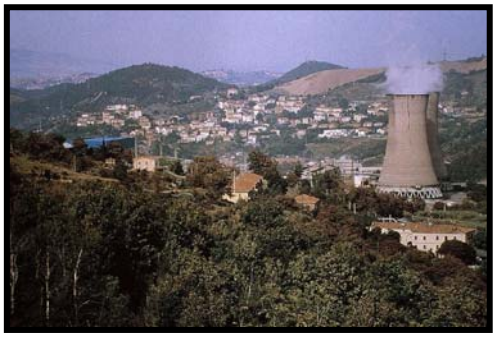

Geothermal Energy: International Market Update

Geothermal Energy Association

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May 2010

Photos on Cover: (from top to bottom) Flash geothermal power plant in Turkey, Soultz project in France, Olkaria II power plant in Kenya, Workers at Oserian Development Company in Kenya, Laderello power plant in Italy

INTRODUCTION AND SUMMARY

Reports examining the international status of geothermal development were published by the US Geothermal Energy Association (GEA) in 2007 and by the International Geothermal Association (IGA) in 2005 and 2010. This report builds on those documents to present a view of the world geothermal market, in particular to identify trends in the market, its underlying drivers, and the extent to which the potential of geothermal resources is being utilized for national and international clean energy purposes.

Both public and private sources were used to develop the information in this report. GEA reviewed available information from a wide range of sources, which are reflected in the extensive endnotes to the report. However, GEA did not independently confirm the information reported. In some instances the data available is incomplete, and in others fairly detailed information was available. Without initiating a major research project, GEA was not able to independently address the unevenness of the information available. However, wherever possible the authors sought to be as accurate as possible, and the authors believe that the final report represents a fair portrayal of the state of the world geothermal power market in May 2010.

Overview/Results

Both the number of countries producing geothermal power and the total worldwide geothermal power capacity under development appear to be increasing significantly.

In 2005, there were 8,933 MW of installed power capacity in 24 countries, generating 55,709 GWh per year of green power, according to the International Geothermal Association. IGA reports in 2010 that 10,715 MW is on line generating 67,246 GWh. This represents a 20% increase in geothermal power on line between 2005 and 2010. IGA projects this will grow to 18,500 MW by 2015, which based upon the large number of projects under consideration appears reasonable if not conservative.

According to Bertani/IGA, the countries with the greatest increase in installed capacity (MW) between 2005 and 2010 were: 1) US - 530 MW, 2) Indonesia - 400 MW, 3) Iceland - 373 MW, 4) New Zealand - 193 MW, and 5) Turkey 0 62 MW. In terms of the percentage increase the top five countries were 1) German - 2,774%, 2) Papua-New Guinea - 833%, 3) Australia - 633%, 4 Turkey - 308%, and 5) Iceland - 184%

While power on-line grew 20% between 2005 and 2010, countries with projects under development grew at a much faster pace. GEA reported in 2007 there were 46 countries considering geothermal power development. In 2010, this report identified 70 countries with projects under development or active consideration, a 52% increase since 2007.

Projects under development grew the most dramatically in two regions of the world, Europe and Africa. Ten countries in Europe were listed as having geothermal projects under development in 2007, and in 2010 this has more than doubled to 24. Six countries in Africa were identified in

2007, and in 2010 eleven are found to be actively considering geothermal power. It would appear that efforts such as ARGeo and the European Bank for Reconstruction and Development's geothermal initiatives are having considerable beneficial effect.

Despite these growth trends, however, the potential of geothermal resources to provide clean energy appears to be under-realized. In 1999, GEA prepared a report that examined geothermal power potential internationally. The results of this report show that in the vast majority of countries the estimated potential remains undeveloped and largely untapped, even assuming the lowest projections for geothermal resource potential. Moreover, the number of countries with geothermal power potential that are not developing their resources is still high. In fact, of the 39 countries identified in 1999 as having the potential to meet 100% of their electricity needs through domestic geothermal resources, significant power production had been developed in only nine -- Costa Rica, El Salvador, Guatemala, Iceland, Indonesia, Kenya, Nicaragua, Papua New Guinea, and the Philippines. However, this report identified projects under consideration in another 14 of these countries. (For a list of countries identified in the 1999 GEA report which could be 100% geothermal powered, see Appendix B.)

The underlying trend of the expansion of geothermal power is complemented by the development of projects in entirely new areas. It is interesting to note that there are 24 countries identified with geothermal power projects under development that were not included in the GEA 1999 study. Most of these countries are in Europe and are accessing resources due to new technology developments that allow development of lower temperature resources. In addition, EGS technologies, or enhanced geothermal systems, are being developed in a number of countries including Australia, France, Germany, the United Kingdom and the US.

The trends in both the number of new countries developing geothermal energy and the total of new megawatts of power capacity under development appear to continue a growth trend showing a clear reverse from slowdowns in international markets seen in the late 1990s. Buttressed by the development of low-temperature power and EGS technologies, the geothermal market appears to be expanding to encompass most of the world's nations.

This report finds that both national and international policy and financial support are key in achieving the potential of successful geothermal development.

Observations From the Report

- In 2010, global geothermal development is being driven in part by a number of regional institutions which, in addition to financing geothermal projects, are enhancing regional cooperation within an emerging renewable energy sector. Examples include the African Rift Geothermal Energy Development Facility (ARGeo), which underwrites drilling risks in six African nations and is backed by UNEP, and the World Bank and the geothermal initiatives of the European Bank for Reconstruction and Development supported by European Union climate policies.

- Geothermal development appears to be increasingly supported by a global financial market. A growing number of countries, including Australia, China, Germany, Iceland, Italy, Japan, and the US, are facilitating geothermal development projects around the world. Forms of support other than financing, including technology sharing, training, and geological surveys are also being endorsed by outside governments.
- The growth in geothermal projects under consideration or in development is in part attributable to international and multi-lateral support for development in new areas. The question going forward is whether that support will be sustained over time and adequate to address risks involved in geothermal project development. Geothermal resources are abundant in East Africa, for example, and support for resource assessment has helped spur interest in project development in several countries. But, new projects will have high associated costs and risk factors. Sustained support for development at this crucial stage will be essential to achieving expanded use of geothermal energy in this and other developing areas.
- Geothermal development appears to be trending beyond traditional hydrothermal reserves prevalent along the Ring of Fire. Lower temperature power systems and EGS technology are allowing a growing and diversified collection of countries to actively pursue geothermal development in areas previously assumed to have little exploitable resource. This is especially true among European countries, notably France, Germany, Latvia, and the United Kingdom, all of which are currently exploring and developing local resources by employing EGS. These developments are supported by government policies (such as feed-in tariffs), which make higher-risk and higher-cost projects more feasible. These policies are typically components of broader climate initiatives.
- District heating and direct use geothermal application appear to be progressively more commonplace in many countries and are being emphasized in a number of national renewable energy policies as effective measures for curbing greenhouse gas emissions.
- Around the world, villages and tribes are looking to geothermal as a way to utilize land and become energy independent. Warm Springs Indian Reservation in Oregon, the Northwestern Band of Shoshone Nation in Idaho, and the Jemez Pueblo in New Mexico have shown interest in developing geothermal energy. Additionally, the Pyramid Lake Paiute Tribe is actively developing its geothermal resources and was recently awarded funding from the US Department of Energy.[1] In New Zealand the Te Arawa iwi is examining the possibility on Maori land in Rotorua. In the Philippines, nine of 11 ancestral domain areas consented to the Kalinga geothermal exploration project. And a geothermal plant is expected to open in the small settlement of Innamincka, Australia, in early 2012.

Some Country Highlights

- Kenya hopes to be producing 490 MW of geothermal power by 2012 and as much as 4,000 MW within 20 years.

- Germany has over 150 geothermal power plant projects at some stage of development, and expects to have over 280 MW on line by 2020 according to the European Commission.
- Turkey has a goal to reach 550 MW of geothermal power on line by 2013.
- The Philippines now follows the US as the second highest producer of geothermal power in the world, with 1,904 MW. Energy from geothermal power makes up approximately 18% of the country's electricity generation.
- Geothermal power plants provide 26% of the electricity in El Salvador.
- Indonesia's National Energy Blueprint sets a goal of 9,500 MW of geothermal power production, an 800% increase.
- Iceland derives 25% of its electricity and 90% of its heating from geothermal resources.
- The US continues to lead the world in geothermal electricity production with approximately 3,086 MW of installed capacity from 77 power plants.

Countries Generating Geothermal Power in 2010

Country	Installed Capacity (MW)	Rank
United States	3,086	1
Philippines	1,904	2
Indonesia	1,197	3
Mexico	958	4
Italy	843	5
New Zealand	628	6
Iceland	575	7
Japan	536	8
El Salvador	204	9
Kenya	167	10
Costa Rica	166	11
Nicaragua	88	12
Russia	82	13
Turkey	82	14
Papua New Guinea	56	15
Guatemala	52	16
Portugal	29	17
China	24	18
France	16	19
Ethiopia	7.3	20
Germany	6.6	21
Austria	1.4	22
Australia	1.1	23
Thailand	0.3	24

Countries Projected to Install Initial Geothermal Capacity by 2015 (IGA)
Argentina, Canada, Chile, Greece, Honduras, Hungary, Nevis, Romania, Spain, Slovakia, The Netherlands

Additional Countries with Identified Projects Under Consideration (GEA)
Algeria, Armenia, Belarus, Bolivia, Comoros Islands, Croatia, Czech Republic, Dominica, Denmark, Djibouti, Fiji, Georgia, Guadeloupe, India, Iran, Ireland, Latvia, Madagascar, Montserrat, Nepal, Norway, Peru, Poland, Rwanda, Saba, Samoa, Serbia, South Africa, Switzerland, Tunisia, United Kingdom, Vanuatu, Yemen, Zambia

Summary Table

Country	Installed Capacity in 2010 (MW)	Projects Under Consideration Identified in 2007**	Projects Under Consideration in 2010?	IGA 2015 Capacity Estimate (MW)	GEA 1999 Resource Estimate (Low-High MW)	Supporting Policies Identified?
Algeria	0	No	Yes			No
Argentina	0	No	Yes	30	490-1010	Yes
Armenia	0	Yes	Yes			Yes
Australia	1.1	No	Yes	40	100-400	Yes
Austria	1.4	Yes	No	5		Yes
Belarus	0	No	Yes			Yes
Bolivia	0	No	Yes		510-1260	Yes
Canada	0	Yes	Yes	20		Yes
Chile	0	Yes	Yes	150	780-1630	Yes
China	24	Yes	Yes	60	830-1860	Yes
Comoros Islands	0	No	Yes		3-10	No
Costa Rica	166	Yes	Yes	200	970-1990	Yes
Croatia	0	No	Yes			Yes
Czech Republic	0	No	Yes			Yes
Denmark	0	No	Yes			Yes
Djibouti	0	Yes	Yes		230-460	No
Dominica	0	Yes	Yes		240-680	No
El Salvador	204	Yes	Yes	290	660-1450	Yes
Ethiopia	7.3	Yes	Yes	45	640-1710	No
Fiji	0	No	Yes		20-70	No
France	1.5**	No**	Yes	35		Yes
Georgia	0	No	Yes		*	No
Germany	6.6	Yes	Yes	15		Yes

Greece	0	Yes	Yes	30	160-450	Yes
Guadeloupe	15**	Yes	Yes		500-1500	No
Guatemala	52	Yes	Yes	120	1050-2260	Yes
Honduras	0	Yes	Yes	35	310-590	Yes
Hungary	0	No	Yes	5	220-380	Yes
Iceland	575	Yes	Yes	800	390-890	Yes
India	0	Yes	Yes		100-280	Yes
Indonesia	1,179	Yes	Yes	3,500	5600-9790	Yes
Iran	0	Yes	Yes			No
Ireland	0	No	Yes			No
Italy	843	Yes	Yes	920	500-1000	Yes
Japan	536	Yes	Yes	535	860-1460	Yes
Kenya	167	Yes	Yes	530	850-1810	Yes
Latvia	0	No	Yes			No
Madagascar	0	No	Yes			No
Mexico	958	Yes	Yes	1,140	2560-5180	Yes
Montserrat	0	No	Yes		280-130	No
Nepal		No	Yes			No
Nevis & St. Kitts	0	Yes	Yes	35	450-590	No
New Zealand	628	Yes	Yes	1,240	1000-2000	Yes
Nicaragua	88	Yes	Yes	240	1080-2270	Yes
Norway	0	No	Yes			No
Papua New Guinea	56	Yes	Yes	75	480-1610	No
Peru	0	No	Yes		600-1410	Yes
Philippines	1,904	Yes	Yes	2,500	3500-5730	Yes
Poland	0	No	Yes		50-110	Yes
Portugal	29	Yes	Yes	60		No
Romania	0	No	Yes	5	50-100	Yes
Russia	82	Yes	Yes	190	*	Yes
Rwanda	0	Yes	Yes		50-170	No
Saba	0	No	Yes		500-1000	No
Samoa	0	No	Yes			No
Serbia	0	No	Yes		*	No
Slovakia	0	Yes	Yes	5	50-100	Yes
South Africa	0	No	Yes			Yes
Spain (Canary	0	No	Yes	40		Yes

Islands)						
Switzerland	0	Yes	Yes			Yes
Taiwan	3.3	Yes	No		90-210	No
Thailand	0.3	Yes	No	1	40-120	Yes
The Netherlands	0	No	Yes	5		No
Tunisia	0	No	Yes			No
Turkey	82	Yes	Yes	200	360-740	Yes
United Kingdom	0	No	Yes			Yes
United States	3,087	Yes	Yes	5,400	3780-6520	Yes
Vanuatu	0	No	Yes		30-80	No
Yemen	0	Yes	Yes		50-100	No
Zambia	0	No	Yes		20-90	No

*Former USSR with total potential of 768-1902 and Yugoslavia with a potential of 50-100.
** The GEA 2007 report considered France and Guadeloupe as one entity. Also development interest identified in six countries is not identified in 2010 -- Korea, Solomon Islands, St Lucia, Tanzania, Uganda and Vietnam. Guadeloupe's 15 MW installed capacity is included in the 2010 IGA report as part of France's total installed capacity. Mainland France has 1.5 MW installed geothermal capacity in 2010.

