UPDATE ON GEOTEERMAL DEVELOPMENT IN THAILAND

TAVISAKDI RAMINGWONG[1] AND SUTHEP LERTSRIMONGKOL[2]

[1]Chiang Mai University, Faculty of Science, Chiang Mai 50200
[2]Electricity Generating Authority of Thailand, Nonthaburi 11000

Keywords : Thailand, Fang, San Kampaeng, Pai, multipurpose

ABSTRACT

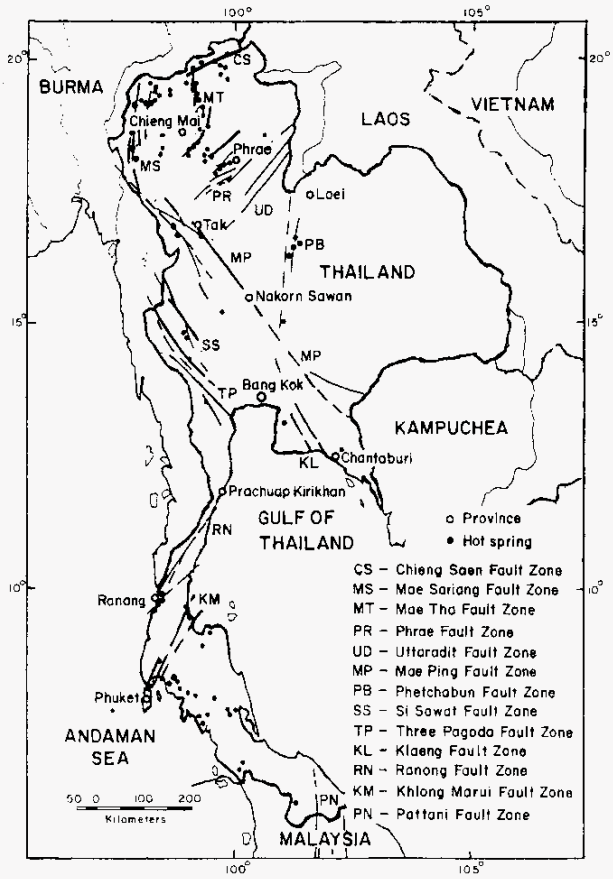
Geothermal exploration in Thailand with foreign cooperation has been mainly focused in two areas, Fang and San Kampaeng, Chiang Mai Province. Since 1990, Fang has been the only geothermal field that has been fully developed for multipurpose utilization. This includes generating electricity, drying and cooling processes, and tourism purposes. Subsequently, deep exploration has been conducted in Fang for commercial scale utilization. The results of vertical drilling were unsucessful and indicate that deviated dnlling techniques must be used in such a limited area and geological setting. Development in San Kampaeng has been postponed after two unsucessful deep wells were drilled in 1985-1989.

Recently, a new geothermal area, located in Pai district, Mae Hong Son Province, is being investigated to develop a shallow reservoir in similar manner to the Fang multipurpose project.

INTRODUCTION

Over 90 hot springs with surface temperatures ranging from 40 to 100°C are scattered throughout the country (Fig. I). These hot springs were mapped starting in 1946. However, studies of their geothermal potential did not begin until late 1979. Later on, a working group consisting of personnel from the Electricity Generating Authority of Thailand (EGAT), the Department of Mined Resources (DMR), and Chiang Mai University (CMU) was formed and a tentative schedule for geothermal energy development in northern Thailand was set.

The working group investigated more than 30 hot springs and gradually narrowed down the investigations to the two most promising areas, both of which have calculated subsurface temperatures close to or above 180 °C. These two promising areas were in San Kampaeng and Fang and during 1980-1990, two feasibility study projects were wnducted in them with foreign cooperation. The results of the studies in these two areas indicated that only medium enthalpy geothermal resources are present. Most of the reservoirs are likely to be associated with faults or faults sets which have very steep dips There is a possibility of producing hot water having a temperature of 130 °C from a shallow fractured reservoir at a depth less than 500 m. These geothermal resources have energy potential enough for multipurpose uses, including electricity production by binary cycle, drying, and tourism.



