field trip were prepared by the DGMV and the CEHIVEGEO. Information was collected during the meetings with the major institutions of the electricity sector: Ministry of Industry and Trade, Institute of Energy, Electricity Regulatory Authority of Vietnam and Electricity of Vietnam. During these meetings several issues were discussed like the existence of subsidies of the state of Vietnam and of other potential financial supporters for small and medium-sized enterprises in the domains of utilization of energy use, energy efficiency and renewable energies. Even though, in the National Power Sector Master Plan in the period of 2006-2015, the yearly increase of renewable energy was politically decided and publicized, there are no federal instruments for the promotion of geothermal power generation. According to the principle of minimal costs, electricity is bought from EVN across the nation.

According to the evaluated reports the geological setting, together with the chemistry of the fluids and gases, strongly suggests that the thermal springs represent hydrothermal systems that have developed in **fracture and fault zones** caused by deformations in the Mesozoic and Cenozoic. All geothermal waters are considered to be predominantly **meteoric waters** that are heated in a normal or elevated thermal gradient with no magmatic associations. The best prognosis for successful geothermal electricity generation was determined **for the location Hoi Van**. Specific electricity generation costs of **11 €/kWh<sub>el</sub>** were roughly calculated for the best suited scenario with electricity generation by ORC plant and water recooling by a river. In the scope of the project workshop on 12<sup>th</sup> March 2008 in Hanoi the participants recommended to perform a pilot project at the location Hoi Van and to involve the different stakeholders. The best economic efficiency can be reached with the combination of geothermal electricity generation and direct use of the residual heat at one location. In the scope of this **cogeneration** the provided residual heat is delivered for a prize of 3.9 – 4.7 €/kWh<sub>th</sub>.

For **industrial use**, the current electricity sales price amounts 15.5 €/kWh. It is efficient to generate electricity on site for industrial customers, who can use the residual heat of the geothermal power plant for their operating process. In **rural areas** for communities it can be efficient to generate electricity by thermal energy and use the residual heat for drying goods to replace other expensive technologies like diesel power generators. In this case a promotion by CDM projects, World Bank or Asian Development Bank can be applied and useful. The requirement for these projects is that the government submits a road map for projects in future dealing with renewable energies. It is suggested to conduct a **prefeasibility study for geothermal electricity generation** and the use of residual heat. Cooling for **cold storage facilities** with geothermal heat is probably the **most interesting utilization** possible. Cold storage facilities have to be settled next to thermal springs already to use the thermal water. In addition, it is suggested to conduct a **prefeasibility study for direct use** of geothermal heat for the locations Hoi Van, Phu Sen, Tu Bong and Thach Tru. It is recommended to talk to private investors e.g. Infracore about the operation of refrigeration warehouses through geothermal energy.

**Keywords:** Socio-economic study, electricity generation, direct use, fracture and fault zones, meteoric waters, Vietnam, location Hoi Van, geothermal electricity generation costs, cogeneration, industrial use, cold storage facilities, ORC plant.

## 1. INTRODUCTION

The Federal Institute for Geosciences and Natural Resources (BGR) on behalf of the Federal Ministry for Economic Cooperation and Development of Germany (BMZ) performs the GEOTHERM program, to promote the use of geothermal energy. The program promotes selected partner countries to improve the exploitation of their geothermal potentials.

In August 2006, the Vietnam Central Division of Hydrogeology and Engineering Geology (CEVIHEGEO) on behalf of the Department of Geology and Mineral Resources Vietnam (DGMV) submitted a project proposal for the exploration of geothermal resources in the southern central region of Vietnam to BGR. Based on this request a project appraisal was performed by BGR, DGMV and CEVIHEGEO between 21.01 and 02.02.2007. FUGRO CONSULT GmbH and the Transfer Office for Efficient and Renewable Energy Use in Bingen was commissioned by BGR, Hannover, to work on the study concerning the socio-economic framework for use of geothermal energy in Vietnam in cooperation with the project partner CEVIHEGEO, Vietnam. During the project 6 locations in southern central Vietnam were investigated: Tu Bong, Phu Sen, Thach Tru (Mo Duc), Nghia Thuan, Hoi Van and Kon Du.

As one result of the project appraisal mission, it was decided to carry out a detailed assessment of the chances of success of the use of geothermal energy for power generation and direct use of heat in Vietnam with a view to economic and socio-cultural environment. The study provides a link between economic analysis and geological conditions. The economic analysis shall estimate actual costs of a geothermal power plant at the sites Hoi Van and Thach Tru taking into consideration local geological conditions and existing geoscientific investigations.