AFRICA

With massive geothermal potential, Africa could see unprecedented growth in geothermal development in the coming decade due to regional support for geothermal power, international financial and development aid, and government commitment to securing reliable energy for growing populations. Geothermal energy is a key resource for African countries along the East African Rift Valley System, a volcanic region with an estimated 7,000 MW of electricity-generating potential.[2]

The African Rift Valley Geothermal Development Facility (ARGeo) is working to assist six member countries, Djibouti, Eritrea, Ethiopia, Kenya, Tanzania, and Uganda, "in accelerating the pace of geothermal resource development in the region." It is doing so primarily via a Risk Mitigation Facility (RMF) which would serve to mitigate risk associated with geothermal exploration and drilling. High upfront costs and associated risks involved in geothermal development have been daunting barriers to geothermal development worldwide. A regional mitigation strategy is expected open the door to private and public sector funding for power plant development. Geothermal energy is a prominent component of individual energy policies and poverty reduction strategies among countries in the African Rift region, but there has also been a push for "increased regional cooperation, knowledge sharing and mobilization of investment resources" through ARGeo. ARGeo is supposed to work closely with the various government agencies in the member countries, in addition to other national government agencies, institutions, universities, the private sector and power utilities. It currently has not enlisted the participation of the private sector. ARGeo is designed to be implemented by UNEP and the World Bank with financing coming from the Global Environment Facility (GEF) as well as participating countries.[3] Despite the U.S. government's early involvement in establishing the initiative, the US' lack of sustained support for and participation in ARGeo has been disappointing to some US companies.[4]

Germany is also heavily involved with geothermal development on the African continent, working with partner countries Eritrea, Ethiopia, Kenya, Rwanda, Tanzania, and Yemen through its GEOTHERM program. The program is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and carried out by the Federal Institute for Geosciences and Natural Resources (BGR) in cooperation with a number of national agencies. The second phase of the GEOTHERM program is in place from 2009-2013.[5]

Another regional development that will influence the geothermal realm is the Eastern African Power Pool (EAPP). Formed in 2005, it is comprised of utility firms from Burundi, Democratic Republic of the Congo, Egypt, Kenya, Ethiopia, Rwanda, and Sudan. EAPP was devised to secure reliable power supply for member countries and to optimize regional energy resources. Within four years, seven Eastern African countries are expected to jointly produce power and connect their supplies. In order to accomplish this, high voltage transmission lines are being constructed between countries; Ethiopia-Djibouti lines are expected to be finished by June of this year.[6] Uganda-Kenya lines should be completed by 2012, and Ethiopia-Kenya and Kenya-Tanzania lines are expected to be operational by 2015.[7]

Algeria

Geothermal resources in Algeria are primarily utilized for balneotherapy and thermal resorts, although there has been a recent spike in interest of geothermal aquaculture projects, three sites having already been selected for this purpose. Some direct use application also exists in the country, with at least one school deriving its heating and cooling via a geothermal heat pump.

Geothermal Development Highlights

▪Algeria's first binary cycle power plant is planned near Guelma.[8]

Comoros Islands

One of the world's largest active volcanoes, Mount Karthala, is located on Grand Comoro Island, endowing the island nation with ample geothermal resources.

Geothermal Development Highlights

▪In April 2008, the Kenya Electricity Generating Company (KenGen) carried out a nine day reconnaissance survey on Grand Comoro Island, yielding promising results. Comoros recently signed a tripartite agreement with KenGen and Geothermal Development Associates to carry out further studies, develop, and implement a geothermal program.[9]

National Policies

While the Comoros Islands do not have a formal climate change policy, the nation has undertaken several mitigation and adaptation strategies, focusing especially on reducing dependence on foreign oil imports in favor of cultivating the abundant renewable energy resources on the islands.[10]

Djibouti

The Scientific Research Center of Djibouti (CERD) and Djibouti Electrical Power Company (EDD) have conducted internal studies of the energy and electricity sectors, including geothermal.[11] Geothermal power potential is currently estimated to be at least 352 MW in the African country.[12]

Geothermal Development Highlights

▪Djibouti is reportedly working with Reykjavik Energy to plan for a 50 MW geothermal power plant in the Asal area to be completed by 2012. According to additional studies conducted in the Asal region, three independent subfields exist in the area.[13] If the plant is later expanded as anticipated, it could generate 100-150 MW electricity from geothermal resources.

Ethiopia

Ethiopia has an estimated geothermal potential as high as 5,000 MW.[14] The regional Geologic Survey has identified sixteen potential geothermal sites that could yield a combined 1,000 MW of electric power to the East African nation. Ethiopia currently generates about 6 MW, or less than one percent of the country's 730 MW total electricity production, at the Aluto-Langano Geothermal Power Pilot Plant. The Government of Ethiopia and the Ethiopian Electric Power

Corporation (EEPCo) are actively encouraging participation from the private sector and international entities to expand the national grid as part of a fifteen-year geothermal resource exploration and development strategy. To this effect, the Ethiopian Ministry of Mines and Energy signed a Memorandum of Understanding with the Japanese Marubeni Corporation to survey the Aluto-Langano Geothermal Area project in Southern Ethiopia. Significant exploration has also taken place at the Tendaho field and in northeastern Ethiopia and, as part of Ethiopia's long-term electricity development strategy, surface exploration will be conducted at various sites along the Ethiopian and Afar Rifts. Feasibility studies at the Tendaho field project a 20-MW potential. Six additional geothermal projects have been launched, but financing remains a barrier to geothermal development in the country.[15]

Geothermal Development Highlights

▪Expansion work is being considered at the Aluto-Langano Geothermal Power Plant.
▪Geothermal Development Associates (GDA), based in Reno, Nevada worked with the Ethiopian Electric Power Corporation to complete repairs and re-commission the Ormat Energy Converter (OEC) at Aluto-Langano from early 2006 to July 2009.
▪GDA also worked with EEPCO to repair and restart the Geothermal Combined Cycle Unit (GCCU) at the Aluto-Langano in 2007.
▪Plans for future development include the expansion of the Aluto-Langano geothermal power plant to a full 30 MW capacity as soon as possible, followed by the development of the Tendaho geothermal field in 2013. Geochemical monitoring and production testing is in progress at the Tendaho geothermal field; early studies suggest that a pilot power plant could generate about 5 MW with a deep reservoir potential estimated at 20 MW.[16]
▪The "Geo-scientific Exploration for Development of the Tendaho Geothermal System" project was completed in 2009 by the Geological Survey of Ethiopia and the German Federal Institute for Geo-sciences and Natural Resources (BGR).[17]
▪Other developments include geoscientific studies and the drilling of temperature gradient wells at Corbetti and Tulu-Moye, detailed scientific studies by the Geological Survey of Ethiopia (GSE) at the Abaya, Fantale, and Dofan areas located on the Main Ethiopian Rift (MER), and reconnaissance investigation at, among others, Teo, Danab, Meteka, and Kone.

National Policies

Ethiopia has devised a fifteen-year government-led geothermal resource exploration and development strategy.[18]

Kenya

Located on the East African Rift, Kenya boasts massive geothermal potential, as high as 7,000 MW by some estimates.[19] While financial obstacles have hindered development, geothermal is a primary focal point of the country's strategy for energy stability. Kenya currently exploits 167 MW of geothermal power at the Olkaria Geothermal Field and is fast-tracking programs to increase the country's renewable energy capacity, of which geothermal energy resources could contribute 490 MW by 2012.[20] According to the state-run Geothermal Development Company (GDC), Kenya is moving to expand geothermal generating capacity by 4,000 MW over the next twenty years. GDC currently reports a total in-development geothermal capacity of 490 MW coming from six geothermal projects in Olkaria and Menengai (where drilling will begin in

October 2010).[21] Construction of four 70 MW geothermal plants in Olkaria and Naivasha commenced in early 2010. The project is the result of a contract between Kenya Electricity Generating Company (KenGen) and Sinclair Knight Merz, a New Zealand Company and, at a cost of US$1.4 billion, it will be financed by a host of development partners including the Kenyan government, the Japan International Corporation Agency, AFT, and the World Bank. Kenya's largest geothermal power generating project to date, the 280 MW installation project also provides for the construction of substations and the laying of transmission lines and other infrastructure.[22]

Geothermal Development Highlights

▪Ormat Technologies, Inc. completed a 35-MW expansion to its Olkaria III Plant in early 2009, now at 48 MW. In February 2010 Ormat announced plans to expand the plant by up to another 52 MW, which would bring the plant's total installed capacity to 100 MW. The first expansion is expected to be completed by 2015.
▪Kenya anticipates requiring US$ 992 million to add 600 MW of geothermal power to the national electricity grid over the next three years.
▪German Development Bank KfW is currently building co-financing for development of the Olkaria IV geothermal field.
▪Iceland, KenGen, and United Nations University (UNU) are coordinating to build a regional geothermal training center, an ARGeo project, in Kenya.
▪A small binary pilot plant is planned in the Eburru region.[23]

National Policies[24]

Policy (year)	Description
Feed-In Tariffs For Renewable Energy Resource Generated Electricity (2008, Revised to include Geothermal in 2010)	Fixed tariff not exceeding US$ 0.085 per kWh supplied to the grid. Tariff will apply to the first 500 MW geothermal capacity developed under policy, for geothermal power plants not exceeding 70 MW, for twenty years.

Madagascar

Eight geothermal sites have been identified in Madagascar and France reportedly intends to finance "a prototype (micro-geothermal) pre-feasibility study for a 50-100 kw facility using a low temperature geothermal resource to supply electrical energy to isolated villages."[25]

Rwanda

Rwanda has an estimated geothermal potential of more than 300 MW and possesses a high number of geothermal zones. Geothermal resources are seen by the government as an important development solution, serving "to minimize the dependency on energy imports, save foreign currency and create conditions for the provision of safe, reliable, efficient, cost-effective and environmentally appropriate source of energy."[26] Initial exploration is under-way; analyses suggest that geothermal systems exist in Northern and Western Rwanda. Support for geothermal development in Rwanda has come from Germany (BGR) and Chevron in conjunction with the Ministry of Environment and Natural Resources (MININFRA).

Geothermal Development Highlights

▪Further surface studies are planned that will include geological, geochemical and geophysical surveys at two prospects with a view of refining the conceptual model to locate the best targets for drilling exploration wells. The geophysical work will involve electrical resistivity measurements, heat flow studies and microearthquake studies to determine fluid-filled fractures and will take place from July to September 2010. The geological work will involve structural and geological mapping, dating of the rocks, and alteration studies. The geochemistry will involve use of geothermometers to evaluate reservoir temperatures taking into account the unique geology of the western branch of the East Africa Rift Valley.[27]

South Africa

Of the 87 thermal springs that have been identified in South Africa, 29 have currently been developed for direct use, despite abundant and cheap coal supplies hindering interest in researching and developing renewable energy resources.

Geothermal Development Highlights

▪A feasibility study was recently launched to look into power generation from thermal spring binary systems and from hot granite.[28]

National Policies[29]

Policy (year)	Description
Vision, Strategic Direction and Framework for Climate Policy (2008)	Emphasizes greenhouse gas emission reductions/limits, strengthening existing initiatives, adaptation/mitigation, growing renewable energy sector,
White Paper on Renewable Energy (2003)	Sets target of an additional 10,000 GWh from renewable energy sources contributing to final energy consumption by 2013 and removes barriers preventing renewable energy from penetrating the market

Tunisia

Tunisia's geothermal resources are largely employed for irrigation and direct-use heating of the country's greenhouses. Pursuant to a 2009-2014 Presidential program, Tunisia plans to double the 194,000 hectares currently used for geothermal farming to 310,000 hectares in 2010.[30] Tunisia is ranked third in the world for agricultural application of geothermal resources (the first two positions being occupied by the US and Hungary, respectively). Tunisia's geothermal development has benefited from foreign investments, which are facilitating the country's regional development strategy goal of reaching 150 hectares of greenhouses by 2016. Foreign capital is also contributing to executing Tunisia's 2005 framework policy on energy conservation and renewable energy which, among other objectives, aims to enhance energy capitalization of geothermal waters.[31]

Yemen

Up to 47% of the Yemen Geothermal Development Project is being financed by the Global Environment Facility (GEF) Trust Fund, which aims to "accelerate the exploration and the development of geothermal power use in Yemen."[32] As part of the GEF project, BGR is conducting feasibility studies at Al Lisi.[33]

Zambia

Although Zambia apparently has a number of sites planned for geothermal development, lack of funding is currently prohibiting construction.[34]

ASIA

The great geothermal reserves found in Asia's eastern countries are part of the Pacific Ring of Fire, where 90% of all earthquakes occur and geothermal power is historically most developed. Geothermal potential also extends west to Central Asia, where many new interests are being explored. Despite the potential, Asian countries have relatively ignored geothermal resources in the shadow of oil development and there is largely a lack of adequate policy framework to promote renewable energy. At the same time, it is due to a history of oil explorations that geothermal resources have been identified. Although geothermal electrical output is not extensive in the region, direct uses are widespread.

Countries covered in this section that currently have producing geothermal power plants are, Tibet, Thailand, and Turkey. Iran appears to have its first geothermal power plant in construction and expected to come on line in 2011. Many others have seen proposals, are in discussions, or are in preliminary stages on geothermal projects.

The Europe and Central Asia (ECA) Geothermal Energy Development Program aims to promote the use of geothermal energy in the region. The program includes technical assistance to remove barriers to geothermal energy growth, direct investment funding to support project developers, and geological risk insurance to mitigate geological risks.[35]

Asia and the Pacific are often grouped together in reference to geothermal energy, but in this document are considered separately. See also the Pacific Islands section of this report for more information on geothermal development on Pacific Islands.

Armenia

Field investigations in 2003-2004 under the Ministry of Energy discovered hot water reservoirs at the Jermaghbyur site in Syunik Marz. Estimates were around US$ 39.1 million for a 25 MW installation at the site; sources now put the output capacity at 150 MW. There is no geothermal electricity currently on line in Armenia.

Geothermal Development Highlights

▪The Jermaghbyur Geothermal Power Plant when completed will be the first geothermal electricity generating plant in Armenia and is expected to have an output capacity of 150 MW.[36]
▪In February 2009, the World Bank announced a US$1.5 million grant for comprehensive geothermal field investigation works for the Gridzor, Gegharkunik region and Karkar, Sjunik region sites.[37] This is the second grant Armenia has received under the World Bank/GEF (Global Environment Facility) GeoFund program. [38] The field investigation at Karkar and Gridzor geothermal sites will be carried out in two phases: scouting and magneto-telluric (MT) sounding followed by three dimensional (3D) seismic survey. Project cost is expected to be about US$ 60,000.

National Policies[39]

Policy (year)	Description
Diversification Strategy Document (2005)	emphasized geothermal power as the only renewable energy source which could be used to meet the base load.[40]
Energy Law, Law on Renewable Energy (2001)	local utilities required to buy all electricity generated for the next 15 years[41] with higher than average electricity tariff after the commissioning of the given local renewable energy power plant

China

Geothermal energy exploitation in China began around 1970. National investment in geothermal exploration was reduced as the economy was privatized in the 1980s, and the only productive geothermal fields are located in Tibet. In Yangbajain, eight double flash units have a total capacity of 24 MW but are still unexploited. Shaanxi Green Energy's first district heating project was built in Xianyang in Shaanxi Province and has an installed peak-load capacity of 100 MW, and Time magazine referred to it as the "Rejkyavik of the east."[42] Direct uses in the country have a total thermal installed capacity of 3,687 MW. Geothermal heat pumps were used to heat and cool some of the venues at the 2008 Olympic Games in Beijing.

Geothermal Development Highlights

▪In November 2009 Shaanxi Green Energy signed an agreement with Xiong County, Hebei Province for a new geothermal district heating development project.

National Policies[43]

Policy (year)	Description
Shandong Province One Million Rooftops Sunshine Plan (2008)	targets use of solar power and geothermal power into building construction
Shandong Province Village Renewable Energy Regulations (2008)	provides subsidies for specified renewable energy technologies in farming villages
National Climate Change Program (2007)	outlines the impacts that China faces from climate change and sets out a strategy to address it
Preferential Tax Policies for Renewable Energy (2007)	names income tax cuts for the producers and consumers of renewable energy and a reduction of the import tax for green equipment
Renewable Energy Law (2006)	lays out the general conditions for renewable energy to become the preferential area for energy development

Georgia

Most of Georgia's identified geothermal fields are located in the western part of the country. Direct use purposes use 350 MW capacity with 465 MW of proven reserves.[44] These are utilized extensively for purposes such as district heating, greenhouses, fish ponds, agricultural drying, industrial applications, and bathing and swimming. No geothermal power production has been reported.[45] In October 2009 USAID announced funding for rehabilitation and expansion of a 9.3 MW geothermal heating and hot water facility.[46] Georgia's renewable energy efforts are focused on hydropower development.