▲ FIGURE 1. MAJOR FAULT ZONES AND HOT SPRINGS IN THAILAND

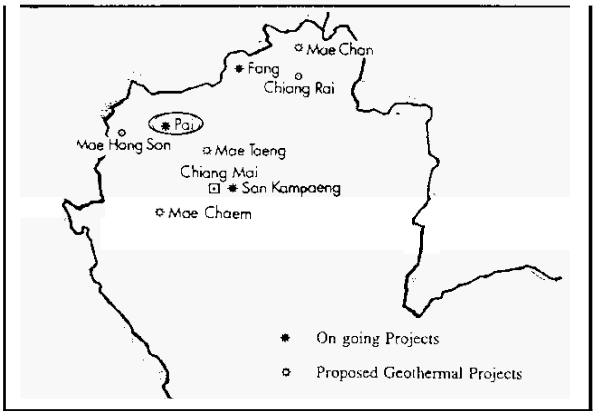
Geothermal Development plan for the years 1993 - 1997

Facing the problems of few potential resources, personnel, and budget, the Geothermal Working Group still makes an effort to continue the exploration and development of these medium enthalpy resources and has proposed four geothermal energy development projects for 1993-1997(Fig. 2), as follow:

1. San Kampaeng geothermal multipurpose utilization project
2. Large scale Fang geotheml project
3. Pai geothermal project
4. Shallow reservoir geothermal project in northern Thailand

It is expected that, after 1997. Thailand will produce approximately 12 million kWhr of electricity from geothermal resources. This is equivalent to annual oil saving of 3 million libes. Thermal energy can also be used in drying and cooling of agriculture products, saving an equivalent of thermal energy from 0.5 million lives of crude oil annually.

▼ FIGURE 2. GEOTHERMAL SITES IN NORTHERN THAILAND



STATUS OF ON-GOING PROJECTS

Fang Geothermal Project

Technical cooperation on the Fang deep geothermal development project, under an extended agreement with the French Environment and Energy Management Agency (ADEME), were started in **1990.** The aim of this cooperation was to define the potential of the deep reservoir. Detailed geological, electrical, and geochemical surveys were implemented in order to locate the deep reservoir and its controlling structure. During **1992-1993,** EGAT drilled three intermediate depth wells, targeted for **500** meters depth. The second well, **FX-2,** encountered a fracture at **270** meters depth, and produced **25 t/hr** of hot water having a temperature of **125 °C** The other wells, FX-1, and FX-3, were non-productive and had bottom hole temperatures of 108 °C and 113 °C, respectively. These data indicated that the behavior of fractures developed in granitic formations in Thailand could form large reservoirs. Moreover, these fractures are most likely associated with faults or fault sets which have very steep dips. Such high dips create a high risk for encounting these faults by normal vertical drilling.

The developments at Fang have shown that tracing a narrow fracture reservoir by deep drilling is still a difficult task and that there is an urgent need to develop exploration techniques which allow tracing such small reservoirs by methods other than expensive exploratory drilling.

San Kampaeng Geothermal Project

EGAT and the Japan International Cooperation Agency (JICA) agreed to establish technical cooperation for the San Kampaeng geothermal development project, in late **1981**. The purpose of this cooperation was to define the geothermal potential of the area. An exploration program was carried out during **1982 -1989.** Two deep exploration wells, GTE-7 and **GTE-8, 1227** m and **1300** m depths, were completed in **1989**. These wells failed to provide enough data to evaluate reservoirs. However, well GTE-8 encountered fracture zones at various depths from **330 - 920** m., but only the last fracture, at a depth of **920** m., discharged **40 t/hr**. of **125** °C hot water.

The San Kampaeng geothermal project was postponed afler the deep dnlling did not succeed in encounting the expected high enthalpy reservoirs It was concluded that in order to wntinue this project and to prove the expected reservoirs the use of directional drilling is necessary. However, this technology still needs time to be transferred and to reduce its cost.

