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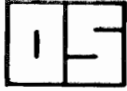
NATIONAL ENERGY AUTHORITY
GEOTHERMAL DIVISION

**ICELANDIC PARTICIPATION
IN GEOTHERMAL DEVELOPMENT
OVERSEAS**

Prepared for Orkustofnun by
Sveinn S. Einarsson

OS-86069/JHD-30 B

Nóvember 1986



ORKUSTOFNUN
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1. UN TECHNICAL ASSISTANCE PROGRAMMES

During the last 30 years exploration and development of indigenous energy resources in the developing countries has enjoyed very high priority under the various UN Technical Assistance Programmes due to obvious reasons. Since the Rome Conference on New Sources of Energy in 1961 geothermal energy has received special attention. In view of our particular experience in this area, Iceland has become one of the main sources of expertise for manning UN geothermal projects around the world over the last 25 years. The input from Iceland consisted mostly of providing individual experts for various assignments such as:

- Short time assessment and other missions in developing countries.
- Short and longterm consultant and expert services for implementing projects.
- Advisory services at UN Headquarters, New York.

2. THE UN GEOTHERMAL DEMONSTRATION PROJECTS

The Rome conference aroused vastly increased interest for geothermal energy not only in the developing countries but also in several industrial ones. As a follow-up the UN sponsored relatively largescale demonstration projects in the 1960's - 1970's in Chile, El Salvador, Turkey, Nicaragua and Kenya, executed by the UN Office of Technical Cooperation (OTC), predecessor of DTCD and financed by the UN Special Fund (and later UNDP) as well as the respective governments. The objectives of these project were to:

- Evaluate and select geothermal fields for development.
- Provide essential equipment.
- Training of national personnel.
- Carry out all the necessary scientific and technical

studies for evaluation and development.

- Carry out exploratory drilling programmes to confirm the resource and its production characteristics.
- Complete a techno-economic feasibility study with preliminary design for the exploitation works (electric power stations).

All the projects achieved the main objectives of demonstrating that geothermal power generation was competitive with available alternate energy sources such as hydropower and petroleum, even at the pre-OPEC price level, and attracted investment capital in all cases but one.

Table 1 shows the duration of each of the demonstration projects which in all cases but one ranged from 5-6 years and even the El Salvador project, where a serious environmental problem was encountered, was remarkably short, and had to be solved by reinjection of highly saline waste water.

This was primarily due to the fact that full financing for the complete projects was secured in advance and loss of time between phases could hence be minimized. The longer time used for the Turkey project was related to serious scaling problems.

The preliminary design and feasibility study for each project was subcontracted after competitive bidding to consulting engineering firms, and the Feasibility Study Report was a basic document for soliciting investment capital by the governments.

The feasibility study and preliminary design of the demonstration project in Kenya was made under UN subcontract by the Icelandic consulting firm VIRKIR LTD in cooperation with SWECO of Sweden.

The total manpower from Iceland to the above demonstration projects amounted to about 235 man-months and is broken down in Table 2.

The time for commissioning of the geothermal power plants which were constructed depended on the follow-up given by the respective governments and their ability to provide investment capital.

3. OTHER UN/UNDP GEOTHERMAL PROJECTS

The fact that the first geothermal stations resulting from the demonstrations projects came on line in El Salvador in 1974-1975, in the beginning of the petroleum crisis, turned out to be a great stimulus for geothermal developments elsewhere, creating a high demand for UN assistance in geothermal development from other developing countries.

Now, however, the availability of funds became a limiting factor especially after introduction of the UNDP system of country programmes. In the smaller countries (with limited country programmes) the activities were mostly confined to low-cost projects such as assessment missions and preliminary investigations etc.

Several larger projects were however implemented in some of the larger countries, and in cases where external funds were made available through cost sharing. The most important ones were the following:

- India, where a large project including equipment delivery, large training component and exploration drilling was carried out.
- The Central American Energy Programme which completed country wide reconnaissance surveys in Honduras and Panama, and regional training seminars for the C.A. countries, financed with support from the OPEC.
- Country-wide reconnaissance of Madagascar (subcontract).
- Provision of high-technology equipment and training for Mexico and the Philippines.
- Large exploratory drilling programmes, equipment and training in Ethiopia, with support from EEC.

- Project on direct uses of low-enthalpy fluids in China Peoples Republic, with provision of equipment, and training, and study of high-enthalpy areas in Tibet, with cost sharing from the Italian Government.
- Prefeasibility studies in the East African Rift Valley in Kenya with cost sharing by the Italian, British and Japanese Governments.
- Follow-up projects in Honduras and Bolivia, with Italian cost sharing.
- A geothermal drilling programme is going on in Djibouti with cost sharing from various sources.
- A project for study of the use of low-enthalpy geothermal sources for non-power applications in the Philippines.

Icelandic personnel has actively participated in several of the above projects, and carried out the Madagascar reconnaissance study under UN subcontract. Since 1980 Icelandic Technical Advisers have been stationed at the UN/DTCD Headquarters in New York being responsible for the technical supervision of the geothermal activities of this agency. These latter have frequently taken part in special tasks not only for the DTCD but in cooperation with various other UN Agencies when such needs came up.