India

India professes direct use of geothermal energy with a cited capacity of 203 MW. Though there is yet to be any geothermal electricity generated. Over 300 hot spring locations have been identified by the Geological Survey of India, and estimates put India at about 10,600 MW of geothermal power potential.[47] Potential sites have been identified in Puga Valley (J&K), Tatapani (Chhattisgarh), Godavari Basin Manikaran (Himachal Pradesh), Bakreshwar (West Bengal), Tuwa (Gujarat), Unai (Maharashtra), and Jalgaon (Maharashtra).[48]

Geothermal Development Highlights

▪Glitnir Bank of Iceland announced exploration in India in February 2008.

▪In January 2010, India and Iceland announced a cooperation on geothermal energy development including technologies used in deep drilling, reservoir assessment, and geothermal demonstration power plants.[49]

National Policies[50]

Policy (year)	Description
Geothermal Energy R&D Program (2010)	Ministry of New and Renewable Energy seeking proposals for geothermal energy projects based on results of assessment studies[51]
India-Brazil-South Africa Declaration on Clean Energy (2007)	agreement to work together in the promotion of nuclear energy, clean energy technologies, other renewable energies, and climate change mitigation
Integrated Energy Policy (2006)	addresses all aspects of energy, including energy security, access and availability, affordability and pricing, efficiency and the environment
Tariff Policy (2006)	included provisions for renewable energy such as percentages for energy purchase made applicable for tariffs
National Electricity Policy (2005)	released in accordance with the Electricity Act of 2003 and promoted non-conventional energy resources
Electricity Act (2003)	comprehensive framework for power development with key provisions

	recognizing the role of renewable energy

Iran

Geothermal development in Iran has gained momentum in the last five years, with increased exploration and foreign technology sharing spurring industry growth in the country. In addition to numerous feasibility studies related to geothermal heat pumps, Iran is also developing a geothermal plant for power production and exploring the possibility of using wastewater from the plant for direct use. In January 2010, Iran's deputy minister for electricity Abbas Aliabadi said the Iranian government plans to build 2,000 MW of renewable energy capacity over the next five years.[52]

Geothermal Development Highlights

▪Exploration drilling is currently in-progress for the Meshkinshahr project in North-Western Iran. The Sabalan geothermal power plant is expected to produce 50 MW electric power when it is completed in 2011. The plant is planned by the Ministry of Energy (MOE) and the Renewable Organization of Iran (SUNA).[53]

Nepal

Manifestations of geothermal activity have been documented in Nepal in at least 33 places. No geothermal power installations have been reported, though direct use has a total thermal installed capacity of 2.1 MW.[54] In 2001, the Alternative Energy Promotion Center initiated a Feasibility Study of Geothermal Resource in Nepal. Nepal has shown interest in developing the geothermal potential throughout the country, and the south-north road network is expected to open up prospects in some remote areas. However, there are no definite government programs to support it.[55]

Geothermal Development Highlights

▪In February 2008, Glitnir bank and LNJ Bhilwara Group established a 60:40 joint venture for geothermal power development in India & Nepal.[56]

Taiwan

Taiwan is home to a 3 MW unit at Qingshui field that operated from 1981 to 1993. A second, 300 kW unit operated on the same field for a portion of that time. The field was reevaluated in 2007-2008.[57]Taiwan has shown interest in geothermal development in the Caribbean island of Nevis.

Thailand

Much of the approximately 64 identified geothermal resources in Thailand are located to the north. A small 300-kW binary plant provides electric power to the village of Fang. The San Kampaeng geothermal area was also once considered for development.[58] Installed capacity for direct uses is 1.7 MW.

National Policies[59]

Policy (year)	Description
Feed-in premium for renewable power (2007, modified 2009)	BHT 1.00/kWh for seven to ten years, 1.50 for wind and solar
Strategic Plan for Renewable Energy Development: 8% Target (2004)	renewable energy share target 8% by 2011
Small and Very Small Power Purchase Agreements (1994, expanded 2002)	small power producer purchase agreements to initiate private participation in power sector
Energy Conservation Program (1992)	provide financial support to introduce and promote new and renewable energy technologies

Turkey

Geothermal electricity is currently produced in the province of Denizli at the 20 MW capacity Kizildere plant, which began operations in 1968.[60] A target of 500 MW geothermal power production is set for this year (2010).[61] Nearly 274 geothermal fields are documented, with a proven potential of 3293 MW. Total geothermal potential estimates are 31,500 to 35,600 MW. Installed capacity for direct usage is 1,177 MW.

Geothermal Development Highlights

▪In March 2010, the Dora-2 geothermal power plant came on line with 9.5 MW capacity. The project was partially funded in a project by Irish celebrity Bono of the rock band U2.[62]

▪In October 2009, Turkey's Zorlu Group discovered a new 60 MW field in its feasibility studies.[63]

▪In February 2009, the Energy Ministry announced plans to launch around 120 investment projects for energy by 2020, with the focus on geothermal energy projects.[64]

National Policies[65]

Policy (year)	Description
Renewable Energy Law	promotes the use of renewables in a free energy market; introduces feed-in tariffs and purchase obligation
9th Development Plan of Prime Ministry State Planning Organization (2007-2013 period)	sets target for geothermal electricity production to 550 MW by 2013
Energy Efficiency Law (2007)	promotes efficient use of energy, prevents waste, mitigates energy costs on the economy, protects the environment
Law on Geothermal Resources and Natural Mineral Waters (2007)	regulates exploration, production and protection of geothermal and natural mineral water resources
Utilization of Renewable Energy Resources for the Purpose of Generating	regulates conservation, utilization, and certification of renewable energy resource

Electrical Energy (2005)	areas
Electricity Market Licensing Regulation (2001)	separates generation, transmission and distribution activities toward a liberalized electricity market

CENTRAL AMERICA AND THE CARIBBEAN

As is the case in South America, energy demand and consumption is expected to increase throughout Central America and the Caribbean. However, while hydropower provides much of South America's energy, carbon intensive fossil fuels provide the bulk of electricity in Central America and especially the Caribbean. Indeed, between 1990 and 1999 emissions from energy production in the Central American and Caribbean regions increased 50%.[66]

While many Central American countries produce a significant portion of their electricity from fossil fuels, geothermal energy has played an important role in the energy mix of some of the regions countries. Costa Rica, El Salvador, Guatemala, and Nicaragua all harbor operational geothermal power plants. In Costa Rica and El Salvador geothermal energy comprises, respectively, 13% and 26% of national electricity generation.[67] An abundant resource base combined with the desire to increase energy security and address climate change throughout the region have led to the continued development of Central America's geothermal resources. Costa Rica, El Salvador, Guatemala, and Nicaragua all have geothermal projects in development.

The island nations of the Caribbean Sea are almost entirely net energy importers. As these nations are dependent upon oil imports to generate electricity they are sensitive to fluctuations in the prices of fossil fuels.[68] In an attempt to move away from dependence upon fossil fuels, a small number of Caribbean island nations are exploring and developing their geothermal resources with a project currently under development on the island of Nevis.[69]

Costa Rica

Costa Rica has been producing geothermal electricity from units located in the foothills of the Miravalles volcano since 1994. Currently, there are five geothermal units producing 165.5 MW of electricity at the Miravalles geothermal resource, which comprises approximately 13% of Costa Rica's total installed electricity capacity.[70] Geothermal resources in Costa Rica are continuing to be developed in order to bring more clean, baseload electricity to the country's electricity grid.

Geothermal Development Highlights

▪The 35-MW Las Pailas geothermal project, located at the Rincón De La Vieja Volcano, is in its latter stages of development.[71] Recently, Ormat Technologies, Inc. signed a US$ 65 million contract with the Banco CentoAmericano de Integración Económica (BCIE) for the construction of the planned 35 MW Las Pailas geothermal power plant.[72]
▪In addition to developments at Las Pailas, geothermal exploration and a plant feasibility study have been initiated at the Borinquen geothermal resource in the north of the country.[73]

National Policies

The Costa Rican government has made efforts to expedite the development of geothermal resources there. Recently the Costa Rican Congress introduced a bill that would allow for the development of some geothermal resources located within the country's national parks.[74]

El Salvador

The Ahuachapán (95 MW) and Berlin (109.4 MW) geothermal power plants supply approximately 26% of El Salvador's electricity.[75] The majority state-owned company, LaGeo, operates the two plants which have a cumulative installed capacity of ~204 MW, making El Salvador the largest producer of geothermal energy in Central America.[76] El Salvador has encouraged the development of its geothermal resources as a response to the reliance upon oil imports and the corresponding sensitivity to high oil prices.

Geothermal Development Highlights

▪The Central American geothermal developer LaGeo has engaged in early exploration activities at the Chinameca geothermal resource located in San Miguel. Initial exploration results have been positive and could pave the way for the country's third geothermal power plant.[77]

National Policies[78]

Policy (year)	Description
Fiscal Incentives Law for the Promotion of Renewable Energy (2007) [79]	Includes a 10 year tax exemption for projects below 10 MW installed capacity
National Energy Strategy (2007)	supports the diversification of its energy resources
System for the Promotion of Renewable Energy	Provides soft loans and other assistance in the financing of feasibility studies

Guatemala

Studies of Guatemala's geothermal resource indicate that the country has up to 4000 MW of geothermal potential, of which a small portion has already been developed for electricity production. [80] Two geothermal power plants currently operate in Guatemala. The Zunil I (28 MW) and the Amatitlan (24 MW) binary geothermal power plants provide a combined 52 MW of geothermal energy to Guatemala's electricity grid. [81] Interest in developing Guatemala's geothermal resources continues to grow and the government of Guatemala is eager to encourage the development of geothermal and other forms of renewable energy within its borders.

Geothermal Development Highlights

▪A recent announcement by US-based geothermal developer US Geothermal, Inc. indicates that the company intends to develop known geothermal steam fields southwest of Guatemala City. US Geothermal will build upon previous resource development conducted at the El Ceibillo steam field in order to quantify a MW value for the geothermal resource and complete the eventual construction of a geothermal power plant there.[82]

National Policies[83]

Policy (year)	Description
Renewable Project Incentives Act (2003)	Provides exemptions from fees associated with developing the country's geothermal resources including a customs tariff, value-

	added tax, and income tax during the first ten years of commercial operation.[84]

Honduras

Honduras is a net importer of energy with the majority of its energy consumption needs being met by heavy fuel oil and hydropower.[85] While the country currently produces no electricity from geothermal energy, it does harbor lower temperature geothermal resources which provide some opportunity for exploration and possibly development.

Geothermal Development Highlights

▪Geothermal exploration company EGS, Inc. is currently devising a development strategy and performing data analysis in preparation for the possible further development of the Platanares and Azacualpa geothermal fields.[86]

National Policies[87]

Policy (year)	Description
Decrees No. 85-98 and 267-98 (1998)	Promotes the development of renewable energy generating power plants by offering tax-breaks to developers and secure buyers at prices equivalent the electricity systems short term marginal cost. For renewable energy units whose installed capacity is below 50 MW the national utility, ENEE, must pay a 10% of the short-run marginal cost premium for electricity.
Decree 85-98 (1998)	Provides tax exemptions on import sales tax on equipment and a 5-year income tax holiday.[88]

Nicaragua

The electricity production potential of Nicaragua's geothermal resources has been estimated at approximately 1,500 MW.[89] Geothermal development in Nicaragua began as early as 1974 when initial drilling took place at the Momotombo steam field; a geothermal plant was brought on line in 1983.[90] In the late 1990's Ormat Technologies took over operations, repaired equipment, and improved plant capacity, which had suffered.[91] The resource has a current installed capacity of 77 MW. Polaris Geothermal developed an additional 10 MW plant, which went on line in 2007 at the San Jacinto-Tizate area.[92] A number of companies are in the development of Nicaragua's geothermal resources.

Geothermal Development Highlights

▪Ram Power, Corp. is in the process of engineering the San Jacinto-Tizate resource in order to increase production from 10 MW to 82 MW. The San Jacinto-Tizate expansion will occur in three phases. The first phase, to be completed in Q1 2011, will expand capacity to 46 MW. The

second phase, to be completed in Q4 2011, will expand capacity to 72 MW. The third and final phase will expand capacity to 82 MW. [93]

▪Ram Power and Magma Energy, Corp. won a bid to jointly explore and develop the Volcán Mombacho and Caldera de Apoyo geothermal resources. Under the agreement Ram Power's subsidiary, Polaris Geothermal Inc. will act as project operator and both companies will share development costs equally.[94]

▪GeoNica (a joint venture between Enel Latin America and LaGeo) has been engaged in a geothermal resource exploration program at the Managua-Chiltepe and the El Hoyo Montegalán geothermal resources.[95]

Projects in Development

Project Name	Developer	MW
San Jacinto-Tizate	Ram Power	82
Managua-Chiltepe	GeoNica	44
El Hoyo Montegalán	GeoNica	44
Volcán Mombacho	Ram Power, Magma	NA
Caldera de Apoyo	Ram Power, Magma	NA

National Policies

The Nicaraguan government has set the ambitious goal of increasing the country's renewable energy generation capacity to meet 80% of the country's electricity needs by 2014. In order to spur the development of geothermal resources the Nicaraguan government has granted geothermal concessions to a number of national and international companies. In 2002 The Geothermal Law to regulate the exploration and exploitation of Nicaragua's geothermal resources. Requests for bids on any particular geothermal resource area are issued by the Nicaragua Energy Institute.[96]

The Caribbean: Dominica, Guadeloupe, Montserrat, Netherland Antilles (Saba), St. Kitts and Nevis

While the Caribbean islands harbor potentially significant geothermal resources, efforts to develop them to produce geothermal electricity have been minimal. On the French island of Guadeloupe a 15-MW geothermal flash plant meets approximately 8% of the islands electricity demand.[97] Challenges to the development of geothermal energy in Caribbean exist. Most of the island countries have not enacted policies promoting the development of their geothermal resources and have limited laws regulating their electricity sectors. Additionally, small island populations result in smaller electricity markets. Little in the way of incentives is offered by the island nations of the Caribbean.

