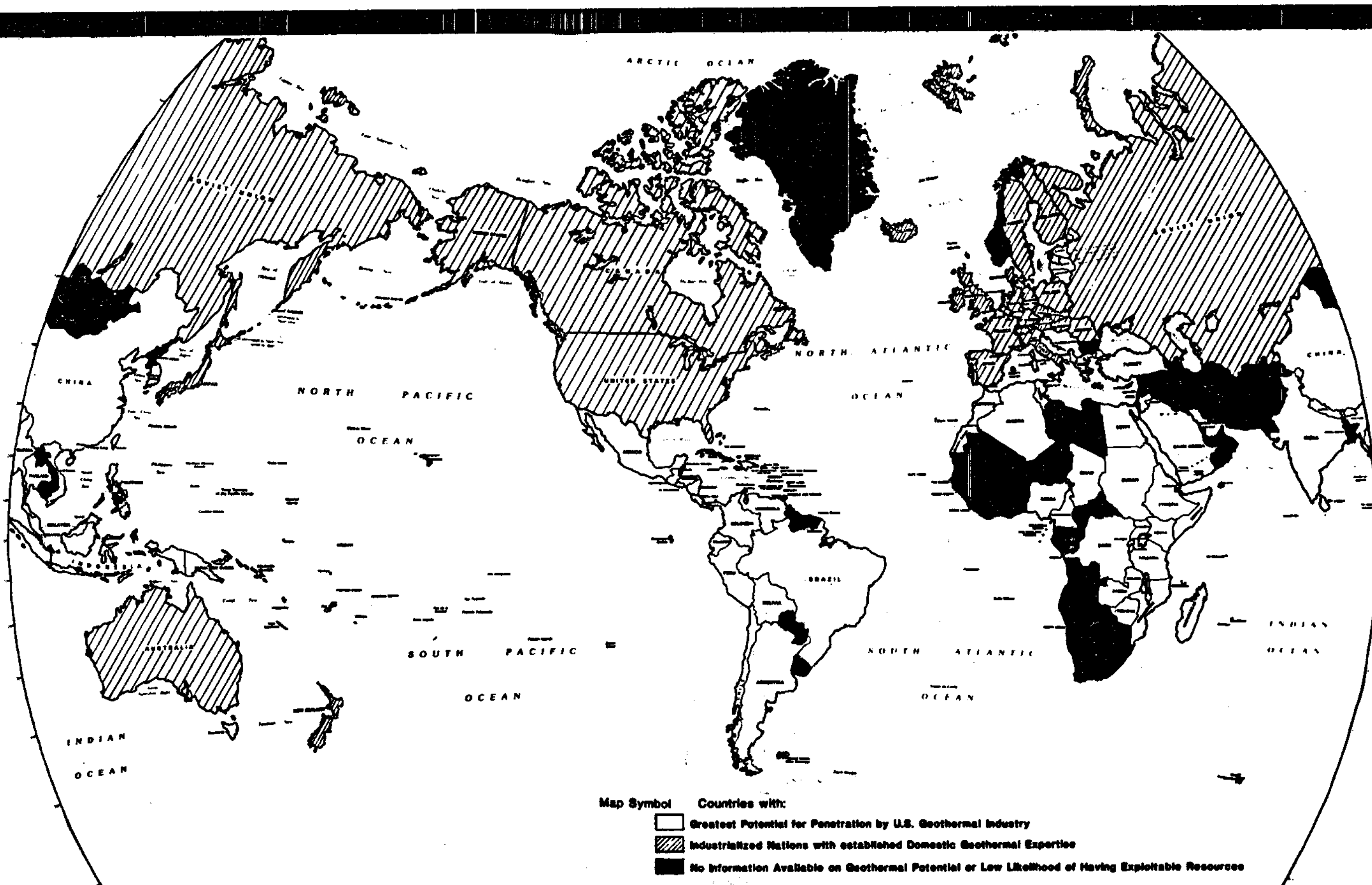
LA-11066-MS, Vol. I

REVIEW OF INTERNATIONAL GEOTHERMAL ACTIVITIES AND ASSESSMENT OF U. S. INDUSTRY OPPORTUNITIES

Final Report



Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico, 87545

Los Alamos National Laboratory is operated by the University of California for the United States Department of Energy under contract W-7405-ENG-36.

LA-11066-MS, Vol. I

UC-66
Issued: August 1987

Review of International Geothermal Activities and Assessment of U.S. Industry Opportunities

Final Report

Report prepared by

Meridian Corporation
4300 King Street, Suite 400
Alexandria, Virginia 22302

Los Alamos

Los Alamos National Laboratory
Los Alamos, New Mexico 87545

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ABSTRACT

This study was initiated to review and assess international developments in the geothermal energy field and to define business opportunities for the U.S. geothermal industry. The report establishes data bases on the status of worldwide geothermal development and the competitiveness of U.S. industry. Other factors identified include existing legislation, tax incentives, and government institutions or agencies and private sector organizations that promote geothermal exports.

Based on the initial search of 177 countries and geographic entities, 71 countries and areas were selected as the most likely targets for the expansion of the geothermal industry internationally. The study then determined to what extent their geothermal resource had been developed, what countries had aided or participated in this development, and what plans existed for future development. Data on the energy, economic, and financial situations were gathered.

Information has been selected and presented to (1) provide background data on the status of worldwide geothermal development and U.S. industry's involvement and (2) serve as a reference source for the geothermal industry.

The following sections have been included:

- Detailed summaries, with bibliographies, of past, present, and planned geothermal development in the 71 selected countries and areas.
- Information on the involvement of U.S. and foreign geothermal industry in these countries.
- Summaries of the energy, economic, and financial situations in these countries.
- Information on the various international and U.S. agencies and organizations that either fund geothermal development projects or promote the export of U.S. goods and services.

General conclusions drawn pertaining to international geothermal activities and U.S. geothermal industry opportunities are:

1. Their potential for geothermal development in the world is much larger than is currently being exploited.
2. The U.S. geothermal industry is one of the leaders in geothermal development worldwide despite stiff competition from Japan, New Zealand, France, and Italy.
3. A five-point strategy is outlined to aid U.S. penetration of the international geothermal market.

Executive Summary

The U.S. geothermal industry has established itself as the world leader in the development and exploitation of the geothermal resource as an efficient, cost-competitive and environmentally compatible source of energy. This is reflected by the fact that the U.S. leads the world in terms of geothermal electric power generating capacity with over 2,000 MWe presently on-line. U.S. industry today is faced with a new challenge, brought about by declining oil prices and the present overabundance of electric energy - a redirection of its near and mid-term growth potential from the domestic to the international market. This is a major undertaking for the majority of U.S. geothermal companies who have developed in response to and have grown with the domestic market. One of the basic ingredients in making this transition is information about the international market, its needs and its requirements. This study was initiated for the purpose of assessing international developments in geothermal energy, and to identify opportunities for the U.S. geothermal industry to evaluate and exploit.

The number of countries throughout the world exploring the use of geothermal resources has increased substantially over the past 15 years. This increase is primarily due to heightened emphasis on national energy security, and corresponding increases in aid from industrialized countries and international funding organizations for developing indigenous energy resources in less developed countries. Simultaneously, the capabilities of the U.S. geothermal industry have also progressed. The U.S. industry is technologically superior, has gained a prominent position in the international market, and is well positioned to increase export of its products and services.

The primary purpose of this report is to present a comprehensive, consolidated international geothermal energy development data base (developed from the best available published literature) and analyses, to:

- o assist U.S. geothermal industry, its potential users, and financiers in understanding the status of current and future international markets;
- o assist the Federal Government in establishing program plans and activities to promote geothermal export development; such as those called for under the "Renewable Energy Industry Development Act of 1983" (Public Law 98-370).

While advances have been made in promoting geothermal export development, certain needs must still be overcome for U.S. industry to successfully expand and continue international market penetration. To address these needs, this study:

- o Identifies those countries that have the greatest actual or potential geothermal resources, and will import the technology and services necessary to exploit these resources.
- o Defines the current level of geothermal development within the identified countries, with respect to available U.S. goods and services.
- o Assesses, at a general level, the economic and energy market conditions within the identified countries that may impact a company's decision to pursue business development within that country.

- Identifies the principal competitors and relative U.S. market share within the identified countries, based on historic data and future projections.

- Selects target market countries based on a collective analysis of the resource, market, economic, energy, and competitive data.

- Assesses the financing resources available to support or fund international geothermal development projects.

Based on the results of this study the following conclusions were drawn:

- U.S. geothermal industry is a world leader in geothermal development, as demonstrated by its past activities.

  - conducted exploration projects in at least 21 of the target countries;

  - supplied geothermal drilling equipment or services in at least 6 of the target countries;

  - participated in field development in at least 10 of the target countries; and

  - participated in power plant design and construction in at least 3 of the target countries.

- The necessary ingredients exist for continued expansion of U.S. geothermal industry penetration into the international market, including:

  - U.S. geothermal industry is technologically superior and has extensive experience and visibility in the international arena.

  - Of 177 countries reviewed, 71 countries/areas exist with demonstrated or potential geothermal resources and current or future needs for U.S. technology and expertise.

  - Eight international funding organizations have been involved with geothermal projects, and four general funding mechanisms exist for accessing funds from these agencies.

- A five-point strategy could be easily employed by the Federal Government to enhance the export development of U.S. geothermal technology:

  - measure U.S. industry interest in export development;

  - expand the international geothermal data base;

  - educate industry on international business and development techniques, and educate the market and financiers on geothermal energy;

  - expand efforts to disseminate information on international projects to U.S. industry; and

  - improve access to funding for international projects.

This study focuses primarily on developing nations and industrialized countries/areas that have evidence of geothermal resources, and are likely to require the assistance of foreign geothermal experts. Brief summaries of industrialized countries with established competitor industries (including USSR-aligned countries), and countries/areas with negligible geothermal potential are included to assist the reader in understanding the global market. This report is not intended to represent a comprehensive market research analysis, which generally must be accomplished by the individual firm to address its specific interests.

The supporting data are presented in both summary (within the report), and detailed (within the appendices) formats, and is organized for the reader to easily focus on the industry sector or market country of their choice.

Chapter 1: Study Overview

1.1 Introduction

The U.S. geothermal industry is well equipped, from the perspective of its unsurpassed expertise and hands-on experience in the development of geothermal energy in the domestic market, to expand its opportunities in the international market. The Federal Government through the "Renewable Energy Industry Development Act of 1983" has been mandated to facilitate promotion of U.S. renewable energy, including geothermal energy technology products and services. A key element affecting both industry's desire to penetrate international markets, and government's efforts to establish effective programs and policies to promote the export of U.S. geothermal technology, is information; information on the status of international geothermal development needs and on the status of U.S. industry in the international market.

To address this problem, this study was initiated to review and assess international developments in geothermal energy and to define market opportunities for the U.S. geothermal industry.

The number of countries exploring the use of geothermal resources has increased substantially over the last 15 years. Prior to the mid-1970's, the industrialized nations, (i.e., the United States, Japan, Italy and New Zealand) were the primary users of geothermal energy for electrical generation. However, the dramatic rise in oil prices that occurred in the early 1970's, coupled with increased aid from industrialized countries and international development organizations, has caused many other countries to become interested in alternative energy supplies, including geothermal resources. Exhibit 1.1 illustrates the recent expansion of geothermal power generation. This along with the increase in the number of countries exploring geothermal opportunities is a clear indication of the immense growth potential of this market.

Just as international geothermal interest has increased in recent years, so has the capability of the U.S. geothermal industry. The U.S. industry is technologically second to none, and has gained a prominent position in the international market, and is well positioned to increase exports of its products and services. However, before the U.S. industry can successfully increase its penetration into the international marketplace, it must:

- o fully understand the status of worldwide geothermal development;
- o assess the competitiveness of the U.S. geothermal equipment and services;
- o define future geothermal opportunities for U.S. industry; and
- o develop a coherent strategy for developing and funding these opportunities.

This study is intended to provide the basis for the collection and interpretation of data needed to address these issues.

The study was composed of four tasks:

- o conduct a review of international geothermal development, including identification of those areas with high geothermal potential that have not yet been exploited;

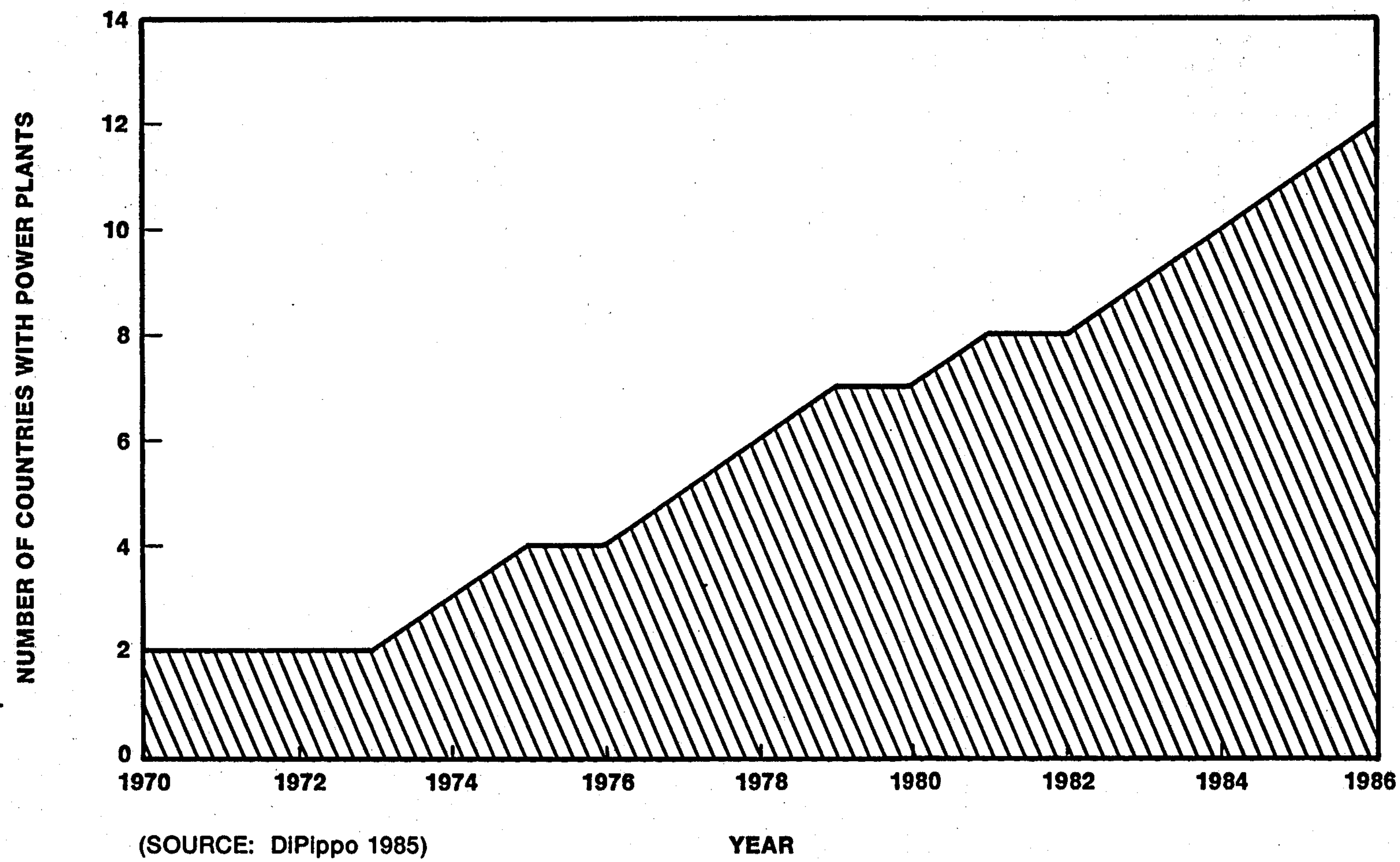

Exhibit 1.1: Worldwide Expansion of Geothermal Power (Excluding US, NZ, USSR, Italy, Japan, Iceland)

- assessing the competitiveness of U.S. industry and its future opportunities as indicated by its penetration in the international geothermal market;

- review the federal and international agencies responsible for funding or financing geothermal development; and

- develop a strategy and recommendations for enhancing the export potential of geothermal technology for action on the part of the Federal Government.

The purpose of this report is to present the results of this study and inform U.S. industry and potential users and financiers of the commercial status and potential of U.S. geothermal technology. This report describes the data, methodology and results of each of the study tasks, and provides extensive detailed country-specific resource and economic data.

Summaries and data presented in this report reflect information available through mid-1986.

1.2 Value to Industry

The data presented in this report will be useful to the Federal Government, as well as to geothermal companies interested in expanding their overseas markets. Larger companies and those with extensive international experience may find this report presents limited new information, but a comprehensive consolidation of all available information. Companies that have not yet invested heavily in marketing overseas will find sufficient reliable data on which to base initial export development decisions.

To develop and implement a successful international marketing strategy, the U.S. geothermal industry must have a clear picture of the geothermal opportunities that exist throughout the world. A thorough assessment of the opportunities for geothermal development must incorporate such factors as geothermal resources and the energy market and economic conditions within a given country. Each of these are addressed on a general level in this report. A company interested in marketing its goods or services internationally must develop an approach unique to its situation. This would be a function of the character of the company, its contracts and market intelligence sources, and its products.

1.3 Study Approach

This study utilizes a generic approach that also may be useful to any company attempting to investigate the international geothermal market. This approach includes the following steps:

1. Narrow the study to those countries where the greatest opportunity exists, in terms of the actual or potential geothermal resources. For this study, a comprehensive literature review was conducted to accomplish this. The results are summarized in Chapter 2.

2. Define the current level of geothermal development for the selected countries, and various fields, along with the quality and extent of the resource. For this study, this information is summarized in tabular form herein (Chapter 2 was collected from the literature review) and detailed data are presented in Appendix B.

3. Examine the economic and energy conditions in the selected countries, including current consumption and production levels, and domestic energy

resources that would compete with geothermal in the future (hydropower, oil, gas, coal, etc.). These data were collected from various energy surveys and are summarized in Chapter 2. Detailed data are presented in Appendix C.

4. Identify the principal competitors and their relative market share in the country in question. This information has been gathered from an extensive search of the published and company-specific literature, and is summarized in tabular form in Chapter 3.

5. Select target market countries based on collective analysis of resource, market, economic, energy and competitor data. Chapter 4 presents these results for this study on a global scale.

6. Assess the ability of the various countries to support or secure financing for geothermal development projects. This includes overall economic strength, as well as probable access to borrowed capital. This information was gathered from various funding organizations, publications, and is summarized in Chapter 5. More detailed information can be found in Appendix C.

The combined result of the above steps is an overall picture of the climate for geothermal development in a given country, a region, or, in this report, the world. Summaries of all data described above for each country are found in Chapter 4. The countries are grouped by level of geothermal development to allow interested companies to focus immediately on those countries with the highest potential markets for their expertise or equipment.

1.4 Study Results

Based on the data collected, and this employed approach, the following conclusions were drawn:

- U.S. geothermal industry is technologically one of the world leaders, and has extensive experience and visibility in the international arena.

- Of 177 countries reviewed, 71 countries/areas exist with demonstrated or potential geothermal resources and probable needs for U.S. technology and expertise.

- The necessary ingredients exist for expanded and continued U.S. geothermal industry penetration into the international market.

- A 5-point strategy could be employed by the Federal Government to enhance the export development of U.S. geothermal technology.

- Collectively, the data presented in this report and its' appendices compile the most comprehensive, international geothermal resource data base publicly available.

Chapter 2: The Status of Geothermal Development in the World

2.1 Selection of Countries and Areas for Detailed Study

To facilitate the study and focus the analysis of the collected information, all countries and geographic areas were divided into three categories:

- developing nations and industrialized countries/areas that have evidence of geothermal resources and which are likely to require the assistance of foreign geothermal experts.
- industrialized countries/areas that have established competitor industries (to include USSR-aligned countries); and
- countries/areas with negligible geothermal potential or for which no information was available.

Included in these lists are Puerto Rico, Taiwan, the Azores, and Ascension Island. Although these geographic entities are not countries, political or economic circumstances dictate they should be addressed separately. Exhibits 2.1, 2.2 and 2.3 list the countries in each of these three categories. Exhibit 2.4 shows the global distribution of these countries.

The countries and areas included in the detailed study include those with existing evidence, or potential of geothermal resources (Exhibit 2.1). In addition, the literature search concluded that these countries are not highly industrialized and, therefore, will most likely seek foreign expertise and industry to assist exploiting their geothermal resources to their maximum potential. The level of geothermal development in these countries varies greatly. Some countries have not developed their resources at all, while other already have substantial power on-line. Similarly, the level of resource quality varies from unknown, to widespread, high-temperature resources. Summaries of the geothermal development in these countries, historical, as well as future plans (where known), are included in Appendix B.

Industrialized nations with established competitor industries and USSR-aligned countries (Exhibit 2.2), are not considered to be the primary target for the expansion of U.S. geothermal industry abroad. Countries of this group with high-enthalpy resources, also have well-developed geothermal industries. The countries with low- and medium-enthalpy resources have established construction and engineering industries that would be adequate for geothermal direct-use development. Therefore, the majority of geothermal work in these countries will most likely be performed by their own domestic industry. Historically, U.S. industry has had some penetration into these markets, but, in view of their own strong domestic industries, an appreciable increase in the U.S. industry's market share is unlikely. These industrialized countries are not considered in detail in this study. Brief summaries of the status of geothermal development in these countries are included in Appendix A.

The countries with no evidence of geothermal potential, or for which no information was available (Exhibit 2.3), are also not considered in this report. A comprehensive review of published information did not reveal any data supporting likely geothermal resources in these countries.

Algeria	Malaysia
Argentina	Mexico
Ascension Island	Morocco
Azores	Mozambique
Bhutan	Nepal
Bolivia	Nicaragua
Brazil	Nigeria
Burma	Panama
Burundi	Papua New Guinea
Cameroon	Peru
Cape Verde	Philippines
Chad	Puerto Rico
Chile	Rwanda
China	Saint Christopher and Nevis
Colombia	Saint Lucia
Costa Rica	Saint Vincent and the Grenadines
Djibouti	Samoa, Western
Dominica	Saudi Arabia
Dominican Republic	Solomon Islands
Ecuador	Somalia
Egypt	Sudan
El Salvador	Taiwan
Ethiopia	Tanzania
Fiji	Thailand
Greece	Tunisia
Grenada	Turkey
Guatemala	Uganda
Haiti	Vanuatu
Honduras	Venezuela
India	Vietnam
Indonesia	Yemen, North
Jordan	Yemen, South
Kenya	Yugoslavia
Korea, South	Zaire
Madagascar	Zimbabwe
Malawi	

Exhibit 2.1: Countries and Areas Selected for Detailed Consideration

Austria
Australia
Belgium
Canada
Czechoslovakia
Denmark
Finland
France (including Guadeloupe, Reunion Island)
Germany, East
Germany, West
Great Britain
Hungary
Iceland
Ireland
Italy
Japan
Netherlands
New Zealand
Poland
Portugal
Romania
Spain
Sweden
Switzerland
U.S.S.R

Exhibit 2.2: Industrialized Nations with Established Domestic Geothermal Expertise

Afghansitan	Lebanon
Albania	Libya
Andorra	Lesotho
Angola	Liberia
Antigua and Barbuda	Liechtenstein
Bahamas	Luxembourg
Bahrain	Macau
Bangladesh	Mali
Barbados	Malta
Belize (British Honduras)	Mauritania
Benin (Dahomey)	Mauritius
Bermuda	Monaco
Botswana	Mongolia
Brunei	Namibia
Bulgaria	Nauru
Burkina Faso (Upper Volta)	Netherlands Antilles
Central Africa Republic	New Caledonia
Comoros	Niger
Congo	Norway
Cuba	Oman
Cyprus	Pakistan
Equatorial Guinea	Paraguay
French Guinea	Qatar
French Polynesia	Sao Tome and Principe
Gabon	San Marino
Gambia	Senegal
Ghana	Seychelles
Greenland	Sierra Leone
Guinea	Singapore
Guinea-Bissau	South Africa
Guyana	Sri Lanka
Hong Kong	Suriname
Iran	Swaziland
Iraq	Syria
Israel	Togo
Ivory Coast	Tonga
Jamaica	Trinidad and Tobago
Kampuchea (Cambodia)	Tuvalu
Korea, North	United Arab Emirates
Kuwait	Uruguay
Laos	

Exhibit 2.3: Countries and Areas with No Information Available On Geothermal Potential or Having Low Likelihood Of Exploitable Resources

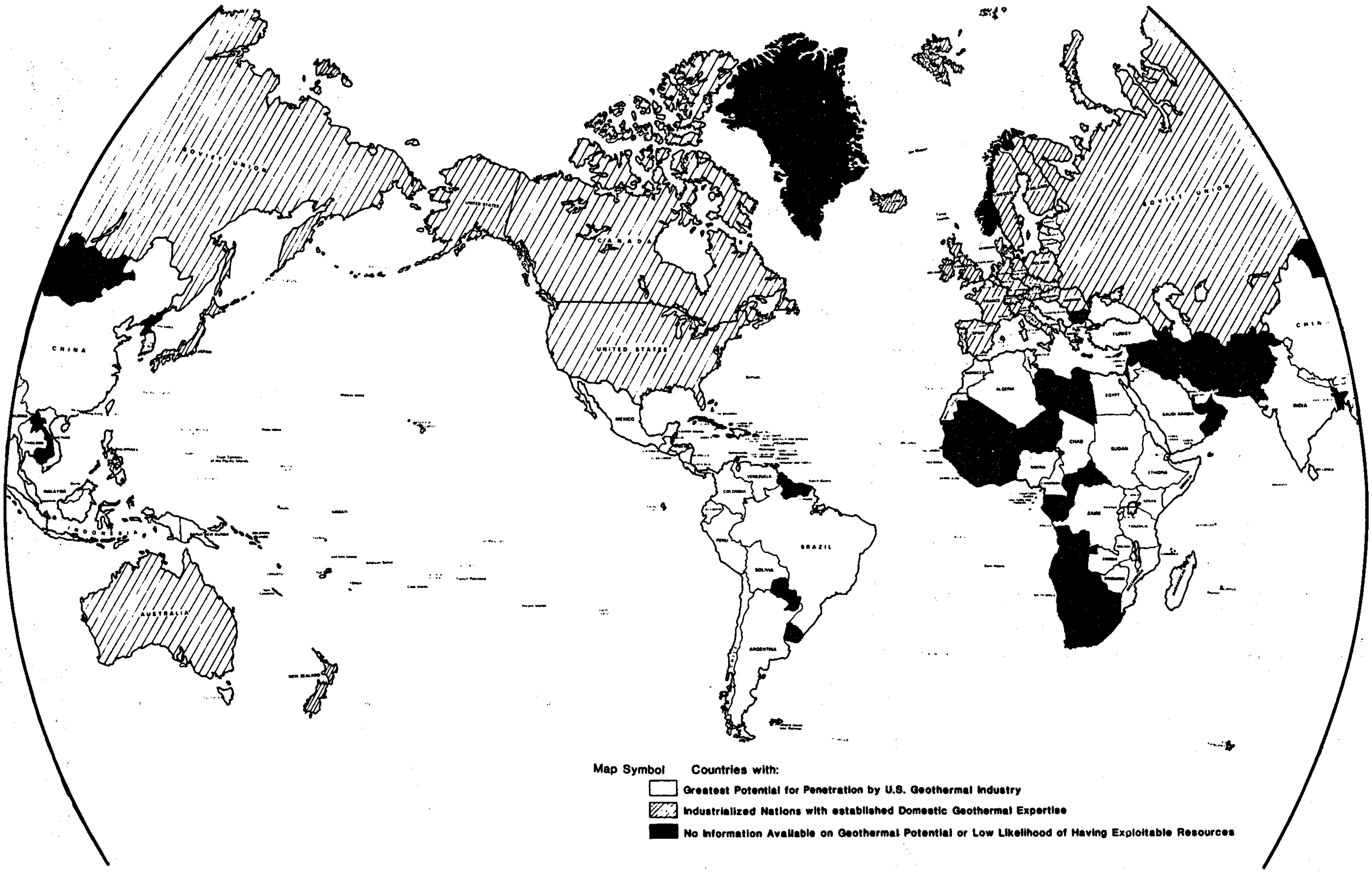

Exhibit 2.4: Worldwide Distribution of Geothermal Development Potential

2.2 Geothermal Development and Resources in Target Countries

Exhibit 2.5 indicates the current level of development, estimated resource temperature, and existing geothermal electric capacity for each country included in the detailed study. These data are listed for all identified fields in each country in which shallow thermal gradient drilling has been conducted, and for additional identified fields in which exploration may or may not have begun.

2.2.1 Level of Geothermal Development

The levels of geothermal development for the identified field within each country study, characterized in Exhibit 2.5 (column three), is by the following:

I. Exploration

a. Nationwide preliminary assessment: Resource estimates exist and are based on preliminary geological evidence and presence of hot springs. Detailed site-specific studies have not been performed.

b. Site-specific reconnaissance: Detailed site studies have been conducted, including field geology, surface geochemical analysis of existing wells and data, and some surface geophysics.

c. Detailed geophysical studies: Sites have been evaluated using surface geophysical methods, and shallow thermal gradient drilling.

II. Field Development

a. Exploratory drilling: Deep exploratory well drilling has been conducted to locate and characterize the geothermal reservoir.

b. Production drilling: Wells have been drilled to delineate and develop the geothermal field.

III. Resource Utilization

a. Demonstration: Small research and development (R&D), or demonstration plant exists.

b. Construction: Commercial power plant (>10 MWe) is under construction.

c. Operation: Successful commercial facility (>10 MWe) is in operation.

The levels of development shown for each entry are based on an interpretation of published information and are believed to be reasonably accurate. Development levels may vary by a sub-category in cases where the results of existing studies have not been published. Detailed descriptions of the history and potential for geothermal development in each country are included in Appendix B. The key references used in conducting this study are listed after the detailed descriptions of each country in Appendix B.

2.2.2 Estimated Resource Temperature

The resource temperature data for each field, indicated in Exhibit 2.5, (column four), are estimated based on available information. The scale used is as follows:

	: no information available.
*	: resource temperature >50°C confirmed by drilling or measurement of hot spring temperatures.
**	: resource temperature >90°C suspected based on geothermometry or shallow thermal gradient wells.
***	: resource temperature >90°C confirmed by drilling or measurement of hot spring temperatures.

NAME OF COUNTRY	FIELD NAME	MAX. DEV.	EST. TEMP.	MW ONLINE
ALGERIA	NONE IDENTIFIED	Ib	***	
ARGENTINA	JUJUY	Ib	****	
	COPAHUE	IIa	*****	
ASCENSION ISLAND	ASCENSION ISLAND	Ic	****	
AZORES	2 OTHERS	Ia		
	RIBEIRA GRANDE	IIIa	*****	3
	PICO ALTO	Ic	****	
BHUTAN	NONE	0	**	
BOLIVIA	5 OTHERS	Ia		
	SOL DE MANANA	Ic	*****	
	SALAR DE EMPEXA	Ic	****	
BRAZIL	NONE IDENTIFIED	0	**	
BURMA	NONE IDENTIFIED	0	***	
BURUNDI	NONE IDENTIFIED	0		
CAMEROON	NONE IDENTIFIED	0		
CAPE VERDE	FOGO CALDERA	Ib	****	
CHAD	NONE IDENTIFIED	0		
CHILE	19 OTHERS	Ib	****	
	EL TATIO	IIb	*****	
	PUCHILDIZA	IIa	*****	
	SURIRE	Ic	****	
CHINA	40 OTHERS	Ib	****	
	YANGBAJING	IIIc	*****	10
	REHAI	Ic	****	
	PANZHIHUA	Ic	****	
	RUIDIAN	Ic	****	
	21 OTHERS	IIIb	***	7.231
COLOMBIA	7 OTHERS	Ib	****	
	MACHIN VOLCANO	Ic	****	
	CHILES-CERRO NEGRO	Ic	****	
COSTA RICA	5 OTHERS	Ib	****	
	MIRAVALLES	IIb	*****	
DJIBOUTI	5 OTHERS	Ib	****	
	ASAL	IIa	*****	
	HANLE	IIb	*****	
	GAGGADE	Ic	*****	
DOMINICA	BOILING LAKE	Ib	****	
	SOUFRIERE	Ic	****	
	WOTTEN WAVEN	Ic	****	
DOMINICAN REPUBLIC	4 FIELDS	Ib	**	
ECUADOR	6 OTHERS	Ib	****	
	TUFINO-CHILES-CERR	Ic	****	
EGYPT	NONE IDENTIFIED	Ia	**	
EL SALVADOR	4 OTHERS	Ia		
	AHUACHAPAN	IIIc	*****	95
	BERLIN	IIa	*****	
	SAN VICENTE	IIa	*****	
	CHINAMECA	Ic	****	
	CHIPILAPA	Ic	*****	
ETHIOPIA	5 OTHERS	Ia		
	LAKE LANGANO-ALUTO	IIb	*****	
	LAKE ABAYA	Ic	****	
	CORBETTI CALDERA	Ic	****	
	TENDAHO	Ic	****	
FIJI	3 FIELDS	Ib	****	
GREECE	8 OTHERS	Ib	****	
	MILOS	IIIa	*****	2
	NISYROS	IIa	*****	
GRENADA	MT.ST.CATHERINE	Ia	**	
GUATEMALA	7 OTHERS	Ib	****	
	ZUNIL	IIb	*****	
	MOYUTA	IIa	***	
	AMATITLAN	Ic	*****	
HAITI	4 FIELDS	Ib	**	
HONDURAS	11 FIELDS	Ib	****	
INDIA	14 OTHERS	Ia		
	PUGA	Ic	****	
	CAMBAY BASIN	Ic	****	
INDONESIA	11 OTHERS	Ib	****	
	BANTEN	IIa	****	
	GUNUNG SALEK	IIa	****	
	PALABUHAN RATU	IIa	****	
	KAMOJANG	IIIc	*****	30.25
	DARAJAT	IIa	****	
	DIENG	IIa	*****	
	BALI	Ic	****	
	GUNUNG PATUHA	Ic	****	
	GUNUNG IJEN	IIa	****	
	LAHENDONG	IIa	****	
JORDAN	ZARGA MA'IN	Ic	**	
KENYA	5 OTHERS	Ia		
	OLKARIA	IIIc	*****	45
	EBURRU	Ic	****	
KOREA, SOUTH	2 FIELDS	Ia	****	
MADAGASCAR	8 FIELDS	Ia	**	
MALAWI	NONE IDENTIFIED	0	*	
MALAYSIA	NONE IDENTIFIED	0	**	
MEXICO	18 OTHERS	Ia		
	CERRO PRIETO	IIIc	*****	620
	LOS AZUFRES	IIIa	*****	25
	LOS HUMEROS	IIb	*****	
	LA PRIMAVERA	IIa	*****	
	LOS NEGRITOS	Ic	****	
	IXTLAN DE LOS HERV	Ic	****	
MOROCCO	NONE IDENTIFIED	Ia	**	
MOZAMBIQUE	NONE IDENTIFIED	0		
NEPAL	NONE IDENTIFIED	0		
NICARAGUA	8 OTHERS	Ia		
	MOMOTOMBO	IIIc	*****	35
	SAN JACINTO-TISATE	Ic	****	
	EL HOYO	Ic	****	
	MASAYA-NANDAIME	Ic	****	
NIGERIA	NONE IDENTIFIED	Ia	**	
PANAMA	7 OTHERS	Ib	****	
	CERRO PANDO	Ic	****	
PAPUA NEW GUINEA	RABAUL	Ia	****	
PERU	5 FIELDS	Ib	****	
PHILIPPINES	20 OTHERS	Ib	****	
	TIWI	IIIc	*****	330
	MAKILING-BANAHAW	IIIc	*****	330
	TONGONAN	IIIc	*****	153
	PALINPINON-DAUIN	IIIc	*****	118.5
	BACON-MANITO	IIb	*****	
	BILIRAN	IIa	*****	
	MANAT-AMACAN	IIa	*****	
	DAKLAN	IIa	*****	
	ACUPAN-ITOGON	IIa	****	
PUERTO RICO	NONE IDENTIFIED	0		
RWANDA	NONE IDENTIFIED	0		
ST. CHRISTOPHER AN	NONE IDENTIFIED	0	**	
ST. LUCIA	2 OTHERS	Ib	**	
	SULPHUR SPRINGS	Ic	****	
ST. VINCENT AND TH	NONE IDENTIFIED	0		
SAMOA, WESTERN	NONE IDENTIFIED	0		
SAUDI ARABIA	NONE IDENTIFIED	Ia	**	
SOLOMON ISLANDS	NONE IDENTIFIED	0	**	
SOMALI REPUBLIC	NONE IDENTIFIED	0	**	
SUDAN	JEBEL MARRA	0	**	
TAIWAN	2 OTHERS	Ia		
	TATUN	IIa	*****	
	TUCHANG-CHINGSHUI	IIIa	*****	3
TANZANIA	3 FIELDS	Ib	****	
THAILAND	2 OTHERS	Ia		
	SAN KAMPHAENG	IIa	****	
	FANG	Ic	***	
	PONG HOM-PONG HOG	Ic	**	
TUNISIA	NONE IDENTIFIED	Ia	**	
TURKEY	8 OTHERS	Ia		
	KIZILDERE	IIIc	*****	20.6
	GERMANCIK	IIa	****	
	TUZLA	IIa	****	
	ERZURUM	Ic	****	
	SEFERIHISAR	Ic	***	
	AFYON	IIa	**	
	ANKARA	Ic	**	
UGANDA	3 OTHERS	Ia		
	SEMPEYA	Ic	**	
VANUATU	2 FIELDS	Ib	****	
VENEZUALA	2 FIELDS	Ib	****	
VIETNAM	NONE IDENTIFIED	Ia	**	
YEMEN, NORTH	DHAMAR-RADA'A	IIa	****	
YEMEN, SOUTH	NONE IDENTIFIED	Ia	**	
YUGOSLAVIA	NONE IDENTIFIED	Ib	**	
ZAIRE	NONE IDENTIFIED	0	*	
ZIMBABWE	NONE IDENTIFIED	0	**	

KEY

Temperature	*	> 50° C
	**	possibly > 90° C
	***	> 90° C
	****	possibly > 150° C
	*****	> 150° C

KEY

Levels of Geothermal Development	0	None
	Ia	Nationwide Reconnaissance
	Ib	Site-specific Exploration
	Ic	Thermal Gradient Drilling
	IIa	Exploratory Drilling
	IIb	Production Drilling
	IIIa	Demonstration Plant
	IIIb	Commercial Plant Construction
	IIIc	Commercial Operation

Exhibit 2.5: Level of Development and Resource Quality for Countries and Geothermal Fields

**** : resource temperature >150°C suspected based on geothermometry or shallow thermal gradient wells.
*****: resource temperature > 150°C confirmed by drilling.

2.2.3 Existing Geothermal Electric Capacity

The on-line geothermal capacity shown for each country in Exhibit 2.5, (column 5), is based on information given by DiPippo (1985), and updated where possible. Countries with existing geothermal power plants have already developed a domestic experience base and have overcome the "novelty" of geothermal development. Expanding geothermal capacity in these countries would more than likely encounter fewer infrastructure-related difficulties.

2.3 Economic and Energy Factors

2.3.1 Overview

All of the identified countries and areas listed in Exhibit 2.3 have the potential for geothermal energy exploitation, and may offer principal foreign market opportunities for U.S. geothermal industry. However, the countries vary significantly, in economic and energy market conditions, including: size; level and rate of economic development; overall economic health; need for new energy capacity; and domestic energy resources. In addition, some of the countries are somewhat industrialized, while others have achieved little industrial development. Also, some countries are important oil exporters, while others rely on imports for almost 100 percent of their commercial energy consumption.

This section is intended to allow a quick assessment of the energy and economic climate for geothermal development in the selected countries. To accomplish this, a series of statistical indicators is presented to provide a comprehensive and meaningful profile on these countries. These indicators cover a variety of factors ranging from demographic and economic data to commercial energy, trade, and financial statistics and can be used as a preliminary screening device. The primary source for the majority of this information is the latest edition of the World Development Report 1985, which is published annually by the World Bank. Where necessary, other reliable sources were used to complement the World Bank data, especially in the areas of energy consumption, production, and reserves. Although the data presented here have been compiled in a form suitable for comparative purposes, extreme care should be exercised in interpreting these data because statistical methods, coverage, and definitions vary significantly from country to country.

Entering foreign markets requires extensive research, time and cost investments and acceptance of risk. This section is not intended to provide all of the additional information required to target specific foreign markets. Such information must be developed as part of a comprehensive, specialized, and detailed market research study that would incorporate, among other things:

o an assessment of a country's political risk;

o a review of government finances and an assessment of its economic management and policies;

o a study of the trade, investment, employment, licensing, and taxation laws of both the U.S., and the target country to determine incentives and disincentives that might affect the export of U.S. geothermal products and services abroad;

- an identification of any environmental/cultural trends that might influence the U.S. geothermal market potential overseas.

Market research data such as these can be obtained from the U.S. Department of Commerce and other federal and commercial publications and services (see in Appendix C).

2.3.2 Energy and Economic Ratios

Seven categories of statistical indicators were developed to characterize the economic and energy climate within the study countries. These include:

- Gross Domestic Product (GDP)
- Investment Climate Potential
- Degree of Energy Dependence
- New Energy Reserve Needs
- Exports as a Percent of Imports
- Availability of International Reserves
- Debt Service Ability

Ratios were developed for each of these indicators to provide a comparative measure of each country's need for geothermal energy, and its economic strength to pay for that energy. These ratios are presented in Appendix C. Puerto Rico, the Azores, and Ascension Island have been excluded, because they are territories or dependencies of other countries, and, therefore, separate data on their economic, energy, and financial climates are not available. A detailed description of the raw data used to develop these ratios is presented in Appendix C and includes: demographic data; macroeconomic data; statistics on energy production, consumption, and resources; and information on the debt situation of the various countries.

Some of the ratios have no stand-alone numerical significance, but when compared to similarly derived ratios from other nations, they can give useful hints on which countries are most likely to develop their geothermal resources in the near future. For this reason, the calculated values for all of the countries in the target group have been classified as HIGH, MEDIUM, or LOW within each indicator:

- HIGH - position for possible geothermal development; i.e., the country has either a need for new energy or a strong economy to support large, new projects.
- MEDIUM- moderate likelihood of geothermal development.
- LOW- negative outlook for geothermal development; i.e., the country may have substantial fossil or hydropower energy reserves, or it may be unlikely to easily absorb additional debt service.

Exhibit 2.6 presents the comparative ranking for each of the seven energy and economic indicators within each study country.

For Per Capita Gross Domestic Product and Investment Climate potential, higher values indicate strong, growing economies that may need additional energy production to support them. The following breakpoints have been used to define the entries in Exhibit 2.6:

- <u>Gross Domestic Product (GDP) Per Capita</u> (taken directly from the data in Appendix C)

COUNTRY	GDP PER CAPITA	INVESTMENT CLIMATE POTENTIAL	DEGREE OF ENERGY DEPENDENCE	NEW ENERGY RESERVES NEEDS	EXPORTS AS PROPORTION OF IMPORTS	INT'NATIONAL RESERVES AVAILABILITY	DEBT SERVICE ABILITY
ALGERIA	HIGH	MEDIUM	LOW	LOW	MEDIUM	MEDIUM	LOW
ARGENTINA	HIGH	LOW	MEDIUM	MEDIUM	HIGH	*HIGH	LOW
BHUTAN	*	*	*	●	*	*	●
BOLIVIA	MEDIUM	LOW	MEDIUM	LOW	HIGH	HIGH	LOW
BRAZIL	HIGH	MEDIUM	MEDIUM	MEDIUM	HIGH	LOW	LOW
BURMA	LOW	HIGH	MEDIUM	HIGH	HIGH	HIGH	LOW
BURUNDI	LOW	HIGH	HIGH	LOW	LOW	●	*
CAMEROON	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW	MEDIUM
CAPE VERDE	LOW	●	HIGH	HIGH	●	●	*
CHAD	LOW	*	HIGH	HIGH	LOW	LOW	HIGH
CHILE	HIGH	LOW	MEDIUM	LOW	HIGH	HIGH	MEDIUM
CHINA	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM	HIGH	●
COLOMBIA	HIGH	MEDIUM	MEDIUM	MEDIUM	LOW	HIGH	LOW
COSTA RICA	HIGH	LOW	HIGH	MEDIUM	MEDIUM	MEDIUM	LOW
DJIBOUTI	MEDIUM	●	HIGH	HIGH	●	●	*
DOMINICA	LOW	*	HIGH	HIGH	●	●	●
DOMINICAN REPUB	HIGH	MEDIUM	HIGH	HIGH	LOW	LOW	LOW
ECUADOR	HIGH	MEDIUM	LOW	MEDIUM	HIGH	MEDIUM	LOW
EGYPT	MEDIUM	HIGH	MEDIUM	HIGH	LOW	LOW	LOW
EL SALVADOR	MEDIUM	LOW	HIGH	HIGH	MEDIUM	MEDIUM	HIGH
ETHIOPIA	LOW	MEDIUM	HIGH	LOW	LOW	LOW	MEDIUM
FIJI	HIGH	*	HIGH	HIGH	●	●	●
GREECE	HIGH	LOW	MEDIUM	HIGH	LOW	LOW	MEDIUM
GRENADA	LOW	*	HIGH	HIGH	●	●	*
GUATEMALA	HIGH	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM	MEDIUM
HAITI	LOW	MEDIUM	HIGH	HIGH	LOW	LOW	HIGH
HONDURAS	MEDIUM	LOW	HIGH	MEDIUM	MEDIUM	LOW	MEDIUM
INDIA	LOW	MEDIUM	MEDIUM	MEDIUM	LOW	HIGH	MEDIUM
INDONESIA	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM	MEDIUM	MEDIUM
JORDAN	HIGH	HIGH	HIGH	HIGH	LOW	MEDIUM	MEDIUM
KENYA	LOW	MEDIUM	HIGH	MEDIUM	LOW	MEDIUM	LOW
KOREA,SOUTH	HIGH	MEDIUM	HIGH	HIGH	MEDIUM	LOW	MEDIUM
MADAGASCAR	LOW	LOW	HIGH	HIGH	MEDIUM	LOW	*
MALAWI	LOW	*	HIGH	MEDIUM	LOW	LOW	LOW
MALAYSIA	HIGH	MEDIUM	MEDIUM	LOW	MEDIUM	MEDIUM	HIGH
MEXICO	HIGH	MEDIUM	MEDIUM	MEDIUM	HIGH	MEDIUM	LOW
MOROCCO	MEDIUM	MEDIUM	HIGH	HIGH	LOW	LOW	LOW
MOZAMBIQUE	LOW	●	MEDIUM	LOW	LOW	●	●
NEPAL	LOW	*	HIGH	LOW	LOW	MEDIUM	HIGH
NICARAGUA	MEDIUM	LOW	HIGH	MEDIUM	LOW	LOW	MEDIUM
NIGERIA	MEDIUM	MEDIUM	LOW	LOW	MEDIUM	LOW	MEDIUM
PANAMA	HIGH	*	HIGH	HIGH	LOW	LOW	HIGH
PAPUA NEW GUINE	MEDIUM	MEDIUM	HIGH	LOW	MEDIUM	MEDIUM	MEDIUM
PERU	MEDIUM	LOW	MEDIUM	MEDIUM	MEDIUM	HIGH	MEDIUM
PHILIPPINES	MEDIUM	MEDIUM	HIGH	HIGH	LOW	LOW	MEDIUM
RWANDA	LOW	●	HIGH	MEDIUM	LOW	MEDIUM	HIGH
ST. KITTS	MEDIUM	*	HIGH	HIGH	●	*	●
ST. LUCIA	MEDIUM	*	HIGH	HIGH	●	*	*
ST. VINCENT/GRE	MEDIUM	●	HIGH	HIGH	●	●	●
SAMOA	●	●	●	●	*	*	●
SAUDI ARABIA	HIGH	HIGH	LOW	LOW	HIGH	HIGH	●
SOLOMON ISLANDS	MEDIUM	*	HIGH	HIGH	*	*	●
SOMALIA	LOW	LOW	HIGH	HIGH	LOW	LOW	MEDIUM
SUDAN	LOW	MEDIUM	HIGH	MEDIUM	LOW	LOW	MEDIUM
TAIWAN	*	●	*	*	*	*	●
TANZANIA	LOW	MEDIUM	HIGH	LOW	LOW	LOW	●
THAILAND	MEDIUM	MEDIUM	HIGH	HIGH	LOW	LOW	MEDIUM
TUNISIA	HIGH	MEDIUM	LOW	MEDIUM	LOW	LOW	LOW
TURKEY	HIGH	MEDIUM	MEDIUM	MEDIUM	LOW	MEDIUM	LOW
UGANDA	LOW	LOW	HIGH	MEDIUM	MEDIUM	●	●
VANUATU	*	●	●	●	●	*	*
VENEZUELA	LOW	MEDIUM	LOW	MEDIUM	HIGH	HIGH	MEDIUM
VIETNAM	*	●	●	●	*	●	●
YEMEN, NORTH	LOW	HIGH	HIGH	MEDIUM	LOW	LOW	MEDIUM
YEMEN, SOUTH	LOW	●	*	*	LOW	LOW	LOW
YUGOSLAVIA	HIGH	MEDIUM	MEDIUM	MEDIUM	MEDIUM	LOW	HIGH
ZAIRE	LOW	MEDIUM	MEDIUM	LOW	HIGH	LOW	●
ZIMBABWE	MEDIUM	LOW	MEDIUM	LOW	MEDIUM	LOW	LOW

Note: Information not shown for non-countries (Puerto Rico, Azores, Ascencion* not available

Exhibit 2.6: Summary of Energy/Economic Indicators

High: > $1000
Medium: > $500 and >$1000
Low: < $500

- Investment Climate Potential (defined as the annual average investment growth rate)

  High: > 14%
  Medium: > 2% and < 14%
  Low: < 2%

- The degree of energy dependence is calculated using the ratio of:

  commercial energy consumption - commercial energy production and commercial energy consumption

This ratio provides a measure of a given country's ability to satisfy its own energy demands; negative values indicate production greater than consumption.

High: > 0.7
Medium: < 0.7 and > -1.0
Low: < -1.0

- The New Energy Reserve Needs, quantifies the degree to which the indigenous energy resources of a particular country will satisfy the future demand for commercial energy in that country. It was assumed that the currently proven coal, oil, and gas resources would be produced and consumed at uniform rates over the next 20 years. The full hydropower potential was also assumed to be available over this period. The total annual energy available from these resources was divided by the current annual consumption of commercial energy. A low ratio value indicates insufficient domestic reserves and therefore greater need for alternative forms of energy. The breakpoints used in this ratio are:

  High: < 2
  Medium: > 2 and < 10
  Low: > 10

Exports as a Percent of Imports represents a sample ratio of exports of the country divided by the imports and presents a measure of the balance of trade. A high value indicates a healthy economy and an ability to increase imports for new capital projects. It should be noted that the figures presented here are taken from 1983 data and, therefore, reflect a price of oil much higher than the present. As a result, countries such as Mexico are shown as having excellent trade balances and reveal no sign of the magnitude of the economic problems that they may presently be facing. The breakpoints used in this ratio are:

High: > 1.35
Medium: < 1.35 and > 0.75
Low: < 0.75

- The Availability of International Reserves, is a ratio of international reserves of the country (its "savings") to the value of its annual imports. This ratio indicates the availability of foreign exchange cash to cover imports or to finance new projects. The breakpoints used are:

  High: > 60%
  Medium: < 60% and >30%
  Low: < 30%

- Debt Service Ability, quantifies the ability of the country to take on new debt, as would be required to finance new projects. It is a ratio of the amount of money the country must pay in debt service to its annual exports. The breakpoints in this ratio are:

  High: < 10%
  Medium: > 10% and < 20%
  Low: > 20%

2.3.3 Using Energy and Economic Indicators

The indicators in Exhibit 2.6 are attempts to summarize the energy, economic, and financial situation in the various countries with the use of specific data. While these indicators do not give the complete picture, they do provide an objective basis to estimate the climate for geothermal development in a particular country. However, the statistics presented in Exhibit 2.6 do not reflect the quality of the geothermal resource or political factors that may impact the likelihood of development. Serious factors such as political unrest, may preclude geothermal development in a country with excellent resources and a strong economy. Further, a geothermal development within a country may be sponsored by foreign aid in the form of grants, making the development totally independent of any problems a country may have in servicing its public debt. Obviously, a company considering marketing in a particular country would first thoroughly review the most recent information available, to fully assess the economic, energy, financial, and political climate of a target country.

Chapter 3: International Potential of the U.S. Geothermal Industry

Once the U.S. geothermal industry has a clear picture of worldwide geothermal opportunities, it must examine these opportunities in light of its own capabilities. This chapter characterizes the capabilities of the U.S. geothermal industry in the international market, and compares the competitiveness of U.S. industry to that of the other primary exporters of geothermal technology (Italy, France, New Zealand, and Japan). This assessment provides the information necessary to develop a comprehensive marketing strategy.

3.1 Characterization of the U.S. Geothermal Industry

The United States is by far the world leader in geothermal development. As of 1985, its on-line geothermal electric generating capacity was 2022 MWe, representing 42% of the world's total on-line geothermal electricity. This is 2.26 times greater than the capacity of the Philippines, the world's second largest producer of geothermal electricity (DiPippo, 1985). In addition, U.S. experience in geothermal energy extends far beyond electric generation. In fact, according to a recent survey, there are currently 253 direct-use projects on-line in the U.S. These projects account for an estimated annual energy usage of 1,625 billion Btu/year (Kenkeremath and others, 1985).

These figures demonstrate the technological capability of the U.S. geothermal industry and its success in leading the U.S. to its preeminent position in the world of geothermal development. The U.S. geothermal industry has matured substantially since the early days of geothermal development. In fact, this industry has evolved into a non-homogeneous entity that meets the geothermal needs of the U.S. through the work of companies that are large and small, specialized and integrated, and national and international. For some of these companies, geothermal is their entire business, for others it is secondary to their primary market, which may include oil, construction, manufacturing, etc.

The U.S. geothermal industry can be characterized by dividing it into seven sectors, or categories, with particular functions and various facets of the industry. These categories are:

Exploration: This category incorporates all phases of geothermal exploration up to the point of deep exploratory drilling, including geological and geochemical studies, geophysical equipment and services, and the drilling of shallow heat flow/thermal gradient wells.

Oilfield Service/Supply Companies: This category includes the industry needed to drill deep exploratory and production wells. Subsets of this sector include drilling contractors, mud companies, cement companies, logging companies, tubular manufacturers/suppliers, etc.

Engineering/Consulting Services: This category includes drilling, production, and reservoir engineers whose services may be required throughout the exploration, drilling, field development, and production phases.

Operating Companies: This classification includes those companies that develop and operate geothermal fields, usually selling the steam produced by the field to a utility or power plant owner. These are primarily management/engineering companies that perform the complete management task, from exploration through production. Often, these companies will fund their own projects and will generally sub-contract to drilling service/supply companies.

Project Design and Construction Management: This sector of industry refers to those companies involved in designing and/or building end-use facilities, either for electric production or direct use. This category is primarily a service sector, where the contractor is hired to manage the project from the design through the construction phase. These companies will often be responsible for subcontracting various power plant components and work.

Turbo-Generator Manufacturers: This category encompasses those companies that supply turbines or turbine generator sets for geothermal applications. This sector includes companies that build large turbines for power plants over 100 MW, down to those companies who produce small (< 1 MW), modular systems.

Other Component Manufacturers/ Suppliers: This is the sector of industry that supplies generic materials, such as valves, pipes, and controls. Most of these components are non-geothermal specific. Companies in this category will generally be contracted by the firm managing the construction.

Exhibit 3.1 illustrates the levels of geothermal development and the sectors of industry that primarily operate in each phase.

3.2 Historic U.S. International Market Penetration

3.2.1 Methodology

To characterize the U.S. geothermal industry's technological capabilities in the foreign market, it is necessary to determine the involvement of the industry, as well as the key foreign competition, in past and present overseas geothermal projects. A matrix was developed defining the countries with high geothermal potential, versus the nationalities of companies and consultants who have worked within six of seven sectors of the geothermal industry in these countries (Exhibit 3.2). The matrix is a result of information on international projects, both foreign and domestic, and available literature describing world geothermal projects. (Data on the sources of miscellaneous power plant equipment, corresponding to the industry sector "Other component manufacturers/suppliers," were almost totally unavailable. Therefore, this sector is not presented in the matrices.) Based on the available data, Italy, France, New Zealand, the U.S., and Japan were determined to be the primary exporters of geothermal technology.

The matrix is divided into sectors of the geothermal industry, then sub-divided by the five primary geothermal technology exporting countries. The matrix also includes a column labeled "Other" to account for any significant contribution by companies from other than the five major countries, and a column labeled "Domestic" to account for work performed by companies based within the importing country. Subsidiaries were considered to be of the nationality of their parent company. (For example, Union Geothermal of the Philippines was classified as a U.S. company.) The entries in the matrix have been assigned scores from 1 to 5, signifying the following estimated values of work:

1 - Companies or individual consultants from the exporting country have conducted brief, scoping studies. These studies gen-

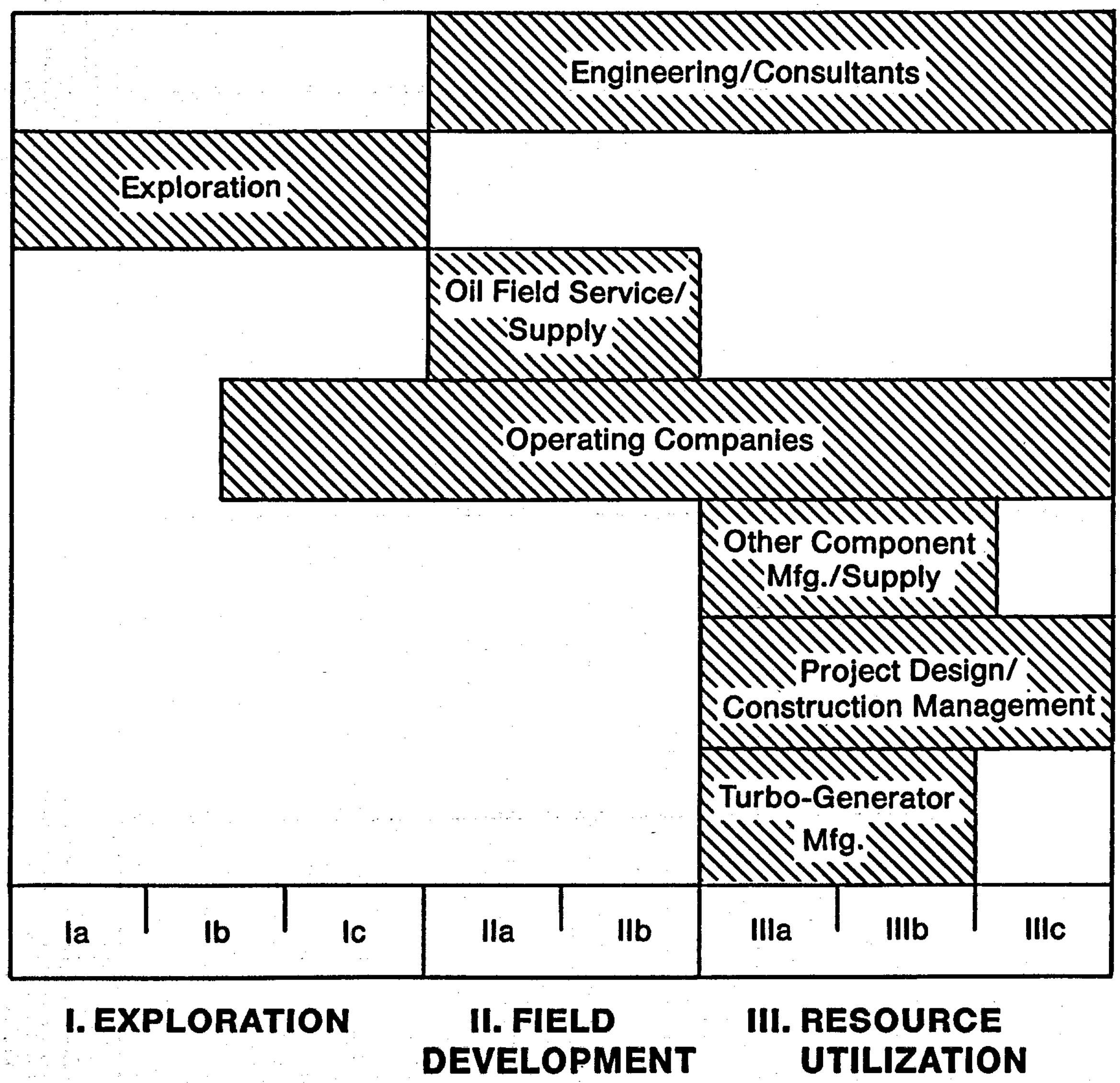

Exhibit 3.1: U.S. Industry Sectors Operating within Each Level of Geothermal Development

NAME OF COUNTRY	EXPLORATION COMPANIES U.S.	JAPAN	FRANCE	N.Z.	ITALY	DOMES.	OTHER	OILFIELD SERVICE AND SUPPLY COMPANIES U.S.	JAPAN	FRANCE	N.Z.	ITALY	DOMES.	OTHER
ALGERIA			3			2	GER.-P	(P				P	P	)
ARGENTINA	2		P			3		P				P	P	BEL.-P
ASCENSION ISLAND	4													
AZORES	3	2		3		4		1					4	
BHUTAN								(						)
BOLIVIA	P				5	2		P				4	1	
BRAZIL	P					2		(P					P	GER.-P)
BURMA						1		(						)
BURUNDI						1		(						)
CAMEROON			P			P		(P		P				)
CAPE VERDE							SWE-1	(						)
CHAD								(P						)
CHILE		1		1	1	3		P					P	
CHINA	2	2	2		4	5		2	1	1		5	5	ROM-4
COLOMBIA	P	2	P		3	3		(P		P			P	)
COSTA RICA	5					4		4						
DJIBOUTI			3	3	3						3			
DOMINICA			2	1				(						)
DOMINICAN REPUBLIC	1					1	CLADE-2	(					P	)
ECUADOR	2		2			3	CLADE-2	(P					P	)
EGYPT	2		P		P	3	GER-P	(P	P	P		P	P	GREECE-P)
EL SALVADOR					2	5	GER,GB-2	5		5				
ETHIOPIA	2			2	3	2							1	GB-4
FIJI	2			3		3	GB-2	(			P			)
GREECE			2		4	5		P						IRNO-3
GRENADA								(						)
GUATEMALA	1	2			2	4	CLADE-2	P		P				P
HAITI						2	CLADE-3	(						)
HONDURAS	2				4	2								
INDIA	1					4		P				P	P	GB-P
INDONESIA	3	2	2	4	3	4	CA,ICE-1	P	P	P	5		5	GB-P
JORDAN	1		1		1			(						)
KENYA	2					5		5		3			5	
KOREA, SOUTH	2					1		(P						)
MADAGASCAR								(P						)
MALAWI								(						)
MALAYSIA	P							(P					P	GER-P)
MEXICO	3					5		P					5	
MOROCCO						P		(						)
MOZAMBIQUE								(						)
NEPAL						1		(						)
NICARAGUA	4				3	3				3			3	
NIGERIA	2					3		(P		P		P		)
PANAMA	1		2			3	EL.S-1	(						)
PAPUA NEW GUINEA								(P						)
PERU	2	1			3	3		(P					P	)
PHILIPPINES	3	3		3		4	CAN-P	5			5		P	GER-P
PUERTO RICO								(						)
RWANDA								(						)
ST. CHRISTOPHER AN								(						)
ST. LUCIA	4				2		GB-3							
ST. VINCENT AND TH							GB-1	(						)
SAMOA, WESTERN								(						)
SAUDI ARABIA	P					2		(P					P	)
SOLOMON ISLANDS								(						)
SOMALI REPUBLIC						1		(P						)
SUDAN	P					1		(P		P				)
TAIWAN						3		P						
TANZANIA					P	1	SWE,ICE-2	(P						GER-P)
THAILAND	1	3	1			3		2		P				GER-P
TUNISIA			P		P	2		(P		P		P		)
TURKEY						4		P						GB-P
UGANDA								(						)
VANUATU	1		2	1			GB-2	(						)
VENEZUELA	P				1	3	CLADE-1	(P					P	)
VIETNAM	1					2		(					P	)
YEMEN, NORTH	2		1		2	3	GER-1							
YEMEN, SOUTH					P			(						)
YUGOSLAVIA	2					2		(P					3	)
ZAIRE								(						GER-P)
ZIMBABWE						2		(						)

NAME OF COUNTRY	ENGINEERING/CONSULTING SERVICES U.S	JAPAN	FRANCE	N.Z.	ITALY	DOMES.	OTHER	OPERATING COMPANIES U.S	N.Z.	DOMES.
ALGERIA	(P		P			P	GB.-P)	(		)
ARGENTINA			P			P				
ASCENSION ISLAND	3							(		)
AZORES	3		2	1	2	4				
BHUTAN	(						)	(		)
BOLIVIA					5	P				
BRAZIL	(P					P	)	(		)
BURMA	(						)	(		)
BURUNDI	(						)	(		)
CAMEROON	(						)	(		)
CAPE VERDE	(						)	(		)
CHAD	(						)	(		)
CHILE				1	3		GB.-2			
CHINA	1	1	P	1	4	1	ICE-1			5
COLOMBIA	(					P	)	(		)
COSTA RICA	5			2	5	3				
DJIBOUTI		3		3	3					
DOMINICA	(						)	(		)
DOMINICAN REPUBLIC	(					P	)	(		)
ECUADOR	(					P	)	(		)
EGYPT	(		P			P	)	(		)
EL SALVADOR	2			2	5	3	GB-2			
ETHIOPIA				3		1			3	
FIJI	(			1			)	(	P	)
GREECE				3	4	3				
GRENADA	(						)	(		)
GUATEMALA										
HAITI	(						)	(		)
HONDURAS										
INDIA				1						
INDONESIA	P			5		5		5	4	5
JORDAN	(						)	(		)
KENYA	1			5		1	ICE,SWE,GB-2		5	
KOREA, SOUTH	(						)	(		)
MADAGASCAR	(						)	(		)
MALAWI	(						)	(		)
MALAYSIA	(						)	(		)
MEXICO						P				5
MOROCCO	(						)	(		)
MOZAMBIQUE	(						)	(		)
NEPAL	(						)	(		)
NICARAGUA	4		4	1	4					
NIGERIA	(						)	(		)
PANAMA	(P						)	(		)
PAPUA NEW GUINEA	(					P	)	(		)
PERU	(			1			)	(		)
PHILIPPINES		3		5	2	2	NOR-P	5		5
PUERTO RICO	(						)	(		)
RWANDA	(						)	(		)
ST. CHRISTOPHER AN	(						)	(		)
ST. LUCIA				1						
ST. VINCENT AND TH	(						)	(		)
SAMOA, WESTERN	(						)	(		)
SAUDI ARABIA	(						NOR-P)	(		)
SOLOMON ISLANDS	(						)	(		)
SOMALI REPUBLIC	(						)	(		)
SUDAN	(						NOR-P)	(		)
TAIWAN	2					P				3
TANZANIA	(						CAN-P)	(		)
THAILAND										
TUNISIA	(						)	(		)
TURKEY						1		2		3
UGANDA	(						)	(		)
VANUATU	(			1			)	(		)
VENEZUELA	(					P	GB-P)	(		P)
VIETNAM	(						)	(		)
YEMEN, NORTH										
YEMEN, SOUTH	(						)	(		)
YUGOSLAVIA	(			2			)	(		)
ZAIRE	(						)	(		)
ZIMBABWE	(						)	(		)

NAME OF COUNTRY	PROJECT DESIGN AND CONSTRUCTION MANAGEMENT U.S	JAPAN	FRANCE	N.Z.	ITALY	DOMES.	OTHER	TURBO-GENERATOR MANUFACTURERS U.S	JAPAN	ITALY	DOMES.	OTHER
ALGERIA	(	P	P		P	P	GB.-P)	(				)
ARGENTINA	(P	P			P	P	GB.-P)	(		P		)
ASCENSION ISLAND	(						)	(				)
AZORES	3							4	4			
BHUTAN	(						)	(				)
BOLIVIA	(						)	(				)
BRAZIL	(P	P	P		P	P	GB.-P)	(		P		)
BURMA	(						)	(				)
BURUNDI	(						)	(				)
CAMEROON	(						)	(				)
CAPE VERDE	(						)	(				)
CHAD	(						)	(				)
CHILE	(P	P					GB-P)	(				)
CHINA			P			5					4	
COLOMBIA	(P	P	P		P		GB-P)	(		P		)
COSTA RICA	(				P	P	)	(	1	P		)
DJIBOUTI	(						)	(				)
DOMINICA	(						)	(				)
DOMINICAN REPUBLIC	(						)	(				)
ECUADOR	(	P				P	)	(				)
EGYPT	(P					P	)	(				)
EL SALVADOR		P			5	5	GB-3		5			
ETHIOPIA	(	P					)	(				)
FIJI	(			P			)	(				)
GREECE					P	P			3			
GRENADA	(						)	(				)
GUATEMALA	(	P					)	(				)
HAITI	(						)	(				)
HONDURAS	(						)	(				)
INDIA		P	P		P	1	GER,GB-P			P		
INDONESIA	1	2	P	5	P	P		3	5	P		
JORDAN	(	P				P	GR-P)	(	P			)
KENYA		P							5			
KOREA, SOUTH	(P	P				P	)	(				)
MADAGASCAR	(						)	(				)
MALAWI	(						)	(				)
MALAYSIA	(P	P	P			P	)	(				)
MEXICO	3	P			P	5	GB-P	3	5	P		ISR-2
MOROCCO	(P						)	(				)
MOZAMBIQUE	(						PORT-P)	(				)
NEPAL	(						)	(				)
NICARAGUA					3							
NIGERIA	(	P			P		)	(		P		)
PANAMA	(	P					)	(				)
PAPUA NEW GUINEA	(						AUS-P)	(				)
PERU	(P	P					)	(				)
PHILIPPINES	2	3				P			5			
PUERTO RICO	(					P	)	(				)
RWANDA	(						)	(				)
ST. CHRISTOPHER AN	(						)	(				)
ST. LUCIA	(						)	(				)
ST. VINCENT AND TH	(						)	(				)
SAMOA, WESTERN	(						)	(				)
SAUDI ARABIA	(P				P	P	)	(		P		)
SOLOMON ISLANDS	(						)	(				)
SOMALI REPUBLIC	(						)	(				)
SUDAN	(						KUN-P)	(				)
TAIWAN	P	P										
TANZANIA	(						)	(				)
THAILAND	(	P					)	(				)
TUNISIA	(						)	(				)
TURKEY	P	P			4					4	2	
UGANDA	(						)	(				)
VANUATU	(						)	(				)
VENEZUELA	(P	P	P		P	P	GB-P)	(	P	P		)
VIETNAM	(						)	(				)
YEMEN, NORTH	(						)	(				)
YEMEN, SOUTH	(						)	(				)
YUGOSLAVIA	(	P					)	(				)
ZAIRE	(						)	(				)
ZIMBABWE	(						)	(				)

NOTES: Countries not shown if no information on industry presence was available. Parenthesis indicate that a country/area has not yet reached the point where it requires that sector of industry.