The total input of Icelandic experts in the above projects including the services of the Technical Advisors at UN Headquarters is estimated 298 man-months. It is worth noting that of the 533 man-months provided to the various UN projects 291 m/m or about 56% represents projects managers, chief technical advisers and other supervisory positions.

4. INDEPENDENT ACTIVITIES OVERSEAS BY ICELANDIC INSTITUTIONS

Apart from the above described services to the UN, there has been growing demand for consulting services direct from Icelandic institutions in geothermal exploration and development abroad. The limiting factor has however been acute lack of financial resources especially in the developing countries.

While Iceland has the technical expertise and proven experience in providing such services, with a total population of only 250.000 it is clearly unable to provide significant financial support to promote such undertakings through cost sharing or other contributions.

Fig. 3 lists overseas activities by Icelandic institutions in 1969-1986. The most important assignment was the contract for consulting engineering services for the design and construction supervision of the Olkaria power project in Kenya awarded to VIRKIR LTD and Merz & McLelland in 1977, including scientific consulting services to the Kenya Power Company regarding management of the field under exploitation, based on monitoring and interpretation of the behavior of the reservoir under load. Various other contracts have been completed or are in progress and a few assessment and reconnaissance missions have been carried out. The total input is estimated as 237 man-months.

5. CONCLUDING REMARKS AND FUTURE OUTLOOK

Table 4. shows a list of 36 countries where Icelandic geothermal experts have rendered services from 1951 to 1986, and demonstrates the wide experience in the developing world.

The VIRKIR consulting group has been specially active in this respect, but has enjoyed very valuable support from the Orkustofnun, the University Science Institute and a number of individual experts.

Table 5. shows the main sources of specialized personnel for the overseas work up to now. The "private sector" includes VIRKIR, LTD, and personnel provided by them including both individual experts and experts on loan from the University Research Institute. About 30% have been provided by the Orkustofnun and about 70% from the private sector.

The government has shown increased interest in strengthening this initiative which represents export of Icelandic knowhow and experience. With view to this Orkustofnun International, Ltd., a state-owned company, has recently been organized, backed up by the excellent facilities of the Geothermal Division of Orkustofnun. The Icelandic Drilling Company Ltd., which is owned by the state and the municipality of Reykjavík, and has carried out all geothermal drilling in Iceland, is also considering participation in overseas contract drilling in the future. VIRKIR will as before provide engineering, overall project management, consultation on production management of geothermal reservoirs, and other technical and scientific services as it has successfully done in the past overseas.

These three organizations are now in position to offer first class services, singly or jointly, for complete geothermal exploration and development projects from the first reconnaissance stage through the feasibility study phase, as well as planning, design commissioning and operation of all kinds of projects including electrical power generation and non-power applications.

In addition the well known Geothermal Training Programme of Orkustofnun which is sponsored by the Icelandic Government and the UN University in Tokyo will continue to provide advanced training in all aspects of geothermal exploration and development.

Table 1. UN Demonstration Projects

Countries	UN Project Duration Years	Commissioning of power units Years/Capacity	Total Installed Capacity MW
Chile	1967-1973	-	-
El Salvador	1966-1972	1974/30 MW 1975/30 MW 1980/35 MW	95
Turkey	1966-1977	1982/20 MW	20
Nicaragua	1972-1977	1981/35 MW	35
Kenya	1971-1976	1981/15 MW 1982/15 MW 1985/15 MW	45
Total			195 MW

Table 2. Input by Icelandic geothermal personnel in UN
geothermal projects 1951-1986

Country	Short term assignments 6 or less man-months	Long term assignments 6 or more man-months	Project Manager or Chief Tech- nical Adviser	Total man- months
<u>A. The UN Demonstration Projects:</u>				
El Salvador	35.0	10.0	40.0	85.0
Turkey	6.0	17.0	-	23.0
Nicaragua	10.0	28.0	61.0	99.0
Kenya (Olkaria)	-	-	20.0	20.0
- Subcontract				8.0
Subtotal	51.0	55.0	121.0	235.0
<u>B. Other UN Projects:</u>				
Various	18.0	-	-	18.0
C.A. Energy Programme	17.0	17.0	26.0	60.0
Madagascar (Subcontract)	-	-	-	12.0
Djibouti	8.0	-	27.0	35.0
China Peoples Rep.	6.0	-	-	6.0
Kenya (Rift Valley)	1.0	48.0	40.0	89.0
Philippines	1.0	-	5.0	6.0
Subtotal	51.0	65.0	98.0	226.0
DTCD Headquarters			Technical Advisors	72.0
TOTAL				533.0