Geothermal Development Highlights

▪Once completed, the power plant (10 MW), located on Nevis, will meet nearly all of the island's power needs. A planned second geothermal power plant (30 MW) will deliver electricity to St. Kitts via submarine cable.[98]

▪Additional projects are planned for the islands of Dominica, Guadeloupe, Montserrat, Saba, and St. Vincent.[99]
▪West Indies Power is developing the Caribbean Interconnect which will provide power from its geothermal power plants to islands throughout the Caribbean.[100]

Geothermal Projects in Development

Project Name	Developer	MW	Location
Nevis Geo.	West Indies Power	10	Nevis
St. Kitts Geo.	West Indies Power	30	Nevis
Wotten Waven	French Development Agency	17	Dominica
Soufriere/Scotts Head	West Indies Power	50	Dominica
Montserrat Geo.		NA	Montserrat
Saba Geo.	West Indies Power	NA	Saba
St. Vincent Geo.	West Indies Power	NA	St. Vincent
Guadeloupe Geo.		20	Guadeloupe
Total		**77**	

EUROPE

Many areas in Europe lack traditional hydrothermal resources currently utilized in geothermal power production, but there is significant interest among European nations to develop EGS technology to tap into the vast hot rock potential available. The European Union (EU) plays a centralizing role in promoting energy development from renewable sources, which has contributed to sustained growth in the geothermal sector, both for direct and district heating, and for electricity production. The European Investment Bank (EIB) has been and will likely continue to be instrumental in pursuing EU geothermal objectives, especially in funding EGS research and development. The EU-funded GEOFAR (Geothermal Finance and Awareness in European Regions) project also serves to develop and promote financing for geothermal projects as part of the Intelligent Energy Europe (IEE) program. The European Geothermal Energy Council (EGEC) has set targets for installed electric power from geothermal capacity at 5,000 MW total for all of Europe by 2020, increasing to 15,000 MW by 2030. The goal for the geothermal sector is to contribute 5% of the total energy production in Europe by 2030.[101]

National targets for electricity from renewable energy sources (RES-E) by 2010 and Renewable Energy Source (RES) by 2020 as of October 2008.[102]

Country	RES-E target 2010	RES target 2020
Austria	78.10%	34.00%
Czech Republic	8.00%	13% (15.0-16.0%) (2030 target)
Denmark	29.00%	30%
France	21.00%	23%
Germany	12.50%	18% (30.0% for RES-E)*
Greece	20.10%	18.00%
Hungary	3.60%	13%
Ireland	13.2% (15.0%)*	16% (33% for RES-E) *
Italy	25.00%	17%
Latvia	49.30%	42.00%
Netherlands	9.00%	14.0% (20%)*
Poland	7.50%	15%
Portugal	39.0% (45%)*	31%
Slovakia	31.00%	14%
Spain	29.4% (30.3%)*	20%
UK	10.00%	20.0%

* Values in brackets indicate national targets deviating from those of the RES-E Directive or RES Directive, respectively.

Austria

Geothermal developments in Austria have stagnated since 2005, but future projects are expected to emerge in the Vienna Basin. Austria currently has three binary geothermal power plants, Altheim, Bad Blumau, and Simbach/Braunau, which was commissioned in 2009.[103]

National Policies[104]

Policy (year)	Description
Feed-in-tariffs (2010)	Tariffs for new geothermal energy contracts are € Cents 7.4/kWh and last 10-15 years
Combined Heat and Power Law (2009)	Subsidies available for new or modernized CHP plants for public district heating, 30% of which will be allocated to industrial-use cogeneration plants. Plants up to 100 MW can receive €100/kW; plants between 100 and 400 MW can receive €60/kW; and plants above 400 MW can receive up to €40/kW

Belarus

Geothermal potential in Belarus lies predominately in the Pripyat Trough and the Brest Depression areas, both in the southeastern part of the country.[105] Most of the geothermal energy utilization in Belarus comes in the form of space heating and cooling, with 15 geothermal installations supplying heat to industrial buildings and another 12-15 heat pump installations under construction.

Geothermal Development Highlights

▪A 1-MW geothermal pilot station will provide heat to a greenhouse complex in Western Belarus.[106]

National Policies[107]

Policy (year)	Description
Energy Saving Program 2006-10 (2006)	Intend to replace fuel and energy imports with local resources, including from renewable (to increase by 1.7 million tons of fuel equivalent)
Feed-in Tariffs for Renewable Energy (1994)	Standard feed-in tariff set at US$ 0.08/kWh compared to consumer price of US$ 0.012/kWh.

Croatia

A few geothermal fields have been drilled in Croatia and regional and geological studies are being performed in order to define geothermal resources. The country's estimated geothermal potential is up to 48 MW of economically viable geothermal production.[108] Croatia currently utilizes a small percentage of its thermal power potential and has worked to increase direct geothermal energy usage. Plans for the construction of a geothermal electric power plant are expected to resume this year. [109]

Geothermal Development Highlights

▪Hungarian geothermal developer PannErgy signed a contract with the government of Koprivnica, Croatia to conduct geological analysis to be considered for continuation on the company's Csurgó, Hungary project, located just across the Hungary-Croatia border. If studies

demonstrate that the Koprivnica area is suitable for geothermal drilling, PannErgy may pursue geothermal development in the region.[110]

National Policies

Policy (year)	Description
National Energy Program	GEOEN (Geothermal energy use program) was established to create conditions to increase geothermal use as part of a larger energy management framework[111]

Czech Republic

The Czech Republic initiated plans for its first geothermal power plant in February 2009 with CEZ, the country's largest power company, providing US$ 11.3 million to fund exploratory digging in Liberec, north Bohemia. It was noted that surveying might take up to four years, but the proposed geothermal plant, which is estimated to produce under 10 MW of power when completed, could generate 0.3% of Czech's overall energy production.[112] Total exploitable geothermal potential in the country is estimated to range between 2,500 and 3,000 MW.[113]

National Policies[114]

Policy (year)	Description
Act on the Promotion of the use of Renewable Energy Sources (2005, amended 2010)	Provides for minimum feed-in tariffs and green bonuses (surcharges on market price of electricity); Fixed feed-in tariffs set at €Cents 17.2/kWh for 15 years and premium set at €Cents 19/kWh for 15 years; target share of electricity produced from renewable sources is 8% by 2010
State Energy Policy (2004, amended 2010)	Target of 15-16% of the total primary energy supply (TEPS) derived from renewable sources, 17% share of renewable in electricity consumption by 2030
Tax exemption for renewable energy use (2005)	Renewable energy equipment owners (includes heat pumps and geothermal power) are exempt from paying income tax for five years

Denmark

While Denmark is not well suited for geothermal power production, the country excels in geothermal heat production, with plants currently exploiting geothermal heat energy and more in the works. Two plants are operational in the country, one producing 7 MW heat; the second, located in Copenhagen, designed to produce up to 14 MW heat.[115]

Geothermal Development Highlights

▪DONG Energy has established contracts with numerous towns to explore geothermal options, potentially leading to locally partnered power plants.[116]

▪Geothermal drilling was expected to start in 2009 in Sønderborg following the completion of a seismic survey. The planned project could produce up to 15 MW heat.

▪Plans for a 17-MW heat geothermal plant in Hjørring are being negotiated.

▪Expansion of the Thisted power plant is under consideration.

▪Preliminary planning for a geothermal project in Copenhagen is in motion and the potential for long-term heat storage is being explored. If the project is realized, it could yield 400 MW geothermal heating capacity for the city.

National Policies[117]

Policy (year)	Description
Feed-in Tariffs (2009)	For renewable energy plants connected before after April 21, 2004: range between DKK 0.10/kWh for 20 years to DKK 0.60/kWh for ten years and 0.40kWh for the next ten years
Promotion of Renewable Energy Act (2009)	Provides feed-in tariffs for renewable sourced electricity production and creates a special fund to promote small-scale, grid-connected renewable energy plant development (to be managed by Energinet.dk, Denmark's transmission system operator at DKK 25 million per year for four years)
Agreement on Danish Energy Policy 2008-2011 (2008)	20% gross energy consumption coming from renewable energy sources by 2011
Heat Supply Act (1979, updated 2006)	Minister for Energy can ban use of electric heating in new buildings located within district heating or natural gas supply network; plants larger than 1MW must be operated as combined heating plants
Carbon Tax/Green Tax System (2000)	Different tax levels with reallocation as subsidies for energy efficiency activities, etc. energy tax: about €6.8/GJ, standard CO2 rate: €13.3/tonne; electricity tax calculated on basis of fuel used in production

France

France currently has an installed capacity of 16.5 MW (15 MW of which produced on the French West Indies Island of Guadeloupe). A number of renewable energy policies support the expansion of the country's geothermal exploitation, including the Grenelle de l'Environment process (2007) and French Energy Law (2005). France has a diverse geothermal resource base and has been dedicated to exploring the potential of EGS technologies at its power plant in Soultz-sous-Forêts. The plant went on line at the end of 2008 and currently produces 1.5-MW

geothermal power. France has invested in developing geothermal resources in its Overseas Departments, which include territories in French West Indies and the Indian Ocean. Bouillante, a 15-MW power plant is currently operational in Guadeloupe and generates 8% of the energy consumed on the island. When a long-term investment in electricity plan was passed in 2006 it set targets of 90 MW additional geothermal energy capacity by 2010 and 200 MW to be installed by 2015.[118]

Geothermal Development Highlights

▪Testing is under way prior to installing the full 6 MW power plant at the Soultz-sous-Forêts site; several other drilling projects in the Paris Badin are also in progress.
▪An additional power plant project, Bouillante 3, is in development in Guadeloupe, which could bring geothermal-derived energy sources up to 20% of total energy consumption on the island.[119]
▪The Alsace Regional Council, in conjunction with ADEME, intends to provide financial support for five deep geothermal projects to be in development by 2015.[120]
▪In mainland France, geothermal drilling is being conducted near the Saint-Denis canal as part of a heating project which will provide hot water and heat to around 12,000 apartments by 2011. France currently heats approximately 17,000 homes with geothermal resources, and the government plans a 6X increase to that total by 2020.[121]

National Policies[122]

Policy (year)	Description
Feed-in tariffs (amended 2010)	Feed-in tariffs for geothermal raised nearly 70% to € 0.20/kWh for 15 years from 2006 levels of € 0.12/kWh.
Grenelle de l'Environment (2007)	A gathering of civilian and public service representatives to define government policies on ecological and sustainable development issues. The discussion was codified in laws and actions setting up financial incentives to boost investment in renewable energy (including geothermal)[123]
National Strategy for Research and Development in the Field of Energy (2007)	Strategy to increase energy security, reduce GHG emissions, mitigate climate change by promoting RD&D in a variety of renewable energies
Preferential Loans for Energy Saving Measures (2007)	€ 10 billion fund for domestic energy conservation projects; by 2010 banks must dedicate 10% of the funds to energy conservation loans which can be awarded to individuals, co-properties, entrepreneurs for the purchase, installation of equipment producing energy from renewable sources
ADEME grants for feasibility studies	Geothermal projects can be granted up to 50% of the cost of feasibility studies (limited to € 300,000 for deep geothermal energy). Additional grants can be added for consultant assisting project owner (30% of the sum up to € 100,000).
French Energy Law (2005)	23% of energy consumption should come from renewable sources by 2020. Establishes energy

	savings certificates and introduces quota system for producers, suppliers, and distributers of electricity, gas, and oil.

Germany

Germany's fifth power plant came on line in December 2009, adding 0.5 MW capacity at Baden-Wuerttemberg to the existing 210kW at Neustadt-Glewe, 3.8 MW at Landau, 3.4 MW at Unterhaching, and 200 kW at Simbach Braunau.[124] Following the release of a 2008 report concluding that Germany utilizes very little of its geothermal potential, government has vowed to establish a 280 MW (representing more than 40 times the country's current installed capacity) geothermal network by 2020.[125] Development rose significantly and is expected to continue the upward trend due to a feed-in tariff scheme providing € 0.20/kWh for electricity produced from geothermal resources. Plants in Sauerlach, Durrnhaar, Riedstadt, Speyer, Gross Schöenebeck, Kirchstockach and Mauerstetten are expected to come on-line this year. According to the German government, 150 geothermal power plant projects are being developed, representing a € 4 billion investment and contributing to the 14% annual growth rate of geothermal energy branch in the country.[126]

Geothermal Development Highlights

▪BE Geothermal is getting ready to begin drilling for a combined geothermal power and heating project in Bavaria, in August of this year with the plant scheduled to come on-line by the end of the year 2012. The Höhenried West site is expected to generate 10.5 MW electric power and save 50,000 tons of CO2 emissions.[127]

▪Construction on power plants at Landau and Unterhaching began in 2008, each with a 3 MW capacity. A number of additional 10 MW projects are planned at several sites.

▪Drilling works are scheduled for at least three projects, one in Hagenbach and two near Munich.

▪Construction has started on a biomass/geothermal hybrid power plant at Neuried.[128]

▪Further research is being conducted at the EGS R&D site at Broß Schöneck.

▪After initial drilling revealed lower than expected flow rates, German developer Exorka is looking to continue a geothermal power plant project in Mauerstetten and Kaufbeuren, located in Southern Germany, using a petrothermal EGS system. Renewable energy legislation in Germany provides a technology bonus as part of the feed-in tariff scheme, which could generate additional income for Exorka.[129]

▪A 3.36-MW power plant is in development in Unterhaching, a municipality of Munich.[130]

▪A plan for a deep geothermal project in Walldorf to provide electricity and heating to the local airport is being pursued by Fraport, Frankfurt Airport's owner and operator, in conjunction with D&S Geo Innogy and Daldrup & Söhne. Extensive seismic and geothermal potential exploration will be conducted at the Walldorf field, located in the Upper Rhine Rift, in the coming months.

National Policies[131]

Policy (year)	Description
2009 Amendment of the Renewable Energy Sources Act (2009)	Increased tariffs for geothermal facilities to € Cents 16/kWh for plants with <10 MW capacity and € Cents 10.5/kWh for plants >10 MW over 20 years

Renewable Energy Sources Act (2004, amended 2006 and 2008) (Feed-in tariffs)	Aims to increase share of renewable energies in total electricity supply to 20% by 2020, obligates grid operators to purchase and transmit all electricity available from renewable sources
Market Incentive Program (1999)	Provides funding for, among other projects, heat generation from geothermal energy, district heating systems, geothermal heating and power stations
Green Power (1996)	Renewable energy plant operators not operating under the German Feed-in scheme can sell electricity generated in their plants at a premium on the market

Greece

Greece hosts a geothermal power potential of at least 500 MW which, despite geothermal resources being well known throughout the country, has yet to be exploited. Thirty geothermal fields have been identified in Greece, mainly in the South Aegean Active Volcanic Arc on the islands of Milos and Nisyros. In addition to strict feed-in tariffs, government subsidies are available at 35% of the total investment for developing geothermal resources until 2013.[132]

Geothermal Development Highlights

▪Several projects are being evaluated in Nisyros and Tracia by PPC Renewables and foreign investors. Wells have already been drilled for an 8-MW binary plant in Lesvos.[133]

National Policies[134]

Policy (year)	Description
Feed-in tariff (2006, amended 2009)	Tariffs for geothermal energy production set at €Cents 7.3/kWh in the interconnected electric system and €Cents 8.46/kWh in the non-interconnected island system over 12 years
National Operational Program for Competitiveness II (2000)	Provides grants to private investment in renewables, including geothermal, rational use of energy, and small-scale co-production.