"P" indicates that companies with geothermal experience have an office or representative in-country, although no local geothermal work has been done.

KEY: Value of Work

Value	Turbo-Generator Manufacturing	All Other Sectors
1	Brief Visit	Brief Visit
2	< $1 million	< $100,000
3	< $5 million	< $500,000
4	< $10 million	< $1,000,000
5	> $10 million	> $1,000,000

Exhibit 3.2: Historical Penetration of Geothermal Technology Exporters in the International Market

erally include a brief visit to the areas of interest in the country and preparation of a brief report or travel log.

2 - Companies or individuals have conducted small studies, or very specific portions of larger studies. The estimated value of the work performed is less than $100,000 (or $1,000,000 for turbo-generator manufacturers).

3 - Companies or individuals have conducted in-depth studies, or supplied goods and services whose estimated value exceeds $100,000, but is less than $500,000 (between $1,000,000 and $5,000,000 for turbo-generator manufacturers).

4 - The estimated value of supplied goods and services is between $500,000 and $1,000,000 (or $5,000,000 and $10,000,000 for turbo-generator manufacturers).

5 - Companies or individuals from the country have had extensive involvement in large projects. Where estimable, the value of the services/goods exceeds $1,000,000 (or $10,000,000 for turbo-generator manufacturers).

The values assigned to the countries are cumulative, covering all the different projects in which the given country may have been involved. Exhibit 3.2 does not include countries for which project source country information is not available.

As would be expected, the exact value of the goods or services provided by a particular company, on a given project, is seldom published. In cases where no figures were available, the approximate value of the work was estimated, based on the scope of the work performed or goods provided. The entries are sufficiently accurate and complete to provide an approximate profile of the activities of various countries in the international geothermal market.

3.2.2 Comparison of Market Penetration by Country

Exhibit 3.3 summarizes the data from Exhibit 3.2, to define the number of countries in which work was performed for each sector of the geothermal industry and for each major geothermal exporter. These figures provide a comparison of market penetration indicators, and the relative strength of each country's industry within each sector.

The market penetration of the five major exporters of geothermal technology, can be ranked in each of the six industry sectors considered, based on the number of countries in which work has been performed. These rankings are as follows:

Exploration: The U.S. has a commanding lead (21 countries), followed by Italy (14), and then France, Japan, and New Zealand, (9, 7, and 6 respectively). Several other countries have performed international work in this sector, although to a lesser extent.

Oilfield Service/Supply: The U.S. leads (7), undoubtedly due to the widespread nature of the U.S. oil industry. However, the other countries also have some representation in this sector. France has performed work in 3 countries; New Zealand,(3); and Italy,(2). Other countries that have performed work in this sector include Great Britain and Hungary.

Engineering/Consulting Services: Italy and New Zealand, with work performed in 10 and 9 countries respectively, have the lead in this category, primarily due to the government-owned Italian companies

GEOTHERMAL EXPORTING COUNTRY

INDUSTRY SECTOR	U.S.	JAPAN	FRANCE	N.Z.	ITALY
Exploration	21/8	7/2	9/3	6/3	14/3
Oilfield Service/ Supply	6/1	0/1	3/1	3/0	2/0
Engineering/ Consulting	6/2	2/1	2/0	9/9	10/0
Operating Companies	3/0	-	-	3/0	-
Project Design/ Construction	3/1	2/0	-	1/0	3/0
Turbo-Generator Manufacturers	3/0	7/1	-	-	1/0

Numerator: Number of countries in which the sector is represented excluding levels of "1"

Denominator: Number of countries in which the sector is represented including levels of "1"

Exhibit 3.3: Summary of Market Penetration Figures for Key Geothermal Exporting Countries

and Geothermal Energy of New Zealand (GENZL). Italy and the U.S. (10 and 8 respectively) follow, with France and Japan at the bottom.

Operating Companies: Only the U.S. (3) and New Zealand (4) are represented. The U.S. company being Unocal and the New Zealand company is once again GENZL. Both Unocal and GENZL are companies that combine exploration and engineering/consulting on particular projects.

Project Design/Construction Management: The information available does not present a clear superiority for any of the major exporters. It does, however, point out that France is absent in this particular sector.

Turbo-Generator Manufacturers: Japan has the clear lead (8), followed by the U.S. (3), and Italy (1).

3.3 Future U.S. International Market Penetration

Geothermal industries of the various countries that export by technology sector, can be characterized by the above data, with respect to one another. The data also reveal the historical competition for business in the developing countries where work might be performed (Exhibit 3.2). To predict the future competition for U.S. geothermal industry in countries where geothermal work is not yet in progress, company literature and various petroleum industry directories were used to locate offices and subsidiaries of geothermal-related companies of various nationalities within potential market countries or regions. These office and subsidiary locations are indicated in Exhibit 3.2. A "P" is used to indicate the presence of companies in a particular industry sector in cases where there is no indication that they have conducted any work. Collectively, the data in Exhibit 3.2 are useful in gauging the competition in a particular country, because they reveal who has already worked on geothermal projects in the country, and also, the nations well positioned for future work.

Chapter 4: Potential Markets for U.S. Geothermal Export Development

Companies attempting to market their geothermal products or expertise abroad will primarily be interested in areas, regions, or countries where the level of geothermal development is appropriate for the services they can best provide. Based on the classifications of the geothermal industry and the levels of development in each area, the study countries have been aggregated within five categories of geothermal technology requirements to identify target countries and fields that may be of interest to a given company. These represent the type of work required for the next step of development for each country or field:

- o nation-wide assessment (corresponds to level 0 from Chapter 2);
- o preliminary site studies (levels Ia and Ib);
- o detailed geophysics (level Ic);
- o exploratory drilling (level IIa); and
- o development (levels IIb, IIIa, IIIb, and IIIc).

Charts are presented in the following sections, that summarize the resource data, information on geothermal competitor countries, and energy and economic information for each country within the five categories. It should be noted that countries with several geothermal fields may appear in more than one category, describing the corresponding levels of development of the particular fields.

The energy, economic, and debt summaries presented below are based on the statistical data included in Appendix C. Where published data were unavailable, descriptive summaries were compiled from information in the U.S. Department of State's "Background Notes" and The World Factbook (1985). Exhibit 4.1 presents a matrix summarizing the opportunities for U.S. geothermal industry within each country by category of technology required. It can be used as a quick reference to determine the opportunities in one or more specific countries, or, alternatively, to determine all countries requiring a particular level of work.

4.1 Countries Requiring Nationwide Resource Assessments

The descriptions presented in Exhibit 4.2 are countries or geographic regions, determined to be in need of a nationwide geothermal assessment (Category 1). Of those countries, only Burma has been identified as having resources estimated to be greater than 90°C. Other countries such as Bhutan, Brazil and Malaysia are estimated as having resources possibly greater than 90°C. For other countries, such as Burundi, Cameroon, and Chad, no information was available regarding resource characteristics. None of the countries under this category have had a comprehensive study directed at assessing geothermal resource potential.

4.2 Countries and Regions Requiring Preliminary Geological/Geophysical Surveys

The descriptions presented in Exhibit 4.3 are countries and regions in need of preliminary geological/geophysical surveys (Category 2), and where relatively comprehensive, nationwide assessments have already been conducted to identify potential geothermal fields. All of these fields have not yet undergone detailed site studies. Some of these

Country	1	2	3	4	5
Algeria		●			
Argentina		●		●	
Ascension Island			●		
Azores		●	●		●
Bhutan	●				
Bolivia		●	●		
Brazil	●				
Burma	●				
Burundi	●				
Cameroon	●				
Cape Verde		●			
Chad	●				
Chile		●		●	●
China		●	●		●
Columbia		●	●		
Costa Rica		●			●
Djibouti		●	●	●	●
Dominica			●		
Dominican Republic		●			
Ecuador		●	●		
Egypt		●			
El Salvador		●	●	●	●
Ethiopia		●			●
Fiji		●			
Greece		●		●	●
Grenada		●			
Guatemala		●	●	●	●
Haiti		●			
Honduras		●			
India		●	●		
Indonesia		●	●	●	●
Jordan			●		
Kenya		●	●		●
Korea, South		●			
Madagascar		●			
Malawi	●				
Malaysia	●				
Mexico		●	●	●	●
Morocco		●			
Mozambique	●				
Nepal	●				
Nicaragua		●	●		●
Nigeria		●			
Panama		●	●		
Papua New Guinea		●			
Peru		●			
Philippines		●		●	●
Puerto Rico	●				
Rwanda	●				
St. Christopher and Nevis	●				
St. Lucia		●	●		
St. Vincent and the Grenadines	●				
Samoa	●				
Saudi Arabia		●			
Solomon Islands	●				
Somalia	●				
Sudan	●				
Taiwan		●		●	●
Tanzania		●			
Thailand		●	●	●	
Tunisia		●			
Turkey		●	●	●	●
Uganda		●	●		
Vanuatu		●			
Venezuela		●			
Vietnam		●			
Yemen, North				●	
Yemen, South		●			
Yugoslavia		●			
Zaire	●				
Zimbabwe	●				

KEY TECHNOLOGY REQUIREMENTS

1 - Nationwide Assessment Needed

2 - Preliminary Geological/Geophysical Surveys Needed

3 - Fields Possibly Ready for Deep Exploratory Drilling

4 - Explored Fields Possibly Ready for Production Drilling

5 - Proven Fields Undergoing Production Drilling, Plant Construction or Operation

Exhibit 4.1: OPPORTUNITIES FOR U.S. GEOTHERMAL INDUSTRY BY LEVEL OF WORK REQUIRED

EXHIBIT 4.2: Countries Requiring Nationwide Resource Assessments (Category 1)

BHUTAN

- Geothermal Status: No comprehensive studies performed to date; geologic setting indicate that potential economic geothermal resources may be present.
- Foreign Geothermal Involvement: None.
- Energy Situation: Substantial undeveloped hydropower resources.
- Economic and Demographic Situation: Extremely low per capita GDP.
- International Debt Situation: Insufficient/inadequate data. Heavily dependent on foreign aid (primary from India).

BRAZIL

- Geothermal Status: Preliminary assessment completed in 1981; comprehensive nationwide assessment needed; no high-temperature areas have been identified; low- to moderate-temperature resources might be developable from deep aquifers in the Parana Basin.
- Foreign Geothermal Involvement: None known.
- Energy Situation: Net energy importer; substantial energy import burden amounting to 56% of total exports. Substantial hydropower potential. Moderate oil reserves, low gas reserves. High per capita consumption of energy.
- Economic and Demographic Situation: Moderate population growth rate, high GDP per capita; good average annual GDP growth rate; moderate average annual investment growth.
- International Debt Situation: External public debt amounts to almost a third GNP. Debt servicing ratios are moderate, but Brazil has recently obtained two debt reschedulings (1983) and (1984) that indicate a certain amount of debt servicing difficulties.

BURMA

- Geothermal Status: No nationwide assessments performed to date; numerous thermal springs with surface temperature up to 90°C occur near to border with Thailand.
- Foreign Geothermal Involvement: None.
- Energy Situation: Presently a marginal exporter of energy; some oil and gas reserves; low per capita energy consumption.
- Economic and Demographic Situation: Burma is experiencing a moderate annual population growth rate; its GDP per capita is among the lowest in the world, but its average annual growth rate is relatively high, around 6%. Good investment climate. Adequate international reserves.
- International Debt Situation: External public debt amount to over a third of GNP. Debt servicing ratios are moderately high: 2.4% of GNP and 33.8% of exports, and indicate a low debt service ability.

BURUNDI

- Geothermal Status: No comprehensive resource assessments to date; country is located within a technically active region; resource potential is considered to be good.
- Foreign Geothermal Involvement: None.
- Energy Situation: Energy importer in general, and oil importer in particular. Very substantial hydropower potential.
- Economic and Demographic Situation: Relatively high average annual population growth rate; low per capita income. Economic growth, as measured by GDP average annual growth rate, is moderate. However, substantial investment growth was recorded between 1973 and 1983 (15.7%).
- International Debt Situation: External public debt amounts to over a quarter of the country's GNP; debt servicing data are incomplete.

CAMEROON

- Geothermal Status: No known comprehensive geothermal assessment to date; evidence of tertiary period volcanism and other geologic features indicate potential for resources to be present.
- Foreign Geothermal Involvement: None.
- Energy Situation: Energy production growth rate has been very rapid between (1973-1983). Currently a net energy exporter. Excellent hydropower potential, very moderate per capita energy consumption. Adequate oil and gas reserves.
- Economic and Demographic Situation: High population growth rate; moderate GDP per capita; good economic growth and high average annual investment growth rate (10.6%).
- International Debt Situation: External public debt over a quarter of GNP. Debt servicing ratios have increased rapidly over the past decade, but remain moderate relative to other countries (3.1% of GNP and 13.9% of exports). Low international reserves.

EXHIBIT 4.2: (Continued)

CHAD

- Geothermal Status: No comprehensive assessment performed to date; the country is situated in a region of active volcanism and may posses potential for discovering geothermal resources.
- Foreign Geothermal Involvement: None.
- Energy Situation: Among the lowest per capita energy consumption in the world. Lack of domestic commercial conventional energy reserves (hydropower, oil, gas, or coal).
- Economic and Demographic Situation: Relatively high average annual population growth rate; lowest GDP per capita in the world; economic growth as indicated by a GDP average annual growth rate of -5.8% is severely impeded.
- International Debt Situation: External public debt is a substantial burden on the economy as it accounts for 43% of GNP. However, debt servicing ratios are almost insignificant, .1% of GNP and .6% of exports; low international reserves.

MALAWI

- Geothermal Status: No comprehensive studies have been performed to date.
- Foreign Geothermal Involvement: None.
- Energy Situation: Energy importer, very low per capita energy consumption. Moderate hydropower potential.
- Economic and Demographic Situation: High population growth rate; good economic growth rate; very low GDP per capita. No data available on investment climate. Balance of payments deficit; low international reserves.
- International Debt Situation: External debt is 38.5% of GNP, debt servicing ratios are relatively high. Three debt reschedulings indicate a deterioration in the debt situation.

MALAYSIA

- Geothermal Status: Country is located with a technically active region. No comprehensive studies have been performed.
- Foreign Geothermal Involvement: None.
- Energy Situation: Oil exporter. Exceptional hydropower potential; very high oil and gas reserves.
- Economic and Demographic Situation: Moderate population growth rate; very high GDP per capita; very high economic growth rate and good investment growth rate. Trade surplus; adequate international reserves.
- International Debt Situation: External public debt amounts to 38.6% of GNP. Debt servicing ratios are relatively low.

MOZAMBIQUE

- Geothermal Status: No comprehensive investigations to date.
- Foreign Geothermal Involvement: None.
- Energy Situation: Oil importer, promising hydropower potential; very low per capita energy consumption.
- Economic and Demographic Situation: Very low per capita GDP; high population growth rate.
- International Debt Situation: No data available.

NEPAL

- Geothermal Status: Although thermal spring areas have been reported in the literature, no exploration is known to have been performed.
- Foreign Geothermal Involvement: No information available.
- Energy Situation: Oil importer; extremely low per capita energy consumption; excellent hydropower potential.
- Economic and Demographic Situation: Moderate population growth rate and economic growth rate; low GDP per capita. Moderate international reserves; large trade deficit.
- International Debt Situation: External public debt is 14.% of GNP; debt servicing ratios are low.

PUERTO RICO

- Geothermal Status: No comprehensive assessment has been performed. A few thermal springs exist in the southern part of the island.
- Foreign Geothermal Involvement: None.
- Energy Situation: Small amount of hydropower. Imports almost all of commercial energy needs.
- Economic and Demographic Situation: The Commonwealth of Puerto Rico is a territory of the United States.
- International Debt Situation: Not applicable.

EXHIBIT 4.2: (Continued)

RWANDA

- Geothermal Status: No comprehensive investigations have been performed. Geologic setting is somewhat favorable for the occurrence of hydrothermal resources.
- Foreign Geothermal Involvement: None.
- Energy Situation: Oil importer; very low per capita energy consumption; excellent hydropower potential.
- Economic and Demographic Situation: Very high population growth rate; low per capita income; high economic growth. Large trade deficit; adequate international reserves.
- International Debt Situation: External public debt is 13.9% of GNP. Debt servicing ratios are low indicating a good debt service ability.

ST. CHRISTOPHER AND NEVIS

- Geothermal Status: No comprehensive studies performed to date. The island is located in a favorable are (Lesser Antilles volcanic arc) and reportedly has springs and fumaroles exceeding 90°C.
- Foreign Geothermal Involvement: None.
- Energy Situation: Insufficient data.
- Economic and Demographic Situation: Moderate per capita income; insufficient data.
- International Debt Situation: Insufficient data.

ST. VINCENT AND THE GRENADINES

- Geothermal Status: As yet, no comprehensive assessment has been performed on the island of St. Vincent. The island is located in the southern Lesser Antilles (volcanic arc) and reportedly has springs and fumaroles exceeding 90°C.
- Foreign Geothermal Involvement: None.
- Energy Situation: Insufficient data.
- Economic and Demographic Situation: Moderate per capita income, insufficient data.
- International Debt Situation: Insufficient data.

SAMOA, WESTERN

- Geothermal Status: No comprehensive studies have taken place. The island is within an area of active volcanism, indicating potential for the existence of hydrothermal convection systems.
- Foreign Geothermal Involvement: None
- Energy Situation: Economy primary agricultural, very serious problems with balance of payments.
- Economic and Demographic Situation: Economy primary agricultural, very serious problems with balance of payments.
- International Debt Situation: Insufficient unavailable/data.

SOLOMON ISLANDS

- Geothermal Status: No comprehensive investigations are known to have taken place. Islands are located along tectonic plate margin near an active spreading zone. Thermal springs reported to have temperatures of up to 90°C.
- Foreign Geothermal Involvement: None.
- Energy Situation: Oil importer.
- Economic and Demographic Situation: Economy primary agricultural, low per capita GDP.
- International Debt Situation: Insufficient data.

SOMALIA

- Geothermal Status: No comprehensive investigations have been made. Geologic setting is favorable for the occurrence of moderate- to high-temperature hydrothermal resources.
- Foreign Geothermal Involvement: None.
- Energy Situation: Imports most or all commercial energy; some undeveloped hydropower reserves may exist.
- Economic and Demographic Situation: High population growth; low per capita GDP; moderate economic growth; very sluggish investment climate with investment growth rate negative (-8.2%).
- International Debt Situation: External public debt amounts to 62% of GNP. Moderate debt servicing ratios, large trade deficit low international reserves.

SUDAN

- Geothermal Status: No comprehensive investigations have been performed. The only promising geothermal prospect is at Jebel Marra. Other areas are considered to possess only limited potential for developing geothermal resources.
- Foreign Geothermal Involvement: None known.
- Energy Situation: Substantial developed and undeveloped hydropower resources. Currently an oil importer, but known and estimated domestic oil reserve may satisfy the country's needs by the 1990's. Energy imports constitute 57% of total foreign exchange earnings.
- Economic and Demographic Situation: High population growth; low per capita income; high economic growth as indicated by GDP growth rate; moderate investment growth rate. Large trade deficit; very low international reserves.
- International Debt Situation: External public debt is 77.8% of GNP; and debt servicing ratios are moderate, but the country experienced serious debt servicing difficulties that required restructuring through five debt reschedulings.

ZAIRE

- Geothermal Status: No comprehensive investigations to date. The country is situated within a tectonically stable region although some hot springs have been reported with surface temperatures of up to 60°C.
- Foreign Geothermal Involvement: None.
- Energy Situation: Net energy exporter, exceptional hydropower potential, some oil reserves, marginal gas reserves.
- Economic and Demographic Situation: High population growth rate, low per capita income, sluggish economy, good investment growth rate.
- International Debt Situation: External debt amounts to 91.5% of GNP; the country's debt servicing difficulties are reflected by six loan reschedulings. Trade balance surplus; good international reserves.

ZIMBABWE

- Geothermal Status: No comprehensive studies performed to date. Region is predominantly faulted metamorphic terrain with 32 identified thermal springs that have surface temperatures ranging to more than 90°C.
- Foreign Geothermal Involvement: None.
- Energy Situation: Moderate per capita energy consumption; plentiful coal resources and good hydropower potential; currently imports some electricity and all of its petroleum.
- Economic and Demographic Situation: Very high population growth rate; moderate per capita income; low economic and investment growth ate.
- International Debt Situation: External debt is 15.7% of GNP; debt servicing ratios are very high; trade balance deficit; low international reserves.

EXHIBIT 4.3: Countries and Regions Requiring Preliminary Geological/Geophysical Surveys (Category 2)

ALGERIA

- Geothermal Status: Preliminary regional assessments performed in late 1960's; uses to date are limited to balneological. The northwest coast along the Mediterranean Sea is a prospectively valuable region.
- Foreign Geothermal Involvement: French assistance in early studies. Recent scientific and technical cooperation agreement with the French Energy Control Agency for R&D in renewable energy.
- Energy Situation: Oil exporter, substantial oil and gas reserves.
- Economic and Demographic Situation: High population growth rate; high GDP per capita ($2.291); medium annual investment growth rate (7.2%); high average annual GDP growth rate.
- International Debt Situation: External public debt amounts to 28% of GNP. Debt servicing ratios are moderate: 9.8% of GNP and 33% of exports; moderate international reserves.

ARGENTINA

- Geothermal Status: Fields have been identified at Copahue in the Patagonian region (Neuquen) and at Jujuy near the Bolivian border; exploratory drilling reportedly successful at Copahue.
- Foreign Geothermal Involvement: Some U.S. industry presence in exploration projects.
- Energy Situation: Oil importer; energy imports amount to 9% of total exports; moderate hydropower potential; good oil and gas reserves; moderate coal reserves.
- Economic and Demographic Situation: Moderate population growth rate; relatively high: 3.1% of GNP and 26% of exports; low international reserves. Two recent debt reschedulings.

AZORES

- Geothermal Status: 3 MWe power plant on-line at Pico Vermelho with plans to add another 10 MW. Pico Alto, also on the main island of San Miguel, is a good possibility ready for exploratory drilling. The islands of Terceira and Fayal are prospective areas in need of detailed exploration.
- Foreign Geothermal Involvement: In exploration substantial work has been performed by companies and individuals from Portugal, the U.S., New Zealand, and to a lesser extent, Japan.
- Energy Situation: The Azores have virtually no domestic resources of commercial conventional energy.
- Economic and Demographic Situation: The Azores is an autonomous regional district of Portugal. No separate information on the Azorean economy is available.
- International Debt Situation: No information available.

BOLIVIA

- Geothermal Status: Nationwide geothermal assessment initiated in 1976; most promising resource area are located in the southwest; notable resources have been located within the Empexa River Valley and at Sol de Manana. Five other possible fields have been identified.
- Foreign Geothermal Involvement: Extensive assistance by the Italian government and Italian companies in the regional exploration efforts.
- Energy Situation: Net energy exporter; excellent hydropower potential; adequate reserves of oil and gas; low commercial energy consumption per capita.
- Economic and Demographic Situation: High population growth rate; GDP per capita ($556); low average annual GDP growth rate; very poor average annual investment growth rate (-11.4%).
- International Debt Situation: International public debt is a substantial proportion of GNP (77.7%). Debt service ratios are high, they amount to 7% of GNP and 30.5% of exports. Two debt reschedulings (1981) and (1984). Adequate international reserves.

CAPE VERDE

- Geothermal Status: Potential high-temperature hydrothermal system has been indicated, by preliminary reconnaissance, to be located with in the Fogo Caldera.
- Foreign Geothermal Involvement: Moderate degree of involvement by Sweden (Lund University) in the form of a preliminary reconnaissance study.
- Energy Situation: Energy deficient; highly reliant on oil imports.
- Economic and Demographic Situation: No data available on GDP or population growth rate; low GDP per capita.
- International Debt Situation: No data available.

CHILE

- Geothermal Status: Nationwide resource assessment performed beginning in 1968; most promising resource areas are in northern Chile at El Tatio and Puchuldiza where exploratory and/or production drilling has occurred. Nineteen other potential geothermal fields have been identified, including two, Surire and Pampa Lirima, where preliminary studies have been performed.
- Foreign Geothermal Involvement: Italy, New Zealand, and Japan have participated to a minor extent in the exploration of fields in Chile.
- Energy Situation: Oil importer, energy imports amount to almost a quarter of total exports. Moderate hydropower potential; good oil and coal reserves; moderate gas reserves. High energy consumption per capita.
- Economic and Demographic Situation: Low average annual population growth; economic growth as indicated by GDP is moderate; high per capita income. Poor average annual investment growth rate (-.3%). Good international reserves.
- International Debt Situation: External public debt amount to almost 40% of GNP. Debt servicing ratios are not very high: 5.1% of GNP and 18.3% of exports. Some debt servicing difficulties as indicated by the two debt rescheduling in 1975 and 1983.

CHINA

- Geothermal Status: About 3000 thermal areas identified; uses are mainly balneological; major development is at Yangbajing (high-temperature area) in Tibet where 6 MWe is installed; other notable areas are at Huitang (0.3 MWe), Tong'an (0.3 MWe), Zhaouyan (0.2 MWe), and Fuzhou. Forty potentially high-temperature fields identified in the region of Tibet.
- Foreign Geothermal Involvement: Major financial assistance from Italy, as well as the involvement of Italian companies in exploration. Lesser involvement in this phase by companies from the U.S., Japan, and France.
- Energy Situation: Net energy exporter; moderate energy consumption per capita; extensive domestic commercial conventional energy reserves, including hydropower, coal, oil, and natural gas.
- Economic and Demographic Situation: Low average annual population growth rate; good economic growth; low GDP per capita; moderate average annual investment growth rate. Good international reserves.
- International Debt Situation: No data available.

COLOMBIA

- Geothermal Status: Regional reconnaissance in the Massif Del Ruiz in 1968; detailed exploration of selected areas in the region began in 1978; detailed studies conducted at Machin Volcano and Chiles-Cerro Negro, seven other areas selected for further study including Nereidas, Lake Otyn, and Cerro Espana.
- Foreign Geothermal Involvement: Companies from Italy and Japan have assisted Colombia in its exploration efforts.
- Energy Situation: Commercial energy production slightly less than consumption. High per capita energy consumption; large hydropower potential; good oil gas, and coal reserves.
- Economic and Demographic Situation: Moderate average annual population growth rate; high per capita income; good economic growth rate and average annual investment growth rates. Adequate international reserves.
- International Debt Situation: External public debt amounts to 18.3% of GNP. Debt servicing ratios are 2.4% of GNP and 21.3% of total exports, hinting to a low debt service ability.

COSTA RICA

- Geothermal Status: Nationwide assessments began in 1959; numerous potential areas have been identified, most notably in the Guanacaste region. Production drilling underway at Miravalles, five other fields identified as potential high-enthalpy resource areas.
- Foreign Geothermal Involvement: Extensive U.S. involvement in exploration work.
- Energy Situation: Energy importer; high dependency on petroleum products. Energy imports amount to 22% of total exports. High per capita energy consumption. Rich hydropower potential.
- Economic and Demographic Situation: High average annual population growth rate; high per capita GDP; low economic growth rate; poor average annual investment growth rate.
- International Debt Situation: External public debt amounts to 126.3% of GNP. Debt servicing ratios emphasize the country's difficulties as they constitute 22.7% of GNP and 50.6% of total exports. Inadequate international reserves. Two debt reschedulings in 1983, indicating debt servicing difficulties.

DJIBOUTI

- Geothermal Status: Geothermal development underway at Asal, other explored areas include Gaggade and Hanle. The Abbe field has potential but needs detailed exploration work. Projected installed geothermal electric power capacity by 1990 is between 20 and 30 MWe.
- Foreign Geothermal Involvement: Prior to the independence of Djibouti in 1977, geothermal reconnaissance was carried out by French Bureau of Research, Geology and Mines. Recent major exploration work has been conducted by companies from Italy and New Zealand.
- Energy Situation: Virtually no domestic commercial conventional energy resources.
- Economic and Demographic Situation: Insufficient data available; moderately high GDP per capita.
- International Debt Situation: No data available.

DOMINICAN REPUBLIC

- Geothermal Status: Prefeasibility study underway at Los Yayas-Constanza. Three other potential areas identified. Resource areas are probably all low- to moderate- temperature systems.
- Foreign Geothermal Involvement: Some assistance by OLADE in exploration efforts.
- Energy Situation: Oil importer, heavy dependence on energy imports, which have reached 71% of total exports, some hydropower potential.
- Economic and Demographic Situation: Relatively high annual population growth rate; high per capita income; good economic growth; moderate average annual investment growth rate.
- International Debt Situation: External public debt amounts to 26.7% of GNP. Debt servicing ratios are moderate: 2.8% of GNP and 22.7% of total exports. One debt rescheduling in 1983. Low international reserves.

ECUADOR

- Geothermal Status: Nationwide assessment began in 1978. Area of greatest potential was shown to be the Tufino-Chiles area, a part of the Chiles-Cerro Negro binational (Columbia) field. A total of five other areas of prospective value have been identified, including Chalupas, Imbabura, Iguan Volcano, and Chalpatan Caldera.
- Foreign Geothermal Involvement: Some exploration work performed by companies or individuals from the U.S., France, and OLADE.
- Energy Situation: Oil exporter; moderate per capita energy consumption. Large hydropower potential. Abundant oil and gas reserves.
- Economic and Demographic Situation: High annual population growth rate; high per capita income; good economic growth; moderate average annual investment growth rate.
- International Debt Situation: External debt amounts 63% of GNP. Debt servicing ratios are significant. Marginal international reserves. The deterioration of debt indicators is reflected by four debt reschedulings since 1983.

EL SALVADOR

- Geothermal Status: Two single-flash steam units currently on-line at Ahuachapan. Detailed exploration has also taken place at Chinameca, Chipilapa, Berlin, and San Vicente. Four other fields have been identified as of possible interest and in need of initial site studies.
- Foreign Geothermal Involvement: Some assistance by Italian, British, and West German companies in exploration efforts.
- Energy Situation: Oil importer; high burden of energy imports as they constitute 57% of total exports. Some hydropower potential.
- Economic and Demographic Situation: High population growth rate; moderate GDP per capita; adequate international reserves. Positive balance of payments; negative investment growth rate.
- International Debt Situation: External public debt amounts to 29.2% of GNP. Debt servicing ratios are manageable: 1.8% of GNP and 6.4% of total exports, and suggest a good debt service ability.

EXHIBIT 4.3: (Continued)

ETHIOPIA

- Geothermal Status: Nationwide assessment performed in early 1970's. Nine prospective areas were identified, including three areas in the Lake District. Drilling has been performed at Lake Langano-Aluto area where 5 out of 8 wells drilled were reported successful. Other areas where exploration has been undertaken are Lake Abaya, a Corbetti Caldera, and at Tendaho in the Afar region. Five other fields have been identified as possible geothermal areas.
- Foreign Geothermal Involvement: Exploration to date conducted with the assistance of companies from Italy, New Zealand, and the U.S.
- Energy Situation: Imports almost all of commercial energy needs. One of the lowest per capita energy consumption in the world. Abundant undeveloped hydropower potential.
- Economic and Demographic Situation: Very high population growth rate; mediocre GDP per capita; low GDP growth rate; medium investment growth rate. Negative balance of payments with imports equal to double of exports; low international reserves.
- International Debt Situation: External public debt over a 1/4 of GNP. Debt servicing ratios are reasonable: 1.4% of GNP and 11.5% of total exports.

FIJI

- Geothermal Status: Hot springs and thermal anomalies identified on the island of Vanua Levu at Lambosg and Savusvu, and on Viti Levu Island. Reservoir temperatures may exceed 150°C.
- Foreign Geothermal Involvement: First assessment of geothermal potential carried out by New Zealand geological survey. Some presence of U.S. and British industry in exploration projects.
- Energy Situation: Imports most of commercial energy needs.
- Economic and Demographic Situation: Relatively high per capita GDP.
- International Debt Situation: No data available.

GREECE

- Geothermal Status: Regional exploration of the Aegean volcanic arc began in the 1970's. High-temperature resources were discovered on Milos where a 2 MWe demonstration plant has been installed. Other potential areas were identified on the island of Nisyros and Lesbos. Exploratory drilling has occurred on Nisyros. Seven other fields have been identified as needing initial exploration work.
- Foreign Geothermal Involvement: Substantial presence of Italian companies in exploration work, some French involvement also.
- Energy Situation: Energy imports amount to 59% of foreign exchange earnings. Very high per capita energy consumption. Some hydropower potential, good coal and some oil and gas reserves.
- Economic and Demographic Situation: Low population growth, high GDP per capita, moderate GDP growth rate, negative investment growth rate. Negative balance of payments; marginal international reserves.
- International Debt Situation: External public debt amounts to almost 1/4 of GNP. Debt servicing ratios are relatively high: 3.8% of GNP and 18.3% of total foreign exchange earnings.

GRENADA

- Geothermal Status: Mt. St. Catherine has been identified as an area for prefeasibility studies. Highest spring temperatures are near 50°C.
- Foreign Geothermal Involvement: No information available.
- Energy Situation: Imports almost all of commercial energy needs.
- Economic and Demographic Situation: No adequate data available; low per capita GDP.
- International Debt Situation: No data available.

EXHIBIT 4.3: (Continued)

GUATEMALA

- Geothermal Status: Regional exploration was begun in 1972. Most notable prospectively valuable geothermal fields are at Zunil, Moyuta, and Amatitlan. A 15 MWe plant is scheduled for construction at Zunil. Seven other fields are thought to have high-enthalpy potential, but need initial detailed exploration.
- Foreign Geothermal Involvement: Some exploration work conducted by companies from Japan and Italy, as well as OLADE.
- Energy Situation: Energy imports are a heavy burden on the economy, amounting to 68% of total exports. Good hydropower potential; moderate oil and gas reserves.
- Economic and Demographic Situation: High population growth; relatively high per capita GDP; moderate GDP growth rate; low investment growth rate. Satisfactory balance of payments; moderate international reserves.
- International Debt Situation: External public debt amounts to 15.8% of GNP. Debt servicing ratios are reasonable: 1.6% of GNP and 11.7% of total exports.

HAITI

- Geothermal Status: Low- to moderate-temperature resources may be present in four areas located by nationwide reconnaissance studies.
- Foreign Geothermal Involvement: Assistance in exploration by OLADE.
- Energy Situation: Highly dependent on energy imports. Low per capita energy consumption; some hydropower potential.
- Economic and Demographic Situation: Moderate population growth rate; low GDP per capita; moderate investment growth rate. Balance of payment deficit; very low international reserves.
- International Debt Situation: External public debt amounts to 26.8% of GNP. Debt servicing ratio are low including a good debt service ability.

EGYPT

- Geothermal Status: No known high-temperature systems. Hot springs near the Red Sea Coast have surface temperatures up to 50°C. Numerous warm springs and wells are present in the central and western deserts.
- Foreign Geothermal Involvement: Some geothermal-related geophysics work conducted by U.S. individuals and universities.
- Energy Situation: Oil exporter; net energy exporter. Some hydropower potential, good oil and gas reserves.
- Economic and Demographic Situation: High population growth rate; moderate GDP per capita; high GDP growth rate; substantial investment growth rate.
- International Debt Situation: External public debt amounts to almost half, 6.5% of GNP and 27.5% of total exports. Large balance of trade deficit; low international reserves.

HONDURAS

- Geothermal Status: Nationwide reconnaissance performed in 1979. Eleven areas are considered to be prospectively valuable for high-temperature resources including San Ignacio, Planatanres, Azacualpa, El Olingo, Sambo Creek, and Pavana. The other five areas are considered of secondary importance. All areas require initial detailed geophysical work.
- Foreign Geothermal Involvement: Italian companies have performed a substantial portion of the exploration work in Honduras. There has been some participation by U.S. industry.
- Energy Situation: Highly dependent on energy imports, which amount to 28% of the country's exports. Moderate hydropower potential.
- Economic and Demographic Situation: Very high population growth rate, moderate per capita GDP; high annual GDP growth; very low average investment growth rate. Balance of payment deficit; low international reserves.
- International Debt Situation: External public debt is 56.3% of GNP; debt servicing ratios are moderate: 4.3% of GNP and 14.9% of exports. One debt rescheduling in 1984.

INDIA

- Geothermal Status: Seven high-temperature prospects identified along the northern border. Most promising high-temperature areas include Puga and the Cambay Basin, where detailed geophysical studies have begun.
- Foreign Geothermal Involvement: None.
- Energy Situation: Marginal energy production surplus; low per capita energy consumption. Good hydropower potential and oil gas reserves. Abundant coal reserves.
- Economic and Demographic Situation: Moderate population growth rate. Low per capita GDP; high annual GDP growth; moderate investment growth rate. Balance of payments deficit. Adequate international reserves.
- International Debt Situation: External public debt amounts to 11.2% of GNP. Debt servicing ratios are relatively low.

INDONESIA

- Geothermal Status: Geothermal power plants have been installed or are under construction at Kamojang (140.25 MWe). An additional 875 MWe capacity is planned for seven other geothermal fields. Eleven other areas require detailed exploration.

- Foreign Geothermal Involvement: Extensive participation of foreign industry in exploration including companies from (by approximate order of level of involvement, high to low) New Zealand, U.S., Italy, Japan, and France.

- Energy Situation: Oil exporter, net energy exporter. Substantial hydropower potential; large oil, gas, and coal reserves. Moderate per capita energy consumption.

- Economic and Demographic Situation: Moderate rate of population growth; moderately low GDP per capita; high economic growth rate as indicated by the GDP growth rate. Very high investment growth rate.

- International Debt Situation: External public debt amounts to 28.9% of GNP, debt servicing ratios are moderate: 3.4% of GNP and 12.8% of exports. Balance of payments surplus and moderate international reserves.

KENYA

- Geothermal Status: Geothermal exploration was initially performed in the early 1950's. At Olkaria, three generators (45 MWe total) are supplied by 25 production wells. Drilling is scheduled for the Eburru field in 1987. Five other areas require detailed site study.

- Foreign Geothermal Involvement: U.S. companies have conducted some exploration work in Kenya, other information not available.

- Energy Situation: Oil importer; low per capita energy consumption; some hydropower potential.

- Economic and Demographic Situation: Very high population growth rate; low per capita GDP; good economic growth; moderate investment growth rate. Balance of payments deficit; moderate investment growth rate. Balance of payments deficit; moderate international reserves.

- International Debt Situation: External public debt is 43.1% of GNP. Debt servicing ratios are high: 5.5% of GNP and 20.6% of exports, suggesting a low debt service ability.

KOREA, SOUTH

- Geothermal Status: Geothermal resources were assessed as part of a broader study in 1981. High-temperature systems may be present on offshore volcanic islands of Cheju-do and Uleung-do. Resources on the mainland occur as low- to moderate-temperatures systems.

- Foreign Geothermal Involvement: Preliminary assessment with U.S. help.

- Energy Situation: Oil importer; heavy dependence on energy imports (28% of exports). Moderate hydropower potential and coal reserves. Very high per capita energy consumption.

- Economic and Demographic Situation: Low population growth rate; high per capita GDP; excellent economic growth and very good investment growth rate. Low international reserves.

- International Debt Situation: Marginal balance of payment deficit.

MADAGASCAR

- Geothermal Status: Reconnaissance investigations were performed in 1981. Numerous thermal springs with temperatures ranging up to 60°C were identified. Eight areas were identified for further study.

- Foreign Geothermal Involvement: No information.

- Energy Situation: Energy imports make up 32% of total exports; very low per capita energy consumption. Some domestic energy resources in the form of coal, hydropower, and tar sands. Initial oil exploration underway.

- Economic and Demographic Situation: High population growth rate; low per capita GNP, very low economic growth and negative investment growth rate. Trade deficit; low international reserves.

- International Debt Situation: International debt is 52.3% of GNP; low debt servicing ratios. Four debt reschedulings since 1982 indicate debt servicing difficulties.

EXHIBIT 4.3: (Continued)

MEXICO

- Geothermal Status: Comprehensive studies have been carried out since 1959. Production at Cerro Prieto began in 1973 and is continuing today with the installed capacity at 400 MWe. Deep drilling began at Los Azufres in 1976, installed capacity is now 25 MWe. Expansion at Los Azufrus underway. At Los Humerous, deep exploratory drilling has been done, and a demonstration power plant is scheduled to begin in 1987. Detailed exploration has been conducted at La Primavera, Los Negritos, and Ixtlan de Los Hervoures. Eighteen other potential high-enthalpy fields have been identified and are in need of detailed exploration.

- Foreign Geothermal Involvement: Some assistance from U.S. universities in exploration work.

- Energy Situation: Oil exporter; good hydropower potential; large oil and gas reserves; good coal reserves. Very high per capita energy consumption.

- Economic and Demographic Situation: Moderate population growth rate; very high GDP per capita; good economic growth; moderate investment growth rate. Balance of payments surplus; adequate international reserves.

- International Debt Situation: External public debt is almost half of GNP. Debt servicing ratios are substantial and three debt rescheduling occurred in the past three years.

MOROCCO

- Geothermal Status: Nationwide geothermal surveys have not yielded evidence of high enthalpy fields. Possible medium temperature resources in the northwestern part of the country.

- Foreign Geothermal Involvement: No information available.

- Energy Situation: Oil importer; energy imports make up 57% of exports. Some hydropower potential; very modest oil and coal prospects.

- Economic and Demographic Situation: High population growth rate; moderate per capita income; good economic growth; moderate low investment growth rate. Trade deficit; international reserves are low.

- International Debt Situation: External public debt is almost 70% of GNP. Debt servicing ratios are substantial. Two debt reschedulings indicating some debt servicing difficulties.

NICARAGUA

- Geothermal Status: Studies have been carried out since late 1960's. Momotombo area was identified and later developed by construction of a 35 MWe geothermal power plant in 1983. Other areas where detailed exploration has been conducted are El Hoyo, Massaya-Nandaime, and San Jacinto-Tisate. Eight other fields have been identified as needing detailed site studies.

- Foreign Geothermal Involvement: Substantial participation by U.S. and Italian geothermal industries in exploration phase.

- Energy Situation: Oil exporter; good hydropower potential; exceptional reserve of oil, gas, and coal.

- Economic and Demographic Situation: Very high population growth rate; moderate GDP per capita; low economic growth as indicated by GDP growth rate; moderate investment rate. Marginal trade deficit; low international reserves.

- International Debt Situation: External public debt is 17.7% of GNP. Debt servicing ratios are relatively high with one debt rescheduling.

PANAMA

- Geothermal Status: Nationwide reconnaissance has resulted in the identification of a number of prospectively valuable areas. Detailed geophysical studies have been conducted at Cerro Pando indicating a potential high-enthalpy reservoir. Seven other areas have been identified as attractive and in need of further study.

- Foreign Geothermal Involvement: Some involvement of French companies in exploration efforts.

- Energy Situation: Oil importer; very high per capita consumption; some hydropower potential.

- Economic and Demographic Situation: Moderate population growth rate; high economic growth; high per capita GNP. Large trade deficit; low international reserves.

- International Debt Situation: External public debt amount to 73.6% of GNP. Debt servicing ratios are moderate.

EXHIBIT 4.3: (Continued)

PAPUA NEW GUINEA

- Geothermal Status: No clear geothermal fields have been identified. The country is located in a tectonically active region, but the more favorable potential geothermal areas are in remote regions. Most promising area is near Rebaul.
- Foreign Geothermal Involvement: None.
- Energy Situation: Oil importer; low per capita energy consumption; excellent hydropower potential; some oil and gas reserves.
- Economic and Demographic Situation: Moderate population growth rate; moderate per capita GDP; low economic growth; moderate investment growth rate. Balance of payment deficit; adequate international reserves.
- International Debt Situation: External public debt amounts to 40.4% of GNP; debt servicing ratios are moderate.

PERU

- Geothermal Status: Geologic studies for geothermal resources have been carried out since the early 1970's. Among five areas identified to have geothermal potential. Calacoa and Salinas are considered to be prospectively the most valuable.
- Foreign Geothermal Involvement: Reconnaissance studies conducted by Italian companies. Some involvement of U.S. industry in exploration.
- Energy Situation: Oil exporter; moderate per capita energy consumption; good hydropower potential; very good oil and gas reserves.
- Economic and Demographic Situation: Moderate population growth; moderate GDP per capita; low economic growth; negative investment growth rate. Balance of payments surplus; good international reserves.
- International Debt Situation: External public debt amounts to 48.1% of GNP; debt servicing ratios are relatively high. Peru has experienced a marked deterioration in its international debt situation as reflected by six debt reschedulings since 1978.

PHILIPPINES

- Geothermal Status: Geothermal development has been carried out since the 1960's. Installed geothermal electric power capacity is presently 894 MWe from four geothermal fields: Tongonan (115.5MW), Tiwi (220 MW), Mak-Ban (330 MW), and Palinpinon (115.5MW). Four areas are currently being explored with deep wells and twenty to the fields have been identified and require detailed site studies.
- Foreign Geothermal Involvement: Considerable involvement by companies from the U.S., New Zealand, and Japan in exploration.
- Energy Situation: Oil importer; low per capita energy consumption; moderate hydropower potential; some oil and gas reserves; energy imports amount to 44% of exports earnings.
- Economic and Demographic Situation: High population growth rate; moderate GDP per capita; high economic growth rate, moderate investment growth rate. Large trade deficit; low international reserves.
- International Debt Situation: External public debt amounts to 30.4% of GNP; debt servicing ratios are moderate; one debt rescheduling.

ST. LUCIA

- Geothermal Status: Geothermal investigations began in the early 1970's Considered to have high geothermal potential in the Qualibou Caldera where evidence suggests reservoir temperatures of more than 230^{o}C. Potential areas within the Qualibou Caldera are Belfond, Sulfur Springs Valley, and Etangs.
- Foreign Geothermal Involvement: Substantial U.S. involvement through Los Alamos National Laboratory. Exploration has also been conducted by companies or individuals from Britain and Italy.
- Energy Situation: Imports virtually all commercial energy.
- Economic and Demographic Situation: Low per capita income.
- International Debt Situation: Insufficient data.

SAUDI ARABIA

- Geothermal Status: Regional studies performed by the Directorate General of Mineral Resources. Areas with potential for discovering high-temperature resources are associated with recent volcanism around the Saudi Plateau.
- Foreign Geothermal Involvement: None.
- Energy Situation: Oil exporter; high per capita energy consumption; exceptional oil and gas reserves.
- Economic and Demographic Situation: Very high population growth rate; very high per capita GDP; very high economic growth as indicated by the GDP growth rate; excellent investment climate with investment growth around 27.1%
- International Debt Situation: No debt, excellent international reserves.

EXHIBIT 4.3: (Continued)

TAIWAN

- Geothermal Status: Geothermal studies performed beginning in 1965. A promising area is in the Tatun region north of Taipei. At Tuchang-Chingshui, a 3 MWe single-flash plant has operated since 1981, and construction of a 0.3 MWe binary plant has been reported. Other promising areas in need of detailed site studies are at Lushan and Chihpen.
- Foreign Geothermal Involvement: Some U.S. presence through studies conducted by Stanford University.
- Energy Situation: Some coal and natural gas resources. Imports more than 75% of its energy needs.
- Economic and Demographic Situation: High GNP, country fairly industrialized.
- International Debt Situation: Unavailable data.

TANZANIA

- Geothermal Status: Reconnaissance studies performed indicating high-temperature systems (>220°C) may exist beneath Mbeya and Rungue volcanoes. Other prospectively valuable areas are Ngorongora, and Kisaki Tangalala.
- Foreign Geothermal Involvement: Reconnaissance study performed by Swedish and Icelandic consulting firms.
- Energy Situation: Oil importer; excellent hydropower potential; good gas reserves.
- Economic and Demographic Situation: Very high population growth rate; very low per capita GDP; good economic growth, moderate investment climate. Large trade deficit; extremely low international reserves.
- International Debt Situation: External public debt amounts to 58.9% of GNP and debt servicing data are incomplete but seem to be satisfactory.

THAILAND

- Geothermal Status: Reconnaissance studies performed have identified numerous thermal spring area in northern Thailand. The San Kamphaeng geothermal area, located northeast of Chaing Mai, has been subjected to shallow exploratory drilling indicating a potential high-enthalpy reservoir. The Fang and Pong Hom-Pong Nog fields have been subject to detailed geophysical studies; they are likely to be medium-enthalpy systems. Two other fields have been identified but require detailed study.
- Foreign Geothermal Involvement: Japanese technical assistance in exploration project.
- Energy Situation: Oil importer; moderate per capita energy consumption; energy imports make up 39% of exports earnings; good hydropower potential; some oil reserve; good gas reserves.
- Economic and Demographic Situation: Moderate population growth rate; moderate per capita GDP; good economic growth; moderate investment growth. Large trade deficit; moderate international reserves.
- International Debt Situation: External public debt make up 18% of GNP; debt servicing ratios are high.

TUNISIA

- Geothermal Status: Regional reconnaissance studies have been completed. Potential low- to moderate-temperature areas in the northern part of the country lie within a geologically complex belt adjacent to the Mediterranean Sea.
- Foreign Geothermal Involvement: No information available.
- Energy Situation: Oil exporter; moderate per capita energy consumption; substantial oil and gas reserves.
- Economic and Demographic Situation: High population growth rate; high income per capita; good economic growth; good investment growth rate; large trade deficit; low international reserves.
- International Debt Situation: External public debt make up 42.4% of GNP; debt servicing ratios are high.

TURKEY

- Geothermal Status: Nationwide thermal spring inventory, which began in 1962, identified nearly 600 thermal springs. Selected sites were prioritized for future studies. Kizildere, one of the high priority sites, was later explored and developed. As a result of a successful 16-well drilling program, a 0.5 MWe generating unit was installed at Kizildere in 1972. This was followed by the installation of 20.6 MWe unit. Other potential high-temperature areas where exploratory drilling has been done are Germencik, Afyon, and Tuzla. At Eskisehir, thermal water is used for space and water heating of nearly 70,000 homes connected to a district heating system. Eleven other areas have been identified and are in various stages of development.
- Foreign Geothermal Involvement: None indicated in exploration.
- Energy Situation: Oil importer; relatively high per capita energy consumption; good hydropower potential; some oil prospects; some gas and coal reserves; energy imports make up 66% of foreign exchange earnings.
- Economic and Demographic Situation: Moderate population growth rate; high per capita income; good economic growth; moderate investment growth rate.
- International Debt Situation: External public debt makes up 30.2% of GNP; debt servicing ratios are high; balance of payments deficit; adequate international reserves.

UGANDA

- Geothermal Status: Regional reconnaissance, shallow drilling, and some geophysical surveys have identified prospective areas of the East African Rift system. Highest potential is at Sempeya. Three other potential areas are located near the eastern and western borders of the country.
- Foreign Geothermal Involvement: Unknown.
- Energy Situation: Oil importer; very low per capita energy consumption; good hydropower potential.
- Economic and Demographic Situation: Very high population growth rate; very low per capita GDP; sluggish economic and investment growth rates (12.1) and (15.2) respectively.
- International Debt Situation: External public debt amounts to 17.9% of GNP; marginal trade surplus.

VANUATU

- Geothermal Status: Preliminary reconnaissance studies have been completed. Prospective areas include Tahara-Teuma on Efate, and Suritemeat on Vanu Lava. The island chain lies along the active New Hebrides arc-trench system.
- Foreign Geothermal Involvement: Joint Britian-France assistance in exploration.
- Energy Situation: Unavailable data.
- Economic and Demographic Situation: Unavailable data.
- International Debt Situation: Unavailable data.

VENEZUELA

- Geothermal Status: Preliminary reconnaissance has led to the subdividing of the country into 3 geothermal provinces. Areas of particular interest are El Pilar-Casanay and Barcelona-Cumana, both located in the northwest.
- Foreign Geothermal Involvement: No information available.
- Energy Situation: Power exporter; very high per capita energy consumption; moderate hydro potential; abundant oil reserves and gas reserves; some coal reserves.
- Economic and Demographic Situation: High population growth rate; moderate per capita income; moderate economic and investment growth rate.
- International Debt Situation: External debt amounts to 19.8% of GNP; debt servicing ratios are relatively high and the country experienced some debt servicing difficulties which required one debt rescheduling. Trade surplus; adequate international reserves.

VIETNAM

- Geothermal Status: Preliminary reconnaissance and thermal spring inventories have identified about 125 low- temperature springs. The warmest springs occur near the country's "coastal strip." A few of the springs have been used for therapeutic baths.
- Foreign Geothermal Involvement: No information available.
- Energy Situation: Insufficient data.
- Economic and Demographic Situation: High population growth rate.
- International Debt Situation: Unavailable data.

EXHIBIT 4.3: (Continued)

YEMEN, SOUTH

- Geothermal Status: No comprehensive studies to date. Low- to moderate-temperature resources may occur near the Gulf of Oman.
- Foreign Geothermal Involvement: None.
- Energy Situation: Oil importer, moderate per capita energy consumption.
- Economic and Demographic Situation: Low GDP per capita.
- International Debt Situation: External public debt amounts to 118.5% of GNP; debt servicing ratios are high. Large trade deficit; moderate international reserves; negligible oil reserves.

YUGOSLAVIA

- Geothermal Status: Resource assessment programs are presently underway in several regions. Low- to moderate-temperature resources could be developed in the regions of the Pannonian Basin, Dinaric Alps, and near the Adriatic.
- Foreign Geothermal Involvement: Some involvement in exploration by U.S. companies.
- Energy Situation: Oil importer, with energy imports making up 33% of foreign exchange earnings; some hydropower potential; widespread coal reserves.
- Economic and Demographic Situation: High per capita GDP, good annual GDP growth rate; low population growth.
- International Debt Situation: External public debt makes up 19.9% of GNP; debt servicing ratios are moderate; trade deficit; low international reserves. The country experienced some degree of difficulties in its debt servicing as reflected by four debt reschedulings.

countries have other fields in more advanced stages of geothermal development and, hence, are also included in later sections.

4.3 Fields Possibly Ready for Deep Exploratory Drilling

The descriptions presented in Exhibit 4.4 are countries with fields that appear ready for deep exploratory drilling (Category 3). The fields included in this section are those that have already undergone shallow thermal gradient drilling and now appear ready for consideration of a deep exploratory well.

4.4 Explored Fields Possibly Ready for Production Drilling

The descriptions presented in Exhibit 4.5 are countries that appear ready for production drilling (Category 4). The fields included in this section are those containing at least one deep exploratory well, and for which production drilling is required to further delineate or develop the field.

4.5 Proven Fields Undergoing Production Drilling, Plant Construction or Operation

The descriptions presented in Exhibit 4.6 are countries in which the existence and viability of the geothermal field has already been established (Category 5). Most of these fields are ready for power plant construction. Many of those with existing power plants include plans for future expansion.

EXHIBIT 4.4: Fields Awaiting Deep Exploratory Drilling (Category 3)

ASCENSION ISLAND

- Geothermal Status: Detailed study of the potential field on a U.S. Air Force base on Ascension Island has indicated a likely high-enthalpy reservoir. Confirmation drilling is necessary.
- Foreign Geothermal Involvement: Exploration work to date conducted by U.S. companies.
- Energy Situation: Island imports virtually all commercial energy supply.
- Economic and Demographic Situation: Island is a possession of the United Kingdom and the site of a U.S. Air Force base.
- International Debt Situation: Not Applicable.

AZORES

- Geothermal Status: 3 MWe power plant on-line at Pico Vermelho with plans to add another 10MW. Pico Alto, also on the main island of San Miguel, is a good possibility ready for exploratory drilling.
- Foreign Geothermal Involvement: Substantial work had been performed by companies and individuals from Portugal, the U.S., New Zealand, and, to a lesser extent, Japan, Italy and France. Portuguese companies have conducted deep geothermal well drilling.
- Energy Situation: The Azores have virtually no domestic resources of commercial conventional energy.
- Economic and Demographic Situation: The Azores is an autonomous regional district of Portugal. No separate information on the Azorean economy is available.
- International Debt Situation: No information available.

BOLIVIA

- Geothermal Status: Most promising resource areas are located in the southwest; notable resources have been located within the Empexa River Valley and at Sol de Manana.
- Foreign Geothermal Involvement: Extensive participation by Italian companies in exploration and drilling efforts.
- Energy Situation: Net energy exporter; excellent hydropower potential; adequate reserves of oil and gas; low commercial energy consumption per capita.
- Economic and Demographic Situation: High population growth rate; moderate GDP per capita ($556); low average annual GDP growth rate; very poor average annual investment growth rate (-11.4%).
- International Debt Situation: International public debt is a substantial proportion of GNP (77.7%). Debt service ratios are high, they amount to 7% of GNP and 30.5% of exports. Two debt reschedulings (1981) and (1984). Adequate international reserves.

CHINA

- Geothermal Status: Major geothermal development is at Yangbajing (high-temperature area) in Tibet where 6 MWe is installed; other notable areas are at Huitang (0.3 MWe), Denguir (0.26 MWe); Wentang (0.05 MWe), Yingkow (0.1 MWe), Tong'an (0.3 MWe), Zhaouyan (0.2 MWe), and Fuzhou, Rehai, Panzhihua, and Ruidian have been explored and show potential to be high-enthalpy systems. Deep exploratory wells are needed.
- Foreign Involvement: Major financial assistance from Italy, as well as the involvement of Italian companies in exploration and development. Lesser degrees of involvement by companies from the U.S., Japan, and France.
- Energy Situation: Net energy exporter; moderate energy consumption per capita; extensive domestic commercial energy reserves, including hydropower, coal, oil and natural gas.
- Economic and Demographic Situation: Low average annual population growth rate; good economic growth; low GDP per capita; moderate average annual investment growth rate. Good international reserves.
- International Debt Situation: No data available.

COLOMBIA

- Geothermal Status: Regional reconnaissance in the Massif Del Ruiz in 1968; detailed exploration of selected areas in the region because in 1978; detailed studies conducted at Machin Volcano and Chiles-Cerro Negro.
- Foreign Geothermal Involvement: Companies from Italy and Japan have assisted Colombia in its exploration efforts.
- Energy Situation: Commercial energy production slightly less than consumption; large hydropower potential; good oil, gas, and coal reserves.
- Economic and Demographic Situation: Moderate average annual population growth rate; high per capita income; good economic growth rate; high per capita income; good economic growth rate and average annual investment growth rates. Adequate international reserves.
- International Debt Situation: External public debt amounts to 18.3% of GNP. Debt servicing ratios are 2.4% of GNP and 21.3% of total exports, hinting to a low debt service ability.

DJIBOUTI

- Geothermal Status: Geothermal development underway at Asal. Other explored areas include Gaggade and Hanle. Projected installed geothermal electric power capacity by 1990 is between 20 and 30 MWe.
- Foreign Geothermal Involvement: Prior to the independence of Djibouti in 1977, geothermal reconnaissance was carried out by the French Bureau of Research, Geology and Mines. Exploration work has been conducted by companies from Italy and New Zealand. Companies from Japan, New Zealand, and Italy have been involved in drilling and/or engineering services.
- Energy Situation: Virtually no domestic commercial conventional energy resources.
- Economic and Demographic Situation: Insufficient data available; moderately high GDP per capita.
- International Debt Situation: No data available.

DOMINICA

- Geothermal Status: Prefeasibility studies performed in early 1970's. Nine prospective areas were identified, including three areas in the Lake District. Drilling has been performed at Lake Langano-Aluto area where 5 out of 8 wells drilled were reported successful. Other areas where exploration has begun are Lake Abaya, Corbetti Caldera, and at Tendaho in the Afar region.
- Foreign Geothermal Involvement: Exploration to date conducted with the assistance of companies from Italy, New Zealand, and the U.S. Wells drilled by a British drilling firm, engineering and project management assistance from New Zealand.
- Energy Situation: Imports almost all of commercial energy needs. One of the lowest per capita energy consumption in the world. Abundant undeveloped hydropower potential.
- Economic and Demographic Situation: Very high population growth rate; mediocre GDP per capita; low GDP growth rate; medium investment growth rate. Negative balance of payments with imports equal to double of exports; low international reserves.
- International Debt Situation: External public debt over a 1/4 of GNP. Debt servicing ratios are reasonable: 1.4% of GNP and 11.5% of total exports.

GUATEMALA

- Geothermal Status: Regional exploration was begun in 1972. Most prospectively valuable geothermal fields are at Zunil, Moyuta, and Amatitlan. A 15 MWe plant is scheduled for construction at Zunil.
- Foreign Geothermal Involvement: Some exploration work conducted by companies from Japan and Italy, as well as OLADE.
- Energy Situation: Energy imports are a heavy burden on the economy, amounting to 68% of total exports. Good hydropower potential; moderate oil and gas reserves.
- Economic and Demographic Situation: High population growth; relatively high per capita GDP; moderate GDP growth rate; low investment growth rate. Satisfactory balance of payments; moderate international reserves.
- International Debt Situation: External public debt amounts to 15.8% of GNP Debt servicing ratios are reasonable; 1.6% of GNP and 11.7% of total exports.

INDIA

- Geothermal Status: Seven high-temperature prospects identified along the northern border. Most promising high-temperature areas include Puga and the Cambay basin, where detailed geophysical studies have begun.
- Foreign Geothermal Involvement: None.
- Energy Situation: Marginal energy production surplus; low per capita energy consumption. Good hydropower potential and oil and gas reserves. Abundant coal reserves.
- Economic and Demographic Situation: Moderate population growth rate. Low per capita GDP; high annual GDP growth; moderate investment growth rate. Balance of payments deficit. Adequate international reserves.
- International Debt Situation: External public debt amounts to 11.2% of GNP. Debt servicing ratios are relatively low.

EXHIBIT 4.4: (Continued)

INDONESIA

- Geothermal Status: Geothermal power plants have been installed or are under construction at Kamojang (140.25 MW). An additional 875 MW capacity is planned for seven other geothermal fields.

- Foreign Geothermal Involvement: Extensive participation of foreign industry in exploration, drilling, and project management including companies from (by estimated level of involvement, high to low) the U.S., New Zealand, Italy, Japan and France.

- Energy Situation: Oil exporter, net energy exporter. Substantial hydropower potential; large oil, gas and coal reserves. Moderate per capita energy consumption.

- Economic and Demographic Situation: Moderate rate of population growth; moderately low GDP per capita; high economic growth rate as indicated by the GDP growth rate. Very high investment growth rate.

- International Debt Situation: External public debt amounts to 28.9% of GNP, debt servicing ratio are moderate: 3.4% of GNP and 12.8% of exports. Balance of payments surplus and moderate international reserves.

JORDAN

- Geothermal Status: Geothermal resources were assessed as part of a broad minerals evaluation program. The thermal area at Zarga Ma'in was identified as a low- to moderate-temperature prospect and drilling is planned or underway.

- Foreign Geothermal Involvement: Unknown.

- Energy Situation: Oil importer; very heavy dependence on energy imports which account for 101% of foreign exchange earnings. Virtually no commercial conventional energy resources reserves. Very high per capita energy consumption.

- Economic and Demographic Situation: Very high population growth rate; economic growth rate as measured by GDP growth rate is very high. High GDP per capita, investment growth rate is exceptionally high.

- International Debt Situation: External public debt is 47.9% of GNP. Debt servicing ratio are moderate. Large balance of payment deficit. Adequate international reserves.

KENYA

- Geothermal Status: Geothermal exploration was initially performed in the early 1950's. At Olkaria, three generators (45 MWe total) are supplied by 25 production wells. Drilling is scheduled for the Eburru field in 1987.

- Foreign Geothermal Involvement: U.S. industry has participated in drilling and exploration. Drilling also conducted by a French firm. Development project management being conducted by a New Zealand company.

- Energy Situation: Oil importer; low per capita energy consumption; some hydrothermal.

- Economic and Demographic Situation: Very high population growth rate; low per capita GDP; good economic growth; moderate investment growth rate. Balance of payments deficit; moderate international reserves.

- International Debt Situation: External public debt is 43.1% of GNP. Debt servicing ratios are high: 5.5% of GNP and 20.6% of exports, suggesting a low debt service ability.

MEXICO

- Geothermal Status: Comprehensive studies have been carried out since 1959. Production at Cerro Prieto began in 1973 and is continuing today with the installed capacity at 400 MWe. Deep drilling began at Los Azufres in 1976, installed capacity is now 25 MWe. Expansion at Los Azufres underway. At Los Humeros, deep exploratory drilling has been done, and a demonstration power plant is scheduled to begin in 1987. Detailed exploration has been conducted at La Primavera, Los Negritos, and at Ixtlan de Los Hervores.

- Foreign Geothermal Involvement: Some assistance from U.S. universities in exploration work.

- Energy Situation: Oil exporter; good hydropower potential; large oil and gas reserves; good coal reserves. Very high per capita energy consumption.

- Economic and Demographic Situation: Moderate population growth rate; very high GDP per capita; good economic growth; moderate investment growth rate. Balance of payments surplus; adequate international reserves.

- International Debt Situation: External public debt is almost half of GNP. Debt servicing ratios are substantial and three debt reschedulings occurred in the past three years.

EXHIBIT 4.4: (Continued)

NICARAGUA

- Geothermal Status: Studies have been carried out since late 1960's. Momotombo area was identified and later developed by construction of a 35 MWe geothermal power plant in 1983. Other areas where detailed exploration has been conducted are El Hoyo, Masaya-Nandaime, and San Jacinto-Tisate.

- Foreign Geothermal Involvement: Substantial participation by Italian, U.S., and French geothermal industries in drilling and exploration.

- Energy Situation: Oil importer with energy imports making up 46% of total exports; excellent hydropower potential.

- Economic and Demographic Situation: High population growth rate; moderate GDP per capita; negative GDP growth rate indicating a sluggish economy; negative investment growth rate. Large trade deficit; low international reserves.

- International Debt Situation: External public debt has reached 133.3% of GNP; debt servicing ratios are relatively high, especially as a percentage of exports. Three debt reschedulings have occurred since 1980 indicating a certain degree of debt servicing difficulties.

PANAMA

- Geothermal Status: Nationwide reconnaissance has resulted in the identification of a number of prospectively valuable areas. Detailed geophysical studies have been conducted at Cerro Pando indicating a potential high-enthalpy reservoir.

- Foreign Geothermal Involvement: Some involvement of French companies in exploration efforts.

- Energy Situation: Oil importer; very high per capita consumption; some hydropower potential.

- Economic and Demographic Situation: Moderate population growth rate; high economic growth; high per capita GNP. Large trade deficit; low international reserves.

- International Debt Situation: External public debt amounts to 73.6% of GNP. Debt servicing ratios are moderate.

ST. LUCIA

- Geothermal Status: Geothermal investigations began in the early 1970's Considered to have high geothermal potential in the Qualibou Caldera where evidence suggests reservoir temperatures of more than 230°C. Potential areas within the Qualibou Caldera are Belfond, Sulfur Springs Valley, and Etangs.

- Foreign Geothermal Involvement: UK presence in the form of an initial comprehensive geothermal resource exploration program conducted by the UK Ministry of Overseas Development. Also Italian and U.S. involvement (through Los Alamos National Laboratory).

- Energy Situation: Imports virtually all commercial energy.

- Economic and Demographic Situation: Low per capita income.

- International Debt Situation: Insufficient data.

THAILAND

- Geothermal Status: Reconnaissance studies performed have identified numerous thermal spring areas in northern Thailand. The San Kamphaeng geothermal area, located northeast of Chaing Mai, has been subjected to shallow exploratory drilling indicating a potential high-enthalpy reservoir. The Fang and Pong Hom-Pong Nog fields have been subject to detailed geophysical studies; they are likely to be medium enthalpy systems.

- Foreign Geothermal Involvement: Japanese technical assistance in exploration projects; some U.S. participation in drilling.

- Energy Situation: Oil importer; moderate per capita energy consumption; energy imports make up 39% of exports earnings; good hydropower potential; some oil reserves; good gas reserves.

- Economic and Demographic Situation: Moderate population growth rate; moderate per capita GDP; good economic growth; good economic growth; moderate investment growth. Large trade deficit; moderate international reserves.

- International Debt Situation: External public debt make up 18% of GNP; debt servicing ratios are high.

TURKEY

- o <u>Geothermal Status</u>: Nationwide thermal spring inventory, which began in 1962 identified nearly 600 thermal springs. Selected sites were prioritized for future studies. Kizildere, one of the high priority sites, was later explored and developed. As a result of a successful 16-well drilling program, a 0.5 MWe generating unit was installed at Kizildere in 1972. This was followed by the installation of 20.6 MWe unit. Other potential high-temperature areas where exploratory drilling has been done are Germencik, Afyon, and Tuzla. At Eskisehir, thermal water is used for space and water heating of nearly 70,000 homes connected to a district heating system. Eleven other areas have been identified and are in various stages of development.

- o <u>Foreign Geothermal Involvement</u>: A U.S. geothermal operation is assisting in exploration.

- o <u>Energy Situation</u>: Oil importer; relatively high per capita energy consumption; good hydropower potential; some oil prospects; some gas and coal reserves; energy imports make up 66% of foreign exchange earnings.

- o <u>Economic and Demographic Situation</u>: Moderate population growth rate; high per capita income; good economic growth; moderate investment growth rate.

- o <u>International Debt Situation</u>: External public debt makes up 30.2% of GNP; debt servicing ratios are high; balance of payments deficit; adequate international reserves.

UGANDA

- o <u>Geothermal Status</u>: Regional reconnaissance, shallow drilling, and some geophysical surveys have identified prospective areas of the East African Rift system.

- o <u>Foreign Geothermal Involvement</u>: Unknown.

- o <u>Energy Situation</u>: Oil importer; very low per capita energy consumption; good hydropower potential.

- o <u>Economic and Demographic Situation</u>: Very high population growth rate; very low per capita GDP; sluggish economic and investment growth rates (-2.1) and (-5.2) respectively.

- o <u>International Debt Situation</u>: External public debt amounts to 17.9% of GNP; marginal trade surplus.

