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UPDATE ON THAILAND GEOTHERMAL ENERGY RESEARCH AND DEVELOPMENT

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ABSTRACT

Systematic studies of geothermal energy resources in Thailand started in 1979. Presently, the development is still in progress as evidenced by continuous exploration and research activities of the organizations concerned. The development at Fang system has led to a very successful 'multipurposes geothermal energy development project' i.e. electricity generation, agricultural direct uses, and tourism. The paper gives updated information on status of on-going and future geothermal research and development projects. Recently, Thailand has joined an international research project, collaborated by IAEA, on Interregional Collaboration Among Circum-Pacific (Asia and Latin America) Countries for Development of Geothermal Energy Resources with Environmental Protection through Geochemistry and Isotope Techniques. The Geothermal Working Group proposed that the national Geothermal Research Centre to be established to be responsible for the national geothermal energy development programme.

1. INTRODUCTION

More than 90 hot springs with surface temperature ranging from 40_0 to 100_0 C are scattered throughout the country (Fig. 1). These geothermal areas are evidently associated with granitic rocks of various ages and major faults nearby. Most of them are manifested by hot pools and seepages although some are by hot springs and geysers. Although a number of hot springs are found in other rocks, their geographic positions are never located far beyond 25 km from granitic plutons (Ratanasthien and others, 1985). It has also been suggested that these associations limit the areas of high density as well as high potential geothermal resources to northern Thailand (Fig. 2) where almost half of the total area is covered by granites and related rocks.

Many geothermal systems are commonly characterized by hot-water dominated type with sodium bicarbonate species and small amounts of dissolved solids. Chemical composition of the hot spring waters from northern Thailand have been compiled by Praserdvigai (1997). The association with granitic rocks which influences the chemical composition of the water does not, however, imply whether the water was heated up by steam and gas from hydrothermal fluids, or by long-term heat transfer produced from chemical reactions, fault movements, or radioactive disintegration.

Available isotopic and geological information point out that the thermal waters of most, if not all, geothermal systems in northern Thailand are formed by meteoric water recharged at higher elevations in the vicinity of the hot spring areas (Ramingwong and others, 1980; Takashima and Jarach, 1987; Tunsakul, 1987; and Ratanasthien and others 1987). The cold meteoric water circulates down to some depth, acquires heat and then rises up to the surface. Chemical and isotopic data, however, indicate the absence of mixing between cold groundwater and the uprising thermal water even at shallow depth (Asnachinda and others, 1997). Takashima and Jarach (1987) believed that the period of the meteoric water circulation in a geothermal system of northern Thailand is probably over 100 years. They also suggested that the water is confined within a channel-like reservoirs which provide a large cumulative water to rock ratio. Such geothermal reservoirs may occur hypothetically at depth greater than 1000 m which may not be exploited economically. However, recent geothermal energy exploration results indicate the existence of potentially shallow reservoir at depth less than 200 m.

The preliminary results from reconnaissance surveys which had been done by the National Energy Administration (NEA) of Thailand and Kingston Reynolds Thom & Allardice Ltd. of New Zealand in 1973 indicated that utilization of geothermal energy for power generation and agricultural application was warranted. Contemporaneously, a multi-disciplinary working group, Thailand Geothermal Working Group, consisting of personnel from the Electricity Generating Authority of Thailand (EGAT), the Department of Mineral Resources (DMR), Department of Energy Development and Promotion (DEDP)and Chiang Mai University (CMU) was formed with the aim to define the potential of geothermal development for power generating. The tentative schedule for geothermal energy development in northern Thailand was set up and implemented. Since 1979 the working group has investigated more than 30 well known hot springs of northern Thailand although the exploration drilling had not begun until 1981 (Table 1). The exploration has subsequently been narrowed down to the five most promising areas, namely Fang, San Kampaeng, Pa Pae, Mae Chaem and Mae Chan where reservoir temperatures estimated from chemical geothermometers are close to or above 180_0 C

2. STATUS OF ON-GOING GEOTHERMAL DEVELOPMENT PROJECTS

Since most geothermal reservoirs in northern Thailand are probably of channel-like shape closely associated with highly-dipping faults or fault sets (MacDonald and others, 1977; Ramingwong and others, 1980; and Takashima and Jarach, 1987) then tracing such narrow fracture reservoirs by deep vertical drilling is a difficult task and too expensive to afford the risk of missing the target. In addition, data from the well-investigated medium enthalpy geothermal fields such as Fang indicate the presence of relatively shallow fractured reservoirs which could be large if developed in the granitic terrain. Therefore, instead of exploiting the deep geothermal reservoirs, the Geothermal Working Group then suggested a possibility of utilizing hot water having temperatures of more than 100 ^{0} C from relatively shallow reservoirs at a depth less than 500 m.

