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# Geothermal Risk Mitigation Programs

Kai Imolauer, Maria Ueltzen

Äußere Sulzbacher Str. 100, 90491 Nürnberg

kai.imolauer@roedl.com, maria.ueltzen@roedl.com

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**ABSTRACT**

Public Risk Funds – design, chances and challenges. Public risk funds have been established to foster the development of geothermal markets in various countries of the world. A detailed comparison of structure, objective and impact between the models of - GDF – South America (www.gdflac.com) - GRMF – East Africa (www.grmf-eastafrica.org) and will be given. [The authors have designed the GDF and are currently fund manager for GRMF (basic concept also created by authors)]. Moreover a short introduction to the facilities established in Switzerland & France as well as the scheduled facility for Indonesia (GREM) will be given. The particular fund systems follow the same objective: to lower the necessity of venture capital placement in the early stages, which consequently decreases levelized costs of electricity (LCOE) and therefore impacts the competitiveness of geothermal power generation in relation to alternative generation technologies. Furthermore , projects with a less advantageous risk-reward-ratio (e.g. heat supply projects on medium or low enthalpy resources) face significant financing problems during the early stages which can only be financed by venture capital. The expected outcome or profitability of such projects - taken the connected risk into consideration - will hardly lead to a placement of venture capital. A public fund system therefore takes the burden of early stage exploration or discovery risks and stimulates the market for geothermal projects and consequently leverages the investment in geothermal based infrastructure. Such funds will be essential to allow the transition in power and especially heat sectors worldwide to geothermal based regenerative systems. The different approaches of such facilities are usually depending on the particular target markets or region, the geology and the financing situation. The program of East Africa (as a grant based system) e.g. shows that even less developed markets can definitely be stimulated by such capital and that such programs leverage substantial equity and public investments into the geothermal sector.

Due to the long lasting experience in the fund management of GRMF (6 years), the authors will provide also insight views in the largest challenges for the fund handling, which are directly connected to the development of geothermal projects (about 30 projects in pipeline of GRMF) in East Africa and give indication to possible way outs or solutions to accelerate the market development.

## 1. INTRODUCTION

In 2002, Rödl & Partner (R&P) as consulting company for geothermal projects developed the first private enterprise insurance concept for the low enthalpy geothermal in Unterhaching, nearby Munich. The solution led to the first private insurance in this field which was signed by Munich Re and the community of Unterhaching covering the discovery risk of the first geothermal drilling in Unterhaching.

This first project and the experience gained formed the base for the following conceptualization and management of risk mitigation projects over the globe. Further concepts were developed for

- Germany, as a nation-wide soft loan program for KfW (German development bank),
- The EU, a Guarantee Fund system concept (GEOFAR),
- Indonesia, as a fund system for the Indonesian National Development Agency,
- East Africa, based on the fund system concept of Indonesia, a geothermal risk mitigation fund (GRMF),
- and South America, as a revolving fund concept of the Geothermal Development Facility (GDF) which was awarded twice as best financing program at GEOLAC conference

All listed programs have the objective to lower the obstacle of venture capital placement in the early stages, which consequently decreases the venture in the exploration phases and due to lower risk related financing costs the LCOE. Consequently such funds improve the competitiveness of geothermal power generation in relation to alternative generation technologies.

Especially important are risk mitigation programs for projects with low cash flows as e.g. heat supply projects from medium or low enthalpy resources since early stage explorations bear high risks and can only be financed by venture capital. In the case that the site conditions are not optimal, the early stage costs are sunk costs and thus the risk mitigation in that stage is paramount to allocating private investment. A public fund system therefore takes the burden of early stage exploration or discovery risks and stimulates the market for geothermal projects and consequently leverages the investment in geothermal based energy supply.

## 2. UNDERSTANDING GEOTHERMAL RISK MITIGATION PROGRAMS

### 2.1 Typical phases

The typical phases of a geothermal project are the following:

1. Exploration and Reconnaissance
2. Prefeasibility
3. Feasibility
4. Detailed Design and Construction
5. Operating

The risk profile of the different phases varies. Generally, the early stages are the phases exhibiting the highest risk level, with an increasing capital intensity as can be seen in Figure 1.