Pai Geothermal Project

Because the first demonstration power plant was well operated and gave a very positive image to Thai engineers / scientists, EGAT planned to develop the shallow reservoirs of the Pai geothermal area in Pai district, Mae Hong Son Province, as a multipurpose project. Two study areas, the Ban Maung Rae and Ban Maung Paeng geothermal fields were selected. Pre-feasibility study is scheduled to be implemented during **1994-1995**. the resource assessment step, consisting of geological mapping and water chemical analysis, was carried out under the cooperation of CMU and EGAT. The geological study showed that both sites are situated with in a center of granitic terrain and that the structural features are faults and joints similar to the Fang area. The Na-K-Ca and silica geothermometers indicated subsurface temperatures of around 140-180 °C (Table I). Resistivity *survey* using the 'head-on' resistivity method, were done at both sites, and wvered an area of about 0.5 sq. km at each site. The resistivity array showed that low resistivity anolmalies conformed with the main faults at the two areas. Ten shallow temperature gradient wells, **50** m deep, were completed by EGAT in May **1994,** at the Ban Maung Rae site. This temperature gradient well program confirmed that a thermal anomaly extends down to SO m for at least 0.5 km along the Pai River in the area of the natural discharge. As a result of this initial drilling, five shallow exploration/production wells, of **200** m depth are scheduled to be drilled at the beginning of **1995.** These wells are expected to confirm the reservoir characteristics and productivity for electricity generation by a binary cycle power plant.

▼ TABLE 1. CHEMICAL CONSTITUENTS OF SOME GEOTHERMAL WATER

Unit : ppm.

COMPONENT		SAN KAMPAENG			FANG			PAI
		SPRING	GTE-6	GTE-8	SPRING	F-14	F-15	SPRING
Temp.	(° C)	90	98	98	99	134 *	134 *	96
pH		8.6	9.0	9.0	8.8	9.5	9.5	8.0
TDS	(ppm.)	592	600	649	402	393	396	315
SiO_2	(ppm.)	143	162	165	189	225	201	122
H_2S	(ppm.)	29.1	29.0	28.3	19.5	16.1	15.4	na
Na^+	(ppm.)	148	152	15	111	117	119	88
K^+	(ppm.)	13.5	15.0	13.9	8.9	10.5	10.7	5.3
Ca^{++}	(ppm.)	2.6	1.4	1.6	3.8	1.2	1.2	3.3
Mg^{++}	(ppm.)	0.20	0.10	0.20	0.17	0.04	0.04	0.02
CO_3	(ppm.)	12.0	53.0	61.0	32.0	82.0	69.0	8.1
HCO_3^-	(ppm.)	321	251	251	185	115	128	186
Cl^-	(ppm.)	11.0	14.3	14.8	6.5	8.9	7.3	1.8
SO_4	(ppm.)	64.7	43.6	43.6	26.0	31.0	32.0	40.0
NO_3	(ppm.)	1.1	2.4	0.2	na	na	na	na
F^-	(ppm.)	25.0	26.1	30.5	20.2	22.1	22.8	12.5
B^+	(ppm.)	1.80	1.90	1.90	1.33	1.68	1.68	na
Fe^{++}	(ppm.)	0.15	0.15	0.17	0.02	0.01	0.01	na
Li^{++}	(ppm.)	0.35	0.34	0.35	na	na	na	na
Cu^{++}	(ppm.)	0.10	0.10	0.10	na	na	na	na
Zn^{++}	(ppm.)	0.02	0.02	0.02	na	na	na	na
Mn^{++}	(ppm.)	0.07	0.10	0.08	0.01	0.01	0.01	na
Al^{++}	(ppm.)	1.50	1.50	1.70	0.02	0.02	0.02	na
Cr^{++}	(ppb.)	1	1	1	na	na	na	na
As^{++}	(ppb.)	16.0	21.0	24.0	2.5	2.6	2.5	na
Ni^{++}	(ppb.)	8	5	5	na	na	na	na
Cd^{++}	(ppb.)	1	1	1	na	na	na	na
Pb^{++}	(ppb.)	6	5	6	na	na	na	na
T_{SiO_2}	(°C)	155	164	170	155	168	159	142
T_{NK}	(°C)	199	193	179	199	207	208	177
T_{NKC}	(°C)	278	206	196	278	305	305	159

