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Geothermal Power Plants Project Finance through Public-Private Partnership: A case of Africa.

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ABSTRACT

Geothermal power plant projects range generally from small modular power plants to large plants of over 100MWe and are often located in remote areas. These projects are also characterized by higher initial capital costs, on a cost per kilowatt basis, than large thermal power projects because these capital costs include a lifetime supply of fuel. Owing to their very nature, geothermal energy projects face several financing hurdles, including (a) higher capital costs and credit risk issues in developing countries; (b) subsidized use of fossil fuels; (c) statutory limitations in the method by which multi-lateral agencies share project financing, and (d) time consuming and expensive reviews of projects, which may delay and even preclude project implementation. These challenges have resulted in the need to craft innovative financing solutions that resonate with the pressing needs experienced in most African states. One of the solutions is financing through Public-Private Partnership. The World Bank Group defines Public-Private Partnership as "A long-term contract between a private party and a government entity for providing a public asset or service in which the private party bears significant risk and management responsibility and remuneration is linked to performance."

Fast track financing of geothermal projects through public-private partnership and recognition of the real value of the benefits of public-private partnership in a geothermal project, will provide the opportunity for the development of new geothermal projects in Africa. Financing participants should choose a team leader, establish a budget for financing costs and set a closing timetable. Countries where geothermal is being developed and multi-lateral agencies should provide quantifiable credits for geothermal benefits. A shorter period from planning through financing approval while considering all the risks should be the realizable goal so that projects are developed when and where they are most needed.

This paper aims at exploring and highlighting how to conceptualize and structure geothermal projects to reap maximum benefits offered by the Public-Private Partnership for effective project financing in Africa. In addition, we intend to showcase to the various stakeholders in Africa, the opportunities and risks involved in investing in the geothermal space consistently and transparently.

1. INTRODUCTION.

Geothermal energy is a renewable energy source that occurs as natural heat within the earth's crust. It is majorly utilized for generating electricity as well as for direct use. Geothermal is present in areas where tectonism and volcanism have brought magma closer to the surface. In Africa, countries of the East African Rift Region are endowed with a significant geothermal potential for electricity production due to the conducive geological zones (IRENA, 2020). As groundwater circulates in permeable rocks through convection hydrothermal geothermal reservoirs are formed. It is considered to be a renewable energy source because the heat within the crust continuously flows toward the surface. Harnessing these resources can provide a stable and affordable energy supply to the countries. It can also assist governments to meet the objectives of the 2030 Agenda for sustainable development and climate change objectives set out by the Paris Agreement.

In today's stormy economic development many African governments have turned to a partnership with the private sectors as they face progressively constrained budgets and inadequacy to generate additional revenue. While public demand has not receded, quite, on the contrary, they have intensified: Public agencies are facing a growing scarcity of financial resources. Today, many find that traditional financing sources are no longer adequate to adequately address existing infrastructure needs such as energy and power (Anker et al, 2008). The contractual agreements are usually associated with improved service delivery, increased quality, cost savings, a high level of technology, and lower costs of financing. Public Private Partnership (PPP) has developed impeccably in the last two decades and currently represents a critical bit of public investments (Posner et al, 2009). Also regarded as a highly powerful arrangement that can mobilize resources and develop solutions to complex problems cutting across sector and policy domains (Muriithi, 2017). PPP allows the government to tap into the private sector's expertise, innovativeness, and flexibility towards the timely conclusion of projects, financial efficiency, and quality assurance (Juris Nooks –Legal article, 2015). African governments can leverage PPP to finance geothermal power plants and hence boost the development of geothermal power plants.

2. STATUS OF GEOTHERMAL IN AFRICA.

The East Africa Rift System (EARS) and the Comoros Island have reported temperatures as high as 400^0C (degrees Celsius) at depths of about 2300 meters (IRENA, 2020). Kenya and Ethiopia are the countries in Africa that have installed geothermal power plants with about 1000MW net capacity. Geothermal resources have been confirmed via drilling of exploration wells in Djibouti and shallow wells in the Democratic Republic of Congo and Zambia (IRENA, 2020). Currently, there is active drilling of geothermal wells taking place in Djibouti, Ethiopia, and Kenya with other countries in Eastern Africa only at the surface exploration phase of development. Tanzania Uganda and Zambia have drilled slim wells (IRENA, 2020).

In Zambia, the drilled slim wells intercepted a geothermal reservoir at a shallow depth, while in Uganda the drilling of gradient thermal well was temporarily suspended in April 2020 to allow completion of the ongoing environmental and social impact assessment. Exploration drilling in Rwanda was unsuccessful and Comoros is in the process of fundraising for exploration drilling.

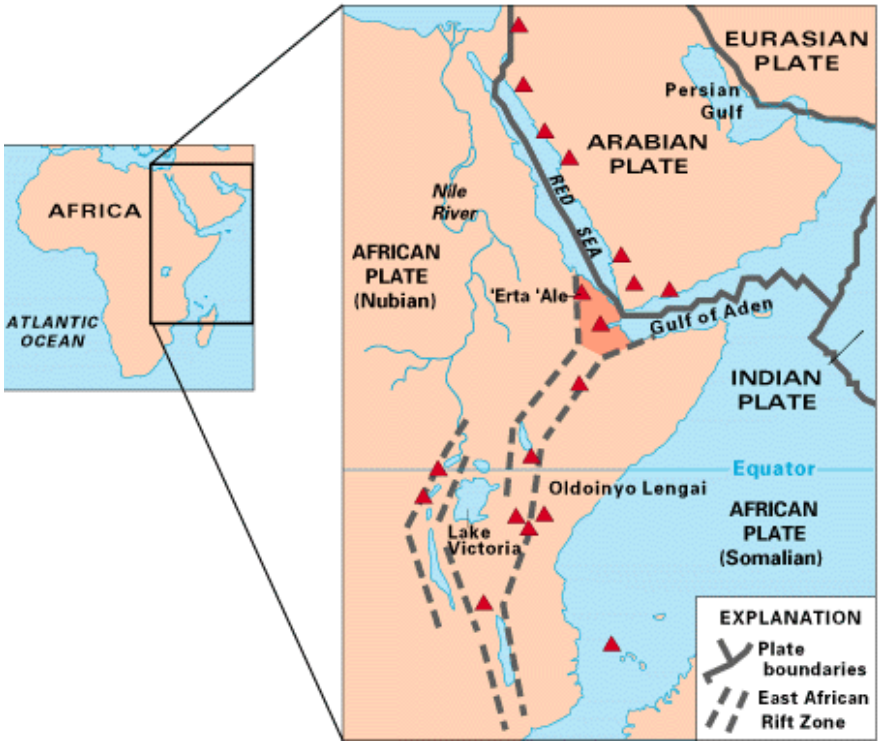

Figure 1. Map of East Africa showing some of the historically active volcanoes (red triangles) and the Afar Triangle (shaded, center) (USGS, 1999).

In Africa, there are countries known to produce oil and gas. Such countries include Algeria, Angola, Libya, and Nigeria which are some of the largest producers of oil and gas. Retrofitting oil and gas infrastructures is very possible with different technologies such as In Situ Combustion technology. The development of geothermal resources on abandoned oil and gas reservoirs is considered environmentally friendly. Zhu et al, 2019 found that the computational results showed that an optimal water injection velocity of 0.06 m/s provides the highest outlet temperature of (165.8 ◦C) and the greatest power output of (164.6 kW) for a single well in all the performed scenarios. While retrofitting the infrastructure, the importance of properties of working fluids, wellbore architecture, and operational parameters (circulation rate, inlet temperature, etc.) in geothermal energy production is emphasized (Sui et al, 2018). Zheng et al 2008, proposed to produce geothermal energy from abandoned oil and gas reservoirs by oxidizing the residual oil with injected air. Davis and Michaelides, 2009 investigated the feasibility of the heat exchanger using abandoned wells for power generation by ORC (Organic Rankine Cycle). Their proposed geothermal systems provided an output of 3.4MW when at optimal conditions. Advantages of utilizing abandoned oil reservoirs are that there is little or no drilling cost at all, which is generally the main upfront investment in any geothermal project.