The goal of the study is to analyse the socio-economic conditions of geothermal energy use in Vietnam. In the first part of the study, Vietnamese institutions from the energy sector have been visited and interviewed. The interviews should clarify the existing conditions for geothermal energy use in Vietnam. Conditions such as electricity demand, development of the electricity market, electricity price and aid mechanisms have been examined.

## 2. PREVIOUS WORKS

In Vietnam, about 300 geothermal sources are known where hot springs with a temperature over 30° C arise, 45 of them with temperatures above 60 °C. In the region of southern central Vietnam 8 of the 72 geothermal sources have outflow temperatures of over 70 °C. The south-eastern central region of Vietnam consists of Mesozoic, Palaeozoic and Precambrian metasedimentary and igneous rocks, bordered locally by narrow, alleviated coastal zone or cut by narrow alleviated valleys. The southern central region mainly consists of cretaceous Deo Ca Granite Complex and Hai Van Granite Complex. Several tectonic structures have been formed in the Mesozoic and the Cenozoic with a major deformation during late Tertiary. According to the evaluated reports the geological setting, together with the chemistry of the fluids and gases, strongly suggests that the thermal springs represent hydrothermal systems that have developed in **fracture and fault zones** caused by deformations in the Mesozoic and Cenozoic. All geothermal waters are considered to be predominantly **meteoric waters** that are heated in a normal or elevated thermal gradient with no magmatic associations.

## 3. METHODS

The interviews and the field trip were prepared by the DGMV and the CEVIHEGEO. Information was collected during the meetings with the major institutions of the electricity sector: Ministry of Industry and Trade, Institute of Energy, Electricity Regulatory Authority of Vietnam and Electricity of Vietnam. During these meetings several issues were discussed like the existence of subsidies of the state of Vietnam and of other potential financial supporters for small and medium-sized enterprises in the domains of utilization of energy use, energy efficiency and renewable energies. Even though, in the National Power Sector Master Plan in the period of 2006-2015, the yearly increase of renewable energy was politically decided and publicized, there are no federal instruments for the promotion of geothermal power generation. According to the principle of minimal costs, electricity is bought from EVN across the nation.

The purpose of the study was the realistic assessment of the chances of success of the use of geothermal economics for power generation and direct use of heat in Vietnam with a view of the economic and socio-cultural environment and to propose possible activities to facilitate the development of geothermal resources.

### **Economical investigation**

An economic analysis for estimation of the costs for power generation from geothermal energy was worked out dependent on the local geological data for southern central Vietnam.

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During the field trip existing local industries and enterprises, which could use the geothermal heat in the vicinity of the hot springs for industrial processes were contacted and interviewed. The aim of the interviews was to estimate the possibilities for a settlement of industries or enterprises (e.g. textile), which have an interest in the use of low-cost process heat from the geothermal resources. Additionally the study has to examine the local availability of raw materials and the local needs for the respective products, as well as the potential for their national and international marketing. Furthermore, there is a current interest especially in the energy consumption and their manufacturing processes, the currently paid energy prices and their general interest in a direct use of geothermal energy.

### **Political / Institutional situation**

As part of the Vietnam trip, the following project objectives were given:

- Estimation of the new framework, resulting from the in May 2007 published PDP 6th. In particular it could be estimated, which promotion instruments the new PDP deals with for the development of renewable energy sources including geothermal energy.
- Contacting of the provincial government incorporated with the target to inform and to clarify their willingness to support the different projects.
- Clarification of the rights for the use of energy at the geothermal sites.
- Analysis of the existing promotion instruments of the Vietnamese Government and other potential donors for small and medium-sized enterprises.

In the meetings with the Local People Committees of the provinces the GEOTHERM-program and the goal of this study were presented. The Local People Committees of the provinces determine the political and administrative decisions of the geothermal locations. The presentation was followed by an interview on the economic situation of the region and the regional industry. Future planning was mentioned. Furthermore, the conversations had the aim to acquire new projects using geothermal energy. The interview guideline and the minutes of the Interviews are attached in the Appendix.

