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Geothermal Energy Development in Latin America and the Caribbean and the Role of International Development Partners

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ABSTRACT

The technical paper describes the geothermal status in Latin America and the Caribbean. Several development partners are active in the region aiming to assist in geothermal energy development. Project approaches differ depending whether they are conducted in the framework of technical or financial cooperation. Determining factors also include the funding source, multilateral, bilateral, regional bank funding and others. Project approaches are presented and their effectiveness analyzed.

1. INTRODUCTION

In Latin America and the Caribbean various bilateral and regional technical and financial support schemes were established for geothermal energy development. Examples include the regional Central American GIZ 4e initiative, the capacity building project of the Interamerican Development Bank (IDB) and the Nordic Fund (NDF), bilateral support of Iceland in Nicaragua and the Geothermal Andes initiative of the International Renewable Energy Agency (IRENA). Regarding financial cooperation the KfW (German development bank – Kreditanstalt für Wiederaufbau) aims to enable further geothermal project development by creating a financial incentive scheme, a geothermal risk mitigation fund as it already exists in East Africa (Geothermal Risk Mitigation Fund). The procedures, criteria and implementation of the risk mitigation scheme are described.

The paper is structured as follows: Chapter 1 introduces the topic. Chapter 2 outlines the geothermal resource setting, sites and briefly touches respective challenges in Latin America and the Caribbean. Thereafter, current and recent technical and financial cooperation projects are described in Chapter 3 and project approaches and their effectiveness are assessed. Chapter 4 closes with concluding remarks and recommendations.

2. GEOTHERMAL RESOURCES IN LATIN AMERICA AND THE CARIBBEAN

This chapter provides an overview of geothermal resources and their exploration status in the different regions, South America, Central America and the Caribbean.

2.1 Geothermal Resources in South America

Plate tectonics and particularly the convergence of the South American tectonic plate and the Nazca plate have caused the rise of the Andes mountain chain. Despite the good resource base, no geothermal power plants exist in South America until the date. However, in Chile 13 firms already obtained 20 concessions in 2012. First drilling operations were conducted at Sol de Mañana in Bolivia. In Peru first consortia formed to explore geothermal fields in the country.

The continental heat flow map of Cardoso, Hamza and Alfaro (2010) in Figure 1 shows South America's high temperature resources. The study employed updated data sets on crustal seismic velocities, gravity anomalies, radiogenic heat production, terrestrial heat flow and thermal springs. Regional geothermal resources can be suspected to lie within the regional variations of the lithosphere. Areas of interest for geothermal energy are the following:

- Northern half of Chile
- Altiplano (high mountain area) in Bolivia,
- Parts of the Peruvian western Andean belt, and
- Sites along the magmatic arc of western Ecuador, central volcanic belt of Colombia and southern Venezuela.

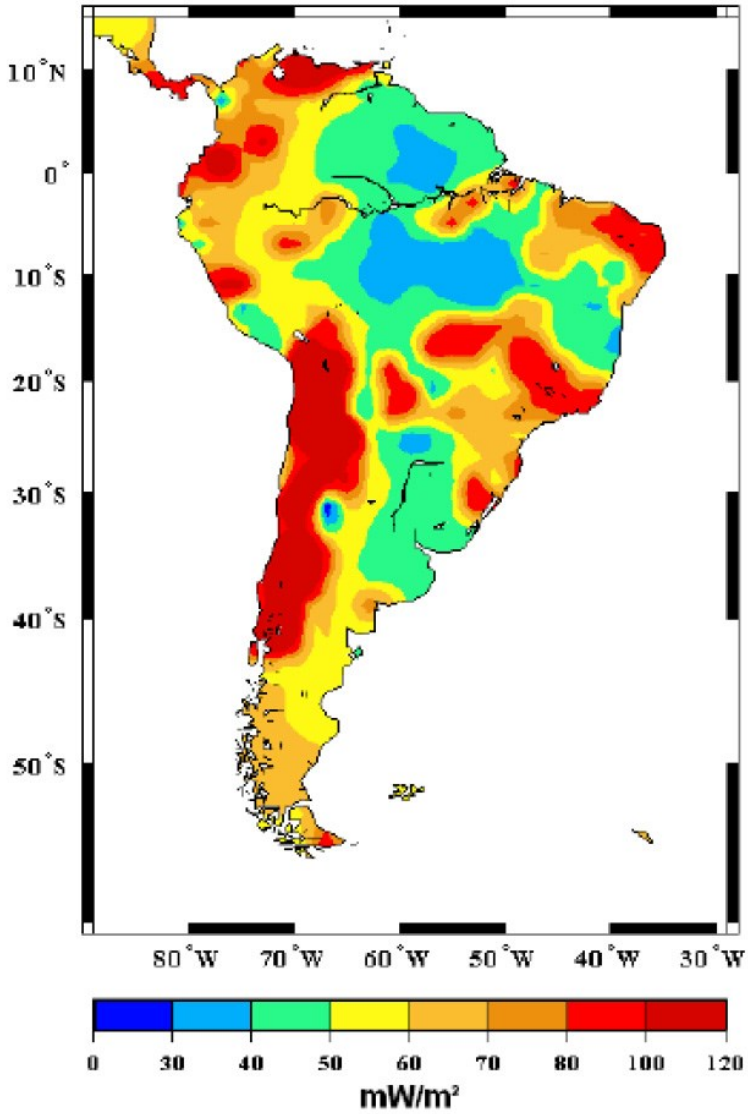

Figure 1: Heat flow map of South America (Cardoso et al., 2010)

Figure 1 also shows that large parts of Central America are located in regions with high temperature alterations. In the following some highlights of selected countries are outlined:

Bolivia: Drilling took place at Laguna Colorada in the Cordillera Occidental at elevations above 4,000 m in the southwest of Bolivia near the Chilean border. Haraldsson (2011) estimates that potential for at least 120-300 MW exist and that funds are expected to be provided by the Inter-American Development Bank. The state power company Empresa Nacional de Electricidad (ENDE) leads project development and a confirmation for the government's motivation is declared in the power generation expansion plan wherein geothermal power plants are marked to come online by July 2017 and January 2018 respectively.

Chile: According to Lahsen, Muñoz and Parada (2010) geothermal resources occur in close spatial relationship with active volcanism. Two main volcanic zones exist: the northern one extends from 17°S to 28°S and the southern zone extends from 33°S to 46°S. Lahsen et al. report that geological, geochemical and geophysical surveys and drilling operations were carried out in many geothermal areas. A preliminary assessment of the geothermal potential of the country indicates an electricity generation potential in the order of 16,000 MW for 50 years with temperatures exceeding 150°C, withdrawn from a depth less than 3,000 m.

Colombia: A national inventory was conducted in 1982 already. Identified geothermal sites include the Complejo Volcánico Parque Natural Los Nevados, Cumbal, Azufral de Túquerres and Paipa-Izade. A binational project exists with Ecuador on the border: Chiles-Cerro Negro-Tufiño.

Ecuador: Prefeasibility studies exist for Tufiño, Cachimbiro, Chalupas, Chalpatán and Proyecto Geotérmico Binacional Chiles-Cerro Negro-Tufiño. Currently, hydro power dominates the electricity mix with 51%. Haraldsson (2011) reports that Ecuador imports approximately 500 GWh of electricity from Colombia and Peru annually.

Peru: In Peru a geothermal development plan (Plan Maestro) and a geothermal law exists which regulates concession processes and resource use (Ley orgánico de Recursos Geotérmicos, Ley 26848). Prefeasibilities already exist for a number of sites in the

southern area (Eje Volcánico Sur), i.e. Calientes, Borateras, Ancocollo and Tutupaca. In 2012 a total of 21 authorizations were awarded to develop geothermal sites. It must be noted however that the Peruvian hydro potential and use dominate other renewable energy technologies.

2.2 Geothermal Resources in Central America

In Central America the Cocos plate and the Caribbean plate converge, cause volcanic activities and created accessible geothermal reservoirs (see Figure 2). Various geothermal power plants already exist and contribute significantly to the countries' energy mix. Just over 500 MW are currently installed in the region. In El Salvador for example 25% of power generated derives from the use of geothermal resources. Also, increasing interest exists for direct use applications.

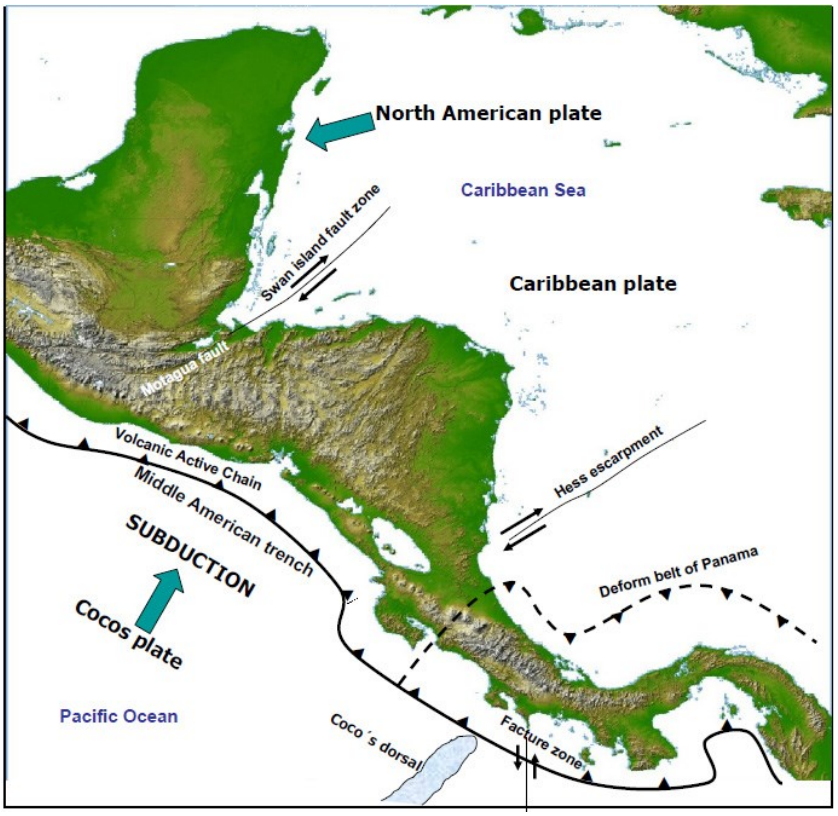

Figure 2: Tectonic setting of Central America and subduction of the Cocos plate under the Caribbean plate and the active volcanic chain (adapted from Chandrasekharam and Bundschuh, 2008)

In the following a brief country overview of the geothermal projects is provided (GIZb 2013):

Costa Rica: Two geothermal power plants with a total installed capacity of 206 MWe are operated by ICE (Instituto Costarricense de Electricidad). The power generated contributes with 15% to the national energy mix. Various geothermal sites are under development in Pailas, Borinquen and Pocosol.

El Salvador: Two geothermal power plants with the total installed capacity of 204 MWe are operated by LaGeo, the national geothermal company. Further geothermal sites under resource assessment include Chinameca, San Vicente and Lago Coatepeque. In El Salvador the Regional Geothermal Training Centre (Centro Regional de Entrenamiento en Geotermia = CREG) is under development.

Guatemala: Two geothermal power plants exist in the country with a total installed capacity of 49 MWe. Further development is underway in El Ceibillo.

Honduras: In Honduras a range of projects are under development at Platanares, Azacualpa, San Ignacio, Sambo Creek and Pavana.

Nicaragua: In Nicaragua 154 MWe are generated at two geothermal power plants: Momotombo and San Jacinto. Further research is conducted at Casita-San Cristóbal, Managua-Chiltepe, El Hoyo-Monte Galán and Volcán Cosigüina.

Panama: So far geothermal fluids are mainly used for the tourist industry. One power generation is in development at Barú-Colorado.

In 2011 the International Geothermal Association together with the International Geothermal Centre produced a map showing the geothermal power plants in Central America (see Figure 3).



Figure 3: Geothermal Power Plants in Central America (International Geothermal Association and International Geothermal Centre of Bochum, 2011)

Located in the 'Ring of Fire' that encircles the Pacific Ocean, the geothermal potential for power generation is estimated to be between 3,000 and 13,000 MW. Approximately 50 sites were identified for eventual development. Given the relatively high costs of other power generation technologies in the region, geothermal is one of the lowest-cost sources of electric power in Central America. The technology faces some of the same barriers to geothermal power development as in other parts of the world, including high upfront risks and geoscientific challenges.

2.3 Geothermal Resources in the Caribbean

Figure 4 shows the volcanic arc subduction of the North American plate under the Caribbean plate. Brophy and Poux (2013) explained the status of geothermal development in Figure 5. Of the Caribbean islands Guadeloupe is the most developed with a power plant of 15 MW in operation. Drilling activities also take place in Dominica, Martinique and St. Lucia. Also on Nevis and Montserrat wells were drilled with promising results. Even though the loads on islands are small, the topography is steep and demands are low, geothermal companies are still interested to become active in the Caribbean. A number of companies operate in the region, including French companies, West Indies Power Holdings and a Canadian company. Also the US Department of Energy is active with geophysical and geochemical studies.

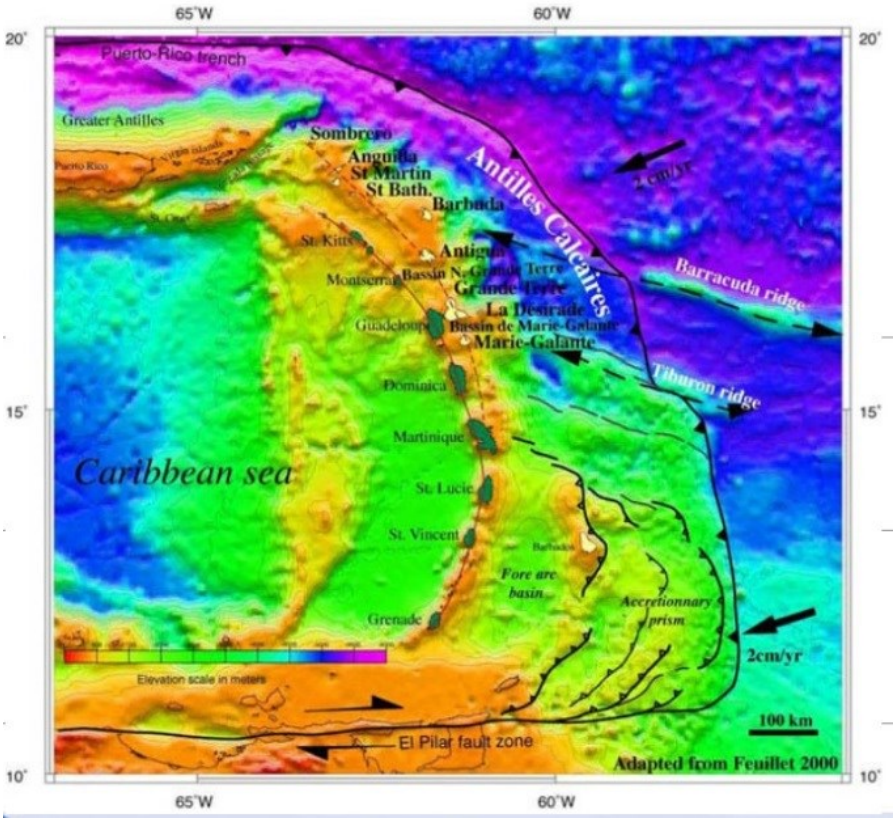

Figure 4 Tectonic setting of the Caribbean islands (Brophy and Poux, 2013)

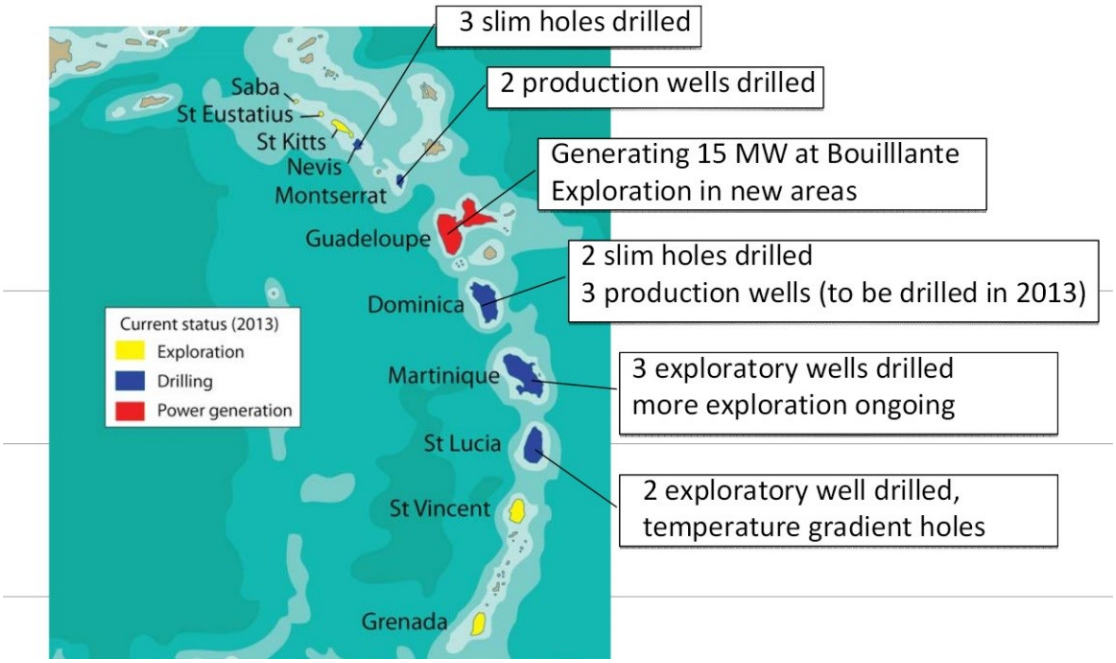

Figure 5: Summary map of development status of geothermal projects in the Caribbean (Brophy and Poux, 2013)

3. GEOTHERMAL PROJECTS, THEIR CONCEPTS AND EFFECTIVENESS

Geothermal energy exploration requires different components, a technical engineering component, a financial component, legal, social and other considerations. International development partners generally concentrate their efforts and either focus on technical support through advisory and capacity building or financial support. Some development partners also combine both support schemes, financial and technical by encouraging equipment purchases and service delivery from their respective country in subsequent project steps.

Development partners increasingly pay attention to the effectiveness of projects, monitor the impact of their support closely and encourage South-South dialogue. Also, the sustainability aspect, particularly economic feasibility, the ability to repair and sustain operations and financial sustainability in the long run are important. Figure 6 gives an overview of the stakeholders of international development cooperation.

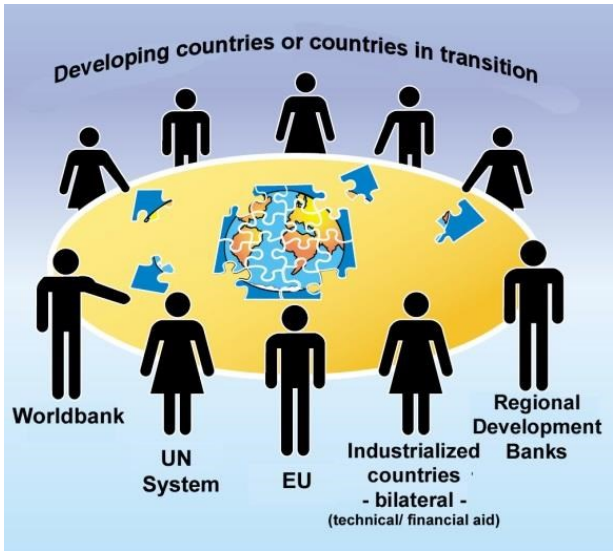

Figure 6: Stakeholders of international development cooperation (BMZ, 2008)

International development partners active in the region include regional development banks such as the Development Bank of Latin America (CAF), the Interamerican Development Bank (IDB) or Central American Bank for Economic Integration (BCIE); the German Development Bank (KfW Entwicklungsbank), the DEG (Deutsche Investitions- und Entwicklungsgesellschaft, German Development and Investment Bank), the International Renewable Energy Agency (IRENA), the Japan International Cooperation Agency (JICA), the European Union mechanisms like the EU-Infrastructure Trust Fund or the European Investment Bank (EU-ITF, EIB) ,the United Nations Environmental Program (UNEP) amongst others. This paper presents selected recent projects aiming to define the project approaches and assess their outreach and effectiveness.

3.1 Technical Cooperation Projects

Technical cooperation projects in the geothermal sector include the following components: Capacity building, awareness raising, political advisory on regulatory framework conditions, resource assessments and estimates, planning assistance, networking and events like training courses, congresses and workshops. Depending on the source of funding, projects are either bilateral, multilateral, target only one site or the whole country/ region. In the following some technical cooperation projects in the region are presented.

3.1.1 Geothermal Initiative in the Andes of the International Renewable Energy Agency (IRENA)

Since early 2013 the Andean governments of Bolivia, Chile, Colombia, Ecuador and Peru are working with IRENA to prepare a roadmap for the development of geothermal energy in the sub-region (IRENA 2013). The Geothermal Initiative in the Andes is implemented in collaboration with the Latin America Energy Organization (OLADE) and the International Geothermal Association (IGA). Project focus is on technical assistance with the aim of building expertise in creating appropriate legal frameworks, identifying financing options and capacity building. An innovative project approach includes a close collaboration with the mentor countries France, Iceland, Mexico and New Zealand who regularly send experts to workshops and support on strategic topics. The kick-off multi-stakeholder workshop was held in Reykjavík, Iceland on 4-5 March 2013. Topics discussed included the identification of main barriers, learn from mentor countries' experience and forge a path forward for each country. Other workshops are held and core results of the first phase are five country studies.

3.1.2 Bilateral support: Renewable Energies and Energy Efficiency (4E) in Central America of the GIZ

In Central America the German International Cooperation (GIZ) supports renewable energy technologies and energy efficiency projects. Depending on the demands from the initial focus countries Costa Rica, El Salvador and Honduras three focus activities are supported (GIZ 2013a):

(1) Governmental institutions receive advisory in improving their regulatory framework conditions for renewables,
(2) Institutional capacities are strengthened and
(3) Private and public sector initiatives and collaborations.

In the 2nd project phase additional member countries of the SICA (Central American Integration System) are included in the program: Belize, Guatemala, Nicaragua and Panama. The close collaboration with the SICA enables direct access to political decision makers and a regional approach. Project partners are electricity providers and transmission entities, industry associations and other stakeholders. Also the use of low enthalpy geothermal resources is a topic which is supported by the GIZ in a partnership with LaGeo from El Salvador. A specific project output is the ecological industry park in partnership with Red Fox where about 44

ha of greenhouses are planned to be developed for agricultural production. The heat and electricity demands are planned to be met with renewable energies.

3.1.3 Bilateral support: Geothermal Capacity Building Project (GCBP) Iceland - Nicaragua

From 2008-2012 the Icelandic International Developing Agency (ICEIDA) worked with the Nicaraguan Ministry of Energy and Mines (MEM) in enhancing the geothermal resource use in Nicaragua for power production. The project aims were capacity building, evaluating the geothermal potential of geothermal areas, classifying resources and installing a geochemical laboratory.

The project had a strong geoscientific training focus with many training courses, practical work in the field and studies at the United Nations University Geothermal Training Program in Iceland. The project budget used was USD 4.3 million. Outcomes include the evaluation of surface studies, evaluation of drilling reports and well testing, prefeasibility studies, EIAs, etc. More on project approaches and outputs is available in the 'Final Project Document' of ICEIDA (ICEIDA 2013)

3.1.4 Regional Geothermal Training Programme of the Nordic Development Fund

The main project objective is to develop a geothermal training program and facilitate the training activities in El Salvador to serve the Central American region. It is expected that the project activities intensify research and development, result in concrete geothermal projects, and gradually increase the share of geothermal energy in the region. The project period is from 2012-2016 with the partner agency Inter-American Development Bank (IDB) and shared funding streams (NDF: EUR 1.5 million; IDB: EUR 0.6 million; El Salvador: EUR 0.6 million). A close collaboration exists with the United Nations University – Geothermal Training Program (UNU-GTP), their experts and lecturers from Iceland. After three full years of operation the program is expected to cover its costs from tuition fees paid by public and private power companies in Central America and elsewhere in Latin America.

3.2 Financial Cooperation Projects

Challenges in geothermal energy projects include (a) the high risks, (b) significant upfront costs for drilling operations and (c) the belated delivery of tangible information on the resource outputs only after the drill completion tests were conducted. Many governments therefore initially prefer other energy resources which at first appear cheaper and more reliable to install.

In the 1990s many power generation facilities were financed by public offers, including concessionary loans from development finance institutions. These publicly financed generation assets were considered one of the core element in state-owned power systems. Due to the diminishing availability of public funds the participation of the private sector were encouraged and Independent Power Projects (IPP) introduced.

Depending on the availability of funds of a country, financial schemes with different levels of grants, loans or equity finance are possible. With private sector and other sponsors being involved decisions must be taken which management system is most appropriate (BOOT=Build–Own–Operate–Transfer, BOT=Build–Operate–Transfer, BOO=Build–Own–Operate, BLT= Build–Lease–Transfer, other schemes). Similar to other energy projects the financial project set-up, obligations and agreements can be quite complex between the project management, lender(s), borrower(s) or sponsor(s) providing equity and third parties like the building contractor or input suppliers.

Depending on the degree of private sector involvement banks offer different financing schemes. The IFC and DEG for example concentrate on the private sector whereas development banks like the World Bank and KfW Entwicklungsbank also provide grant funding to countries under certain conditions.

3.2.1 Geothermal Risk Mitigation Schemes by the KfW

Based on the example set by the Geothermal Risk Mitigation Facility (GRMF) in East Africa (see Figure 7), the KfW (German development bank) prepares the launching of a Geothermal Development Facility (GDF) in Latin America.

The GRMF is financed by the KfW of the German Federal Ministry for Economic Cooperation and Development with 20 million Euro and the EU-Infrastructure Trust Fund with 30 million Euro. It provides grants for surface studies and exploration drillings, a continuation premium and provides financing for a data collection of regional information. Both public and private investors as well as public private partnerships (PPP) can apply for funding. In the first application round in 2012/2013 out of seven applications five projects were invited to sign grant agreements for further project development and drilling operations. Three agreements were signed already (Geothermal Risk Mitigation Fund 2014).

Several donors already put down pledges for the GDF in Latin America (CAF, BCIE, EU, IDB). Similar to the GRMF in East Africa the GDF in Latin America is planned to become a grant-based risk mitigation fund to facilitate early stage project exploration and development (Wirth 2013). CAF intends managing the fund for projects in Bolivia, Chile, Colombia, Ecuador and Peru. At present, the fund management structure, funding schemes and the evaluation criteria for applications and granting of financing are prepared by the KfW and consultants.

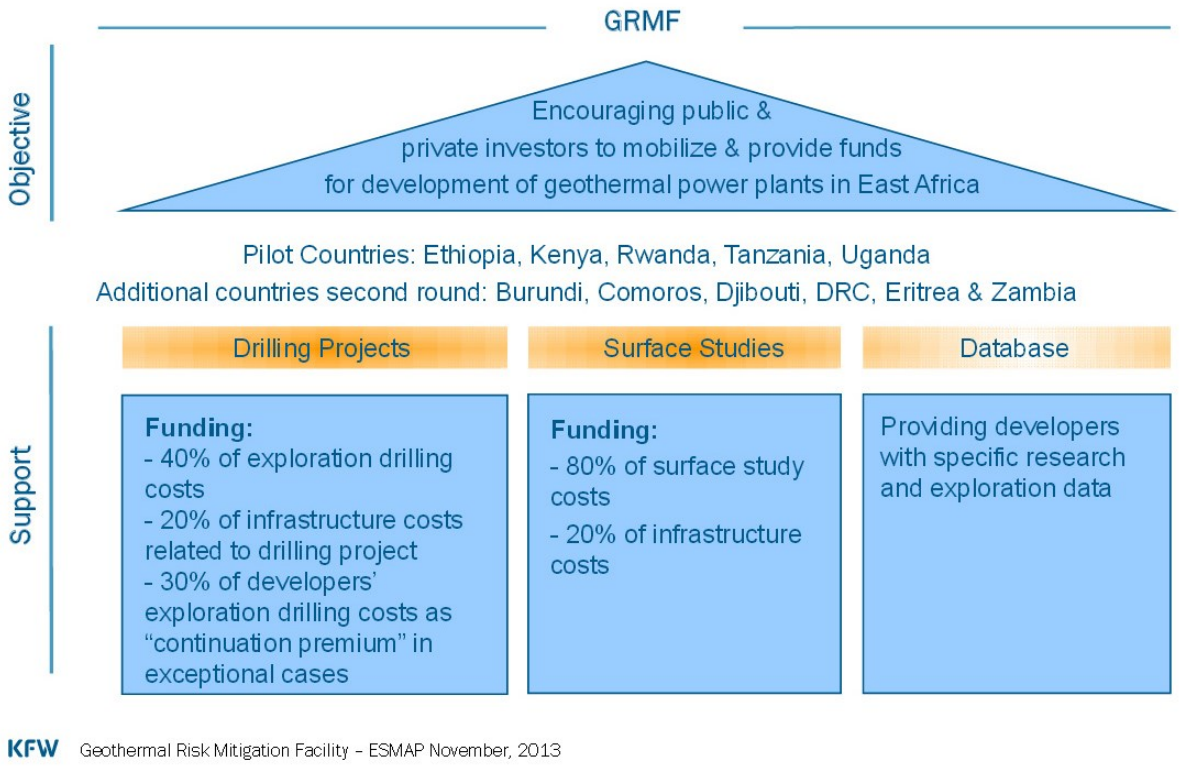

Figure 7: Concept of the GRMF (Schubert, 2013)

3.2.2 Financial Support Schemes from Development Banks for the Private Sector

Some banks focus on the private sector and thereby promote entrepreneurial development cooperation. The DEG as subsidiary of KfW, finances investments of private companies in developing and transition countries. Products offered include long term loans, mezzanine finance, equity finance and guarantees. Raising capital for Independent Power Production Projects (IPPs) is one of DEG's competencies (Grundwald 2012). Grants can also complement the financing schemes. In Central America the DEG provided Polaris Energy (Nicaragua) with a senior loan of USD 19 million for the San Jacinto geothermal plant (Vitinius 2012).

As a member of the World Bank Group, the International Finance Cooperation (IFC) strengthens private sector development in developing countries. IFC focuses on mobilizing capital in the international financial markets and providing advisory and risk-mitigation services to business and governments. In Nicaragua for example the IFC provided $50 million and mobilized $110 million to build the San Jacinto geothermal power plant which is currently Nicaragua's largest greenfield geothermal power project. San Jacinto is expected to supply almost 20% of Nicaragua's power (IFC 2012).

On a more global and strategic level the IFC supports geothermal energy with sector studies. In 2013 the IFC released a Global Study on the success of drilling geothermal wells, with insights into success rates and average numbers for wells drilled in around 70% of all geothermal fields world-wide. Also, in 2013, the document 'Geothermal Exploration Best Practices: A Guide to Resource Data Collection, Analysis and Presentation for Geothermal Projects' was released by IFC and IGA Service Company.. Together with Munich RE the IFC is currently developing and piloting a geothermal exploration risk insurance for Turkey (Munich RE 2013).

3.2.3 Regional Development Banks

In Latin America and the Caribbean the main regional banks are the Development Bank of Latin America (CAF), the Inter-American Development Bank (IDB) and the Central American Bank for Economic Integration (BCIE). The regional banks obtain most of their funding from their regional member states. The capital is used to finance only projects and programs in their member states. Bank products include loans and non-repayable grants for investments in the public sector and for private sector promotion. Also technical assistance is provided in some cases to help countries implement their measures.

The Inter-American Development Bank (IDB) is the largest multilateral financing institute in Latin America. Their support mechanisms include technical assistance (i.e. prefeasibility studies, capacity building), access and co-financing with other donors and loans for the public and private sector. Significant support was provided by the IDB to the following projects (Guzman 2013):

- Bolivia: 70 million USD
- Chile: 30 million USD for IDB risk mitigation mechanism (tbd)
- Colombia: 3.6 million USD for four pre-investment studies
- Costa Rica, Miravalles I and III: 124 million USD loan
- El Salvador, Berlin: 215 million USD loan

- El Salvador: Geothermal Regional Training Center
- Mexico: 1.58 million USD in geosciences and regulatory studies
- Nicaragua, San Jacinto: 40 million USD private sector loan

At the Roundtable of the Global Geothermal Development Plan in November 2013 in De Hague the IDB outlined the following experiences in geothermal energy financial structuring and future plans. Figure 8 shows different financial support mechanisms planned to be provided by the IDB and other partners.

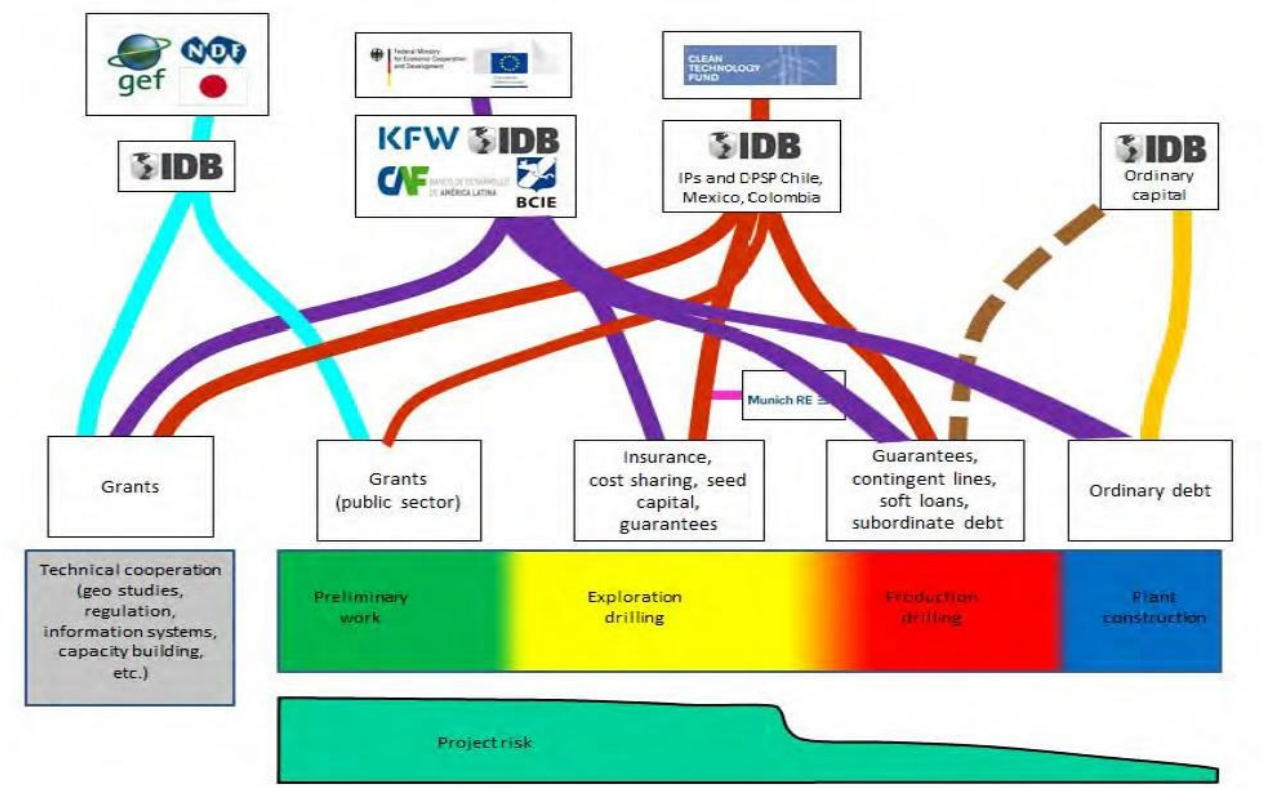

Figure 8: Financial support structure and mechanisms provided by the IDB and other partners for geothermal energy projects (Guzman, 2013)

3.3 Global Geothermal Support Scheme

The Energy Sector Management Assistance Program (ESMAP) of the World Bank launched the Global Geothermal Development Plan (GGDP) in 2013 in collaboration with bilateral and multilateral development agencies, banks and client countries. The GGDP is expected to be transformational by creating a global momentum in geothermal energy investments through a concerted focus on exploratory test drilling. So far already 115 million USD were acquired from the Clean Technology Fund. In Latin America and the Caribbean the GGDP dedicated support to Nicaragua, Dominica; two additional projects are implemented by the Inter-American Development Bank in Chile and Mexico (ESMAP 2014)

In Latin America and the Caribbean the GGDP identified 17 sites as primary and secondary target fields for exploratory drilling (ESMAP 2014). Examples of potential geothermal hydrothermal fields technically ready for further exploration drilling. The 17 sites are located in 12 countries in Latin America and the Caribbean.

3.4 Analysis of Project Approaches and their Effectiveness

With the above project approaches presented it becomes clear that different financial and technical portfolios are applied for different demands and conditions. Technical cooperation projects are advisable to build human and institutional capacity, raise awareness among decision-makers and planners and assist governmental entities is establishing appropriate regulations, regulatory frameworks (concessions, exploration/ exploitation licenses, geothermal law, etc.) and energy strategies. Expected impacts include a more effective regulatory regime, improved ownership over energy processes by political decision-makers and a competent workforce for geothermal energy projects.

The financial risk mitigation schemes outlined above aim to create investor friendly conditions by providing financial incentives for the exploration phase and reimbursement mechanisms when drilling operations were not successful. This includes drilling and testing of reservoir confirmation wells at the most promising geothermal prospects to assist developers secure financing for subsequent reservoir confirmation and/or well field development wells. With the existence of the fund it is expected that access to equity or other funding sources is improved. As a result, reduced risks and costs for early stage geothermal development are expected to encourage the development of further geothermal investments. Often, an additional technical assistance component helps to gather outstanding data of surface studies to define the drilling location.

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In the ideal scenario both technical and financial cooperation projects are complimentary and are aware of the support schemes of the other actors. Sometimes, projects are approved by different donors for the same area. But generally, project stakeholders then define their areas of work and target group once project operation started.

Regional banks provide additional support in their regions, are partially funded by their regional member countries and thus often have a closer surveillance over activities on the ground.

Regional approaches are advisable, particularly in the Latin American context where the language sometimes proves to be a limiting factor in capacity building efforts overseas. Training courses in Spanish are therefore advisable.

4. CONCLUSION AND RECOMMENDATIONS

Global experience shows that there are a number of ways to overcome the barriers to geothermal development within the context of power sector structure and business environment. What seems clear is that there is a need for mechanisms to overcome the upfront risks associated with resource exploration and confirmation, such as through upfront studies, geological prospecting, and test-drilling. In practice, such activities have been supported by the government or through public-private risk-sharing mechanisms. Interestingly, there are no proven record, to date, of an entirely private sector concession-based system for geothermal development as is common with other energy and natural resources

At the regional level, regional power planning and regional risk sharing mechanisms are recommended. Given the relatively small size of the countries involved, i.e. in Central America, there is an advantage to consider a regional risk mitigation scheme. This can serve as incentive mechanism for public/ private investors. A more realistic assessment of geothermal costs and development prospects at the regional level would also help to prioritize geothermal versus other thermal and renewable technologies.

From experience in other countries it is evident that the State plays a large role in the initiation and continued support of geothermal development. Development partners can thus only stimulate first geothermal projects and thereby demonstrate the viability of geothermal energy. In the long run the State together with the private sector and academic institutions has to take the leading role.

ACKNOWLEDGEMENT

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