Hungary

The Earth's crust is significantly thinner beneath Hungary than it is in other European countries, making it a high-potential geothermal location. Testing is currently underway by CEGE Zrt, a unit of Hungary's national oil company, MOL, and Australia's Green Rock Energy at some 8,000 oil and gas wells for water that could be used for heating and electricity production.[135]

Geothermal Development Highlights

▪MOL, the national oil company, has drilled several wells that could be used to develop geothermal production projects. A 5-MW pilot project is planned at Ortaháza.[136]

▪PannTerm, a joint venture company established by PannErgy, the Hungarian alternative-energy company, and the local council of Kiskunhalas, is slated to begin drilling geothermal wells in the Kiskunhalas area pending securing necessary land rights and permits.[137] PannErgy has also established joint ventures with local councils in the Southern Hungarian cities of Szentlorinc, Tamási, and Csurgó. Successful test drilling at Szentlorinc suggests 4 MW heating capacity exists at the site.[138]
▪Miskolci Geotermia, a joint venture between PannErgy and Miskolci Hőszolgáltató (Miho), a district-heating company, plans to build a € 50 million geothermal plant in Miskoc which could produce 170 MW of heat energy and supply almost all of the district heating for the city.[139]
▪Central European Geothermal Energy Private Company Ltd. (CEGE) plans to contribute over US$ 45 million investment projects (still in the preparatory stage) in several locations in Hungary. Geothermal power plant construction isn't expected to start for another three years, following two years of geological-geophysical tests and seismic measures and one year of drilling.[140]

National Policies[141]

Policy (year)	Description
Hungary Strategy on Renewable Energy Sources 2007-2020 (2007)	Sets target of 186.4 PJ from renewable energy by 2020, which includes 79.7 PJ in electricity production and 87.1 PJ in heat production; sets target values for shares of renewable energy for electricity and heat achieved through EEOP
Structural Funds for Environment Protection and Infrastructure Operative Program (EIOP) Subsidies (2006)	EPIO provided 280 million HUF in subsidies to, among other objectives, promote investment in renewable energy, district heating systems using sources including geothermal energy, and district heating systems
Feed-in Tariff (Electricity Act) (2003)	Electricity suppliers are obligated to purchase electricity from producers using renewable energy sources if their capacity is over 100 kW. Feed-in tariff is set at €Cents 10.5/kWh, adjusted annually for inflation
New Hungary Development Plan (NHDP) and Environment and Energy Operative Program (KEOP)	Provides subsidies for many renewable sources, including geothermal electric and/or thermal energy generation and utilization, heat pumps, and introduces regulatory measures supporting renewable energy sources into the electricity and other energy networks

Iceland

Often considered the model of geothermal development, Iceland continues to grow its geothermal portfolio. With a small population, the country is currently generating 100% of its power from renewable sources, deriving 25% of its electricity and 90% of its heating from geothermal resources.[142] Seven geothermal power plants have been constructed in Iceland (six are currently operational) representing 575 MW of an estimated 4,255 MW of installable capacity.[143] According to a recently released Iceland Geothermal Energy Market Report, "geothermal power projects represent the majority of planned capacity, or 1,068 MW of a total of 1,658 MW" planned energy capacity installations.[144]

Geothermal Development Highlights

▪Icelandic geothermal producers Hitaveita Sudurnesja and Orkuveita Reykjavikur signed an agreement with Century Aluminum Co. to supply 250 MW geothermal electricity for aluminum production. The project, which will be commissioned in 2010, can be expanded to up to 435 MW. The IGA notes in its 2005-2010 Update Report that "this will be a very efficient way of exporting the surplus of cheap and abundant geothermal electricity production from Iceland."[145]
▪230 MW geothermal capacity is currently under construction.[146]

Projects in Development:

Plant site	Developer	MW Potential	Estimated Operation	Status*
Reykjanes 2	HS Orka	50	2010	3
Hellisheidi 4	Reykjavik Energy	45	2010	4
Hellisheidi 5	Reykjavik Energy	45	2010	4
Reykjanes 3	HS Orka	45	2011	3
Hverahlid	Reykjavik Energy	90	2011	4
Krisuvik 1	HS Orka	75	2013	2
Eldvord	HS Orka	45	2013	2
Grahnjukar	Reykjavik Energy	45	2013	2
Theystareykir 1	Theystareykir/Landsvirkjun	45	2014	2
Bjarnarflag 1	Landsvirkjun	45	2014	3
Theystareykir 2	Theystareykir/Landsvirkjun	45	2015	2
Theystareykir 3	Theystareykir/Landsvirkjun	45	2015	2
Bjarnarflag 2	Landsvirkjun	45	2015	3
Krafla II 1	Landsvirkjun	45	2015	2
Bitra	Reykjavik Energy	113	2015	3
Krisuvik II	HS Orka	75	2015	1
Krisuvik III	HS Orka	75	2015	1
Krafla II 2	Landsvirkjun	45	2016	2
Trolladyngja	HS Orka	50	2017	1

*Status:
1 = Existing interest, feasibility work in progress
2 = Feasibility closed (interest, electricity likely in sight) work on environmental impact analysis and permits

3 = Environmental Impact Analysis closed/ not needed, work on permits, construction could have started
4= Permits given, construction already far advanced, work on financing
Source: Iceland Geothermal Energy Market Report, Íslandsbanki Geothermal Research

National Policies

Policy (year)	Description
Iceland Climate Change Strategy (2007)	Set long-term goal of reducing GHG by 50%-75% below 1990 levels by 2050. Emphasizes research and innovation and promoting the exportation of Icelandic expertise in renewable energy and climate-friendly technology. Prioritizes researching feasibility of pumping CO2 from geothermal power plants back into the earth, exporting technology, and engaging in Clean Development Mechanism projects concerning geothermal and other climate-friendly technologies[147]

Ireland

Geothermal development is gaining momentum in Ireland and a strategic alliance between the Ballymena Borough Council and GT Energy, the Irish geothermal company, could result in the country's first geothermal district heating energy system.[148] Despite limited geothermal resources, the country's first deep drilling project, a trial well in Dublin, could lead to district heating. Ireland is currently estimated to have 164 MW or approximately 9500 units of geothermal energy in use in the form of heat pumps. Irish officials are also initiating the process of introducing uniform regulatory controls to the geothermal industry in the country and are involved in the EU geothermal standardization process.[149] Some estimates suggest that geothermal energy could contribute up to 15% of Dublin's hot water and heating in the next 5-7 years.[150]

Italy

Italy's major geothermal areas of Larderello-Travale/Radicondoli and Mount Amiata have seen sustained development over the past century. Enel Green Power, wholly owned by Enel Group, operates all geothermal fields in the country. Two additional geothermal power units were commissioned in Tuscany in 2009, bringing the total installed geothermal power capacity in Italy to 843 MW.[151] In 2010 the country has seen the inception of the Campi Flegrei Deep Drilling Project. In addition to evaluating regional potential for geothermal energy exploitation, the Campi Flegrei project is a broad research program being conducted by the Naples Department of the Italian Institute of Geophysics and Volcanology and various international institutions, including the US Geological Survey. According to some estimates, "given the political will, the fraction of the country's electricity generated by geothermal could rise five-fold to as much as 10% within the next 10 years."[152]

Geothermal Development Highlights

▪Projects yielding an expected 112 MW of geothermal power have been approved: four plants in Larderello-Travale and one Bagnore in addition to field development in Piancastagnaio.[153]

▪Drilling of a 4-km deep well at Campi Flegrei is expected to start later this year. The project will utilize supercritical fluid (water and steam existing simultaneously at high temperature and pressure) and, if successful, each supercritical well drilled could translate into 50 MW geothermal power.[154]

National Policies[155]

Policy (year)	Description
2% Renewables Target – Green Certificates (2002, amended 2008)	Companies producing or importing more than 100 GWh/year of electricity must meet renewable energy-sourced quotas increasing by 0.75% annually, until reaching 7.55% in 2013. Quotas can be met by way of green certificates achieved by purchasing from, building new, or importing electricity from renewable energy plants. Geothermal plants are granted tradable green certificates under a 2002 introduction of partial refurbishment category. Amendments passed in 2008 raised the incentive period to 15 years and set the number of certificates issued according to a coefficient multiplicative energy produced (0.9 for geothermal)
"All Inclusive" Feed-in Tariff for small renewable plants (2008)	Fixed feed-in tariff of € Cents 20/kWh for 15 years for geothermal plants. Per the policy, small renewable plants (<1 MW) commissioned after January 1, 2008 have the option of choosing between Green Certificates and feed-in tariffs

Latvia

Latvia's capital city, Riga, is looking into developing an EGS pilot project for a petrothermal power plant which would generate between 3 and 4 MW electricity and between 30 and 40 MW for heating.[156] While the country currently has no on-line geothermal capacity, Latvia's total estimated geothermal potential is around 175 MW.[157] According to a presentation delivered by Riga's Energy Agency, EGS technology could be employed to exploit Latvia's hot dry rock potential where hot water resources are unavailable. Existing feed-in tariffs in Latvia exclude geothermal.

Norway

Geothermal use in Norway has skyrocketed with the installation of 26,000 ground source heat pumps. The country is also exploring the potential EGS within its borders and is planning a demonstration project in Oslo in 2010.[158]

Poland

Geothermal energy in Poland is currently characterized primarily by heat pumps and balneotherapy, but future prospects include "adaptation of abandoned wells; multipurpose, integrated systems; heat pumps; heat extractions from the underground mines."[159]

Geothermal Development Highlights

▪The Lodz City Council and Lodz Technical University signed a deal to develop dual heating and electricity generating project at the University. The Lodz region of Poland has significant geothermal potential and the project currently in-development, which is anticipated to cost around US$ 15.2 million, will provide heat and electricity to a new sports and educational complex, in addition to some existing University buildings. Work on the project was expected to start in late 2009 and to take two years to complete.[160]

National Policies[161]

Policy (year)	Description
Program for Renewable Energy and High Efficiency Cogeneration Projects (2009)	Funding of up to €1.5 billion in the form of low-interest loans for the construction of renewable energy; 20% of the budget will go to geothermal and hydroelectric projects under 5MWe
Renewable Energy Tax Excise (2002)	Electricity produced from renewable sources is exempted from paying excise tax, assuming at least 2% of the fuel is produced from biocomponents
Energy Law Act (1997, amended 2005, 2007)	Reduced grid connection fee for electricity produced from renewable sources; 2005 amendment implements certificate of origin trading system, obligating energy producers, traders, and purchasers to obtain a certain amount of energy from renewable sources; 2007 amendment requires license for all renewable energy generation and sets required RES share at 10.4%

Portugal

Azores, Sao Miguel, Portugal's largest and most populated island, currently meets about 40% of the population's electricity needs with geothermal power generated at the Ribeira Grande field. This figure is expected to double over the next few years.[162]

Geothermal Development Highlights

▪A forecasted investment of about €200 million will be directed to expanding the Ribeira Grande power plant.[163]

▪Extensive drilling is being conducted at the Pico Alto and Ribeira Grande fields. The drilling projects are expected to provide additional capacity for new investments that will potentially increase the portion of geothermal energy to 75% of power generated by 2018.[164]

▪In 2008, private investors were granted concessions for geothermal exploration over 2655 km2. Potential small scale generation projects could add up to 12 MW generating capacity from geothermal resources.[165]

▪Kernow Resources and Development Inc., in a joint venture with Green Bull Energy, is exploring geothermal resources in the Chaves in Northern Portugal.[166]

▪Petratherm and Enel Green Power signed a memorandum of understanding to assess and develop geothermal projects on the Iberian Peninsula, which encompasses Spain and Portugal.[167]

National Policies

While Portugal does have "Modified feed-in tariffs for renewable" (2007), the law currently does not mention geothermal.

Romania

Currently, geothermal resources in Romania are utilized for "space and district heating, bathing, greenhouse heating, industrial process heat, fish farming and animal husbandry."[168] Minor projects are under evaluation in the Oradea reservoir. A planned pilot binary unit project in the area never entered construction, but the project has not been entirely abandoned.[169] Petrom, Romanian oil and gas production company, has stated that it is "examining several projects" in the renewable energy sector, including geothermal.[170]

National Policies

Policy (year)	Description
Renewable Energy Law (2007)	Incentives for renewables, including geothermal, lasting up to 15 years after new power plant completion[171]

Russia

Geothermal resources in Russia are located primarily in the Kamchatka Peninsula and the Kuril Island with a combined potential of up to 2000 MW geothermal power available for electric production.[172] Geothermal development for heat supply is planned in the Krasnodar and Kaliningrad Regions.

Geothermal Development Highlights

▪A 6.5-MW binary plant is under construction at Verkhne-Mutnovsky, with a second 100 MW plant under initial development. The projects are located in the Kamchatka peninsula, operated by SC Geoterm. Additional exploration of the high-potential region is expected in the coming years.[173]

▪A 2.5-MW Pauzhetsky binary power plant is being planned in Kamchatka, as is a 12 MW extension to the existing Mutnovsky GeoPP (currently 50 MW).[174]

National Policies

Policy (year)	Description
State Policy Guidelines for Promoting Renewable Energy in the Power Sector (2009)	Sets targets for share of electricity generated from renewable at 1.5% in 2010, 2.5% in 2015, 4.5% in 2020, in addition to strengthening state oversight measures. Also calls for the establishment of feed-in premiums.[175]

Serbia

Serbia's most promising geothermal areas are located in the Pannonian and Neogen provinces.[176] Geothermal energy in Serbia is currently being utilized for space heating and heat pumps, agriculture, and balneology. Increases in geothermal exploration and development investments are likely due to Serbia's decision last year to introduce feed-in tariffs of € Cents 7.5/kWh of electricity derived from geothermal resources.[177]

Geothermal Development Highlights

▪In February, Southern European Exploration (SEE) was granted three licenses to explore geothermal energy in Kupusina, Adorijan, and Vrbica, located in the Vojvodina region in Northern Serbia, and one exploration permit for Vranjska Banja in Southern Serbia.[178] SEE is the wholly-owned subsidiary of Canadian Reservoir Capital Corp.

Slovakia

A 5-MW binary project is currently under evaluation in Kosice, located in the south east part of the country with low-temperature geothermal potential.[179]

National Policies[180]

Policy (year)	Description
Feed-in Tariff (2009)	Feed-in tariffs for geothermal energy are established at € Cents 15.2/kWh, classified into the following categories: <50kW; >50 kW<1,000 kW; and >1 MW<10 MW
Environmental Fund (2005)	Provides grants and soft loans to promote energy efficiency and renewable energy.

Spain (Canary Islands)

A surge of interest in geothermal energy is resulting in the development and exploration of geothermal resources in Spain and on the Canary Islands. Institutional support for geothermal development is a prominent factor bolstering the status of geothermal in Spain.

Geothermal Development Highlights

▪Two separate 20-MW projects are under evaluation in Tenerife and Gran Canaria, located in the Spanish Canary islands.[181]

▪Petratherm España signed an agreement with the Spanish Federal and the Madrid Regional governments to develop an 8-MW Madrid Geothermal District Heating Project. The project is part of a larger push to advance renewable energy developments in the region as part of the Madrid Regional Government's Renewable Energy Cluster. Petratherm has an additional four investigation permits to explore geothermal areas in the Valles and Abro Basins, near Barcelona.[182]

▪Petratherm España is also conducting extensive magneto-telluric surveying on the Spanish Canary Island of Tenerife to identify additional deep-test well sites.[183] Petratherm is working with Sinclair Knight Merz, a global geothermal consulting firm, and local volcanologists to conduct further studies on the Canary Islands.