SPRING = Water from Natural Hot Spring ; F , GTE = Water from Exploration Well
* Well Head Temperature ; na = Not Analyzed
T_{SiO_2} = SiO2 geothermometer
T_{NK} = Na-K geothermometer
T_{NKC} = Na-K-Ca geothermometer

UTILIZATION

Fang geothermal area

Since December 1989, thermal fluids have been produced by EGAT from three shallow wells (150 m depth) at the Fang geothermal prospect at a rate of about 60 t/hr (120°C inlet temperahue). This energy is use to generate electricity in a 0.3 MWe ORMAT plant (85-90% availability factor). The preliminary economics study indicated that the electricity generating cost is about 63-86 Mills/kWh based on the assumption of a 5% interest rate and a 90% capacity factor (Table 2 and Fig. 3).

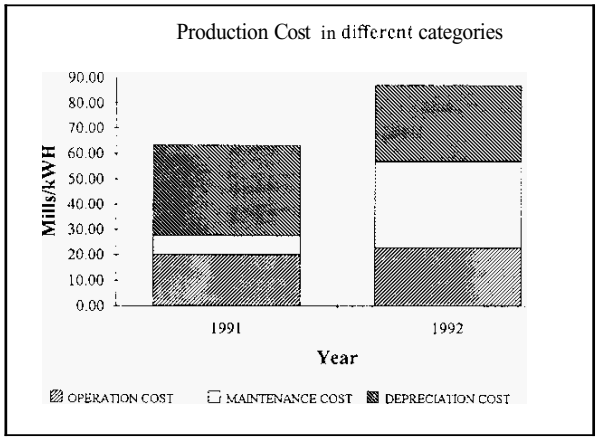
EGAT also implemented an air conditioning w1d storage and crop dryer using exhausted hot water(80 °C) from the power plant to demonstrate the downstream utilization for local people (Fig. 4). Now the Food Processing Section of the Royal Recommended Project is constructing a new larger crop dryer using geothermal heat source to preserve products. Meanwhile, the Mae Fang National Park constructed a public bathing pond and a sauna room to serve visitors. The utilisation of geothermal energy at the Fang area is sucessful, even on a very small scale, and this project is known as the first 'multipurpose project' in Thailad which can be applied to other geothermal resources.

▼ TABLE 2. PRODUCTION COST ANALYSIS OF FANG BINARY CYCLE POWER PLANT

CLASSIFICATION		FISCAL YEAR 1990	1991	1992
GROSS GENERATION	(kWH)	782,150	916,376	1,085,341
IMPORT	(kWH)	(11,741)	(6,894)	(6,377)
NET GENERATION	(kWH)	770,409	909,482	1,078,964
OPERATION COST SUB TOTAL	(MM$)		0.018	0.024
OPERATION COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		20.10	22.61
MAINTENANCE COST SUB TOTAL	(MM$)		0.007	0.037
MAINTENANCE COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		7.43	34.07
DEPRECIATION COST* SUB TOTAL	(MM$)	0.027	0.033	0.033
DEPRECIATION COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		35.80	30.14
GRAND TOTAL	(MM$)			
PRODUCTION COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		63.33	86.82

* Source : Economic Policy Department, EGAT

▼ FIGURE 3. PRODUCTION COST IN DIFFERENCE CATEGORIES OF FANG BINARY CYCLE POWER PLANT



San Kampaeng geothermal area

Although the estimated resource potential is up to 5 MWe, its utilisation for electricity production is still not feasible due to the lack of available cooling water in the area and the high wst of deep production wells. Recently, however the available hot water from the exploration wells is being used for tourism promotion and bathing. Research work for direct use, such as tobacco curing and earth-bean drying, was also carried out to determine the reliability of geothermal exploitation on a commercial scale.