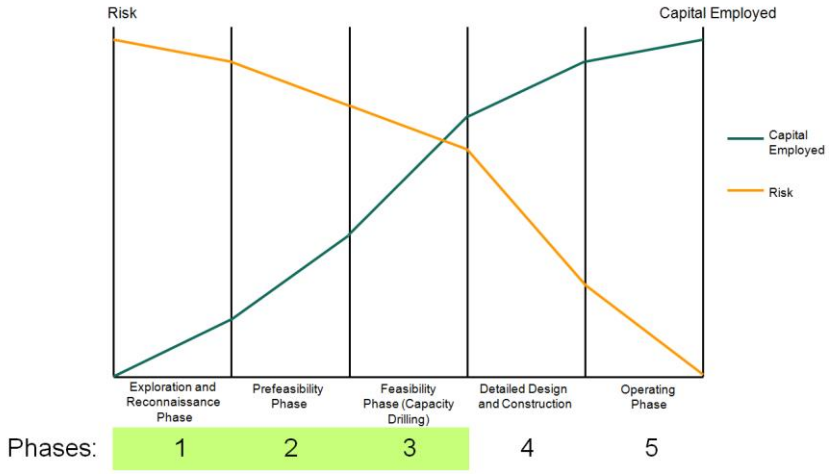


**Figure 1: Risk and capital profile of the construction of a geothermal power plant**

Therefore, a public risk mitigation program is an important and relatively inexpensive way to mitigate the high risks of the early project stages. Especially the three initial stages (Exploration and Reconnaissance, Prefeasibility and Feasibility) are best to mitigate risks and costs of the projectors through a risk mitigation program.

### 2.2 Factors and Risks Influencing Geothermal Programs

Typically the most important factors are the following:

- The geothermal resource potential across the country;
- The current conditions for large scale development of geothermal resources in the respective country which can be,
    a. legal, respectively regulatory – meaning e.g. the existence of a geothermal regulation which enables the development of geothermal projects and assures legal security regarding concessions, Power Purchase Agreement (PPA), water rights, etc.,
    b. financial – meaning the availability of financing also for the later stages especially confirmation wells as well as power plant construction,
    c. economic – meaning the stage of development of the power market; the general power price level and need for carbon free baseload power generations facilities,
    d. and institutional – meaning that the involved institutions are aware of the potential of geothermal energy and have a clear guideline, above all for the licensing procedure how to deal with geothermal projects to avoid severe delays.
- The investment potential and remaining impediments for investments – meaning a sufficient large potential for geothermal projects ideally for public, public-private-partnership (PPP) or private developers to be developed, so that the effort of implementation of a risk fund makes sense (otherwise regional approaches should be considered).

In particular, in countries where geothermal potential is knowingly available but no funding program is existent often only a small number or no geothermal projects are realized. Above all, due to the required decarbonization of the heat sector in Europe, geothermal heat could contribute substantially but its implementation is strongly inhibited by the required venture capital or financing of the early stages.

In a benchmark study in Hungary (conducted by R&P) other risks apart from technical (discovery) risk, which also inhibit project developers from investing or completing a geothermal project in the respective country, were analyzed. Non-technical barriers such as administrative, economic and legal aspects have a restrictive effect on geothermal investment. Administrative barriers can be missing knowledge of the staff in administration about geothermal projects or awareness of possibility; or a lacking knowledge/experience how to handle permission processes for instance. Similar "barriers" could be identified in East Africa – where the particular discovery risk is not the main obstacle for the project developers to be overcome in order to get to the drilling phase.

In general, economic aspects are e.g.

- missing economic feasibility (below, a further section will discuss the competitive ability of geothermal in relation to other generation technologies),
- feed-in regulations or PPAs (ideally backed up by guarantees)
- low heat prices or a poor market situation for heat sales (e.g. no free price determination, but controlled by public entities).
- also, legal aspects such as mining law regulation concerning concession, water regulation, construction law, energy sales regulation, any energy market regulation, and heat price regulations can inhibit investment.

The problem is that generally the geothermal risk mitigation programs rather tackle technical risks than non-technical risks. Therefore, it is important to be aware of the existence of the non-technical barriers and intent to mitigate those too. However, from the experience from GRMF we may add that the structured due diligence to be applied on each project applying for funding also supports a professional project development.

Excursus: Another experience made, above all in the East Africa fund, is the repeatedly raised question regarding the competitive ability of geothermal power generation in comparison to fossil or renewable energy technologies. Certainly a conventional lignite power plant, with a domestic supply of lignite (the same for coal), will be able to generate low cost electricity – probably around 5-9 ¢ USD (Fraunhofer ISE, 2018). But such calculations often leave out any economic evaluation of the environmental impact of such plants, e.g. like $CO_2$ or other emissions. If taken into consideration such power plants become rather uneconomic. In comparison to other renewable technologies geothermal power plants (around 7 ¢ USD) (IRENA, 2017) are not yet competitive if ignoring the base load ability, as the upscaling of wind turbine sizes and the large decrease of production cost of PV-modules led to a strong decline of LCOE of these technologies.

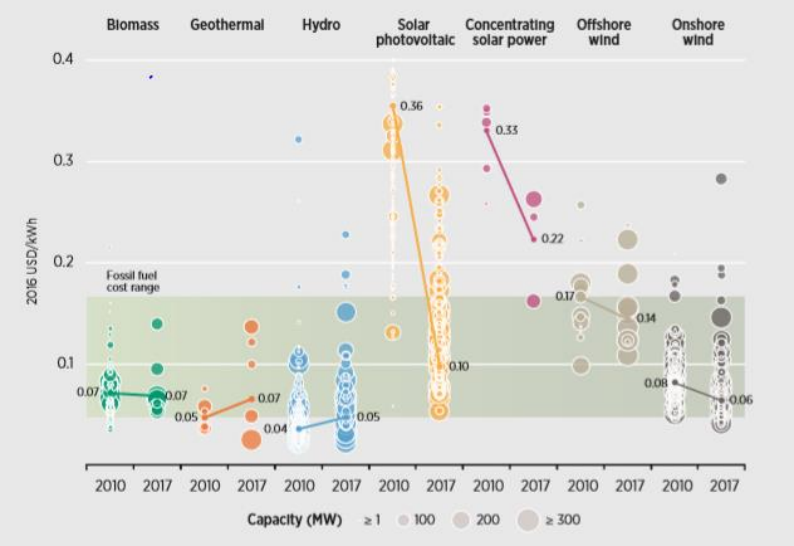


**Figure 2: LCOE decreases in wind and PV power vs. increases in geothermal power**[1]

Consequently, energy ministries prefer to go for that options, rather than facing the involved discovery risks which are characteristic for geothermal projects.

**But, the advantages of geothermal power plants remain very often undervalued**. In East Africa for example certainly PV and hydro power will have a substantial share of the generation capacity, but bring challenges to the power system, which are (predictable) volatility[2] in generation or substantial output decreases in cases of drought In exactly these aspects, geothermal power

[1] (IRENA; 2017)

[2] Dr. Harry Wirth, Fraunhofer ISE, 2019 Freiburg, Germany, Chapter 11.2

generation show its strength: as base load with availability of 90% and capacity factors of more than 70%[3], no volatility over the day and practically no dependence on any climate changes or weather, make geothermal power generation probably the best backbone a country could have in their generation portfolio. Very often these very special properties of geothermal power generation remain undervalued. Geothermal power operates the most efficiently when it runs continuously without interruption; however, some geothermal plants can load follow and depending on the engineering of the plant can provide other flexible system needs.[4]

It will be essential for any country wide supply system to have reliable must-run units from renewable resources, which will determine e.g. frequency in the grid and therefore will be a reference point for any further generator connected to the grid, being a small decentralized system or a utility size PV-plant. Such aspects have to be highlighted by the geothermal community to achieve the support required to foster the development of further power plants.

### 2.3 Different types of risk mitigation programs

There are in general 6 different types of geothermal risk mitigation programs. Generally programs are based on an insurance, a grant, a contingency grant, a guarantee for commercial loan, a concessional loan or loan with redemption clause or a loan with indemnification clause.

- **Insurance** solutions would function as risk mitigation instruments allowing the public fund to bear the risks and therefore enable commercial loans for financing.
- **Grants** contribute directly to project financing as equity. In case of the high risk exploration phases these grants can be considered as venture capital without costs. The stimulation of the market can be considered to be strong, as monetarily valued project risks are reduced substantially. They can either be paid in advance which requires strict control of the funded project or in arrear advantageous and more secure considering the funding proceeding, which makes a significant difference in the objection of funding.
- **Contingency grants** have the character include the possibility of pre-defined contingencies that lead to no or partial repayment.
- **Loan guarantees** are given to a project developer by the risk mitigation facility; these guarantees enable the acquisition of loans from the capital market and in case of unsuccessful projects, the risk mitigation system would be obliged to repay loans.
- **Concessional loans** as well as loans with redemption clause are loans with subsidized interest rates or redemptions paid by a public fund.
- A loan with an **indemnification clause**, which comes into force if the project fails according to predefined conditions.

In every country or region a different type of program is adequate and therefore an individual analysis is crucial to implement an optimal risk mitigation framework in that specific country.

[3] Bloomberg New Energy Finance, 2012

[4] BENJAMIN MATEK, KARL GAWELL, 2015

### 3. OVERVIEW OF RISK MITIGATION PROGRAMS

In the following Figure 3, different risk mitigation programs are distinguished regarding their program name, agency, fund volume, region, status and instruments used. The tabular form aids to notice differences between the programs at a quick glance.

| Program | Organisator | Fund volume | Region | Status | Instrument | |
|---|---|---|---|---|---|---|
| French Geothermal Risk Guarantee System [1] | French Agency for Energy Mgmt. | • unknown | France | Ongoing | • Short-term partial risk guarantee up to 90% or €3 million of the total cost of the first well. Premium between 3.5-5% of the costs.<br>• Compensation depending on success. | • Long-term partial risk guarantee<br>• Compensates consequences of possible damage<br>• Premium 3.2% of the hedge amount |
| Swiss Geothermal Risk Guarantee [2] | Swiss Office of Energy, Swiss Grid Company | Max. €143 Mio./Year | Switzerland | Ongoing | • Grant covers up to 60% of development costs<br>• Financed by levy (€0.08/kWh) | • In the event of non/partial discovery, an external committee of experts determines the sum to be disbursed |
| Private Sector Early Stage Geothermal Development Framework ("PLUTO") [3] | TKB, CTF (EBRD) | CTF $25 Mio., EBRD $100 Mio. | Turkey | Ongoing | • 40% to 60% of the cost of failed drilling will be paid to the beneficiary up to a total amount of USD 4 million.<br>• EBRD - Financing independent of CTF risk protection | • Contingency fee in the amount of 10% of the estimated drilling costs is either paid in advance by the beneficiary or a guarantee bond is issued.<br>• Success fee will be refunded if project is unsuccessful |
| Risk mitigation fund [4] | EBN, Ministry of Economic Affairs Netherlands | EBN €30 Mio./a IAE €100 Mio. von (2010-2014) | Netherlands | Ongoing | • Coverage of 85% of drilling and testing costs (max € 7.2 million)<br>• Premium amounts to 7% of drilling and testing costs<br>• Additional cover of 10 % via private insurance permitted, but at least 5% of the risk for project developers<br>• Disbursement if thermal output is below P90 value | • Maximum 2 drillings (duplicate) insurable<br>• Drilling must begin within 6 months, complete in 1 year and start using geothermal energy in 2 years from the date of approval of warranty production |
| Regional guarantee for geothermal risk [5] | Walloon Government | unknown | Belgium | In process | • Costs are tied to the first duplicate;<br>• Developer investigates a project and evaluates the expected resources (thermal performance) → applies to the government for a guarantee<br>• Technical Committee validates the entire project on the basis of available scientific evidence and recommends the Government to grant or refuse the guarantee | • Applicant pays a premium → carries out its initial drilling and evaluates the actual resources → if these are lower than the expected resources (flow rate or temperature), may claim compensation for partial & non-existence.<br>• Technical Committee Determines Amount of Compensation |

**Figure 3:Overview of different geothermal risk mitigation programs**

It is evident from the table and the different models, that the particular programs have been tailor-made to the particular markets. The geological potentials, regulatory framework, economic conditions and the objectives have to be included in the particular design. The French program also comprises an assurance of operational risks, which results from the geochemical conditions of the geothermal fluids in the Paris Basin.

The Dutch program was initiated by the agricultural sector with the objective to increase the competitiveness of the Dutch greenhouse sector. A very interesting model, as it is dedicated to heat for an agricultural purpose – it would be very desirable that such a program would be extended to further industrial uses that are requiring substantial decarbonisation.

Furthermore the model of Suisse is very interesting regarding refinancing, as a surcharge is charged from the end consumer to enable refinancing of the mitigation system.

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[5] (Bommensatt, N.; Maestro, A.; Laplaige, P.; 2015)

[6] (Siddiqi, G.; Minder, M.; 2015)

[7] (Think geoenergy; 2018)

[8] (Interreg Danube; 2017)

[9] (ETIP-DG; 2018)

## 4. RISK MITIGATION PROGRAMS IN DETAIL

### 4.1 GRMF (R&P is fund manager)

The German Ministry for Economic Cooperation via KfW Entwicklungsbank ('KfW') and the African Union Commission ('AUC') established the Geothermal Risk Mitigation Facility for Eastern Africa ('GRMF') in 2013.[10] The objective of the GRMF is to encourage public and private investors ('Project Developers') to develop geothermal prospects for power generation in Eastern Africa by providing grants for financial contributions for two main types of activities:

- Drilling of exploration wells at the most promising geothermal prospects to assist developers secure finance for subsequent exploration or appraisal wells.
- Surface studies to determine the optimal location of exploration wells at the most promising geothermal prospects.

Additional objectives:

- fund, facilitate and accelerate geothermal development in Eastern Africa,
- encourage public and private sector investment into geothermal power generation,
- act as a catalyst in establishing geothermal energy as a strategic option for power generation capacity expansion in eleven partner countries in the Eastern African Rift region.

An exploration drilling program for funding by the Facility may comprise:

- up to three full size reservoir confirmation wells (≥ 5" diameter of the last casing or liner) or
- a combination of up to three slim hole wells (< 5" diameter of last casing or liner) and one full size reservoir confirmation well or
- a combination of up to two slim holes- and two full size reservoir confirmation wells.

In case, project developers have been awarded GRMF grants for undertaking drilling program activities and decide to further develop their project after the initial successful resource exploration, depending on the availability of funds, the GRMF Facility may provide additional financial support in form of a Continuation Premium (CP) grant. The eligible activities in the course of the CP include:

- Wellhead unit(s) installation,
- Long term discharge testing (minimum six months),
- Reservoir evaluation update,
- Feasibility Study (after the successful drillings and testing, there is a new informational base, which can lead to an updated, bankable documentation of the projects, required to acquire further financing capped at a maximum eligible cost of USD 100,000.)

The organizational structure of the GRMF is adapted to the idea of tender programs managed by the AUC and by the Regional Geothermal Coordination Unit (RGCU) within the AUC. A technical consultant supports the RGCU in the management and processing of the Fund.

The GRMF focuses currently on geothermal prospects in 11 countries in Eastern Africa, namely Burundi, Comoros, Djibouti, Democratic Republic of Congo, Eritrea, Ethiopia, Kenya, Rwanda, Tanzania, Uganda and Zambia.

Map of awarded projects during five application rounds:

[10] (GRMF, 2014)

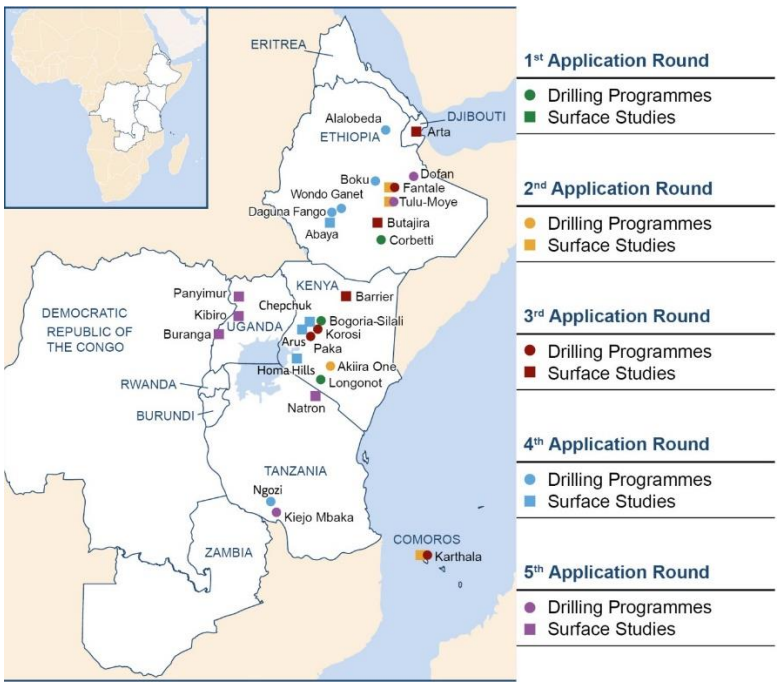


**Figure 4: Map of sites where projects were approved**

### 4.2 GDF (concept developed by R&P)

The Geothermal Development Facility (GDF) was initiated in 2016 and is currently conducting the 4th application round.

**Figure 5: Countries where GDF is offered (Bolivia, Chile, Columbia, Ecuador, Peru, Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua )**

The GDF fund concept described in this chapter focuses on the mechanisms for supporting the exploration and reconnaissance phase as well as the prefeasibility phase of geothermal project development by two instruments. The instruments aim at reducing the drilling exploration risk by supporting the early exploration phases.

- Instrument A: partial grants for the exploration and reconnaissance phase (activity: surface studies)
- Instrument B: contingency grants for the prefeasibility phase (activity: exploratory drilling)

*Instrument A* aims at providing an incentive to motivate developers to start any exploratory activities. It also can be considered as the 'creation' of a geothermal project, where the surface study aims at laying the geoscientific base for the further development. It can be considered as highest venture phase, with investments reaching already volumes of up to 2 MEUR. Besides the 40 % subsidy intensity a second cap regarding the maximum subsidy is set at EUR 600,000, resulting that surface studies with higher costs will only be supported till this maximum amount to avoid too high financial contributions in particular projects. The surface study grants will be awarded post completion of the study in one disbursement unless the applicant requires partial disbursements.

Generally, the project developer must demonstrate that a minimum share of 20% of the eligible costs is covered by own resources.

The eligible activities of the surface study are:

- geophysical surveys (e.g. seismic, gravity, magnetics or magnetotelluric or other resistivity surveys) including supplementary geological, hydro-geological and/or
- geochemical surveys,
- shallow temperature gradient wells, if necessary, and justifiable for siting exploration wells,
- drilling of one slim hole well (< 5" diameter of last casing or liner),
- an integrated resource report interpreting and summarizing the results of the surface studies in terms of a detailed three dimensional conceptual model of the resource and identification of high priority drill sites and targets at depth.

In the case of *Instrument B* the funding intensity of up to 40 % is oriented to typical project financing structures, where the equity share typically is between 30 - 40 %. The remaining share of at least 60 % still leaves a rather high share on the developer avoiding any moral hazard effects. The Drilling Grant is also capped at 40% of the eligible costs. Furthermore, an overall cap of MEUR5.8 is used to limit the particular contribution of GDF for a project resulting that drillings with higher costs will only be supported till this maximum amount to avoid too high financial contributions in particular projects.

In addition to the eligible costs funded by the pre-defined funding intensity, costs related to the third party consultant assessing the test procedures and results of the drillings will be funded by GDF. Instrument B includes a revolving mechanism. In case of successful program completion within one year solely a repayment of 80 % of the provided grant is required. If the grantee needs 2 or 3 years for the successful completion, the grantee must repay 90% or 100% respectively.

The eligible content of the drilling programs differ between high and medium enthalpy projects due to the different exploration strategies.

- High enthalpy:
  - Funding may comprise up to three full size reservoir wells (≥ 5" diameter of the last casing or liner),
  - A feasibility study that has the explicit aim of securing finance for subsequent confirmation production wells.
  - Mobilization and demobilization of drilling rigs cutting analyses and well logging; well-testing and completion of a reservoir model.
  - 20% of the incurring infrastructure costs required for exploration drilling, e.g. access roads, water supply will be covered

- Medium enthalpy:
  - A geothermal doublet consisting of two full size reservoir wells (≥ 5" diameter of the last casing or liner).
  - In case a drilling program targets only one full size production well without reinjection, this might be eligible for funding in exceptional cases e.g. reservoir does not allow for pressure compensation through reinjection.
  - Mobilization and demobilization of drilling rigs cutting analyses and well logging; well-testing and completion of a reservoir model.
  - 20% of the incurring infrastructure costs required for exploration drilling, e.g. access roads, water supply will be covered

To prevent few applicants from receiving the majority of available funds a maximum of four grant contracts, two Surface Studies and two Drilling Grants, per applicant is possible.[11]

### 4.3 GREM – Indonesia

Not completely clear is the schedule of the implementation of the World Bank´s Geothermal Resource Risk Mitigation Facility (GREM) in Indonesia. The proposed Project will be a Financial Intermediary (FI) operation implemented by PT SMI. PT SMI will manage the Facility. The Facility will have two components: Component 1, USD 650 million, for geothermal resource risk mitigation; and Component 2, USD 10 million, for technical assistance and capacity building.

Component 1: Geothermal Resource Risk Mitigation (USD 650 million). This Component will provide financing for exploration and delineation drilling for resource confirmation. Public and private sector developers will apply for financing from PT SMI, which will screen proposals and, under the guidance of the Joint Committee, determine the size of the approved financing package. The funding size, the financing package and the blend soft loan terms differ between the public and private sector window (see Figure 6). Based on the potential project pipeline as indicated by MEMR and the state-owned and private developers, the Facility is expected to enable drilling of up to 20 projects.

Component 2: Technical Assistance and Capacity Building (USD 10 million). The Component will finance a capacity building program to enhance PT SMI's capacity in managing the Facility, and technical assistance to key sector stakeholders in improving the overall sector governance and investment climate for geothermal in Indonesia.[12]

[11] Reference is made to GDF Developers´ Manual (Version October 2017). For further information please contact GDF Fund management team via website: www.gdflac.org

[12] (World Bank, 2018)

| | Public Sector Window | Private Sector Window |
|---|---|---|
| Coverage | Resource confirmation and delineation drilling | |
| Funding Size | Capped at US$30 million | Capped at US$30 million, or three-quarters of the drilling costs, whichever is smaller |
| Prior requirements | Access road and site infrastructure planned | Access road and site infrastructure |
| Financing package | • 50% blended soft loan (IBRD + GCF/CTF)<br>• 50% PT SMI loan | • 37.5% IBRD Exploration Loan<br>• Guarantee/contingent financing to cover 50% of the loan or 37.5% of the exploration budget<br>• 25% developer equity |
| Blended soft loan terms | Linked to IBRD and PISP terms | Linked to IBRD and GCF/CTF terms |

**Figure 6: Public and Private Sector Window risk mitigation program[13]**

## 5. CHALLENGES AND WAY FORWARD

Drawing the conclusion on the issue of risk mitigation systems world-wide has first of all a clear answer: it makes absolutely sense to foster the development of geothermal power or heat generation by bearing the discovery risk on public shoulders.

The authors see the role that geothermal can play in a power or heat generation portfolio as so favorable, that the risk capital to be spent in relation to the investments and economic and ecological benefits, considering the baseload generation of power and heat, can easily be justified.

The leverage effects of spending public money for the early stages of geothermal project development, identification of projects in reconnaissance studies, surface studies, exploration phase, enables the identification of prospects and their development.

But risk mitigation will be one other instrument to really foster the development. The energy policy of the particular market will have to show a clear will to decarbonize the heat sector and to include geothermal as base load to their power generation portfolio.

For heat projects the general financing for existing heat supply structure will not only struggle with the early phases, but the financing in general. Public district heat suppliers will be very challenged to finance the substitution of fossil fuels by geothermal by financing it on their balance sheet. Thus, a political will to decarbonize the heat market will have to be accompanied by tailor-made financing solutions to simply enable project developments in this regard.

For power projects, bearing in mind above all East Africa with a potential of 15 GW, it will be essential to establish a regulatory framework which enables bankable projects – this includes a transparent licensing for water, geothermal, etc. and certainly fair conditions for PPA conditions. Furthermore, the geothermal community will have to struggle with the upcoming volatile power generations from wind and especially PV. Currently the large storage systems are still too expensive, so that the accumulation of PV LCOE and LCOS (levelized costs of storage) will not be competitive. But the number of companies involved in the battery business, economies of scale and technical innovation ,bearing in mind that the battery systems anyway will be developed for electric vehicle, will bring medium-term solutions which could be difficult for geothermal to compete with.

Consequently, the geothermal branch should face these challenges and show innovation in reduction of discovery risk, decrease drilling costs and increase the efficiency of the power plants. Above all the combination of use of geothermal power and heat at the particular project location show great economic potential on local level, which is hard to achieve with e.g. Wind or PV.

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