2.1 Fang Geothermal System

Since December 1989 the EGAT has successfully produced hot water from three shallow wells (150 m depth) at Fang geothermal prospect at a rate of about 60 t/hr (120^{0}C inlet temperature). This thermal energy is use to generate electricity in a 0.3 MWe ORMAT plant (85-90 % availability factor). In 1990 the Fang deep geothermal development project was started under technical cooperation with the French Environment and Energy Development Agency (ADEME). The aim of this collaborative project was to define the potential of the deep reservoir and its controlling structure through detailed geological, geochemical and electrical surveys. Three intermediate depth wells, FX-1, FX-2, FX-3 and FX-4, were drilled during 1992-1994. Only well FX-2 and FX-4 are productive. The well FX-2 encountered a fracture at 270 m depth and produced 25 t/hr of water as hot as 125 ^{0} C. Well FX-4 whose bottom hole temperature is 130 ^{0} C encountered fractures at depth of 268, 337, and 417 m. This well produces hot water at a flow rate of 36t/hr. It should be noted also that the non-productive wells, FX-1 and FX-3, have bottom temperatures of 108 ^{0} C and 113^0 C respectively. Since the end of 1996, the well FX-4 has been connected to the hot water system to increase the volume of hot water for the power plant.

Apart from generating electricity from geothermal energy EGAT also implemented an air conditioning cold storage and crop dryer using exhausted hot water (80_0 C) from the power plant to demonstrate the downstream utilization for local people (Fig. 3). Recently the King's Project has constructed a new larger crop dryer using the geothermal heat source to preserve agricultural produce. Meanwhile, the Mae Fang National Park constructed a public bathing pond and a sauna room to serve visitors. The utilization of geothermal energy is said to be successful and is well known as a first "multi-purpose geothermal energy development project" in Thailand which can be applied to other geothermal resources. Production cost analysis of Fang binary cycle power plant is presented in Table 2 .

2.2 San Kampaeng Geothermal System

The San Kampaeng geothermal development project has been conducted under technical collaboration between EGAT and JICA (Japan International Cooperation Agency) since late 1981. The objective of this collaboration was to define the geothermal potential of the area. Exploration holes were drilled during 1982-1989. Two deep exploration wells, GTE-7 and GTE-8, 1227 and 1300 m depths, were completed in 1989. These wells failed to provide enough data to evaluate the reservoirs. Only well GTE-8 encountered fracture zones at various depths from 330-920 m., and only the last fracture at depth of 920 m., discharged 40 t/hr. of water at 125^0 C. The project was postponed after the deep drilling did not strike the expected high enthalpy reservoirs.

Unlike Fang's situation, the geothermal energy at San Kampaeng field was not successfully developed although the estimated resource potential is up to 5 MWe. Its utilization for electricity generation is still not feasible due to lack of available cooling water in the area. At the moment, 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 ground nut drying (Sithipong and others, 1986), was also carried out to determine reliability of geothermal exploitation on a commercial scale.

2.3 Pai Geothermal System

Recently EGAT has planned to develop the shallow reservoirs of the Pai geothermal area in Pai District, Mae Hong Son Province, as a multi-purpose project similar to that of Fang. A pre-feasibility study of Pai geothermal area at Ban Muang Rae and Ban Muang Paeng sites was implemented during 1994-1995 under the cooperation of EGAT and CMU. The resource assessment step consisted of geological mapping and hydrogeochemical investigations (Asnachinda and others, 1994). The geological study showed that both sites are situated within a centre of granitic terrain and have structural settings similar to those of Fang area. The Na-K-Ca and silica geothermometers indicated subsurface temperatures of around 140-180^{0}C. Resistivity surveys using the 'combined head-on' resistivity method, were conducted at both sites,