FUTURE ACTIVITIES

In the exploration stage, shallow reservoirs can be developed by using normal techniques. On the other hand, deep reservoirs are most likely associated with very steep dipping faults or fault sets. This makes them very difficult to encounter by vertical drilling and they are thus, generally uneconomic to exploit. Directional drilling is considered the most suitable and effective method to trap and exploit deep geothermal resources but the problem is that the cost of directional drilling is still high.

In the Fang geothermal area, in order to maintain the operation of the binary cycle power plant, drilling of a new production well was started in May 1994. The planned depth of this well is 500 m. Reservoir characteristics are being monitored continuously in the area to examine the effect on production from the shallow reservoir. This reservoir engineering study is important, and it can be used as a guide for other geothermal resources in northern Thailand that have similar fractured reservoirs

In the San Kampaeng geothermal area, since the deep drilling program was postponed, EGAT plans to wntinue to cooperate with the local authorities to establish a joint project to make reliability of geothermal exploitation reliable on a wmmercial scale using hot water from the deep exploration well, GTE-8.

For the Pai geothermal area, following the exploration program, five exploration/ production wells are scheduled to be drilled in 1995 to confirm reservoir characteristics and productivityn for electricity generation. These wells will be 200 m. deep.

The geothermal working group has also proposed another shallow reservoir geothermal development project in northern Thailand for the years 1996-1997. This project is aimed at exploration of geothermal resources that exist in isolated areas, for local usage.

CONCLUSION

Geothermal development in Thailand is still in progress. We believe that the development of medium enthalpy geothermal resources can support the energy demands of our country. The Fang project is a good example for other projects because it has already shown that the development of geothermal energy is very competitive, even on a small scale. The problems being faced now are the low potential of the resources, lack of personnel. lack of technology know-how, and lack of budget. There is an urgent need to develop exploration techniques that allow mapping small fractured reservoirs. Also, geothermal reservoir engineering studies and certain direct-use applications should proceed as well.

UTILIZATION

Fang geothermal area

Since December 1989, thermal fluids have been produced by EGAT from three shallow wells (150 m depth) at the Fang geothermal prospect at a rate of about 60 t/hr (120°C inlet temperature) This energy is use to generate elecmcity in a 0.3 W e ORMAT plant (85-90% availability factor). The preliminary economics study indicated that the electricity generating wst is about 63-86 Mills/kWh based on the assumption of a 5% interest rate and a 90% capacity factor (Table 2 and Fig. 3).

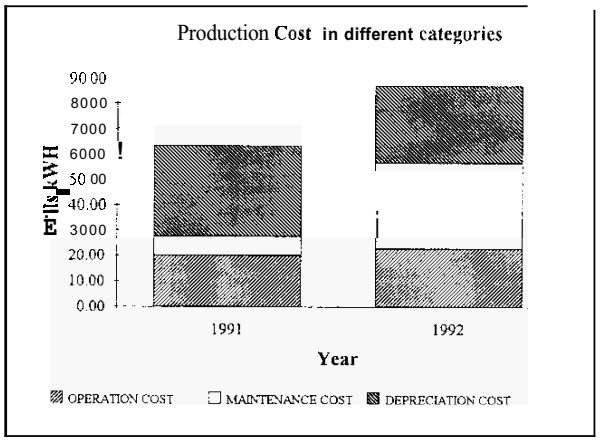
EGAT also implemented an air conditioning cold storage and crop dryer using exhausted hot water(80 °C) from the power plant to demonstrate the downstream utilization for local people (Fig. 4). Now the Food Processing Section of the Royal Recommended Project is constructing a new larger crop dryer using geothermal heat source to preserve products. Meanwhile, the Mae Fang National Park constructed a public bathing pond and a sauna room to serve visitors The utilisation of geothermal energy at the Fang area is sucessful, even on a very small scale, and this project is known as the first 'multipurpose project' in Thailad which can be applied to other geothermal resources.