EXHIBIT 4.5: Explored Fields Awaiting Production Drilling
(Category 4)

ARGENTINA

- <u>Geothermal Status</u>: Exploratory drilling reported successful at Copahue.
- <u>Foreign Geothermal Involvement</u>: No information available.
- <u>Energy Situation</u>: Oil importer; energy imports amount to 9% of total exports; moderate hydropower potential; good oil and gas reserves; moderate coal.
- <u>Economic and Demographic Situation</u>: Moderate population growth rate; relatively high GDP per capita ($2,417); low average annual GDP growth rate; negative average annual investment growth rate (-2%).
- <u>International Debt Situation</u>: External public debt amounts to almost 1/3 of GNP; debt servicing ratios are relatively high: 3.1% of GNP and 26% of exports; low international reserves. Two recent debt reschedulings.

CHILE

- <u>Geothermal Status</u>: Most promising resource areas are in norther Chile at El Tatio and Puchuldiza, where exploratory and/or production drilling has occurred.
- <u>Foreign Geothermal Involvement</u>: Participation by Italian firms in project engineering studies.
- <u>Energy Situation</u>: Oil importer, energy imports amount to almost a quarter of total exports. Moderate hydropower potential; good oil and coal reserves; moderate gas reserves. High energy consumption per capita.
- <u>Economic and Demographic Situation</u>: Low average annual population growth; economic growth as indicated by GDP is moderate; high per capita income. Poor average annual investment growth rate (-.3%). Good international reserves.
- <u>International Debt Situation</u>: External public debt amount to almost 40% of GNP. Debt servicing ratios are not very high; 5.1% of GNP and 18.3% of exports. Some debt servicing difficulties as indicated by the two debt rescheduling in 1975 and 1983.

DJIBOUTI

- <u>Geothermal Status</u>: Geothermal development underway at Asal. Projected installed geothermal electric power capacity by 1990 is between 20 and 30 MWe.
- <u>Foreign Geothermal Involvement</u>: Drilling, engineering, and project management services supplied by firms from New Zealand, Italy, and
- <u>Energy Situation</u>: Virtually no domestic commercial conventional energy resources.
- <u>Economic and Demographic Situation</u>: Insufficient data available; moderately high GDP per capita.
- <u>International Debt Situation</u>: No data available.

EL SALVADOR

- <u>Geothermal Status</u>: Two single-flash steam units currently on-line at Ahuachapan.
- <u>Foreign Geothermal Involvement</u>: Drilling performed by French and U.S. companies. Other engineering services provided primarily by Italian companies with some participation from the U.S., New Zealand, and Britain.
- <u>Energy Situation</u>: Oil importer; high burden of energy imports as they constitute 57% of total exports. Some hydropower potential.
- <u>Economic and Demographic Situation</u>: High population growth rate; moderate GDP per capita; adequate international reserves. Positive balance of payments; negative investment growth rate.
- <u>International Debt Situation</u>: External public debt amounts to 29.2% of GNP. Debt servicing ratios are manageable: 1.8% of GNP and 6.4% of total exports, and suggest a good debt service ability.

GREECE

- <u>Geothermal Status</u>: High-temperature resources exist on Milos where a 2 MWe demo-plant has been installed. Other potential areas were identified on the islands of Nisyros and Lesbos. Exploratory drilling has occurred on Nisyros.
- <u>Foreign Geothermal Involvement</u>: A Hungarian firm has drilled four wells as part of development activities. Companies from Italy and New Zealand have been involved in engineering and project management.
- <u>Energy Situation</u>: Energy imports amount to 59% of foreign exchange earnings. Very high per capita energy consumption. Some hydropower potential, good coal and some oil and gas reserves.
- <u>Economic and Demographic Situation</u>: Low population growth, high GDP per capita, moderate GDP growth rate, negative investment growth rate. Negative balance of payments; marginal international reserves.
- <u>International Debt Situation</u>: External public debt amounts to almost 1/4 of GNP. Debt servicing ratios are relatively high: 3.8% of GNP and 18.3% of total foreign exchange earnings.

EXHIBIT 4.5: (Continued)

GUATEMALA

- Geothermal Status: Most prospectively valuable geothermal fields are at Zunil, Moyuta, and Amatitlan. A 15 MWe plant is scheduled for construction at Zunil.

- Foreign Geothermal Involvement: Unknown.

- Energy Situation: Energy imports are a heavy burden on the economy, amounting to 68% of total exports. Good hydropower potential; moderate oil and gas reserves.

- Economic and Demographic Situation: High population growth; relatively high per capita GDP; moderate GDP growth rate; low investment growth rate. Satisfactory balance of payments; moderate international reserves.

- International Debt Situation: External public debt amounts to 15.8% of GNP. Debt servicing ratios are reasonable: 1.6% of GNP and 11.7% of total exports.

INDONESIA

- Geothermal Status: Geothermal power plants have been installed or are under construction at Kamojang (140.25 MW). An additional 875 MW capacity is planned for seven other geothermal fields.

- Foreign Geothermal Involvement: Extensive participation of foreign industry in drilling and project management including companies from the U.S. and New Zealand.

- Energy Situation: Oil exporter, net energy exporter. Substantial hydropower potential; large oil, gas, and coal reserves. Moderate per capita energy consumption.

- Economic and Demographic Situation: Moderate rate of population growth; moderately low GDP per capita; high economic growth rate as indicated by the GDP growth rate. Very high investment growth rate.

- International Debt Situation: External public debt amounts to 28.9% of GNP, debt servicing ratio are moderate: 3.4% of GNP and 12.8% of exports. Balance of payments surplus and moderate international reserves.

MEXICO

- Geothermal Status: Production at Cerro Prieto began in 1973 and is continuing today with the installed capacity at 400 MWe. Deep drilling began at Los Azufres in 1976, 25 MWe is no installed. Planned expansion at Los Azufres includes construction of a 50 MWe central plant and advanced planning for two additional 55 MWe plants. At Los Humerous, deep exploratory drilling has been done, and a demonstration power plant is scheduled to begin in 1987.

- Foreign Geothermal Involvement: Unknown.

- Energy Situation: Oil exporter; good hydropower potential; large oil and gas reserves; good coal reserves. Very high per capita energy consumption.

- Economic and Demographic Situation: Moderate population growth rate; very high GDP per capita; good economic growth; moderate investment growth rate. Balance of payments surplus; adequate international reserves.

- International Debt Situation: Moderate population growth rate; very high GDP per capita; good economic growth; moderate investment growth rate. Balance of payments surplus; adequate international reserves.

PHILIPPINES

- Geothermal Status: Installed geothermal electric power capacity is presently 894 MWe from four geothermal fields: Tongoan (115.5 MW), Tiwi (220 MW), Mak-Ban (330 MW), and Palinpinon (115.5 MW). Four other areas are currently being explored with deep drilling.

- Foreign Geothermal Involvement: Considerable involvement in drilling and project engineering by companies from the U.S. and New Zealand. Some participation from Italy and Japan.

- Energy Situation: Oil importer; low per capita energy consumption; moderate hydropower potential; some oil and gas reserves; energy imports amount to 44% of exports earnings.

- Economic and Demographic Situation: High population growth rate; moderate GDP per capita; high economic growth rate, moderate investment growth rate. Large trade deficit; low international reserves.

- International Debt Situation: External public debt amounts to 30.4% of GNP; debt servicing ratios are moderate; one debt rescheduling.

EXHIBIT 4.5: (Continued)

TAIWAN

- Geothermal Status: At Tuchang-Chingshui, a 3 MWe single-flash plant has operated since 1981, and construction of a 0.3 MWe binary plant has been reported. Exploratory drilling has been at Tatun confirming the existence of a high-temperature system.
- Foreign Geothermal Involvement: Some U.S. involvement in reservoir engineering studies.
- Energy Situation: Some coal and natural gas resources. Imports more than 75 % of its energy needs.
- Economic and Demographic Situation: High GNP, country fairly industrialized.
- International Debt Situation: Unavailable data.

THAILAND

- Geothermal Status: The San Kamphaeng geothermal area, located northeast of Chaing Mai, has been subjected to shallow exploratory drilling indicating a potential high-enthalpy reservoir.
- Foreign Geothermal Involvement: Some U.S. participation in drilling.
- Energy Situation: Oil importer; moderate per capita consumption; energy imports make up 39% of exports earnings; good hydropower potential; some oil reserves; good gas reserves.
- Economic and Demographic Situation: Moderate population growth rate.
- International Debt Situation: External public debt make up 18% of GNP; debt servicing ratios are high.

TURKEY

- Geothermal Status: As a result of a successful 16-well drilling program, a 0.5 MWe generating unit was installed at Kizildere in 1972. This was followed by the installation of 20.6 MWe unit. Other potential high-temperature areas where exploratory drilling has been done are Germencik, Afyon, and Tuzla. At Eskisehir, thermal water is used for space and water heating of nearly 70,000 homes connected to district heating system.
- Foreign Geothermal Involvement: A U.S. geothermal operator is assisting in exploration.
- Energy Situation: Oil importer; relatively high per capita energy consumption; good hydropower potential; some oil prospects; some gas and coal reserves; energy imports equal to 66% of foreign exchange earnings.
- Economic and Demographic Situation: Moderate population growth rate; high per capita income; good economic growth, moderate investment growth rate.
- International Debt Situation: External public debt makes up 30.2% of GNP; debt servicing ratios are high; balance of payments deficit; adequate international reserves.

YEMEN, NORTH

- Geothermal Status: Resource assessment and field development projects were begun in 1982 in the Dhamar- Rada's region.
- Foreign Involvement: U.S. and Italian assistance in exploration.
- Energy Situation: Imports virtually all commercial energy needs.
- Economic and Demographic Situation: High population growth rate; low income per capita; high economic growth; very high investment growth rate.
- International Debt Situation: External public debt amounts to 38.4% of GNP; debt servicing ratios are moderate. Large trade deficit; adequate international reserves.

EXHIBIT 4.6: Proven Fields Undergoing Production Drilling, Plant Construction Operation (Category 5)

AZORES

- o Geothermal Status: 3 MWe power plant on-line at Pico Vermelho with plans to add another 10 MW.
- o Foreign Geothermal Involvement: 3 MW turbo-generator manufactured in Japan. A consortium of U.S. companies are conducting the plant expansion.
- o Energy Situation: The Azores have no domestic resources of commercial conventional energy.
- o Economic and Demographic Situation: The Azores is an autonomous regional district of Portugal. No separate information on the Azorean economy is available.
- o International Debt Situation: No information available.

CHILE

- o Geothermal Status: Most promising resource area in northern Chile at El Tatio and Puchuldiza, where exploratory and/or production drilling has occurred.
- o Foreign Geothermal Involvement: Italian assistance in feasibility studies.
- o Energy Situation: Oil importer, energy imports amount to almost a quarter of total exports. Moderate hydropower potential; good oil and coal reserves; moderate gas reserves. High energy consumption per capita.
- o Economic and Demographic Situation: Low average annual population growth; economic growth as indicated by GDP is moderate; high per capita income. Poor average annual investment growth rate (-.3%). Good international reserves.
- o International Debt Situation: External public debt amount to almost 40% of GNP. Debt servicing ratios are not very high: 5.1% of GNP and 18.3% of exports. Some debt servicing difficulties as indicated by the two debt reschedulings in 1975 and 1983.

CHINA

- o Geothermal Status: Major development is at Yangbajing (high-temperature area) in Tibet where 6 MWe is installed; other notable areas are at Huitang (0.3 MWe), Denguir (0.26 MWe); Wentang (0.05 MWe), Yingkow (0.1 MWe), Tong'an (0.3 MWe), Zhaouyan (0.2 MWe), and Fuzhou.
- o Foreign Geothermal Involvement: Italian assistance in project management.
- o Energy Situation: Net energy exporter; moderate energy consumption per capita; extensive domestic commercial conventional energy reserves, including hydropower, coal, oil, and natural gas.
- o Economic and Demographic Situation: Low average annual population growth rate; good economic growth; low GDP per capita; moderate average annual investment growth rate. Good international reserves.
- o International Debt Situation: No data available.

COSTA RICA

- o Geothermal Status: Production drilling underway at Miravalles.
- o Foreign Geothermal Involvement: Italian, U.S., and New Zealand participation in field development and feasibility studies.
- o Energy Situation: Energy importers; high dependency on petroleum products. Energy imports amount to 22% of total exports. High per capita energy consumption. Rich hydropower potential.
- o Economic and Demographic Situation: High average annual population growth rate; high per capita GDP; low economic growth rate; poor average annual investment growth rate.
- o International Debt Situation: External public debt amounts to 126.3% of GNP. Debt servicing ratios emphasize the country's difficulties as they constitute 22.7% of GNP and 50.6% of total exports. Inadequate international reserves. Two debt rescheduling in 1983, indicating debt servicing difficulties.

DJBOUTI

- o Geothermal Status: Geothermal development underway at Asal. Projected installed geothermal electric power capacity by 1990 is between 20 and 30 MWe.
- o Foreign Geothermal Involvements: Drilling, engineering, and project management services supplied by firms from New Zealand, Italy, and Japan.
- o Energy Situation: Virtually no domestic commercial conventional energy resources.
- o Economic and Demographic Situation: Insufficient data available; moderately high GDP per capita.
- o International Debt Situation: No data available.

EL SALVADOR

- o Geothermal Status: Two single-flash steam units currently on-line at Ahuachapan.
- o Foreign Geothermal Involvement: Japanese turbo-generators. Italians heavily involved in project design.
- o Energy Situation: Oil importer; high burden of energy imports as they constitute 57% of total exports. Some hydropower potential.
- o Economic and Demographic Situation: External public debt amounts to 29.2% of GNP. Debt servicing ratios are manageable: 1.8% of GNP and 6.4% of total exports and suggest a good debt service ability.

ETHIOPIA

- Geothermal Status: Drilling has been performed at Lake Langano-Aluto area where 5 out of 8 wells drilled were reported successful.
- Foreign Geothermal Involvement: Engineering, project management, and initial exploratory drilling performed by New Zealand firm.
- Energy Situation: Imports almost all commercial energy needs. One of the lowest per capita energy consumption in the world. Abundant undeveloped hydropower potential.
- Economic and Demographic Situation: External public debt over a 1/4 of GNP. Debt servicing ratios are reasonable: 1.4% of GNP and 11.5% total exports.

GREECE

- Geothermal Status: High-temperature resources exist on Milos where a 2 MWe demo-plant has been installed. Exploratory drilling has occurred on Nisyros.
- Foreign Involvement: Demonstration plant (2 MW) installed by a Japanese firm. A Hungarian company drilled 4 wells as part of development activities. Companies from Italy and New Zealand have been involved in engineering and project management.
- Energy Situation: Energy with energy imports amount to 59% of foreign exchange earnings. Very high per capita energy consumption. Some hydropower potential, good coal and some oil and gas reserves.
- Economic and Demographic Situation: Low population growth, high GDP per capita, moderate GDP growth rate, negative investment growth rate. Negative balance of payments; marginal international reserves.
- International Debt Situation: External public debt amounts to almost 1/4 of GNP. Debt servicing ratios are relatively high: 3.8% of GNP and 18.3% of total foreign exchange earnings.

GUATEMALA

- Geothermal Status: A 15 MWe plant is scheduled for construction at Zunil.
- Foreign Geothermal Involvement: Unknown.
- Energy Situation: Energy imports are a heavy burden on the economy, amounting to 68% of total exports. Good hydropower potential; moderate oil and gas reserves.
- Economic and Demographic Situation: High population growth; relatively high per capita GDP; moderate GDP growth rate; low investment growth rate. Satisfactory balance of payments; moderate international reserves.
- International Debt Situation: External public debt amounts to 15.8% of GNP. Debt servicing ratios are reasonable: 1.6% of GNP and 11.7% of total exports.

INDONESIA

- Geothermal Status: Geothermal power plants have been installed or are under construction at Kamojang (140.25 MW). An additional 875 MW capacity is planned for seven other geothermal fields.
- Foreign Geothermal Involvement: Large turbo-generators built by Japanese manufacturers. Small, modular units have been supplied by a U.S. company. Extensive New Zealand involvement in project design and construction. Companies from the U.S. and New Zealand have participated in field development.
- Energy Situation: Oil exporter, net energy exporter. Substantial hydropower potential; large oil, gas, and coal reserves. Moderate per capita energy consumption.
- Economic and Demographic Situation: Moderate rate of population growth; moderately low GDP per capital; high economic growth rate as indicated by the GDP growth rate. Very high investment growth rate.
- International Debt Situation: External public debt amounts to 28.9% of GNP, debt servicing ratio are moderate: 3.4% of GNP and 12.8% of exports. Balance of payments surplus and moderate international reserves.

KENYA

- Geothermal Status: At Olkaria, three generators (45 MWe total) are supplied by 25 production wells. Drilling is scheduled for the Eburru field in 1987.
- Foreign Geothermal Involvement: Turbo-generators supplied by a Japanese company. New Zealand firm involved in field development.
- Energy Situation: Oil importer; low per capita energy consumption; some hydropower potential.
- Economic and Demographic Situation: Very high population growth rate; low per capita GDP; good economic growth; moderate investment growth rate. Balance of payments deficit; moderate international reserves.
- International Debt Situation: External public debt is 43.1% of GNP. Debt servicing ratios are high: 5.5% of GNP and 20.6% of exports, suggesting a low debt service ability.

MEXICO

- Geothermal Status: Production at Cerro Prieto began in 1973 and is continuing today with the installed capacity at 400 MWe. Deep drilling began at Los Azufres in 1976, installed capacity is now 25 MWe. Planned expansion at Los Azufres includes construction of a 50 MWe central plant and advanced planning for two additional 55 MWe plants. At Los Humeros, deep exploratory drilling has been done, and a demonstration power plant is scheduled to begin in 1987.
- Foreign Geothermal Involvement: Large turbo-generators have been supplied by Japanese firms. Smaller units have come from the U.S. and Israel. Some U.S. participation.
- Energy Situation: Oil exporter; good hydropower potential; large oil and gas reserves; good coal reserves. Very high per capita energy consumption.
- Economic and Demographic Situation: Moderate population growth rate; very high GDP per capita; good economic growth; moderate investment growth rate. Balance of payments surplus; adequate international reserves.
- International Debt Situation: External public debt is almost half of GNP. Debt servicing ratios are substantial and three debt reschedulings have occurred in the past three years.

NICARAGUA

- Geothermal Status: Momotombo area has been developed by construction of a 35 MWe geothermal power plant in 1983.
- Foreign Geothermal Involvement: Italian involvement in project design and construction.
- Energy Situation: Oil importer with energy imports making up 46% of total exports; excellent hydropower potential.
- Economic and Demographic Situation: High population growth rate; moderate GDP per capita, negative GDP growth rate indicating a sluggish economy; negative investment growth rate. Large trade deficit; low international reserves.
- International Debt Situation: External public debt has reached 133.3% of GNP; debt servicing ratios are relatively high, especially as a percentage of exports. Three debt rescheduling have occurred since 1980 indicating a certain degree of debt servicing difficulties.

PHILIPPINES

- Geothermal Status: Installed geothermal electric power capacity is presently 894 MWe from four geothermal fields: Tongonan (115.5MW), Tiwi (220 MW), Mak-Ban (330 MW), and Palinpinon (115.% MW).
- Foreign Geothermal Involvement: Turbo-generators have been supplied from Japan. U.S. and Japanese companies have participated in project design and construction. Field developers include U.S. and New Zealand companies.
- Energy Situation: Oil importer; low per capita energy consumption; moderate hydropower potential; some oil and gas reserves; energy imports amount to 44% of exports earnings.
- Economic and Demographic Situation: High population growth rate; moderate GDP per capita; high economic growth rate, moderate investment growth rate. Large trade deficit; low international reserves.
- International Debt Situation: External public debt amounts to 30.4% of GNP; debt servicing ratios are moderate; one debt rescheduling.

TAIWAN

- Geothermal Status: At Tuchang-Chingshui, a 3 MWe single-flash plant has operated since 1981, and construction of a 0.3 MWe binary plant has been reported.
- Foreign Invelvement: Unknown.
- Energy Situation: Some coal and natural gas resources. 75% of energy needs are imported.
- Economic and Demographic Situation: High GNP, country fairly industrialized.
- International Debt Situation: Unavailable data.

TURKEY

- Geothermal Status: As a result of a successful 16-well drilling program, a 0.5 MWe generating unit was installed at Kizildere in 1972. This was followed by the installation of 20.6 MWe unit. At Eskisehir, thermal water is used for space and water heating of nearly 70,000 homes connected to a district heating system.
- Foreign Geothermal Involvement: Construction of 20.6 MWe plant including turbo-generators, conducted by an Italian firm.
- Energy Situation: Oil importer; relatively high per capita energy consumption; good hydropower potential; some oil prospects; gas and coal reserves; energy imports make up 66% of foreign exchange earnings.
- Economic and Demographic Situation: Moderate population growth rate; high per capita income; good economic growth; moderate investment growth rate; balance of payments deficit; adequate international reserves.
- International Debt Situation: External public debt makes up 30.2% of GNP; debt servicing ratios are high.

Chapter 5: Export Financing and Assistance Available for U.S. Geothermal Industry

Export financing has been identified as a primary obstacle to expanding U.S. markets overseas. The less developed countries (LDCs) constitute a promising market for applications of geothermal technology, services and products. The LDCs, however, lack the capital resources to independently purchase geothermal energy systems. Thus, the assistance of federal and multilateral development and funding institutions can be essential to bringing together U.S. suppliers and potential end-users/purchasers in successful sales arrangements. Export financing involves complex and interactive issues that present unusual difficulties due to: misperceptions of the technology's maturity and competitiveness; indigenous banks in developing countries lend on a short-term basis at high interest rates; many developing countries lack the hard currency to finance imports of alternative energy technologies; and many exports are integrated projects, not simple equipment/unit sales, which complicates the international transaction.

The World Bank estimates that, over the next 10 years, $130 billion in investment will be needed annually to meet the projected energy demand in developing countries, and half of that total will come from international sources (World Bank, 1983). The degree to which geothermal energy will help meet these needs will depend, to some extent, on the ability of individual companies to secure competitive project financing. Multilateral lending institutions such as the United Nations and its component agencies, the World Bank and its component agencies, and the regional development banks, provide financial assistance to programs and projects in geographic areas and end-use applications pertinent to the U.S. geothermal industry.

The federal government also provides a complete range of programs and services that can assist U.S. geothermal energy firms as they expand into the foreign marketplace. These programs cover the spectrum of business export needs, which include: providing financing; insuring investments; sponsoring feasibility studies; providing assistance in identifying target markets; locating specific business opportunities and foreign joint venture partners; assisting in trip preparations; conducting trade analyses; and providing in-country training and assistance. At present, more than 20 agencies are involved in some aspect of overseas marketing and trade. The eight major agencies offering export assistance include: the U.S. Agency for International Development (USAID), U.S. Department of Energy (DOE), Department of Commerce (DOC), Export-Import Bank (ExImbank), Office of the U.S. Trade Representative (USTR), Overseas Private Investment Corporation (OPIC), Small Business Administration (SBA) and Trade and Development Program (TDP).

Federal and international funding have been successfully utilized by U.S. industry for several international geothermal projects. The following sections describe these activities and the organizations involved. Several other programs and services applicable to geothermal projects are offered by other agencies and trade associations as summarized in this chapter and the list of contacts presented in Appendix D. More descriptive information regarding all federal and international financing and export assistance programs applicable to the geothermal industry and their administering organizations can be found in "Federal Export Assistance Programs Applicable to the U.S. Renewable Energy Industry" and "Guide to the International Development and Funding Institutions for the U.S. Renewable Energy Industry" (prepared for the Committee on Renewable Energy Commerce and Trade, June 1986 and September 1986, respectively).

5.1 Federal Export Financing and Assistance

Federal export financing and assistance programs offer a variety of useful support and information for the U.S. geothermal industry. These programs provide financial, market development, tax and regulatory assistance. Exhibit 5-1 summarizes the key agencies and their available services. The following paragraphs briefly summarize federal agencies that have recently participated in international geothermal projects and other agencies with relevant programs.

5.1.1 Federal Geothermal Financing Activities

U.S. Agency for International Development

USAID has been involved in an airborne geothermal exploration project in Jordan, a renewable energy assessment in Thailand, feasibility studies in the Philippines, and an evaluation of the Tiwi geothermal project in the Philippines.

U.S Agency for International Development (USAID) supports renewable energy technologies that can compete on an economic, technical, and institutional basis with conventional energy alternatives. USAID assistance to host countries is provided in the form of training and institution building, technical assistance, research and technology transfer. USAID also seeks to leverage funds from the private sector and major development banks.

USAID emphasis is on enhancing in-country capabilities rather than on developing markets for U.S. products. USAID technology demonstration projects are, however, required by law to use U.S. equipment. These projects also serve to document system performance in indigenous market settings with an emphasis on economics, reliability and institutional factors.

USAID operates in a very decentralized manner, with energy and energy-related programs dispersed throughout its functional and geographic bureaus. The two functional bureaus that are most relevant to geothermal energy activities are the Bureau of Science and Technology and the Bureau for Private Enterprise. The geographic bureaus for Africa, Asia, Latin America/Caribbean, and the Near East have an emphasis on renewable energy technology and planning.

The Bureau of Science and Technology (S&T) provides technical support to all agency activities in many sectors including energy, administers centrally funded R&D programs, and coordinates these activities with the geographic bureaus and host country missions. The Bureau for Private Enterprise (PRE) promotes the development of host country private businesses by providing grants and investment funds to stimulate local business development. There are potential opportunities for U.S. renewable energy firms to secure financial assistance through PRE. However, since the program is directed to indigenous businesses, requests for assistance must originate from a local joint venture partner.

Exhibit 5-1
FEDERAL AGENCY EXPORT ASSISTANCE PROGRAM SUMMARY

FEDERAL AGENCY \ EXPORT ASSISTANCE ACTIVITY	Market Identification	Targeting Opportunities	Trip Planning	Feasibility Studies	Trade Regulations	Financing	Insurance	Training/Technical Assistance
Agency for International Development (AID)		●	●	●		●		●
Department of Commerce (DOC)	●	●	●		●			
Export-Import Bank (EXIMBANK)				●		●	●	
Office of the United States Trade Representative (USTR)					●			
Overseas Private Investment Corporation (OPIC)		●	●		●	●	●	
Small Business Administration (SBA)		●	●	●	●	●		●
Trade and Development Program (TDP)				●				●

Export-Import Bank (ExImbank)

In 1985, ExImbank guaranteed 85 percent of a $9.1 million package of geothermal power plant equipment to Mexico.

ExImbank is directed by statute to aid in the financing and facilitation of U.S. exports by: offering financing for U.S. exporters that is competitive with the financing provided by foreign export credit agencies to assist sales by their nation's exporters; determining that the transactions supported provide for a reasonable assurance of repayment; supplementing, rather than competing with, private sources of export financing; recognizing the effect of its activities on small business, the domestic economy, and U.S. employment. ExImbank offers a wide range of loan, guarantee and insurance programs to supplement and encourage private sector financing of U.S. firms' foreign sales. In 1986, ExImbank was required by law to set aside 10 percent of its funds for small business.

Some programs that may be particularly relevant include: the Small Business Credit Program for small businesses; the Medium-Term Credit Program which requires evidence of foreign competition; the Commercial Bank Guarantees Program which ensures repayment of medium-term credit obligations by financial institutions; the Working Capital Guarantee Program which provides working capital loans for pre-export activities; and the Export Credit Insurance Program which provides export insurance.

During the past two years, ExImbank has countered government subsidized project bids by foreign firms by offering arrangements involving combinations of low interest rates, extended grace periods and extended repayment periods.

5.1.2 Other Relevant Federal Agencies

Other federal agencies that offer programs or services that may facilitate exporting of geothermal products are listed below.

- Office of the U.S. Trade Representative - has primary responsibility for developing international trade policy and coordinating its implementation; negotiates with foreign governments to resolve trade barriers to the importation of U.S. renewable energy products; and disseminates information to private industry on international trade agreements entered into by the U.S.

- Overseas Private Investment Corporation - promotes U.S. business investment in developing countries, primarily by providing insurance against political risk; provides loan guarantees ($1 to $25 million) and small business direct loans ($100,000 to $4 million); and sponsors overseas pre-investment and investment missions and the Opportunity Bank for matching U.S. firms with foreign business opportunities and joint venture partners.

- Small Business Administration - offers the SBA Energy Loan Program which has issued direct loans and loan guarantees to renewable energy firms; offers loan guarantees for pre-export activities through the Export Revolving Line of Credit Program; and offers legal assistance, marketing assistance, and export workshops and training programs.

- Trade and Development Program - operates in middle-income developing countries (with particular emphasis on the Caribbean Basin and China) where planning services are requested or formally endorsed by the host government; has sponsored renewable energy studies in several countries; and has financed feasibility studies that have a high potential for leading to follow-on projects involving significant U.S. exports.

- U.S. Department of Energy - conducts substantial renewable energy technology research and development, particularly in areas that have potentially high payoffs to U.S. industry; chairs the Committee on Renewable Energy Commerce and Trade (CORECT) and thus is responsible for coordinating and monitoring CORECT activities; supports overseas and domestic energy trade events sponsored by agencies such as Department of Commerce; assesses foreign government support of renewable energy exports; and provides technical guides and product catalogues for overseas buyers.

- U.S. Department of Commerce - provides broad range of market development services to potential exporters; provides reports analyzing foreign business trends, trade opportunities and investment conditions; maintains up-to-date international trade and market information; and counsels businesses regarding export regulations.

- U.S. Department of Defense - purchases energy systems of various sizes and types for domestic and overseas facilities to establish energy supplies independent from local grids.

- U.S. Department of State - works closely with all business sectors to increase exports and help companies resolve problems involved in securing contracts and investments abroad; provides country specific market information, business assistance and risk assessment, and export information publications.

- U.S. Department of Labor - provides labor climate information in countries/regions of interest.

- Patent and Trademark Office - provides information on the Patent Cooperation Treaty which enables individuals and companies to file patent applications in several countries simultaneously.

- U.S. Department of Interior - serves as coordination point for potential energy development projects in the seven U.S. territories; provides technical analysis, information and training to planners, and assists in policy formulation in these territories; maintains awareness of energy development plans, activities, and participants in the territories.

5.2 International Funding and Development Institutions

The international institutions that have traditionally been involved in international geothermal projects include: United Nations, World Bank, Inter-American Development Bank, Asian Development Bank, African Development Bank, European Economic Community, and Caribbean Development Bank. These and other international lending agencies offer assistance in identifying target markets, locating business opportunities, including joint venture partners, conducting feasibility studies and trade analyses, providing financing, insuring investments, and providing in-country training and assistance.

The loans and grants from these institutions are usually issued directly to the host country government agency responsible for the project who generally procure goods and services directly from the supplier. However, lending agencies can often facilitate the process and clarify contractual uncertainties. International organizations that have been involved with geothermal activities are discussed below. Exhibit 5-2 summarizes activities of these and other development and funding institutions. Appendix D presents a list of contacts.

United Nations Development Program (UNDP)

The UNDP is involved in all stages of the geothermal development process. It has funded 39 geothermal resource-related projects around the world. In 1985, projects were funded in Ethiopia, China, Kenya, Bolivia, and Honduras. UNDP also provided technical assistance and training in a number of countries.

The UNDP is the focal point of the United Nations' development system, and is the world's largest channel for multilateral technical and pre-investment activities. The UNDP is represented in more than 150 countries and territories, with 80 percent of its aid directed toward the world's 60 poorest countries.

UNDP assistance is provided only at the request of the host government, in the form of project grants. The UNDP Energy Account provides resources for two programs which are jointly executed with the World Bank: the Energy Sector Assessment Program (ESAP) which consists of missions by World Bank economists to individual developing countries; and the Energy Sector Management Program (ESMP), which follows through on ESAP reports and assists countries to implement priority investments. U.S. industry can participate in various projects by becoming partners in joint ventures with firms in the host country.

World Bank

The World Bank began financing the power plant component of geothermal projects but has now expanded its role to include financing for exploration and development of the resource. Through mid-1985, the World Bank financed 18 projects involving geothermal resources, including projects in Mexico (75 MW), El Salvador (65 MW), Kenya (45 MW), and Indonesia (110 MW), totaling 295 MW of generating capacity. Geothermal exploration projects were financed in the Philippines, North Yemen, Kenya and Djibouti. The World Bank also financed technical assistance projects in a number of countries.

The World Bank Group is divided into three institutions, two of which engage in renewable energy projects: the International Bank of Reconstruction and Development (IBRD) (commonly referred to as the World Bank) and the International Development Association (IDA) (the "softloan window" in the Group). The third institution, the International Finance Corporation (IFC), not covered in this summary, concentrates on the promotion of private sector growth in developing countries.

The World Bank aids in construction and development of member countries by mobilizing capital investment to: promote private foreign investment; encourage balanced growth of international trade; and maintain balance of payments to members.

The IBRD provides loans and credits for developing countries in more advanced stages of economic growth. The loans have a grace period of 5 years and a repayment term of up to 20 years. Loans and

Exhibit 5-2
INTERNATIONAL DEVELOPMENT AND FUNDING INSTITUTIONS
Summary of Activities

	SECTORS							REGIONS				FUNDING TO LDC GOV'T *	
	RENEWABLE ENERGY	ENERGY/POWER	AGRICULTURE/IRRIGATION	HEALTH	WATER SUPPLY/RURAL DEVELOPMENT	TELECOMMUNICATIONS	INDUSTRY	EAST ASIA/PACIFIC	AFRICA	LATIN AMERICA/CARIBBEAN	MIDDLE EAST	PROJECT LOANS	CONCESSIONAL FINANCING/GRANTS
FUNDING INSTITUTIONS													
UN Development Programme	▲	▲	▲	▲	▲	▲	▲	●	●	●	●		√
UN Department of Technical Cooperation for Dev.	▲	▲	▲	▲	▲	▲	▲	●	●	●	●		
UN Children's Fund	▲			▲	▲			●	●	●	●		√
World Health Organization	▲			▲	▲			●	●	●	●		√
Food and Agriculture Organization	▲		▲		▲			●	●	●	●		√
International Fund for Agricultural Development	▲		▲		▲				●	●	●		√
International Bank for Reconstruction and Dev.	▲	▲	▲	▲	▲	▲	▲	●	●	●	●		√
UN Capital Development Fund	▲	▲	▲	▲	▲	▲	▲	●	●	●	●	√	√
International Development Association	▲	▲	▲	▲	▲	▲	▲	●	●	●	●		√
International Finance Corporation	▲	▲	▲	▲	▲	▲	▲	●	●	●	●		
African Development Bank	▲	▲	▲	▲	▲	▲	▲		●			√	√
Asian Development Bank	▲	▲	▲	▲	▲	▲	▲	●				√	√
Caribbean Development Bank	▲	▲	▲		▲	▲	▲			●		√	√
Inter-American Development Bank	▲	▲	▲	▲	▲	▲	▲			●		√	√
Islamic Development Bank		▲	▲	▲	▲	▲	▲	●	●		●	√	√
NON-FUNDING TECHNICAL/ADVISORY INSTITUTIONS													
UN Institute for Training and Research	▲	▲											
Economic Comm. for Latin America and the Caribbean	▲	▲	▲	▲	▲	▲	▲						
Economic Commission for Western Asia	▲	▲	▲	▲	▲	▲	▲						
Economic Commission for Africa		▲	▲	▲	▲	▲	▲						
Economic and Social Comm. for Asia and the Pacific	▲	▲	▲	▲	▲	▲	▲						
Organization of American States	▲	▲	▲	▲	▲	▲	▲						

* Note: Financing is provided to developing countries, NOT U.S. exporters. These loans and grants enable the LDCs to procure project inputs.

Source: Guide to the International Development and Funding Institutions for the U.S. Renewable Energy Industry, Committee on Renewable Energy Commerce and Trade, September 30, 1986.

credits for financing geothermal projects totaled $326.1 million by mid-1985. Projects worthy of investment are identified by: (1) a member country proposing a project to the Bank; (2) a Bank mission suggesting a follow-on project; (3) the Bank itself dispatching missions to identify projects; or (4) UN agencies overseeing the broad picture. International competitive bidding procedures are used to ensure equal acquisition opportunity to all bidders.

The IDA financial aid is in the form of credits or "soft loans" that have flexible repayment schedules for the very poorest countries. The IDA loans are distinct in that they are provided only to host governments, carry out 10 year grace period, and are repayable in up to 50 years. IDS funds are derived from IBRD subscriptions from member countries and from IDA's more wealthy members. The IDA specifically concentrates on funding projects in the very poorest countries. Procurement requirements are identical to the IBRD requirements.

Inter-American Development Bank (IDB)

The IDB has considerable experience in financing all phases of geothermal development. The IDB has co-financed geothermal reconnaissance and prefeasibility studies in Panama (1983), feasibility studies at El Hoyo in Nicaragua, construction of a 15 MW geothermal power plant at Zunil in Guatemala, exploratory studies at Zunil II and Amatitlan in Guatemala, and a series of loans for development at Miravalles volcano in Costa Rica.

The IDB is comprised of 43 member countries and is focused to help accelerate economic and social development in member states, provide technical assistance, and promote regional economic integration. U.S. industry can access IDB resources through joint venture arrangements with a partner in one of the member countries. Each member country has a vote on appropriation of funds that is proportional to their subscription to Bank capital stock.

The Bank extends loans to member governments, as well as to local private firms, for development of projects in the region. The IDB offers loans through its ordinary capital resources, and offers concessional loans for the region's poorer countries through the Fund for Special Operations and the Social Progress Trust Fund. The Bank offers technical cooperation on both a reimbursable basis and a grant basis. A special Non-Conventional Energy Section was created within the Bank's Energy Division in 1981 to promote the development of alternative and renewable energy resources in the region.

Asian Development Bank (ADB)

Since 1976, ADB efforts have emphasized development of indigenous energy resources, including geothermal. THE ADB provided technical assistance for a feasibility study at the Lahendong/Darajat geothermal field in Indonesia and a geothermal steam pricing policy study in the Philippines.

The ADB is comprised of 45 member countries. The Bank was founded to facilitate the economic and social advancement of developing member countries, provide technical assistance for project development and execution, and coordinate development policies among member countries. The Bank's current development priorities -- water supply, irrigation, sanitation and health, and rural development -- are well-suited to renewable energy applications.

Traditionally, the Bank conducts

missions to identify and assess projects. Loans are provided following completion of a feasibility study in which a Bank appraisal team has approved the project. Special attention, including concessional lending procedures, is given to smaller less developed member countries.

Because procurement of goods and services is conducted by the host government directly with the supplier, U.S. industry can best access these resources by assisting the host government in identifying and assessing its geothermal resources, application, and needs, and then work with the host country to develop project plans for funding by ADB.

African Development Bank (AfDB)

The AfDB is beginning to gain operational experience with renewable energy projects. The Bank allocated $2.2 million in 1984 toward a successful $16.6 million geothermal exploration project in Djibouti.

The AfDB was founded to contribute to the economic and social progress of its 50 member states and 22 nonregional members. It provides financing to member countries whose economic condition requires that such financing be on concessional terms. The Bank encourages public and private capital investment in Africa and provides technical assistance to study, prepare, finance, and execute development projects.The current emphasis of its programs is on drought and famine relief in Africa which presents numerous opportunities for alternative energy technology applications. According to the Bank's charter, loan proceeds are to be used only to procure goods and services produced in member countries (except under special circumstances).

European Economic Community (EEC)

The EEC has co-financed several geothermal projects including: geothermal exploration projects in the Lake District of Ethiopia; preliminary studies of a low-enthalpy project in Los Chillos Valley in Ecuador; prefeasibility work at Qualibou Caldera on St. Lucia Island; installation of a third generator and expanded field development at Olkaria geothermal field in Kenya; and support for projects in Nisyros, Lesbos, Platystomon, Loutraki-Sousaki, and Macedonia in Greece.

The EEC is currently composed of 10 countries (Belgium, Germany, France, Italy, Luxembourg, The Netherlands, Denmark, Ireland, United Kingdom, and Greece), with Spain and Portugal soon to become members as well. The EEC channels funds on a non-profit basis into projects that promote the Community's smooth and balanced development.

The EEC grants mostly long-term loans for regional development, two-thirds of which have been expended in lesser developed countries. The Community has a strong interest in developing internal energy resources.

Caribbean Development Bank (CDB)

The CDB provided recommendations on the development of the Soufriere geothermal field on St. Lucia Island.

The CDB promotes regional economic integration and cooperation, and assists its 20 regional and 2 nonregional member countries implement their development objectives. The Bank created an Alternative Energy System fund in 1980 to study new and renewable sources of energy. This Fund has been used to finance several renewable energy resources assessments. Bank loans are extended to member governments, government agencies, and public or private entities for projects within those countries with high development priority.

5.3 Trade Associations

The Geothermal Resources Council (GRC) is the only domestic private sector organization that exclusively promotes geothermal industry. The GRC is a center for information that actively encourages research, exploration, development, and understanding of geothermal resources. The GRC offers a number of educational opportunities including special meetings, workshops, conferences, courses, symposia, and an annual meeting. Its activities are generally well supported by the international geothermal community and provides a forum for U.S. industry. GRC publications include annual meeting transaction volumes and monthly bulletins. Currently there are approximately 1300 individual members and 80 corporate members. GRC is currently planning a geothermal reverse trade mission which is expected to bring representatives from 24 countries to the U.S. to review U.S. geothermal technology and project sites, and meet with U.S. industry.

Chapter 6: Conclusions and Recommendations

6.1 Study Findings

Three key conclusions were drawn from this study concerning worldwide geothermal energy development and opportunities for U.S. industry. In summary, this study revealed that the three necessary ingredients for successful U.S. geothermal industry penetration into the international marketplace (technical ability, available market, and funding mechanisms), are already present.

- o U.S. industry, on the whole, has extensive experience and involvement in the international geothermal market and possesses unquestionable qualifications to perform all aspects of geothermal exploration and development.

- o 71 countries and areas were identified with demonstrated or likely geothermal resources and probable needs for U.S. technology and expertise. These countries/areas are the primary international markets for the U.S. geothermal industry.

- o There are four primary mechanisms (and various combinations of these) through which an international geothermal project can be funded: (1) international lending or funding organizations; (2) foreign aid grants from a specific country; (3) host country governments where the project is located; and (4) private funding sources.

The question to be answered, then, is what is the best strategy for the U.S. geothermal industry to take when marketing its goods and services in the international arena.

The data analyses presented in this report provide a basis for the Federal Government to promote U.S. geothermal exports with confidence, that their actions address existing market conditions. In addition, this information should directly assist individual geothermal companies in planning their expansion in the international marketplace.

6.1.1 U.S. Industry Qualifications

Through the comprehensive literature search and resultant data analysis, primary exporting countries of geothermal energy technology were identified. The results clearly substantiated that the United States is a world leader in geothermal development. In considering only the 71 countries and areas identified as primary markets, the U.S. geothermal industry has:

- o participated in exploration projects in 21 of the 53 countries where projects were identified;

- o supplied geothermal drilling equipment or services in at least 6 of the 24 countries that have reached this stage of development;

- o participated in field development, either as operator or consultant, in at least 10 of the 24 countries at this stage;

- o been involved in power plant design and construction in at least 3 of 12 countries; and

- o supplied turbo-generator equipment to projects in 3 of 12 countries.

It is likely that these represent minimum values and that U.S. industry has been involved in several more projects where its participation has not been documented through publications.

Even in the face of serious competition from the other industrialized geothermal nations, the overseas market penetration statistics for industry are impressive. However, the majority of this international presence primarily involves a small group of companies. These include: the oil field drilling and service companies, whose international presence is more related to the oil industry than geothermal; Unocal Corporation, which is heavily involved in the Philippines and Indonesia; a few geophysics/exploration companies with particular expertise in geothermal energy; and a select few, large architectural and engineering firms which are related to geothermal energy. There is undoubtedly a large sector of the U.S. geothermal industry that could be, but currently is not, significantly involved with international geothermal activities.

6.1.2 Potential International Geothermal Market Opportunities

The study identified 71 countries/areas with demonstrated or possible geothermal resources, and with an apparent need for foreign technology and know-how. Of these countries, 20 require nationwide resource assessments, 11 currently have power on-line, and another 5 are in the process of plant construction or production drilling. Twenty-eight countries have geothermal fields that have been subject to either thermal gradient or deep exploratory drilling and may be ready for field development. In addition, other fields in 47 countries have been identified by nationwide reconnaissance and may warrant detailed geophysical analysis.

6.1.3 Mechanisms for Financing International Geothermal Development Activities

There are four primary mechanisms through which a geothermal project is likely to be funded in a developing country. Each of these funding mechanisms has peculiarities that make it more or less appropriate depending on the country of interest, and the current level of geothermal development within that country.

Internationally Funded Projects

This category includes projects funded by international organizations, such as, the United Nations and projects financed through agencies, such as, the World Bank and the regional development banks. Funding procedures of these organizations are complex, and projects range from small exploratory reconnaissance, to building and installing multimillion dollar power plants. Effective marketing strategies must include extensive research information collection and contact, to understand the programs procedures and requirements of each institution, as well as those of the individual host country. Marketing must generally be done directly through the country in question, often facilitated by contact with the local office, or headquarters of the funding institution.

Foreign Aid Funded Projects

These projects are funded by grants or loans from agencies within particular countries (generally industrialized nations). The level of funding for these projects is typically less than that for internationally funded projects, although it is not unusual to see projects funded by a combination of national and international aid. The procurements are generally limited to companies and individuals in either the host country or the funding country. Marketing for these projects must focus on the host country agency overseeing the project, or the headquarters or regional offices of the particular funding institution.

Domestically Funded Projects

These projects are funded directly by the government of the country where the work will be performed. Since most of the countries in the target group are developing nations, the amount of funds they have available for new energy projects may be limited. Therefore, projects of this type that are funded without the aid of foreign governments or international lending institutions are generally small. Most often, these project are regional or site-specific exploration studies conducted to gather evidence to support a request for a grant or loan for further studies. These projects are often conducted by the government of the country itself or, occasionally, by universities in the country. Foreign experts are often hired as consultants or to perform specific activities requiring equipment unavailable in the country, such as, geophysical studies. Companies interested in becoming involved in these studies must be highly visible in the international area in a particular field, or develop and maintain necessary contacts within the host country government to receive advanced information on developing opportunities.

Privately Funded Projects

These projects are funded by private capital based on the premise that they will be money-making ventures. The companies that will do the work, banks, or venture capitalists usually supply the funds for these type of projects. Since the project must make a profit, very risky exploration is not likely to be funded in this manner. Most projects funded from private capital are power plant installations where the geothermal field is well characterized and a market for the generated power has been established. Occasionally, operating companies will fund their own exploration projects with the hope that, if successful, they can then develop the field and sell the geothermal fluid to a yet-to-be-built power plant.

6.2 Study Recommendations

This study has demonstrated that the U.S. geothermal industry has successfully penetrated the international market. Based on the result of this study, a recommended strategy has been developed for the Federal Government to promote expanded and continued U.S. penetration of the international geothermal market. The five components of this strategy are:

1. Measure U.S. industry interest in export development

2. Expand the international geothermal resource and market data base

3. Educate U.S. industry on export development and educate, collect and host country governments and financial institutions regarding geothermal energy

4. Disseminate information on international projects to U.S. industry

5. Improve access to funding for international projects.

Before embarking on any major effort to increase U.S. geothermal industry penetration overseas, the interest of the industry to compete in these markets should be measured

(Item 2). Specifically, interest is defined here as a sincere commitment to expand the necessary resources to seek the work in the international market. U.S. firms must be willing to invest their time and financial resources into international marketing activities if they truly desire to compete in this arena.

For Item 1, a continual effort should be made to expand and supplement the data base created in this study. Country write-ups could be enlarged into summary reports for each country or field in question and published as a series. The data base also could be expanded to include resources and activities in the countries with established geothermal expertise (and therefore excluded from this study). If possible, more complete information should be developed to identify participants of various projects.

Item 3 of this strategy, is to educate U.S. industry on business development in the international market. The existing penetration of the international market by U.S. companies demonstrates that the industry can successfully compete in these overseas markets. Expansion of the U.S. international market could be increased by helping companies that may not understand the international marketplace.

The Federal Government can also aid in the dissemination of information to increase the awareness of U.S. companies regarding international projects (Item 4). By tracking projects through intelligence gathered by U.S. embassies, the UN, or other international funding organizations, the information could be provided in a publication such as a "Geothermal Opportunities Newsletter." By aggressively seeking information on proposed and upcoming international projects, the publishers of this newsletter could help industry focus its marketing efforts. It would also be possible to reverse this information dissemination path and make information on U.S. companies and technologies available to international funding organizations and host governments. This would require an effort to collect the information from the companies and distribute it within target countries.

Finally, by increasing access to federal and international export financing sources (Item 5), the major obstacle to U.S. exporting could be reduced. As previously discussed, numerous funding sources exist with individually complex structures, programs and requirements. This complexity prohibits easy access to funding. This, combined with industry's lack of international business development skills, has resulted in underutilization of most programs provided for U.S. industry. U.S. firms must become educated on how to effectively utilize these sources. In addition, these funding institutions must be educated about the applications, commercialization, technological risks and benefits of geothermal energy. These issues are currently being addressed by CORECT, which is currently developing a series of recommendations for enhancing accessibilities and effectiveness of federal export financing programs.

Activities such as geothermal export workshops could provide opportunities to address Items 2, 3, 4 and 5. Such workshops could help increase the interest of U.S. firms (Item 2) in exporting, by including export business development seminars (Item 3), updates of international market opportunities, dissemination of cultural, regulatory and economic information describing target countries (Item 4) and seminars addressing export financing opportunities and mechanisms (Item 5). While the DOC and other agencies have numerous similar seminars available, none are tailored to the needs and markets of the geothermal industry. Similar activities are being conducted by CORECT and its member agencies for various renewable energy technologies.

ACKNOWLEDGEMENTS

This document is the product of the collective efforts of a number of dedicated people who believe in the promise and future of geothermal energy as an important component of a secure, cost competitive, and environmentally compatible energy base for the United States, as well as for those many developing nations around the world which are fortunate enough to have the resource within their borders. The principal author was James Satrape of Meridian Corporation. He was responsible for shaping this report and spent many hours researching and writing to achieve this product. The following individuals contributed significantly in developing the information contained herein: Kerry Schwartz and Robert Blackett (country resource summaries), and Fadia Farrell (country by country demographic and economic data). Special thanks go to Jan Bowers and Claudia MacDonnell of Meridian Corporation; Jan for her assistance and hard work in reviewing and editing the final report, Claudia for her able coordination of the final production effort.

Mr. Robert Hendron of Los Alamos National Laboratory, Dr. John E. Mock and Marshall Reed of the U.S. Department of Energy, Geothermal Technology Division, and Deepak C. Kenkeremath of Meridian must receive special thanks for sharing their knowledge, insight, and perspectives with the project team in formulating this valuable resource document.

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References used in compiling geothermal development information on particular countries are included with each country description in Appendices A and B.

Sources of statistical data on energy, economics, and finance are included with the detailed data in Appendix C.

Appendix A

Target Geothermal Country Descriptions

INTRODUCTION

This appendix contains detailed country descriptions for the 71 countries considered to be the most potential target markets for U.S. geothermal goods and services. These descriptions vary significantly in their level of detail, depending on the available information. A bibliography of the most useful sources of information on a particular country is included with each description. The following sources were used when other information was unavailable:

DiPippo, R., 1985, "Geothermal Electric Power, The State of the World -- 1985," 1985 International Symposium on Geothermal Energy, International Volume, Geothermal Resources Council, pp. 3-18.

National Geographic, 1985, "Earth's Dynamic Crust," Volume 168, No. 2, map supplement.

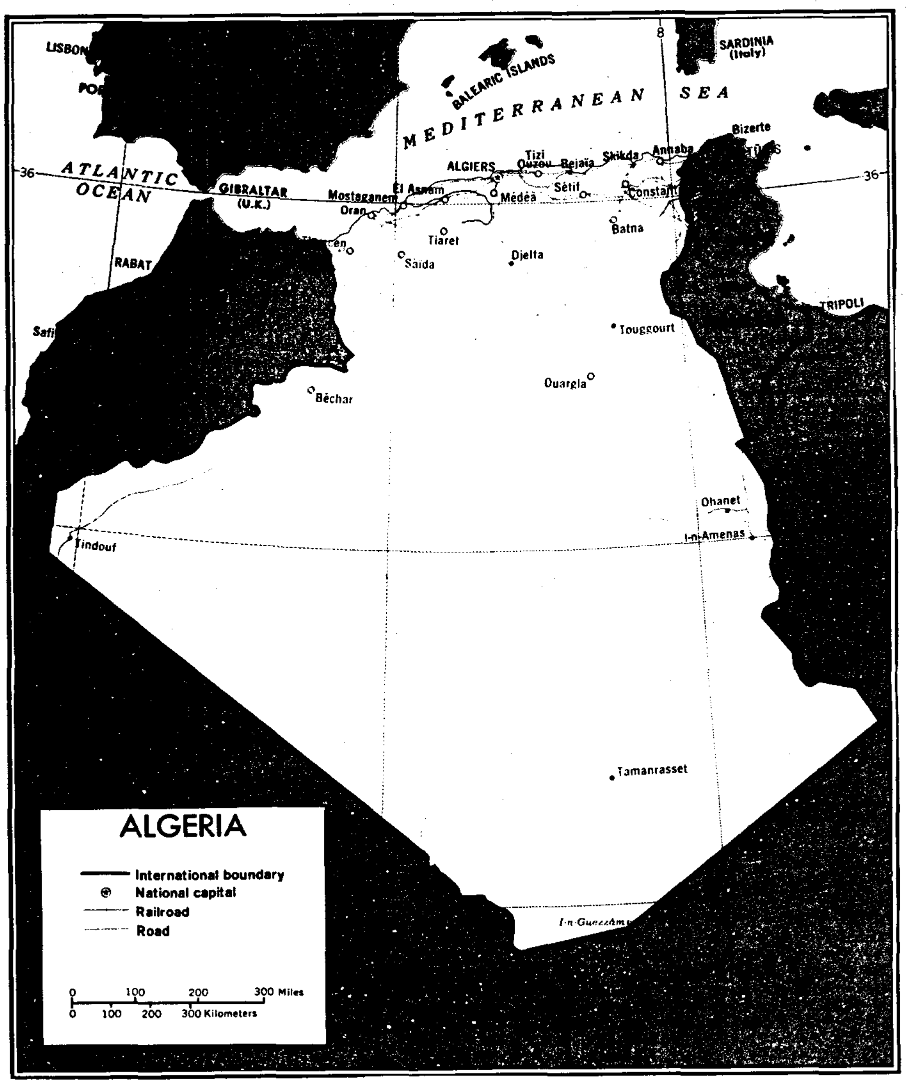
U.S. Department of State, 1983, Status of the World's Nations, Government Printing Office, Washington, D.C.

Waring, G.A., 1965, Thermal Springs of the United States and Other Countries of the World --- A Summary, U.S. Geological Survey Professional Paper 492.

Most of the maps used in Appendix A were copied from U.S. Department of State "Background Notes" for the various countries.

ALGERIA

The geothermal energy in Algeria remains largely undeveloped, although numerous hot springs with temperatures nearing 100°C in Hamman Mescoutine have been used since Roman times for balneologic purposes. Preliminary geothermal exploration studies in Algeria were initiated by the Eurafrep (France) from 1966 to 1969. The detailed geochemical and geophysical exploration revealed limited evidence of recent volcanism in the country. High enthalpy resources may exist in the northeast along the Mediterranean Coast.



Until 1979, Sonatrach, the national oil company, was in charge of geothermal R&D, but presently the activities in Algeria are conducted by the Ministry of Energy. In late 1982, the Commission for New Forms of Energy was formed to develop renewable energy resources, including geothermal. They recently signed a scientific and technical cooperation agreement with the French Energy Control Agency for R&D in renewable energy. Another active participant in the development of renewable energies in Algeria is Annaba University.

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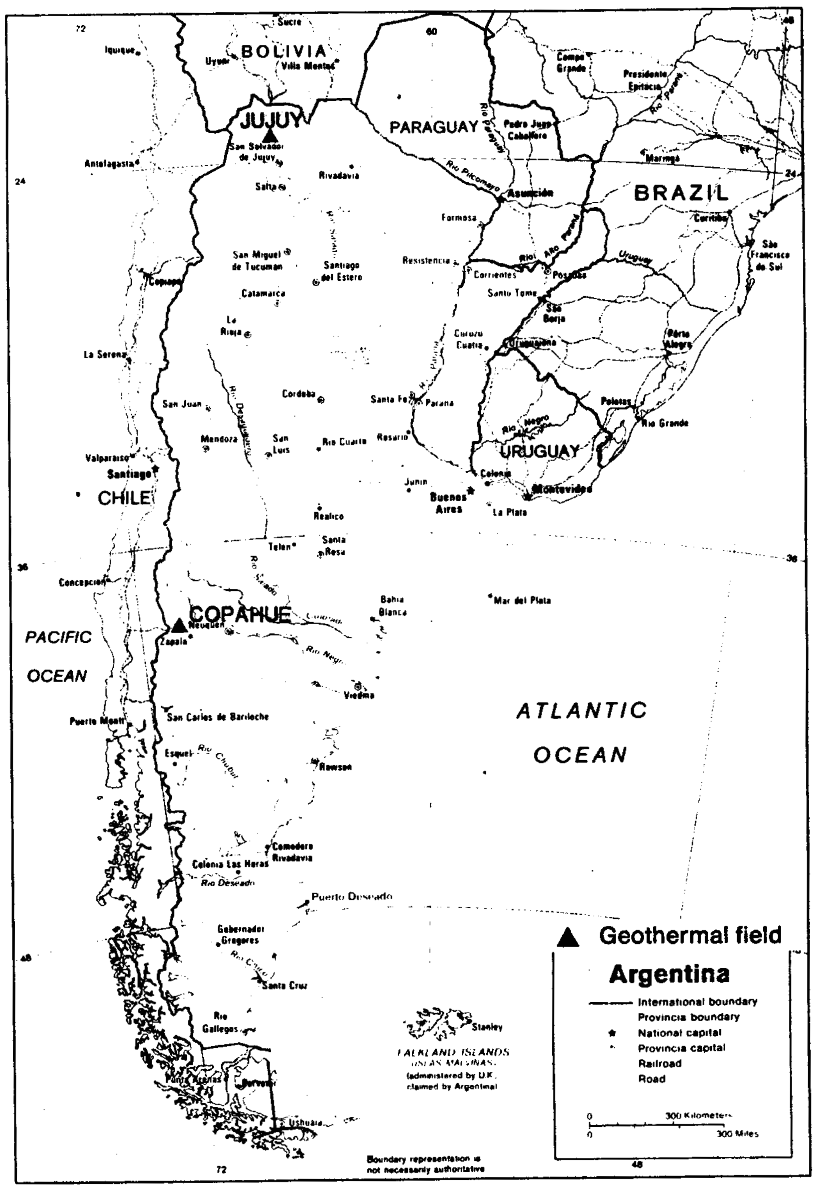
World Solar Markets, Sept. 1985, p. 12.

ARGENTINA

Argentina's geothermal resources are in many stages of geothermal development. The highest level of development, thus far, is the proven geothermal fields that have not been financed for production.

Geothermal fields have been identified at Copahue in the Neuquen district of the Patagonia region and at Jujuy near the Bolivian border. Preliminary studies have been completed at Copahue, and in February of 1983 the funds for the drilling of an exploratory well were appropriated. The successful exploratory well displayed high temperatures around 230°C. The well produced 4.4 kg/s of saturated steam, enough to drive a 2.5 MWe condensing turbine. The field power potential may be in excess of 50 MWe. The Copahue project will be presented to the Inter-American Development Bank for financing. The project entails deep drilling and continued studies to complete the feasibility assessment for the country's first geothermal power plant.



Detailed reconnaissance in other areas was conducted between 1981 and 1984. In March of 1981, reconnaissance began in the Iglesia and Payun Matru regions. In October of the same year, reconnaissance of the Bahia Blanca low enthalpy resource began in Puerto Belgrano.

<u>Bibliography</u>:

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Donovan, P.R., 1985, "The Status of High Enthalpy Geothermal Exploration in the Developing Countries," <u>Geothermics</u>, Vol. 14, No. 2/3, pp. 487-494.

ASCENSION ISLAND

Ascension Island lies along the Mid-Atlantic Ridge in the South Atlantic Ocean. The island is owned by Great Britain but is an important communications center for the U.S. Air Force, NASA, and the BBC.

As a result of a study conducted by the Idaho National Engineering Laboratory (INEL) and the University of Utah Research Institute (UURI), the Air Force is proceeding with plans to construct a geothermal power plant at Ascension Island. Preliminary studies consisted of engineering, economic, and geophysical analyses. The studies have derived positive results, encouraging the drilling of a resource confirmation well. The geothermal energy produced would supply electricity, displacing generators powered by oil transported to the island. The geothermal project, calculated to have a four year payback period, would reduce energy costs in addition to providing the island with a secure and independent energy source.

The Air Force requested $16 million of its fiscal 1986 budget for well completion and construction of a power plant.

MAP UNAVAILABLE

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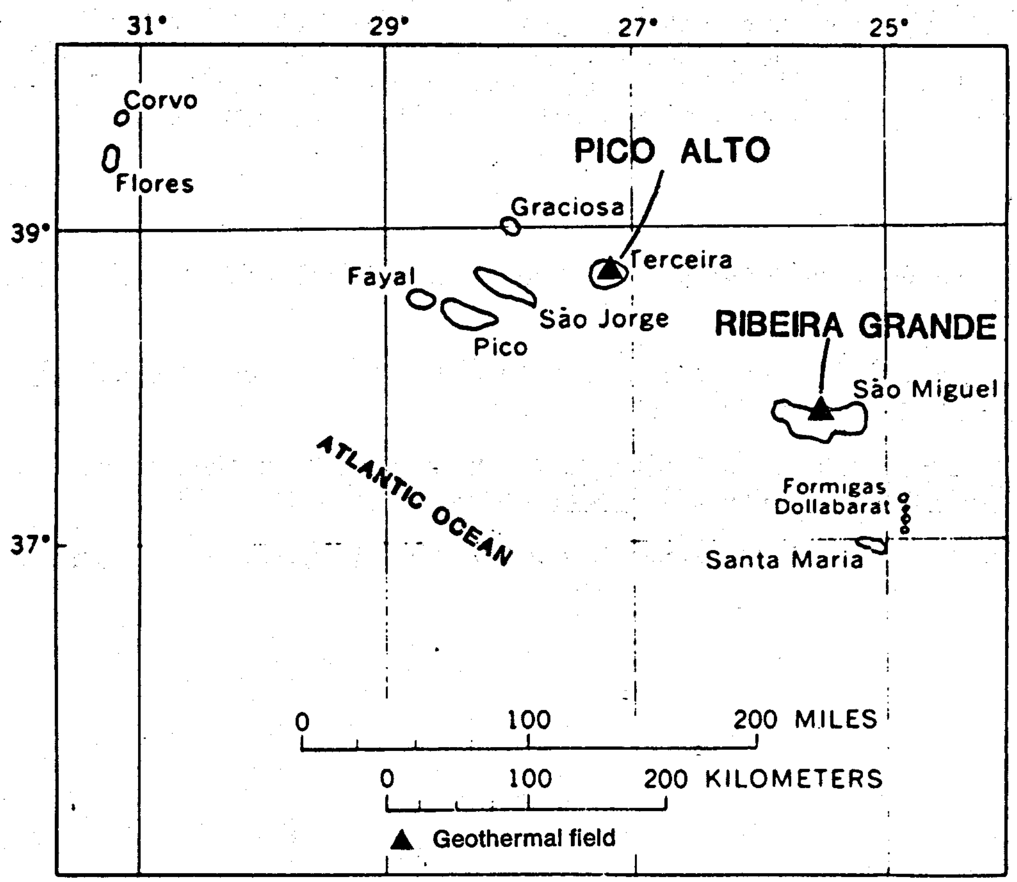
AZORES

The Azores are an autonomous region of the Portuguese Republic. The Azores Archipelago is located nearly 1000 miles west of the coast of Portugal at 37^{0} 44'N latitude and 29^{0} 25' W longitude in the Atlantic Ocean. The Azores lie in a volcanically active "hotspot" along an active transform fault. The nine islands have a total surface area of 900 km2, with a population of 258,000.

Today, geothermal development is underway on San Miguel, the largest and most heavily populated island in the Azores. The central region of San Miguel is dominated by the Aqua de Pau Massif, also known as the Fogo Volcanic Area. The Pico Vermelho cinder cone is located in northern Aqua de Pau Massif near the town of Ribeira Grande (both the cinder cone and the town are referred to as within the same geothermal field).

Although initial interest in geothermal development of the Azores began in 1950, the first exploratory borehole was not drilled until 1974, by Dalhousie University. The Dalhousie well (981 m) south of Ribeira Grande, yielded a temperature of $200^{0}C$ upon testing.



AZORES

A $1.4 million Portuguese government grant for geothermal research and development of the Azores was awarded to a U.S. company in 1976. The grant was for geothermal reconnaissance through the drilling of deep exploratory wells. Before deep drilling began, the company filed for bankruptcy and the Azorean Laboratory of Geosciences and Technology took over management of the project. Drilling consulting services were provided by Eurafrep, (France), while a Portuguese firm, Acavaco, was retained to carry out the drilling. Three boreholes, drilled between 811 and 1500 m deep, were found to have temperatures between 220-248°C.

After the drilling of successful exploratory boreholes, magnetotelluric surveys were run. The magnetotelluric and borehole information was combined to formulate a target model that was tested by the drilling of two production wells. Thermal fluids are produced from these wells at depths between 500 and 700 m with a maximum temperature of 248°C achieved at 645 m.

In 1980, a 3 MWe pilot plant supplied by two production wells was installed by Mitsubishi near the Pico Vermelho cinder cone. Reportedly, a 10 MWe power plant is to be installed on San Miguel by 1989 by General Electric and Stone and Webster (U.S.A) with financial backing from private Portuguese sources.

Future geothermal development is possible on all of the other islands. The Pico Alto Volcanic Center on Pico Island is a good geothermal prospect. The 240°-250°C geothermal center lies at a depth of 400 m and continues down to more than 1100 m. The islands of Terceira and Fayal are also prospective geothermal areas. All three islands have plans to install small geothermal power plants by 1987 with an estimated 7.5 MWe total capacity.

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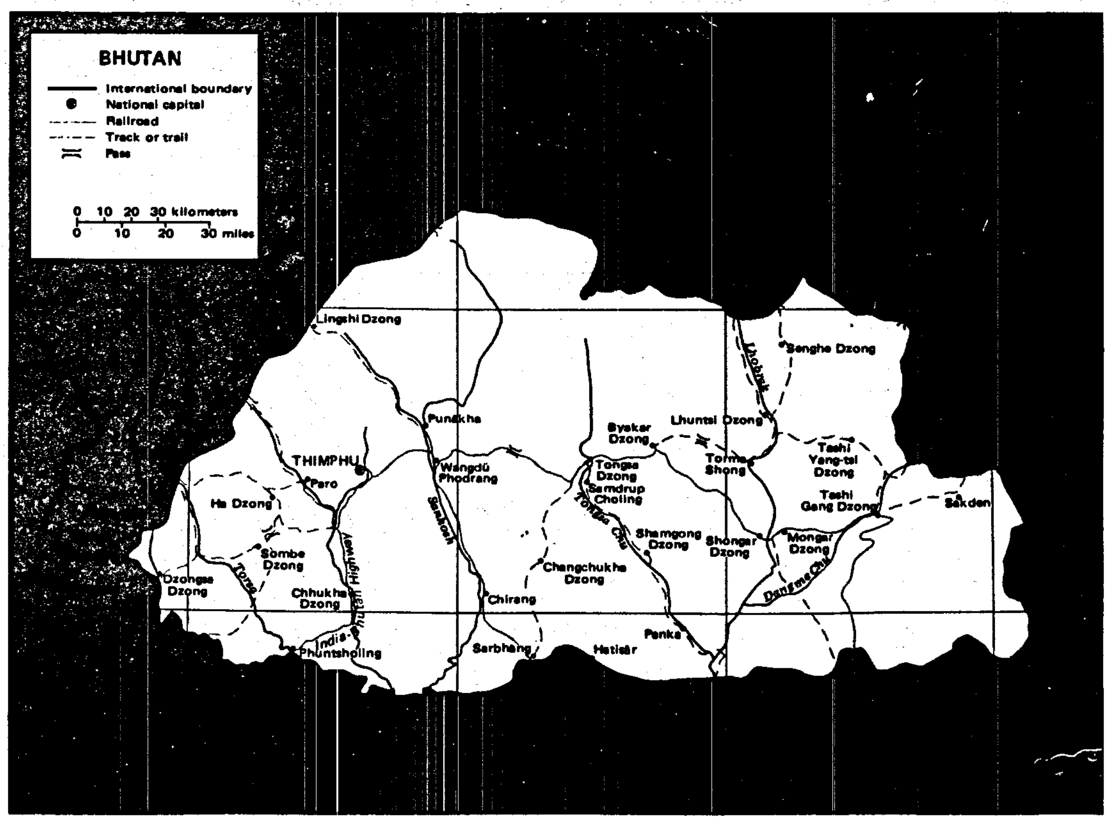
BHUTAN

Bhutan is located approximately where the Java Trench meets the Himalayan Frontal Thrust at a subduction zone. Therefore, the 47,000 km2 of Bhutan should be a promising geothermal prospect. No feasibility studies have been published to date, although hot springs reportedly do exist in the country.

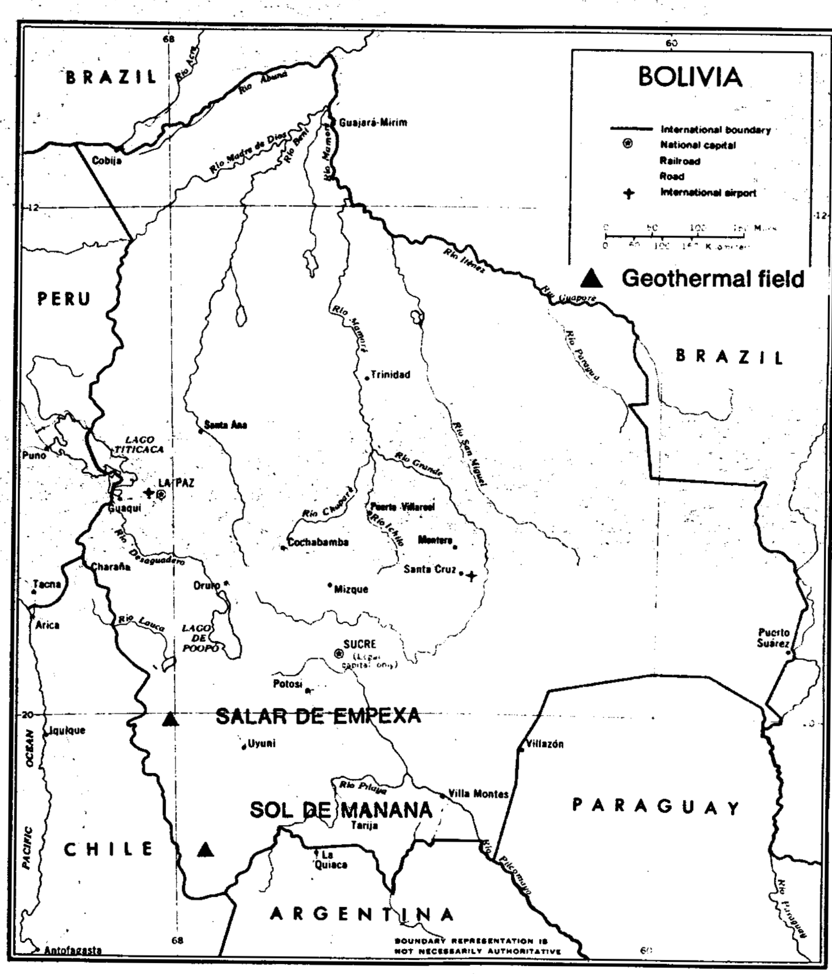


BOLIVIA

A nationwide inventory and assessment of Bolivia's hot springs, thermal areas, and other surface thermal expressions began in 1976. Since then, a total of 42 thermal features have been identified within the southwestern region of the country. The most favorable areas observed are located within the Empexa River Valley (Salar de Empexa) and Laguna Colorada (Sol de Manana field).

The early studies showed that the most valuable geothermal prospects were situated adjacent to the Chilean border in the province known as the Western Cordillera, and were related to recent volcanic activity. Other attractive areas for future prospecting were identified within the Highlands (Altiplano Basin) and in the Eastern Cordillera.

The 1976 assessment was funded as part of the United Nations Development Program (UNDP), and carried out under the direction of Bolivia's National Electric Power Company (ENDE). Prefeasibility studies within the Empexa River Valley (Solar de Empexa) and at Laguna Colorada were completed in 1978-79. The investigations included geoscience studies, remote sensing techniques, and thermal gradient drilling.



The prefeasibility study of resources within the Empexa River Valley was performed and incorporated the results of geophysical, geohydrological, and geochemical surveys. From these studies, a locality of interest between Desert Hot Springs and Towa Hot Spring was defined. Six thermal gradient test holes were then drilled at this locality to depths ranging from 154 to 165 m. The wells measured a shallow thermal gradient ranging between 20 and 60°C/100 m. Surface geophysical surveys, when used in conjunction with chemical geothermometry applied to Towa Spring fluids, suggest a high-temperature resource at relatively shallow depths. A layer of low resistivity is present in the area at a depth of 500 m and may be an expression of a hydrothermal reservoir. Geothermometry suggests an equilibration temperature of 240°.

The Laguna Colorado geothermal area lies adjacent to the Chilean border and approximately 200 km south of the Empexa area. Within the area, abundant Quaternary volcanic rocks are present at the surface and three areas of fumarolic activity have been observed. Geochemical studies indicate that thermal fluids issue from a vapor-dominated system at temperatures between 200° and 250°C.

The Sol de Manana prospective geothermal field lies within the Laguna Colorada area and has been designated as the most promising geothermal area in Bolivia. Geophysical studies performed to date have indicated that the depth to basement at Sol de Manana is likely to be between 1000 and 1500 m. The single thermal gradient test hole drilled in the area was drilled to a depth of 127 m where the well produced dry steam and fluid at a temperature above 150°C. In 1985,the UNDP and the Bolivian and Italian governments began funding a feasibility study of Laguna Colorada to prove the existence of commercially exploitable geothermal resources in Bolivia. The $11 million project is expected to be completed before the close of 1987. The total projected geothermal use by 1990 in Bolivia is predicted to be 30 MWe.

Other prospective areas in Bolivia include Sajama, Salar de la Laguna, Volcan Ollague, Quetena, and Laguna Verde. Although no deep wells have yet been drilled, reservoir temperatures are predicted to be up to 240 to 250°C.

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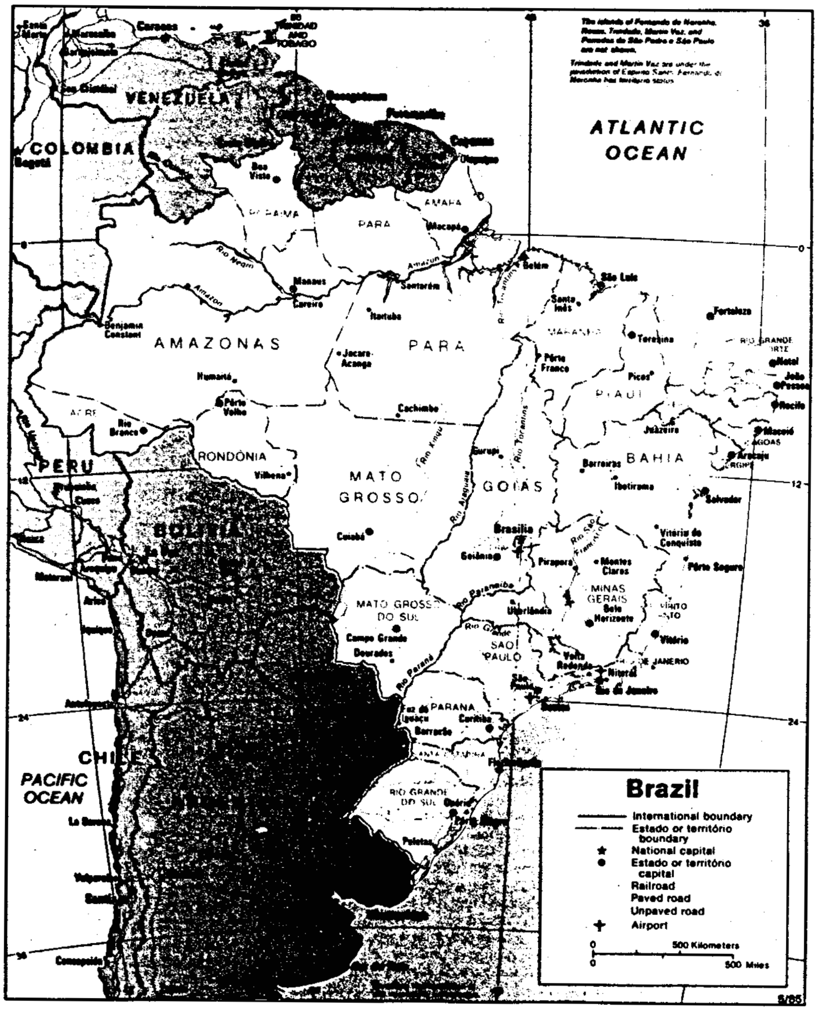
BRAZIL

A geothermal resource assessment of Brazil was completed in 1981 using available heat flow, thermal conductivity and radiogenic heat productivity data. From this study, the total estimated thermal resource base of Brazil was 19.0 x 1024 Joules. Since this assessment is the only geothermal study done in Brazil thus far, it is evident that reconnaissance still needs to be carried out in order to determine the country's geothermal potential.

No high-temperature resources have been discovered to date. The data have indicated that very little of Brazil's heat is associated with young igneous systems. Therefore, low- and moderate-temperature systems are the predominant geothermal resources in Brazil. In the study, they were divided into (1) thermal spring systems (hydrothermal convection), and (2) deep hot water aquifers (conduction dominated regimes). Thermal energy associated with thermal spring systems was estimated to be 8.3 x 1019 Joules (J). Deep hot water aquifer systems were considered only for the Parana Basin, where the upper aquifer was estimated to contain 27.4 x 1020 J, and the deeper aquifer roughly 22 x 1020 Joules (J).



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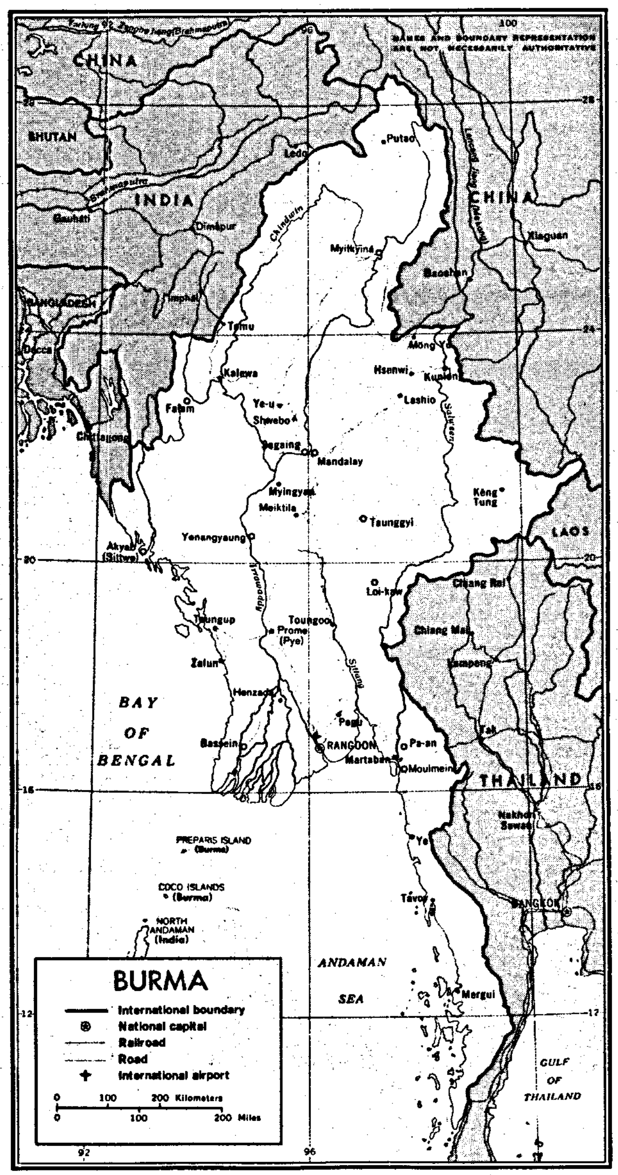
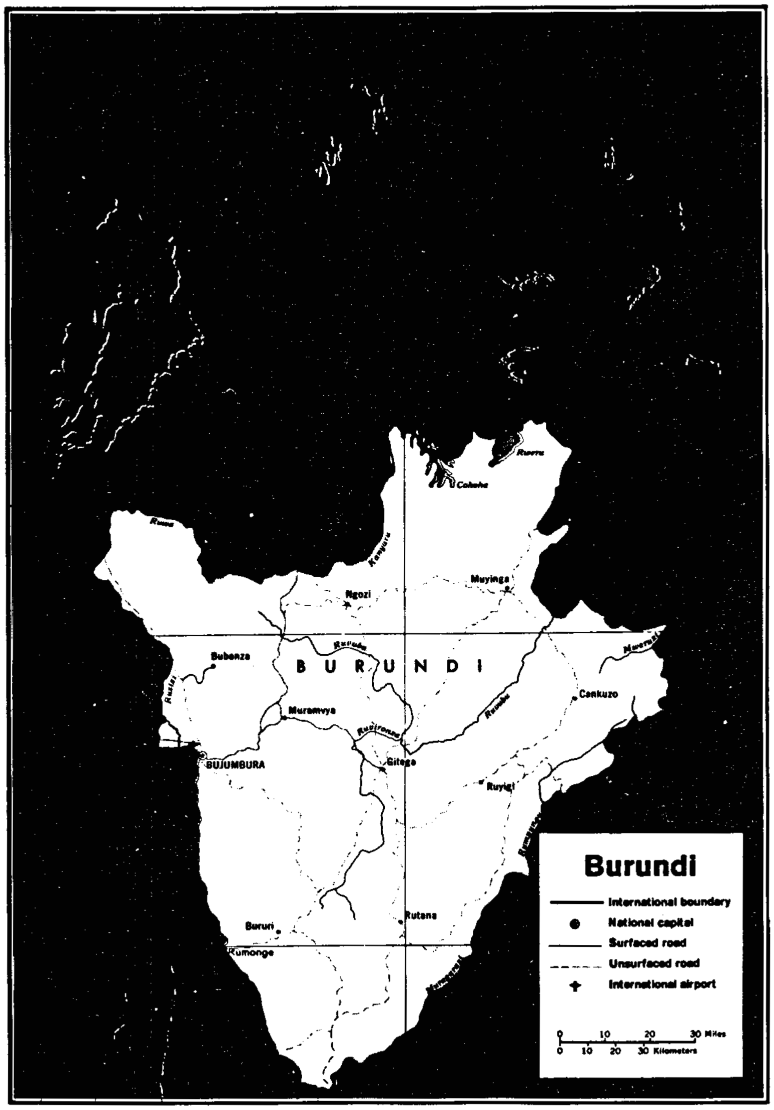
BURMA

Burma, located northwest of Thailand, lies along an active transform fault close to a trench within the Bay of Bengal. Volcanic rocks are not common, but are present in some parts of the country. There are numerous thermal springs primarily located in the east near the Thai border. The hottest of these springs reportedly have temperatures near 90°C. Although geothermal reconnaissance has been done in neighboring Thailand, Burma has not received funds nor support for geothermal resource exploration.



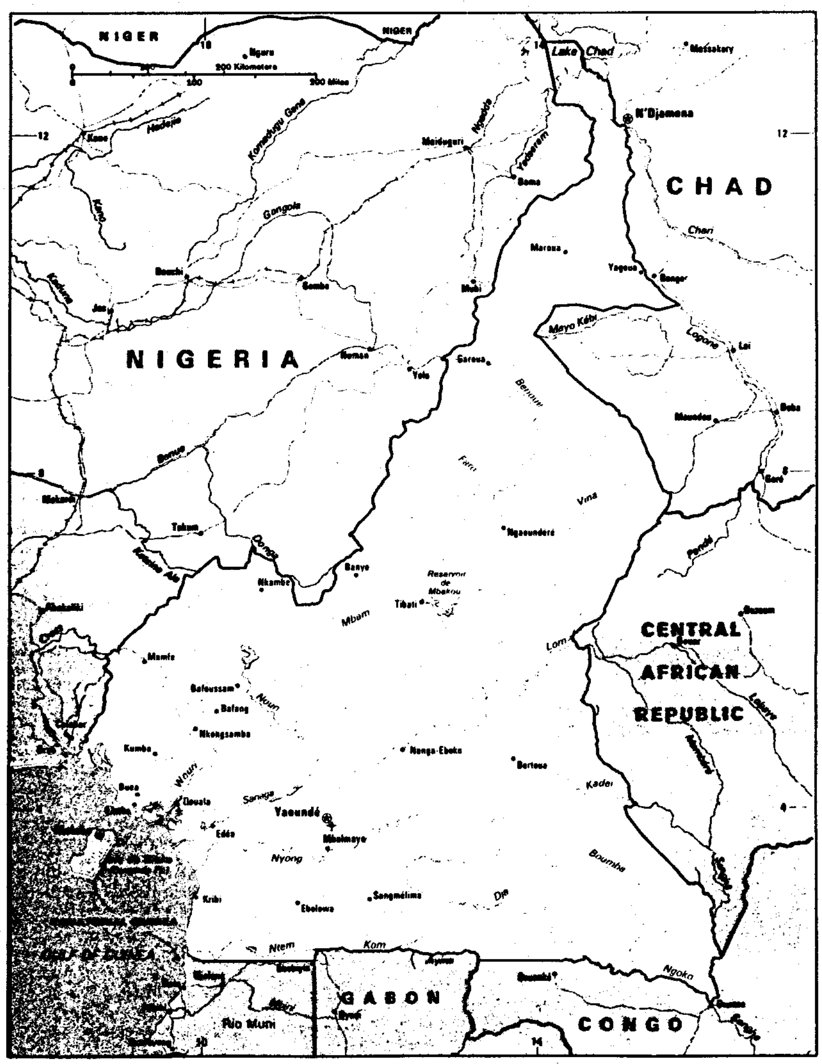
BURUNDI

Burundi is a small African country surrounded by the nations of Zaire, Tanzania, and Rwanda. It lies within a region of active faulting and volcanism. The 27,834 km2 of land contains a population of 4,348,000 people. Burundi is a good prospect for geothermal reconnaissance, though no studies have been initiated.



CAMEROON

Located in west-central Africa, Cameroon consists of 475,442 km2 of area on which 8,650,000 people live. The country lies along a chain of Tertiary to Holocene age volcanoes and is underlain by numerous intrusions. Some hydrothermal and hot dry rock systems may exist within the volcanically active area. As a developing African country, Cameroon would be a prime candidate for development of its geothermal energy if available.



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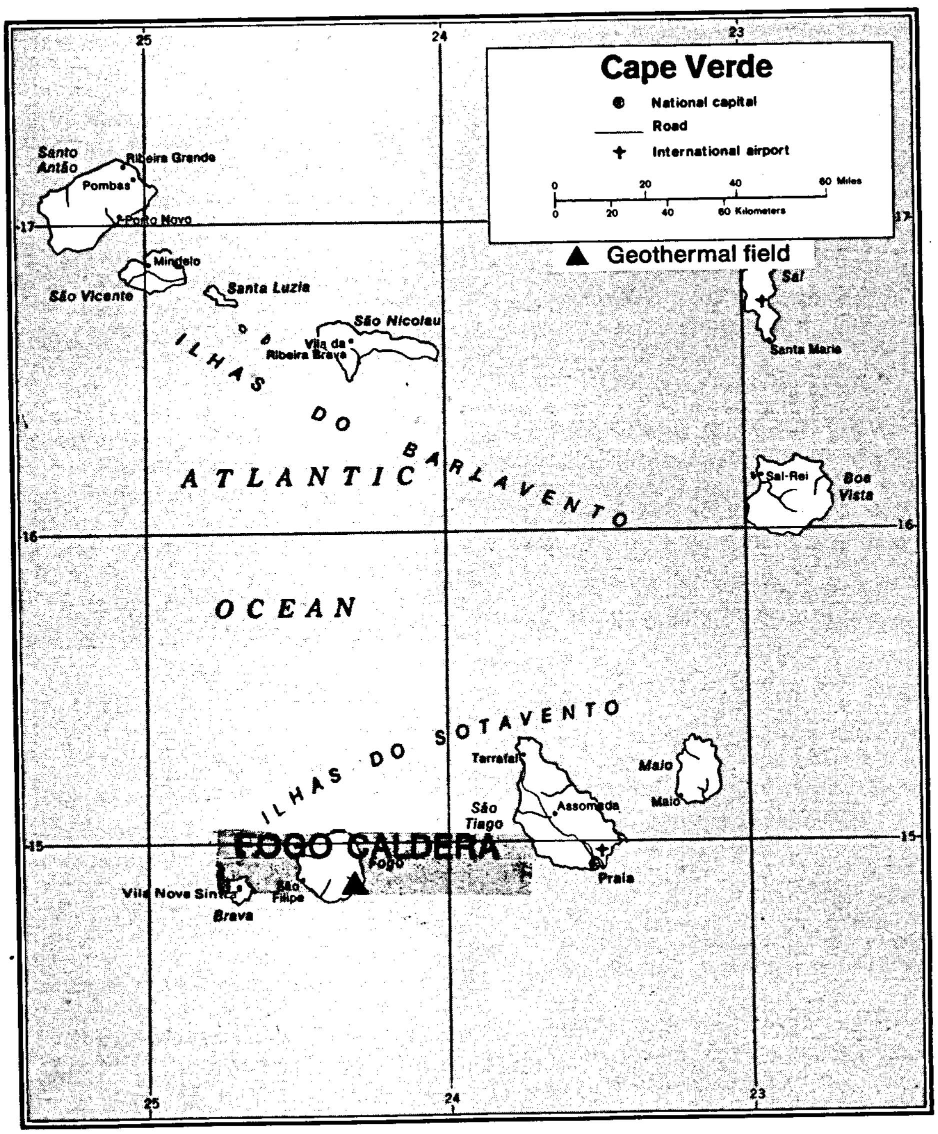
CAPE VERDE

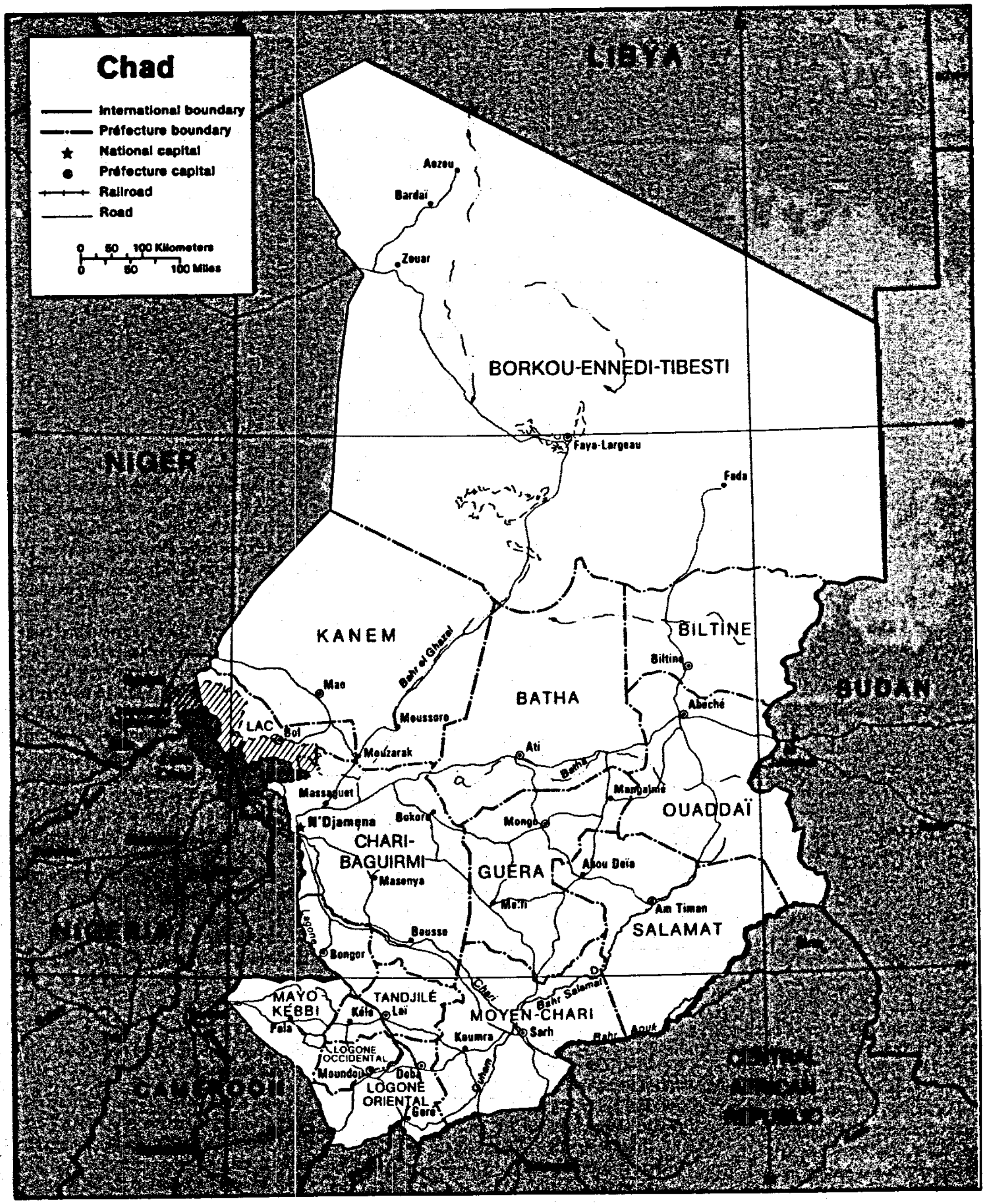
The Cape Verde Islands are a group of eight islands off the west coast of North Africa. Geothermal energy for power generation is under consideration on the Island of Fogo, one of the southernmost islands. Fogo's current electrical generating capacity is 600 kW for a population of 31,000.

A preliminary reconnaissance study performed by Lund University (Sweden) suggested that there could be a hydrothermal system on the island of Fogo that attains reservoir temperatures between 270 and 300°C. The system is thought to be contained in a crescent-shaped zone within the Fogo caldera.



CHAD

The northern branch of the Benue Trough forms the Chad rift in north central Africa. The 1,284,000 km2 area remains volcanically active. Chad is a developing African country of 4,547,000 people that would benefit from utilizing its geothermal resources.

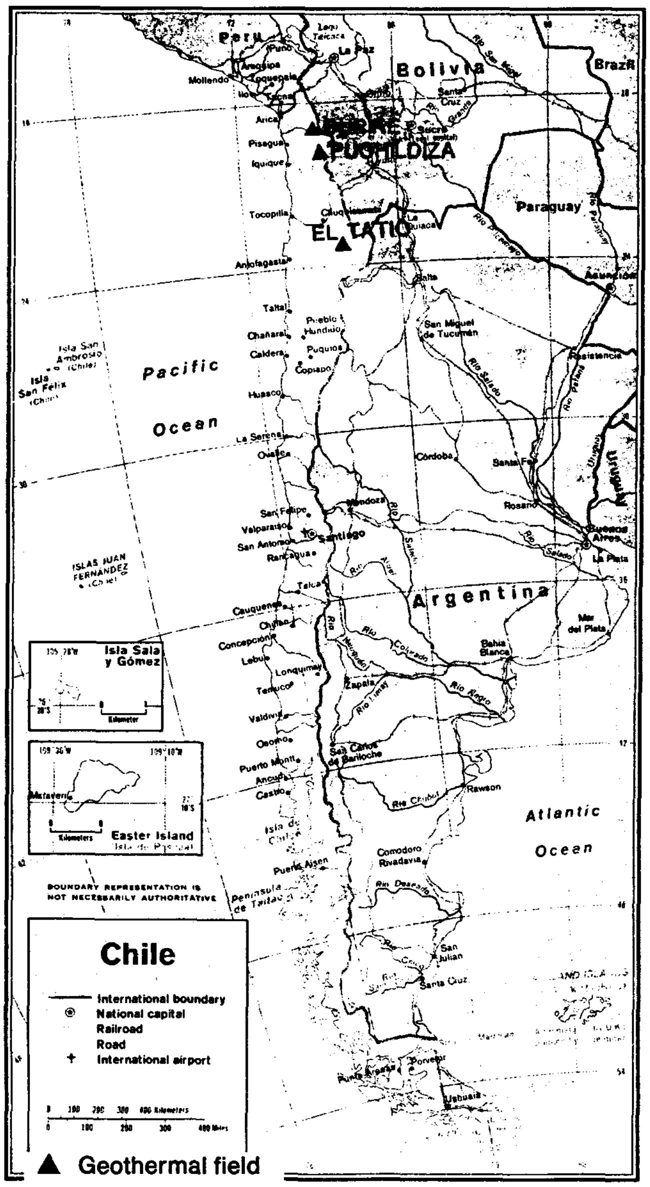


CHILE

The full extent of Chile lies east of the Peru-Chile Trench, explaining the great amount of tectonic and thermal activity in the country. Though often inaccessible due to the Andes Cordillera, the geothermal potential is high.

Systematic exploration of Chile's geothermal resources began in 1968 as a result of an agreement signed between the United Nations Development Program (UNDP) and the Chilean government. The assessment of the country's geothermal resources was done by the Chilean owned company, Production Development Corporation (CORFO).

Initially, reconnaissance exploration was performed and preliminary geoscience studies were undertaken at selected areas in northern Chile. As a result of this program, favorable areas for additional studies were identified and prioritized on the basis of resource potential. The El Tatio area was recognized as the most valuable area and thereby given high priority for future work. Detailed studies including geology, geochemistry, shallow thermal studies, and electromagnetic surveys were carried out at El Tatio and Puchildiza. Preliminary geoscience investigations were also performed at Surire and Pampa Lirima.



The El Tatio geothermal area lies about 80 km east of the community of Calama in Antofagasta Province, northern Chile. The 10 km2 area contains boiling springs, geysers, fumaroles, and salt evaporite deposits that result from precipitation from saline thermal fluids. El Tatio, according to geophysical investigations, overlies an area of low resistivity that extends over 30 km^2 at 1000 m depth.

Exploratory and production wells were drilled between the years of 1969 and 1974. The wells, which included six deep slim-hole exploratory wells and seven deep larger diameter production wells, were drilled to depths from 600 to 1815 m. Three of the large diameter wells eventually produced significant volumes of fluid. The wells showed that the main production zone occurs between 750 and 900 m and delivers fluids at temperatures between 225^o and 250^{o}C.

An overall economic feasibility study to determine the field's competitiveness with respect to other thermoelectric plants was performed in 1975. The work, sponsored by UNDP, was performed by the company ELECTROCONSULT (Italy) and managed by CORFO. The study showed that a 15 MWe power plant could be constructed at the field and produce electricity at competitive prices. In the past, construction plans at El Tatio have been delayed and presently the field is open to bidding for development.

The Puchuldiza geothermal area is located nearly 150 km northwest of the community of Iquique, in northern Chile. The area is part of the Western Andean Cordillera and is characterized by a number of surrounding volcanic centers. The Puchuldiza area contains thermal springs and fumaroles occurring at the intersection of multiple fault sets. Within the area, fluids issue at low levels along the Puchuldiza River with surface temperatures often near the boiling point (86^{o}C at 4250 m elevation).

To date, the Pulchuldiza project includes six exploratory wells drilled to depths up to 1150 m with a maximum temperature recorded in one well of 200^{o}C. The project was discontinued in 1982 when sufficient flow rates were not encountered.

The Surire geothermal area is located at the southeast edge of the Surire Salt Desert along the Chile-Bolivia border. The area covers about 45 km2 and consists of nearly 230 hot pools and springs. The Surire area has undergone resource assessment studies including preliminary geologic and hydrologic investigations as well as shallow temperature surveys.

The vast majority of Chilean geothermal fields are located within the Western Andean Cordillera. The other areas (nineteen have been identified) considered to be of prospective value are burdened by adverse climatic conditions, inaccessibility, and remoteness from population centers.

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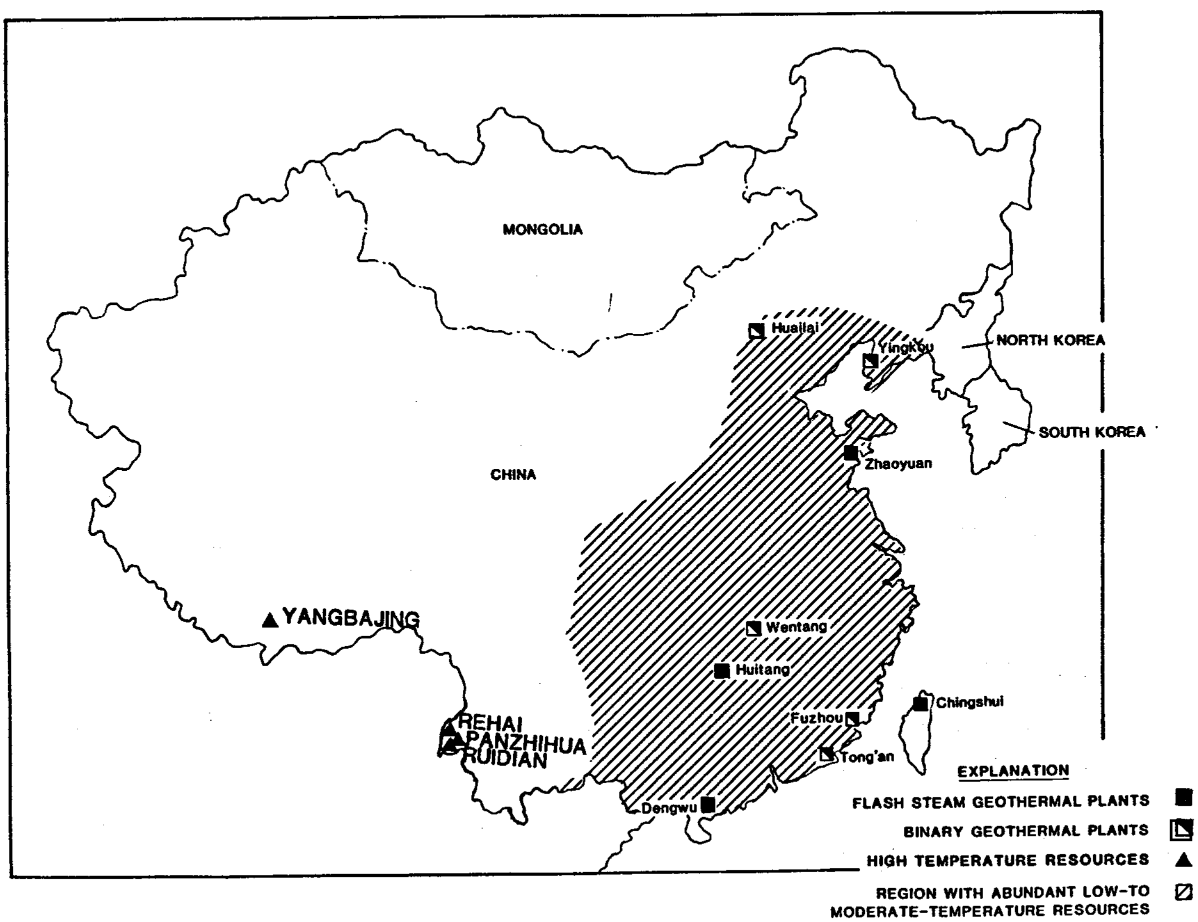
CHINA

The use of geothermal waters by the Chinese can be traced back 2,000 years. Up to the 1960's, much of the resource in the country had been used for bathing and medicinal applications. Since that time, China has steadily developed its exploitation of geothermal energy by direct-use applications and power generating stations. Although a national development plan remains unfinished, China appears strong in its commitment to geothermal energy development.

About 3,000 geothermal areas exist in China, about 2,400 of which are natural hot springs. Currently 40 geothermal fields, mostly low- to moderate-temperature, have been or are being explored and assessed. Geothermal energy currently produces 14.3 MWe and a total of 20 to 30 MWe is planned by 1990. The overall identified potential for electrical generation is 220 MWe.

A major part of China's geothermal development is at Yangbajing in the Xizang (Tibet) Province. This field has been under study since 1975. A 3 MWe dual-flash unit has been on-line since 1981, with another 3 MWe unit coming on-line in 1983. Although a comprehensive geothermal power estimate for the region is not available, Yangbajing is considered to be one of the fields with the greatest developmental potential in China and is expected to add an additional 15 MWe by 1990. China has also identified 44 potential high enthalpy geothermal fields in the western part of the country.

GEOTHERMAL DEVELOPMENT IN CHINA



The western to mid-Western part of China seems to have the greatest potential for high-temperature geothermal resources. Three other high temperature (>220°C) resources exist there at Rehai, Panzhihua and Ruidian. These three fields have been targeted as power generating fields.

Other power plants (mostly binary) exist at a number of low- and moderate-temperature locations in China. The Dengwu field, located in Fengshun in Guandong Province, was the first field developed in China for electrical production. The first unit was an 86 kW unit that came on line in 1970 and is still on-line. A 200 kW unit was brought on-line in 1978, and a third unit is under construction. The temperatures at this field range from 87 to 94°C.

Since 1971, a binary-cycle power station has been on-line in Huailai within the province of Hebei. The Wentang power station, located in the Jiangxi Province in southeastern China, also came on-line in 1971 and produces 50 kWe. The flash-steam plant at Huitang (in Hunan Province), brought on-line in 1975, produces 300 kWe. Wastewater from the plant is cascaded to greenhouses, a spa, and a hospital. A 100 kWe unit has been operating at Yingkou since 1977. A geothermal power plant located in the Tong'an field, Fijian Province near Hong Kong, reportedly produces 300 kWe from a binary system. The Zhaouyan power plant in Shandong Province on the east coast of China along the Yellow Sea reportedly has a capacity of 200 kWe. A geothermal power plant is reported to be operating in Fuzhou, Fijian Province; no details are available on its present status and/or capacity.

Since July 1983, a $10 million geothermal development project with UN and Italian funding has been underway in China. The project provides for consultant services, a geophysical model of the Tianjin basin, exploration of the Yangbajing area, overseas training facilities for 30 Chinese engineers and more than 30 pieces of geothermal equipment including a computer facility and 3000 m capacity rig.

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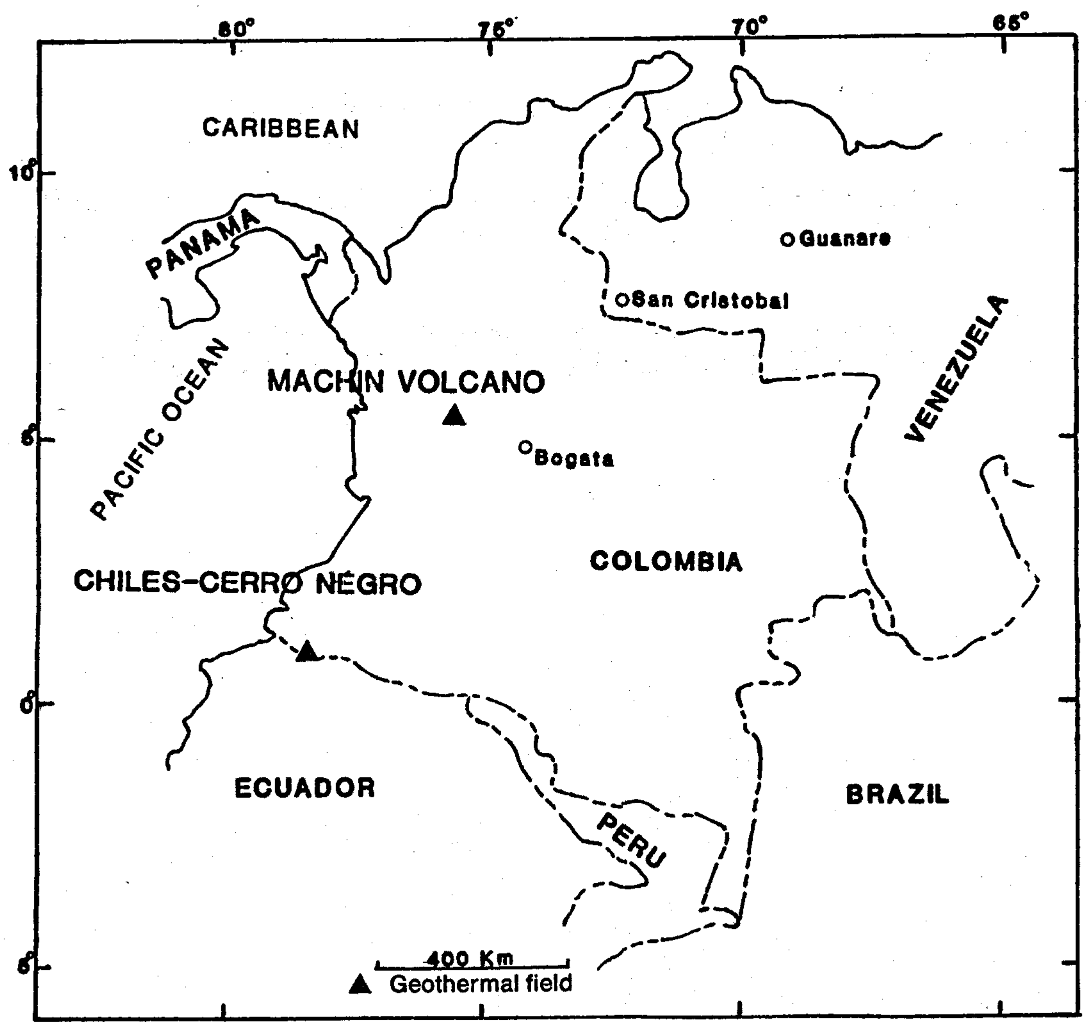
COLOMBIA

Colombia is located in a fault zone close to where the Peru-Chile Trench and the Middle American Trench meet. Western Colombia is traversed by three cordilleras of the Andean mountain system. A few warm thermal springs are located around Bogota and in the southwest corner of the country.

In 1968, an agreement was made between ENEL (Italy) and the Caldas Hydroelectric Station (CHEC) to perform a preliminary assessment of the geothermal resource potential of a 15,000 km2 region of Colombia. The region is known as the Volcanic Massif Del Ruiz and extends southward from the department of Antioquia between the Magdalena and Cauca Rivers.

By 1978, smaller areas within the study region had been identified for more detailed exploration. Area exploration was begun with the cooperation of ENEL, the Colombia Institute of Electricity (ICEL), and CHEC. Partial funding was provided by the Development Project Fund (FONADE). A Colombian consulting group (CONTECOL) was contracted to perform much of the work. Geological,



geochemical, and geophysical studies were performed by CONTECOL in selected localities within the study region. The conclusion reached was that a high-temperature resource may be present in the Ruiz area while low- to moderate-temperature systems may be present at Espiritu Santo, Manzanares, and San Diego.

The effort was continued in 1983 with financial assistance from FONADE and technical support provided by CHEC, CONTECOL, and Geothermia Italiana. Prefeasibility studies were performed in the region between Cerro Bravo Volcano and the Tolima and Machin Volcanic areas. The Machin Volcano was selected for deep exploratory drilling.

From these area investigations, sites were selected for drilling programs: Nereidas, Lake Otun, Cerro Espana, and Machin Volcano. A 3 MWe pilot plant may be installed by 1990.

Another potential area in Colombia is The Chiles-Cerro Negro geothermal area, a binational field situated astride the Colombia-Ecuador border. A prefeasibility study is being executed under a joint venture by the Ecuadorian and Colombian governments and OLADE.

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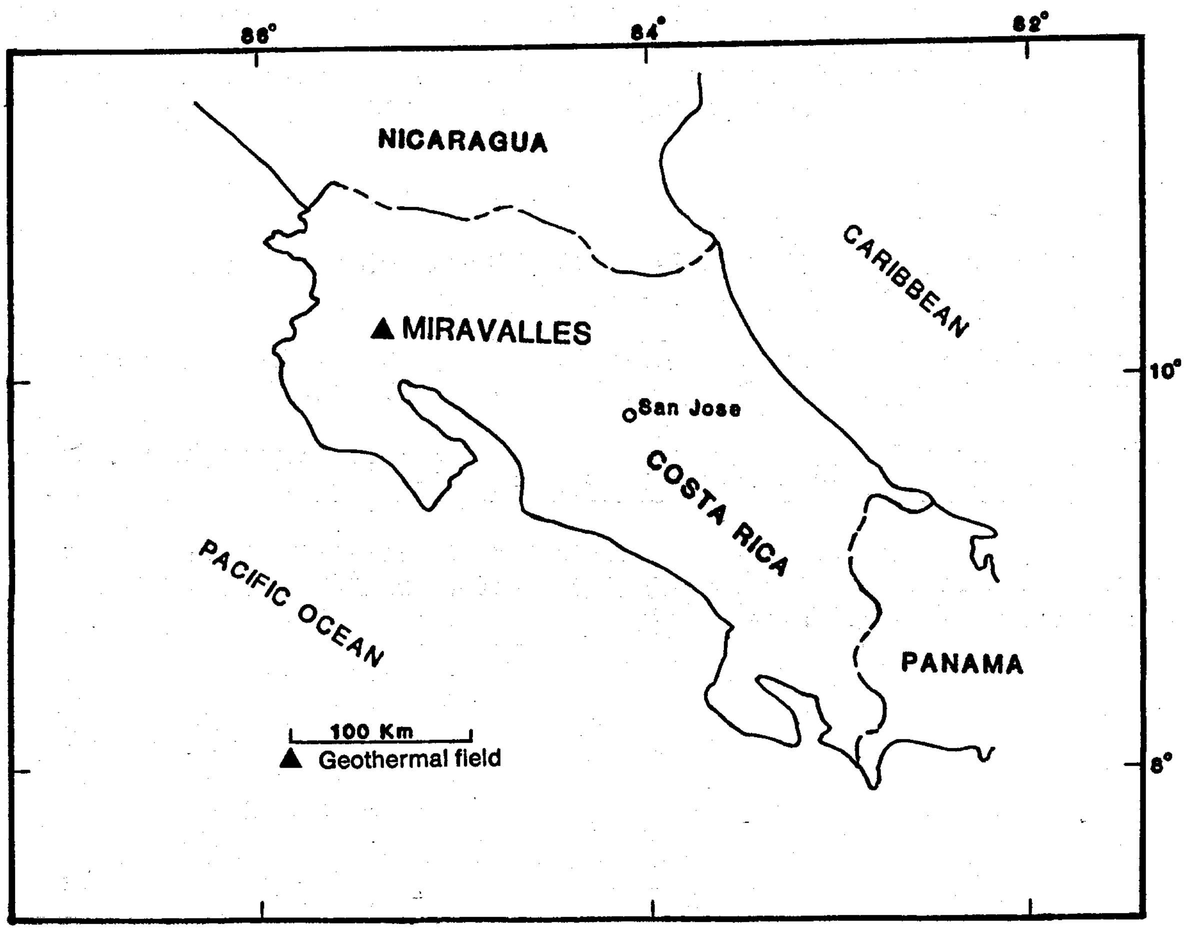
COSTA RICA

As a product of the subduction of the Cocos plate beneath the Caribbean plate, Costa Rica is a volcanically active region. Hot springs are very prevalent in the central part of the country.

Geothermal energy has been of interest in Costa Rica since 1959, when preliminary nationwide inventories of thermal manifestations were made. Subsequent visits by United Nations geothermal experts indicated the importance of detailed exploration in the thermal areas of the volcanic Guanacaste Range. Between 1964 and 1974, however, no specific effort was made toward geothermal development.

Interest in geothermal development was renewed in 1975 and a regional assessment was begun in the area surrounding the Miravalles, Ricon de la Vieja, and Santa Maria volcanoes. Based on a prefeasibility study funded with IDB assistance, Miravalles was targeted as the most promising area.



The Las Hornillas de Miravalles geothermal area is located within the Guanacaste geothermal province. The Guanacaste area is characterized by a line of surface thermal features 30 km in length occurring along the flank of an active volcanic chain. As recommended by the reconnaissance studies, three wells were drilled into the 240°C reservoir. Production drilling began at Miravalles in 1979 and continued through 1980 with the completion of three wells to depths of 1200 to 1300 m.

A new drilling program was initiated in March 1984 aimed at drilling 5 to 6 deep wells. The new drilling program was advised by Electroconsult and funded by IDB. The drilling led to a 23 MWe single-flash and a 32 MWe double-flash wellhead potential. It is projected that a power generating station of 55 MWe may be on-line by 1990.

In addition to the areas mentioned, preliminary studies have indicated that 54 localities may hold geothermal potential. Many of these areas possess moderate-temperature resources and therefore, may be attractive for binary electric generation technology. Other areas that have been explored in the Guanacaste region include Las Pailas, Salitral, and Boringuen where geochemistry has indicated high (240°C) subsurface temperatures.

The Instituto Costarricense de Electricidad (ICE) is the agency within the country that began planning for geothermal development. To date only Miravalles has undergone feasibility studies but prefeasibility studies have been performed at Pailas-Rincon de la Viega. Other fields have been identified but not assessed.

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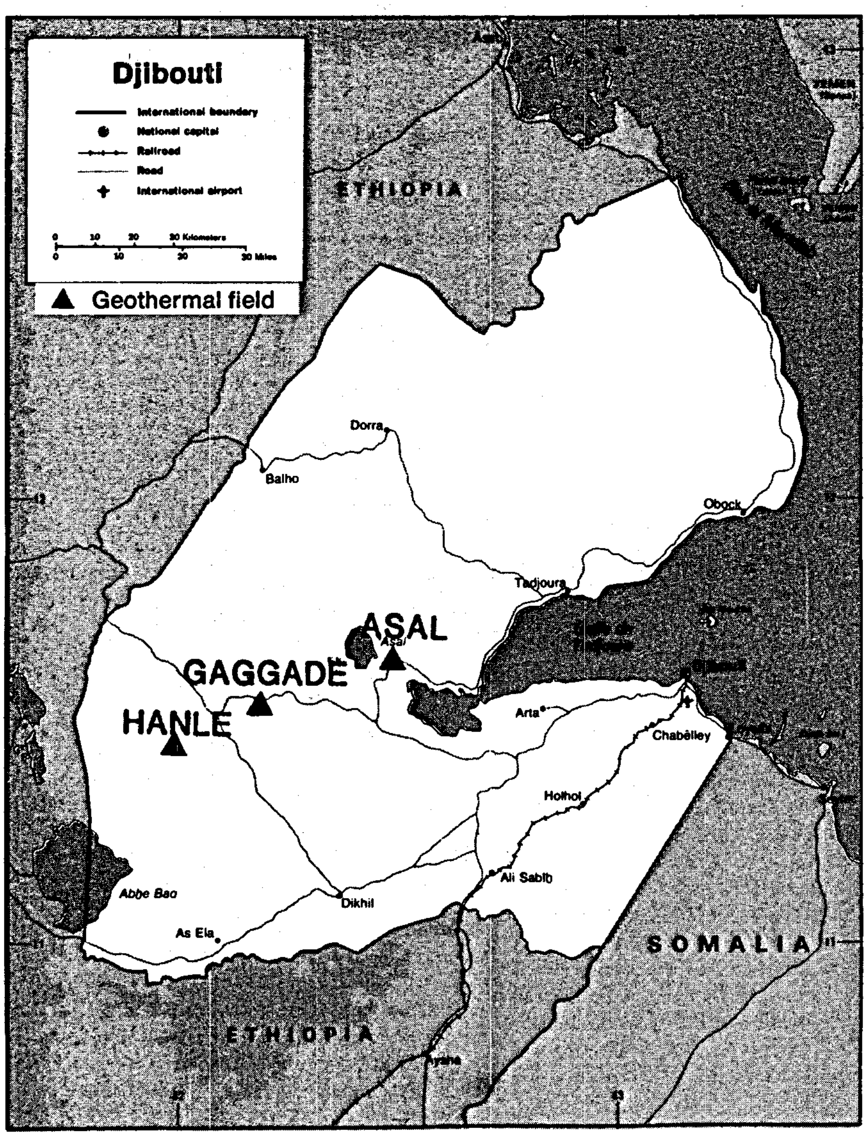
DJIBOUTI

The Republic of Djibouti, prior to 1977 the Afars/Issas Territory of France, is situated near the southern end of the Red Sea with an area of 22,000 km2. Djibouti is at one end of the East African Rift system near the spreading ridge within the Red Sea. Reconnaissance for geothermal resources began in 1970.

Prior to 1977, the French Bureau of Research, Geology, and Mines (BRGM) was responsible for geothermal prospecting in the region. The rift zones of Gaggade, Hanle, and Asal were identified by BRGM as having "good geothermal potential."

At Asal, BRGM found temperatures of 250^{o}C at a depth of 1000 m through exploratory drilling during 1974-75. Detailed exploration in the Hanle area began in 1981, with the assistance of Italian scientists. Three temperature gradient wells have been drilled and the area has been selected as the site of Djibouti's first production wells. In 1984, $16.6 million was approved for



field development, including two temperature gradient wells (450 m) and four production wells (2000 m). If early production drilling at Hanle is unsuccessful, Gaggade will be considered as an option. This project was financed by the World Bank, UNDP, OPEC Fund, the African Development Bank, the Italian government, and the government of Djibouti.

International funding will also be used for installation of a power plant of a yet unspecified capacity. By 1995 installed geothermal capacity should be 20 to 30 MWe. With financial and technical assistance, Djibouti will be a self-sufficient electricity producer within the next 10 to 15 years.

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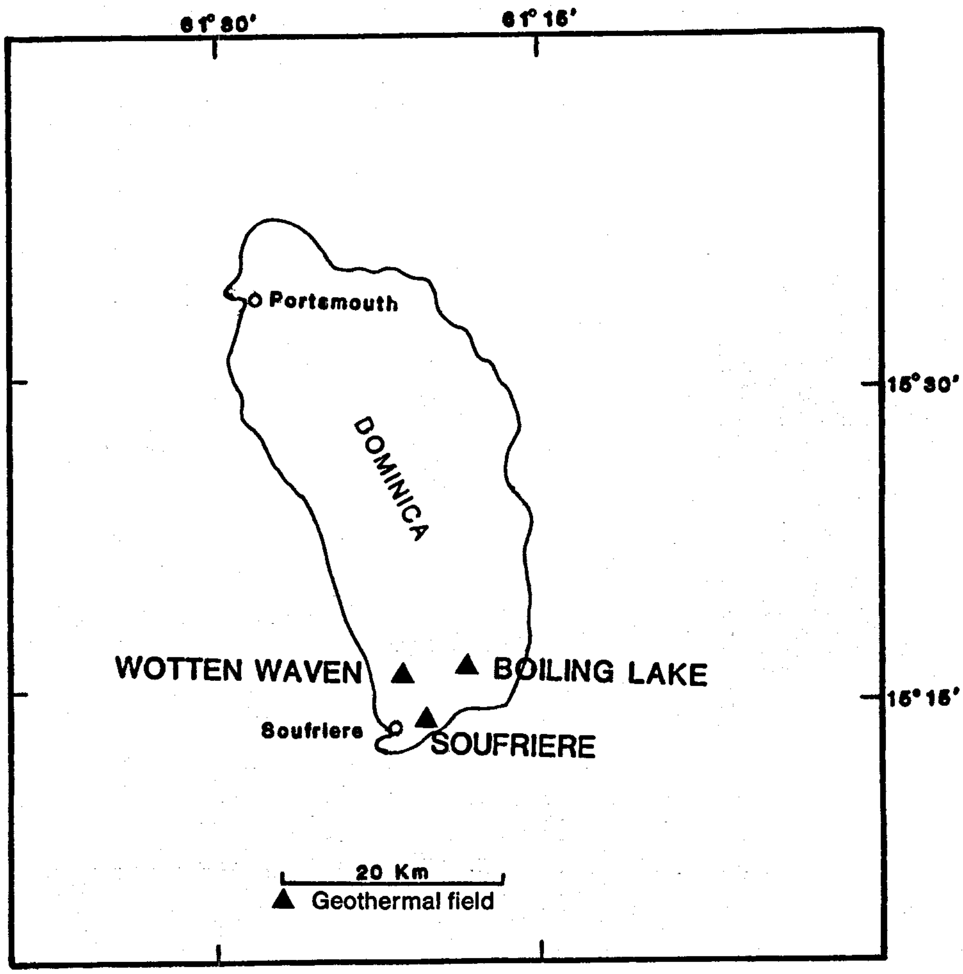
DOMINICA

Dominica, one of the largest islands of the volcanically active Lesser Antilles island arc, is located within the Caribbean plate. Dominica is a good prospect for high temperature geothermal resources. In 1982-83, the French Bureau de Recherches Geologiques et Minieres conducted a prefeasibility study of the Soufriere, Wotten Waven, and Boiling lake prospects. The effort included volcano logic, geochemical, and geophysical studies and resulted in the selection of Wotten Waven as the zone of priority. According to DiPippo (1985), 10 to 15 gradient wells have reportedly been drilled at Soufriere and Wotten Waven. Each of these sites may have a geothermal potential in the range of 50 to 100 MWe.



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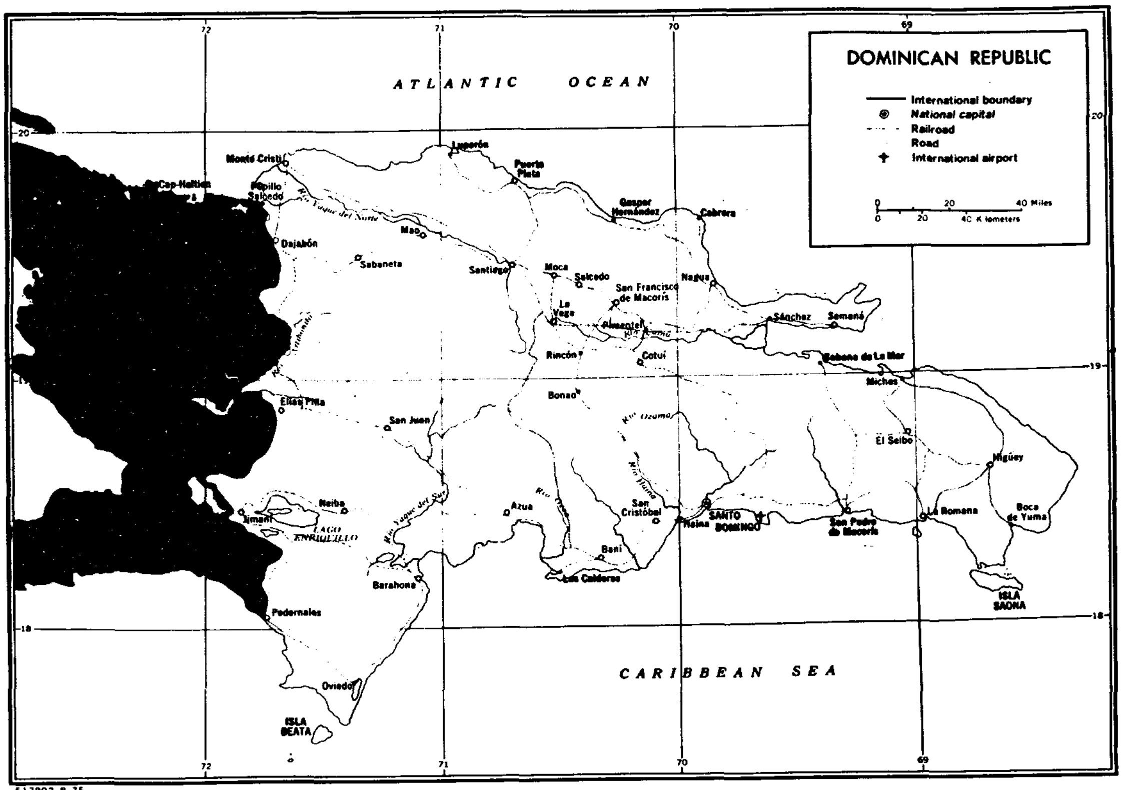
DOMINICAN REPUBLIC

Located in the Greater Antilles, the island of the Dominican Republic has an area of 48,734 km2 and a population of 5,647,977.

The Cul de Sac Graben tectonic structure, 130 km long and 20 km wide, continues from Haiti as the Enriqullo graben in the Dominican Republic. Normal faults bound the graben on either side and extend in vertical fashion. Reservoir temperatures of the hot springs of the area are indicated to be about 100°C based upon geothermometry. Since many calculated temperatures are at or above 70°C, resources probably occur as low- to moderate-temperature systems.

In 1983 the Dominican Republic received funds from the International Development Bank and Italian bilateral aid to continue geothermal prefeasibility studies at the Las Yayas-Costanza area.



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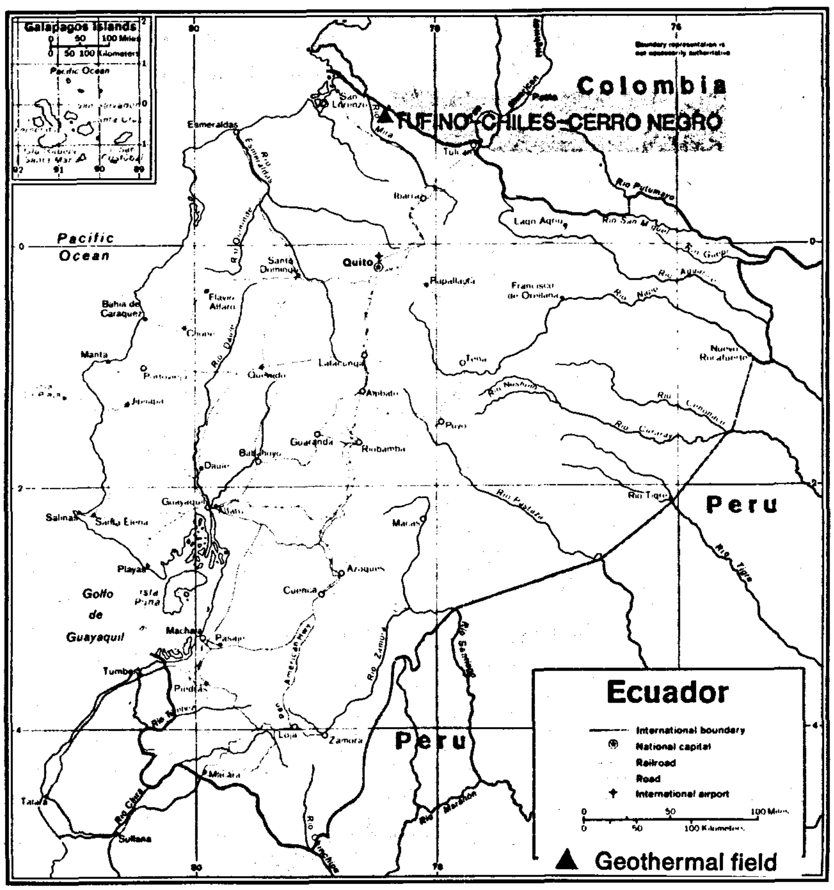
ECUADOR

Ecuador is located along the equator between Columbia and Peru in South America. Volcanic activity is prevalent in central Ecuador, where over 40 hot springs are located in the Andes Mountains.

The Ecuadoran Institute of Electrification (INECEL) began the first assessment of the geothermal resources of Ecuador in 1978. Reconnaissance investigations were carried out nationwide jointly by INECEL and OLADE technicians. From these initial studies, which were completed in 1980, potential high-enthalpy geothermal areas were selected and prioritized based on the results of hydrologic studies and water chemistry, and spacial relationship with recent volcanic rocks. Three areas were eventually classified as high priority areas.

As a result of the reconnaissance investigations, the Tufino-Chiles area of Ecuador was identified as having the greatest geothermal potential. In 1981, INECEL began prefeasibility studies in the Tufino geothermal area, located along the Colombia-Ecuador border in the Western Andean Cordillera. The border between the two nations passes through the peaks of two volcanic centers (Chiles in Ecuador and Cerro Negro in Colombia) dividing the area in two. The Tufino area is characterized by pervasive hydrothermal alteration and wide-spread distribution of young volcanic rocks (less than 35,000 years old). A small phreatic explosion crater is also present.



The first binational integration project based on the utilization of geothermal energy was negotiated between ICEL of Colombia and INECEL of Ecuador for the Tufino-Chiles-Cerro Negro field. The prefeasibility studies proposed for this field would probably be carried out by OLADE with financing from the IDB and the Italian government.

The Chalupas geothermal area is located approximately 70 km southeast of Quito, Pichincha Province. The thermal anomaly is centered within a caldera formed from an eruption/collapse of the Chalupas Volcano. The caldron substrate consists of Pliocene volcanics that are thought to be potential reservoir rocks.

The Imbabura area is situated in the Province of Imbabura approximately 20 km north of Quito and includes three volcanic centers and one volcanic dome complex. According to reconnaissance studies, numerous hot springs are present with high dissolved gas contents. An application to finance a prefeasibility study in the Imbabura Cayambe geothermal fields has been submitted.

The Iguan Volcano and the Chalpatan Caldera, located in the Province of Charchi, have been identified by regional studies as two other promising areas.

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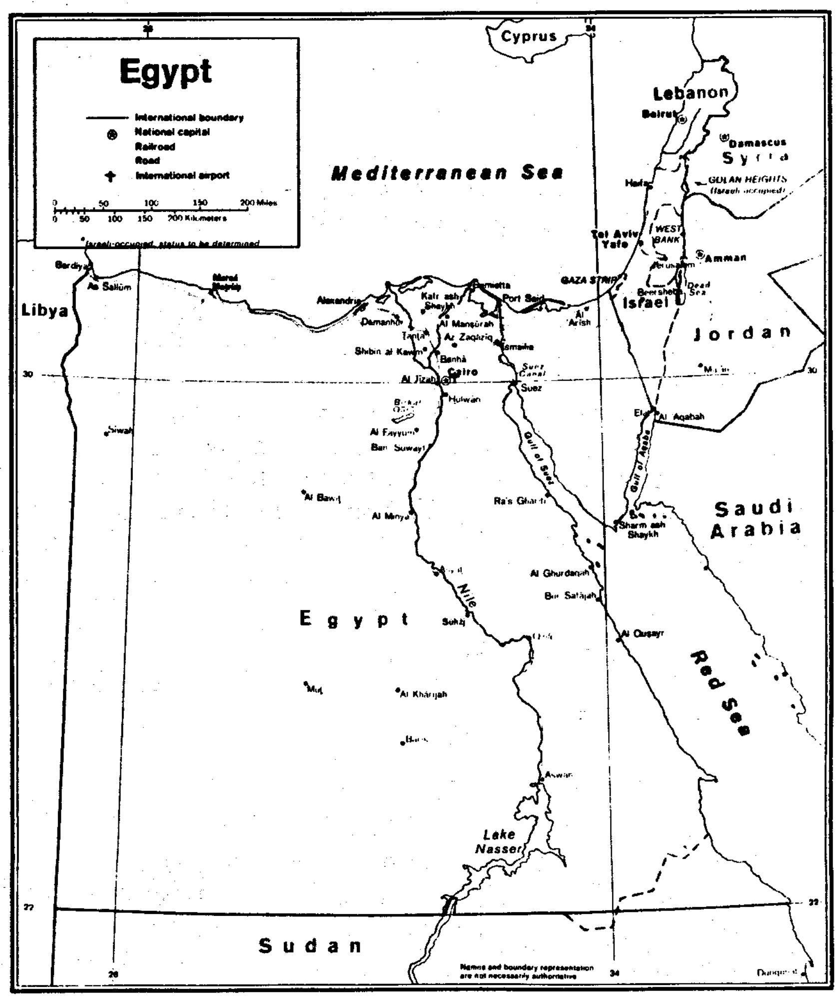
EGYPT

Egypt's location on the African plate suggests that geothermal resources may exist along its eastern margin. Significantly high heat flow values have been determined east of the Nile River with the most promising area being the Red Sea. In this area several hot springs and wells reportedly have surface temperatures exceeding 50^{o}C. There is also potential for use of low-temperature waters from deep sedimentary basins in the Western Desert. At this time, Egypt's low enthalpy geothermal resources are probably only feasible for use in small scale, direct use applications.



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EL SALVADOR

El Salvador is located in a volcanically active zone containing numerous hot springs. The country lies just northeast of the Middle America Trench.

Geothermal studies in El Salvador began in 1953 by the Geological Survey of El Salvador and the Lempa River Executive Hydroelectric Commission (CEL). The studies, which began at Ahuachapan, included geoscience surveys and shallow temperature gradient drilling. CEL continued geothermal studies with support from the El Salvadorian government and the United Nations Development Program. The results of the regional investigations showed that five areas had geothermal development potential. In order of priority, potential areas for further studies include: Ahuachapan, Berlin, San Vicente, Chinameca, and Chipilapa. Other promising areas have also been noted from preliminary studies.

Continued efforts by CEL, with UN assistance, eventually led to the completion of four production wells at Ahuachapan by 1970. The results of testing led to the decision to develop the Ahuachapan geothermal field.

The Ahuachapan geothermal field is located in western El Salvador, approximately 18 km east of the Rio Paz. Within the region occur many fumaroles, hot-springs, and other thermal manifestations. To date, nearly 30 wells have been completed in the field. A typical well is completed to a depth of approximately 800 m in the fractured Ahuachapan and sites. Geofluid from the reservoir is produced at temperatures of approximately 230°C and provided to two single-flash steam generating units of 30 MWe capacity, and one dual-flash unit with a rated capacity of 35 MWe. The third unit came on-line in 1980, after installation by the CEL. The power plant units were installed by Mitsubishi Heavy Industries, Ltd.

The Berlin geothermal area is situated in eastern El Salvador approximately 90 km from the capital city of San Salvador. A deep test well was drilled in 1968 to a depth of 1,424 m where a temperature of 240°C was encountered within rocks of low permeability. No further work was conducted until 1978, when a 3 year program began, resulting in the drilling of 5 wells. These wells were drilled to depths ranging from 1,900 to 2,375 m and encountered a shallow reservoir at 800 m and a deeper hydrothermal system at 1,800 m. The temperatures in the systems have been measured up to 300°C. Additional geophysical studies will be necessary to better define the limits of the two systems.

Geoscience surveys and exploratory drilling have been performed at Chinameca located near Berlin. Results to date have been inconclusive and additional studies will be necessary to better characterize the geothermal anomaly.

The San Vicente geothermal area is situated approximately 50 km southeast of San Salvador on the slopes of the Chichontepeque Volcano. One 1300 m deep well has been drilled with a maximum recorded temperature of 230°C. The civil conflict in El Salvador has prevented any additional work in this area.

The Chipilapa geothermal field, located adjacent to the Ahuachapan field, may be an expression of the same heat source. Early geoscience investigations in the area between 1965 and 1968 led to the siting of a deep exploratory test well that yielded a maximum temperature of 200°C. Later geophysical studies led to the drilling of two gradient test holes (400 m) that yielded maximum temperatures of 220°C. In 1984, interest was expressed in requesting IDB cooperation for development of Chipilapa geothermal field.

El Salvador currently maintains 95 MWe geothermal capacity entirely from the Ahuachapan field, which provides 20% of the country's electrical power. Geothermal resource potential is high and continued development is likely if political and economic climates allow.

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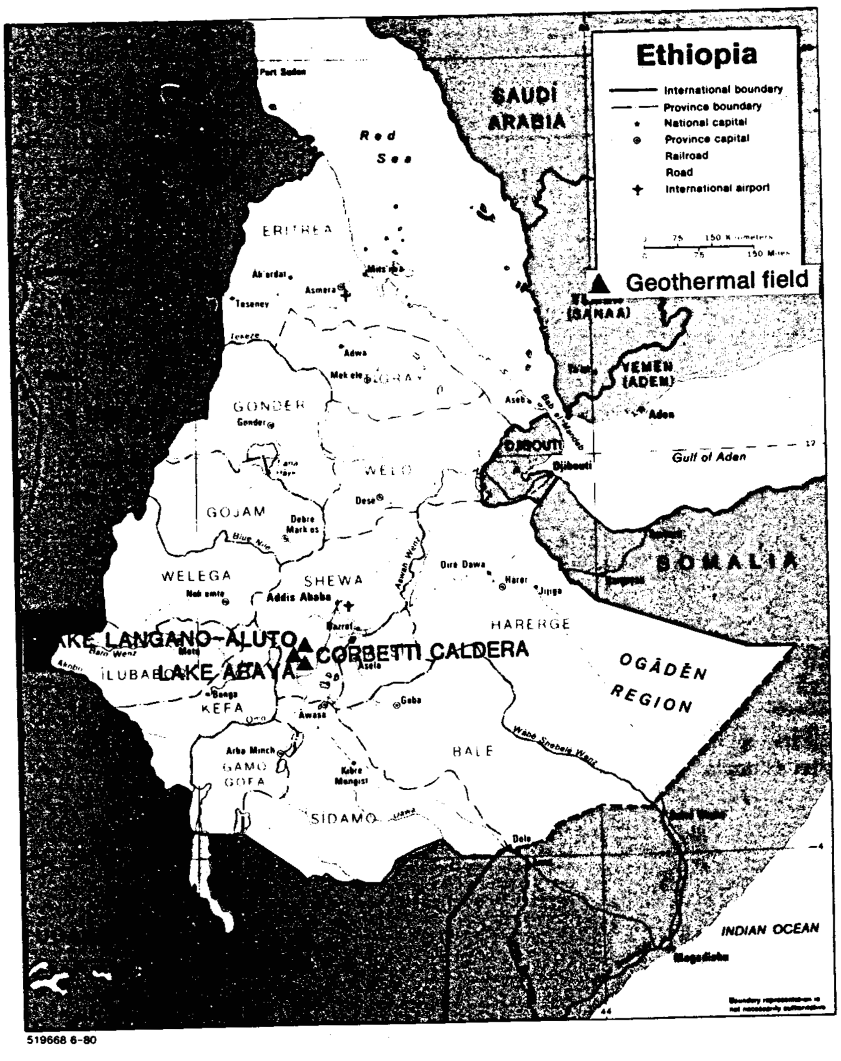
ETHIOPIA

The Ethiopian Rift of the East African Rift Zone nearly bisects the country of Ethiopia from the northeast to the southwest. Regional uplifts and volcanism during the Tertiary period eventually gave way to rifting in the Pleistocene period. The Ethiopian Rift, which is widest (65 km) in the Lake District, now separates the Ethiopian Plateau from the Somalian Plateau.

Ethiopia probably has the largest geothermal potential of African countries and is one of the few lesser-developed countries to make progress in geothermal exploration. Its geothermal potential has been estimated by the World Bank to be 4000 MWe.

A comprehensive assessment of the nation's geothermal resources was conducted, with UN assistance, in the early 1970's. Nine hydrothermal areas have been identified so far, including 3 in the Lake District. The Lake district, which lies approximately 300 km south of Addis Ababa (the capital city), is an area containing many hot springs with surface temperatures as high as 96^{o}C and measured subsurface temperatures of 163^{o}C. The two most likely prospects located in the this area are Lake Abaya and Lake Langano-Aluto. Initial exploratory drilling was performed under the direction of GENZL (New



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GEOTHERMAL AREAS ▲

Zealand), during the period of 1981-82.

The Lake Langano-Aluto area was chosen for further study over Lake Abaya. The Lake Langano area has a high (290°C) reservoir temperature but low permeability. An 8 well exploratory drilling program began in 1980 to investigate the feasibility of a 30 MWe plant. The international financial contribution to the project was $3.2 million from UNDP and over $22 million from EEC. Of the 8 wells drilled (2000 m average depth), 5 were successful.

Geothermal exploratory wells have been proposed at Corbetti Caldera and Lake Abaya in the Lake District and Tendaho in the Afar region. The prefeasibility work sponsored by the Italian government in 1981 at Tendaho may be followed up by exploratory drilling if bilateral aid can be obtained. A World Bank-financed prefeasibility study of the Fantale-Dofan area, in the Awash Valley, is also presently underway.

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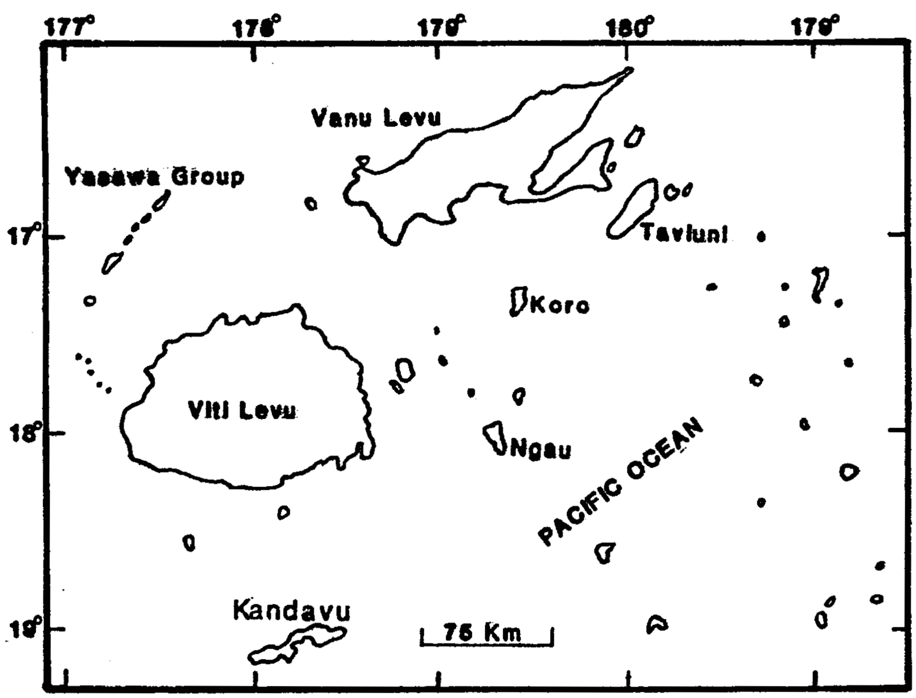
FIJI

Fiji, an island of 645,000 people with a land area of 18,272 km2, is located about 3,000 km east of Australia along the margin of the Indo-Australian and Pacific crustal plates. The first assessment of geothermal potential of Fiji began in 1956 by the New Zealand geological survey. During the 1960's and 70's the Fiji Mineral Resources Department (MRD) mapped the area. Infrared imagery surveys were conducted in 1972, and from 1974 to 1977 the MRD began more detailed studies of Fiji's geothermal resources. During 1978-81, reconnaissance surveys were conducted by Pacific Energy and Minerals, Ltd. (PEML) including temperature gradient studies.

Fiji's principal geothermal targets, Lambasa and Savusavu, are on the secondary island Vanua Levu. Hot springs on Vanua Levu have surface temperatures between 60 and 100^{o}C. The Lambasa system has a relatively low temperature, but the recharge is good owing to the fault-controlled nature of the system. Savusavu has the greatest potential for exploitation of the Fiji geothermal areas. There is indication that higher temperatures exist at depth, along with a fault-controlled circulation system. The reservoir temperature at Savusavu is estimated to be greater than 150^{o}C.

The other geothermally active island is Viti Levu, where thermal spring temperatures range between 40^{o} and 60^{o}C. The Viti Levu reservoir is a low-temperature system probably due to fairly deep circulation of meteoric water. Very small scale direct use would probably constitute the current potential at Viti Levu.



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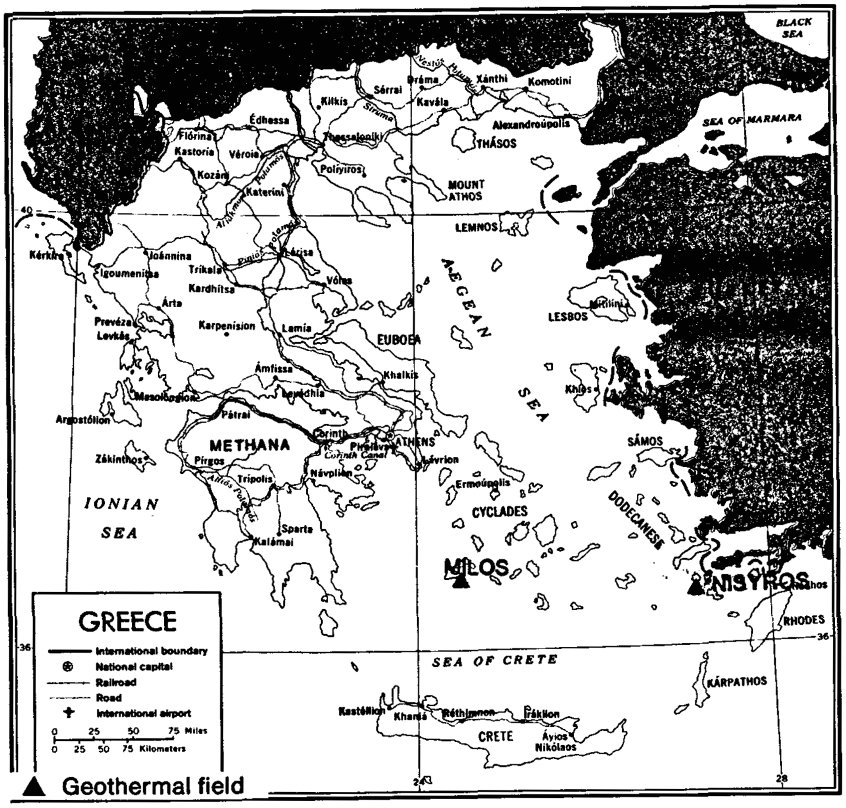
GREECE

Greece is located adjacent to the Hellenic Trench, an active arc-trench system, in the north Mediterranean Sea. Potential high-temperature geothermal areas are present in the south Greek islands, along the Plio-Quaternary Agean volcanic arc, which remains active today. The arc extends from Methana to Nisyros and passes through Milos and Santorini. The Hellenic Trench mirrors the volcanic arc directly to the south.



The Public Power Corporation (PPC) made preliminary reconnaissance surveys for geothermal potential in 1970, with assistance from the Institute of Geologic and Mineral Exploration (IGME). During the 1970's, preliminary geologic studies were performed, with exploratory drilling beginning in the 1980's. Based on these studies, Milos was considered the highest priority for geothermal development.

The island of Milos is located in the Cyclade island group, Aegean volcanic arc. The island is an uplifted north-tilting structural block with many intersecting fault systems. The Zephria graben on Milos has been extensively explored and appears to be the most promising locality for developing high-temperature resources. The geothermal reservoir is located at depths between 700 to 900 m and contains fluid at temperatures between 300° and 320°C. Four production wells were drilled by Nikex (Hungary) as part of development activities on Milos in 1980. Work began on a 2 MWe demonstration plant in June of 1983. Mitsubishi of Japan won the $2.2 million contract for design and installation of the power plant facility with delivery scheduled for October 1985. Transmission cables are being considered to connect to the mainland and the Cyclade Islands by 1990. Fifteen additional wells are planned, and drilling began in 1983 for installation of 60 MWe on Milos by mid-1991. The Public Oil Company will complete the drilling operations and the Public Power Corporation will develop the geothermal resource. A third phase of the geothermal plan for Milos includes the installation of a second 60 MWe by 1994, as well as a second network of submarine cables connecting Milos with the mainland.

Nisyros is one of the Dodecanese Islands located south of Kos. The island was formed by late Quaternary silicic volcanism that resulted in development of alternating lava flows, pyroclastic deposits, and subsequent formation of a caldera. After caldera collapse, domes and phreatic explosion craters developed in the west and southeast parts of the caldera. The geothermal reservoir at Nisyros consists of an old magma chamber capped by dolomitic marble with an average reservoir temperature of 350°C at 1550 m. The first well, drilled in 1981 by Nikex, was tested in September of 1982 and was later followed by a second well. The island has been identified by the PPC as a priority exploration target.

The island of Lesbos has been identified by regional studies to also have potential for the existence of high-enthalpy geothermal systems, along with seven other potential geothermal fields along the Aegean Volcanic Arc.

Low-temperature sedimentary basins exist in the northern mainland of Greece. The basins were produced by progressive subsidence during the Cretaceous and later filled by Tertiary sedimentation. IGME used data from 33 deep oil exploration boreholes within these basins to make a preliminary assessment of low- and moderate-temperature resources.

In late 1984, a new law was passed that claimed all geothermal resources as public property with geothermal energy rights controlled by the IGME and the Public Oil Corporation. Priority for acquisition of exploration leases was given to local and state owned companies. Local governments with jurisdiction over the geothermal resource location were granted 30% of project cost to provide incentive for further exploration.

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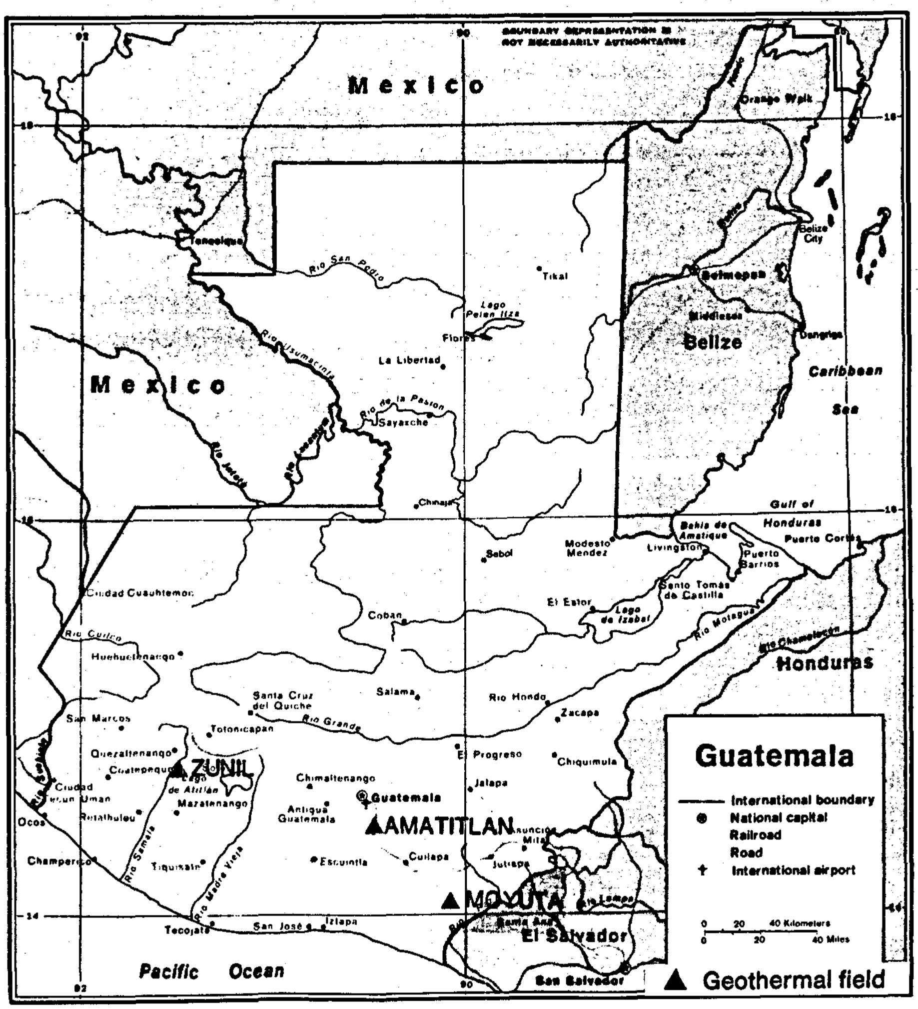
GUATEMALA

The southern part of Guatemala lies along the Middle Trench in a volcanically active area. Numerous hot springs are also present within the high-temperature geothermal prospects of Guatemala.

Geothermal exploration began in Guatemala during 1972. Initial studies were performed at the Moyuta and Zunil geothermal fields. The volcanic belt that hosts the geothermal areas lies in a convex strip, nearly 40 km wide and containing 35 volcanoes (three of which are active). Volcanic activity has continued from the Tertiary to the present, as early fissure eruptions and lateral flows were later covered by composite volcanoes.

The Zunil geothermal field is located in western Guatemala's volcanic province, near the Cerro Quemado and Volcan Santa Maria volcanoes. Preliminary exploration at Zunil began in 1973 and continued through 1977. Technical assistance was provided by the government of Japan through geophysical studies. Deep drilling began in 1977, by the National Electrification Institute (INDE) as a prelude to a power plant feasibility study. The drilling program was successful in discovering a high-temperature (287°C) reservoir encountered at



1,130 m. A total of six exploratory wells were drilled, with five eventually producing steam in commercial quantities. INDE has planned to construct a 15 MWe plant at the field during 1986.

The geothermal reservoir is contained within a conglomeratic unit overlaying a Cretaceous granodiorite basement, which in turn is overlain by Tertiary volcanic rocks. Fluids are thought to migrate "up-dip" (eastward) within the conglomerate unit and into the thermal area. Fractures within the basement granodiorite may also contribute to fluid movement. Production testing has shown that a rapid phase change from liquid to vapor (steam) occurs in the wellbores upon drawdown of formation fluids.

The Moyuta geothermal field was the first geothermal area to be explored in Guatemala. Geological, geochemical, and geophysical prospecting were performed in 1972. After surface studies were completed, two exploratory wells were drilled to a depth of 1000 m each. Maximum temperature reversals were observed below that point. Exploration at Moyuta was terminated after completion of exploratory drilling.

The Amatitlan geothermal field is located within the volcanic belt of south-central Guatemala. Preliminary surface geoscience investigations have shown that high-temperature resources may be present at depth. Geothermometers applied to fluid chemistry data have indicated a possible reservoir temperature of 280°C. Shallow thermal gradient drilling has revealed a temperature of 140°C at a depth of 80 m within the field. Further deep exploratory drilling by INDE was to have been performed at Amatitlan upon release of drilling equipment from the Zunil field.

The Las Majades-Cerro Quemado area, adjacent to Zunil I, has been selected for exploratory drilling, but further prefeasibility work is necessary before a precise drilling location can be chosen.

Other geothermal areas in Guatemala have been assessed in a preliminary manner. Surface geologic mapping and geochemistry has been performed by INDE in the areas of Atitlan, Palencia, Tecuamburro, Los Achiotes, Laguna de Ayarza, and Laguna de Retana.

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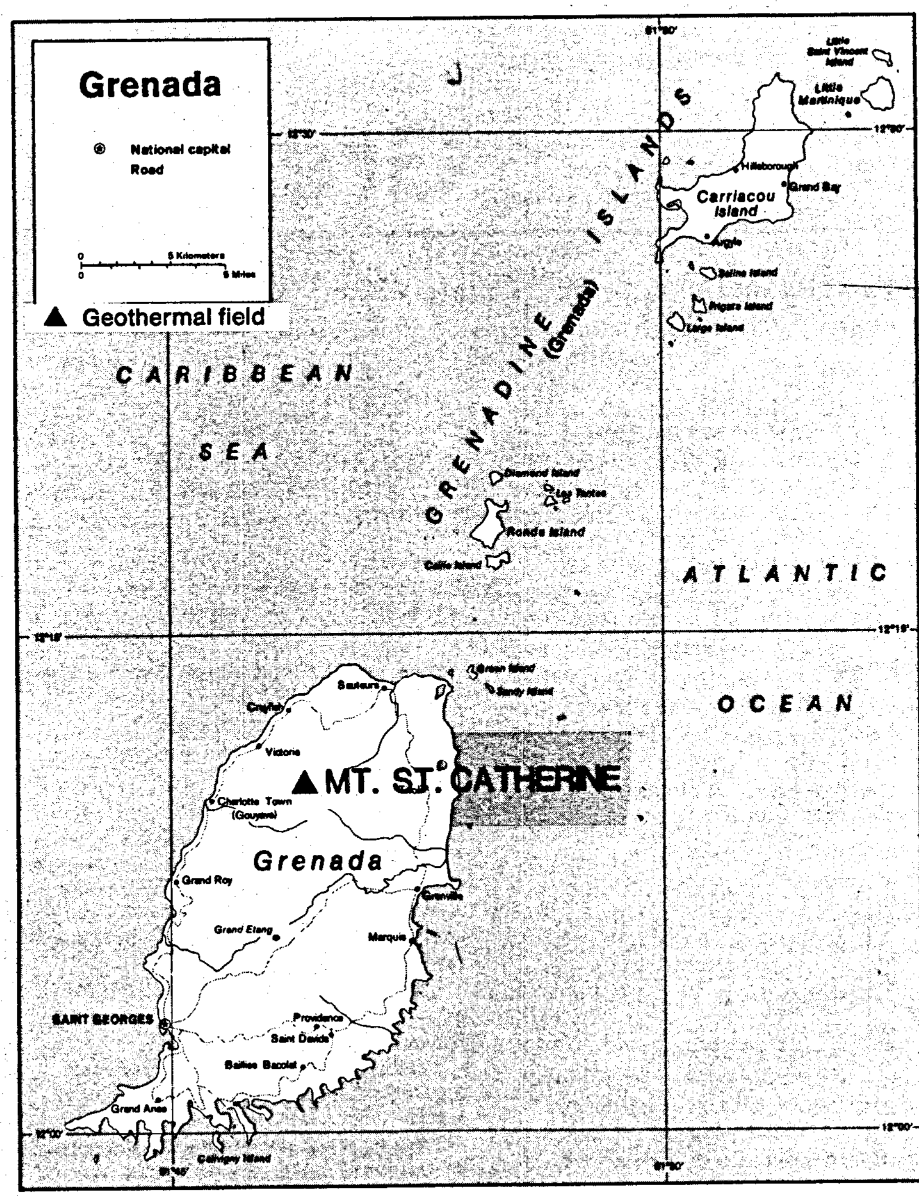
GRENADA

The 344 km2 island of Grenada is located at the southern tip of the Lesser Antilles Volcanic Arc. Surface temperatures of springs on the island close to 50°C. The tectonically active area may be a good geothermal resource prospect. Mount Saint Catherine has been defined for prefeasibility studies.



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HAITI

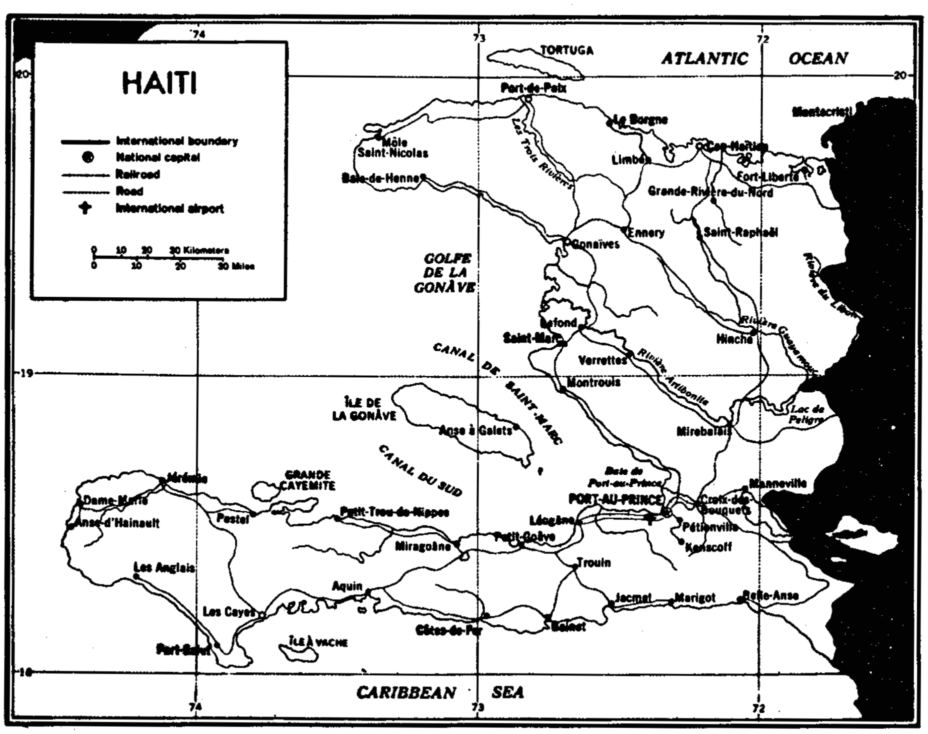
The Haitian National Institute of Mineral Resources (now the Dept. of Mines and Energy Resources) first investigated Haiti's geothermal energy potential in 1977. Interest sparked by the preliminary investigation was continued by an OLADE reconnaissance team six months later. Low- to moderate-temperature resources were discovered and a scheme for development of these resources was set forth in 1981. In late 1983, the Haitian and OLADE sponsored exploration program was begun. Hot water for industrial and therapeutic purposes and possible geothermal electric power plant installations are included in plans for Haiti's economic development.

Reconnaissance studies were completed in several areas, including Sources Chaudes, Los Pozos, Sources Pauntes, and Jeremie. Geothermometry suggests that these reservoirs have temperatures of 120^{o} to 130^{o}C.

The Sources Chaudes hot springs are located northwest of Gonaives and are bordered on the north by a mountain range. Fractured Eocene Limestone is thought to be the primary reservoir rock-type. Five hot springs at Sources Chaudes flow at a total rate of 80 liters/minute at an average surface temperature of 50^{o}C.

The Los Pozos hot springs are located on the Haitian Central Plateau, approximately 5 km from Cerce La Source. The hot springs issue from fractured Oligocene limestone where geothermometry indicates temperature of 120^{o} to 130^{o}C. The springs are thought to originate from one main aquifer.

Sources Pauntes is a thermal area located on the extreme northeast side of the Cul de Sac Plain, at the intersection of a WNW-ESE geologic structure and a NE-SW geologic structure. Temperatures of the hot springs are about 33^{o}C. The main aquifer unit is composed of fractured Miocene sandstone, and the average reservoir temperature, estimated by geothermometer, is 70^{o}C.



Two hot springs emerge in the Jeremie region on the western tip of the southern peninsula from Cretaceous basalt. The two hot springs have recorded surface temperatures of 40°C and 45°C respectively. The combined total flow of the two hot springs is 30 liters/minute.

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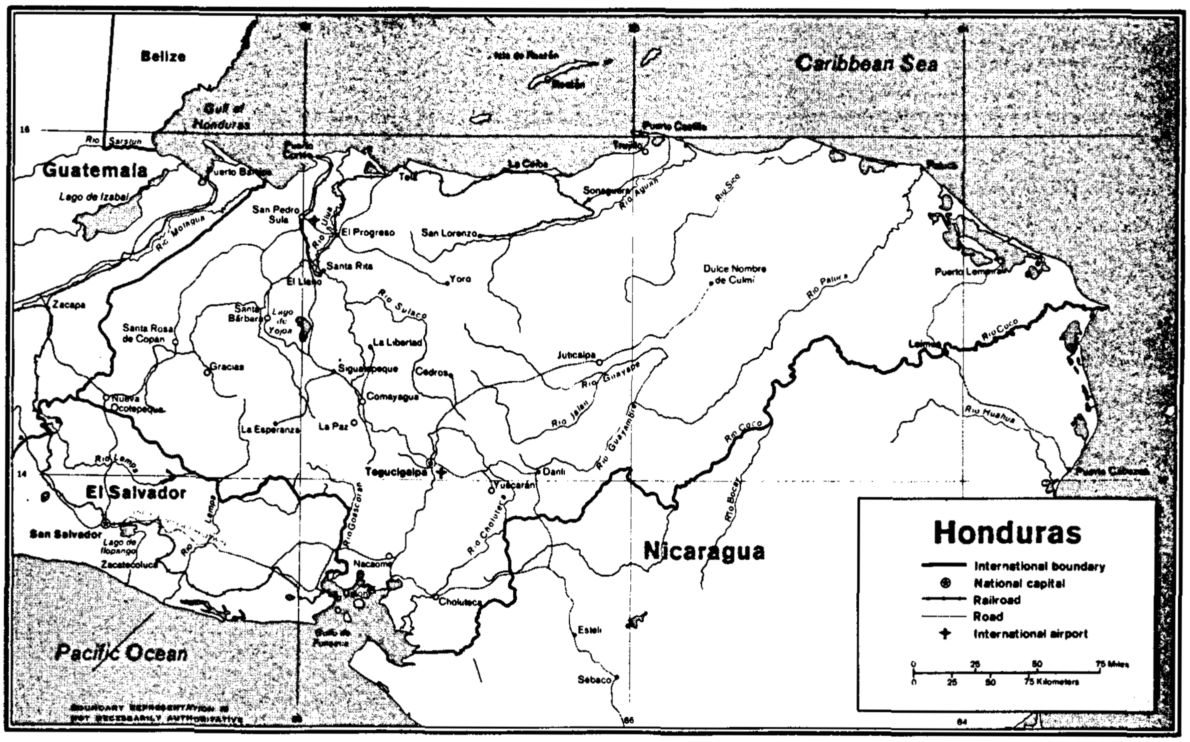
HONDURAS

Organized geothermal investigations in Honduras began in 1976 as part of a technical mission from the United Nations. Financial difficulties prevented completion of the work and the project was not resumed until 1978. At that time, the Central American Isthmus Energy Program (PEICA) was being organized and later incorporated the UN studies.

In 1979, a nationwide hydrogeochemical sampling and reconnaissance program was performed. Along with an inventory at 128 thermal manifestations, water samples were taken at 111 locations and gas samples at 11 locations. The results of this study provided a basis for prioritizing prospective areas for more detailed exploration. In 1982, the World Bank provided $900 thousand for geothermal exploration in Honduras.

Funding for geothermal studies in the next phase of work did not materialize and Honduras' national energy organization (ENEE) began surface geologic studies at selected areas. Through this work, six areas are now considered high geothermal prospects. The areas are: 1) San Ignacio; 2) Platanares; 3) Azacualpa; 4) El Olingo; 5) Sambo Creek; and 6) Pavana. Geochemistry has indicated reservoir temperatures from 185° to 205°C for these areas. In addition to the six areas of primary interest, five other areas are considered to be of secondary interest.

In 1985, the UN Department of Technical Cooperation for Development funded a prefeasibility study in central Honduras. The $290,000 appropriated will be used to assess the geothermal potential of central Honduras.



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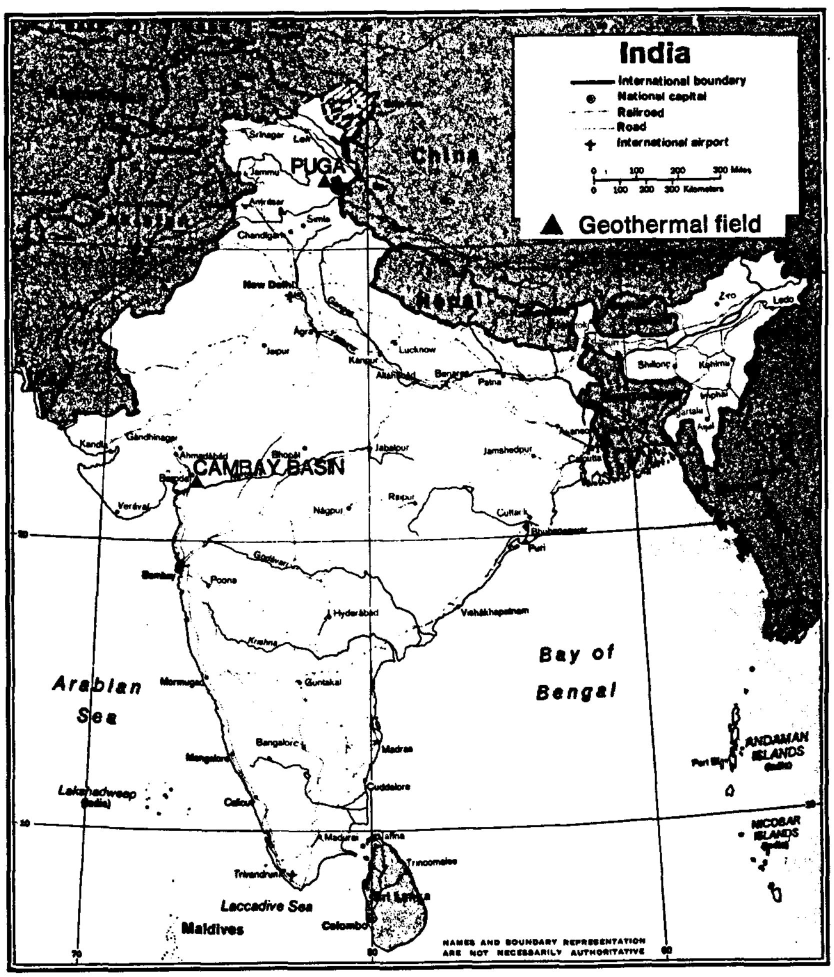
INDIA

The northern border of India, bounded by the Himalayan Frontal Thrust (the convergent margin of the Indo-Australian and Eurasian plates), holds potential for high-temperature geothermal resources. Other regions of India may have low to moderate-temperature resource potential.

According to heat flow studies in India, 29 prospective areas have been identified in 14 major geothermal provinces. Out of 29 prospects, 7 are high enthalpy, 9 are medium enthalpy and 13 are low enthalpy areas. Some of the best areas are the Himalayan tectonic belt, Cambay-Bombay graben, Krishna Godavari graben, Sone Domodar graben, Andaman volcanic zone, and Haridwar Delhi ridge. There are over 340 known thermal springs in India. In non-electrical applications alone, geothermal resources could displace 10,600 MWe of electrical capacity.

Over the last 15 years, the Geological Survey of India (GSI), the Oil and Natural Gas Commission (ONGC), and the National Geophysical Research Institute (NGRI) have collected a wealth of geological information. The main types of geothermal energy are medium- to low-grade hydrothermal resources that could be used for direct heating purposes.



The Puga liquid-dominated reservoir is India's most promising field for geothermal power generation with an estimated reservoir temperature of 226-245°C. The second most promising area is the Cambay Basin field, with an estimated temperature of 160°C.

Industrial use of geothermal energy has been demonstrated and applied in Puga Valley geothermal area by the Regional Research Laboratory, Jammu-Twai. Experiments have also been conducted in Puga and Chumationg geothermal area for space heating and hot house cultivation. At Manikaran, in Himchal Pradesh, an experimental cold storage plant of 7.5 tonnes cooling capacity has been installed under the R&D programme of DNES.

The Cambay basin may be exploitable for geopressured-geothermal resources. The total accessible geothermal resource over all stratigraphic units is 116.41 x 1012 kWh.

The Tattapani geothermal area, located in peninsular India about 450 km east-northeast of Nagpur, is a low- to medium-temperature geothermal reservoir.

A UNDP aided project ($1,244,978) was approved and implemented by the Central Electricity Authority (CEA) and GSI in 1982. Other institutions involved in exploration and assessment of geothermal resources are IIT, Kanpur, Kharagpur, and Jadaupur Universities. The Central Electricity Authority is looking into installing an experimental 1 MWe unit at Puga Valley in the Ladalch region.

The Department of Non-Conventional Energy Sources (DNES), National Aeronautical Laboratory and GSI will design and develop a 5 kWe binary cycle power experimental plant at Manikaran in Himachal Pradesh.

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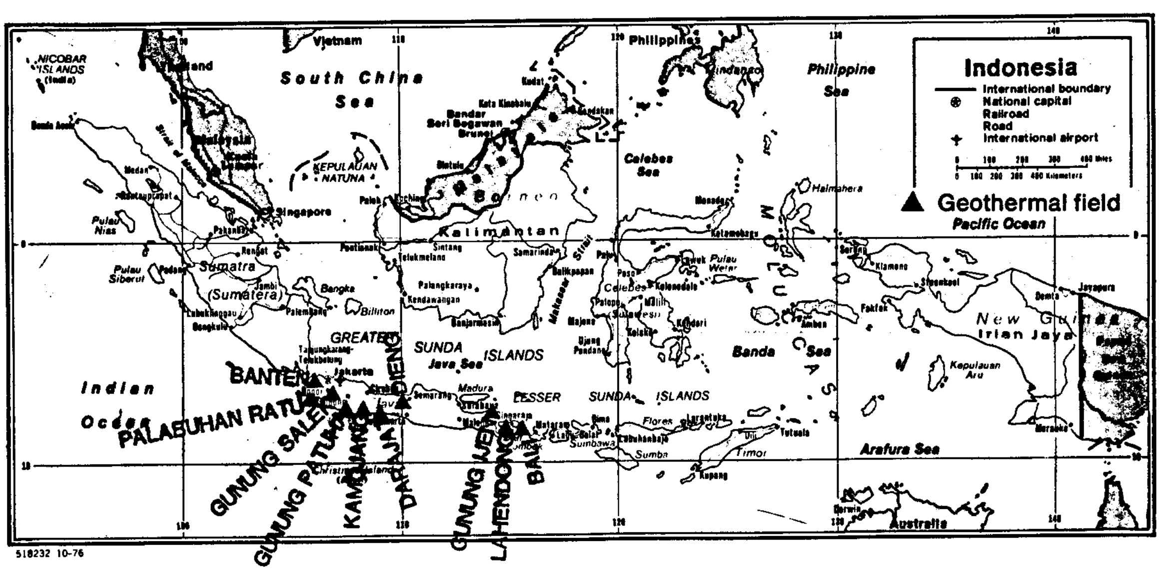
INDONESIA

The Indonesian archipelago is the result of subduction of oceanic crust and island arc volcanism that has created an extensive chain of volcanic islands in the Indian Ocean. Since it is one of the most active volcanic countries in the world, geothermal studies began as early as 1919 by the predecessor agency to the Volcanological Survey of Indonesia (VSI). These investigations resulted in the drilling of five exploration wells in the Kamojang area of West Java during the period of 1926 to 1928. Although these wells were never utilized and the project was abandoned, a new energy resource had been assessed.

Between 1964 and 1974, several foreign geothermal teams helped Indonesia realize its geothermal potential. Groups such as the UNESCO Volcanological Mission, the U.S. Geological Survey, EURAFREP (France), and GENZL (New Zealand) helped advance Indonesian geothermal exploration. The Geological Survey of Indonesia, the Indonesian Power Research Institute, and the Geothermal Division of Pertamina (the government oil and gas agency) have also conducted surveys to evaluate the geothermal potential of Indonesia.

Geothermal energy potential in Indonesia has been estimated to be 10,000 MWe for a 25 year period, primarily concentrated in Java. Presently, geothermal systems provide dry steam to one central plant (30 MWe) and two wellhead units (2.25 MWe). Units 2 and 3 at Kamojang (55 MWe) are under construction to be on-line by mid-1987 and early 1988. Advanced plans call for an additional 855 MW of geothermal power on-line by 1994.

The Kamojang geothermal field is located on the western side of Java, about 42 km southeast of Bandung. Kamojang lies within the Pangkalan caldera on a two fault system. Reservoir data indicate that Kamojang is a vapor-dominated hydrothermal system occupying an area of 15 km2 at a depth of 200 to 1500 m. The mean reservoir temperature is 238°C. A wellhead generating unit with a capacity of 0.25 MWe was installed in 1978 and a 30 MWe dry steam plant



came on line in 1983. Two additional units (55 MWe each) are now under construction with projected start-up in 1987, bringing the total power capacity to 140.25 MWe by 1988. The field is the only electricity distributer in the country and has a rated power potential of between 100 and 250 MWe for a 50 year period. VSI, PLN, Pertamina, and GENZL were the key executers of geothermal development in Kamojang.

The Dieng geothermal field, located in central Java, is a liquid-dominated hydrothermal system with maximum reservoir temperatures near 175^{o}C at a depth of 2000 m. Between 1964 and 1972, the UNESCO Volcanological Mission conducted preliminary studies, but only after 1974 did Pertamina begin detailed surveys. Eleven wells were drilled and two hot reservoirs were found. Two 55 MW flash steam units, to be installed at the field by 1990, have undergone preliminary design and feasibility studies. The estimated power potential of the Dieng geothermal field is 2000 MWe.

Union Oil Company of California has been actively exploring the Gunung Salak geothermal area on southern Djakarta. In early 1982, Union Geothermal of Indonesia was established for the Gunung Salak operations. Union has completed six deep exploratory wells in the area and plans to drill additional wells in the near future. Joint production/sales agreements have been signed by Union, PLN, and Pertamina for the construction of generating facilities for 110 MWe of power by 1990. The estimated potential of the area is 300 MWe.

The Darajat Block, a designated geothermal resource area, comprises an area of almost 43,000 acres and is located approximately 10 km from the Kasojang geothermal field. Exploration wells were drilled by the New Zealand government and later by Pertamina. Subsidiaries of Texaco, Inc. and Chevron Corporation have finalized a contract with Pertamina providing for the exploration and development of the Darajat field. Early development plans call for two 55 MWe units to be on-line by 1990. The estimated potential of the field is 150 MWe.

The Banten geothermal areas in West Java are characterized by high heat flow and abundant hot springs. Exploration has been recently undertaken with favorable results. Development plans include up to four 55 MWe flash steam units to be constructed by the mid-1990's. Scientific work was done by VSI and Pertimina and exploratory drilling was carried out by Pertamina. The first wildcat well was drilled early in 1985. The geothermal energy potential at Banten was estimated to be a maximum of 500 MWe.

The Lahendong geothermal field is located on the extreme northeast tip of Sulawesi in Minahasa. The lateral area occupied by the steam dominated system is between 12 and 18 km2. Exploratory wells have been drilled by the VSI, and a feasibility study and engineering design have been completed for two 15 MWe plants.

Other geothermal fields currently undergoing various stages of exploration include: Bali, Palabuhan Ratu, Gunung Patuha, Gunung Ijen, Gunung Wayang Windu, Gunung Tampomas, Cilayu-Bungbulang, Kawah Karaha, Gunung Endut, Gunung Slamet, Gunung Ungaran, Gunung Muria, Gunung Wilis, Gunung Arjuno-Welirang, and Gunung Lamongan.

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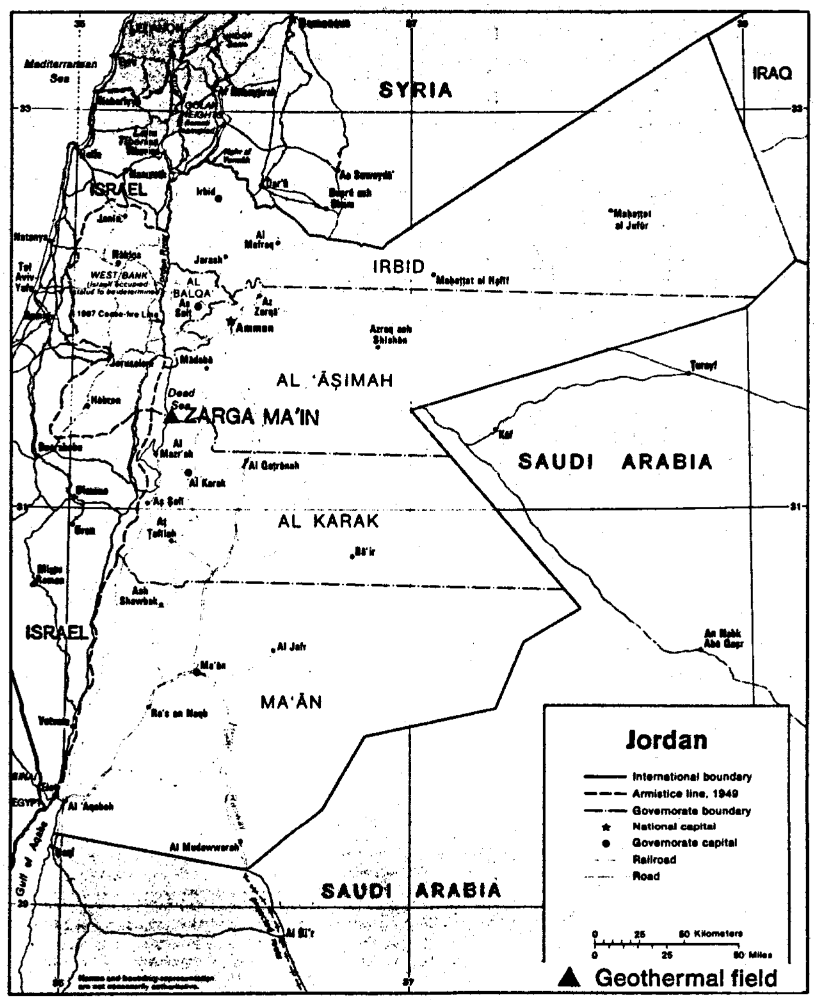
JORDAN

The geothermal resources of Jordan, which are associated with active faulting along a transcurrent structure, were assessed as part of a U.S. Agency for International Development (AID) sponsored study to identify potentially exploitable minerals and plan a national minerals exploration program in Jordan. The project was performed on behalf of the Jordanian Natural Resources Authority (NRA) through AID by the U.S. Geological Survey and U.S. companies. It consisted of airborne geophysical surveys to define areas of potential interest. From these studies, the thermal area at Zarga Ma'in was proposed for further investigations in order to assess the area's geothermal potential. NRA has reportedly made recent plans to drill two 1,500 m geothermal exploratory wells.



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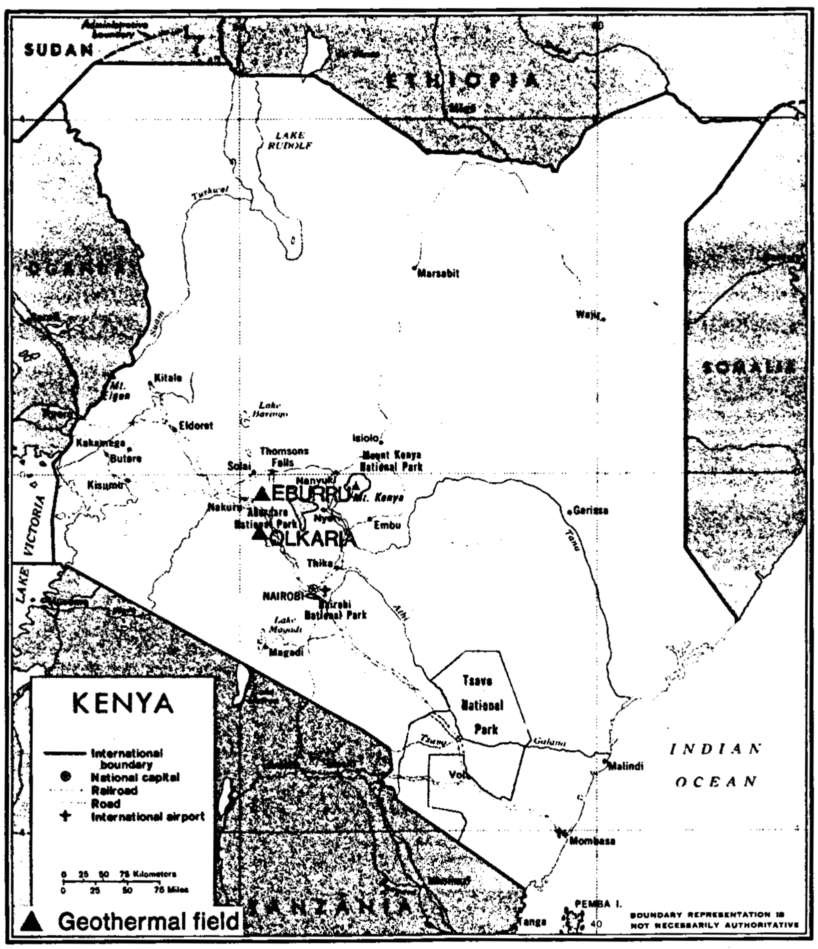
KENYA

Although geothermal exploration initially began at Kenya's Olkaria field in the 1950's, geothermal resources were not exploited until the UNDP and the East African Power & Lighting Company (EAPL) provided financing for a geothermal exploration project in the early 1970's. The Olkaria geothermal field was determined to have the greatest potential for development in Kenya and therefore was targeted for field development.

The Olkaria geothermal field is situated approximately 100 km northwest of the city of Nairobi. Surface thermal springs and alteration extends over an area of 36 km2. Geothermal investigations initiated in 1957 included the drilling of two exploratory holes, which proved to be unproductive. During the 1960's, limited geoscience studies were performed, but heightened interest in the geothermal potential was not seen until the early 1970's. Four exploration wells were drilled in 1974 under a program sponsored by UNDP and EAPL.

Under the management of Kenya Power Company, a single-flash steam plant was ordered for installation at Olkaria in 1979. The first two 15 MWe turbogenerators began operation in 1982 and 1983, with the third 15 MWe unit coming on-line in 1985. The total output of 45 MWe, supplied from 25 production wells, accounts for 15% of Kenya's total energy output.



Data from the wells indicate the presence of a thin (50 to 150 m), vapor-dominated zone that overlies a thick, liquid-dominated, two-phase reservoir. Reservoir rocks are comprised of fine-grained [rhyolitic] (500-700 m deep) lavas and tuff, and overlain by basaltic lavas acting as a caprock to the geothermal system. Geothermal fluid is transported to wells through contraction joints, scoriaceous zones, and contacts separating lava beds.

Development at Olkaria continues with a fourth power station (55 MWe) at Olkaria Hill planned for installation by 1990. The potential capacity at the Olkaria Field is conservatively estimated at 170 MWe over a 25 year period.

The government of Kenya supervised drilling investigations at Olkaria while technical assistance was provided by Geothermal Energy New Zealand Ltd. (GENZL). As a follow-on to the successful program, the International Development Association (IDA) has pledged a $240 million line of credit for geothermal commercialization, over a 50 year term, to the Kenyan geothermal program. As of 1985, IDA has provided $12.1 million, Kenya Power and Light (KPL) has provided $4.2 million, and the Commonwealth Development Corporation (CDC) has given $4.5 million for Olkaria's geothermal development.

The Eburru geothermal field, located 40 km north of Olkaria, is another attractive thermal area where development of geothermal energy resources is anticipated. A $24.5 million loan from the World Bank/IDA has been approved for the drilling of eight exploratory wells at Eburru during 1987-88. Geothermal Energy of New Zealand Ltd. (GENZL) is managing this project.

Other prospectively valuable areas for geothermal development in Kenya are near Lake Hannington (Lake Bogoria), Lake Naivasha, Mengenal Crater, Lake Magadi, and Lake Turkana.

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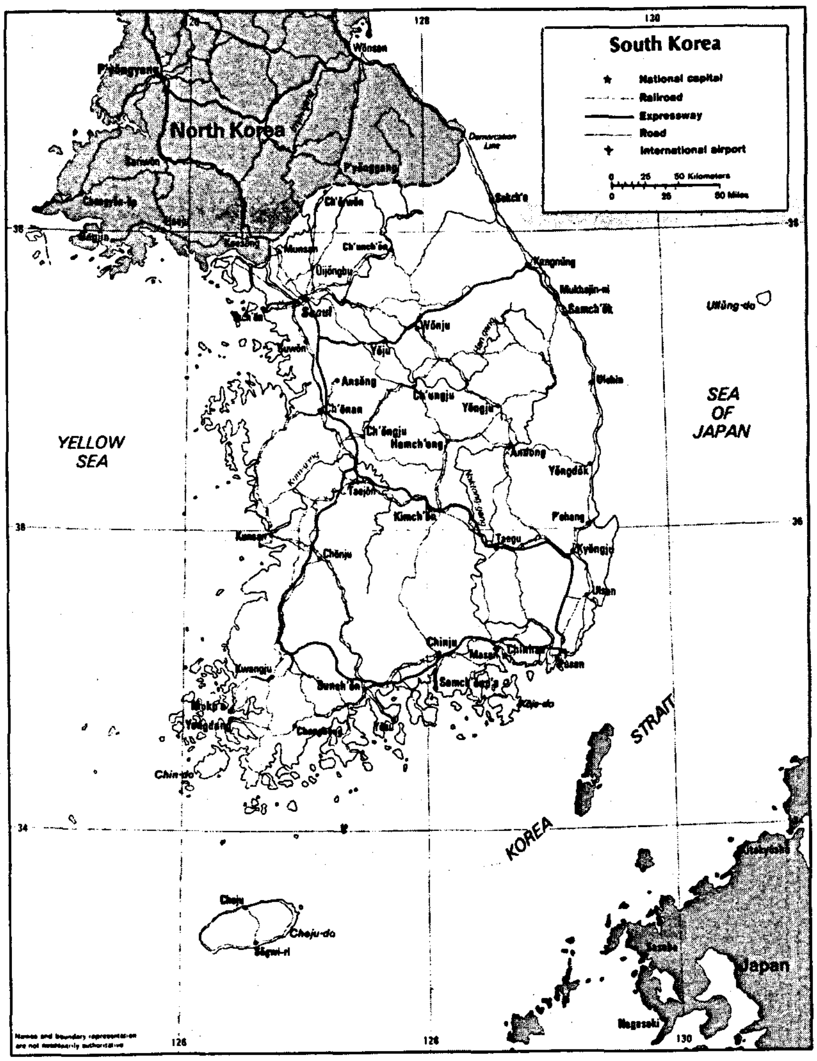
KOREA, SOUTH

Korea is divided into the northern Democratic People's Republic of Korea and the southern Republic of Korea. They form a peninsula that juts out towards Japan and the Ryukyu Trench. Some volcanic islands included in south Korea may have potential for high-temperature geothermal resources.

A cooperative Republic of Korea/United States energy assessment, completed in 1981, included a preliminary assessment of the geothermal energy resources of Korea. The study described the resources on the mainland as appearing to be confined to low-temperature and possibly moderate-temperature systems. Twenty known hot spring localities were assessed in addition to several other areas with similar geologic settings. High-temperature resources on the islands of Cheju-do and Ulleung-do are feasible. These islands are comprised of Quaternary alkalic volcanics, and there have been four recorded eruptions on Cheju-do in the past 1,000 years.



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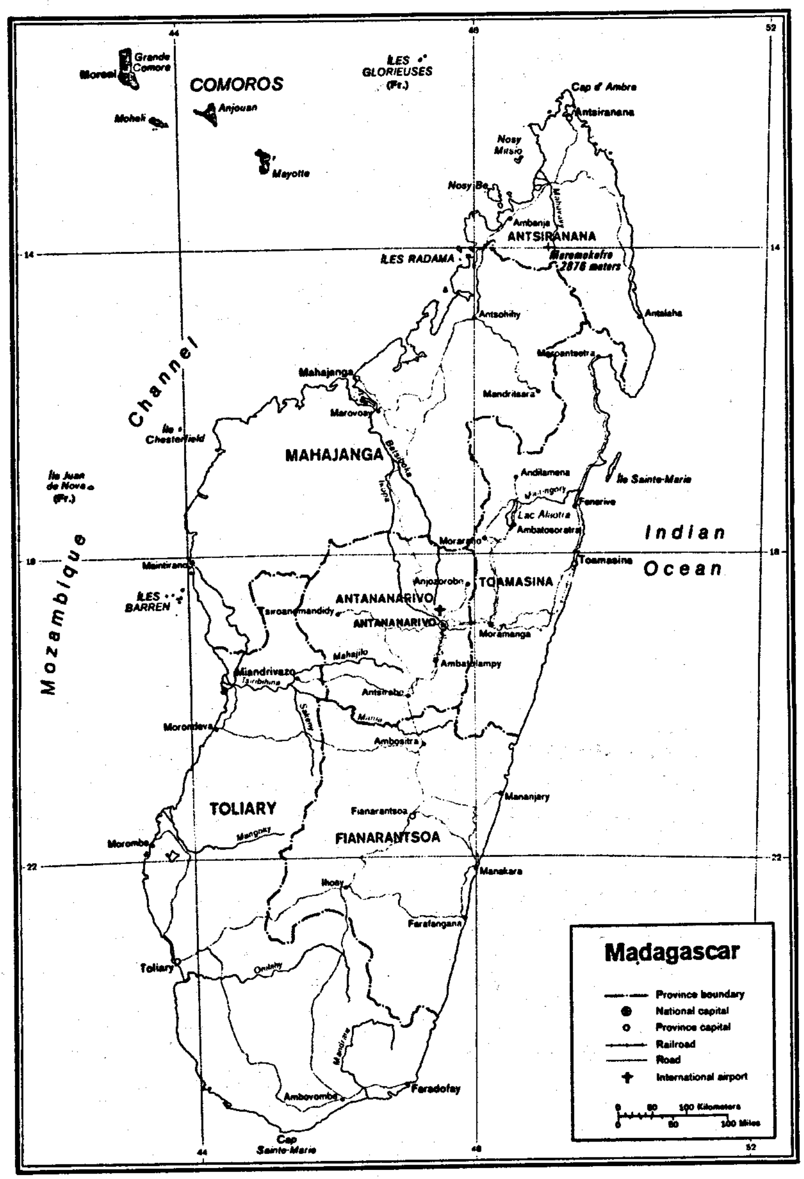
MADAGASCAR

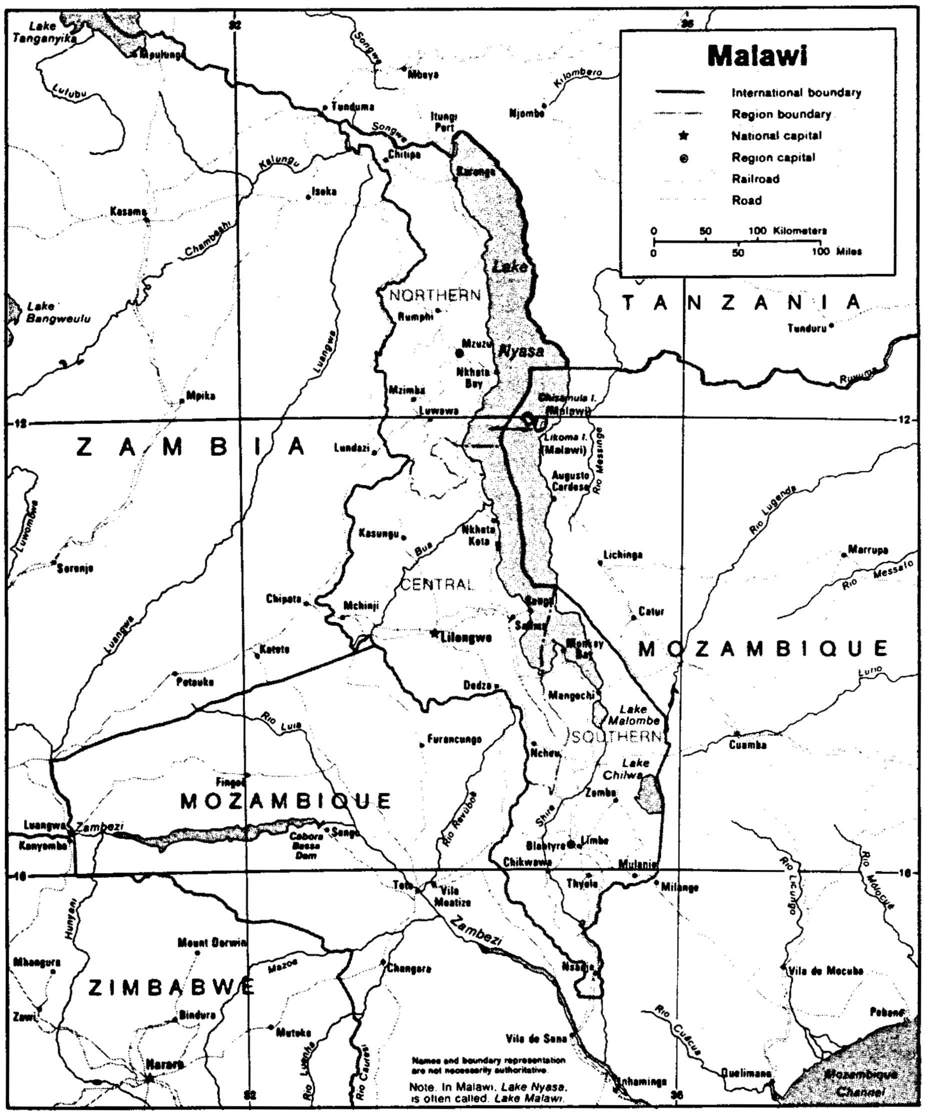
Madagascar is the third largest island in the world and is located approximately 500 km east of the southeast African coast. The country is largely comprised of many mountain ranges of volcanic origin, but no active-volcanoes occur. There are numerous hot and warm springs on the island, with temperatures up to 60°C.

In 1981, a geothermal reconnaissance study was performed in Madagascar as part of a United Nations Department of Technical Cooperation for Development (DCTD) program. The project consisted of geochemical analyses and showed that there were eight prospective areas for further investigation.



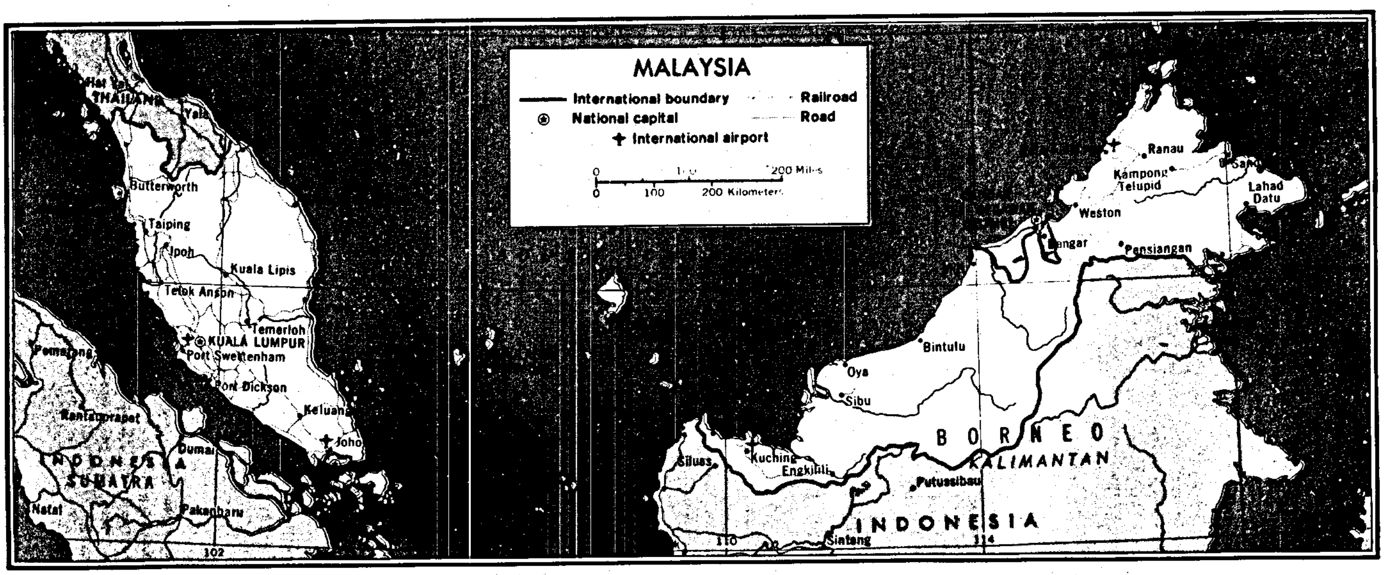
MALAWI

The Republic of Malawi is located south of Tanzania and north of Mozambique in a geologically active zone. Faults extend down from the East African Rift into Malawi. The 118,484 km2 country seems to be a good prospect for geothermal development, but as yet, no studies have been performed. Many hot springs exist with surface temperatures between 40^{o} and $70^{o}C$.



MALAYSIA

The country of Malaysia is comprised of an area of 329,749 km^2 located at the end of the Malay Peninsula. Malaysia is not situated in a tectonically active region, and no comprehensive evaluation of the geothermal resources of the area has been carried out. Numerous hot springs with temperature above $50^{o}C$ exist in the southwestern part of the country. The government has reportedly carried out reconnaissance studies of the Sabah region, but the results are not known.



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MEXICO

Geothermal areas of Mexico are located along the southern extension of the Salton Trough of California into northern Mexico, and along an east-west volcanic axis in south-central Mexico. As of the end of 1985, 645 MWe of geothermal generating capacity is now operation or under construction in Mexico, with another 600+ MWe planned.

As part of a nationwide study to characterize certain geothermal areas, a national inventory of the geothermal areas of Mexico was performed by the Commision Federal de Electricidad (CFE). The purpose was to gather resource information and make an appraisal of the country's geothermal potential for planning and prioritization. The results of CFE's work led to a classification of Mexico's geothermal resources into three categories. The estimated geothermal energy resources of Mexico are: 1340 MWe proven, 4600 MWe probable, and 600 MWe possible.

The Cerro Prieto geothermal field, located in northwestern Mexico along the California-Mexico border in the Mexicali Valley, is the major site of geothermal development in Mexico. The field has been in production since 1973 and has the distinction of being the first liquid-dominated geothermal system in North America to provide significant electrical production.

Cerro Prieto is located along a continental spreading zone bounded by the right-lateral strike-slip Imperial and Cerro Prieto faults. The heat source is presumed to be magma bodies (dikes and sills) intruded into the recent sediments of the Colorado River Delta, and derived from gabbroic plutons rising from an oceanic-type spreading ridge. Volcanic rocks at the surface consist of two rhyodacite cones comprising the Cerro Prieto Volcano. At least five eruptive phases have occurred since late Pleistocene (110,000 years).

The Laguna Volcano area, located a short distance southwest of the developed geothermal field, is the site of many surface thermal manifestations. The area consists of low hills built up by hot spring and fumarolic activity and is thought to result from reservoir leakage to the southwest along high angle fracture zones. Laguna Volcano has been the site of phreatic explosions in the past, the latest occurring in 1927.

Over 140 deep geothermal wells have been drilled at Cerro Prieto since exploration first began in 1959. Fluids at temperatures above 300°C (335°C maximum) are produced from 103 production wells at depths ranging generally between 1000 and 3500 m. The deepest well is 4,125 m deep. Reservoir production zones increase in depth from southwest to northeast partly in response to fluid migration upward along high-angle faults and increasing depth to basement to the northwest. Reservoir modeling studies have shown that the field is recharged from the east by hot (355°C) fluids, and from both the east and west by cooler (50° to 150°C) water.

Cerro Prieto has 620 MWe capacity either operating or currently under construction. A continued commitment by the Mexican government toward geothermal development resulted in the initial investigations within the volcanic regions of southern Mexico. In 1967, CFE began exploration at Los Azufres (Michoacan) and later in 1980 at Los Huseros (Puebla).

The Los Azufres geothermal field is located in central Mexico approximately midway between Mexico City and Guadalajara. Exploration at the field began in 1976 when CFE initiated a deep drilling program to evaluate the geothermal potential of the area. Although there were many drilling problems associated with volcanic rocks and high temperatures, the program was successful in discovering a thermal reservoir with temperatures exceeding 300°C.

The field lies within the Neovolcanic belt in complex Pliocene-Pleistocene successions of basalts, andesites, trachy-andesites, dacites, and rhyolites from three volcanic cycles. The reservoir is separated into two sectors, the Maritaro (or northern) sector is a liquid-dominated system and the Tejamaniles (or southern) sector is a vapor-dominated system.

Presently, over 40 wells have been completed in the two sectors of the field. In the northern sector, fluids are supplied to three 5 MWe portable non-condensing turbine units via 10 production wells that achieve an average depth of 1700 m. Reinjection is facilitated through three wells. Twelve wells in the southern sector, with an average depth of 1000 m, provide thermal fluid to two similar 5 MWe turbine units. Reinjection is also accomplished through three wells.

In 1987, seven additional portable turbine units are scheduled for installation at Los Azufres, bringing total on-line capacity to 65 MWe. Construction of a central 50 MWe plant, to be located in the southern sector, is scheduled to begin during 1985. Two additional 55 MWe power plants are in the advanced planning stages and may be constructed pending further reservoir testing.

The Los Humeros-Derrumbadas geothermal region is located east of Mexico City in the eastern portion of the Trans-Mexican Neovolcanic Axis. The Los Humeros Caldera, a Quarternary collapse structure along the flank of a shield volcano, is situated within the northern portion of the prospective region. Recent surface exploratory programs have indicated a high potential for geothermal development in this region. Subsequent deep exploratory drilling and testing of seven production wells has been successful, and small scale power generation is expected by 1987. If additional reservoir testing proves favorable, two 55 MWe plants are in the preliminary planning stages for installation before 1991.

In addition to the developments occurring in the major fields of Cerro Prieto, Los Azufres, and Los Humeros, other prospective thermal fields lie within Mexico's volcanic region. At La Primavera, near the of Guadalajara, exploration has begun within a volcanic caldera. Five exploratory wells have been drilled to depths of 2,000 m, and have encountered temperatures as high as 305^{o}C.

Within the state of Michoacan, two other areas have been investigated. The Los Negritos thermal area was tested via a 1000 m exploratory well, and produced steam and water intermittently. In the Ixtlan de Los Hervores area, a total of eight shallow exploratory wells have been drilled with inconclusive results.

Today, 645 MWe of generating capacity is either installed or under construction at Cerro Prieto and Los Azufres. An additional 440 MWe between the two fields is planned for installation by 1992.

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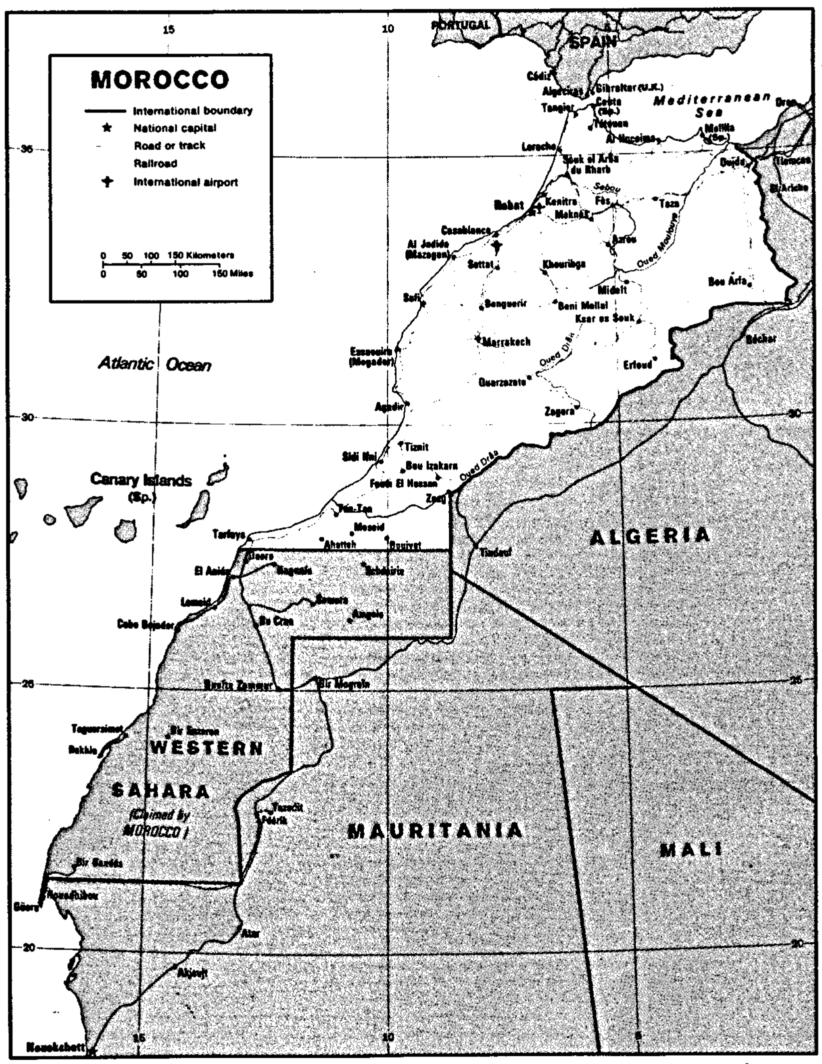
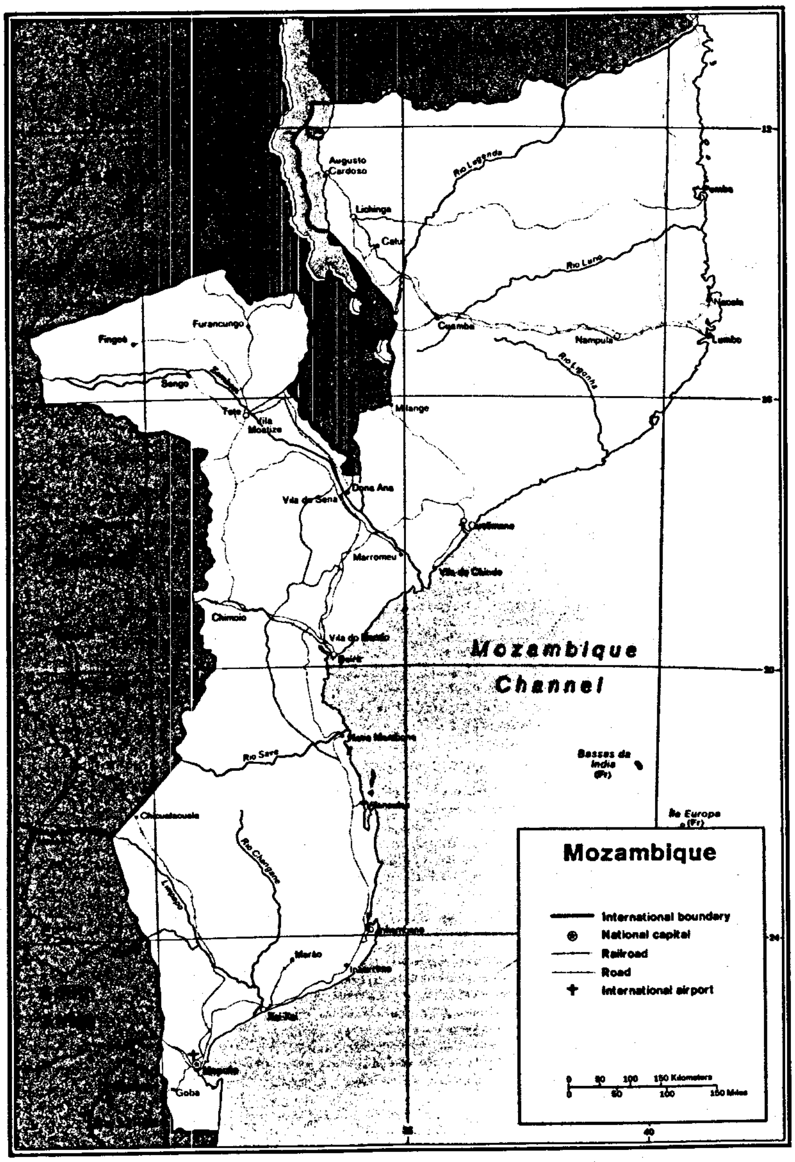
MOROCCO

No comprehensive assessment of Morocco's geothermal resources has been made available to date, although a resource assessment was reportedly undertaken beginning in 1979. Thermal springs are distributed along the northwestern province of Morocco in eight localities, possibly due to an active thrust fault that transects the northern part of the country. Temperatures in many of the springs have been reported around 50°C.



MOZAMBIQUE

Geothermal resources of Mozambique are not well documented and may consist only of sparsely distributed, low-temperature hydrothermal systems. Basaltic rocks are reported to occur in the lower part of the Zambezi River Basin, and rhyolitic rocks are present along the southwest border of the country. No ages have been reported for these rock units.



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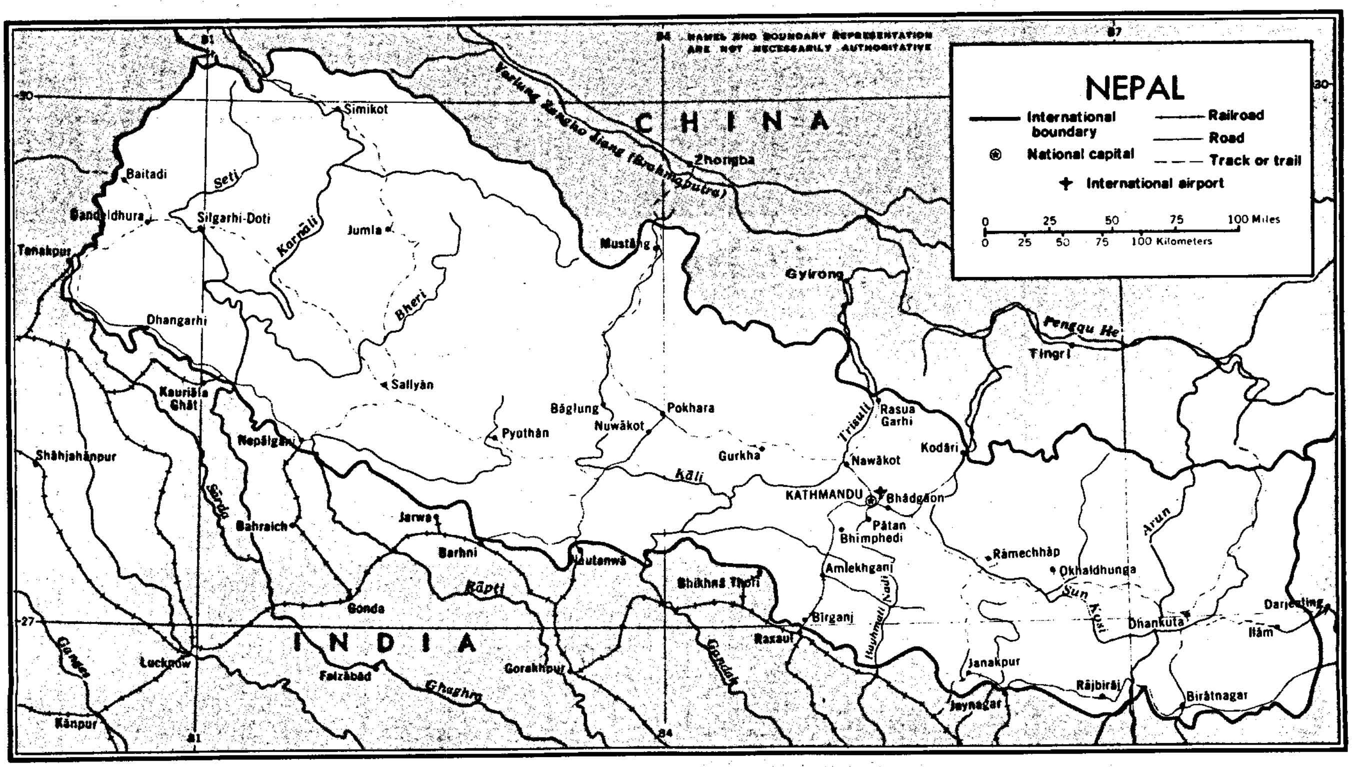
NEPAL

Nepal lies along the Himalayan Trench northeast of India. Geothermal resources have been located and explored along the Indian side of the trench but Nepal has as yet received neither funding nor support to explore its potential resources.

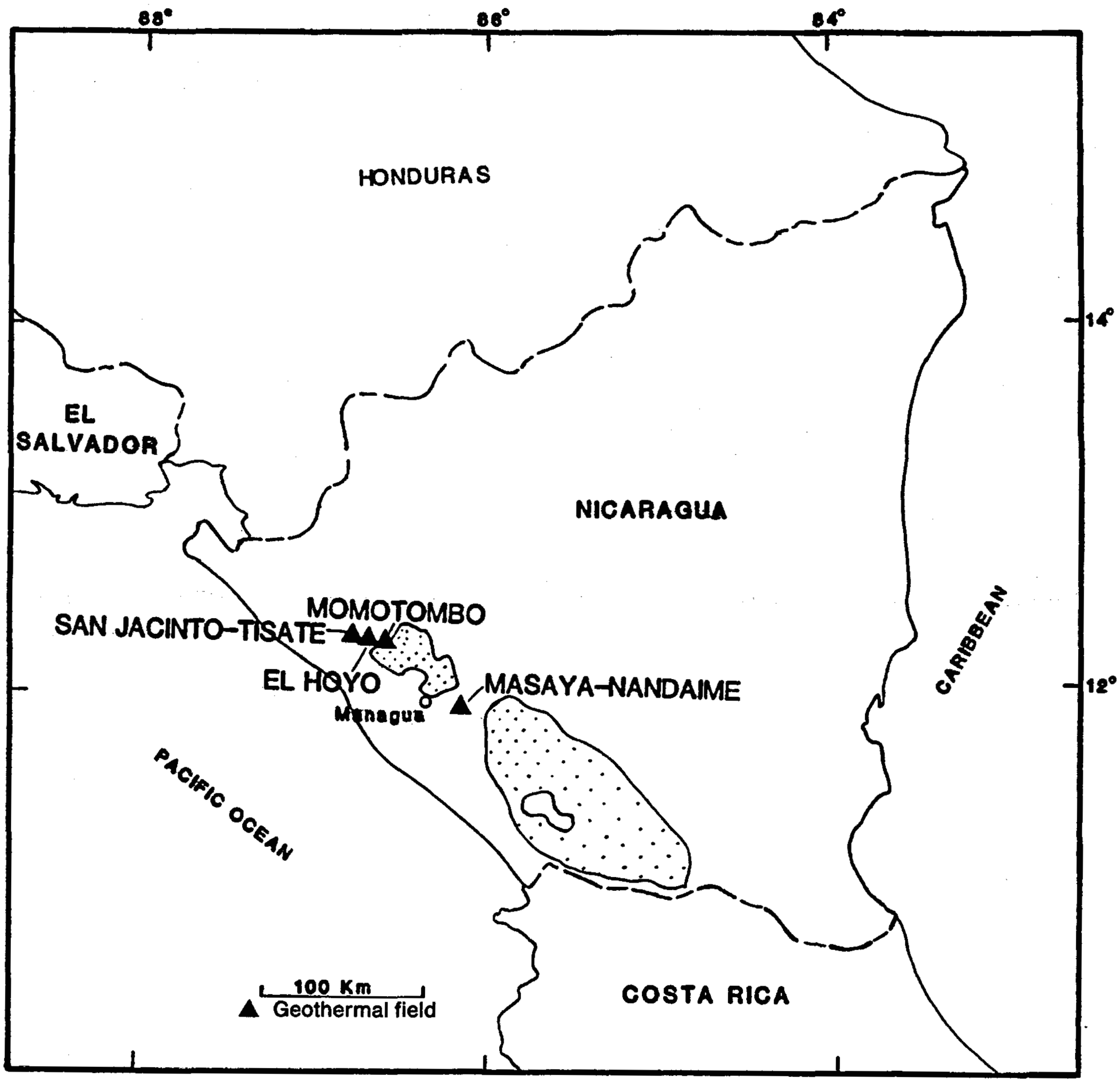


NICARAGUA

Nicaragua is situated in a tectonically active region in Latin America along the Middle American Trench. Volcanoes, earthquake epicenters, and thermal springs manifest the high-temperature geothermal resources of Nicaragua.

The first geothermal studies in Nicaragua were performed during the late 1960's and the early 1970's. During this period, the Momotombo area and the San Jacinto-Tisate area were explored under a program sponsored by the U.S. Agency for International Development (AID).

The Momotombo geothermal field is located at the north end of Lake Managua, along the flank of the Momotombo Volcano. Momotombo is the southernmost volcano of the Marabios Volcanic Axis of northern Nicaragua. The geothermal field is situated within a small graben structure and measures less than one km2 in surface area. Over 30 exploratory and production wells have been drilled in the field defining a reservoir that results from a laterally



spreading plume of hot water from a near vertical fracture zone. Thermal fluids with temperatures around 230°C are confined within the graben by volcanic rock to the east, whereas west of the structure the formations are largely unfractured.

A 35 MWe geothermal power plant was dedicated at Momotombo in 1983. In 1984, an agreement was signed with the Societe de Prospection et d'Etudes Geothermiques (SPEG) of France to supervise and manage the drilling of four additional production wells. The additional wells are to provide fluid to a second proposed 35 MWe plant. The Inter-American Development Bank (IDB) has been requested to aid in financing field development and power plant expansion.

Geothermal prospecting has been active in other areas of Nicaraqua as well. In the El Hoyo region, the IDB has been requested to approve funding for a power plant feasibility study. A prefeasibility study of a possible project in the Masaya-Nandaime region is planned under the cooperation of the National Energy Institute (INE) and OLADE. Other areas include: San Jacinto-Tisate, Volcan Cosiguina Volcan San Cristobal-Casita, Managua-Chiltepe, Masaza-Tipitapa, L. Apoyo-V. Momvacho, Isla Zapatera, Isla Ometepe, and Las Lajas.

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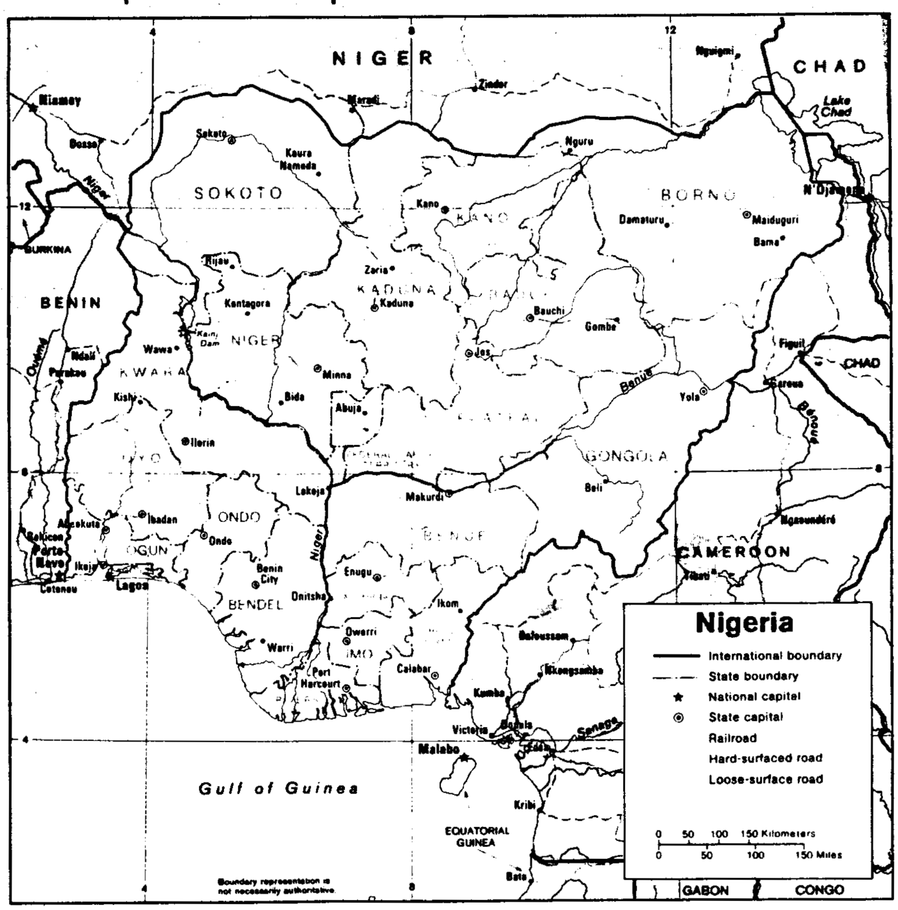
NIGERIA

There has been no comprehensive assessment of geothermal resources of Nigeria to date. The country is characterized by a wide coastal band of post-tertiary marine deposits, and inland mountains comprised primarily of old sedimentary rocks lying on a granitic/metamorphic basement. Nigeria has a general lack of faulting, no extensive areas of young volcanic rocks and low amounts of rainfall. As a result, preliminary reports of geothermal resources in Nigeria indicate a low potential.

A study performed by the University of Nigeria provided a first attempt at assessing the geothermal potential of southern Nigeria's sedimentary basin (Niger Delta region). The study was based upon data gathered from over 1,000 oil wells, and defined thermal gradients on the order of 15^{o} to $50^{o}C/Km$. From this work, it was shown that a possible relationship exists between the $100^{o}C$ isotherm and the top of an "overpressured" zone.



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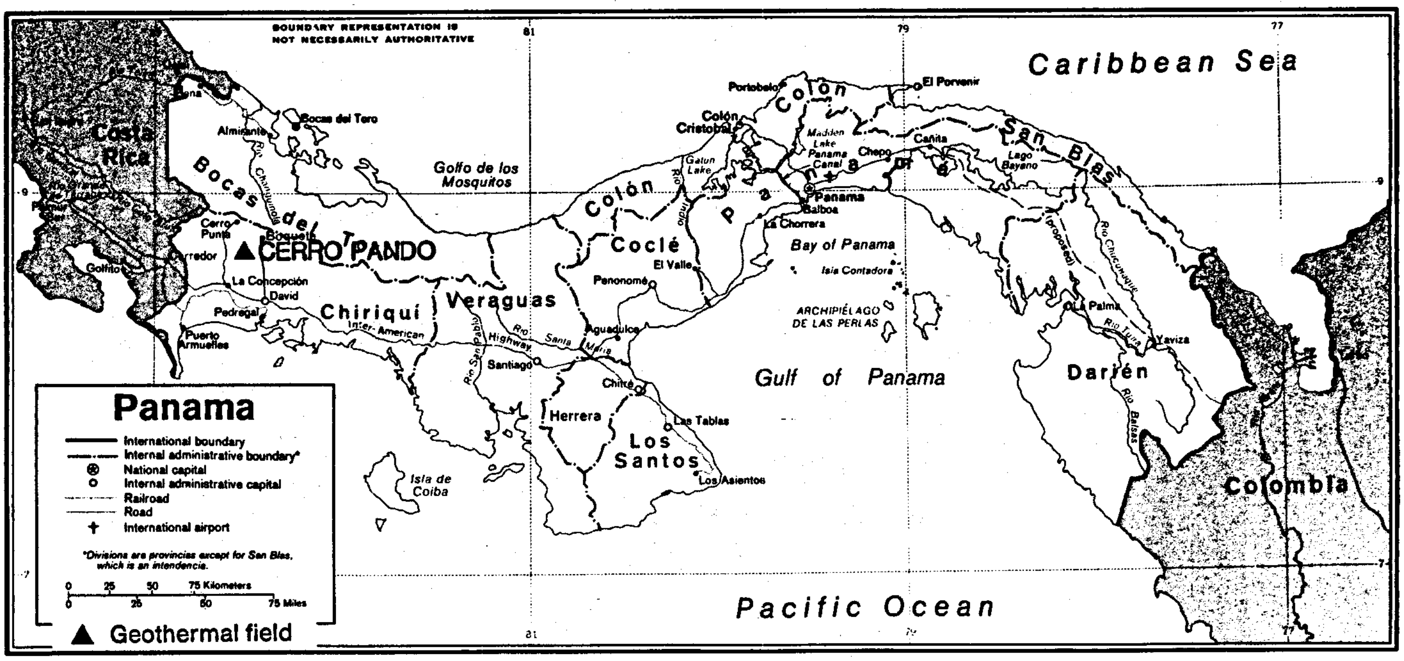
PANAMA

Panama is tectonically situated near the intersection of the Middle American Trench, the Peru-Chile Trench, and the Cocos Ridge (spreading center).

Geothermal studies in Panama were initiated by the government in the early 1970's, with the assistance of the UN and OLADE. Through OLADE's work, data gathering functions and a prefeasibility study have been performed at the Cerro Pando and the Baru Cerro Colorado geothermal areas in western Panama. In Cerro Pando, six gradient wells have been drilled to an average depth of 635 m. In addition, a nationwide reconnaissance study of prospective areas has been completed. Six other geothermal localities have been identified including El Valle, Calobre, Huacas de Quije, Los Santos, Aguas Calientes, and Coiba.



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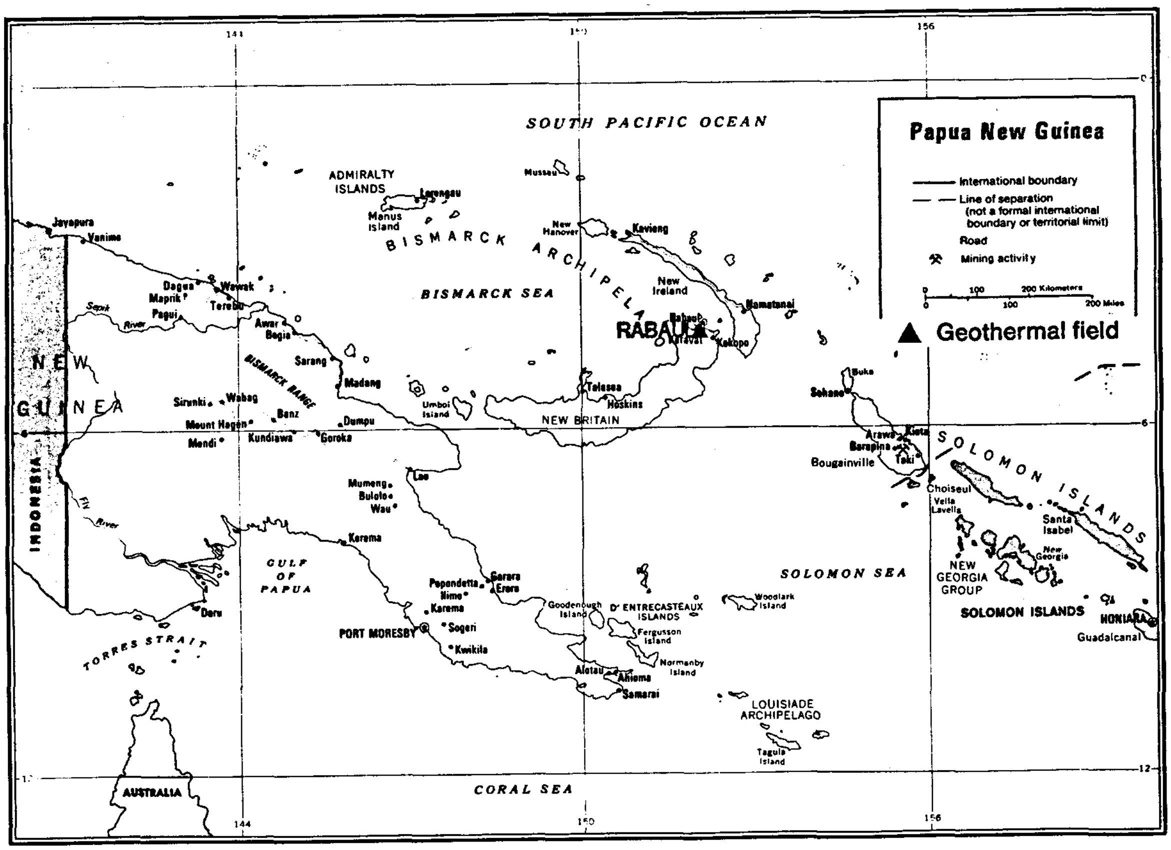
PAPUA NEW GUINEA

Papua New Guinea, with an area of 406,752 km2, is an independent state that shares the island of New Guinea with part of Indonesia. Papua New Guinea lies along the Philippine-New Guinea-New Hebrides arc trench system, which is characterized by at least ten young volcanoes, a number of earthquake epicenters and numerous local "hot spots". The country may have high geothermal potential but most prospects are away from population centers. The most promising area is near the community of Rabaul.



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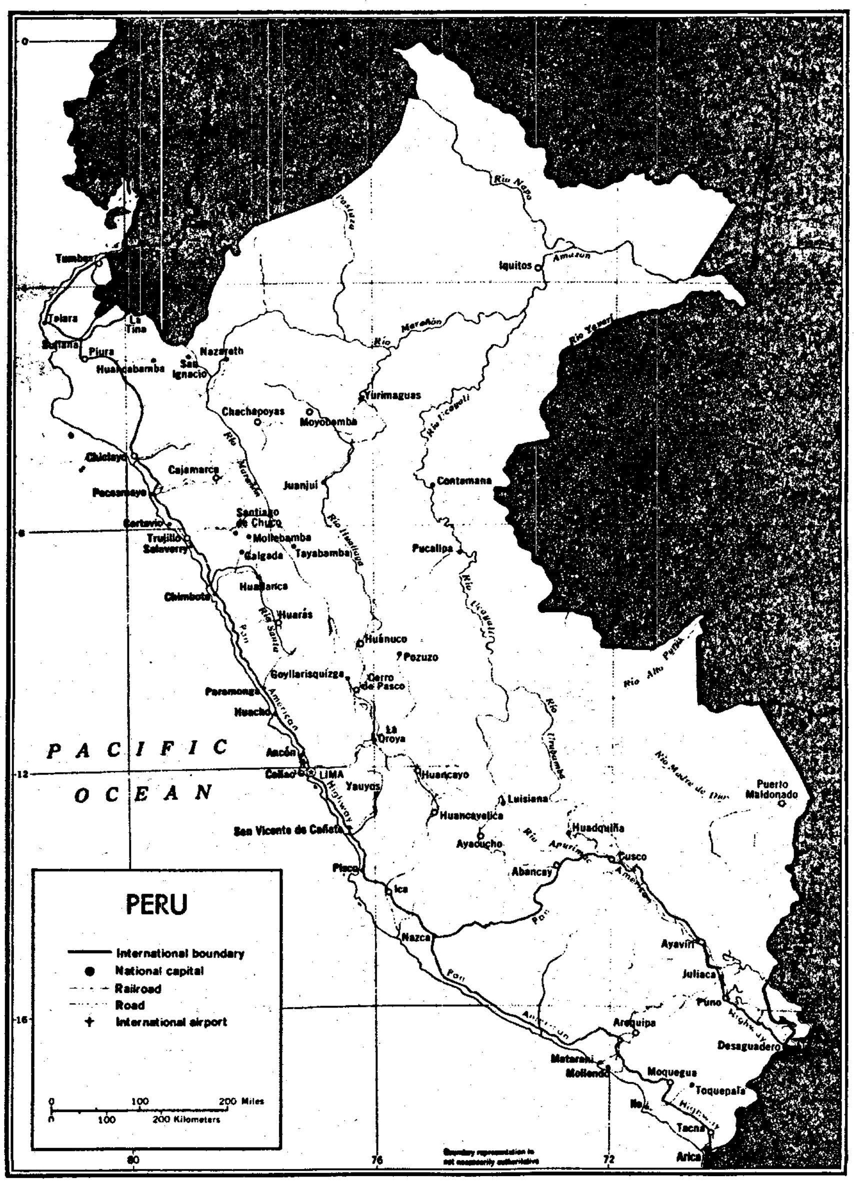
PERU

Peru is in a tectonically active area bordered by the Peru-Chile Trench. The Southern Volcanic Cordillera is the region of greatest geothermal potential in Peru. Within this region, volcanic activity has taken place episodically since the late Miocene to the present. Rocks of the Sillapaca formation and the Viejos volcano group comprise a recent andesitic stratovolcano complex where the prominent volcanos, such as Misti and Ubinas, are located.

Peru's effort to develop alternate energy began in the early 1970's as a direct result of oil price increases. Early efforts included an investigation by the state-owned MINERO-PERU at Calacoa, and a reconnaissance by Geothermal Energy Research and Development (Japan) in the Puno-Cuzo region. Following



these early investigations, the Mining and Metallurgical Institute of Geology (INGEMET) conducted an inventory of the numerous thermal manifestations throughout the Peruvian territory and subdivided the geothermal areas into six regions based upon geography.

Following the inventory, INGEMET and Aquater (Italy) received financial support from OLADE to conduct reconnaissance investigations in the most promising region known as the Southern Volcanic Cordillera. The results of preliminary geoscience studies enabled INGEMET to identify promising geothermal areas and prioritize those areas of later detailed studies.

Reconnaissance investigations have been undertaken in the central and northern regions of Peru. The investigations have included compilation and interpretation of water analyses, geoscience data, and lineament studies. Hydrothermal resources within the two regions probably relate to deep circulation of meteoric water along high angle faults of Cretaceous age. Resources in these regions are therefore most likely to be contained as low- to moderate-temperature systems.

ELECTROPERU, in 1982, entered into an agreement with the Renzo Tasselli Study Center (CESEN) of Italy for the purpose of carrying out geothermal reconnaissance in four other regions of the country.

The early geologic studies of the Southern Volcanic Cordillera conducted by MINERO-PERU located two geothermal areas, Calacoa and Salinas. From these analyses only the Calacoa area was considered to possess economic potential. Geothermometry applied to water analysis there indicated a reservoir temperature in excess of 180°C. The general character of the hot spring activity also indicated that the reservoir is liquid-dominated.

In addition to the Calacoa and Salinas areas, the areas of Tutupaca, Chivay, and Challapalca are also considered to have geothermal potential. OLADE has reportedly performed pre-feasibility at Rio Maure.

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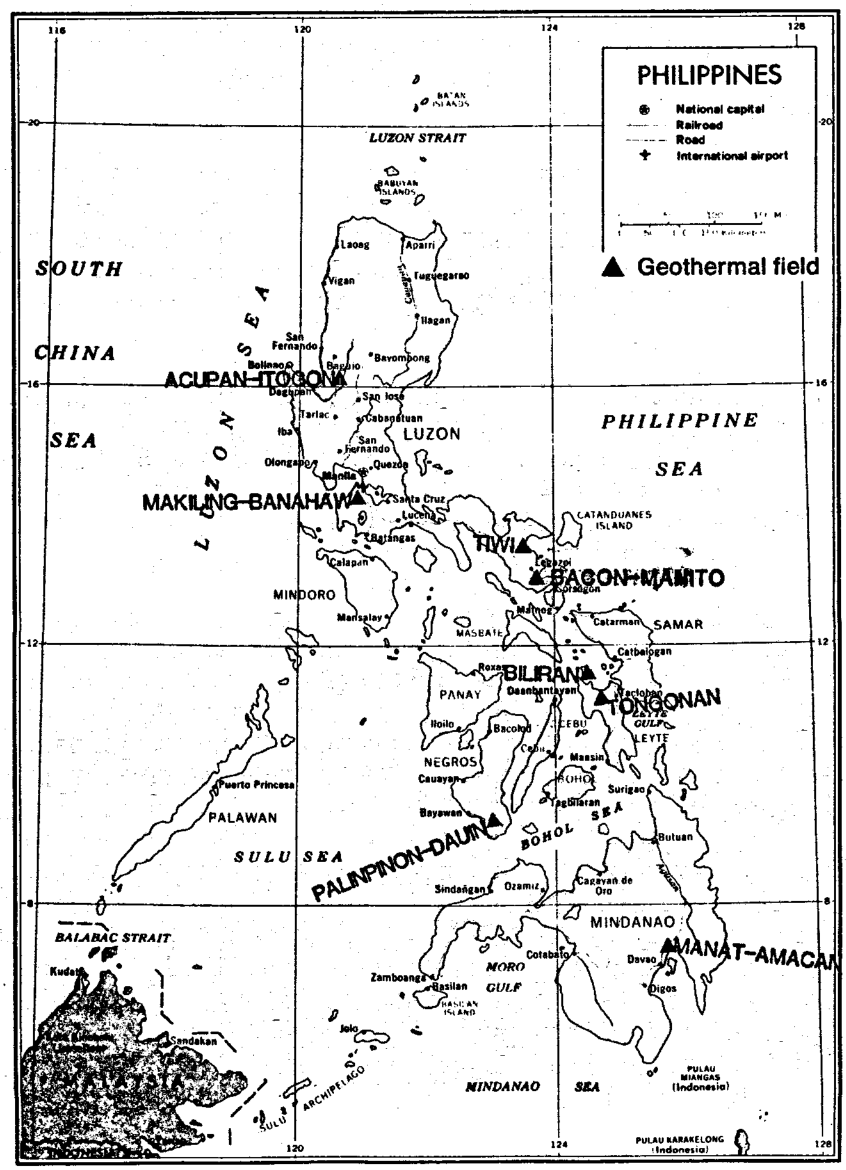
PHILIPPINES

Today, electricity is produced from four geothermal fields in the Philippines with a combined total installed capacity of 894 MWe. Additional generating units with a total capacity of 1300 MWe are planned before 1990.

The Philippine islands are comprised primarily of andesitic volcanic terrain as a result of "arc" volcanism. Crustal subduction may be active today off the eastern coasts along the Philippine Trench as evidenced by active faulting, earthquakes, and the widespread distribution of recent volcanic rocks. A major northwest trending, right-lateral strike-slip fault cuts through the central portion of the islands (Philippine Fault). A similar feature (Mindanao Lineament) crosscuts the island of Mindanao and extends onto southern Negros Island. These structural features are spatially related to hot springs, fumaroles, and centers of recent andesitic volcanism. Many of the geothermal fields of the Philippines are situated along these major structures or along associated secondary structures.



Geothermal resources in the Philippines have been of national interest since the early part of this century when initial studies were performed by the Commission on Volcanology. An effort toward electrical generation did not materialize until the mid-1960's, when a small plant was demonstrated at Tiwi, Albay Province. Heightened awareness of the geothermal potential after this event helped foster legislation that promoted the discovery and commercialization of several geothermal fields.

After the completion of early pilot studies at Tiwi, the National Power Corporation (NPC) was authorized to develop the country's geothermal resources. In an effort to carry out its mission, NPC entered into a joint-venture agreement with Philippine Geothermal, Inc. (PGI) (a subsidiary of Union Oil Company of California) whereby PGI could provide necessary capital and technical expertise. As a result of this agreement, successful drilling and production has taken place at the Tiwi and Makiling-Banahaw geothermal fields.

At Tiwi, the geothermal field has been separated into three sectors by topography and structure. Geothermal fluids migrate vertically upward along high angle north-south trending fractures from an apparent deep source in the southern portion of the field at temperatures exceeding $300^{o}C$ (estimated from geochemistry). The fluids then mix in varying proportions with shallower ground water to be distributed over the field through complex stratigraphic and structural conduits.

Electricity production began commercially at the Tiwi geothermal field in 1979, when two 55 MWe flash steam plants came on-line. Since then, an additional 220 MWe of capacity has been installed by Union bringing total capacity up to 330 MWe. The power plants are supplied by more than 100 producing wells. Total potential capacity for the field has been estimated at 660 MWe.

The Makiling-Banahaw geothermal area, including with the Bulalo field, located on the island of Luzon in Laguna Province, is one of the two hot water producing areas. Unocal Corporation has installed six 55 MWe generating units for a total generating capacity of 330 MWe. The plants are supplied fluid from 55 wells, while an additional 14 wells are used for injection. Geothermal reservoir fluid temperature ranges between 280^{o} to $310^{o}C$.

The Bacon-Manito project (Bac-Man), is situated along the Albay-Sorsogon border. To date, nineteen deep wells have been completed including three injection wells. Thirteen of these wells have a tested combined output of 73 MWe. Plans have been formed to bring a 110 MWe generating station on-line by 1989. The Philippine National Oil Company asked the World Bank in 1986 to finance the drilling of about 17 wells for 2 steam separator stations, the total cost of which will be $95 million.

The Philippine National Oil Company-Energy Development Corporation (PNOCEDC) was delegated the responsibility in 1976 of exploring and developing other geothermal resources. At that time, the country's Energy Development Board was involved with resource assessments and field development projects with help from Italy and New Zealand under bilateral agreements. The PNOC-EDC continues to pursue exploration programs throughout the islands and recently has entered into a joint venture agreement with Caltex Oil Company to explore a number of promising new areas.

In 1973, through cooperative investigations with a New Zealand consulting firm, geothermal studies were initiated by the Philippine government in the Tongonan area on the island of Leyte. As a result of initial surface geoscience surveys and shallow thermal gradient drilling, three exploration wells (1500 m each) were drilled. These early exploratory wells penetrated temperature regimes in excess of 320°C. The early phases of exploration began in the northern sector of the field, known as the Mahiao and Sambaloran areas, and progressed southeastward into the Malitbog, Mamban, and Mahanagdong areas.

Studies have shown that the geothermal area at Tongonan is situated around two thermal anomalies. The two anomalies appear to be centered in the Sambaloran valley and at Mahanagdong. Geothermometry suggests maximum reservoir temperatures in excess of 340°C with mean reservoir temperatures between 200° and 300°C. The lateral area of the system is greater than 25 km2 with reservoir capacity estimated to be nearly 450 MWe. Current installed production capacity at Tongonan is 153 MWe. An additional 37.5 MWe generating unit is planned for 1989.

At Palinpinon, in the southern region of the island of Negros, geothermal exploration began in the mid-1970's and has continued to the present. Total field capacity has been projected at 340 MWe. The first 118.5 MWe geothermal power plant became operational in 1983. Some 21 wells provide fluid to this plant. A nearby geothermal field, known as the Dauin field, is presently being explored and may prove to be of significance in the future. A total of 53 deep exploration wells have been drilled in the two areas.

In addition to the proven geothermal fields described above, many other areas may possess significant potential. Areas of recent interest by the PNOCEDC include:

Mindanao-Palawan

- o Manat-Amacan, Davao del Norte: Three wells have been completed to a maximum depth of 2,692 m. Although the maximum recorded temperature was 267°C, the wells encountered very low permeability.
- o Mt. Apo-Kidapawan: Geochemical and geophysical studies were performed in 1984. Reservoir temperatures were estimated to be in excess of 240°C.

Areas of interest by the Bureau of Energy Development (BED) include:

Luzon Island

- o Daklan and Buguias: An assessment of geothermal resources of Daklan was done by GeothermEx, Inc. for Caltex Petroleum Corporation. An exploration program was completed at Daklan in 1983 by Electroconsult (Italy). Five deep exploration wells were completed and tested, with apparent low permeability.
- o Acupan-Itogon, Benguet: The first deep exploration well (2,000 m) was reportedly completed in 1985.

- Batong-Bukay, Kalinga-Apayao: Preliminary geophysical studies indicate a thermal anomaly of approximately 6 km2 in size.

- Mauit-Saudanga, Mountain Province: Preliminary planning of resource assessments.

- Mt. Labo: Exploration by Total Exploration and Philippine Oil and Geothermal Exploration, Inc. have indicated a prospect of 15 km2 in size.

- Iriga-Isarog: Reconnaissance performed by Ultrana Nuclear and Minerals Corporation and Canada Northwest Energy Ltd.

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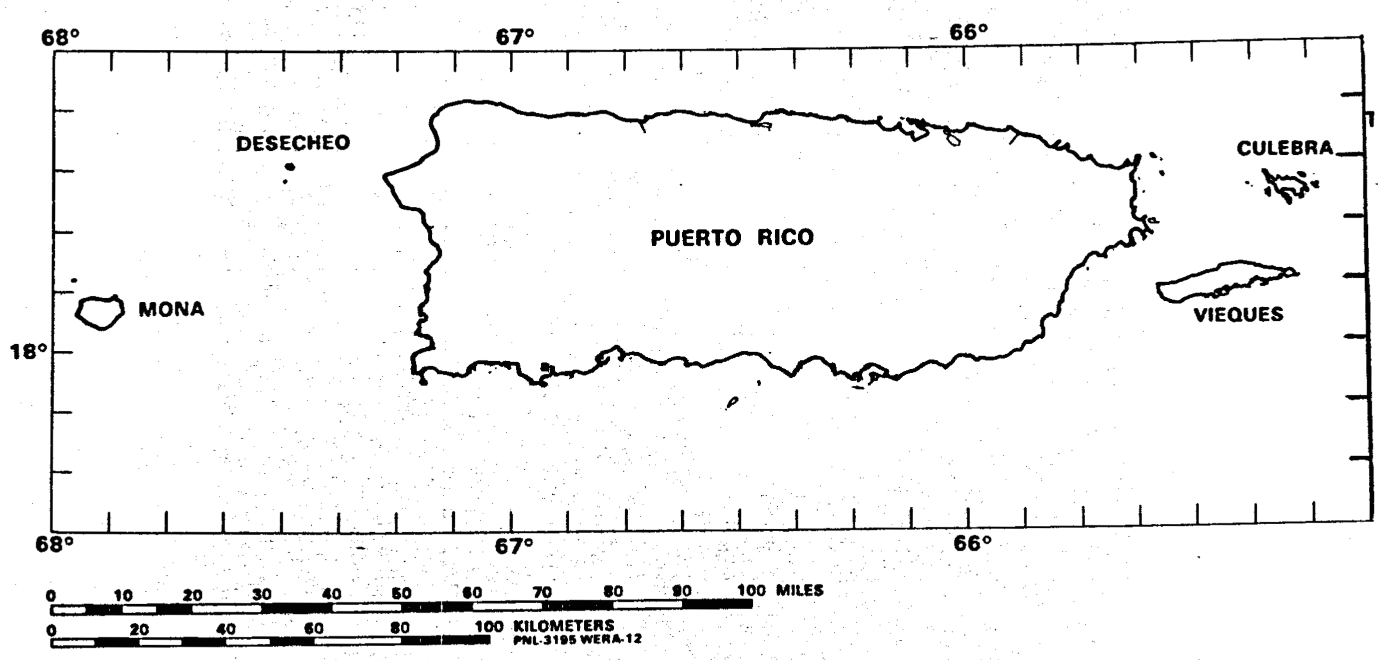
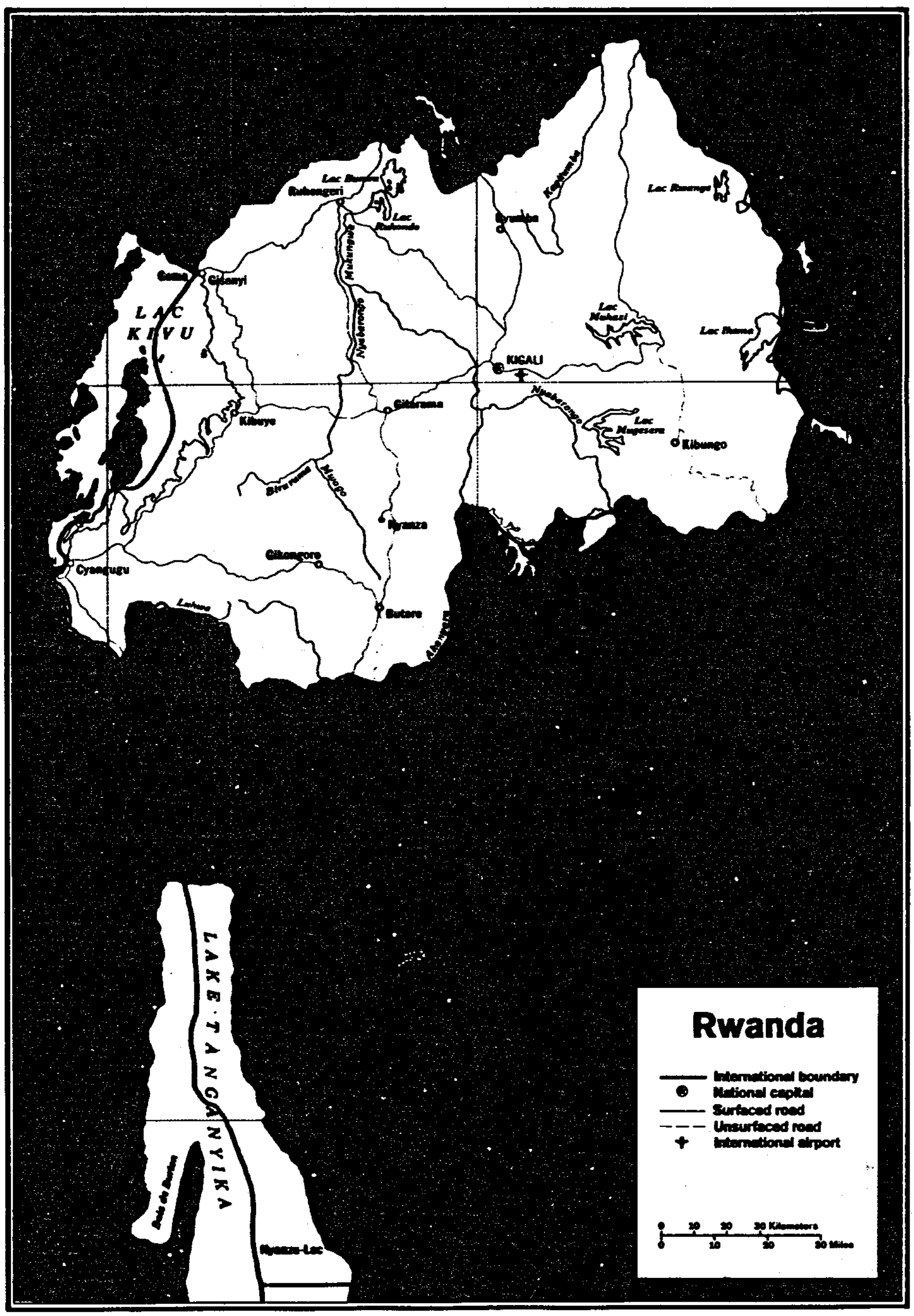
PUERTO RICO

The island's position with respect to the major tectonic features of the Caribbean suggests that hydrothermal systems may be present. A new thermal springs with average temperatures of 30°C exist in southern Puerto Rico. Little is known about Puerto Rico's geothermal resources, as no comprehensive assessment of the island has been made.



RWANDA

Located east of Zaire and west of Lake Victoria, Rwanda lies in a volcanic area just southwest of the East African Rift. The region should be a good geothermal prospect, but no geothermal exploration has been initiated.



SAINT CHRISTOPHER (ST. KITTS) AND NEVIS

An independent state within the British Commonwealth, St. Christopher and Nevis is located along the Lesser Antilles volcanic arc, in an active earthquake zone of the Caribbean. Springs and fumaroles near Mount Misery on the island of St. Christopher reportedly have temperatures exceeding 90°C. The geothermal potential appears promising but initial studies have apparently not been undertaken.

MAP UNAVAILABLE

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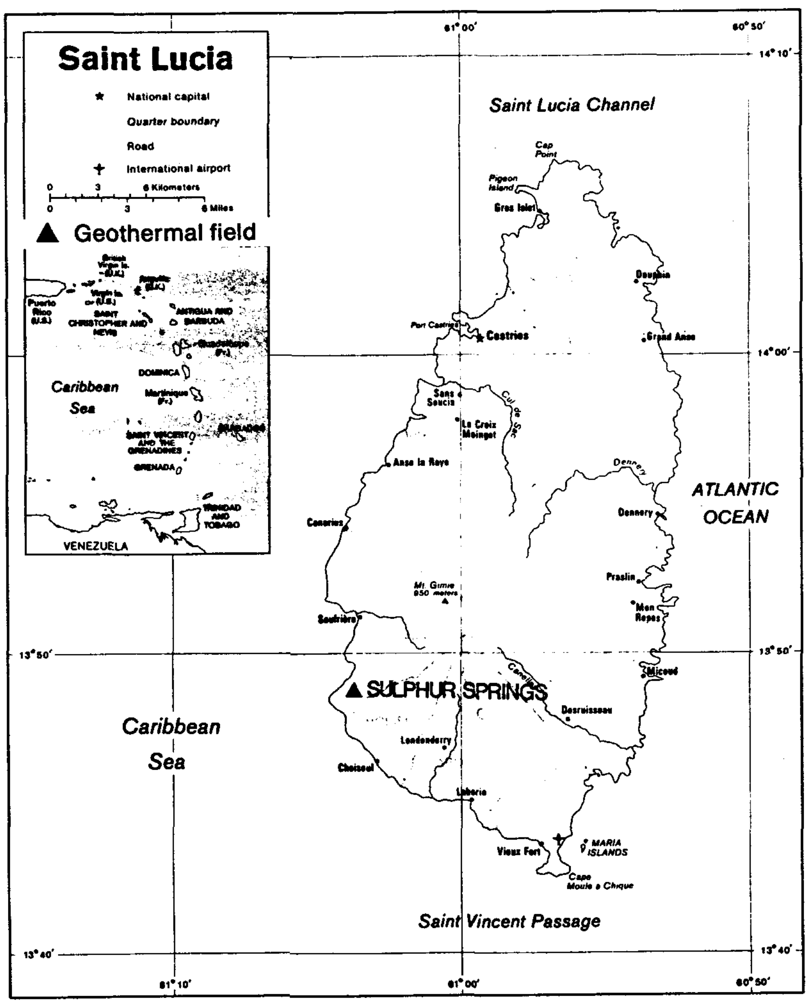
SAINT LUCIA

St. Lucia, of the Lesser Antilles island arc, is an independent country of the Eastern Caribbean Commonwealth. An initial comprehensive geothermal resource exploration program at St. Lucia was conducted by the United Kingdom's Ministry of Overseas Development in the early 1970's, followed by engineering testing in 1976. An evaluation of existing information, including recommended drilling areas, was later completed in 1982 by Aquater (Italy). In 1984, Los Alamos National Laboratory (LANL) implemented a geological, geophysical, hydrogeochemical, and engineering investigation including life-cycle cost estimates and recommendations for future exploratory work.

St. Lucia is part of a 10 million year old, migrating volcanic chain where pre-caldera cones and domes of predominantly andesitic composition began forming 2.5 million years ago. Recent dacitic eruptions, beginning 250,000 years ago, occured mainly in the Petit and Gros Pitons areas. The eruption of the Choiseul Pumice resulted in the formation of the Qualibou Caldera at about 39,000 to 32,000 years ago. The latest (32,000 to 20,000 years ago) magmatic activity, centered around Belfond, created ten phreatic rhyodacitic vents in the southern part of the caldera.

Two regional northeasterly trending faults border the Qualibou Caldera. These regional faults and ring structures, associated with formation of



caldera, provide conduits for thermal waters originating at depth. Thermal spring distribution on the island is primarily controlled by faults and their effect on hydrology. A complex multiple magma chamber with an estimated size of 100 km3 is thought to underlie the caldera.

The Qualibou Caldera contains extremely good potential for geothermal resources. Geophysical, geochemical, and other evidence indicate that brines deep within the caldera exist at temperatures of more than 230°C. Specific regions within the caldera recommended for geothermal development include Belfond, Sulphur Springs Valley, and Etangs.

The Belfond area, located 1.5 km southeast of Sulphur Springs, is the primary target for additional exploration. Three deep craters along the western caldera fault define the youngest thermal activity in the area. Pyroclastic flows and air-fall debris surrounding these craters suggest phreatic explosions and provide support for a permeable groundwater source and magma/water interaction. Fracture permeability may also be present from caldera related faulting. The main geothermal reservoir at 250°C is thought to be located at a depth of 1000 m. The Belfond craters should be prime drilling targets in the future although access is limited to unpaved roads and trails. Low- to moderate-temperature fluids present at shallow depths might be easily extracted from permeable horizons for direct-use.

Sulphur Springs Valley marks the edge of an intra-caldera fault. Fractures associated with phreatic vents at depth may connect the adjacent explosion craters to a fractured geothermal reservoir. Seven shallow exploratory wells were drilled in the area to depths up to 600 m in 1970. The results of the drilling in conjunction with resistivity profiles have indicated that a dry steam reservoir may exist at greater depths, which itself may overlie a hot brine reservoir.

Thermal anomalies and resistivity lows suggest a geothermal reservoir at a depth of 1000 m at the Etangs geothermal area. The geothermal fluid source may stem from the Belfond area along a major northeast-trending fault in the Belle Plaine.

St. Lucia is included as one of two geothermal development projects to be funded partly through the United Nation's Revolving Fund for Natural Resources Exploration. The project will consist of drilling a minimum of two production sized exploratory wells to be drilled not more than 2,500 m. The U.N. Revolving Fund will provide up to $2.5 million for the project. The U.S. Agency for International Development (AID) will provide up to $3 million to co-finance the project through a Management Services Agreement with the Fund and the government of St. Lucia.

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Ander, M. and others 1984, Evaluation of the St. Lucia Geothermal Resource-Geologic, Geophysical, and Hydrogeochemical Investigations: Los Alamos National Laboratory.

Goff, F., and Buataza, F.D., 1984, "Hydrogeochemistry of the Qualibou Caldera Geothermal System, St. Lucia, West Indies," Geothermal Resource Council Transactions, Vol. 8, pp. 377-382.

SAINT VINCENT AND THE GRENADINES

St. Vincent and the Grenadines is an independent state within the British Commonwealth. It is located along the southern Lesser Antilles volcanic arc and reported to have evidence of significant geothermal resources. A number of hot springs exist on the island of St. Vincent. The British Geological Survey is considering comprehensive studies on the island.

MAP UNAVAILABLE

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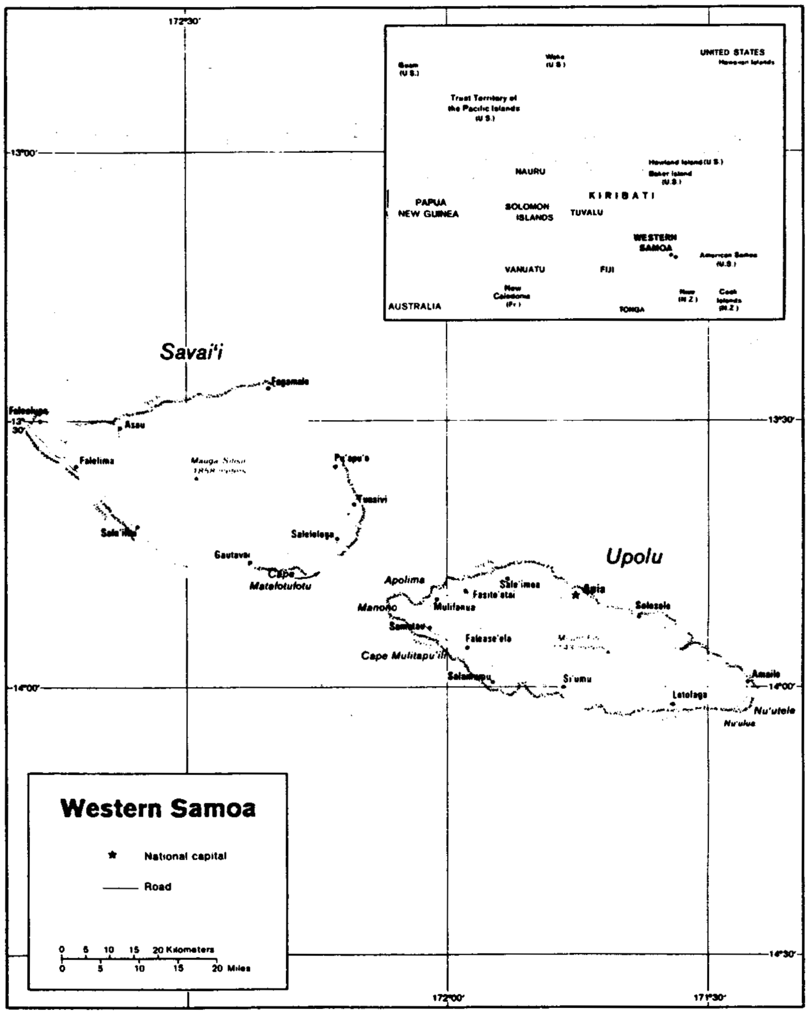
SAMOA, WESTERN

Just west of the Solomon Islands, Western Samoa is a separate independent state in the Samoan island chain. It is located a short distance north of the Tonga Trench and has been identified as a "hot spot" along one of the margins of the Pacific plate. Active volcanism is taking place, indicating good geothermal potential, though electricity needs on the islands are minimal.



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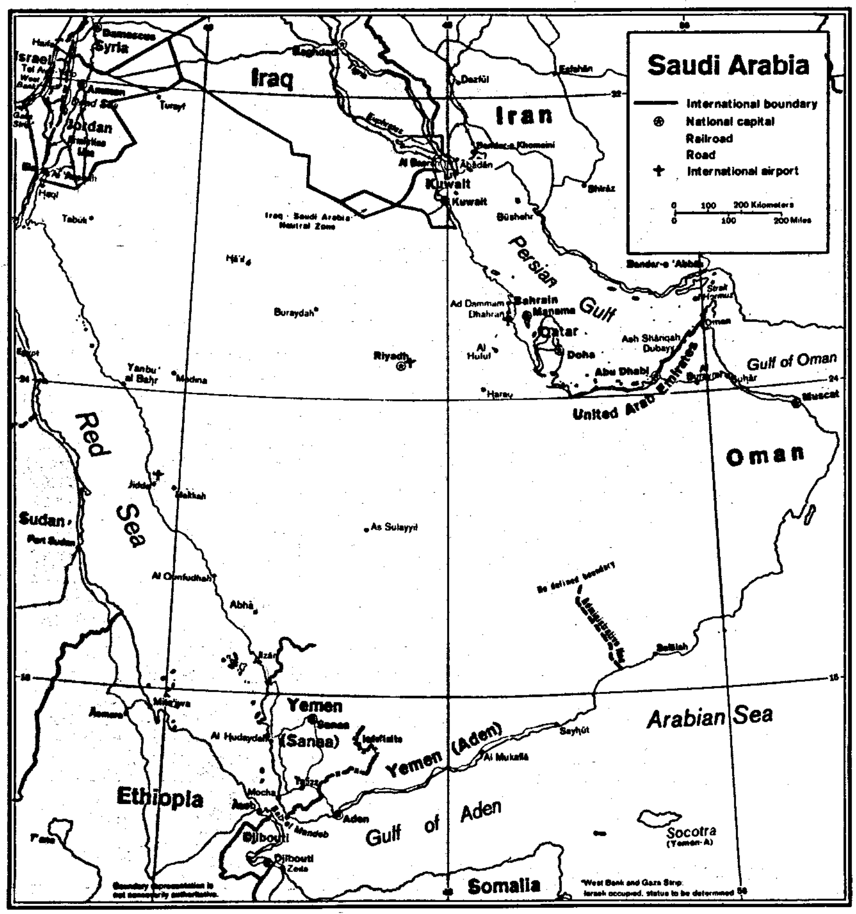
SAUDI ARABIA

Geothermal assessments have been carried out in Saudi Arabia by the Directorate General of Mineral Resources (DGRM). Areas have been categorized based upon potential for discovering high- and moderate-temperature systems. Areas where potential for high-temperature resources may be found include areas of recent volcanism around the Saudi Plateau. Thermal springs are known to occur at Al Lith, Jizzan, and Hofuf where resources may be capable of supporting binary technology.



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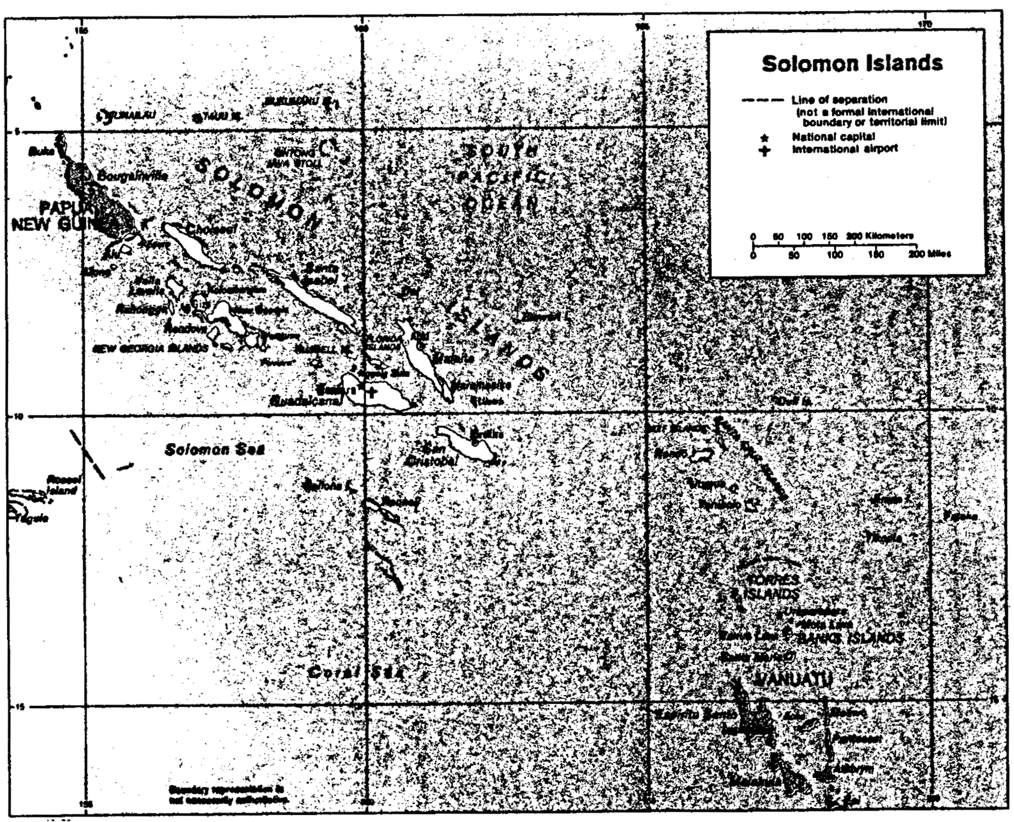
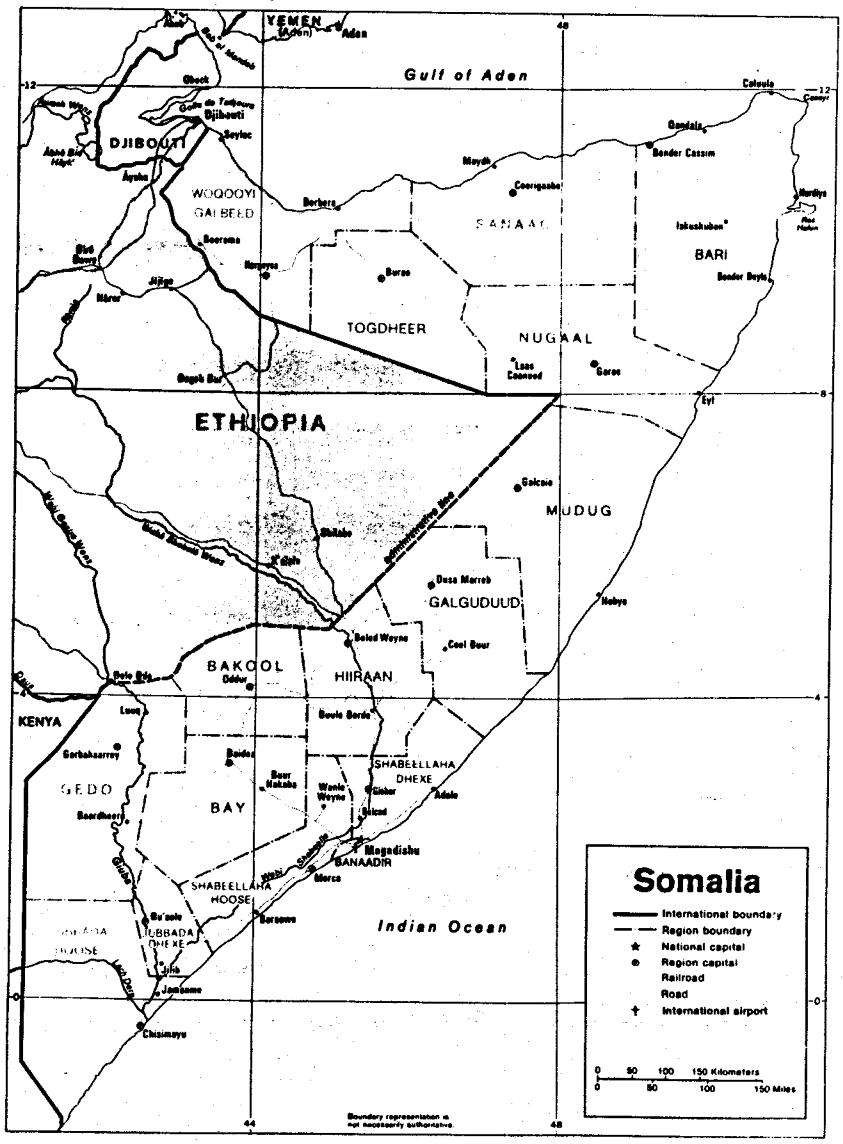
SOLOMON ISLANDS

The Solomon islands is an independent nation and a member of the British Commonwealth. They lie to the east of Papua New Guinea along the Bougainville Trench, an extension of the New Hebrides Trench. The trench is a boundary for the Solomon plate. The islands are located in a highly active spreading zone where geothermal prospects are high. Hot springs have been reported with temperatures as high as 90^{o}C.



SOMALIA

The Somali Republic is situated in east Africa along the southern coast of the Gulf of Aden. Although no comprehensive assessment of geothermal resources has been made, the geologic setting suggests that significant high- and moderate-temperature resources may be present. Hot springs with surface temperatures above 50°C reportedly exist.



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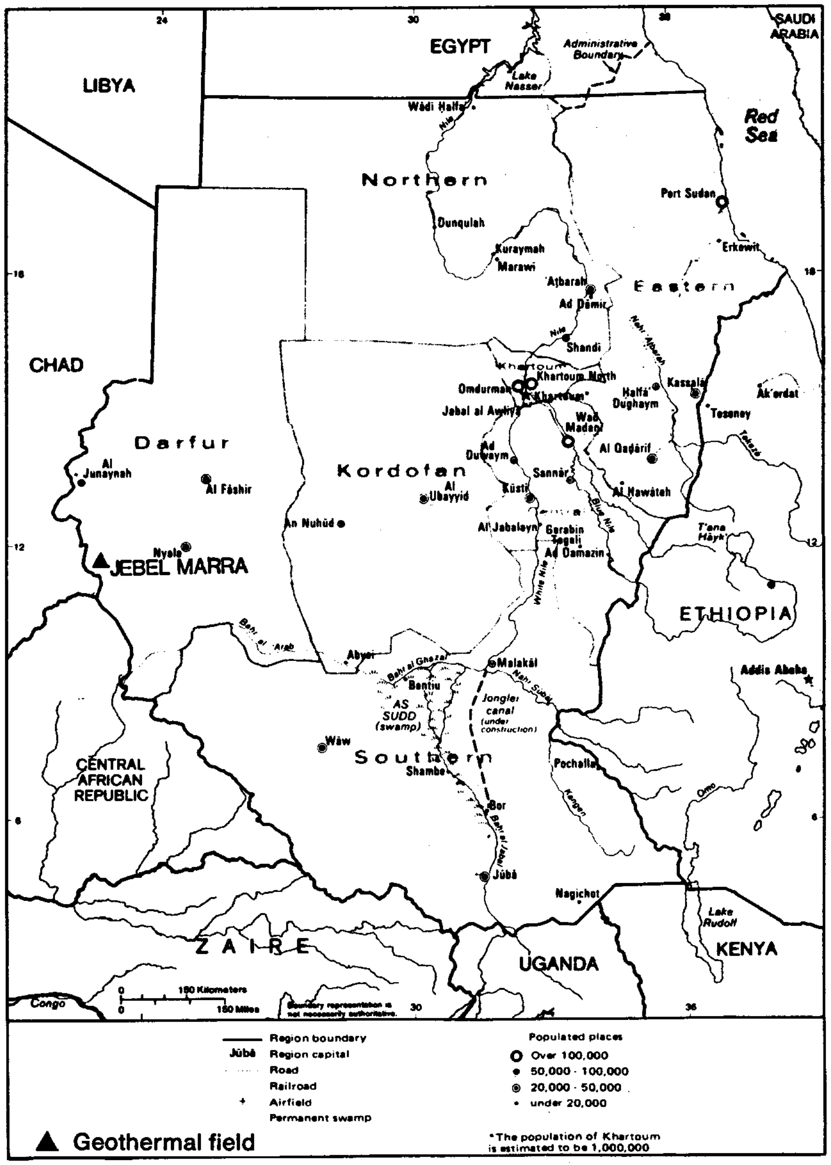
SUDAN

The geothermal energy potential of Sudan is largely unknown. The most promising geothermal prospect is the Jebel Marra area located in the western part of the country. Future work on this prospect would require beginning with reconnaissance studies, as very little preliminary work has been done. A study prepared for the United Nations Commission on Western Asia further characterizes Sudan as having only limited potential for development of low- and moderate temperature resources.



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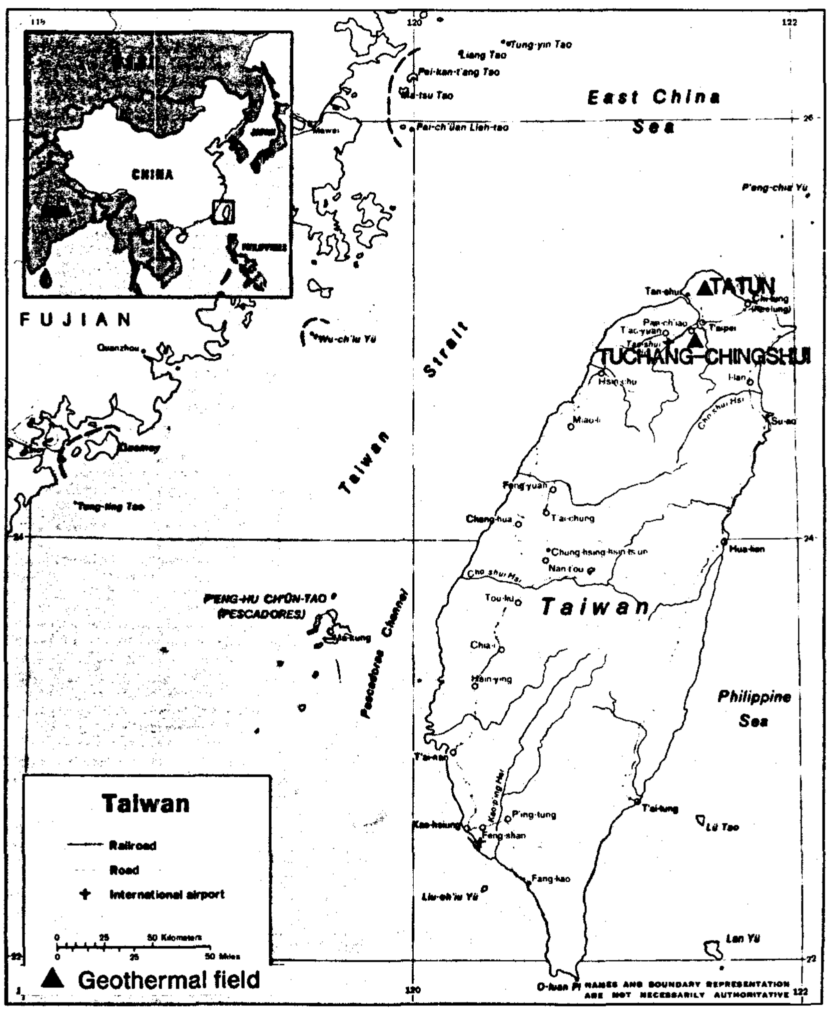
United Nations Commission for Western Asia, 1981, "Geothermal Energy in the Arab World," __New and Renewable Energy in the Arab World__, Chap. IV, pp. 195-229.

TAIWAN

Taiwan, an island with an area of 32,260 km2 and a population over 14 million is a political anomaly. It maintains its own independent government but is officially considered to be a part of the Peoples Republic of China.

Since 1965, limited geothermal studies have been carried out. The Tatun region, 15 km north of Taipei, was first investigated because of the abundance of surface manifestations. Nineteen exploratory wells were drilled, most of which encountered steam and hot water. Corrosion problems later led to suspension of operations at Tatun.

Three other areas studied include Tuchang-Chingshui, Lushan, and Chihpen. Geothermal development is currently underway at Tuchsng-Chingshui where a 3 MWe single flash plant has been in operation since 1981. Construction is also reported to be underway on a 300 kW binary plant. The Lushan field is located in central Taiwan and is the type-locality for the Lushan Formation. The Lushan formation comprises the framework of the "slate terrain" where geothermal exploration is underway. The Chihpen area is situated in the southern coastal region.



Recent investigations have taken place in Taiwan where researchers from Stanford University have studied water-rock reactions at three geothermal sites.

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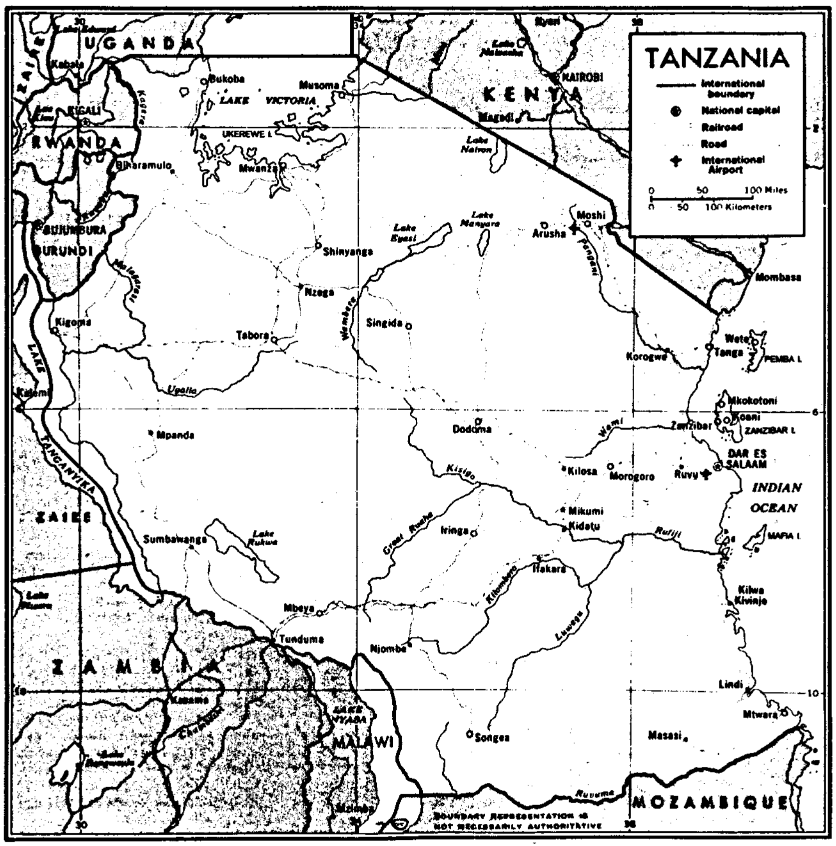
TANZANIA

Hydrothermal resources in Tanzania appear to have good potential for future development. Resources are primarily associated with the East African Rift zone with the most attractive resources located in the southwestern part of the country.

The most promising geothermal area is Mbeya, where initial resource assessments have indicated that reservoir fluids consist of high enthalpy bicarbonate-sulphate-chloride waters at temperatures exceeding 220^{o}C. These resources have been indicated beneath the Mbeya and Rungue volcanoes.

Other areas of interest include Ngorongora, in the northeast, and Kisaki Tangalala, which were covered by a geothermal reconnaissance survey in 1976-1977 performed by Swedish and Icelandic consultants.



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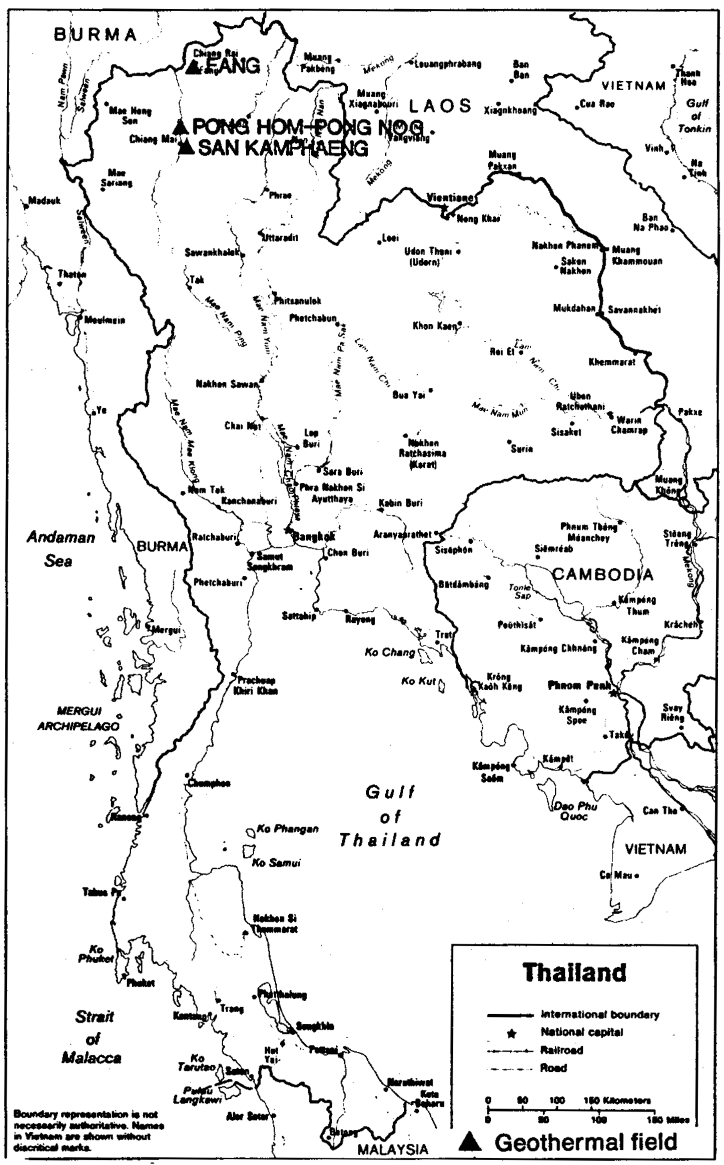
THAILAND

The Agency for International Development (AID) and the United Nations Development Program have financially aided programs aimed at geothermal development in Thailand. AID has supported a program financing development of renewable energy alternatives, including geothermal, while the United Nations has helped fund a geothermal reconnaissance survey of northern Thailand. A total of 40 hot spring areas have been mapped in northern Thailand as part of the Geothermal Exploration Project, Department of Mineral Resources of Thailand.

Assessments of Thailand's geothermal potential were started in late 1977. At the time, San Kamphaeng geothermal field, located northeast of Chaing Mai, was chosen for exploration drilling because of its favorable geology and geographic location. The evaluation was carried out by the Department of Mineral Resources, Chiangmsi University, and the Electricity Generating



Authority of Thailand. A Technical Co-operation Project was later formulated with Japan International Cooperation Agency (JICA) for pre-feasibility geothermal development work. This project resulted in the drilling of six shallow (500 m) exploration wells. Two wells encountered hot water while the remaining four are dry. A deep exploration well was completed to a depth of 1227 m in March of 1985.

Other geothermal prospects are Pong Hom, Pong Nog, and Fang.

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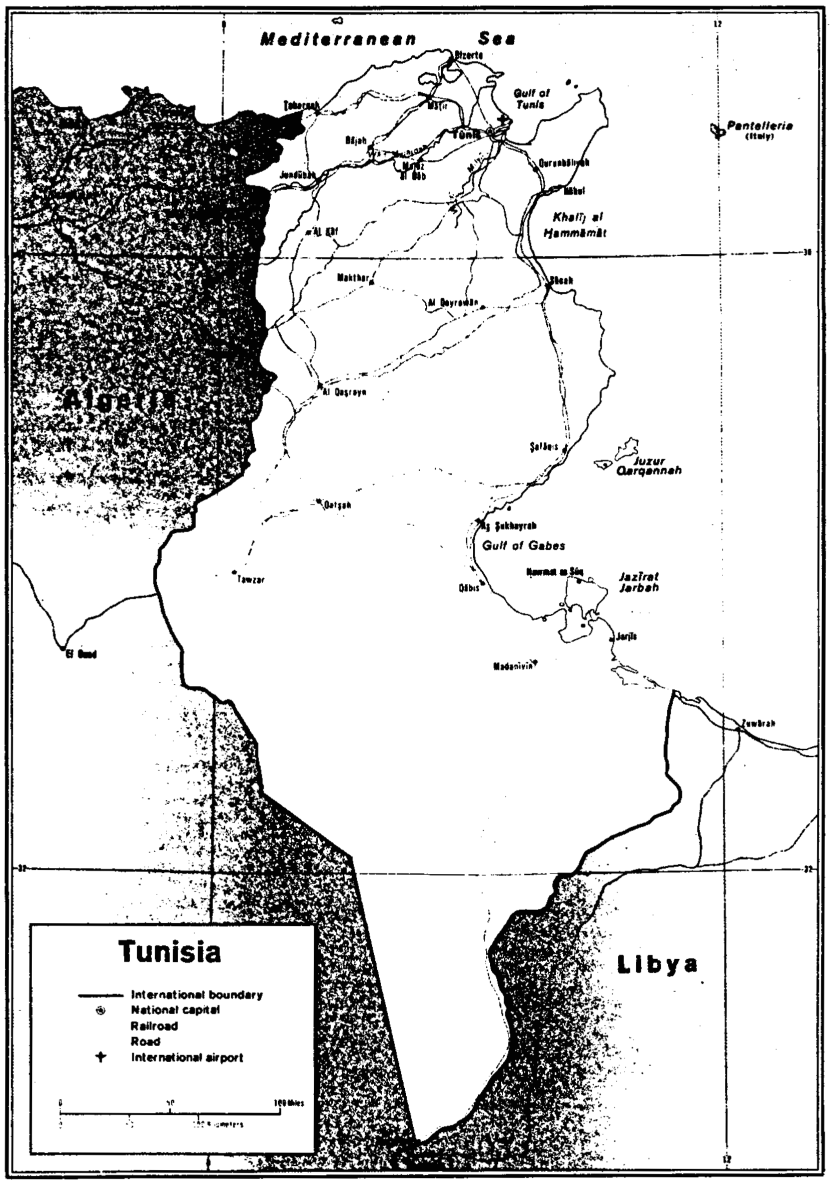
TUNISIA

The country of Tunisia is situated on the northern coast of Africa within what has been described as the Mediterranean Orogenic Zone. The northern region of the country lies within a geologically complex belt and has been identified as a region where high-temperature resources might be located. Many hot springs exist with temperatures as high as 60°C. The southern portion of the country lies primarily within a deep sedimentary basin, where suitable low. to moderate-temperature resources might be developed.

Geothermal studies in Tunisia have been carried out by the Office National des Mines (ONM), and have included regional geologic mapping, water sampling and analysis, and the study of data from deep wells. Areas that are under consideration for exploration and development of low- to moderate-temperature resources include the Zaghouan, Cap Bon, and Gabes regions.



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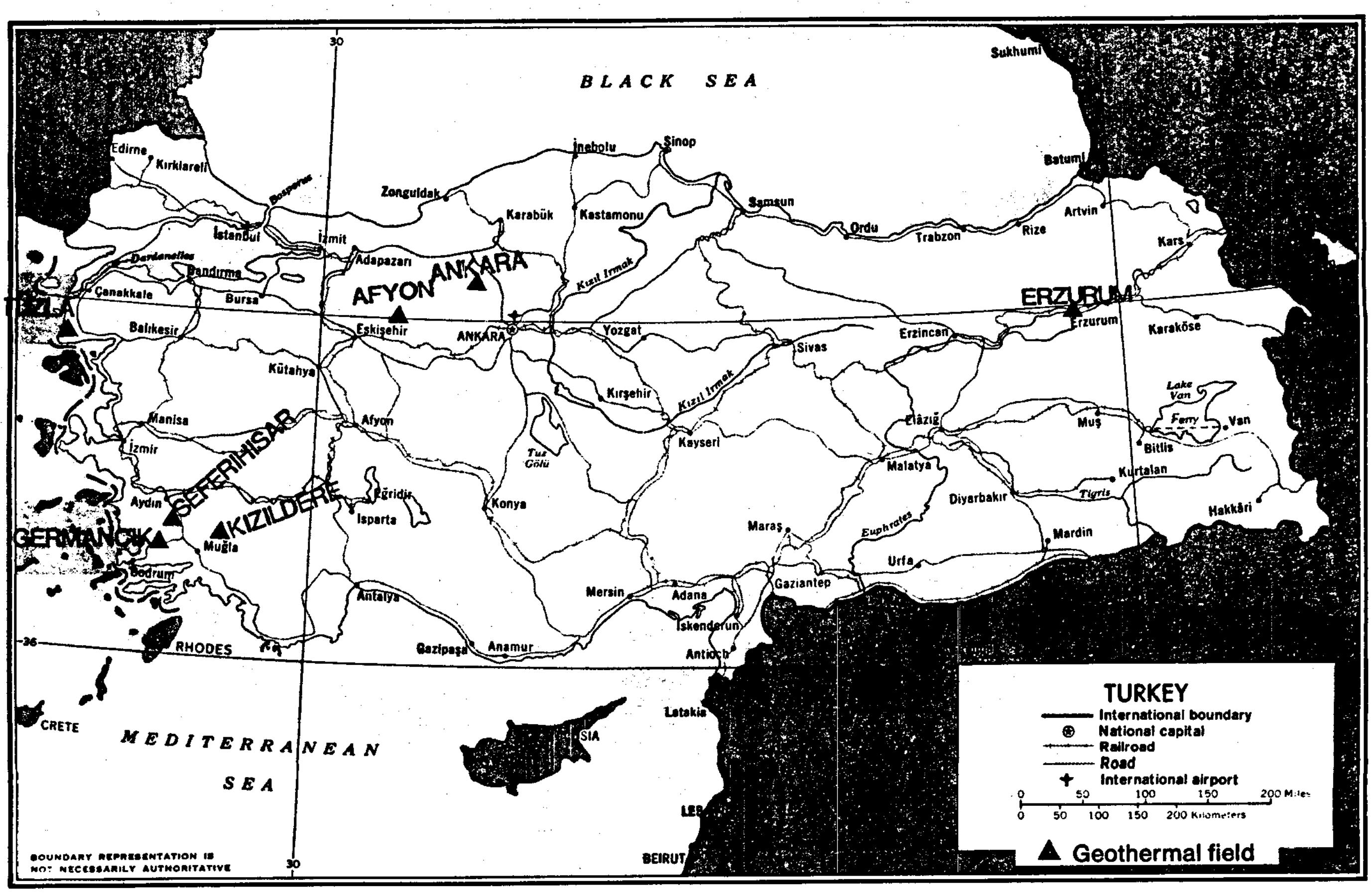
The Mineral Research and Exploration Institute of Turkey (MTA) first began geothermal studies of the country in 1962. The nationwide inventory and sampling program performed in support of these studies resulted in identification, cataloging, and testing of nearly 600 thermal springs. From these studies, a number of promising high-temperature areas were identified and prioritized for future detailed work. MTA estimated the geothermal development potential of Turkey at 4,500 MWe plus 31,000 MWt for non-electrical uses.

One of the areas selected for further studies was the Kizildere site where natural steam was discovered in 1968. Sixteen wells were drilled to a maximum depth of 1241 m. The temperatures encountered by the wells range between 170°C and 212°C. A 0.5 MW turbine, built in 1972 by MTA, was commissioned in 1975. The Turkish Electric Authority installed a 20.6 MWe ANSALDO unit for electric generation and a plastic piping system to heat a 1000 m2 greenhouse with leftover brines.

There are three other high enthalpy fields, Germencik, Afyon, and Tuzla, which were discovered in 1982 and are currently being drilled. As much as 130 MWe may be on-line by 1990. Detailed geophysical studies have been done at Erzurum, Seferihisar, and Ankara.

Currently the Turkish Petroleum Corp. is exploring the south eastern part of the country for geothermal resources under a joint venture with Unocal. If resources are sufficient, 600 MWe capacity is being considered.



Turkey also contains many low temperature geothermal fields. At Eskisehir, thermal water at a temperature of 50°C is produced from geothermal reservoirs for domestic use. It is pumped over 2 km into a large storage tank where the hot water is mixed with cold water to reduce the temperature to 20°-25°C. The water is then distributed to 70,000 homes for warm water supply.

District heating systems are now being built where temperatures are slightly higher than Eskisehir. At Afyon, 90°C water flows at a rate of 20 to 40 liters/second (artesian) from a number of deep wells. Combined with deep well pumps, the 90°C water could be used for residential heating and other direct applications within the surrounding communities.

Kizilcahamam, in the Ankara field, supplies two greenhouses with 43°C water. Other possible geothermal areas are Denizli, Izmir-Seferihisar, Aydin-Germenoik, Ganakkale, Gecek, Munisia, and Balikehir.

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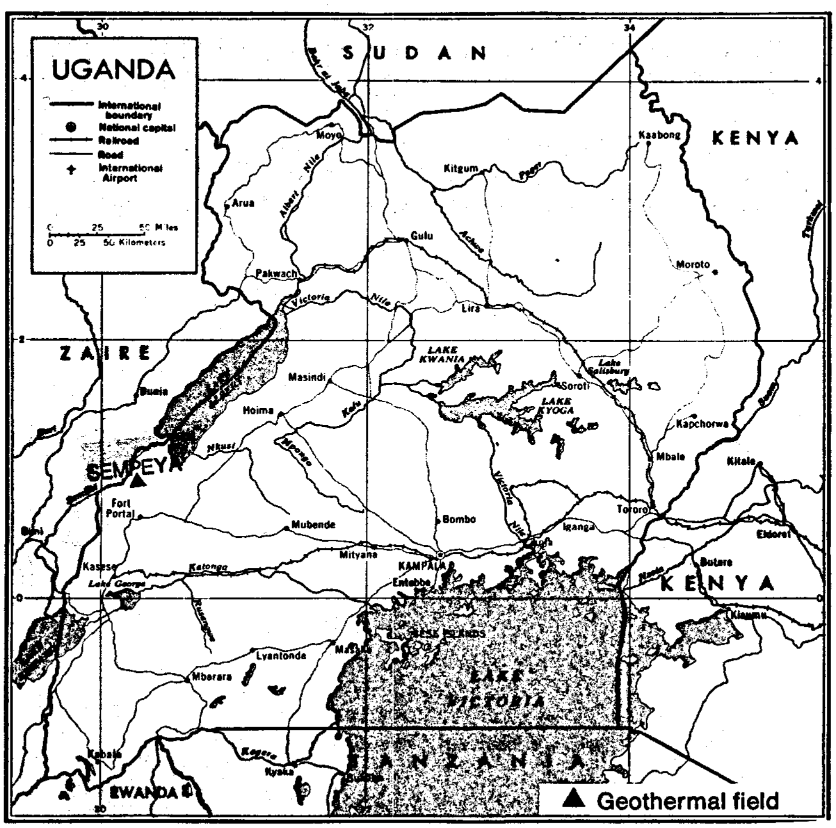
Simsek, S., 1985, "Present Status and Future Development of the Denizli - Kizildere Geothermal Field of Turkey", 1985 International Symposium on Geothermal Energy, International Volume, pp. 203-215.

UGANDA

Hydrothermal convection systems in Uganda occur primarily in connection with the East African Rift system. Hot springs occur along major faults associated with the rift; within minor fault systems, joints, and fissures in Precambrain rocks lying adjacent to the rift; and in areas of young volcanic rocks. Notable geothermal areas associated with the major "rift" (normal) faults are at Kiboro hot springs on the east shore of Lake Mobutu along the Toro-Buryoro fault, and at Sempaya southwest of Lake Mobutu. At Sempaya, hot springs emerge through a cover of Miocene sediments that have accumulated on the downthrown side of a major rift fault. Shear zones in the Precambrain rocks adjacent to the rift system also contain hydrothermal systems. The geothermal areas with highest development potential is within this setting at Sempeya in the southwest. The Sempeya geothermal field has undergone detailed geophysical studies to date.

Geothermal exploration in Uganda has been limited by and large to shallow drilling and surface geophysics. Seismic surveys and electrical methods have been employed through U.N. sponsored programs in other more promising thermal areas of Kitagata, and Lake Kitagata. In addition to these studies, the U.N. has recently been involved with preliminary investigations in the Katwe area.



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VANUATU

Vanuatu, formerly the New Hebrides Islands, is located off the coast of Australia in the Pacific Ocean. The island chain lies along the New Hebrides Trench in an active tectonic zone.

Vanuatu has completed a preliminary reconnaissance of geothermal resources with assistance from the United Kingdom and France. Area investigations have been targeted for the Takara-Teuma area on Efate, and the Suritemeat geothermal area on the volcanic island of Vanu Lava. No specific details have been reported with respect to the work on Efate. Results of geochemical analysis and geologic mapping on Vanu lava have shown that high-temperature (>200^{o}C based on silica geothermometry) hydrothermal systems are likely to exist. The main areas of investigation are located on the east flanks of the Mt. Suritemeat volcano along the drainage of the Sulfur River.

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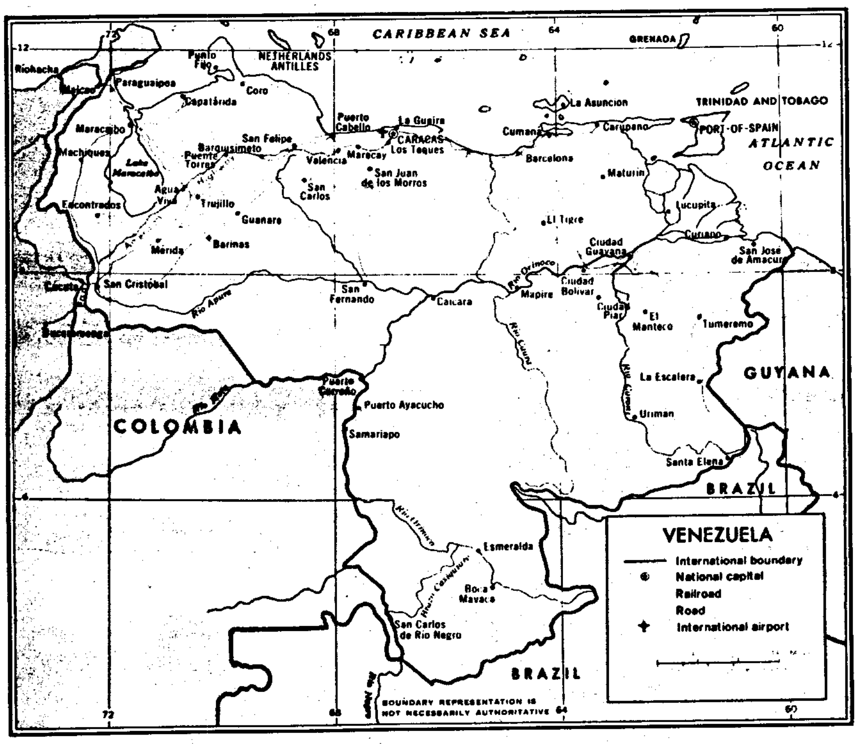
VENEZUELA

The northern part of Venezuela, where an active transform fault bordering the Caribbean plate cuts across the country, contains several geothermal prospects, including hot springs with temperatures in excess of 80°C.

The Venezuela Ministry of Energy and Mines (MEM), in conjunction with private organizations and universities, has made preliminary investigations of Venezuela's geothermal resources. From their efforts, the country has been separated into three geothermal provinces and three subregions. Areas of particular interest are the geothermal districts of El Pilar-Casanay and Barcelona Cumana. Both are located in the Northeastern Geothermal Province.



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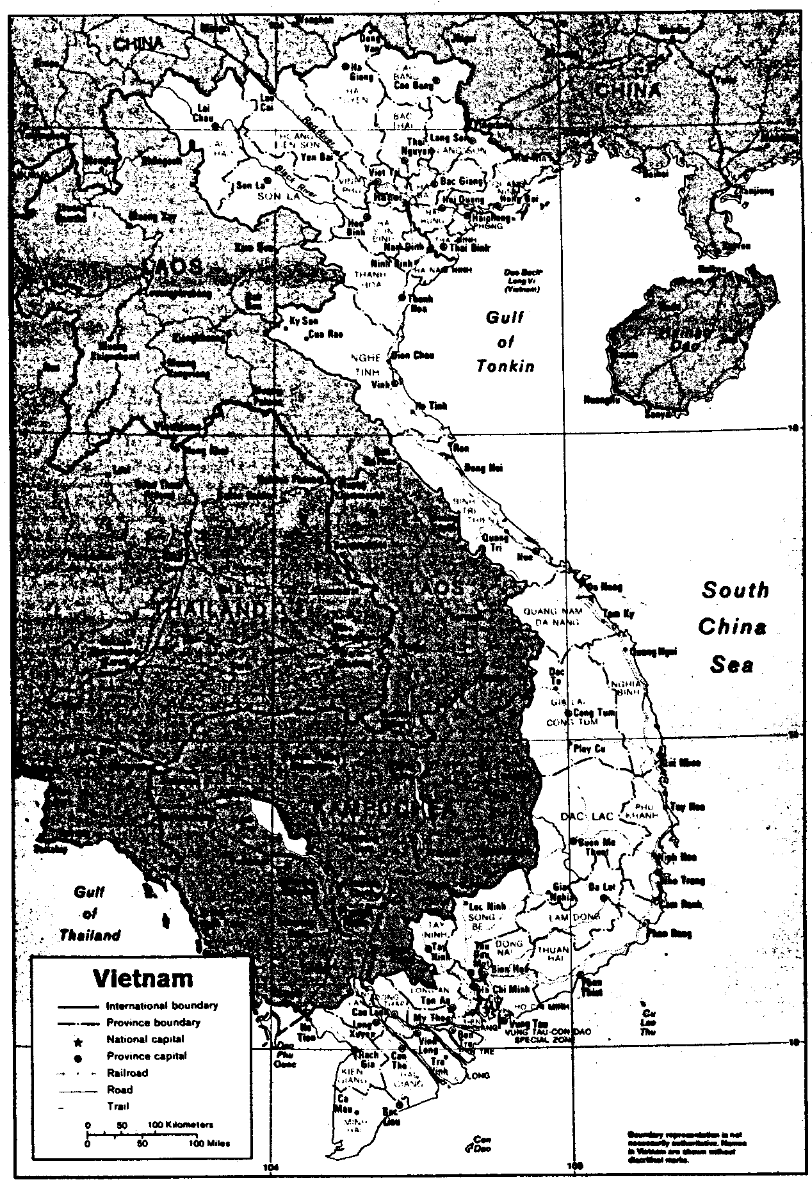
VIETNAM

Since Vietnam is not in a tectonically active zone, prospects for high temperature resources are not likely. Many hot springs do exist in the 329,556 km^2 areas of the country.

Over 125 thermal springs have been catalogued by the General Department of Geology in Vietnam (GDG). These springs have been found in (1) the northern uplands and (2) the central uplands, plateaus, and coastal strip. The five hottest geothermal manifestations are found in the center of the coastal zone, which appears to be the most promising geothermal area for electrical production.

Vietnam has been using its thermal springs for medical purposes. Thermal baths have been set up at Mai Lam, in the north, and Hoi Van, in the south. At Cam Pha on the northern coast, a well has been drilled to 400 m to produce 52°C water for a new sanitorium. No further development plans are known.



Vietnam has expressed a keen interest in geothermal electrical development. This interest stems from the fact that the energy-starved central coastal zone has the most intensive thermal springs in the entire country. Of the 30 highest temperature thermal springs (>60^{o}C), 18 are in the coastal strip.

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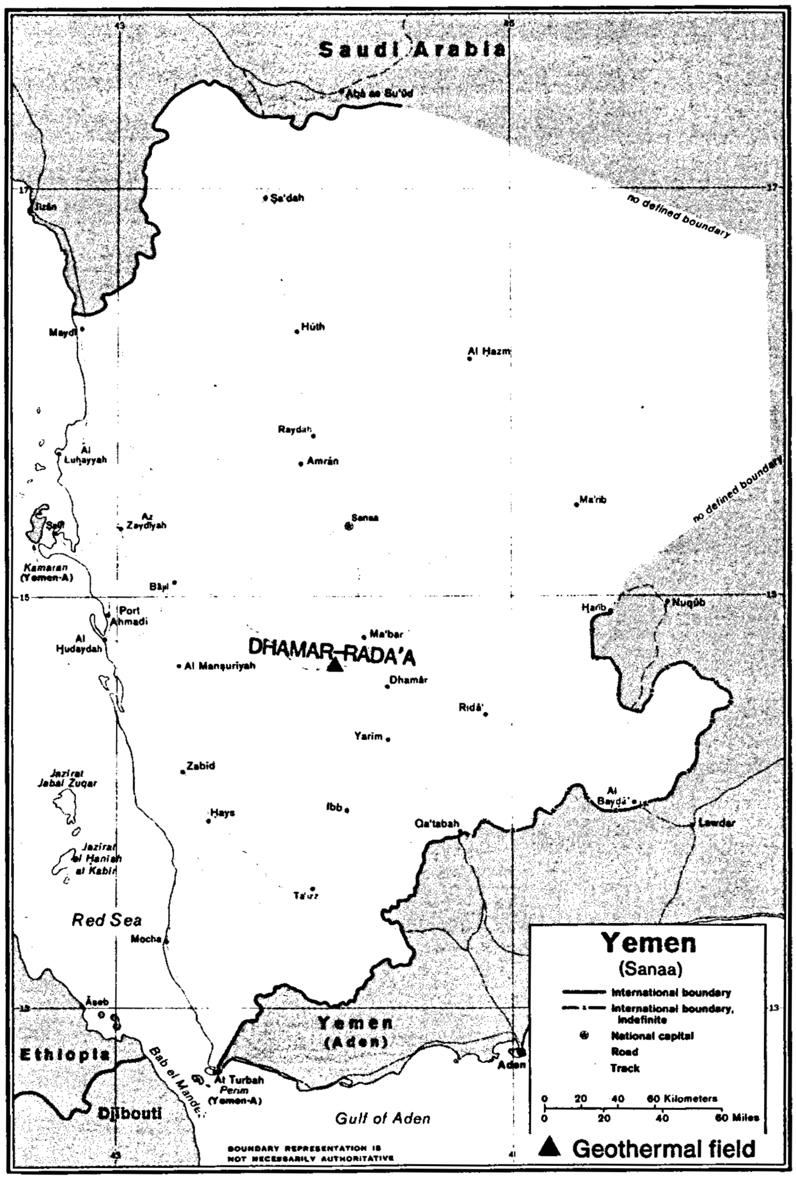
YEMEN ARAB REPUBLIC (North Yemen)

The Yemen Arab Republic (YAR) borders the Red Sea, which is bisected by a spreading ridge. It is likely that geothermal prospects could be abundant in the 195,000 km^2 area.

Since 1982, the World Bank, through the International Development Association (IDA), has provided $13 million to the YAR for geothermal resource assessment and field development. The Yemen government is providing $2.4 million for the project. The major portion of funding was to be directed for field development in the Dhamar-Rada'a region. This field, which is located in the southeast part of the country, was to be explored by drilling four 2,000 m wells. Dhmar is near the main population and industrial centers of the country.



The state company, Yemen Oil and Mineral Resources Corporation (Yominco), was assigned as the supervisors of the project. An American firm has provided technical and economic analyses in support of the project.

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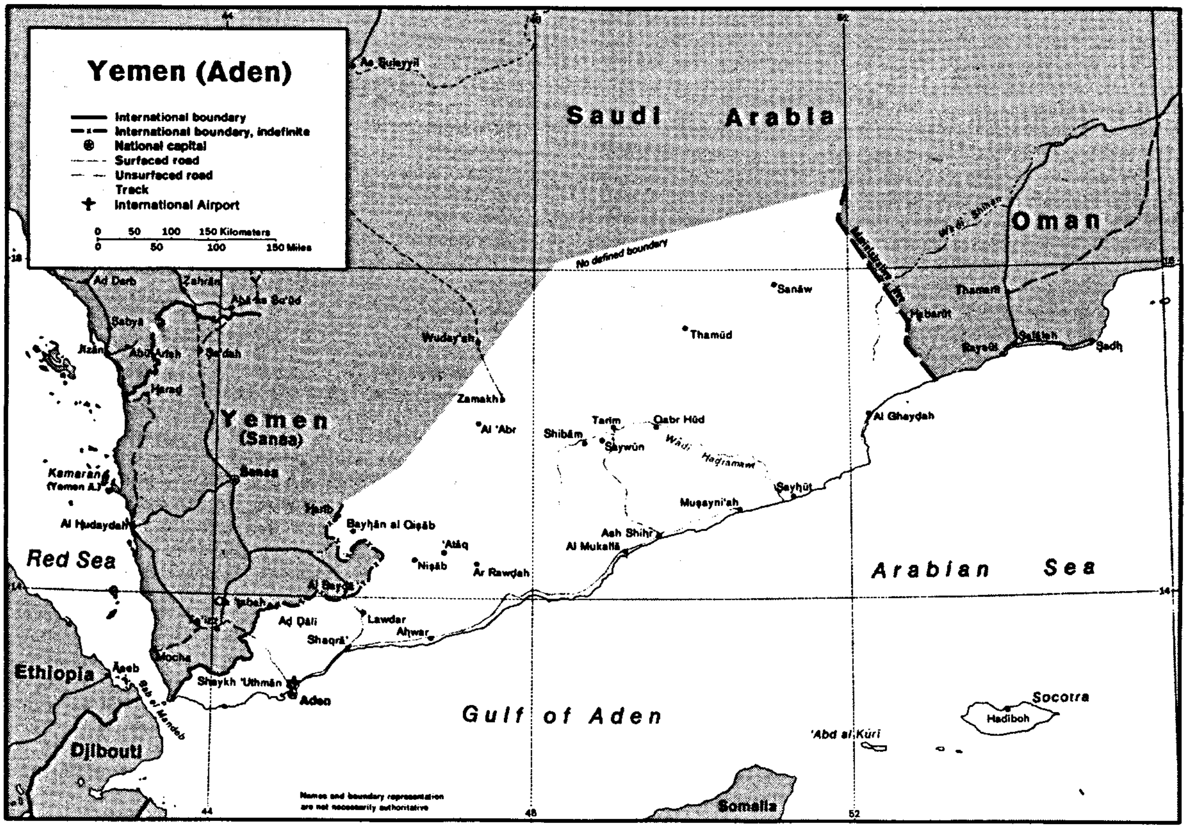
World Solar Markets, July 1984, "Yemen to Look for Geothermal Energy Sources," p. 11.

YEMEN PEOPLES DEMOCRATIC REPUBLIC (South Yemen)

The geothermal potential of South Yemen is largely unknown. The greatest potential for finding moderate-temperature geothermal resources is in the region adjacent to the Gulf of Oman.



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YUGOSLAVIA

Most of the country of Yugoslavia is intermontane highland bounded on the northwest by the Karawanken Alps and on the southeast by low-lying ranges; mountain regions are composed primarily of crystalline rocks flanked by marine paleozoic formations. Low-temperature thermal waters that are heated by conduction occur within intermontane karst areas of mountainous regions. Thermal springs and well (maximum temperature - 88°C) are present at forty locations in the country.

Recent assessments of renewable energy potential have indicated that geothermal energy offers excellent potential for "medium term" growth in Yugoslavia. This potential could be realized within the Pannonian Basin, the Dinaric Alps, and in the Adriatic region for direct-use and industrial process heat.

Current activities are concentrating on resource assessments in the northwest (Serbia) and southeast (Macedonia). Several exploratory wells have been drilled recently in the northwest part of the country, with the intent of supplying low-temperature thermal water to greenhouses. The United Nations Department of Technical Cooperation for Development (UN/DTCD) has funded resource development and feasibility studies in the province of Macedonia.

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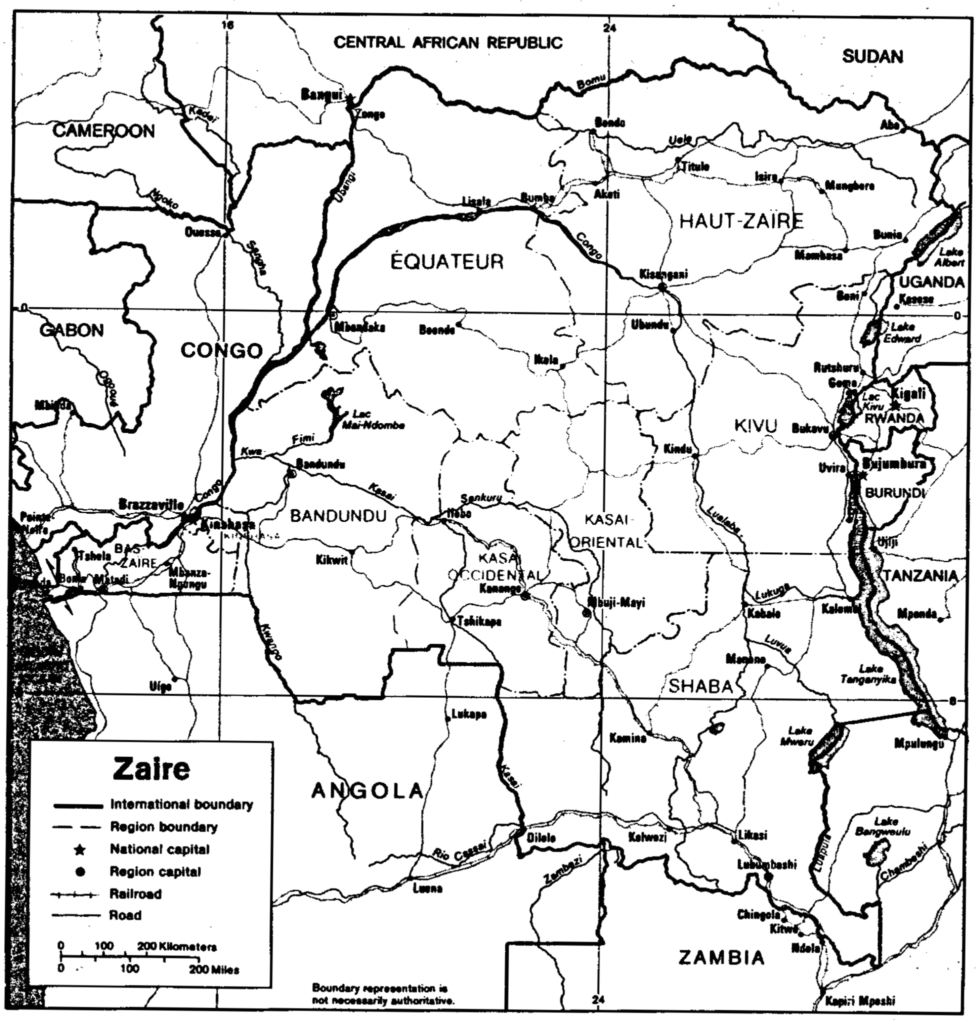
DiPaola, G.M., 1985, "The Role of the United Nations in the Field of Geothermal Resources Exploration in Developing Countries," 1985 International Symposium on Geothermal Energy, International Volume, pp. 247-250.

ZAIRE

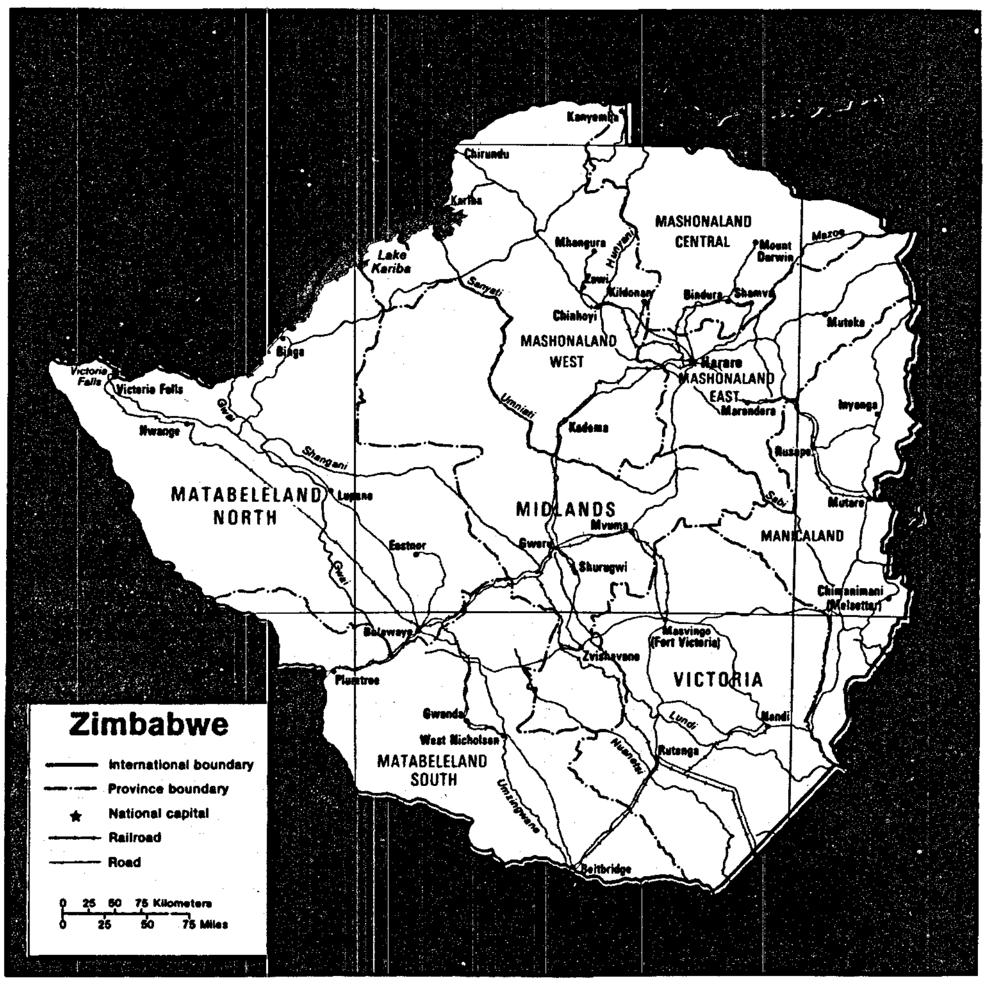
The vast 2,354,409 km2 area of Zaire is located in the middle of the African continent. Since it is not situated along an active spreading ridge or trench, Zaire will most likely contain only low- to medium-temperature geothermal resources. Hot springs with temperatures to 60^{o}C have been reported.



ZIMBABWE

The Republic of Zimbabwe is located in the south-central part of the African Plate. The country is primarily tableland, with some mountains in the northwest. The geology is predominantly faulted metamorphic basement rocks with little evidence of recent volcanism.

There has been no assessment of the geothermal resources in Zimbabwe, although there are over 32 thermal springs with temperatures ranging upward to over 90^{o}C.



Appendix B

Descriptions of Non-Target Country Geothermal Resources

INTRODUCTION

This appendix contains individual, brief overviews of geothermal activities and/or resources for the industrialized nations not considered to be primary targets for expansion of the U.S. geothermal industry abroad. The level of detail provided in the descriptions is not consistent from country to country, largely reflecting the level of geothermal use and the amount of available information. A bibliography of the information sources used is provided with each country write-up. In addition, the following source of information was often used when other sources lacked sufficient detail:

DiPippo, R., (1985), "Geothermal Electric Power, the State of the World -- 1985," 1985 International Symposium on Geothermal Energy, International Volume, Geothermal Resources Council, pp. 3-18.

AUSTRIA

Three regions in Austria have potential for development of low-to-moderate temperature geothermal resources for direct-use applications. Thermal water at Waltersdorf has been developed as a district heating system since 1980, and is the first such system in Austria. Flachgau, another geothermal direct-use prospect, has been described as having potential for greenhouse heating or soil warming.

An oil and gas well (Geinberg I) located in Northern Austria has also been evaluated for its direct-use potential. Temperatures in the well have reportedly been measured to 96°C. However, the resource is located in an isolated area thereby precluding most direct-use applications.

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AUSTRALIA

Although Australia has no apparent geothermal resources associated with young volcanic areas, low-temperature geothermal water is utilized at two localities. Thermal water (58°C) has been reportedly used at Portland, Victoria, for district heating. At Moree, in New South Wales, 60°C water is extracted for therapeutic bathing from one of many aquifers in the Great Artesian Basin, where temperatures in domestic water wells sometimes approach 110°C.

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BELGIUM

The potential for development of low- to moderate-temperature geothermal resources in Belgium is considered to be small. The physiography of Belgium is dominated by Karst terrain; the result of dissolution of carbonate sedimentary rocks (limestone and dolomite), formation of solution caverns and the resultant collapse of the caverns. While low-temperature thermal water occurs at some locations, the predominance of cavernous limestone lessens the potential for formation of large low- and moderate-temperature geothermal reservoirs.

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CANADA

Initial investigations into the geothermal resource potential of western Canada began in 1972 by the Canadian Federal Department of Energy, Mines and Resources. Within a year from the start of reconnaissance studies, the government of the Province of British Columbia, realizing the geothermal potential within its jurisdiction, passed the Geothermal Resources Act, which reserved for the province the energy within the natural high-temperature fluids. This act also coincided with the start of investigations of alternative energy sources by the British Columbia Hydro and Power Authority (B. C. Hydropower). By the end of the 1970's, Canada's geothermal energy research had been focused on two main fronts: the volcanic zones of the western mountains (British Columbia) and the sedimentary basin of the Prairie Provinces.

Meager Creek is probably the most studied geothermal site in Canada. Initial interest in geothermal resources at this site, in British Columbia, began in 1973 when B. C. Hydropower and the Department of Energy, Mines and Resources outlined an area for detailed exploratory drilling. Since that time over 25 exploration wells have been drilled and tested.

Located in the Central Garibaldi Volcanic Belt of British Columbia, Mount Cayley was also identified as a potential high-temperature hydrothermal system in the early 1970's. Since that time, the provincial government designated the area as a "Known Geothermal Resource Area" (KGRA) and, in 1983, O'Brien Resources acquired and began exploration of parcel G3, which includes the principal anomaly.

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CZECHOSLOVAKIA

An organized effort to explore the country's geothermal resources was initiated in Czechoslovakia in 1960. Drilling of geothermal wells began in 1971. By the end of 1974, eight wells had been drilled. The most promising region for discovery and development of low- to moderate-temperature geothermal resources is within what is termed the central depression of the Danubian Basin, where water temperatures approaching 140°C have been measured in oil and gas wells.

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DENMARK

Denmark uses low-temperature geothermal water, for district heating and other direct-use applications. Since 1973, three exploration wells have been drilled to depths of about 3000 meters. The wells, which were drilled at three localities (Års, Farso and Thisted) were evidently drilled into deep stratigraphic aquifers containing thermal fluid.

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FINLAND

A program to assess energy-saving projects in Finland was started in 1985 by the Commerce and Industry Ministry, and included geothermal technology in the context of the program. Although no high-temperature geothermal resources were identified, several low-temperature geothermal prospects were presented as possibly worthwhile investments.

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FRANCE

Geothermal energy resources in France are present primarily as low-temperature hydrothermal systems contained in deep regional aquifers of the Paris and Aquitaine basins, where the aquifers are exploited by wells for domestic use. A district heating system was first established in the Paris Basin at Melum, in 1969. This was followed by the establishment, in 1970, of a district heating system in the city of Creil. Since then, district heating has been facilitated in such notable other places in the Paris Basin as: Paris, Acheres, Strausberg, Clemont-Ferrand and Fontainebleau. In the Aquitaine Basin, district heating systems have been established at Mont-de-Marsan and Balgnac. Many other systems (as many as forty plants) are reported to be in operation.

In addition to the direct-heat applications underway on the French mainland, high-temperature hydrothermal convection systems are either under development or under study on Reunion Island (Indian Ocean) and on the islands of Guadaloupe and Martinique (Caribbean).

Reunion Island is an intraplate volcanic complex located between the mid-Indian Ocean spreading ridge and Madagascar, and is comprised of two, young shield volcanoes. Two geothermal prospects, Salazie Cirque and Grand Brule, have been located through the efforts of three government entities: Bureau French Recherches Geologiques et Minieres (BRGM), Agence Francaise pour le Maitrise de l'Energie (AFME), and Electricite de France (EDF).

The island of Guadeloupe, in the eastern Caribbean, is also a part of the French Republic, and is located along the "Lesser Antilles" island arc chain. A French exploration company, EUROFREP, began reconnaissance exploration on the island in 1969, and eventually identified the Bouillante area as a geothermal prospect. Since then, high-temperature (270°C) fluids have been discovered by exploratory drilling, and a 6 MW capacity electric plant has reportedly been installed.

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GERMANY

Low- to moderate-temperature geothermal water in Germany is contained in deep regional aquifers of (1) the Northern German Basin, (2) the Molasse Basin, and (3) the Upper Rhine Graben. Until recently, applications of low-temperature thermal waters have been largely restricted to groundwater-source heat pumps (currently more than 205,000 installed) for domestic, space and water heating.

In more recent years, district-heating systems have been installed in seven cities. The systems, which use thermal water in the temperature range from 31°C to 69°C, are located in Aachen, Baden-Baden, Bad Ems, Biberach (where a greenhouse complex also uses geothermal water), Konstanz, Urach, and Weisbaden. The Urach area has also been under investigation for a potential shallow, hot dry rock project.

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HUNGARY

Thermal waters in Hungary are contained in (1) low-temperature hydrothermal convection systems bordering mountain ranges comprised principally of fractured, carbonate rock, and (2) in deep stratigraphic aquifers associated primarily with the Pannonian Basin. Natural thermal springs that issue as a result of hydrothermal convection generally have temperatures ranging from 30° to 60°C. Thermal water reservoirs of the Pannonian Basin consist of mainly deep (up to 2,500 m), interbedded Pliocene sandstone. These sandstone aquifers contain fluids ranging in temperature from 70° to 140°C, produced from an average depth of 500 m.

Thermal water from numerous wells completed into Pannonian sandstones is used widely for therapeutic baths, agricultural applications, district heating, and industrial processing. The estimated installed thermal power from 516 wells in Hungary, with temperatures of 35°C or greater, is 1000 MW.

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ICELAND

Geothermal energy constitutes about one third of the total energy consumed in Iceland. The.total estimated installed geothermal capacity is as follows: space heating -- 836 MW, fish culture -- 2 MW, and electricity 41 MW.

Geothermal areas in Iceland have been divided into high-temperature fields (200°C) and low-temperature fields (150°C). As of 1983, there were nineteen known high-temperature geothermal fields, and nine other areas were thought to have considerable potential. It has been estimated that, over a 50 year span, up to 12,000 MW of electricity could be generated from the country's high temperature resources. It has also been estimated that 75% of Iceland's population occupy homes heated directly by low-temperature geothermal water. Further, it is thought that nearly two thirds of this total (approximately 114,400 people) live in houses connected to district heating systems provided since 1930 by Reykjavik Municipal Heating Service.

High-temperature geothermal fields in Iceland are located within or along the margins of the active Neovolcanic rift zone, where the high regional heat flow from the zone provides the heat source for hydrothermal convection systems. Within this broad zone, high-temperature hydrothermal systems are associated with volcanic centers, fault/fissure swarms, and sometimes with fractures related to volcanic calderas. The entire island of Iceland has a relatively high geothermal gradient, although fracture systems and aquifers with the ability to contain hydrothermal convection systems are localized phenomena.

Electricity from high-temperature geothermal resources is generated from three geothermal fields in Iceland. The fields include: Namafjall 3 MW; Krafla -- 30 MW; and Svartsengi -- 8 MW. In addition, a second 30 MW unit has been acquired for eventual installation at Krafla.

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ITALY

Geothermal exploration and development in Italy began in the Mt. Amiata Region in the 1940's. Later, in the 1960's, resources were discovered within the Boraciferous Region, and developments began there. Since the end of the 1960's, two major state supported energy agencies have been largely responsible for geothermal development in Italy. They are the Ente Nazionale per l'Energia Electrica (ENEL), and Ente Nazionale Idrocarburi (ENI). ENEL is responsible for the production and distribution of electricity, while ENI, through its daughter company Azienda Generale Industria Petroli (AGIP), is the state agency responsible for oil development and associated activities.

Geothermal resource areas of Italy are primarily concentrated along a NW-SE trending belt which subparallels the northern and southern Apennine Mountains, referred to as the pre-Apennine Belt. The belt extends over a region of 20,000 km2 from Larderello (near Pisa) to Naples.

The major geothermal regions that are undergoing either development or exploration include: Larderello and Travale-Radicondoli (Boraciferous Region), Mt. Amiata, Latera, Cesano, Torre Alfina, and Phlegraean Fields. Total installed geothermal electrical generating capacity at these fields in 1985 was 459.2 MW, with additional units under construction totalling 60 MW.

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JAPAN

The four major islands that comprise Japan hold a significant geothermal resource potential. These islands of the western Pacific region contain nearly 10 percent (76) of the world's active volcanoes and over 2,200 thermal springs.

The first successful geothermal power demonstration project in Japan was performed by the Agency of Industrial Science and Technology shortly after the end of World War II at Beppu Hot Spring. The first commercial 20 MW power plant was constructed at Matsukawa in northern Honshu in 1966 by the predecessor to the Japan Metals and Chemicals Co. Today, eight geothermal areas have a total installed electrical generating capacity of 215 MW. Additional facilities that are presently being planned, or under construction, may provide capacity for 108 MW in the near future.

Significant geothermal areas that are undergoing development include: Matsukawa, Onuma, Onikobe, Otake-Hatchobaru, Kakkonda, Mori-Machi, Kirishima, and Siginoi.

Other areas that have been investigated for geothermal potential and appear promising include: Takenoyu, Uzen, Kujgu, Beppu, Noya, Ibusaki, Asu, KokonoMachi, Kowakidoni, Ubayu, Oyasu, Akinoma, and Tamagowa.

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NETHERLANDS

Potential low- to moderate-temperature geothermal resources in the Netherlands are confined to deep stratigraphic aquifers. These aquifers, which are primarily sandstone formations of Permian and younger age, have been described as containing fluids that have measured temperatures of about 100°C at depths between 2,000 and 3,500 meters.

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NEW ZEALAND

New Zealand has abundant geothermal resources and a long history of geothermal utilization. In 1940, hot water was used for space heating at Rotorua and Tokanuu of the North Island. In 1949, a well drilled at Wairakei for space heating encountered high pressure steam from a large hot water reservoir which led to initiation of a program by the Department of Scientific and Industrial Research (DSIR) to develop the country's geothermal resources. It was this program that established the first power plant in the world utilizing fluid from a liquid-dominated hydrothermal system. The first electric unit was commissioned in 1958 at Waiakei and 12 additional units were added over time to total 193 MW capacity by the end of 1963. Currently, New Zealand's installed geothermal electric capacity is 167.2 MW (a result of reservoir drawdown and plant decommissioning) with an additional 116.2 MW planned by 1988.

New Zealand's geothermal energy development, overall, is the result of the work of three agencies. The DSIR has been the responsible agency for initiating basic research toward geothermal development. The New Zealand Energy Department (a division of the Ministry of Energy), and the Ministry of Works and Development are government bodies responsible for advancing the commercialization of geothermal energy and securing cooperative agreements with other countries.

New Zealand's geothermal areas are mainly located on the North Island within a volcano-tectonic depression known as the Taupo Volcanic Zone. The zone stretches from White Island, in the Bay of Plenty, southwest some 300 km past Lake Taupo. The zone is 60 km wide and is the result of arc-trench volcanism.

The South Island of New Zealand has numerous thermal springs related to hydrothermal convection along the Alpine Fault; a major northeast trending transcurrent structure through New Zealand's Southern Alps. This structure stretches for over 400 km along the western coast of the island.

The most notable geothermal areas in New Zealand include: Wairakei (157 MW) Kawerau (10 MW), Broadlands, Ngawha, Mokai, Tekopia, Rotura, Waiotapu, Rotokawa, and Orakeikorako.

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POLAND

Geothermal resources of Poland are restricted to low-temperature systems contained in stratigraphic aquifers and low-temperature hydrothermal convection systems. Thirty sites where low-temperature water is used for direct-heat purposes have been located in the Sudetes (massif), the Carpathians (foldbelt), and the Polish Lowland (underlain by regional aquifers).

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PORTUGAL

Geothermal resource potential on the Portuguese mainland is confined to direct-use of low-temperature systems. Geothermometry, as applied to thermal springs in the country, indicate reservoir temperatures generally less than 100°C. Thermal springs in Portugal are located in the northern and southwestern regions of the country, and along the western coastal plain. The springs in the north, which are related to major faults, are the hottest and issue from systems with the highest calculated reservoir temperatures.

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ROMANIA

Low to moderate-temperature geothermal resources in Romania have been described as occurring in the Western Plain (Pannonian depression), the Moesic platform, and the Getic depression. Western Plain resources occur in deep stratigraphic aquifers comprised of Mesozoic carbonate and sandstone strata. In the Moesic platform, thermal fluids are contained principally in Jurassic Cretaceous carbonate rock units. Geothermal resources in the Getic depression are in Cretaceous sandstones and conglomerates, and also in similar rocks of Miocene age. Temperatures in these areas have been measured between 60°C and 120°C with the highest values being recorded in the Western Plain.

Low and moderate-temperature fluids are reportedly used in direct applications at eleven sites. Types of uses include district heating, industrial process heating, greenhouses and bathing.

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SPAIN

Since 1978, as part of the National Energy Plan in Spain, a National Programme of Geothermal Research has been underway to assess the country's geothermal resources. Based upon this program, several areas in the country have been targeted for further study and development. The areas are: Madrid, Burgos, Barcelona, and Murcia. Resources are described as being low-temperature, generally between 80° and 90°C at Madrid and Burgos, and moderate-temperature (120°-140°C) at Barcelona and Murcia.

High-temperature systems (up to 300°C) have been discovered on the Canary Islands, but the impervious nature of the rock prevents the formation of geothermal reservoirs. Because of this, the geothermal areas on the islands are being considered for possible hot dry rock development.

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SWEDEN

Geothermal utilization in Sweden was initiated in 1984 as the National Swedish Energy Administration recommended a $2.1 million grant be given to Lund Energy for the construction of a geothermal addition to the Lund district heating system. The facility has reported to be providing about 20 MW (thermal) from a 700 m well with water temperatures between 22°-26°C.

The concept of energy extraction from hot dry rock is also being tested in Sweden. Hydraulic fracturing tests have been tried at shallow depths in southwest Sweden. Initial experiments have been promising, indicating that energy production could be possible at competitive prices.

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SWITZERLAND

Geothermal resources of Switzerland have been divided based upon their geologic occurrence as follows: the Jura Mountains -- consisting of folded Mesozoic sediments; the Molasse Basin -- which is comprised of Tertiary sandstone, marl, and conglomerate; and the Alps -- which consist of folded sedimentary, crystalline, and metamorphic rocks. Oil and gas exploration in the past has indicated that temperature gradients increase from the Alps to the Molasse Basin where temperatures are comparable to values measured in the

Pannonian Basin of Hungary (i.e., 40° to 60°C at 1 km). Fourteen thermal springs with discharge temperatures ranging from 27° to 62°C occur in the country. The highest concentration of springs are located in the northeastern Jura range.

Commercial uses of geothermal in Switzerland include district heating and bathing at six locations.

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UNITED KINGDOM

Geothermal resources of the United Kingdom of Great Britain and Northern Ireland consist of primarily low-temperature thermal fluids contained in deep regional aquifers. These have been characterized from oil and gas exploration. The aquifers, comprised primarily of Triassic and Permian sandstone formation, contain thermal water in the general temperature range of 50° to 70° and are located in the following Mesozoic basins: (1) Wessex Basin, (2) Worchester Basin, (3) West Lancashire/Cheshire Basins, (4) East Yorkshire/Lincolnshire Basins, (5) Carlisle Basin, (6) Larne Basin (Northern Ireland), and (7) Ballycastle Basin (Northern Ireland); and within the following upper Paleozoic basins; (1) Bath/Bristol Basins, (2) South Wales Basin, (3) East Midlands Basin, (4) West Pennines Basin, and (5) Midland Valley. The Wessex Basin is considered to have the greatest potential and is the best characterized of the basins to date. Other than for therapeutic baths, no direct applications are known.

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USSR

Information pertaining to geothermal resources and related development activity in the USSR has, for the most part, addressed theoretical aspects related to research on geothermal energy extraction and conversion. However, a number of articles published over the past few years have presented a better indication of Soviet geothermal-related activities in the areas of resource assessments and energy use. Research programs in the USSR relating to geothermal energy have included three super deep research boreholes, a test site apparently under study as a potential hot dry rock research area, and proposed large-scale geothermal power expansion projects in the eastern Soviet Union.

A major portion of geothermal resources in the USSR are contained as thermal water within deep regional aquifers. These resources are enclosed in large, artesian basins of the West-Siberian platform (east of the Ural Mountains), the Saythian platform, and the Turanian platforms (surrounding the Aral Sea). Deep aquifers can also be found in relatively small intermontane basins of the Caucasus Mountains (between the Black and Caspian Seas), the Tien-Shan and Dzhungar Basins (south-central Asian area), and in the Baikalian and East Savnay folded regions (near Lak Baikal).

The remaining systems are fissure-vein type hydrothermal convection systems related to recent volcanic areas. These areas are distributed within the Kamchatka-Kuril folded area (extreme east peninsula) and localized folded zones of the Caucasus, Pamirs (south-central Asia), Transbaikalian, and the Carpathian Mountains (extreme south-west, near Romania).

The peninsula of Kamchatka has the only operational geothermal power plant in the country. The plant (11 MW capacity) is located at Pauzhetka and has been operating since 1967. The first 50 MW section of the planned Mutnovsky power plant in eastern Kamchatka, originally slated for commission in 1985, will be commissioned during 1986-90. The total capacity at Mutnovsky will be 200 MW when development is completed. As much as 2,000 MW of geothermal electric power is reportedly planned for Kamchatka in the future.

The island of Sakhalin and the Kurile Island chain are listed as other potential geothermal sites in the Soviet far east. Although the resource potential has not been reported, hydrothermal systems here may be similar to those of the Kamchatka Peninsula.

A 10 MW geothermal plant at Neftekumsk (Stravopol) was reported to be under construction. However, there is no confirmation of the plant's development.

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Appendix C

Detailed Energy, Economic, and Financial Data Used for the Target Country Analyses

INTRODUCTION

This appendix contains descriptions and tables of detailed data used to assess the energy and economic conditions of the market studies. Specifically, the following data are included:

- o Basic Indicators Data (demographic and macro-economic data)
- o Commercial Energy Data (energy market and growth statistics)
- o Trade and Balance of Payments Data (total country export, import, and capital flow data)
- o Debt and Finance Data (public debt and debt service data).

Data are presented in exhibits at the end of this appendix. Exhibit C.5 through C.10 contain numerical data that have been used to develop Exhibit 2.6. For further explanation refer to Chapter 2. Also included, (Exhibit C-11) is a list of suggested sources of information for detailed market studies and risk assessments.

Basic Indicators

Exhibit C.1 lists several basic indicators that, when collectively examined, provide summary profiles of the selected countries. These indicators are divided under two categories: demographic data and macro-economic data.

The demographic data consist of the latest available population figures, the average annual increase in population over the decade 1973-1983, and population projections for the period 1980-2000. The population data provide an indication of the overall market size in the country. The population growth rate is an indicator of how the total demand for goods and services, including energy, is expected to change. Generally speaking, developing countries experience higher population growth rate on the average than industrialized countries. The higher the level of development, the lower the population growth rate tends to be. Countries in Africa, Asia and Latin America

COUNTRY	DEMOGRAPHIC DATA POPULATION in '000 mid-1983	POPULATION AVG % YEARLY GROWTH 1973-1983	1980-2000	MACROECONOMIC DATA GDP million $ 1983	AVG. (%) ANNUAL GDP GROWTH RATE 1965-73	1973-83	1983 GDP PER CAPITA (in $)	% AVG ANN'L INVT GRWTH 1973-1983
ALGERIA	20,600	3.1	3.5	47,200	7.0	6.5	2,291.3	7.2
ARGENTINA	29,600	1.6	1.3	71,550	4.3	0.4	2,417.2	-2.0
BHUTAN	1,200	1.9	2.2	*	*	*	*	*
BOLIVIA	6,000	2.6	2.4	3,340	4.4	1.5	556.7	-11.4
BRAZIL	129,700	2.3	1.9	254,660	9.8	4.8	1,963.5	2.5
BURMA	35,500	2.0	2.3	6,190	2.9	6.0	174.4	14.1
BURUNDI	4,500	2.2	2.9	1,020	4.8	3.6	226.7	15.7
CAMEROON	9,600	3.1	3.2	7,220	4.2	6.8	752.1	10.6
CAPE VERDE	315	*	*	63 /b	*	*	200.0	*
CHAD	4,800	2.1	2.4	320	0.5	-5.8	66.7	*
CHILE	11,700	1.7	1.5	19,290	3.4	2.9	1,648.7	-0.3
CHINA	1,019,100	1.5	1.2	274,630	7.4	6.0	269.5	6.6
COLOMBIA	27,500	1.9	1.8	35,310	6.4	3.9	1,284.0	6.0
COSTA RICA	2,400	2.4	2.1	3,060	7.1	2.7	1,275.0	-3.4
DJIBOUTI	399	*	*	339 /b	*	*	849.6	*
DOMINICA	81	*	*	37 /b	*	*	456.8	*
DOMINICAN REPUB	6,000	2.4	2.2	8,530	8.5	4.4	1,421.7	2.5
ECUADOR	8,200	2.6	2.5	10,700	7.2	5.2	1,304.9	3.2
EGYPT	45,200	2.5	2.0	27,920	3.8	8.8	617.7	12.0
EL SALVADOR	5,200	3.0	2.6	3,700	4.4	-0.1	711.5	-5.7
ETHIOPIA	40,900	2.7	2.6	4,270	4.1	2.3	104.4	2.6
FIJI	670	*	*	1,291 /b	*	*	1,926.9	*
GREECE	9,800	1.1	0.4	30,770	7.5	3.0	3,139.8	-1.4
GRENADA	92	*	*	34 /b	*	*	369.6	*
GUATEMALA	7,900	3.1	2.6	9,030	6.0	3.7	1,143.0	1.2
HAITI	5,300	1.8	1.8	1,630	1.7	3.0	307.5	8.4
HONDURAS	4,100	3.5	3.0	2,640	4.4	4.0	643.9	0.7
INDIA	733,200	2.3	1.8	168,170	3.9	4.0	229.4	4.2
INDONESIA	155,700	2.3	1.9	78,320	8.1	7.0	503.0	12.3
JORDAN	3,200	2.7	3.8	3,630	*	11.1	1,134.4	19.9
KENYA	18,900	4.0	3.9	4,940	7.9	4.6	261.4	3.4
KOREA, SOUTH	40,000	1.6	1.4	76,640	10.0	7.3	1,916.0	9.1
MADAGASCAR	9,500	2.6	3.1	2,850	3.5	0.3	300.0	-1.0
MALAWI	6,600	3.0	3.1	1,330	5.7	4.2	201.5	*
MALAYSIA	14,900	2.4	2.0	29,280	6.7	7.3	1,965.1	11.9

Exhibit C.1: Basic Indicators

COUNTRY	DEMOGRAPHIC DATA: POPULATION in '000 mid-1983	DEMOGRAPHIC DATA: POPULATION AVG % YEARLY GROWTH 1973-1983	DEMOGRAPHIC DATA: POPULATION AVG % YEARLY GROWTH 1980-2000	MACROECONOMIC DATA: GDP million $ 1983	MACROECONOMIC DATA: AVG. (%) ANNUAL GDP GROWTH RATE 1965-73	MACROECONOMIC DATA: AVG. (%) ANNUAL GDP GROWTH RATE 1973-83	MACROECONOMIC DATA: 1983 GDP PER CAPITA (in $)	MACROECONOMIC DATA: % AVG ANN'L INVT GRWTH 1973-1983
MEXICO	75,000	2.9	2.3	145,130	7.9	5.6	1,935.1	4.5
MOROCCO	20,800	2.6	2.4	13,300	5.7	4.7	639.4	2.4
MOZAMBIQUE	13,100	2.6	2.9	4,034 /b	*	*	307.9	*
NEPAL	15,700	2.6	2.6	2,180	1.7	3.0	138.9	*
NICARAGUA	3,000	3.9	3.0	2,700	3.9	-1.3	900.0	-2.7
NIGERIA	93,600	2.7	3.3	64,570	9.7	1.2	689.9	3.5
PANAMA	2,000	2.3	1.9	4,370	7.4	5.3	2,185.0	*
PAPUA NEW GUINE	3,200	2.1	2.1	2,360	6.7	1.0	737.5	4.2
PERU	17,900	2.4	2.2	17,630	3.5	1.8	984.9	-2.7
PHILIPPINES	52,100	2.7	2.1	34,640	5.4	5.4	664.9	7.3
RWANDA	5,700	3.4	3.4	1,560	6.3	5.6	273.7	*
ST. KITTS	46	*	*	40 /b	*	*	869.6	*
ST. LUCIA	125	*	*	69 /b	*	*	552.0	*
ST. VINCENT/GRE	102	*	*	83 /b	*	*	813.7	*
SAMOA	161	*	*	*	*	*	*	*
SAUDI ARABIA	10,400	4.7	3.6	120,560	11.2	6.9	11,592.3	27.1
SOLOMON ISLANDS	254	*	*	141 /b	*	*	555.1	*
SOMALIA	5,100	2.8	3.0	1,540	*	2.8	302.0	-8.2
SUDAN	20,800	3.2	2.8	6,850	0.2	6.3	329.3	5.6
TAIWAN	*	*	*	*	*	*	*	*
TANZANIA	20,800	3.3	3.4	4,550	5.0	3.6	218.8	4.4
THAILAND	49,200	2.3	1.7	40,430	7.8	6.9	821.7	6.2
TUNISIA	6,900	2.5	2.2	7,020	7.3	6.0	1,017.4	9.5
TURKEY	47,300	2.2	1.9	47,840	6.5	4.1	1,011.4	2.3
UGANDA	13,900	2.8	3.3	3,360	3.6	-2.1	241.7	-5.2
VANUATU	127	*	*	*	*	*	*	*
VENEZUELA	17,300	3.5	2.6	8,170	5.1	2.5	472.3	2.5
VIETNAM	58,500	2.7	2.4	*	*	*	*	*
YEMEN, NORTH	7,600	2.9	2.8	3,710	*	8.2	488.2	18.2
YEMEN, SOUTH	2,000	2.2	2.4	850	*	*	425.0	*
YUGOSLAVIA	22,800	0.8	0.6	46,890	6.1	5.3	2,056.6	5.2
ZAIRE	29,700	2.5	3.1	5,440	3.9	-1.0	183.2	4.9
ZIMBABWE	7,900	3.2	3.6	4,730	7.3	1.8	598.7	1.9

SOURCES: (a) World Bank (1985) unless otherwise indicated
(b) Meridian Corporation (1986)

* not available

NOTE: Information not shown for non-countries (Puerto Rico, Azores, Ascension Island)

Exhibit C.1: Basic Indicators (cont'd)

typically experience annual population growth rates between 2.0% and 4.3%, while industrialized countries experience a slower growth, usually below 1%.