and covered an area of about 0.5 sq.km each. The resistivity
results showed that low resistivity anomalies conformed with the main faults of the two areas. Ten shallow temperature gradient wells of 50 m depth at the Ban Muang Rae site were completed by EGAT in May 1994. This temperature gradient confirmed that a thermal anomaly extended down to 50 m for at least 500 m along the Pai River in the area of natural discharge. Three 200 m exploration wells, drilled in 1995, were non-productive. For the Ban Muang Paeng site, four shallow exploration/production wells (MPE1-4) of 250 m depth were drilled from the beginning of 1996 until April 1996. Wells MPE1, MPE3 and MPE4 discharged hot water and had a bottom hole temperature of 94^0 C. The other well, MPE2, was non-productive and had bottom hole temperature of 92 ^{0}C. The results indicate that the total flow rate was about 25 L/sec. from MPE3 and MPE4 with more or less atmospheric pressure. Due to the survey result showing low potential resource, EGAT decided to postpone the development of this geothermal area for electricity generation owing to the low temperature of the hot water. However, this hot water can still be used for agricultural purposes.

2.4 Other Systems

In 1982, the Department of Energy Development and Promotion (DEDP) in cooperation with CMU had carried out the detail study in Ban Nam Ron, Ban Phu Toei, Ban Phu Kham and Ban Wang Kham geothermal areas in Petchabun Province to define potential of these low enthalpy geothermal systems. The exploration work consisted of geological, geochemical and resistivity surveys.

During 1983-1986, the DMR established a geothemal project to evaluate the potential of 50 geothermal areas in northern Thailand using geological and geochemical prospecting criteria, A technical assistance from UNDP under the contract of TCD CON 32/83 was included in this project. The UNDP project covered 9 selected geothermal areas namely: Ban Pong, Ban Nong Krok, Pong Kum, Tepanom, Nam Mae Mon, Nam Mae Hull, Ban Sop Pong, Ban Pong Nam Ron and Ban Mae Chok geothermal areas. The expert mission from Geothermica Italiana Srl., Italy, came to carry out field work during 1983-1984. The geophysical and borehole data which were available on some geothermal areas were also used for evaluating the project.

During 1992-1995, DEDP established a five years geothermal exploration plan in order to exploit hot water from shallow wells for small scale agro-industrial application especially in crop drying. The extensive plan to estimate the actual potential of the prospect was commenced in 1993. The resistivity surveys were carried out covering the prospecting area in order to locate and delineate the resistivity structure and then some shallow exploration wells were drilled at the selected location to examine the subsurface condition. During 1994-1996, nine geothermal areas namely : Mae Chan, Tepanom, Muang Ngam, Pha Bong, Nong Haeng, Mae Kasa, Pong Pu Fuang, Ko Kha, and Pha Sert geothermal areas were investigated as shown in Table 2.

The Mae Chan prospect with surface temperature ranging between 54 - 98^0 C at Mae Chan District, Chiang Rai Province is now under detailed investigation by the DEDP. The main objective of this programme is to exploit hot water from shallow depth (less than 100 m) for non-electrical purposes especially in crop drying. Field investigation has been carried out by resistivity survey and followed by drilling two 100 m depth shallow exploration wells (PR1 and PR2) at locations suggested by the geophysical results. Of the two wells, well PR2 is the successful hole in checking the inferred fracture. A jet of hot water blows spontaneously at a rate of 5.94 L/sec. to a height of approximately 15 m above the ground. According to Manoonvoravong and Veerapun (1996) a down hole temperature profile of well PR2 shows rapid increase from 87^0 to 122^0 C over 0-9 m depth. A break in the temperature curve at 57 m depth is thought to be due the presence of fractures as postulated by a combined head-on resistivity profile.

Since the beginning of 1997 EGAT and CMU have carried out geochemical and resistivity surveys at Muang Ngam and also at Mae Chan geothermal areas. Shallow exploration drilling was planned to commence at Mae Chan by EGAT in the mid of 1997.

3. RESEARCH AND DEVELOPMENT PROJECTS

Recently, the Thai Geothermal Working Group has participated a regional collaborative project funded by the International Atomic Energy Agency (IAEA) which consits of other three participating countries namely: China, Indonesia, and the Philippines. The 3-year project entitled “Regional Collaboration in East Asia and the Pacific for the Development of Geothermal Energy Resources and Environmental Management through Isotope Techniques” started on January 1997. Its general objective is to support the utilization of geothermal energy resources for electrical and non-electrical applications in the east Asia and the Pacific through applications of isotopes and geochemical techniques towards their practical use as an indispensable well established tool for geothermal reservoir management.