▼ TABLE 2. PRODUCTION COST ANALYSIS OF FANG BINARY CYCLE POWER PLANT

CLASSIFICATION		FISCAL YEAR 1990	1991	1992
GROSS GENERATION	(kWH)	782,150	916,376	1,085,341
IMPORT	(kWH)	(11,741)	(6,894)	(6,377)
NET GENERATION	(kWH)	770,409	909,482	1,078,964
OPERATION COST SUB TOTAL	(MM$)		0.018	0.024
OPERATION COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		20.10	22.61
MAINTENANCE COST SUB TOTAL	(MM$)		0.007	0.037
MAINTENANCE COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		7.43	34.07
DEPRECIATION COST* SUB TOTAL	(MM$)	0.027	0.033	0.033
DEPRECIATION COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		35.80	30.14
GRAND TOTAL	(MM$)			
PRODUCTION COST (Mills/kWH)	GROSS GENERATION			
	NET GENERATION		63.33	86.82

* Source : Economic Policy Department, EGAT

▼ FIGURE 3. PRODUCTION COST IN DIFFERENCE CATEGORIES OF FANG BINARY CYCLE POWER PLANT



San Kampaeng geothermal area

Although the estimated resource potential is up to 5 W e , its utilisation for electricity production is still not feasible due to the lack of available cooling water in the area and the high cast of deep production wells. Recently, however the available hot water from the exploration wells is being used for tourism promotion and bathing. Research work for direct use, such as tobacco curing and earth-bean drying, was also carried out to determine the reliability of geothermal exploitation on a wmmercial scale.

FUTURE ACTIVITIES

In the exploration stage, shallow reservoirs can be developed by using normal techniques. On the other hand, deep reservoirs are most likely associated with very steep dipping faults or fault sets. This makes them very difficult to encounter by vertical drilling and they are thus, generally uneconomic to exploit. Directional drilling is considered the most suitable and effective method to trap and exploit deep geothermal resources but the problem is that the cost of directional drilling is still high.

In the Fang geothermal area, in order to maintain the operation of the binary cycle power plant, drilling of a new production well was started in May 1994. The planned depth of this well is 500 m. Reservoir charactenstics are being monitored continuously in the area to examine the effect on production from the shallow reservoir. This reservoir engineering study is important, and it can be used as a guide for other geothermal resources in northern Thailand that have similar fractured reservoirs.