▪In the continuously evolving analysis of geothermal potential, EGEC reports that scientists at the University of Oviedo "are looking into the potential of mine shafts as a source of geothermal energy". If projects utilizing an existing mine tunnel in the area come to fruition, they could generate energy for homes, businesses and industrial units in the vicinity.[184]

National Policies[185]

Policy (year)	Description
Feed-in Tariffs (2007, modified 2009)	Renewable energy facilities not exceeding 100 MW are eligible for feed-in tariffs fixed at € Cents 6.9/kWh for 20 years or premiums at € Cents 9.5/kWh with no limit for geothermal
Regulatory Framework for Administrative Procedures for Renewable Energy Facilities (2009)	Renewable energy power projects have to be pre-registered before becoming eligible for feed-in tariffs. Prerequisites to registering include having adequate funding to cover a minimum 50% of investment costs and an € 20/kW financial guarantee needs to be deposited with the Directorate General for Energy Policy and Mines.
National Plan for Scientific Research, Development, and Technological Innovation 2008-2011 (2008)	Funding for RD&D activities supporting sustainable energy production, including greater use of renewable energy.
Spanish Strategy on Climate Change and Clean Energy 2012-2020 (2007)	Sets an overall objective of 37% renewable energy contribution to gross electricity consumption by 2020.

Switzerland

Switzerland is majorly invested in direct-use geothermal application. Energy from geothermal resources is estimated to have offset 560,000 tons of carbon dioxide emissions per year.[186]

Geothermal Development Highlights

▪Geowatt AG, a Swiss company, is conducting further seismic studies in conjunction with a potential geothermal project in St. Gallen in Northern Switzerland. A geothermal power plant at the location could generate between 3 and 5 MW electricity and 30 MW thermal for heating. Financing of around US$ 135 million, which would cover the cost of development and of extending St. Gallen's district heating grid, is expected to be decided on in 2010.[187]

▪New geothermal drilling technology is reported to be under development at a technical university in Zurich. The new technologies could allow for more cost-effective drilling at greater depts.[188]

▪A large-scale, US$ 173 million geothermal district heating scheme is being planned for the city of Geneva. The scheme was initiated by Services Industriels de Genève (SIG), the local power company, in coordination with the Federal Energy Office. Borehole drilling is expected to begin this year.[189]

National Policies[190]

Policy (year)	Description
Swiss Energy Action Plan (2001)	Sets goals to reduce consumption of fossil fuels by 10% below 1990 levels, cap electricity demand growth at 5% and increase share of renewable energy (specific targets for renewable are: 3,000GWh of heat, 500 GWh of electricity)
Feed-in Tariffs (2008)	Feed-in tariffs determined by technology, size, and application over 20 years for geothermal plants. Plants <5 MW will receive CHF 0.30/kWh, plants <10 MW will receive CHF 0.27/kWh, plants <20 MW will receive 0.17/kWh.
Energy Supply Act (2007)	Provides for feed-in tariffs and sets a national goal of 5.4 TWh generated by renewable energy sources by 2030

The Netherlands

While interest in geothermal resources is relatively new in The Netherlands, interest in geothermal development continues to increase; drilling activities in at least two locations are anticipated this year and the number of deep drilling license applications has increased to more than 40.[191] A feasibility study is underway for a pilot binary project, aided by drilling and geological expertise from the country's active Oil and Gas industry.[192]

United Kingdom

Because traditional geothermal resources are not commonly available in the United Kingdom, EGS technology provides an inroad to exploiting geothermal potential in the area.

Geothermal Development Highlights

▪A 3-MW geothermal demonstration project is planned near St. Austell, Cornwall, sponsored by the Eden Project and EGS Energy Limited at £15 million. The project could result in a series of 50-MW geothermal power plants being developed in suitable areas across the country. EGEC reported in July 2009, "experts believe there is enough untapped energy in the granite below Cornwall alone to provide a tenth of Britain's electricity." [193]

▪Geothermal projects in England, Scotland, and Wales will be eligible for shares of £6 million being funded by the UK Department of Energy and Climate Change to conduct exploratory work to identify viable geothermal sites in the UK.[194]

▪Plans for an additional geothermal project are being developed by Geothermal Engineering Ltd. For a 10-MW power plant near Redruth, Cornwall. Pending drilling approval, drilling is expected to begin in 2010, with a projected completion in 2013. Geothermal Engineering Ltd has expressed intent to deliver up to 300 MW of geothermal power to the South Western United Kingdom in the next twenty years.[195]

National Policies[196]

Policy (year)	Description
Renewables Obligation Order (2002, amended 2009)	Sets electricity supplier obligations of renewable energy-sourced power at 9.7% for 2009-10 rising to 15.4% by 2015-16. Companies can meet their obligations by presenting Renewable Obligation Certificates, by paying a buy-out price currently set at GBP 37.19 adjusted annually with RPI, or a combination of the two.
Energy Act 2008 (2008)	Strengthens Renewables Obligation, enables the introduction of feed-in tariffs
Climate Change Act (2008)	Imposes legally-binding green house gas reductions targets on the UK: 80% reduction below 1990 levels by 2050 and (recommended) 34% reduction by 2020.

NORTH AMERICA

A large portion of the world's installed geothermal generation capacity remains in North America. With approximately 3086 MW of installed geothermal capacity the US is the world's leading producer of geothermal energy for electricity generation.[197] Mexico, with 958 MW of geothermal energy on line, ranks fourth in global installed geothermal capacity.[198]

An abundance of geothermal resources as well as concerns over domestic energy security and climate change have fueled the expansion of the geothermal industry in North America and government has played an important role in facilitating industry growth. In the US the Renewable Energy Production Tax Credit (PTC), provided by the federal government to developers who bring renewable energy projects on line, has acted as a significant driver to geothermal development. Additionally, ambitious state renewable portfolio standards in the Western US have also served as an incentive to geothermal developments in that region.

The geothermal industry continues to develop geothermal resources throughout North America. Not only is there significant development taking place in the US, but Mexico and Canada each have three and six projects under development, respectively. Additionally, the Canadian Geothermal Energy Association recently released its Canadian Geothermal Code for Public Reporting, which will serve to provide transparency, consistency, and confidence in the public reporting of geothermal exploration results.[199]

Canada

No geothermal resources have been developed for power production in Canada to date. However, interest in diversifying energy portfolios through the production of local renewable energy sources has resulted in a number of geothermal projects in development in the countries western provinces of British Columbia and Alberta.

Geothermal Development Highlights

▪The South Meager project in British Columbia is widely considered to be the most advanced project in Canada and it is estimated that the resource could support up to 100 MW of geothermal power.[200]

▪Sierra Geothermal Power, Corporation recently won a bid for the exploration and possible development of the Knight Inlet geothermal parcel.[201]

Projects under consideration

Project Name	Developer	Location
Knight Inlet	Sierra Geothermal	British Columbia
Swan Hills Geothermal	Borealis GeoPower	Alberta
ADK Geo. Demo.	Borealis GeoPower	British Columbia
South Meager	Ram Power	British Columbia
NA	Aqua Terra	British Columbia
NA	Aqua Terra	British Columbia

National Policies

The Canadian Geothermal Industry's trade association, CanGEA, recently released its Canadian Geothermal Code for Public Reporting. While not a direct policy incentive the Canadian Reporting Code is intended to promote the development of geothermal energy by providing transparency, consistency, and confidence in the public reporting of geothermal exploration results as well as geothermal resource and reserve estimates. The increased transparency and standardization provided by the Code is intended to increase investor, stakeholder, and capital market confidence in the Canadian geothermal energy sector.[202] Although not a national policy, the Province of British Columbia recently enacted its Clean Energy Act which promotes the development of a regionally energy industry and sets a goal of 93% of its electricity being generated from renewable energy.[203]

National Policies[204]

Policy (year)	Description
Updated Tax Incentives for Investments in Renewable Energy	Allows investors an accelerated write-off on certain equipment used in the production of renewable energy. Incentive amount: 50% of capital costs
Clean Energy Fund	Provides funding to renewable energy research and demonstration projects through 2014. Incentive amount: CAD 200 million for renewable energy demonstrations
EcoEnergy for Renewable Power	Between April 2007 and March 2011 the program will Invest CAD 1.5 billion to promote growth of the renewable sector. Incentive amount: CDN 1cent/kWh for up to 10 years
Trust Fund for Clean Air and Climate Change	Provides funding to province-based initiatives promoting the development of renewable energy resources. Incentive amount: CAD 1.5 billion total

Mexico

Since 1973 when Mexico's Cerro Prieto geothermal power plant (720 MW) came on line the country has been a significant player in the global geothermal industry. Power generation currently occurs at three other geothermal fields in Mexico: Los Azufres (188 MW), Los Humeros (40 MW), and Las Tres Virgenes (10 MW).[205] Geothermal plant operators and developers intend to expand the production capacity of Mexico's geothermal resources and companies are engaged on a number of projects.

Geothermal Development Highlights

▪Recently, the Mexican state power company CFE awarded a drilling tender to Industrial Perforadora De Campeche (IPC) to drill 30 wells at Cerro Prieto to provide steam for a new 100-MW geothermal power plant.[206]

▪Plans for the expansion of the Los Humeros geothermal resource will bring an additional 50 MW on line there. French firm Alstom received a US$ 61 million contract to design and construct one of the geothermal power plants at Los Humeros.[207]
▪The Cerritos Colorados geothermal plant is reportedly under development.[208]

National Policies
The Mexican government has provided policy incentives to drive the development of its renewable energy sources including geothermal energy. In 2005 the Accelerated Depreciation for Environmental Investment law was enacted making it possible for investors in renewable energy projects to deduct up to 100% of their first year investment.[209]

The United States of America

The United States continues to lead the world in geothermal electricity production with approximately 3086 MW of installed capacity from 77 power plants. Geothermal developers have been actively developing geothermal resources in the western US for the past five years and brought approximately 176 MW of geothermal electricity on line in 2009.[210]

US Power Plants Brought On line in 2009

Plant Name	Operator	MW	Plant Type
Faulkner 1	Nevada Geo Power	50	Binary
North Brawley	Ormat	50	Binary
Stillwater	Enel NA	47	Binary
Salt Wells	Enel NA	18	Binary
Thermo	Raser	10	Binary
OIT	Oregon Institute of Technology	0.28	Binary
RMOTC	Rock Mountain Oil Testing Center	0.25	Binary Co-production
Total		**175.5**	

Source: GEA

The geothermal industry in the US continues to increase its development activity and is currently developing 188 geothermal projects in 15 different states. Taken together, these projects constitute a range of 4584 to 7875 ME of geothermal energy in production.[211]

Projects in Development Totals by State

State	Phase 1 to Phase 4	TOTAL (with unconfirmed)
Alaska	5/35 MW	7/80 MW
Arizona	0 MW	1/2 – 20 MW
California	29/1402.8 – 1765.8 MW	35/1609.7 – 1997.7 MW

Colorado	1/10 MW	1/10 MW
Hawaii	2/8 MW	2/8 MW
Idaho	9/413 – 676 MW	12/413 – 676 MW
Louisiana	2/5.3	2/5.3 MW
Mississippi	1/0.05	1/0.05 MW
Nevada	68/1804.43 – 3265.43 MW	86/2120.43 – 3686.43 MW
New Mexico	2/35 MW	2/35 MW
Oregon	11/242 – 373 MW	15/342 – 473 MW
Texas	1/0.4	1/0.4
Utah	20/628 – 883 MW	21/628 – 883 MW
Washington	0/Unspecified	1/Unspecified
Wyoming	1/0.28	1/0.28
Total	152 Projects 4584.26 – 7057.26 MW	188 Projects 5254.21 – 7875.16 MW

Source: GEA

Project development in the US geothermal industry continues to focus on conventional hydrothermal resources located in the country's western regions. However, new technologies are emerging that are expanding the geological reach of geothermal energy within the US. Oil and gas co-production offer an opportunity to use geothermal technologies to utilize the heat from produced water (a by-product of oil and gas production) to generate clean electricity from oil and gas wells. Geothermal technologies are also being developed to develop geopressured resources where mechanical pressure from highly pressurized natural gas, the heat from co-produced geothermal brine, and the natural gas itself can be utilized to produce energy. In its recent April 2010 *US Geothermal Power Production and Development Update,* the Geothermal Energy Association (GEA) identified 5 different co-production and geopressured projects in the states of Nevada, Texas, Louisiana, and Mississippi.[212]

The geothermal industry in the US is also working to develop and implement technologies that will make the production of electricity from enhanced geothermal systems (EGS) possible. EGS refers to the artificial stimulation of geothermal resources to produce electricity. This includes developing geothermal resources that have to be fully engineered, or ones that produce hydrothermal fluid sub-commercially, to produce electricity. In its recent report the GEA identified seven federally funded EGS projects in development in five different states.[213]

Policy Drivers for Geothermal Growth in the US

State/Federal Renewable Standards

State	Renewable Standard Target (percent of energy mix)	Target Year
Alaska	None	NA

Arizona	15	2025
California	33	2020
Colorado	20	2020
Florida	None	NA
Hawaii	20	2020
Idaho	None	NA
Nevada	25	2025
New Mexico	20	2020
Oregon	25	2025
Utah	20	2025
Washington	15	2020
Senate RPS Proposal	15*	2021
House RPS Proposal	20**	2020

Source: GEA

* 4% can be efficiency

* 8% can be efficiency

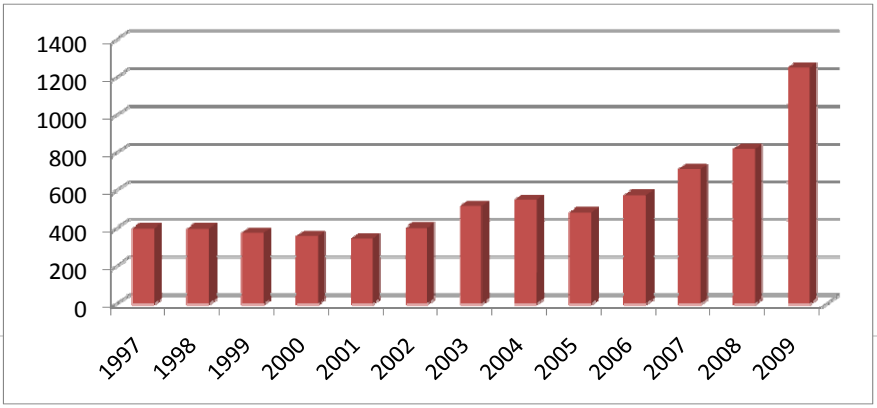
Federal Tax Incentives as Expanded by 2009 Federal Stimulus Legislation (ARRA)[214]

- A three year extension of the production tax credit (PTC) making geothermal power facilities placed in service by December 31, 2013 eligible for the full credit,
- Extension of the 30% investment tax credit (ITC) to new geothermal energy projects and in some cases allowing developers to apply for a cash grant in lieu of the ITC,
- Adoption of a new 30% credit for companies manufacturing renewable/geothermal power equipment,
- US$ 1.6 billion in new bonding authority for Clean Renewable Energy Bonds, used to finance new renewable power projects by public power, municipal and government entities,
- Up to US$ 6 billion in loan guarantees for new renewable/geothermal power projects, explicitly for commercial technologies,

Federal Leasing and Permitting

Since revision of the law governing geothermal leasing in 2005, there has been a steady increase in lease sales and as a result land under lease for development.

Federal Land Under Lease for Geothermal Development



To facilitate federal land leasing, the Bureau of Land Management (BLM) and the USDA Forest Service (FS) prepared a joint Programmatic Environmental Impact Statement (PEIS) to analyze and expedite the leasing of BLM- and FS-administered lands with high potential for renewable geothermal resources in 11 Western States and Alaska.