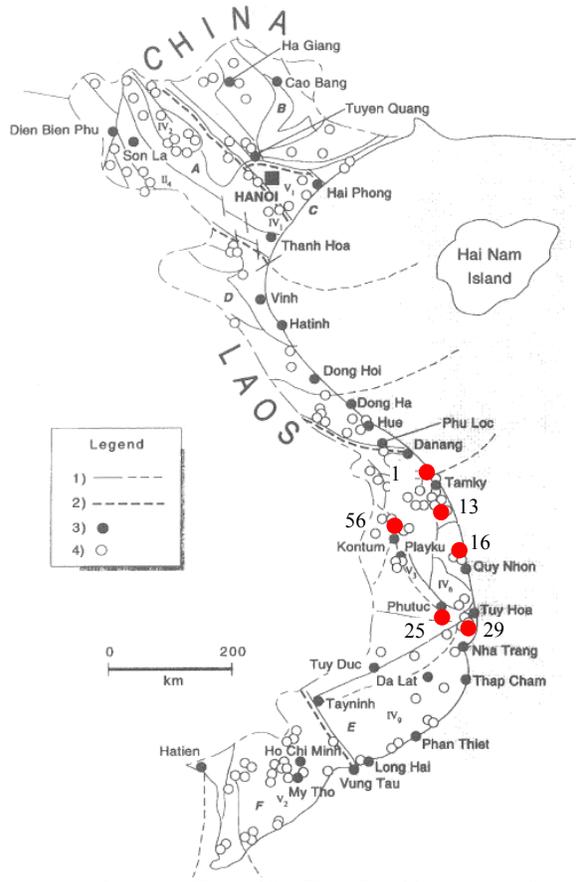
During the field trip enterprises using process heat were interviewed on the required criteria like heat demand, energy prices, energy resources and necessary temperature levels. Additionally, the interest in direct utilization of geothermal heat and the ability to invest were elaborated by the interviews, as well as the availability of raw materials, the existing road and transport network, the local demand for the particular products and the potential for the national and international trade (merchandise).

### **Geoscientific investigation**

In the scope of the study the existing reports and hydro geological maps on the scale 1: 500,000 and 1: 200,000 of the regional geology in southern central region of Vietnam were evaluated. The intention of this evaluation was to get information about the visited sites and the following geo scientific parameters:

- Geothermal system.
- Nature of rocks at location.
- Recharge area of thermal water.
- Facing and kind of fissures (joint spacing, fissure cave, number of fissures).
- Facing and kind of faults of rocks.
- Sustainability of use of the thermal sources.
- Age and provenience of thermal water.
- Salinisation of the sources.
- Geochemical data of thermal water (geothermometer analysis, gas analysis).
- Jointing of rocks.

Figure 1: Overview of the geothermal potential of Vietnam (Hoang, 1998)



● visited locations 1 = Nghia Thuan; 13 = Thach Tru; 16 = Hoi Van; 25 = Phu Sen; 29 = Tu Bong; 56 = Kon Du;  
 Legend: 1) Faults, dashed lines inferred 2) Boundary of geothermal regions 3) Geographic names 4) Thermal springs

During the field trip the following data and literature was collected:

- Quality of recent investigation data.
- Flow rate estimated at a depth of 500 m as an "educated guess" on the basis of data on crossing faults and fissures.
- Flow rate measured while pumping test.
- Hydraulic conductivity estimated at a depth of 500 m.
- Boreholes and wells at the site.
- Depth of the wells.
- Pumping test and geophysical data.
- Temperature estimated by geothermometers.
- Recent basaltic activities, dikes.

The intention of geo-scientific investigations was to facilitate an economic analysis to estimate actual costs of a geothermal power plant at the sites Hoi Van and Thach Tru taking in consideration local geological conditions (estimate of the investment and determination of operating costs). One important task of the study was the exploration of the causes for the stopping of the ORMAT project planned for geothermal power generation in 1995. In particular, ORMAT has been contacted to find out why the advanced project was cancelled and has not been completed.

One of the geochemical methods widely applied in geothermal exploration, is the application of liquid phase **geothermometers** to estimate the reservoir temperature (see Table 1).

**Table 1: Data of the thermal water of the geothermal locations**

Hoang (1998) and Nguyen et al. (1993)				Temperature (°C)				
				calculated by geothermometer method				
Location	l/s	Cl meq	T °C	Chalcedony	Quartz	Na/K *	Na-K-Ca	Mix model
Tu Bong	1,1	9,87	58	115.8	142.0	<b>144.2</b>	139.6	-
Phu Sen	3,4	312	69	90.1	118.7	<b>139,3</b>	130.8	194
Hoi Van	10-24	3,98	85	102.0	129.4	<b>143.1</b>	142.5	132
Nghia Thuan	5,0	-	70.5	111.0	137.7	<b>139.0</b>	132.8	-
Thach Tru	2,4	68.30	80	113.4	139.8	<b>177.0</b>	161.5	218
Kon Du	1,0	0,05	83	99.6	127.3	<b>139.7</b>	134.6	263

\* **best suited method**

## 4. RESULTS OF THE STUDY

### 4.1 Geothermal power generation

The best prognosis for successful geothermal electricity generation was determined **for the location Hoi Van**. Specific electricity generation costs of **11 ¢/kWh<sub>el</sub>** were roughly calculated for the best suited scenario with electricity generation by ORC plant and water recooling by a river. In the scope of the project workshop on 12<sup>th</sup> March 2008 in Hanoi the participants recommended to perform a pilot project at the location Hoi Van and to involve the different stakeholders.