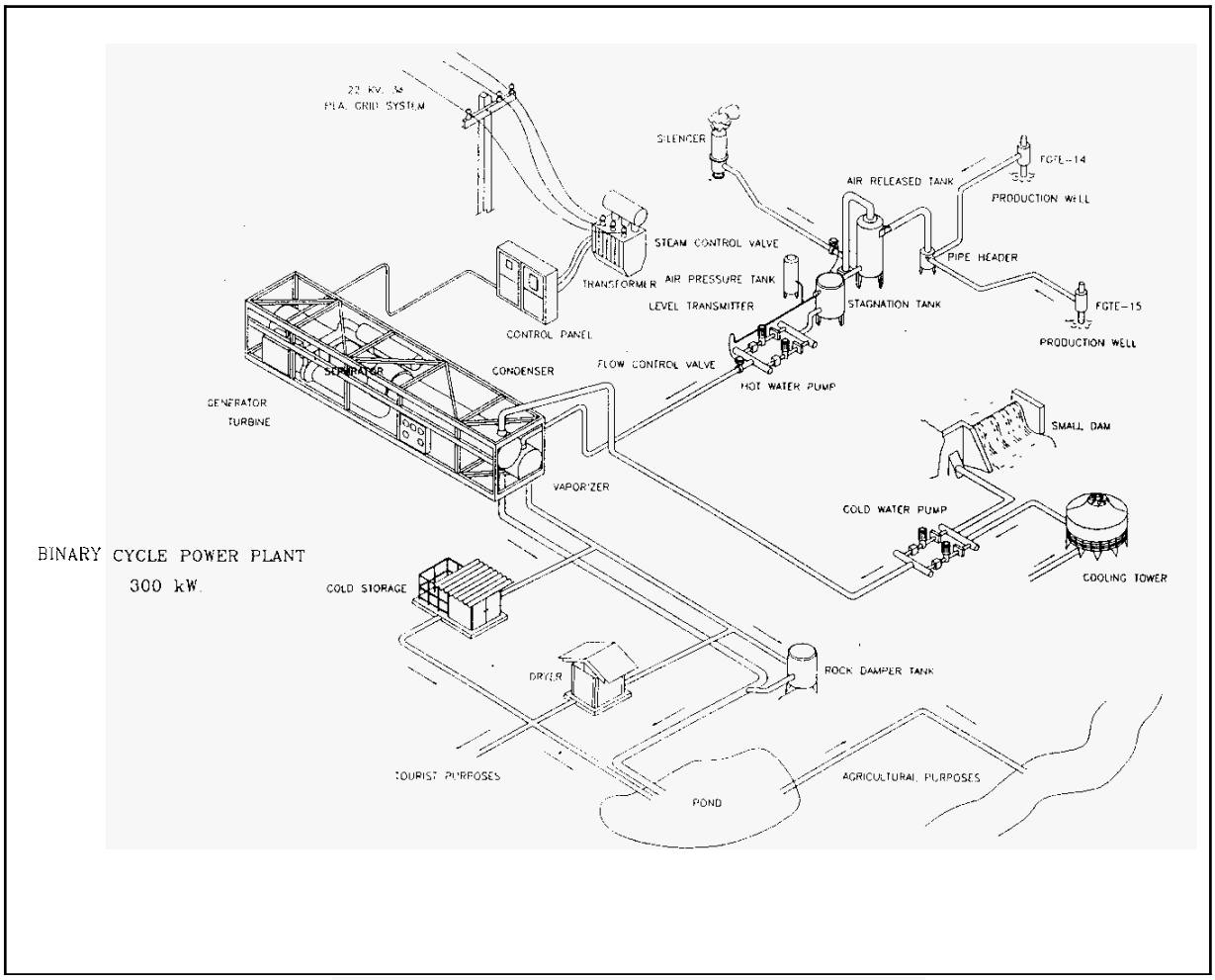
In the San Kampaeng geothermal area, since the deep drilling program was postponed, EGAT plans to wntinue to cooperate with the local authorities to establish a joint project to make reliability of geothermal exploitation reliable on a wmmercial scale using hot water from the deep exploration well, GTE-8

For the Pai geothermal area, following the exploration program, five exploration/ production wells are scheduled to be drilled in 1995 to confirm reservoir characteristics and productivity for electricity generation. These wells will be 200 m. deep.

The geothermal working group has also proposed another shallow reservoir geothermal development project in northern Thailand for the years 1996-1997. This project is aimed at exploration of geothermal resources that exist in isolated areas, for local usage.

CONCLUSION

Gwthermal development in Thailand is still in progress. We believe that the development of medium enthalpy geothermal resources can support the energy demands of our country. The Fang project is a good example for other projects because it has already shown that the development of geothermal energy is very competitive, even on a small scale. The problems being faced now are the low potential of the resources, lack of personnel, lack of technology know-how, and lack of budget. There is an urgent need to develop exploration techniques that allow mapping small fractured reservoirs. Also, geothermal reservoir engineering studies and certain direct-use applications should proceed as well.



▲ FIGURE 4. PICTORIAL DIAGRAM OF FANG GEOTHERMAL MULTIPURPOSE PROJECT

REFERENCES

EGAT/CFG/ADEME, 1992, Prefeasibility study Fang geothermal project Step I, Large Scale Fang Geothermal Exploration Report, no.92 CFG 28, unpublished

JICA, 1988, The Pre-feasibility study for the San Kampaeng geothermal development project in the Kingdom of Thailand, Final report, unpublished.

Vongsuriya K. 1990, Overview of geothermal development in Thailand toward 1990, International Symposium on Geothermal Energy, Kailua, Kona, Hawaii.

Asnachinda, P. Uttamo, W. Ramingwong, T., 1994, Geological and hydrogeochemical investigation of Muang Paeng geothermal area, Amphoe Pai, Changwat Mae Hong Son, Final report, unpublished.