The collaborative activities in which the Working Group are responsible for include :
1.) The investigation of Fang geothermal system under the assigned sub-project entitled “Investigation of hydrology of the Fang geothermal system by isotope and chemical tools”. About 40 water samples have been analysed for their isotopic composition by the IAEA laboratory in Vienna. A

progress report of this investigation submitted to the Agency in May 1999 as a part of its on-the-job training in Isotope Hydrology and Geochistry held at Leyte, the Philippines (see Asnachinda and others, 1999). It is hope that the outcome of this research project will promote a sustainable development of Fang geothermal resources for electric and direct-use of the hot water.

2.) Interlaboratory comparison of isotope (excluding Thailand) and chemical results to ensure the quality of chemical analyses in the region will be organized under the coordination of the IAEA. Two sets of water samples collected from high and low enthalpy hot springs will be shipped to the geochemical laboratories of CMU and DMR later this year. This comparison will be undertaken once a year for the duration of the regional collaboration.

3.) A contribution of Thailand's geothermal water data to the Regional Database on Geothermal Waters administered by China (East China Geological Institute). This database is definitely essential for planning and management of the geothermal resources in this region. The participating countries agreed to submit the data to China every six months. Consequently, the updates will be submitted to participating countries once a year or as requested.

4.) The Working Group also hosted a technical meeting at Chiang Mai in August 1998 whereas the Philippines and Indonesia are responsible of the 1997 and 1999 meeting respectively.

Although Thailand is the first country of the Southeast Asian region to operate a binary cycle geothermal power plant, the national programme on geothermal energy development still has not been firmly established. The major problems facing the development plan i.e. personnel, administration and budget, has not yet been solved. Technical personnel involved are mainly from related fields with no specialized training. Administration of the projects are not properly organized and with no definite designated responsibilities. Research and development budget are not in continuity.

The Thai Geothermal Working Group, at the meeting on 6 September 1996 at Chiang Mai University, have unanimously agreed to submit a proposal to the Sub-committee on Renewable Energy Research and Development, National Research Council, to establish and fund Thailand Geothermal Research Centre (TGRC), Chiang Mai University, with budget of 2.5 million baht (66,000 US$), annually. The full proposal is shown here as Appendix. For the outputs of the TGRC, it is anticipated that the geothermal research and development activities of the country will be effectively carried out and proceeded at internationally standard. Potential indigenous geothermal resources will be effectively developed and exploited.

4. CONCLUSION

Geothermal energy development in Thailand is still in progress as evidenced by continuous exploration and research activities of the organizations concerned. 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 lack of skill personnel, lack technology know-how and lack of budget. The Thai Geothermal Working Group has submitted a proposal to the Sub-committee on Renewable Energy Research and Development, National Research Council, to establish and fund Thailand Geothermal Research Centre (TGRC), Chiang Mai University, with budget of 2.5 million baht (66,000 US$), annually. Through a proper administration by this centre it is expected that the potential indigenous geothermal resources will be effectively developed and exploited.

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Table 1. Summary of exploration drilling for geothermal energy resources in northern Thailand. After Praserdvigai (1997).

Year / Organization	Geothermal Area	Dept of Well (m)	No. of Wells	Remark
1981-1987/EGAT	San Kampaeng	<100 <500 1,227 1,300	40 6 1 1	The development project was postponed.
1981-1995/EGAT	Fang	<100 <200 <150 <500	27 7 10 3	A 300 KWH binary cycle power plant is under operation. Deep reservoir exploration was postponed.
1984/DMR	Pong Kum Ban Sop Pong Ban Pong Ban Nong Krok Ban Mae Chok Ban Pun Jane	20-30 20-30 150 120 100 100	30 16 1 1 1 1	
1994/DEDP	Tepanom Pong Pu Fuang Koh Kha	100 100 101	3 2 1	Geysering well
1995/DEDP	Mae Kasa Nong Haeng	100 100	1 2	
1996/EGAT	Pai (Muang Rae) Pai (Muang Paeng)	<50 <50	10 10	Unfavourable reservoir temperatures.
1996/DEDP	Mae Chan Pha Sert	100 100	2 2	Geysering well
1997/DEDP	Muang Ngam Pha Bong	100 100	2 2	