The Programmatic EIS recommended: 77% of BLM and Forest Service managed lands should be open to geothermal leasing.

- BLM - 118 million acres open to leasing, 25 million acres closed.
- NFS - 79 million acres open to leasing, 24 million acres closed.[215]

The Record of Decision (ROD) was signed on December 17, 2008. The ROD amends 114 BLM land use plans.

DOE/Industry Technology Development

The DOE Geothermal Technologies Program (GTP) was provided US$ 400 million to spur new jobs, new technology, and the geothermal marketplace. DOE developed a series of specific solicitations to support industry and technology advancement. On October 29, 2009 the Department of Energy announces US$ 338 million in awards to accelerate domestic geothermal energy as follows:

- Innovative Exploration and Drilling Technology: 24 Projects, up to US$ 98.1 million.
- Coproduced, Geopressured, and Low Temperature Resource Development: 11 projects up to US$ 20.7 million.
- Enhanced Geothermal Systems Demonstrations: 3 Projects up to US$ 51.4 million.
- Advanced Geothermal Systems Components Research and Development: 45 Projects up to US$ 81.5 million.
- Geothermal Data Development, Collection and Maintenance: 3 Projects up to US$ 24.6 million.
- Ground Source Heat Pump Demonstrations: 37 Projects, up to US$ 61.9 million.[216]

PACIFIC ISLANDS

Located along the legendary Ring of Fire, the Pacific Islands are host to some of the largest resources of geothermal energy in the world. As much as 40% of the world's geothermal potential is found in Indonesia alone. The Philippines is one of the highest producers of the energy source, and both Indonesia and the Philippines have each announced separate intentions to become the world leader in geothermal production. New Zealand has several developments and policies to support the development of its geothermal resources. While parts of the Pacific are well-established geothermal development hubs, others are just getting started. Australia has been making political strides and is working on getting its first geothermal power plant on line. Geothermal resources are seen as an answer in combating the high prices of diesel generation, currently the main source of electricity for many Pacific islands.

There are many nations in the Pacific with high levels of untapped geothermal potential. KUTh Energy and a few other companies have recently begun explorations on several islands with no prior development - such as Fiji and Vanuatu.

The Energy Development in Island Nations (EDIN) is an international partnership between Iceland, New Zealand and the US to further the use of energy efficient and renewable energy technologies in island nations and territories. This effort is based on a study of 20 island nations conducted by GNS Science, New Zealand's leading earth systems research institute, released in June 2009 and covering 20 Pacific island nations.[217]

Australia

In Australia, geothermal resources are primarily found in South Australia and Tasmania and along the southern Victorian coastline. Despite vast resource potential, only 80 kw at one geothermal station is currently on line. This small plant built in the early 1990s produces one-third of the power for the town of Birdsville, Queensland.[218] In 2009 it was reported the government of Queensland will invest up to AU$ 4.3 million to upgrade the station.

Geothermal Development Highlights [219]

▪Proof of concept was successfully established at an EGS (hot fractured rock) project in the Cooper Basin; South Australia in March 2009
▪Petratherm's Paralana 2 well in South Australia was completed in December 2009
▪Two geothermal projects were awarded grants in 2009 subject to successful offer negotiations under the Renewable Energy Development Program: Paralana, SA (MNGI Pty Ltd – US$ 62.762 million) and Cooper Basin, SA (Geodynamics Limited – US$ 90.000 million)
▪The Penola Project Salamander-1 Well by Panax and Hot Rock completed drilling on March 16, 2010
▪The Geothermal Drilling Program has awarded US$ 7 million each under two rounds to the following projects: Paralana, SA (MNGI Pty Ltd); Limestone Coast, SA (Panax Geothermal Ltd); Koroit in the Otway Basin, Victoria (Hot Rock Ltd); Hunter Valley, New South Wales (Geodynamics); Perth, Western Australia (GRE Geothermal WA1 Pty Ltd); Geelong, Victoria (Greenearth Energy Ltd); and Parachilna, SA (Torrens Energy Ltd)

Projects in Development

Developer	Location(s)
KUTh Energy	Tasmania North Queensland
Panax Geothermal	SA (Penola) SA(Limestone Coast)
Fall River Resources	SA
Green Rock Energy	WA (North Perth Basin) SA (Roxby Downs)
Greenearth Energy	Victoria (RMIT University Bundoora Campus) Victoria
Geodynamics	New South Wales (Hunter Valley) SA (Innamincka) SA (Cooper Basin)
Petratherm	SA (Paralana) SA (Renmark) Victoria (East Gippsland)
Pacific Hydro	
Torrens Energy	SA (Parachilna)
Southern Gold Ltd	SA (Roxby Downs)
Hot Rock Ltd	SA (Penola) SA (Otway Basin)
Origin Energy	

National Policies[220]

Policy (year)	Description
Australian Capital Territory Electricity Feed-In Tariff Scheme (2009)	producer entitled to 3.88 times the transition franchise tariff retail price applying at the time for a period of 20 years
Renewable Energy Development Program (2009)	$235 million awarded to four commercial-scale renewable energy projects
Australian Trade Commission (Austrade) - Clean Energy Export Strategy (2008)	$14.9 million over three years for the clean energy sector
Geothermal Drilling Program (2008)	$50 million to companies seeking to develop geothermal energy with the cost of proof-of-concept projects
Geothermal Industry Development Framework and Technology Roadmap (2008)	a comprehensive approach to industry development; incorporates a geothermal energy technology roadmap examining R&D needs
Victorian Renewable Energy Target (2007)	mandates Victoria's consumption of electricity generated from renewable

	sources be increased to 10% by 2016

Fiji

Natural thermal areas are abundant and have been recorded and surveyed throughout the Fiji islands. The island of Viti Levu has the greatest population and energy requirements but already has inexpensive hydro power. The other main island of Vanua Levu has little hydro power and the hottest geothermal fields.[221] Fiji does not currently have any installed geothermal power.

Geothermal Development Highlights

▪Local Geothermal Electric Ltd. has been granted a license to explore for geothermal resources at Savusavu
▪Australian KUTh Energy has four tenement applications pending
▪Australian Morgan Mitchell Investments is in the process applying for geothermal exploration licenses
▪US TriModal has signed a contract to supply 1100 MW of combined geothermal, solar, and wind power to Fiji

Indonesia

With an impressive 28,100 MW potential, Indonesia has approximately 40% of the world geothermal energy reserves.[222] Of that, 1,197 MW has been exploited.[223] Indonesia ranks third in the world in terms of geothermal energy consumption, after the US and the Philippines. It is also the third biggest emitter of greenhouse gases and aims to cut emissions by 16% by 2025. The Indonesian government recently announced it has signed US$ 5 billion worth of geothermal energy deals, and it has a goal to reach 9,000 MW from geothermal resources by 2025 and to be the world's largest producer of geothermal energy.[224] Indonesia hosted the 2010 World Geothermal Congress.[225]

Geothermal Development Highlights

▪Tata Power Company and PT Supraco have partnered for the Sorik Merapi geothermal plant in North Sumatra. It will be built at 55 MW and could be expanded to 200 MW.[226]
▪In April 2010, the US Trade and Development Agency announced US$ 1.6 million in grants for feasibility studies. US$ 732,722 will go to PT Star Energy for the 370-MW Jailolo plant in Halmahera. US$ 934,308 will go to PT Indonesia Power for the 300-MW Tangkuban Perahu project in West Java and Raser Technologies will be the sole source contractor.[227]
▪Pandawa Energy is looking to develop two geothermal resource areas on Java and three on other Indonesian islands.[228]
▪In April 2010, Indonesia signed a 7 million euro loan from Germany for geothermal projects.[229]
▪The World Bank has announced US$ 400 million for geothermal development in Indonesia
▪The East Java Investment Agency is optimizing priority for geothermal in the province, with 11 potential locations

Projects in Development

Developer	Location
Sumitomo (from Japan)	South Sumatra

PGE (Pertamina Geothermal Energy)	South Sumatra (Lumut Balai) South Sumatra (Ulubelu) South Sumatra (Hululais) South Sumatra (Lpenuh River) North Sulawesi (Lahendong) North Sulawesi (Kotamobagu) West Java (Kamojang Unit 5) West Java (Karahas Bodas)
Chevron Geothermal	West Java (Darajat Mountain, Garut)
Medco Energi, Ormat Technologies and Itochu Corp.	North Sumatra
Star Energy	West Java (Bandung, Wayang Windu)
Ormat, Medco Energy, Kyushu Electric Power and Itochu	North Sumatra (Sarulla)
Terra Energy	Java

National Policies

Policy (year)	Description
Presidential Decree (2010)	allows mining, power plants and other projects deemed strategically important into protected forests
Tax Exemptions (2010)	government will reduce net tax by 5% per year on total investment for 6 years
National Energy Blueprint (2005)	identifies short- and long-term development objectives in the electricity sector, with geothermal target 9,500 MW
Green Investment Fund	letters sent to embassies in Jakarta for funding from foreign investors
Fast-Track program For Private Sector Power Producers	

Japan

Japan has 536 MW of installed geothermal electric generating capacity, about 5% of the world total. Sixteen geothermal power plants are in operation, most located in the Tohoku and Kyushu districts. Japan has a target of a 25% reduction of greenhouse gases emissions in 2020 compared to the 1990 level. [230] The Institute for Geo-Resources and Environment (GREEN) of the National Institute of Advanced Industrial Science and Technology (AIST), a public research facility, included an active Asia Geothermal Research Group from 2001 to 2003. [231]

Geothermal Development Highlights

▪There have not been large developments of geothermal power plants in Japan in recent years, but Mitsubishi Materials Corp. and J-Power have plans to develop at Wasabizawa in Akita

prefecture. Estimates put the expected capacity around 30 MW of power and the venture expects to open in 2016.

National Policies

Policy (year)	Description
Feed-in tariff (proposed) (March 2010)	for geothermal and other renewables
EIMY; Energy In My Yard	local energy demands should be met from an optimum combination of local and renewable sources
Geothermal Development Promotion Surveys (started in 2004)	NEDO to carry out advanced studies in likely locations to advance the development of geothermal power generation by private-sector[232]
Renewable Portfolio Standard system (2003)	the utilization target for fiscal 2014 was established at 16 billion kWh as a realistic and ambitious goal, but does not currently include geothermal energy
Support for Deployment of New and Renewable Energy (1997)	
Subsidy for RD&D for New and Renewable Energy (1997)	30.9 billion yen in FY2008 for various renewable R&D projects
Project for Geothermal Power Generation Development (1980)	Prior to 1999, METI was responsible for subsidizing activities for developing geothermal power generation

New Zealand

The first geothermal plant in New Zealand was opened at Wairakei in 1958 as the second large-scale geothermal plant completed in the world, after Larderello, Italy. Geothermal energy now makes up approximately 10% of the country's electricity and has an installed capacity of 628 MW. High-temperature geothermal fields are mostly concentrated around the Taupo Volcanic Zone in the central North Island.[233]

Geothermal Development Highlights

▪The 140-MW Nga Awa Purua Geothermal Power Station became fully operational April 8, 2010.

Projects in Development

Company	Location(s)	MW
Contact Energy	Taheke geothermal field Taupo – Tauhara Taupo – Tauhara 2 Te Mihi	-- 23 250 220
Mighty River Power	Taupo – Nga Awa Purua Taupo – Ngatamariki	132 to 140

	Taupo - Kawerau	
TeArawa iwi	Bay of Plenty, Rotorua	

National Policies[234]

Policy (year)	Description
Electricity Industry Reform Act Amendment (2008)	separates electricity lines and competitive generation and favors renewable energy resources
Projects to Reduce Emissions (Project Mechanism) (2003)	carbon credits for projects to reduce carbon emissions
Energy Efficiency and Conservation Act (2000)	placed emphasis on the importance of renewable energy sources with the development

Papua New Guinea

Surface geothermal activity has been identified in 55 areas, with the majority associated with active volcanism in the Melanesian Arc. Exploration surveys have been carried out in of many of these areas, particularly in New Britain. Geothermal power generation was commissioned in April 2003 on Lihir Island, New Ireland Province, and was expanded to 56 MW in 2007. Estimates have put the country's potential to generate geothermal power at 3,000 to 4,000 MW.[235]

Geothermal Development Highlights

▪The Australian KUTh Energy has carried out some exploration work in Papua New Guinea, with their license application reportedly on hold. Papua New Guinea's government has been encouraged to consider the country's geothermal reservoirs as a major source of renewable energy in the future.

Philippines

The portable 3,000-kE Leyte Geothermal Pilot Plant began operation in July, 1977 as the first geothermal power plant in the country. The Philippines now follows the US as the second highest producer of geothermal power in the world, with 1,904 MW. Energy from geothermal power plants in the islands of Luzon, Leyte, Negros and Mindanao make up approximately 18% of the country's electricity generation.[236] The country's total estimated potential of untapped geothermal resource is about 2,600 MW.[237] The government hopes to increase the on line capacity to 3,100 MW within a decade and to surpass the US as the geothermal power production leader.[238]

Geothermal Development Highlights

▪As of April 2010, the Philippines DOE has awarded 8 out of 10 bid geothermal sites under the Philippine Energy Contracting Round, an open and competitive selection process, and is reviewing two geothermal contract areas (Sta. Lourdes-Tagburos, Palawan, 1 MW; Cagua-Baua, Cagayan, 40 MW)[239]

▪DOE awarded two geothermal service contracts to Philippine National Oil Co.-Renewables Corp. with an estimated total generating capacity of 40 MW
▪Ground was broken in Bataan on two geothermal plants that will together produce 600 MW[240]
▪In February 2010, DOE signed 6 service contracts for geothermal projects, for a projected capacity of 315 MW.
▪EDC won in bid and plans to expand the Bacon-Manito geothermal expansion project, adding 90 MW to the existing 150 MW

Geothermal Projects in Development

Developer	Location (MW)
Envent (Biliran Geothermal)	Biliran, Eastern Visayas region
Primary Energy Corp.	Sta. Lourdes, Palawan
Filtech Energy Drilling Corp./Constellation Energy Corp.	Biliran Leyte
Petroenergy Resources Corp.	Mount Makiling (20-40)
APC Group	Kalinga and Apayao provinces
EDC (Energy Development Corporation)	Bacon-Manito Geothermal Production Field Mt. Ampiro, Misamis Occidental (30) Balingasag, Misamis Occidental (20) Lakewood, Negros Occidental (40) Mandalagan, Negros Occidental (20) Mt. Zion, North Cotabato Tanawon (40) Apo (50)
Chevron Geothermal Philippines Holdings	Kalinga (100)
Basic Energy Corp.	Batangas
Korea International Cooperation Agency (Koica)	
Philippine National Oil Co.-Renewables Corp.	Mainit-Sadanga, Mt. Province (80) Buguias-Tinoc, Benguet, Ifugao (60)

National Policies[241]

Policy (year)	Description
Renewable Energy Law (2008)[242]	benefits to RE developers include seven-year tax holiday, carbon credits from RE are tax-free, and requires energy self-sufficiency to 60% by 2010
Resource Management Act (1991)	regulated access to natural and physical resources such as land, air and water, for the sustainable use of these resources
An Act to Promote the Exploration and Development of Geothermal Resources (1978)	provides incentives for the development of geothermal operations
Rotorua City Geothermal Energy	enabled the Rotorua City Council to make

Empowering Act (1967)	provisions for the control of the tapping and use of geothermal energy in the city of Rotorua
Geothermal Energy Regulations (1961)	defined the role of "geothermal inspectors" and specified processes for applications for authorities and licenses
Geothermal Energy Act (1953)	granted water rights, which have generally been replaced by RMA resource consents

Samoa

No surface geothermal features are reported in Samoa, although Savai'i and Upolu both posses well developed rift systems. Savai'i has seen volcanic eruptions as recently as 1911.[243] Samoa's Minister of Natural Resources and Environment, Faumuina Tiatia Liuga, was quoted in January 2009 that his ministry will present a report to the cabinet to consider geothermal energy. Minister Faumuina also reportedly explored renewable energy projects in talks with Chinese Vice-Minister of Commerce Fu Ziying, who was visiting.[244]

Geothermal Development Highlights

▪Layman Energy Associates has conducted a grant-supported feasibility study for development of a geothermal power plant on Savai'i.[245]

Vanuatu

In Vanuatu, exploration for geothermal energy resources was first conducted in the 1980s and has been most prominent on the islands of Efate and Vannua Lava. In 1991, a report by GENZL/KRTA recommended two production-size wells of 1,500 to 1,800 m. Resources on Efate are close to major population centers, making it the best prospect for geothermal energy generation. The Vanuatu government has expressed interest in geothermal energy as a way to move away from diesel operations.

Geothermal Development Highlights

▪In December 2009, the Australian KUTh Energy announced they would commence geothermal exploration activities on Efate Island. KUTh has signed a Memorandum of Understanding (MOU) with Vanuatu's power provider UNELCO.[246]
▪Layman Energy Associates has conducted a grant-supported feasibility study for development of a geothermal power plant on Efate Island.[247]

SOUTH AMERICA

As a region, South American energy consumption and demand is projected to grow by 60% through 2030.[248] In order to address growing energy demand, as well as issues related to energy security and climate change, South American countries are seeking to develop their renewable resources. For countries along the Andean Mountain Range, and especially in the Southern Cone, geothermal resources represent an opportunity to meet energy needs with a clean, baseload, sustainable form of energy.

While no geothermal power plants are currently producing geothermal energy on the continent, certain South American countries, namely Chile and Argentina, are working to encourage geothermal development within their own borders through the implementation of policy measures incentivizing the development of renewable energy resources, geothermal included.

Both local and foreign companies have taken an interest in the development of South America's geothermal resources. This is especially true in Chile, where local and international mining companies are looking to develop geothermal resources to help meet the electricity needs of their operations. Additionally, shortages of natural gas imports currently undermine Chile's energy security. The Chilean government has sold a number of geothermal exploration and development concessions to local and foreign geothermal developers in order to address issues stemming from increased energy consumption and demand.[249] While Chile stands out as the foremost among South American countries which are actively harboring the development of geothermal energy within its borders, the mining industry and local developers in Argentina are also working to develop geothermal resources there.[250]

Argentina

Argentina's geothermal resources are primarily located in the country's western regions along the Andes mountain range. Geologic and geophysical studies of certain geothermal resources occurred in Argentina as early as the 1970's and a 700 kW pilot plant was even operated at the Copahue field from 1988 to 1995.[251] Recent interest in developing Argentina's renewable energy resources has led to a number of companies seeking to develop the country's reserves.

Geothermal Development Highlights

▪ For information on the five different projects that are being developed in Argentina see the table below.

Projects in Development

Project Name	Developer	MW	Financing
Despoblados	Geotermia Andina	8-17	US$ 1.83 million
Copahue	Pampa Energia, Grupo Minero Aconcagua	30-60	US$ 60 million

Tuzgle[252]	Geotermia Andina	20-60	US$ 35-130 million
Unnamed Project	Copper King Mining Corporation	30-100	NA
Anetta	Area Geofisica, Americas Geothermal	NA	NA

National Policies[253]

Policy (year)	Description
Promotion of Renewable Energy Sources for Electricity Production (2007)	Provides a feed-in-tariff of US$ 0.37 per kWh for geothermal power plants for 15 years after the plant is brought on line; aims to raise the share of renewable energy in the nation's energy production portfolio to 8% by the end of 2016.[254]

Bolivia

Energy demand in Bolivia increased at a rate of 3.1% annually from 1980 to 2002.[255] While no geothermal installed capacity exists Bolivia's government is beginning to move to develop its geothermal resources to help meet increasing demand.

Geothermal Development Highlights

▪The Bolivian state power company, ENDE, has taken initial steps to develop the Laguna Colorada geothermal resource near the border with Chile in Sud Lipez, Potosi. Exploration work done in the early 1990's by the Italian company Enel has been updated in preparation for renewed geothermal exploration and production. The Andean Development Corporation, the Japan External Trade Organization, and the Japan Bank for International Cooperation are providing financial support to the project, which is expected to generate 100 MW when completed.[256]

National Policies

The Bolivian government enacted a rural electrification program in 2000 which promotes the development of renewable energy, including geothermal, in rural areas.[257] Additionally, regulation was passed in 1999 that provides grant incentives to rural electrification projects.[258]

Chile

In order to meet rising domestic energy demand, diversify its energy production portfolio, and to guard itself from fluctuating levels of imported Argentine natural gas, Chile is seeking to develop its geothermal resources. Estimates of the country's domestic geothermal resources by the Chilean Ministry of Mines indicate substantial potential of up to 16,000 MW.[259] Chile has

already attracted a number of foreign companies who are eager to develop the countries abundant geothermal resources.

Geothermal Development Highlights

▪GeoGlobal Energy, LLC. (GGE), with its New Zealand partner Mighty River Power, has obtained a permit to drill a second exploration well at the Tolhuaca geothermal resource site and expect results providing more information on the extent of the resource in the near future. GGE has already obtained a commercial extraction permit for the field which is estimated to be able to produce up to 75 MW. GGE also expects to being exploration drilling at the Puchuldiza project in late 2010.[260]

▪Magma Energy, Corp. was recently given an exploitation permit at the Maule geothermal resource by the Chilean government, enabling it to directly proceed with the construction of a geothermal power plant once initial exploration drilling has been completed. Magma has recently been drilling a series of slimhole wells into the geothermal reservoir at the Maule resource.[261]

Planned Geothermal Projects

Project Name	Developer
Galo	Hot Rock Ltd.
Santa Sonia	Hot Rock Ltd.
Santa Antonia	Hot Rock Ltd.
Pellado	Magma Energy
Maule	Magma Energy
Aucan I	Ram Power
Laguna Verde	Ram Power
Pica	Collahuasi
Tolhuaca Volcano	GeoGlobal Energy
Puchuldiza	GeoGlobal Energy
Alitar	GeoGlobal Energy
Colimapu	GeoGlobal Energy

National Policies

In December of 2009 and January 2010 geothermal concessions were recently awarded to the following companies:[262]

Energy Andina (5 concessions)
Geothermal Empressa Nacional (3 concessions)
Colbun (2 concessions)
Hotrock Chile (2 concessions)
Serviland Minergy (2 concessions)
Polaris Geothermal (2 concessions)
Ormat Andina (1 concession)

National Policies[263]

Policy (year)	Description
Non-conventional Renewable Energy Law	Requires energy providers in systems of an

(2008)	installed capacity of 200 MW or greater to demonstrate that 10% of energy provided comes from non-conventional renewable energy resources including geothermal. The quota was designed to come into force in 2010. Until energy providers are required to demonstrate that 5% of their provided energy comes from non-conventional renewable energy resources. After 2014 the obligation will increase by 0.5% annually until it reaches 10% in 2024.[264]
Law of Geothermal Concessions (2000)	regulate the exploration and development of the countries geothermal resources - delineates specific exploration as well as exploitation geothermal concessions

Peru

The majority of Peru's electricity generation comes from hydropower (65%) and natural gas (24%).[265] While, no geothermal resources have been developed for electricity production in Peru certain estimates indicate that the country has approximately 3000 MW of geothermal potential, most of which is located on the western slopes of the Andes Mountains and in the countries volcanic southern regions.[266] The development of Peru's geothermal resources would augment its energy production portfolio and help guard it against drought induced outages of its large hydropower sector. The Peruvian government has made recent efforts to promote the development of its geothermal resources.

Geothermal Development Highlights

▪Australian company Hot Rock Limited recently formed its Peruvian subsidiary Hot Rock Peru S.A. which has logged four geothermal exploration applications in southern Peru.[267]
▪Canada based Magma Energy Corporation also has exploration properties in Peru.[268]

National Policies

Currently the country's Law on Geothermal Resources is being re-drafted to provide improved standards and regulations for the utilization of Peruvian geothermal resources. Additionally, Peru is planning to launch a tender for a planned 500 MW renewable energy generation projects, of which geothermal is included, via its mining investment regulator Osinergmin.[269]

Notes on Additional Countries

In conducting research for this report, a number of countries were found to be exploring geothermal potential and discussing the possibility of developing programs to exploit domestic geothermal resources. However, we were not able to identify that projects were actively under consideration. These countries are: Albania, Azerbaijan, Bosnia and Herzegovina, Brazil, Bulgaria, Ecuador, Eritrea, Greenland, Lithuania, Macedonia, Malaysia, Northern Marianas Islands, Mongolia, Morocco, Mozambique, Saudi Arabia, South Korea, Sri Lanka, Sweden, Tajikistan, Tanzania, Uganda, Vietnam.

Sources for Information

For those interested in learning more about geothermal energy today, we recommend starting with publications available to download free of charge from GEA's web site (http://www.geo-energy.org/publications/reports.asp):

- A Guide to Geothermal Energy and the Environment. This 87-page booklet covers a wide range of environmental topics as well as provides an introduction to geothermal energy as this resource is being used today.
- A Handbook on the Externalities, Employment, and Economics of Geothermal Energy. This 65-page report covers economic, employment and other issues not examined, or not examined in depth, in the environmental guide.
- The State of Geothermal Energy, Part I: Subsurface Technology. A 70-page report that examines the technologies, risks and difficulties facing geothermal exploration, drilling and reservoir management. It looks at current and emerging technologies.
- The State of Geothermal Technology, Part II: Surface Technology. A 78-page document that covers how geothermal resources are used to provide energy for power plants, homes and commercial uses. It dissects the technologies used today and glimpses into the future.
- Geothermal 101: Basics of Geothermal Energy production and Use. A 53-page handbook covering many of the basic questions asked about geothermal energy.

Sources for International Geothermal Information

To stay current on developments in the US and around the world, we suggest the following sources of information:

- First, sign up for GEA's Geothermal Energy Weekly. It reports on the latest developments in geothermal markets and programs. You can contact GEA to be added to the distribution by emailing research@geo-energy.org. You can also view the Geothermal Energy Weekly online at www.geo-energy.org.

- The US Geothermal Energy Association maintains a web site with data and information about US power plants, policies, and projects under development. The GEA web site is at www.geo-energy.org.

- The International Geothermal Energy Association maintains a web site with data and information about international developments in the geothermal industry. The IGA web site is at www.geothermal-energy.org.

- Alexander Richter of Íslandsbanki operates a web site at http://thinkgeoenergy.com. "This Geothermal Energy News Website was created to provide a place to post industry news, e.g. deals, project and international development."

- The European Geothermal Energy Council (EGEC) maintains a website with information and updates about European geothermal project and policy developments. The EGEC newsletter is also available on the web site. The EGEC web site is at http://www.egec.org/.

- The International Energy Agency maintains a web site with frequent energy-related news updates. IEA also supports a searchable "Global Renewable Energy Policies and Measures" database. The IEA web site is at http://www.iea.org/. The database is available at http://www.iea.org/Textbase/pm/grindex.aspx.

Appendix A: Index of Key Geothermal Support Actors

African Rift Valley Geothermal Development Facility (ARGeo) – Developed by six East African countries with support from UNEP and GEF, among other institutions, ARGeo aims to accelerate both public and private investments in geothermal development and facilitate geothermal growth in the East African Rift Valley region.

Andean Development Corporation (CAF) – the Corporación Andina de Fomento (CAF) is the main source of multilateral financing of the Andean region and has also strengthened its presence throughout greater Latin America. With a focus on projects that contribute to regional integration, CAF mobilizes resources from international markets to both public and private clients in Latin America.

The CAF web site is at http://www.caf.com/view/index.asp?ms=17&pageMs=43181.

Central American Bank for Economic Integration (CABEI) – Central American financial institution focused on regional integration and the competitive insertion of Central America into the global economy. CABEI is a supporter of public as well as small to medium sized private ventures.

The CABEI web site is at http://www.bcie.org/english/index.php.

Geothermal Finance and Awareness in European Regions (GEOFAR) – Funded by the European Union, GEOFAR promotes geothermal energy development in Europe.

The GEOFAR web site is at http://www.energia.gr/geofar/default.asp?lng=1.

Global Environment Facility (GEF) – GEF is an independent financial organization comprised of 180 member governments partnering with additional international institutions, NGOs, and private companies to address global environmental issues.

The GEF web site is at http://www.gefweb.org/default.aspx.

European Bank for Reconstruction and Development (EBRD) - An international financial institution owned by 61 countries and two IGOs and supporting projects in 29 countries in Central Europe and Asia, EBRD provides funding for environmental improvement, among other projects that encourage the transition "towards open and democratic market economies."

EBRD web site is at http://www.ebrd.com/index.htm.

Inter-American Development Bank (IADB) – Development bank focused on reducing poverty and bringing sustainable development to Latin American and Caribbean countries. In addition to providing loans, IADB also provides grants, technical assistance, and research.

The IADB web site is at http://www.iadb.org/index.cfm?lang=en.

International Finance Corporation (IFC) – A member of the World Bank Group, IFC fosters growth in developing countries worldwide by financing private sector investment by accessing

capital in the international financial markets. IFC also provides advisory services to businesses and governments.

The IFC web site is at http://www.ifc.org/.

United Nations Environment Program (UNEP) – UNEP coordinates UN environmental activities and provides support for environmental policies and practices in developing countries.

The UNEP web site is at http://www.unep.org/.

GeoFund - World Bank Geothermal Energy Development Program – Promotes geothermal development in Europe and Central Asia by providing technical assistance and capacity building, supporting capital investment in geothermal projects, supporting policies and reforms to legal, regulatory and institutional frameworks that better facilitate geothermal development, and by monitoring trends of geothermal energy use between 2006 and 2015.

The GeoFund web site is at http://www.geofund.info/.

Appendix B: 39 Countries Identified in the 1999 GEA Report Which Could be 100% Geothermal Powered

Bolivia
Burundi
Comoros Islands
Costa Rica
Djibouti
Dominica
Ecuador
El Salvador
Ethiopia
Fiji
Grenada
Guadeloupe
Guatemala
Honduras
Iceland
Indonesia
Kenya
Malagasy Republic
Malawi
Martinique
Montserrat
Mozambique
Nicaragua
Panama
Papua-New Guinea
Peru
Philippines
Rwanda
Solomon Islands
Somalia
St. Kitts & Nevis
St. Lucia
St. Vincent
Sudan
Tanzania
Tonga
Uganda
Vanuatu
Yemen

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