The best economic efficiency can be reached with the combination of geothermal electricity generation and direct use of the residual heat at one location.

In the scope of this **cogeneration** the provided residual heat is delivered for a prize of 3.9 – 4.7 ¢/kWh<sub>th</sub> - which corresponds to a fuel prize of 39 - 47 ¢/l -, approximately 5,400 – 6,500 MWh<sub>th</sub>/a must be merchandised that the power generation prize (ORC + water cooling) is decreased about 1.5 ¢/ kWh<sub>el</sub>. This means either a year-round utilization of the heat with a thermal capacity of approximately 2 MW<sub>th</sub> or in the other extreme case the utilization of the complete available residual heat at 500 hours per year.

For **industrial use**, the current electricity sales price amounts 15.5 ¢/kWh. It is efficient to generate electricity on site for industrial customers, who can use the residual heat of the geothermal power plant for their operating process.

In **rural areas** for communities it can be efficient to generate electricity by thermal energy and use the residual heat for drying goods to replace other expensive technologies like diesel power generators. In this case a promotion by CDM projects, World Bank or Asian Development Bank can be applied and useful. The requirement for these projects is that the government submits a road map for projects in future dealing with renewable energies.

It is suggested to conduct a **prefeasibility study** for **geothermal electricity generation** and the use of residual heat. The following steps of investigation are recommended:

1. Investigation of the tectonic structures by remote sensing. The provenience and age of the geothermal water has to be investigated.
2. Investigation of the tectonic structures and hydraulic conductivity of the fault system by seismic reflection method and transient electromagnetic method (TEM). The Seismic reflection method requires a controlled seismic source of energy, such as dynamite. CEVIHEGEO themselves operate a Multi Channel Seismic System and a TEM unit with an investigation depth of max. 500 m.
3. The mapping of geologic structures and steep fault zones at all locations are subjects to further investigation. The intention of the investigation is to map the width and spacing of the fault and fissure zones. On the basis of these data, the size of the reservoir has to be estimated. Dependent on the results of the first investigation, the performance of additional geophysical investigations such as magnetotellurics up to 2,500 m must be determined.

#### 4.2 Direct use

In 2005, just 1-2 MW<sub>th</sub> of the geothermal energy in Vietnam were used for heating, iodine-salt production, swimming pools and tourism. The focus of the direct heat utilization lies on industrial and agricultural applications:

- There is no real need for desiccation heat as the products can be dried naturally by air. But the quality and the endurance of the products can be improved by a desiccation with warm air and the products win value for export.
- The production of juice is an interesting application of heat from geothermal sources. Especially the prewarming process is interesting.
- The sugar industry would be an interesting industry to use geothermal heat for. But as seen in the Pho Phong sugar factory during the field trip, the sugar industry predominantly uses cane for their heat production. This combustible material is very cheap, and the price for heat supply by geothermal energy can hardly fall below this price.
- Milk preservation is a possibility for the direct utilization of geothermal heat in Vietnam.
- Geothermal heat can possibly be used for production of hot water for the lautering process and for the boiling of the wort.
- Cooling for **cold storage facilities** with geothermal heat is probably the **most interesting utilization** possible. Cold storage facilities have to be settled next to thermal springs already to use the thermal water.
- Low temperature heat can be used for processes in the textile industry.

For private investors such as Infraco Ltd. it is necessary to improve the data basis for the chosen locations for geothermal electricity generation. It is recommended to contact potential investors and introduce them to the utilization concept. In addition, it is suggested to conduct a **prefeasibility study** for **direct use** of geothermal heat for the locations Hoi Van, Phu Sen, Tu Bong and Thach Tru. It is recommended to talk to private investors e.g. Infraco about the operation of refrigeration warehouses through geothermal energy. The same steps of investigation are recommended like in the section for power generation.

#### 5. SUMMARY

The best prognosis for successful geothermal electricity generation was determined for the **location Hoi Van**. Specific electricity generation costs of **11 ¢/kWh<sub>el</sub>** were roughly calculated for the best suited scenario with electricity generation by ORC plant and water recooling by a river. In the scope of the project workshop on 12<sup>th</sup> March 2008 in Hanoi the participants recommended to perform a pilot project at the location Hoi Van and to involve the different stakeholders. The best economic efficiency can be reached with the combination of geothermal electricity generation and direct use of the residual heat at one location.

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