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

CLASSIFICATION		FISCAL YEAR										
		1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
GROSS GENERATION	(kWH)	56,870	986,040	997,583	1,129,467	1,143,609	903,415	1,055,418	1,196,348	938,550	1,300,420	1,588,808
IMPORT	(kWH)	-2,967	-9,813	-7,583	-4,699	-4,380	-13,947	-16,262	-27,286	-41,292	-35,770	-10,050
NET GENERATION	(kWH)	53,903	976,227	990,000	1,124,768	1,139,229	889,468	1,039,156	1,169,062	897,258	1,264,650	1,578,758
OPERATION COST SUB TOTAL	(MM$)		0.018	0.024	0.028	0.032	0.036	0.038	0.039	0.040	0.040	0.041
OPERATION COST (Mills/kWH)	GROSS GENERATION											
	NET GENERATION		18.73	24.65	24.89	28.09	40.47	36.57	33.53	44.58	31.63	26.10
MAINTENANCE COST SUB TOTAL	(MM$)		0.007	0.019	0.037	0.024	0.035	0.032	0.024	0.029	0.019	0.030
MAINTENANCE COST (Mills/kWH)	GROSS GENERATION											
	NET GENERATION		6.92	19.39	32.68	21.07	39.57	30.95	20.46	32.72	14.87	19.00
DEPRECIATION COST* SUB TOTAL	(MM$)	0.027	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033	0.033
DEPRECIATION COST (Mills/kWH)	GROSS GENERATION											
	NET GENERATION		33.35	32.85	28.91	28.55	36.56	31.29	27.82	36.24	25.71	20.60
GRAND TOTAL	(MM$)											
PRODUCTION COST (Mills/kWH)	GROSS GENERATION											
	NET GENERATION		59.00	76.89	86.49	77.70	116.61	98.81	81.81	113.55	72.21	65.70