Table 3. Independent Overseas Activities by Icelandic Institutions

Year	Country Project	Agency	Contr. Value US\$	Man- months
<u>A. Missions:</u>				
1969	Taiwan, Assessment	OS		1.0
1976	Indonesia, Reconnaissance	OS		2.0
1978	N.Korea, Assessment	OS		1.0
1982	Burundi, Assessment	OS		2.0
<u>B. Contracts:</u>				
1976-77	Tanzania and Zambia Reconnaissance of geo- thermal resources	VIRKIR/SWECO	70.000	6.0
1977-85	Kenya Power Company a) Design and construction supervision of Olkaria Power Project. b) Continued consulting services to the KPC on long term control of the geothermal reservoir and its optimum management during exploitation.	VIRKIR/M&MCL	1.850.000	185.0
1982	ARPAD, Hungary deep well pumping	VIRKIR	25.000	2.0
1984-85	Public Power Co Greece. Evaluation of Milos and Nysiros geothermal fields.	VIRKIR/OS	180.000	19.0
1985	Geothermal consulting services for study of district heating in Beijing and Tientjin, China under DANIDA project	VIRKIR/Harry and Mogens Larsen	25.000	3.0
1986	Prefeasibility study of geothermal district heating, city of Denizli, Turkey	VIRKIR	175.000	16.0
Total			2.325.000	237.0

Table 4. List of countries where geothermal specialist from iceland have been involved

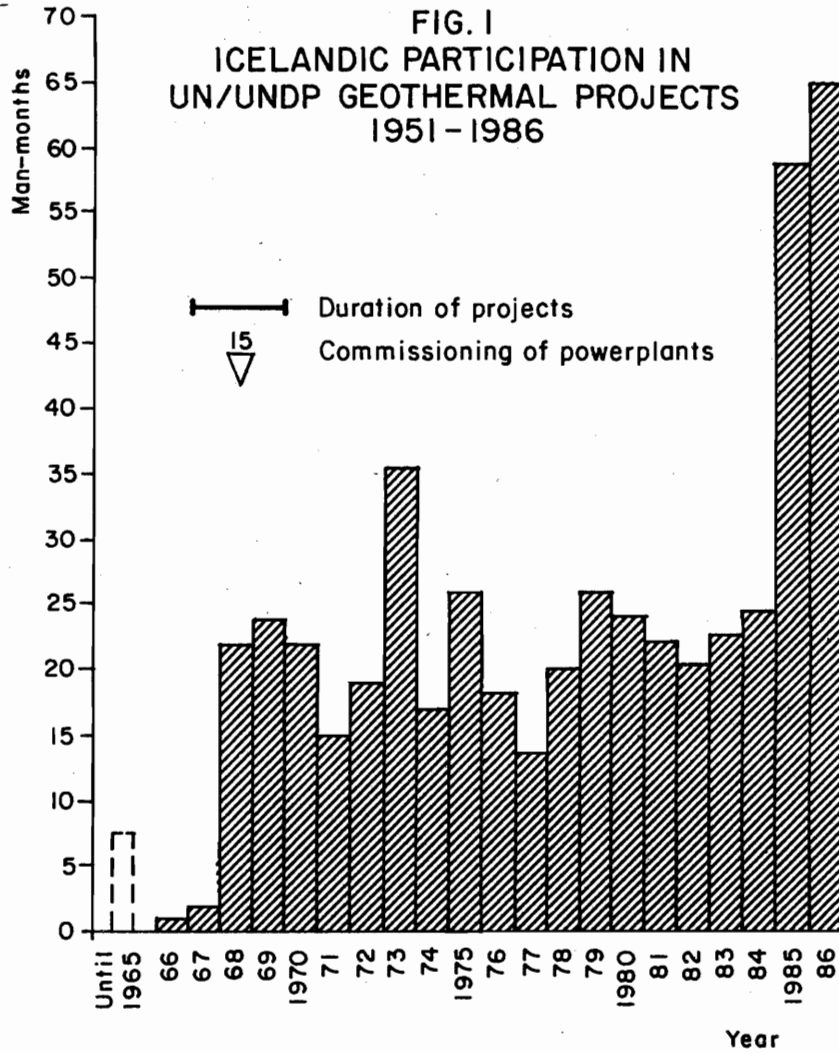
1. Argentina	
2. Burundi	20 Madagascar
3. Cape Verde Islands	21. Mali
4. Chile	22. Mauritius
5. China, Peoples Rep.	23. Mexico
6. Costa Rica	24. Netherlands Antilles (Sana)
7. Djibouti	25. Nicaragua
8. El Salvador	26. Panama
9. Ethiopia	27. Philippines
10. France	28. Romania
11. Greece	29. Taiwan
12. Guatemala	30. Tanzania
13. Honduras	31. Turkey
14. Hungary	32. U.S.A.
15. India	33. St. Vincent
16. Indonesia	34. Yemen Arab Rep.
17. Kenya	35. Yugoslavia
18. N. Korea	36. Zambia
19. St. Lucia	

Table 5. Sources of specialized personnel

	Government		Private m/m	Sector %
	m/m	%		
1. Individual consultants				
a) in service of UN	230	29.9	283	36.8
b) in service of others	6	0.8		
2. Consulting contracts				
a) in service of UN			20	2.6
b) in service of others			231	30.0
	236	30.7	534	69.4



FIG. 1
ICELANDIC PARTICIPATION IN
UN/UNDP GEOTHERMAL PROJECTS
1951-1986



PRINCIPAL PROJECTS:

