

**PRELIMINARY REPORT:**  
**GEOTHERMAL ENERGY,**  
**THE POTENTIAL FOR CLEAN POWER FROM THE EARTH**

**Karl Gawell**

**Dr. Marshall Reed**

**Dr. P. Michael Wright**

April 7, 1999

*Geothermal Energy Association*  
*209 Pennsylvania Avenue, SE*  
*Washington, DC 20003 U.S.A.*  
*Telephone: (202) 454-5261*  
*Fax: (202) 454-5265*  
[www.geo-energy.org](http://www.geo-energy.org)

## Introduction

This collaborative effort produced country-by-country estimates of the potential for geothermal energy Resources to meet electricity demand. Coordinated by Karl Gawell of the U.S. Geothermal Energy Association, Dr. Marshall Reed of the U.S. Department of Energy and Dr. P. Michael Wright of the Energy and Geosciences Institute at the University of Utah, this assessment involved significant contributions from eighteen leading experts in industry, government agencies, and the national laboratories.

## Summary of the Results

The report shows that geothermal Resources using today's technology have the potential to support between 35,448 and 72,392 MW of electrical generation capacity. Using enhanced technology currently under development (permeability enhancement, drilling improvements), the geothermal Resources could support between 65,576 and 138,131 MW of electrical generation capacity. Assuming a 90% availability factor, which is well within the range experienced by geothermal power plants, this electric capacity could produce as much as 1,089 Billion kWh of electricity annually.

The geothermal potential identified by this analysis represents about 8.3% of total world electricity production, using EIA's 1996 data. The potential varies significantly by region. Central America, South America and Africa having the potential to meet a large proportion of their electricity needs through utilizing geothermal Resources. More than half of the current electricity needs of Central and South America (including the Caribbean) could be met by geothermal power. Africa demonstrated the next largest regional opportunity, with 28% of the continents current electricity use being potentially met by geothermal energy.

Estimates for North America indicate a potential for geothermal power between 6,340 MW and 11,700 MW with today's technology, and between 15,080 MW and 25,390 MW using enhanced

technology. These Resources are in both the U.S. and Mexico, with the United States having a significant majority of the geothermal potential identified for North America.

Worldwide, the report indicates that geothermal power could serve the electricity needs of 865 million people, or about 17% of the world's population. Thirty-nine countries are identified which could be 100% geothermal powered, mostly in Africa, Central and South America and the Pacific. These 39 countries have a total population of 620,637,000 (using 1998 UN population data).

The report assesses the potential electrical production from the hydrothermal Resources as it is known today. In light of significant worldwide exploration and development over the past decade, the results represent a refinement over previous estimates. However, these figures do not define the limits of the produceable Resources. Hydrothermal Resources can be difficult to identify without more extensive investigation than has typically been conducted in most countries, and new and improved technology is expected to continually expand the economically produceable Resources.

In addition, significant low temperature Resources have been identified in countries throughout the world which are suitable for direct use applications. Direct use applications, such as heating of homes and greenhouses, which are currently estimated to provide as much energy as geothermal electricity production, are not assessed by this analysis.\* Neither is the potential contribution from geothermal heat pumps included in this analysis.

#### Conduct of the Analysis

The report is based upon the results of a detailed survey conducted in January and February of 1999. The coordinators mailed the survey to individuals identified as having extensive experience with geothermal Resources. The survey sought the assistance of these experts in defining the geothermal Resources on a country-by-country basis. The Resources was defined as the hydrothermal Resources that could reasonably be expected to be developed with today's technology or enhanced technology. Enhanced technology was defined as including development of drilling improvements, techniques to augment permeability, and related advances envisioned in *the Strategic Plan for the Geothermal Energy Program* released by the U.S. Department of Energy in 1998. The questionnaire asked respondents to exclude consideration of project economics, or the timing of potential development.

The respondents were asked to assign a weight to each of their country responses. Persons having visited a country frequently and examined many geothermal sites would weight their estimate as a five (5), while persons using their expertise to estimate a potential based only on geologic maps and similar information for a specific country were instructed to weight their estimate as a one (1). The final geothermal potential figures used in this report employ these weighted averages, thus giving significant emphasis to estimates from people with extensive, direct experience in the countries. While past estimates for some of the countries included here may be higher, these results are intended to have a higher degree of confidence given the large base of contributors, their extensive experience, and the weighting factors employed.

Individuals providing significant information to the report are listed as contributors. They were asked to participate as individuals, and their estimates do not necessarily represent the views of their company or institution. Participation as a contributor does not necessarily indicate approval

of the results of this study by any individual or organization listed. A few contributors asked to remain anonymous, and the coordinators have respected their request.

Karl Gawell

Marshall Reed

P. Michael Wright

April 7, 1999

\*See, "Direct Use of Geothermal Energy Around the World," Ingvar B.

Fridleifsson, President, International Geothermal Association.

## GEOTHERMAL POTENTIAL BY WORLD REGIONS

(all countries)

EIA Region	Geothermal Potential (Billion kWh)	Current Electricity Use (Billion kWh)	% geothermal
North America	200	4,333	4.6%
Central & S. America	224	623	36.0%
w/Caribbean	354	669	52.9%
Europe/Former USSR	97	4155	2.3%
Asia and Pacific	337	3304	10%
Africa	101	357	28%
<b>WORLD TOTAL</b>	<b>1089</b>	<b>13,142</b>	<b>8.3%</b>

**COUNTRIES WHICH COULD BE 100% GEOTHERMAL POWERED (39)**

<b>COUNTRY</b>	<b>POPULATION</b>
Bolivia	7,957,000
Burundi	6,457,000
Comoros Islands	658,000
Costa Rica	3,841,000
Djibouti	623,000
Dominica	71,000
Ecuador	12,175,000
El Salvador	6,032,000
Ethiopia	59,649,000
Fiji	796,000
Grenada	93,000
Guadeloupe	443,000
Guatemala	10.801,000
Honduras	6,147,000
Iceland	276,000
Indonesia	206,338,000
Kenya	29,008,000
Malagasy Republic	15,057,000
Malawi	10.346,000
Martinique	389,000

Montserrat	11,000
Mozambique	18,880,000
Nicaragua	4,807,000
Panama	2,767,000
Papua New Guinea	4,600,000
Peru	24,797,000
Philippines	72,944,000
Rwanda	6,604,000
Solomon Islands	417,000
Somalia	9,237,000
St Kitts & Nevis	39,000
St. Lucia	150,000
St. Vincent	112,000
Sudan	28,292,000
Tanzania	32,102,000
Tonga	98,000
Uganda	20,554,000
Vanuatu	182,000
Yemen	16,887,000
<b>TOTAL</b>	<b>620,637,000</b>

## **FIFTY PERCENT GEOTHERMAL POWERED**

Burma

Chile

Congo

New Zealand

**TWENTY PERCENT GEOTHERMAL POWERED**

Argentina

Columbia

Macedonia

Mexico

Zambia

**TEN PERCENT GEOTHERMAL POWERED**

Australia

Dominican Republic

Greece

Hungary

Turkey

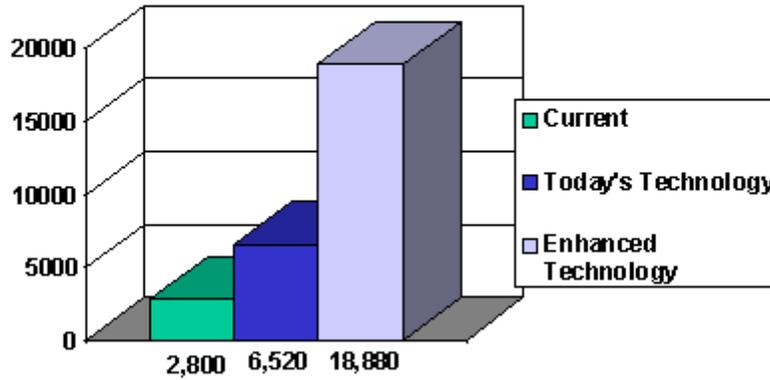
Venezuela

Vietnam

Zimbabwe

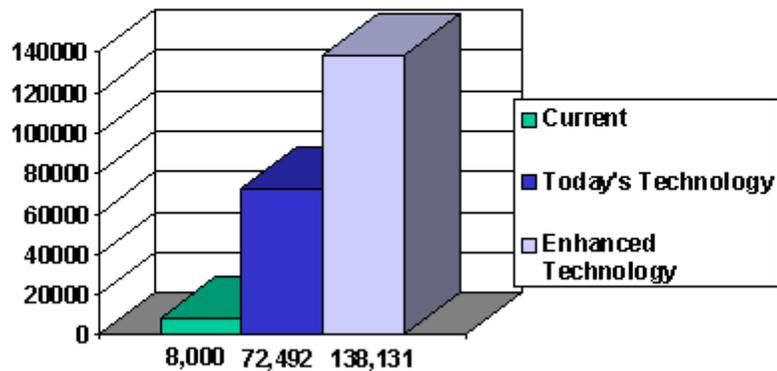
# U.S. Geothermal Potential

Megawatts of Electrical Capacity



# World Geothermal Potential

Megawatts of Electrical Capacity



***FOR A COMPLETE COPY OF THIS REPORT PLEASE WRITE TO:***

***Geothermal Energy Association  
209 Pennsylvania Avenue, SE  
Washington, DC 20003 U.S.A.  
Telephone: (202) 454-5261  
Fax: (202) 454-5265***