Because of compounding, small differences in the annual population growth rates over long periods can result in large additions to the population. Over a period of 100 years, an average growth of 1% would bring an increase in population of 2.7 times, while a rate of 4% would mean an increase in population of 50 times. These numbers help establish the perspective of the impact rapid population increases can put on a country's resources, including energy.

The macro-economic data include the gross domestic product (GDP) for the most recent available year (1983) and its growth rate for the period 1973 to 1983. The GDP is a measure of the total final output of goods and services provided by a given country and, as such, is the most widely used indicator of economic growth and progress. As indicated in Exhibit C.1, the countries selected in this study experienced very different economic, social, and political conditions in the decade 1973 to 1983; these differences in economic performance are reflected in their average annual Gross Domestic Product (GDP) growth rate, which varies from a low of -5.8% to a high of 11.1%. Finally, the percent average investment growth rate is also shown for the period 1973-83, providing yet another measure of economic activity and performance.

<u>Commercial Energy Data</u>

Exhibit C.2 provides fundamental energy statistics aimed at estimating the size of the energy market and its expected growth rate for each of the selected countries. It shows total commercial energy supply and demand as well as the various commercial energy sources, with special emphasis on electricity consumption and production. Electricity production and consumption is emphasized because electricity generation is considered to be the major

COUNTRY	1983 ENGY PRODUCTION (MTOE) /b	ENERGY PRODUCTION GROWTH RATE/YR (%) 1965-73	ENERGY PRODUCTION GROWTH RATE/YR (%) 1973-83	1983 ENGY CONSUMP (MTOE) /c	ENERGY CONSUMPTION GROWTH RATE/YR (%) 1965-73	ENERGY CONSUMPTION GROWTH RATE/YR (%) 1973-83	1983 ENGY CONSMP/CA (kgoe)	ENERGY IMPORTS AS % OF EXPRTS 83	ELECTRICITY GENERATION CAPACITY /c: HYDRO POTENTIAL (MW)	HYDRO (%)	STEAM (%)	GAS TURB (%)	DIESEL (%)	OTHER (%)	ELECTRY PRODUCTN (GWh) /c	INSTALLED ELECTRICTY (MW) /d	ESTIMATED PROVED RESERVES (MTOE): OIL /e	GAS /e	COAL /f
ALGERIA	58.509	7.2	3.3	10.133	11.2	12.5	982	2	287	14	56	30	0	0	7,180	3,133	1278.9	2462.84	*
ARGENTINA	39.047	6.4	4.5	36.348	5.9	2.7	1,460	9	40,000	40	36	14	7	3	39,804	13,661	333.5	542.52	112
BHUTAN	0.002	*	*	*	*	*	*	*	*	*	*	*	*	*	*	15.7	*	*	*
BOLIVIA	3.382	17.8	-0.2	1.943	5.2	6.1	292	*	18,000	57	0	26	0	17	1,703	490	22.3	108.10	*
BRAZIL	34.561	8.7	9.0	84.757	11.5	4.9	745	56	213,140	86	9	0	5	0	151,721	41,300	300.2	75.38	566
BURMA	2.057	9.6	7.2	1.875	5.9	5.7	65	*	*	26	11	28	14	21	1,844	818	9.5	3.68	0
BURUNDI	0.003	*	30.2	0.050	5.6	12.5	17	*	800	7	0	0	93	0	53	20	*	*	*
CAMEROON	5.752	1.2	45.6	3.299	6.5	8.0	128	4	23,000	73	0	0	27	0	2,148	569	80.5	89.24	*
CAPE VERDE	..	*	*	0.039	*	*	*	*	*	0	0	0	100	0	18	14	*	*	*
CHAD	..	*	*	0.068	*	*	*	*	*	0	0	0	100	0	65	25	*	*	*
CHILE	4.486	4.1	1.5	8.491	7.2	0.6	755	24	18,772	50	38	6	7	0	11,871	3,250	105.3	52.90	2,566
CHINA	469.449	11.8	5.7	415.357	11.9	5.4	455	*	378,532	31	52	0	17	0	327,678	79,200	2670.9	690.00	48,030
COLOMBIA	18.070	2.2	3.6	18.763	6.5	5.6	786	21	94,358	68	10	20	2	0	22,564	8,350	177.5	94.99	1,332
COSTA RICA	0.222	10.2	8.9	1.325	12.2	4.9	609	22	9,071	71	2	0	27	0	2,500	820	..	..	*
DJIBOUTI	..	*	*	0.069	*	*	*	*	*	0	0	0	100	0	122	50	*	*	*
DOMINICA	0.001	*	*	0.016	*	*	*	*	*	43	0	0	57	0	17	7	*	*	*
DOMINICAN REPUB	0.066	4.9	40.0	1.779	18.6	1.8	407	71	1,900	16	54	28	3	0	3,586	1,360	..	..	*
ECUADOR	12.221	36.6	2.5	4.882	9.3	13.6	675	*	22,733	19	0	0	81	0	3,360	1,716	239.3	94.07	0
EGYPT	38.841	10.0	16.4	20.060	1.9	11.5	532	12	2,660	42	43	15	0	0	17,720	6,836	558.3	162.38	0
EL SALVADOR	0.127	2.1	14.8	0.954	5.7	3.3	190	57	1,337	54	14	14	0	19	1,500	700	..	..	*
ETHIOPIA	0.048	11.1	6.2	0.781	11.4	4.4	19	*	12,000	91	3	0	6	0	679	412	..	..	*
FIJI	0.004	*	*	0.301	*	*	*	*	*	0	0	0	100	0	321	210	*	*	*
GREECE	5.425	12.7	9.0	16.650	11.7	3.8	1,790	59	*	23	0	0	0	77	23,272	9,928	5.0	69.00	583
GRENADA	..	*	*	0.021	*	*	*	*	*	0	*	*	*	*	25	12	*	*	*
GUATEMALA	0.630	18.3	25.1	1.237	7.1	2.8	178	68	5,426	23	39	30	8	*	1,630	655	7.3	0.69	*
HAITI	0.022	*	9.7	0.266	6.2	6.9	55	*	152	33	0	0	67	0	377	184	*	*	0
HONDURAS	0.076	15.6	10.9	0.787	10.4	3.9	204	28	2,800	57	0	43	0	0	1,090	255	..	..	*
INDIA	109.902	3.7	7.7	108.154	5.1	6.6	182	*	100,000	36	55	0	7	2	138,677	40,000	541.7	388.24	10,909
INDONESIA	82.620	12.7	2.7	24.908	6.4	7.8	204	20	32,000	13	30	37	20	0	12,722	9,100	1232.5	818.80	578 *
JORDAN	..	*	*	1.917	4.3	15.3	790	101	*	0	29	33	21	18	1,512	659	..	..	*
KENYA	0.147	9.9	15.0	1.527	7.1	1.4	109	*	6,000	64	23	6	6	*	1,998	550	..	..	*
KOREA,SOUTH	9.551	2.6	4.6	39.847	15.8	8.8	1,168	28	2,000	12	69	13	0	6	47,197	13,970	..	..	100
MADAGASCAR	0.021	8.6	2.3	0.460	13.6	1.4	59	32	*	24	0	0	37	40	432	110	..	..	0
MALAWI	0.039	31.1	8.3	0.291	8.3	4.3	45	*	900	77	0	15	8	0	408	175	*	*	0
MALAYSIA	19.400	60.8	15.9	10.067	8.5	7.1	702	16	25,800	24	55	5	16	0	11,102	2,500	449.5	1,212	0

Exhibit C.2: Commercial Energy Data

COUNTRY	1983 ENGY PRODUCTION (MTOE) /b	ENERGY PRODUCTION GROWTH RATE/YR (%) 1965-73	ENERGY PRODUCTION GROWTH RATE/YR (%) 1973-83	1983 ENGY CONSUMP (MTOE) /c	ENERGY CONSUMPTION GROWTH RATE/YR (%) 1965-73	ENERGY CONSUMPTION GROWTH RATE/YR (%) 1973-83	1983 ENGY CONSMP/CA (kgoe)	ENERGY IMPORTS AS % OF EXPRTS 83	ELECTRICITY GENERATION CAPACITY /c: HYDRO POTENTIAL (MW)	HYDRO (%)	STEAM (%)	GAS TURB (%)	DIESEL (%)	OTHER (%)	ELECTRY PRODUCTN (GWh) /c	INSTALLED ELECTRICTY (MW) /d	ESTIMATED PROVED RESERVES (MTOE): OIL /e	GAS /e	COAL /f
MEXICO	178.710	4.5	17.0	92.585	7.2	8.7	1,332	*	25,250	37	48	9	5	1	80,589	18,650	7148.5	1,770	666
MOROCCO	0.700	2.6	*	4.445	8.9	5.4	258	57	2,453	44	45	10	2	0	7,290	2,100	0.036	..	25
MOZAMBIQUE	0.770	4.6	18.6	1.172	9.3	1.5	95	*	15,000	99	0	0	10	0	3,400	2,200	..	..	132
NEPAL	0.017	27.2	7.3	0.188	8.8	7.3	13	*	18,250	60	11	*	29	*	356	160	*	*	*
NICARAGUA	0.047	4.8	6.4	0.667	9.8	0.7	262	46	4,106	28	63	9	0	0	1,153	400	..	..	*
NIGERIA	66.552	33.4	-4.4	12.235	9.6	15.4	150	*	12,400	33	25	41	1	0	7,500	3,100	2,407	1081	157
PANAMA	0.073	2.7	17.0	1.351	7.6	-6.3	2,082	82	3,031	39	35	2	24	0	3,457	1,100	..	..	*
PAPUA NEW GUINE	0.030	16.5	7.8	0.668	20.3	3.6	223	*	29,000	30	0	0	70	0	471	720	7.25	11.50	*
PERU	10.117	1.9	11.2	8.983	5.1	3.6	550	2	60,000	60	27	13	0	0	10,400	3,675	92.22	19.60	0
PHILIPPINES	1.802	4.6	20.8	11.815	9.1	2.3	252	44	10,048	21	69	0	0	10	20,560	6,486	2.36	0.25	0
RWANDA	0.014	15.7	2.0	0.095	11.4	13.0	35	*	600	52.	0	0	48	0	163	42	*	*	*
ST. KITTS	..	*	*	0.015	*	*	*	*	*	*	*	*	*	*	*	13.5	*	*	*
ST. LUCIA	..	*	*	0.058	*	*	*	*	*	*	*	*	*	*	63.85	18.5	*	*	*
ST. VINCENT/GRE	0.001	*	*	0.018	*	*	*	*	*	*	*	*	*	*	29	10	*	*	*
SAMOA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	21	*	*	*
SAUDI ARABIA	265.022	15.7	-1.2	33.260	12.4	6.8	3,536	n/a	*	*	*	*	*	*	25,450	18,802	24,476	2,783	*
SOLOMON ISLANDS	..	*	*	0.037	*	*	*	*	*	0	*	*	*	*	23.5	15	*	*	*
SOMALIA	..	*	*	0.360	9.3	16.8	84	*	50	0	0	0	100	0	75	47	*	*	*
SUDAN	0.043	14.7	9.0	1.251	12.4	-3.3	66	57	2,700	53	17	5	25	0	1,010	450	43.50	..	*
TAIWAN	*	*	*	*	*	*	*	*	*	11	*	*	*	*	40,899	13,071	0.80	18.65	0
TANZANIA	0.046	6.8	5.9	0.712	10.5	-2.6	38	*	9,500	66	0	4	30	0	828	429	..	18.40	0
THAILAND	2.394	10.5	13.7	12.926	14.6	5.4	269	39	20,148	33	60	5	2	0	17,687	4,976	15.52	124.20	0
TUNISIA	5.993	58.7	4.3	2.812	8.7	8.2	473	31	65	3	39	55	3	0	3,200	1,070	261	96.60	*
TURKEY	10.637	5.7	3.8	27.872	10.0	4.6	599	66	32,000	42	58	0	0	0	28,160	7,291	43.50	11.27	1,235
UGANDA	0.054	3.7	-2.6	0.287	8.4	-5.8	23	*	1,200	97	0	0	3	0	356	200	*	*	*
VANUATU	..	*	*	*	*	*	*	*	*	*	*	*	*	*	*	10	*	*	*
VENEZUELA	114.087	0.1	-3.5	40.731	4.3	4.5	2,295	1	25,000	31	37	30	2	0	39,000	12,700	3,711	1,358.54	500
VIETNAM	4.262	-3.4	5.6	*	6.7	-2.1	90	*	*	*	*	*	*	*	*	1,795	*	*	50
YEMEN, NORTH	..	*	*	0.509	16.5	22.4	116	*	*	0	0	0	100	0	640	195	29	..	*
YEMEN, SOUTH	..	*	*	*	-21.7	7.1	934	*	*	*	*	*	*	*	*	195	..	..	*
YUGOSLAVIA	23.043	3.5	4.1	36.195	6.8	4.3	1,903	33	17,000	44	56	0	0	0	64,950	17,115	*	*	3,122
ZAIRE	1.588	4.8	9.1	1.456	6.0	1.5	77	*	120,000	94	0	0	6	0	4,392	2,412	15.95	0.69	0
ZIMBABWE	1.960	1.8	-2.6	4.504	9.9	0.5	491	*	3,800	60	40	0	0	0	7,614	1,280	*	*	400

Sources:
(a) World Bank (1985) unless otherwise indicated
(b) United Nations (1985)
(c) Meridian Corporation (1986)
(d) Central Intelligence Agency (1985)
(e) Oil and Gas Journal (1985)
(f) International Energy Agency (1983)

* not available
.. less than 1/2 unit shown

NOTE: Information not shown for non-countries (Puerto Rico, Azores, Ascension Island)

Exhibit C.2: Commercial Energy Data (cont.)

potential use of geothermal energy in developing countries.

An understanding of a country's current energy situation is important in predicting what its attitudes may be towards geothermal development. Countries importing large portions of their energy demand will be more eager to adopt and encourage policies aimed at developing indigenous resources, including geothermal. However it must be pointed out that if geothermal energy is to be marketed as a potential source of energy, particularly of electrical generation, the availability of cost-competitive alternative indigenous energy resources must be considered. For this reason, Exhibit C.2 indicates the current mix of electrical generation capacity in each country and the country's estimated accessible reserves for hydropower, coal, oil, and gas. The current mix of electrical generation capacity is an indicator of the degree of dependence of electricity generation on the various energy resources such as hydropower, gas, diesel, and steam (steam plants use oil, gas, and coal). The country's estimated accessible reserves for hydropower, coal, oil, and gas are shown to provide some measure of the competition facing geothermal resources. If a country possesses very substantial hydropower and/or oil reserves, it is less likely that the country's geothermal resources will be called upon to meet increased demand for energy. It is important to note that "accessible" does not always mean economically competitive. As can also be seen from the exhibit, the energy consumption per capita, which varies from a low of 13 kg of oil equivalent (kgoe) to a high of 2,295 kgoe per capita, emphasizes the vast difference in development stages and energy needs among the study countries.

<u>Trade and Balance of Payments</u>

Exhibit C.3 provides data on each country's total exports and imports for 1983, as well as the percent average annual growth rate for both of these quantities over the period 1965 to 1983. These figures include all

COUNTRY	Merchandise Trade in (million $) EXPORTS 1983	IMPORTS 1983	Average Annual Growth Rate (percent) EXPORTS 1965-73	EXPORTS 1973-83	IMPORTS 1965-73	IMPORTS 1973-83	Balance of Payments and Reserves: CURRENT A/C BALANCE in (million $) 1970	CURRENT A/C BALANCE 1983	GROSS INT'L RESERVES in (million $) 1970	GROSS INT'L RESERVES 1983	In Month of Import Coverage 1983	FLOW OF PUBLIC & PUBLICLY GUARANTEED EXTERNAL CAPITAL (million $) GROSS INFLOW 1970	GROSS INFLOW 1983	PRINCIPAL REPAYMENT 1970	PRINCIPAL REPAYMENT 1983	NET INFLOW 1970	NET INFLOW 1983
MEXICO	21,168	8,201	1.0	14.4	5.7	5.5	-1,068	5,223	756	4,794	2.5	772	6,908	476	3,104	297	3,804
MOROCCO	2,062	3,599	6.0	0.5	6.2	0.8	-124	-889	141	376	0.9	163	840	36	610	127	229
MOZAMBIQUE	260	635	-7.9	-8.3	-8.9	-4.2	*	*	*	*	*	*	*	*	*	*	*
NEPAL	94	464	*	*	*	*	*	-143	94	191	4.1	1	70	2	5	-2	66
NICARAGUA	411	799	2.6	-0.4	2.0	-3.7	-40	-451	49	171	2.1	44	322	17	46	28	276
NIGERIA	17,509	17,600	8.9	-6.2	8.9	13.6	-368	-4,752	223	1,252	1.0	62	4,845	36	1,066	26	3,779
PANAMA	480	1,412	1.1	-6.6	6.5	-4.4	-64	194	16	207	0.4	67	358	24	188	44	170
PAPUA NEW GUINE	822	1071	*	*	*	*	*	-372	*	474	3.8	25	225	0	44	25	181
PERU	3,015	2,688	-2.1	8.5	-2.0	-0.6	202	-871	339	1,898	4.6	148	1,622	101	347	47	1,275
PHILIPPINES	4,932	7,980	4.2	7.5	3.1	1.3	-48	-2,760	255	896	0.9	128	2,224	72	602	56	1,623
RWANDA	80	279	6.3	2.6	4.6	12.9	7	-49	8	111	4.1	..	38	..	2	..	37
ST. KITTS	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
ST. LUCIA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
ST. VINCENT/GRE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SAMOA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SAUDI ARABIA	79,125	40,473	15.0	-4.5	10.4	27.6	71	-18,433	670	29,040	4.4	n/a	n/a	n/a	n/a	n/a	n/a
SOLOMON ISLANDS	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SOMALIA	163	422	6.7	7.3	1.4	0.0	-6	-150	21	16	0.4	4	95	.	13	4	82
SUDAN	624	1,354	3.8	-1.5	4.9	1.3	-42	-213	22	17	0.2	52	439	22	54	30	385
TAIWAN	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
TANZANIA	480	1,134	0.9	-4.6	7.1	-2.7	-36	*	65	19	*	50	303	10	30	40	274
THAILAND	6,368	10,279	6.9	9.0	4.4	3.3	-250	-2,886	912	2,556	2.5	51	1,315	23	419	27	896
TUNISIA	1,851	3,117	8.6	0.2	7.7	5.3	-53	-561	60	639	2.1	87	555	45	403	42	151
TURKEY	5,671	8,548	*	6.3	*	-0.2	-44	-1,880	440	2,710	2.8	328	1,598	128	1,175	200	423
UGANDA	354	340	0.2	-8.0	-2.5	1.9	20	-256	57	*	*	26	93	4	65	22	29
VANUATU	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
VENEZUELA	15,040	6,667	0.2	-6.8	4.8	4.7	-104	3,707	1,047	12,015	10.7	224	1,825	42	937	183	889
VIETNAM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
YEMEN, NORTH	204	1,521	*	*	*	*	*	-558	*	369	2.1	*	326	*	29	*	297
YEMEN, SOUTH	449	1,010	*	*	*	*	-4	-309	59	297	3.6	1	306	..	32	1	274
YUGOSLAVIA	9,914	12,154	7.7	*	12.3	*	-372	275	143	1,686	1.2	180	1,307	168	526	12	781
ZAIRE	1,459	953	6.5	-8.7	9.6	-13.7	-64	-559	189	269	*	31	210	28	39	3	171
ZIMBABWE	1,273	1,432	*	*	*	*	*	-459	59	300	2.0	..	710	5	330	-5	381

SOURCE: World Bank (1985)

* not available
.. less than 1/2 unit shown

NOTE: Information not shown for non-countries (Puerto Rico, Azores, Ascension Island)

Exhibit C.3: Trade and Balance of Payments

	Merchandise Trade in (million $)		Average Annual Growth Rate (percent)				Balance of Payments and Reserves					FLOW OF PUBLIC & PUBLICLY GUARANTEED EXTERNAL CAPITAL (million $)					
							CURRENT A/C BALANCE in (million $)		GROSS INT'L RESERVES in (million $)		GROSS INT'L RESERVES In Month of Import Coverage						
	EXPORTS	IMPORTS	EXPORTS		IMPORTS							GROSS INFLOW		PRINCIPAL REPAYMENT		NET INFLOW	
COUNTRY	1983	1983	1965-73	1973-83	1965-73	1973-83	1970	1983	1970	1983	1983	1970	1983	1970	1983	1970	1983
ALGERIA	11,158	10,332	1.4	-1.1	12.1	6.5	-125	-86	352	4,010	3.5	292	2,921	33	3,292	259	-371
ARGENTINA	7,910	4,666	2.4	8.6	5.4	-0.3	-163	-2,439	682	2,840	2.8	487	2,390	342	1,000	146	1,390
BHUTAN	*	*	●	●	●	*	*	●	●	●	*	●	●	*	●	*	●
BOLIVIA	766	424	5.1	-2.4	0.9	-0.9	4	-183	46	509	5.2	54	86	17	102	37	-16
BRAZIL	25,127	16,844	10.1	8.2	18.4	-4.6	-837	-6,799	1,190	4,561	1.8	884	7,095	255	1,979	629	5,117
BURMA	382	270	-4.8	4.9	-6.7	-0.6	-63	-343	98	185	2.6	16	333	18	86	-2	247
BURUNDI	76	194	●	●	●	*	*	●	●	●	●	1	98	..	4	1	93
CAMEROON	1,057	1,226	4.2	3.9	6.3	5.1	-30	-289	81	170	1.1	28	162	4	112	24	50
CAPE VERDE	*	●	●	●	*	*	*	*	●	*	*	●	●	●	●	●	●
CHAD	58	109	-3.5	-3.1	18.7	-8.6	2	38	2	32	2.2	6	3	2	..	3	2
CHILE	3,836	2,754	-1.4	9.7	2.3	1.2	-91	-1,068	392	2,620	5.3	397	1,808	163	328	234	1,480
CHINA	22,226	21,390	*	●	●	*	*	4,460	●	19,698	10.5	●	●	●	*	●	●
COLOMBIA	3,081	4,967	5.4	2.8	5.5	10.5	-293	-2,738	207	3,512	5.9	252	1,357	78	388	174	970
COSTA RICA	1,071	993	10.3	2.7	8.6	-2.4	-74	-317	16	345	2.7	30	418	21	92	9	326
DJIBOUTI	*	*	●	*	●	*	*	●	●	*	●	●	*	●	●	●	●
DOMINICA	*	●	●	●	●	●	*	●	*	●	●	●	*	*	*	*	*
DOMINICAN REPUB	648	1,279	11.0	2.2	13.3	-0.9	-102	-442	32	171	1.1	45	248	7	121	38	127
ECUADOR	2,550	1,465	3.4	-3.4	8.5	4.0	-113	-104	76	802	3.4	42	745	16	508	26	237
EGYPT	4,531	10,274	3.8	2.3	-3.9	10.1	-148	-785	165	1,699	1.8	394	2,221	297	1,456	97	765
EL SALVADOR	735	891	2.7	1.4	1.8	-2.2	9	-152	64	344	3.5	8	287	6	29	2	258
ETHIOPIA	422	875	3.0	1.4	-0.2	2.7	-32	-171	72	206	2.5	27	242	15	42	13	200
FIJI	*	●	●	●	*	*	●	●	●	*	*	●	*	●	●	*	●
GREECE	4,412	9,500	13.4	9.7	9.6	2.8	-422	-1,868	318	2,381	2.6	164	2,255	61	562	102	1,692
GRENADA	●	●	*	*	●	●	●	●	*	●	●	*	●	●	*	*	●
GUATEMALA	1,220	1,126	5.1	4.6	3.6	-0.1	-8	-226	79	409	3.4	37	314	20	65	17	249
HAITI	412	620	●	*	*	*	2	-100	4	16	0.4	4	45	4	8	1	37
HONDURAS	660	823	4.2	0.6	3.1	-1.3	-64	-225	20	120	1.3	29	236	3	38	26	199
INDIA	9,705	13,562	2.3	4.9	-5.7	2.8	-394	-2,780	1,023	8,242	5.4	890	2,765	307	770	583	1,995
INDONESIA	21,145	16,346	11.1	1.4	13.9	9.8	-310	-6,294	160	4,902	2.2	441	4,965	59	1,295	382	3,670
JORDAN	739	3,217	5.0	17.8	3.8	13.3	-20	-390	258	1,240	3.7	14	450	3	125	12	325
KENYA	876	1,274	3.8	-4.8	5.9	-4.6	-49	-174	220	406	2.8	32	258	16	178	17	80
KOREA,SOUTH	24,445	26,192	31.7	14.8	22.4	7.5	-623	-1,578	610	2,463	0.9	441	3,634	198	1,999	242	1,635
MADAGASCAR	329	439	5.4	-4.3	1.5	-2.5	10	-369	37	29	*	10	216	5	77	5	139
MALAWI	220	312	3.8	2.8	6.4	-0.6	-35	-72	29	29	0.8	38	66	3	29	36	38
MALAYSIA	14,130	13,234	8.0	4.9	4.4	7.3	8	-3,350	667	4,673	2.9	43	3,026	45	286	-1	2,741

Exhibit C.3: Trade and Balance of Payments (cont.)

international changes in ownership of goods passing across custom borders, but do not include trade in services. The current account balance, also shown, is the difference between the exports of goods and services plus inflows of unrequited public and private transfers minus the imports of goods and services and unrequited transfers out of the country. Increased foreign demand, in the form of higher exports, means higher foreign exchange earnings that can be used to meet increased interest payments or more needed imports.

Exhibit C.3 also provides estimates of capital flows into and out of each country for the years 1970 and 1983. These figures include the gross inflow of capital and the repayment for public and publicly guaranteed medium- and long-term loans, the difference between the two being the net inflow of capital. For instance, all countries shown, with the exception of Algeria and Bolivia, experienced an increase in net capital inflow in 1983. In particular, Brazil, Mexico, Indonesia, Malaysia, and India were recipients of substantial foreign capital in 1983. This could mean that the countries economic, social, and political environments appeared promising, thus attracting foreign investments.

Using Exhibit C.3 the availability of domestic and foreign capital for new projects can be estimated for each country. Countries with favorable balances of trade, those with a large influx of foreign capital, or those with substantial international reserves are in a better position to import goods and services with which to develop their geothermal resources.

<u>Debt and Finance</u>

Debt, both in the long term and more critically in the short to medium term, plays a very important part in a country's development. It is through borrowing from outside that developing countries can supplement their own savings. These savings are vital as they boost investments and growth and allow the country to offset shortages of foreign exchange. Though borrowing enhances a nation's opportunities, it can sometimes turn into a hefty burden. Problems occur when debt is expanded beyond a country's servicing capabilities.

Exhibit C.4 provides comprehensive data that indicate the status of each country's financial situation, and each country's credit worthiness. The exhibit contains statistics on each country's external public debt and the corresponding set of debt servicing ratios. These statistics are widely accepted indicators of a country's ability to meet its debt obligations. A deterioration in the debt situation of a country is reflected in higher ratios of debt to GNP and/or exports over time. In particular, increases in these ratios may indicate that its debt servicing ability is threatened. The debt data included in Exhibits C.3 and C.4 are based on information from the World Bank Debtor Reporting System. These data include public loans (i.e., external obligations of public debtors, such as the national government, its agencies, and autonomous public bodies) only. Non-guaranteed private debt is not included because of the lack of comprehensive and reliable information.

The data in Exhibit C.4 give an indication of the ease with which the selected country can finance new projects. Countries with low debt service, as a percent of GNP or as a percent of exports, may be more able to take on new debt than countries already dedicating large portions of their exports or GNP to cover their existing debt.

Once again, the diversity of developing countries is apparent when debt figures and ratios are observed. For instance, countries with similar debt to GNP ratios may have widely different debt to export or debt service ratios. This is due to the various degrees of openness of the various economies and the structure of their debt. Countries that are considered relatively closed, such as Yugoslavia or many in Latin America, have relatively low debt to GNP ratios but high debt to export ratios. Those with a large export base, such as Korea,

COUNTRY	External Public Debt Outstanding & Disbursed (Million $) 1970	External Public Debt Outstanding & Disbursed (Million $) 1983	External Public Debt As % of GNP 1970	External Public Debt As % of GNP 1983	Interest Payments on External Public Debt (Million $) 1970	Interest Payments on External Public Debt (Million $) 1983	Debt Service as % of GNP 1970	Debt Service as % of GNP 1983	Debt Service as % of Exports of Goods & Services 1970	Debt Service as % of Exports of Goods & Services 1983	COMMITMENTS million $ 1970	COMMITMENTS million $ 1983	AVERAGE INTEREST RATE (%) 1970	AVERAGE INTEREST RATE (%) 1983	AVERAGE MATURITY (yrs) 1970	AVERAGE MATURITY (yrs) 1983	AVERAGE GRACE PERIOD (yrs) 1970	AVERAGE GRACE PERIOD (yrs) 1983	# DEBT RESCHLG 1975-1986
ALGERIA	937	12,942	19.3	28.0	10	1,212	0.9	9.8	3.8	33.1	288	3,705	6.5	9.8	10	7	2	1	*
ARGENTINA	1,878	24,593	8.6	32.1	121	1,343	2.1	3.1	21.5	24.0	489	1,854	7.4	12.5	12	5	3	2	2
BHUTAN	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
BOLIVIA	479	2,969	33.8	77.7	6	165	1.6	7.0	11.3	30.5	24	439	3.7	4.9	26	28	6	7	2
BRAZIL	3,234	58,068	7.7	29.3	133	5,004	0.9	3.5	12.5	28.7	1,400	7,640	7.1	11.4	14	9	3	3	2
BURMA	101	2,226	4.7	36.3	3	64	0.9	2.4	15.8	33.8	57	218	4.3	1.4	16	40	4	10	*
BURUNDI	7	284	3.1	26.2	..	3	0.3	0.7	*	*	1	69	2.9	4.3	5	26	2	7	*
CAMEROON	131	1,883	12.1	26.7	4	107	0.8	3.1	3.1	13.9	41	201	4.7	8.9	29	18	8	5	*
CAPE VERDE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CHAD	32	129	11.9	43.5	..	..	1.0	0.1	3.9	0.6	4	6	4.8	3.0	7	23	2	7	*
CHILE	2,066	6,827	25.8	39.2	78	557	3.0	5.1	18.9	18.3	343	2,132	6.9	11.9	12	9	3	4	2
CHINA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
COLOMBIA	1,293	6,899	18.4	18.3	44	516	1.7	2.4	12.0	21.3	362	1,391	5.9	10.8	21	14	5	4	*
COSTA RICA	134	3,315	13.8	126.3	7	504	2.9	22.7	10.0	50.6	58	413	5.6	8.3	28	11	6	5	2
DJIBOUTI	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
DOMINICA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
DOMINICAN REPUB	226	2,202	15.5	26.7	5	110	0.8	2.8	4.7	22.7	20	318	2.5	5.8	28	22	5	7	1
ECUADOR	217	6,239	13.2	63.0	7	365	1.4	8.8	9.1	32.5	78	975	6.1	10.6	20	10	4	3	4
EGYPT	1,750	15,229	23.2	49.4	54	540	4.6	6.5	36.4	27.5	448	2,698	7.7	8.8	17	22	2	4	*
EL SALVADOR	88	1,065	8.6	29.2	4	37	0.9	1.8	3.6	6.4	12	121	4.7	2.9	23	34	6	8	*
ETHIOPIA	169	1,223	9.5	25.9	6	24	1.2	1.4	11.4	11.5	21	505	4.3	2.1	32	25	7	6	*
FIJI	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
GREECE	905	8,193	8.9	23.5	41	755	1.0	3.8	9.3	18.3	242	2,169	7.2	10.2	9	9	4	4	*
GRENADA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
GUATEMALA	106	1,405	5.7	15.8	6	76	1.4	1.6	7.4	11.7	50	350	5.2	8.4	26	13	6	4	*
HAITI	40	433	10.3	26.8	..	7	1.0	0.9	7.7	5.0	5	91	6.7	1.3	9	46	1	10	*
HONDURAS	90	1,570	12.9	56.3	3	83	0.8	4.3	2.8	14.9	23	340	4.1	5.9	30	25	7	6	1
INDIA	7,940	21,277	14.9	11.2	189	553	0.9	0.7	22.0	10.3	933	1,885	2.4	5.0	35	30	8	6	3
INDONESIA	2,443	21,685	27.1	28.9	24	1,256	0.9	3.4	6.9	12.8	518	5,597	2.7	8.8	34	15	9	5	*
JORDAN	118	1,940	23.5	47.9	2	88	0.9	5.2	3.6	11.3	33	532	3.9	7.3	12	14	5	3	*
KENYA	319	2,384	20.6	43.1	12	127	1.8	5.5	5.4	20.6	49	147	2.6	5.5	37	31	8	7	*
KOREA,SOUTH	1,797	21,472	*	*	70	1,744	*	*	19.4	12.3	677	3,320	6.0	9.8	19	12	5	4	*
MADAGASCAR	93	1,490	10.8	52.3	2	64	0.8	4.9	3.5	.	23	283	2.3	3.7	40	27	9	7	4
MALAWI	122	719	43.2	55.2	3	30	2.1	4.5	7.1	20.3	13	103	3.8	2.4	30	28	6	9	3
MALAYSIA	390	10,665	10.0	38.6	21	669	1.7	3.5	3.6	5.9	83	3,101	6.1	9.5	19	11	5	6	*

Exhibit C.4: Debt and Finance

COUNTRY	EXTERNAL PUBLIC DEBT & DEBT SERVICING RATIOS: External Public Debt Outstanding & Disbursed (Million $) 1970	(Million $) 1983	As % of GNP 1970	As % of GNP 1983	Interest Payments on External Public Debt (Million $) 1970	(Million $) 1983	Debt Service as % of GNP 1970	GNP 1983	Exports of Goods & Services 1970	Exports of Goods & Services 1983	TERMS OF PUBLIC BORROWING: COMMITMENTS million $ 1970	COMMITMENTS 1983	AVERAGE INTEREST RATE (%) 1970	AVERAGE INTEREST RATE (%) 1983	AVERAGE MATURITY (yrs) 1970	AVERAGE MATURITY (yrs) 1983	AVERAGE GRACE PERIOD (yrs) 1970	AVERAGE GRACE PERIOD (yrs) 1983	# DEBT RESCHLG 1975-1986
MEXICO	3,206	66,732	9.1	49.1	216	6,850	2.0	7.3	23.6	35.9	826	7,517	8.0	11.9	12	9	3	3	3
MOROCCO	711	9,445	18.0	69.6	23	510	1.5	8.3	8.4	38.2	182	1,786	4.6	7.4	20	16	4	5	2
MOZAMBIQUE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	1
NEPAL	3	346	0.3	14.1	..	4	0.3	0.3	*	3.0	17	183	2.8	1.2	27	40	6	10	*
NICARAGUA	156	3,417	15.7	133.3	7	37	2.4	3.2	11.1	18.3	23	371	7.1	6.8	18	14	4	4	3
NIGERIA	480	11,757	4.8	17.7	20	974	0.6	3.1	4.2	18.6	65	4,994	6.0	11.0	14	7	4	2	1
PANAMA	194	2,986	19.5	73.6	7	283	3.1	11.6	7.7	6.8	111	689	6.9	11.3	15	10	4	3	*
PAPUA NEW GUINE	36	911	5.8	40.4	1	63	0.1	4.7	*	11.2	58	284	6.0	7.5	24	14	8	4	*
PERU	856	7,932	12.6	48.1	44	406	2.1	4.6	11.6	19.6	125	1,782	7.4	9.9	13	12	4	3	6
PHILIPPINES	572	10,385	8.1	30.4	23	650	1.4	3.7	7.2	15.4	158	1,814	7.4	9.1	11	16	2	5	1
RWANDA	2	220	0.9	13.9	..	2	0.2	0.3	1.3	2.6	9	56	0.8	1.6	50	37	11	8	*
ST. KITTS	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
ST. LUCIA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
ST. VINCENT/GRE	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SAMOA	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SAUDI ARABIA																			*
SOLOMON ISLANDS	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
SOMALIA	77	1,149	24.4	62.0	..	10	0.3	1.2	2.1	13.1	2	81	..	2.7	3	32	3	5	*
SUDAN	306	5,726	15.2	77.8	13	37	1.7	1.2	10.7	11.2	95	349	1.8	5.5	17	21	9	5	5
TAIWAN	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
TANZANIA	250	2,584	19.5	58.9	6	36	1.2	1.5	4.9	*	283	307	1.2	3.9	40	24	11	5	*
THAILAND	324	7,060	4.9	18.0	16	531	0.6	2.4	3.4	11.3	106	1,189	6.8	8.3	19	20	4	7	*
TUNISIA	541	3,427	38.2	42.4	18	195	4.5	7.4	19.0	22.3	141	614	3.4	8.5	27	12	6	5	*
TURKEY	1,854	15,396	14.4	30.2	42	1,169	1.3	4.6	22.0	28.9	487	2,454	3.6	8.3	19	14	5	4	5
UGANDA	138	623	7.5	17.9	4	17	0.4	1.9	2.7	*	12	204	3.7	3.9	28	34	7	7	2
VANUATU	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
VENEZUELA	728	12,911	6.6	19.8	40	1,658	0.7	4.0	2.9	15.0	198	1,600	8.2	11.6	8	7	2	3	1
VIETNAM	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
YEMEN, NORTH	*	1,574	*	38.4	*	13	*	1.0	*	13.9	9	101	5.2	1.6	5	36	3	8	*
YEMEN, SOUTH	1	1,263	*	118.5	*	14	*	4.3	*	25.1	62	287	..	2.5	21	22	11	5	*
YUGOSLAVIA	1,198	9,077	8.8	19.9	72	483	1.8	2.2	9.9	7.6	198	1,953	7.1	10.9	17	11	6	3	4
ZAIRE	311	4,022	17.6	91.5	9	87	2.1	2.9	4.4	*	257	144	6.5	1.6	13	42	4	9	6
ZIMBABWE	233	1,497	15.7	27.9	5	105	0.6	8.1	*	31.6	*	477	*	9.7	*	13	*	4	*

SOURCE: World Bank (1985)

* not available
.. less than 1/2 unit shown

NOTE: Information not shown for non-countries (Puerto Rico, Azores, Ascension Island)

Exhibit C.4: Debt and Finance (cont.)

Malaysia, or Thailand, or oil exporters such as Algeria, Indonesia, and Venezuela, tend to have a relatively lower debt to export ratio.

However, a country which has high ratios of debt to GNP or exports can conceivably have relatively low debt service ratios. This is the case of countries such as India, Tanzania, or Egypt, which tend to obtain their capital flows in low-interest, long-maturity loans. By comparison, upper-middle income countries such as Algeria or Venezuela have much higher debt servicing costs and thus cannot tolerate high debt ratios.

Still, debt service ratios are the best guide to a country's debt problem. As a general rule, if the country's economic policies and structures are flexible to changing conditions, high debt servicing ratios are not dangerous.

The commitment figures in Exhibit C.4 refer to public and publicly guaranteed loans for which contracts were signed in the year specified but which have not necessarily been totally disbursed. The maturity of a loan is the interval between the agreement date (i.e., when a loan was signed) and the scheduled date of the last installment of principal. The grace period is the interval between the agreement date and the deadline for the first installment of principal. The longer the maturity of a loan, and, to a lesser extent, the longer the grace period, the greater the confidence the lender has in the borrower's ability to repay the loan. Recent debt-servicing difficulties in the Third World have often been provoked or exacerbated by a shortening of the maturity of foreign debt. As a result of a perception of higher risks, lenders have had a tendency to push for faster repayment. This tendency has in turn increased the probability of defaults on loans. Debt-servicing difficulties experienced by some countries studied in this report are reflected in the number of debt reschedulings that involve the restructuring of debt service payments within a certain period. Some countries have experienced as many as six debt reschedulings over a period of ten years.

GDP per Capita (1983)

SAUDI ARABIA	11592.3	ZIMBABWE	598.7
GREECE	3139.8	BOLIVIA	556.7
ARGENTINA	2417.2	SOLOMON ISLANDS	555.1
ALGERIA	2291.3	ST. LUCIA	552.0
PANAMA	2185.0	INDONESIA	503.0
YUGOSLAVIA	2056.6	YEMEN, NORTH	488.2
MALAYSIA	1965.1	VENEZUELA	472.3
BRAZIL	1963.5	DOMINICA	456.8
MEXICO	1935.1	YEMEN, SOUTH	425.0
FIJI	1926.9	GRENADA	369.6
KOREA, SOUTH	1916.0	SUDAN	329.3
CHILE	1648.7	MOZAMBIQUE	307.9
DOMINICAN REP.	1421.7	HAITI	307.5
ECUADOR	1304.9	SOMALIA	302.0
COLOMBIA	1284.0	MADAGASCAR	300.0
COSTA RICA	1275.0	RWANDA	273.7
GUATEMALA	1143.0	CHINA	269.5
JORDAN	1134.4	KENYA	261.4
TUNISIA	1017.4	UGANDA	241.7
TURKEY	1011.4	INDIA	229.4
PERU	984.9	BURUNDI	226.7
NICARAGUA	900.0	TANZANIA	218.8
ST. KITTS	869.6	MALAWI	201.5
DJIBOUTI	849.6	CAPE VERDE	200.0
THAILAND	821.7	ZAIRE	183.2
ST. VINCENT/GREN	813.7	BURMA	174.4
CAMEROON	752.1	NEPAL	138.9
PAPUA NEW GUINEA	737.5	ETHIOPIA	104.4
EL SALVADOR	711.5	CHAD	66.7
NIGERIA	689.9	SAMOA, WESTERN	*
PHILIPPINES	664.9	TAIWAN	*
HONDURAS	643.9	BHUTAN	*
MOROCCO	639.4	VIETNAM	*
EGYPT	617.7	VANUATU	*

* Information not available

Exhibit C.5:
SUMMARY OR RATIOS USED IN EXHIBIT 2.6

SAUDI ARABIA	27.1	GUATEMALA	1.2
JORDAN	19.9	HONDURAS	0.7
YEMEN, NORTH	18.2	CHILE	-0.3
BURUNDI	15.7	MADAGASCAR	-1.0
BURMA	14.1	GREECE	-1.4
INDONESIA	12.3	ARGENTINA	-2.0
EGYPT	12.0	NICARAGUA	-2.7
MALAYSIA	11.9	PERU	-2.7
CAMEROON	10.6	COSTA RICA	-3.4
TUNISIA	9.5	UGANDA	-5.2
KOREA, SOUTH	9.1	EL SALVADOR	-5.7
HAITI	8.4	SOMALIA	-8.2
PHILIPPINES	7.3	BOLIVIA	-11.4
ALGERIA	7.2	ST. LUCIA	*
CHINA	6.6	TAIWAN	*
THAILAND	6.2	VIETNAM	*
COLOMBIA	6.0	CAPE VERDE	*
SUDAN	5.6	MOZAMBIQUE	*
YUGOSLAVIA	5.2	GRENADA	*
ZAIRE	4.9	SOLOMON ISLANDS	*
MEXICO	4.5	YEMEN, SOUTH	*
TANZANIA	4.4	VANUATU	*
INDIA	4.2	ST. KITTS	*
PAPUA NEW GUINEA	4.2	MALAWI	*
NIGERIA	3.5	ST. VINCENT/GREN	*
KENYA	3.4	DOMINICA	*
ECUADOR	3.2	BHUTAN	*
ETHIOPIA	2.6	PANAMA	*
DOMINICAN REP.	2.5	RWANDA	*
VENEZUELA	2.5	FIJI	*
BRAZIL	2.5	SAMOA, WESTERN	*
MOROCCO	2.4	NEPAL	*
TURKEY	2.3	DJIBOUTI	*
ZIMBABWE	1.9	CHAD	*

*Information not available

Exhibit C.6:
INVESTMENT CLIMATE POTENTIAL
(Average Annual Investment Growth 1973-83)

SOMALIA	1	UGANDA	0.812
YEMEN, NORTH	1	KOREA, SOUTH	0.760
CAPE VERDE	1	GREECE	0.674
ST. LUCIA	1	TURKEY	0.618
DJIBOUTI	1	BRAZIL	0.592
GRENADA	1	ZIMBABWE	0.565
SOLOMON ISL.	1	GUATEMALA	0.491
JORDAN	1	CHILE	0.472
ST. KITTS	1	YUGOSLAVIA	0.363
CHAD	1	MOZAMBIQUE	0.343
FIJI	0.987	BURMA	0.097
SUDAN	0.966	COLOMBIA	0.037
DOMINICAN REP	0.963	INDIA	-0.016
PAPUA NEW GUINEA	0.955	ARGENTINA	-0.074
MADAGASCAR	0.954	ZAIRE	-0.091
PANAMA	0.946	PERU	-0.126
ST. VINCENT/G	0.944	CHINA	-0.130
BURUNDI	0.940	BOLIVIA	-0.741
ETHIOPIA	0.939	CAMEROON	-0.744
DOMINICA	0.938	MALAYSIA	-0.927
TANZANIA	0.935	MEXICO	-0.930
NICARAGUA	0.930	EGYPT	-0.936
HAITI	0.917	TUNISIA	-1.131
NEPAL	0.910	ECUADOR	-1.503
KENYA	0.904	VENEZUELA	-1.801
HONDURAS	0.903	INDONESIA	-2.317
EL SALVADOR	0.867	NIGERIA	-4.439
MALAWI	0.866	ALGERIA	-4.774
RWANDA	0.853	SAUDI ARABIA	-6.968
PHILIPPINES	0.847	TAIWAN	*
MOROCCO	0.843	VIETNAM	*
COSTA RICA	0.832	YEMEN, SOUTH	*
THAILAND	0.815	VANUATU	*
		BHUTAN	*
		SAMOA, WESTERN	*

*Information not available

Exhibit C.7:
DEGREE OF ENERGY IMPORTS DEPENDENCE

NEPAL	73.29	BRAZIL	2.51
SAUDI ARABIA	40.98	MALAWI	2.34
PAPUA NEW GUINEA	34.18	ARGENTINA	2.19
ZIMBABWE	19.29	GREECE	1.97
ALGERIA	18.48	EGYPT	1.90
CHILE	17.71	THAILAND	1.72
NIGERIA	15.66	PANAMA	1.69
MOZAMBIQUE	15.29	EL SALVADOR	1.06
BURUNDI	12.88	DOMINICAN REP.	0.81
ETHIOPIA	11.60	MOROCCO	0.70
TANZANIA	11.37	PHILIPPINES	0.65
ZAIRE	10.39	HAITI	0.43
BOLIVIA	10.35	BURMA	0.35
MALAYSIA	10.19	KOREA, SOUTH	0.16
COLOMBIA	8.07	SOMALIA	0.10
CAMEROON	7.84	MADAGASCAR	0.00
VENEZUELA	7.30	ST. VINCENT/GREN	0.00
ECUADOR	6.93	CAPE VERDE	0.00
CHINA	6.87	FIJI	0.00
TUNISIA	6.38	JORDAN	0.00
INDONESIA	6.25	DOMINICA	0.00
INDIA	6.17	ST. KITTS	0.00
PERU	5.67	DJIBOUTI	0.00
MEXICO	5.38	CHAD	0.00
COSTA RICA	5.17	ST. LUCIA	0.00
RWANDA	4.77	GRENADA	0.00
YUGOSLAVIA	4.69	SOLOMON ISLANDS	0.00
NICARAGUA	4.65	VIETNAM	*
GUATEMALA	4.63	YEMEN, SOUTH	*
SUDAN	3.37	VANUATU	*
UGANDA	3.16	SAMOA, WESTERN	*
TURKEY	3.10	TAIWAN	*
KENYA	2.97	BHUTAN	*
YEMEN, NORTH	2.85		
HONDURAS	2.69		

*Information not available

Exhibit C.8:
NEW ENERGY RESERVES AVAILABILITY
(Ratio of Reserves/Consumptions)

VENEZUELA	180%	TUNISIA	21%
BOLIVIA	120%	EGYPT	17%
CHILE	95%	PANAMA	15%
CHINA	92%	HONDURAS	15%
SAUDI ARABIA	72%	YUGOSLAVIA	14%
COLOMBIA	71%	CAMEROON	14%
PERU	71%	DOMINICAN REPUBLIC	13%
BURMA	69%	PHILIPPINES	11%
ARGENTINA	61%	MOROCCO	10%
INDIA	61%	KOREA, SOUTH	9%
MEXICO	58%	MALAWI	9%
ECUADOR	55%	NIGERIA	7%
PAPUA NEW GUINEA	44%	MADAGASCAR	7%
NEPAL	41%	SOMALIA	4%
RWANDA	40%	HAITI	3%
ALGERIA	39%	TANZANIA	2%
EL SALVADOR	39%	SUDAN	1%
JORDAN	39%	CAPE VERDE	*
GUATEMALA	36%	BURUNDI	*
MALAYSIA	35%	MOZAMBIQUE	*
COSTA RICA	35%	SAMOA, WESTERN	*
KENYA	32%	UGANDA	*
TURKEY	32%	VANUATU	*
INDONESIA	30%	TAIWAN	*
YEMEN, SOUTH	29%	VIETNAM	*
CHAD	29%	ST. KITTS	*
ZAIRE	28%	DJIBOUTI	*
BRAZIL	27%	BHUTAN	*
GREECE	25%	ST. LUCIA	*
THAILAND	25%	DOMINICA	*
YEMEN, NORTH	24%	ST. VINCENT/G	*
ETHIOPIA	24%	SOLOMON ISL.	*
NICARAGUA	21%	GRENADA	*
ZIMBABWE	21%	FIJI	*

*Information not available

Exhibit C.9:
INTERNATIONAL RESERVES AVAILABILITY

COSTA RICA	50.6	THAILAND	11.3
MOROCCO	38.2	SUDAN	11.2
MEXICO	35.9	PAPUA NEW GUINEA	11.2
BURMA	33.8	INDIA	10.3
ALGERIA	33.1	YUGOSLAVIA	7.6
ECUADOR	32.5	PANAMA	6.8
ZIMBABWE	31.6	EL SALVADOR	6.4
BOLIVIA	30.5	MALAYSIA	5.9
TURKEY	28.9	HAITI	5.0
BRAZIL	28.7	NEPAL	3.0
EGYPT	27.5	RWANDA	2.6
YEMEN, SOUTH	25.1	CHAD	0.6
ARGENTINA	24.0	SAMOA, WESTERN	*
DOMINICAN REPUBLIC	22.7	ST. LUCIA	*
TUNISIA	22.3	MOZAMBIQUE	*
COLOMBIA	21.3	ST. VINCENT/G	*
KENYA	20.6	BURUNDI	*
MALAWI	20.3	MADAGASCAR	*
PERU	19.6	GRENADA	*
NIGERIA	18.6	SAUDI ARABIA	*
CHILE	18.3	DOMINICA	*
NICARAGUA	18.3	SOLOMON ISL.	*
GREECE	18.3	VIETNAM	*
PHILIPPINES	15.4	ST. KITTS	*
VENEZUELA	15.0	CHINA	*
HONDURAS	14.9	VANUATU	*
CAMEROON	13.9	DJIBOUTI	*
YEMEN, NORTH	13.9	TAIWAN	*
SOMALIA	13.1	CAPE VERDE	*
INDONESIA	12.8	TANZANIA	*
KOREA, SOUTH	12.3	ZAIRE	*
GUATEMALA	11.7	BHUTAN	*
ETHIOPIA	11.5	FIJI	*
JORDAN	11.3	UGANDA	*

*Information not available

Exhibit C.10:
DEBT SERVICE ABILITY

U.S. Department of State

- Background Notes, series published periodically on selected countries and geographic entities.

U.S. Department of Commerce

- Investment Climate Statement, embassy-prepared background information of interest to potential investors.
- Foreign Economic Trends, available for selected countries.
- Overseas Business Reports, information on marketing in selected countries.

Private Publications

- International Business, published by Ernst and Whinney Services.
- Businessman's Guide to [country name], series published by Price Waterhouse and Co.
- Information Guide for Doing Business in [country name], series published by Price Waterhouse and Co.
- Tax and Trade Guide, published by Arthur Anderson.

Exhibit C.11:
SUGGESTED SOURCES OF INFORMATION FOR DETAILED MARKET STUDIES AND RISK ASSESSMENTS

REFERENCES

The following references were used in compiling the statistics in Exhibits C.1 to C.10.

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Appendix D

Key Contacts in Lending and Funding Institutions

African Development Bank

African Development Bank
P.O. Box 1387
Abidjan, Ivory Coast

Agency for International Development

- Bureau for Science and Technology

Dr. Alan Jacobs
Director, Office of Energy
Bureau for Science & Technology
Room 508, SA-18
Agency for International Development
Washington, DC 20523
(703) 235-8902

Investment

Sean P. Walsh
Director, Office of Investment
Bureau of Private Enterprise
Room 633, SA-14
Agency for International Development
Washington, DC 20523
(703) 235-1822

Grants

Carolyn Weiskirch
Director, Office of Policy and Program Review
Bureau for Private Enterprise
Agency for International Development
Washington, DC 20523
(202) 647-2185

- Bureau for Program and Policy Coordination

Anson Bertrand
Director, Office of Agriculture
Bureau for Science and Technology
Room 409, SA-18
Agency for International Development
Washington, DC 20523
(703) 235-8952

Dr. Worth Fitzgerald
Senior Water Management Specialist
Office of Agriculture
Bureau of Science and Technology
Room 409, SA-18
Agency for International Development
Washington, DC 20523
(703) 235-1275

Kenneth Bart
Director, Office of Health
Bureau for Science & Technology
Room 709, SA-18
Agency for International Development
Washington, DC 20523
(703) 235-8926

Pat Koshel
Bureau for Program & Policy Coordination
Room 3892, NS
Agency for International Development
Washington, DC 20523
(202) 647-8928

- Bureau for External Affairs

Kitty Valtos
Public Inquiries
Bureau for External Affairs
Agency for International Development
Washington, DC 20523
(703) 647-1850

Agency for International Development (cont.)

- Bureau for Africa

Weston Fisher
Energy Advisor for West and Central Africa
Room 2480 NS
Bureau for Africa
Agency for International Development
Washington, DC 20523
(202) 647-8502

Jack VanDerflut
Chief, Health & Nutrition Division
Bureau for Africa
Room 2492 NS
Agency for International Development
Washington, DC 20523
(202) 647-8128

Marcus Winter
Chief, Agriculture & Rural Development Division
Bureau for Africa
Room 2941 NS
Agency for International Development
Washington, DC 20523
(202) 647-3650

- Bureau for Asia

Robert Ichord
Chief, Energy, Forestry & Environmental Division
Bureau for Asia
Room 3311 NS
Agency for International Development
Washington, DC 20523
(202) 647-8279

Charles Antholt
Chief, Agriculture & Rural Development Division
Bureau for Asia and Near East
Room 3327A NS
Agency for International Development
Washington, DC 20523
(202) 647-2467

Charles N. Johnson
Chief, Population, Health and Nutrition Division
Bureau for Asia and Near East
Room 227E SA-6
Agency for International Development
Washington, DC 20523
(703) 234-2205

For more information contact:

Bureau for Asia
Agency for International Development
Washington, DC 20523
For Thailand: Bill Nance, (202) 632-9086
For Indonesia: Henry Miles (202) 632-9842

- Bureau for Latin America/Caribbean

Paul White
Chief, Education, Technology & Science Division
Bureau for Latin America and the Caribbean
Room 2239 NS
Agency for International Development
Washington, DC 20523
(202) 632-7921

Agency for International Development (cont.)

- Bureau for Latin America/Caribbean (cont.)

Linda Morse
Chief, Health & Nutrition Division
Bureau for Latin America and the Caribbean
Room 2247 A
Agency for International Development
Washington, DC 20523
(202) 632-8605

Albert Brown
Chief, Rural Development Division
Bureau for Latin America and the Caribbean
Room 2242 NS
Agency for International Development
Washington, DC 20523
(202) 632-8126

- Bureau for the Near East

Robert Ichord
Chief, Energy, Forestry & Environmental Division
Asia and the Near East
3311 NS
Agency for International Development
Washington, DC 20523
(202) 647-8279

- Energy Budget

Bob Hudec
Chief, Office of Program Information Analyst
Room 3840 NS
Agency for International Development
Washington, DC 20523
(202) 632-9563

- Joint Agriculture Consultative Corporation

James E. Thornton
President
Joint Agriculture Consultative Corporation
1350 New York Avenue, N.W., Suite 200
Washington, DC 20005
(202) 737-0930

- Eastern Caribbean Project Opportunities

Robert Justis
Investor Service Program
Coopers & Lybrand
1800 M Street, NW
Washington, DC 20036
(202) 822-4393

- Caribbean Project Assistance

Hugh Henry May
Manager
Room 136
1818 H Street, NW
Caribbean Project Development Facility
Washington, DC 20433
(202) 676-0482

Asian Development Bank

- General

Asian Development Bank
P.O. Box 789
2330 Roxas Boulevard
Metro Manila 2800, Philippines
Telephone: (63-2) 711-3851
Telex: 23103 ADB PH

- Publications

Operational Information on Proposed Projects
Information Office
Asian Development Bank
P.O. Box 789
Metro Manila 2800, Philippines

Caribbean Development Bank

Mr. William G. Demas
President
Caribbean Development Bank
P.O. Box 408
Wildey, St. Michael
Barbados, West Indies

Department of Agriculture

- Office of International Cooperation & Development

OICD Information Staff
Room 4101 Auditor's Building 4101
U.S. Department of Agriculture
14th St. and Independence Ave., SW
Washington, DC 20250
(202) 475-4071; 382-8401

Beri Milburn
Agribusiness Specialist
OICD/Pricate Sector Regulations
Room 3110 Auditor's Building
U.S. Department of Agriculture
Washington, DC 20250
(202) 447-4515

- Agricultural Research Service (ARS)

Dr. Marvin Jensen
USDA Agricultural Research Service
2625 Redwing Road, Suite 130
Ft. Collings, CO 80526
(303) 226-9425

- Agricultural Research Service (ARS)

Mr. Ralph Nave
National Program Leader
USDA Agricultural Research Service
Room 217, Building 005
BARC - West
Beltsville, MD 20705
(301) 344-3059

- Economic Research Service (ERS)

Information Division
Room 1770-S
U.S. Department of Agriculture
Washington, DC 20250
(202) 447-7305

- Soil Conservation Service

Mr. Doug Sellars
Energy Coordinator
Soil Conservation Service
Room 6014 South
U.S. Department of Agriculture
Washington, DC 20013
(202) 382-1861

Department of Agriculture (cont.)

- Energy Extension Service (EES)

Ms. Glenda Pifer
National Energy & Environment Program Leader
Energy Program Leader
USDA Extension Service
Room 3443-S
U.S. Department of Agriculture
Washington, DC 20250
(202) 447-3387

- National Land Grant Colleges

Mr. Gordon Sloggett
Agricultural Economics Department
Oklahoma State University
Stillwater, OK 74078
(405) 624-6161

- Foreign Agricultural Service (FAS)

Information Services Staff
Foreign Agricultural Service
South Building, Room 5918
U.S. Department of Agriculture
Washington, DC 20250

- Foreign Agricultural Service (FAS)

Assistant Administrator for Foreign Agricultural Affairs
Foreign Agricultural Service
Room 5092
U.S. Department of Agriculture
Washington, DC 20250
(202) 447-6138

U.S. Department of Commerce

- Commodity Reports

Allen J. Lenz
Director
Office of Trade & Investment Analysis
International Trade Administration
U.S. Department of Commerce
Room 2217
Washington, DC 20230
(202) 377-2456

- Office of International Major Projects

Leo Engleson
Office of International Major Projects
International Trade Administration
Room 1004
U.S. Department of Energy
Washington, DC 20230
(202) 377-4332

- Foreign Industry Sector

Les Garden
Renewable Energy Specialist
Office of International Major Projects
International Trade Administration
Room 2811
U.S. Department of Commerce
Washington, DC 20230
(202) 377-0556

- International Business Practice

Friedrich R. Crupe
Director, Office of Service Industries
International Trade Administration
Room 2800A
U.S. Department of Commerce
Washington, DC 20230
(202) 377-3575

U.S. Department of Commerce (cont.)

- International Economic-Policy

Joseph Dennin
Assistant Secretary for International Economic Policy
International Trade Administration
Room 3864
U.S. Department of Commerce
Washington, DC 20230
(202) 377-3022

- Office of Trade Information Service

Saul Padwo
Director
Office of Trade Information Services
International Trade Administration
Room 1332
U.S. Department of Commerce
Washington, DC 20230
(202) 377-1468

- Event Management and Support Service

Office of Event Management and Support Services
International Trade Administration
Room 2806
U.S. Department of Commerce
Washington, DC 20230
(202) 377-4231

- Export Development

Barbara Brown
Far East and Latin America
USFCS
U.S. Department of Commerce
Washington, DC 20230
(202) 377-3741

- Trade Administration

John F. Boidock
Director, Office of Export Administration
International Trade Administration
Room 3897
U.S. Department of Commerce
Washington, DC 20240
(202) 377-4188

- Minority Business Development Centers

Regional Offices:

Atlanta, GA (404) 881-4091
Chicago, IL (312) 353-0182
San Francisco, CA (415) 556-7234
Dallas, TX (214) 767-8001
New York, NY (212) 264-3262
Washington, DC (202) 377-8275 or 8267

or contact:

Minority Business Development Agency
U.S. Department of Commerce
Washington, DC 20230
(202) 377-1936

- DOC Marketing Periodicals

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
(202) 783-3238

U.S. Department of Commerce (cont.)

Trade Opportunities Program
Office of Trade Information Services
International Trade Administration
Room 1324
U.S. Department of Commerce
Washington, DC 20230
(202) 377-2988

U.S. Department of Energy

Marci Schweda
Technical Information Branch
1617 Cole Boulevard
Solar Energy Research Institute
Golden, CO 80401
(303) 231-1158

Kenneth G. Moore
Director of the Research, Technology & Integration Staff
Office of Conservation & Renewable Energy
Mailstop 6B-070
1000 Independence Avenue, SW
U.S. Department of Energy
Washington, DC 20585
(202) 252-9275

Department of the Interior

Frank Solomon
Director of Technical Assistance
Office of Territorial and International Affairs
Interior Department
18th & C Streets, NW
Washington, DC 20240
(202) 343-4707

American Samoa - Mr. Fred Radewagon
Federal States of Micronesia - Mr. Epel Ilon
Guam - Ms. Bernice Carbullido
Marshall Islands - Office for Micronesian Status Negotiations
Palau Mr. Noriwo Ubedei
Virgin Islands - Dr. Carlyle Corbin

Department of Labor

Robert W. Searby
Deputy Undersecretary for International Affairs
Bureau of Ocean and International Labor Affairs
U.S. Department of Labor
200 Constitution Avenue, N.W.
Washington, DC 20520
(202) 523-6243/6043

Export Import Bank

James W. Crist
Vice President, Exporter Credits and Guarantees
Export Import Bank
811 Vermont Avenue, NW
Washington, DC 20571
(202) 566-8819

James R. Sharpe
Senior Vice President, Office of Direct Credits and Financial Guarantees
Export Import Bank
811 Vermont Avenue, NW
Washington, DC 20571
(202) 566-8819

John Wisniewski
Vice President for Engineering, Office of Exporter Credits, Guarantees and Insurance Program
Export Import Bank
811 Vermont Avenue, NW
Washington, DC 20571
(202) 566-8802

Export Import Bank (cont.)

Joseph R. Williams
Vice President, Exporter Insurance
811 Vermont Avenue, NW
Washington, DC 20571
(202) 566-8955

Federal Communications Commission

Janice Obuchowski
Legal Assistance to the Chairman
1919 M Street, NW, Room 814
Federal Communications Commission
Washington, DC 20554
(202) 632-6600

Geothermal Resources Council

David N. Anderson
111 Q Street, Suite 29
P.O. Box 1350
Davis, CA 95617-1350
(916) 758-2360

Inter-American Development Bank

Mr. Gustavo Calderon
Chief
Non-Conventional Energy Section
Inter-American Development Bank
808 17th Street, NW
Washington, C.C. 20577
(202) 623-1978

Mr. Calvin DePass
Macroeconomist
Division of Country Studies
Inter-American Development Bank
808 17th Street, NW
Washington, DC 20577
(202) 623-2441

International Trade Commission

Office of Publications
701 E Street, NW
International Trade Commission
Washington, DC 20436
(202) 523-5178

Office of the U.S. Trade Representative

Mr. Fred Ryan
Director, Private Sector Liaison Division
600 17th Street, NW
Office of the U.S. Trade Representative
Washington, DC 10506
(202) 456-7140

Overseas Private Investment Corporation

- General

Leigh P. Hollywood
Managing Director, International Division
Insurance Department
1615 M Street, NW
Overseas Private Investment Corporation
Washington, DC 20527
(202) 457-7047

- Energy Program

R. Douglas Greco
Manager, Natural Resources
1615 M Street, NW
Overseas Private Investment Corporation
Washington, DC 20527
(202) 457-7044

Overseas Private Investment Corporation (cont.)

- Contractors and Exporters/Leasing

Ruth Good
Manager, Financial Services and Product Development
1615 M Street, NW
Overseas Private Investment Corporation
Washington, DC 20527
(202) 457-7067

- Investment Mission

Grace Shemin
Mission Manager
1615 M Street, NW
Overseas Private Investment Corporation
Washington, DC 20527
(202) 457-7114

- Opportunity Bank

Burton Bostwick
Manager of the Opportunity Bank
1615 M Street, NW
Overseas Private Investment Corporation
Washington, DC 20527
(202) 457-7110

- Investment Programs

Jeffrey Shafer
Financial Analyst
1615 M Street, NW
Overseas Private Investment Corporation
Washington, DC 20527
(202) 457-7093

Peace Corps

Bill Gschwend
Caribbean Basin Initiative Coordinator
Inter-American Operations
806 Connecticut Avenue, NW
U.S. Peace Corps
Washington, DC 20526
(202) 254-9616

Small Business Association

Office of Public Communication
Central Office
U.S. Small Business Administration
1441 L Street, NW, Room 100
Washington, DC 20416
(202) 653-6365

Trade and Development Program

Trade and Development Program
Room 309
SA-16
Washington, DC 20523
(703) 235-3663

United Nations

- United Nations Development Program

Director, Office for Projects Execution
United Nations Development Programme
One United Nations Plaza
New York, NY 10017
(212) 906-6127

United Nations (cont.)

Chief, Division for Administrative and Management Services
United Nations Development Program
One United Nations Plaza
New York, NY 10017
(212) 906-5504

Mr. A. Bruce Harland
Director
UNDP Energy Office
One United Nations Plaza
New York, NY 10017
(212) 906-6090

Mr. Ram S. Ragde
UNDP Energy Office
One United Nations Plaza
New York, NY 10017
(212) 960-6070

- United Nations Department of Technical Cooperation for Development

Mr. Edmund K. Leo
Chief
Energy Resources Branch
Department of Technical Cooperation for Development
One United Nations Plaza
New York, NY 10017
(212) 754-8773

Mr. Suresh Hurry
Energy Resources Branch
Department of Technical Cooperation for Development
One United Nations Plaza
New York NY 10017
(212) 754-8594

Mr. Joseph V. Acakpo-Satchivi
Secretary
Committee on the Development and Utilization of New and Renewable Sources of Energy
Room S-2977D
United Nations
New York, NY 10017
(212) 754-5737

- Publications

Development Business
P.O. Box 5850
Grand Central Station
New York, NY 10163-5850
(212) 754-4460

Energy Branch
Department of Technical Cooperation for Development
One United Nations Plaza
New York, NY 10017

World Bank

- General

Mr. Richard S. Dosik
New Energy Sources Advisor
Energy Department
The World Bank
D 430
1809 G Street, NW
Washington, DC 20433
(202) 477-6894

World Bank (cont.)

Mr. G. Edward Schuh
Director
Agriculture and Rural Development Department
The World Bank
N 1136
801 19th Street, NW
Washington, DC 20433
(202) 676-1755

Mr. Ping-Cheung Loh
Director
Water Supply and Urban Development Department
The World Bank
N 736
801 19th Street, NW
Washington, DC 20433
(202) 676-9484

Mr. John D. North
Director
Population, Health, and Nutrition Department
The World Bank
N 437
801 19th Street, NW
Washington, DC 20433
(202) 676-1571

- Regional Offices

Mr. Bilsel Alisbah
Director
Projects Department
Western Africa Regional Office
The World Bank
B 404
1800 H Street, NW
Washington, DC 20433
(202) 477-6388

Mr. Hans Wyss
Director
Project Department
Eastern and Southern Africa Regional Office
The World Bank
A 1042
1818 H Street, NW
Washington, DC 20433
(202) 477-2668

Mr. Suitbertus M.L. van der Meer
Director
Projects Department
East Asia and Pacific Regional Office
The World Bank
A 607
1818 H Street, NW
Washington, DC 20433
(202) 477-4258

Mr. Enrique Lerdau
Director
Projects Department
South Asia Regional Office
The World Bank
H 4049
600 19th Street, NW
Washington, DC 20433
(202) 477-2776

Mr. Visvanathan Rajagopalan
Director
Projects Department
Europe, Middle East, and North Africa Regional Office
The World Bank
H 10-067
600 19th Street, NW
Washington, DC 20433
(202) 477-2707

World Bank (cont.)

Mr. Robert Picciotto
Director
Projects Department
Latin American and the Caribbean Regional Office
The World Bank
A 813
1818 H Street, NW
Washington, DC 20433
(202) 477-5906

- Publications

Development Business
P.O. Box 5850
Grand Central Station
New York, NY 10163-5850
(212) 754-4460

Public Affairs Office
The World Bank
1818 H Street, NW
Washington, DC
(202) 477-1234