* Source : Research & Development Office, EGAT

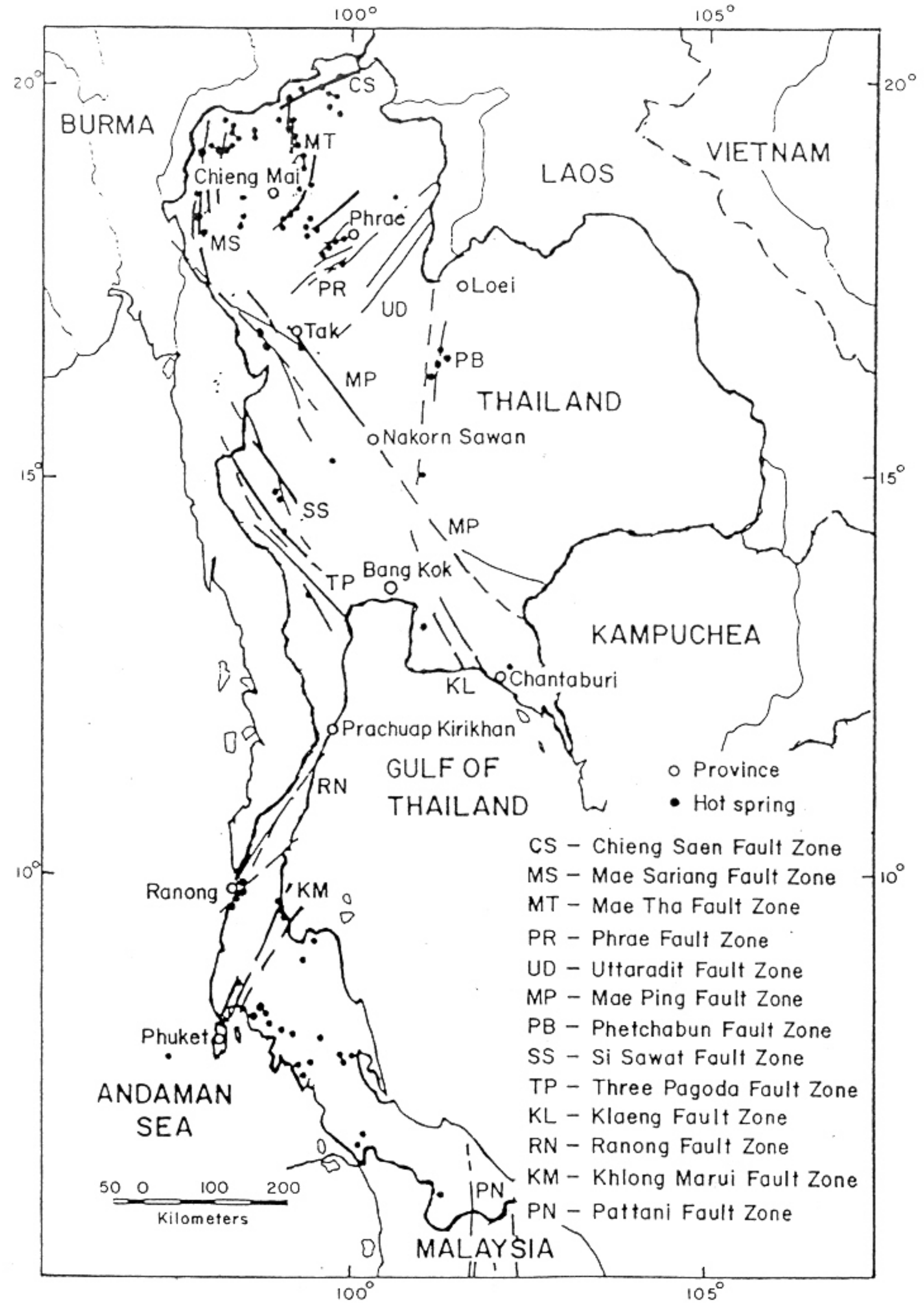

Figure 1 Major fault zones and hot springs in Thailand. After Ramingwong and Lertsrimongkol (1995).

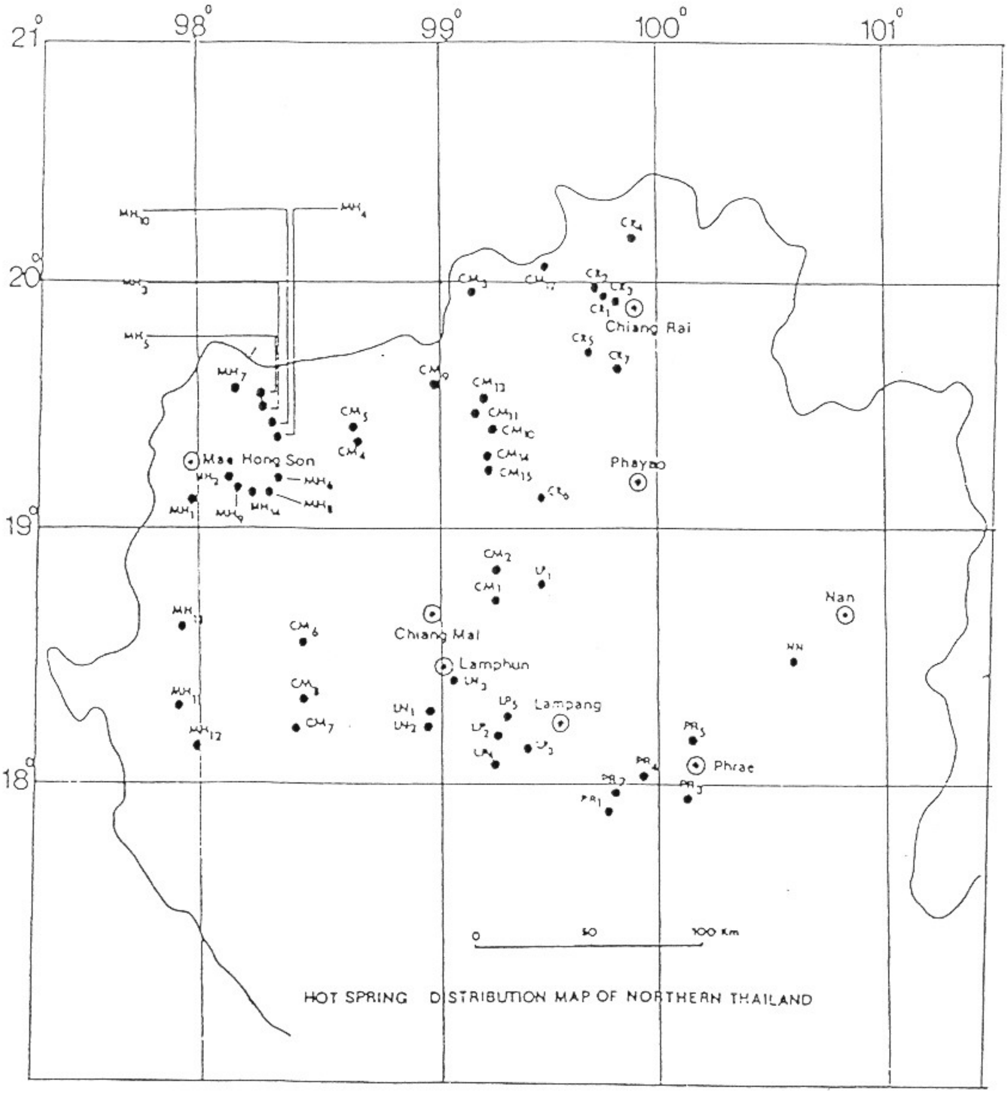

Figure 2. Location of 50 geothermal areas in northern Thailand.After Praserdvigai (1997).

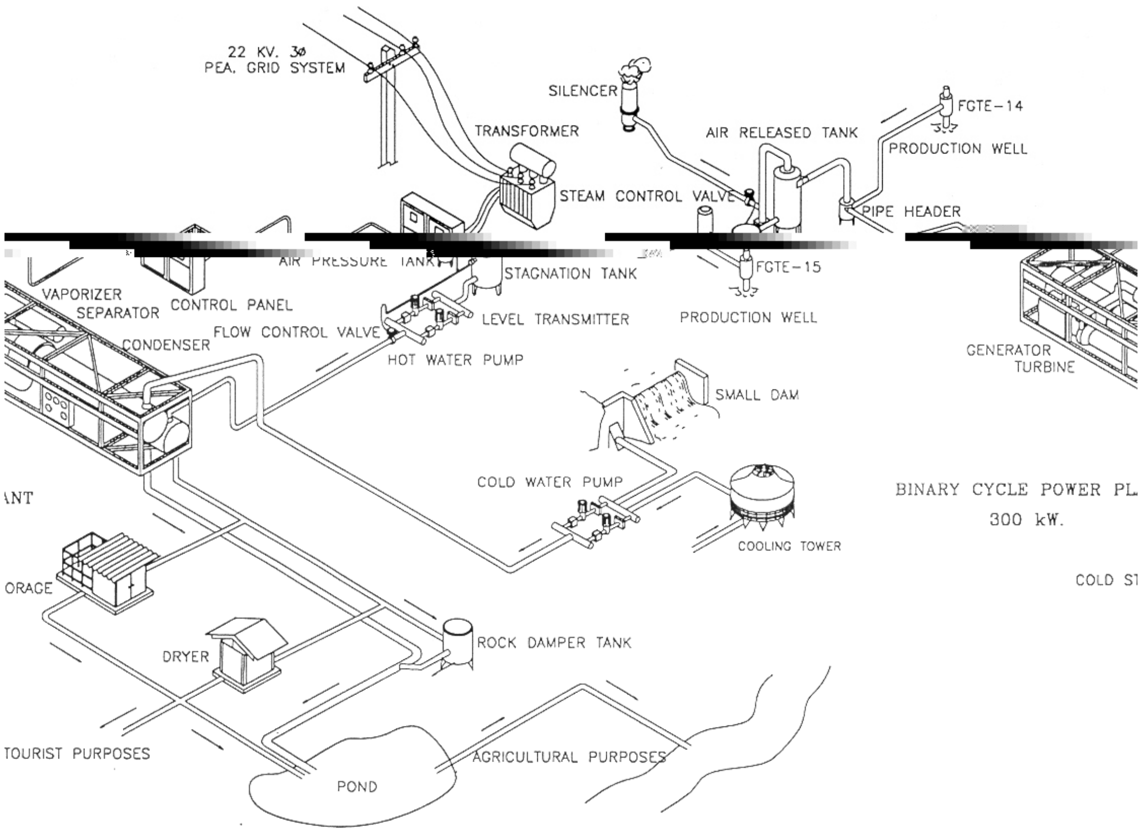

Figure 3. Pictorial diagram of Fang Geothermal Multipurpose Project. After Ramingwong and Lertsrimongkol (1975).