Petrolern & WellPerform, 2020 did a play fairway analysis that focused on the conversion of oil and gas wells to geothermal energy production. They also focused on geothermal resource evaluation and development in sedimentary basins and on the conversion of existing oil and gas wells. The conversion of oil and gas wells to production or co-production of geothermal energy is a game-changing opportunity for increasing the value and reducing the environmental footprint of oil and gas operations. They developed a conceptual diagram of the activities and competencies for the development of a Play-Based Geothermal Exploration program to arrive at well-characterized prospects.

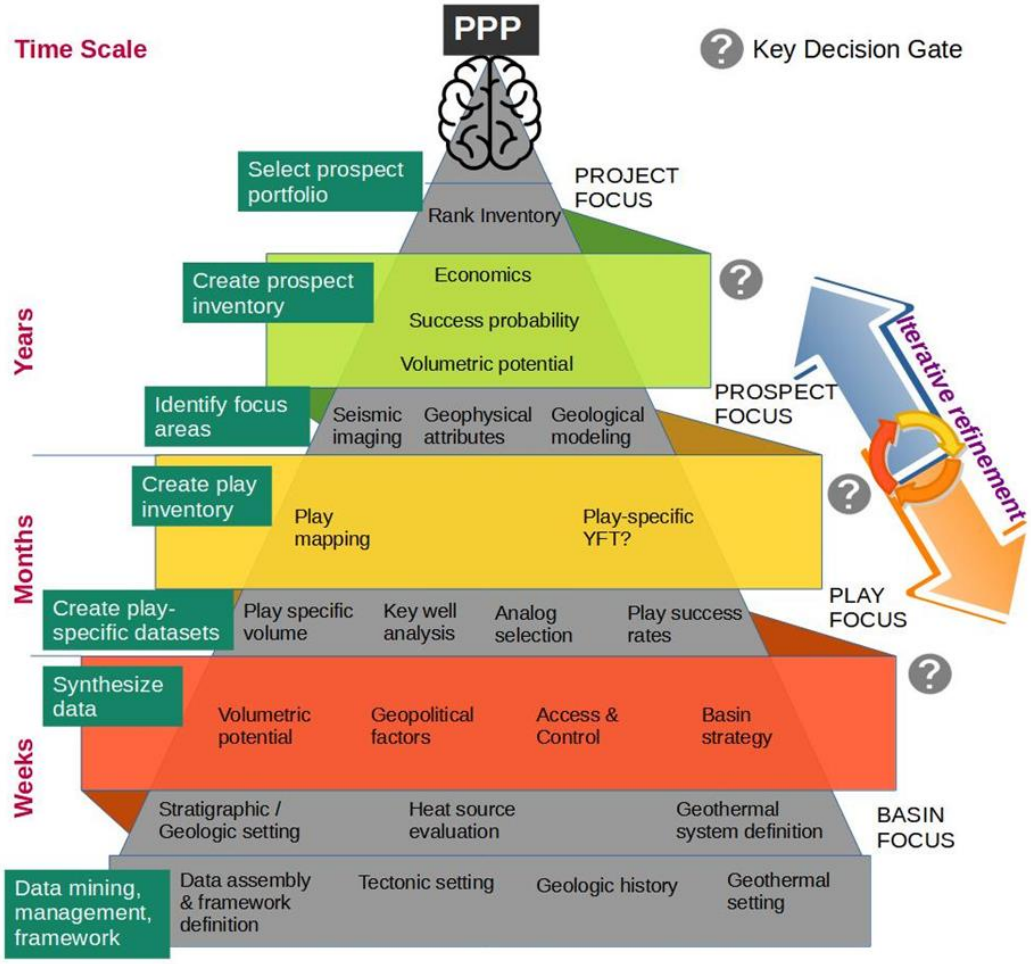

Figure 2. Play-Based Exploration pyramid for the development of geothermal resources (Petrolern, 2021).

For conversion to geothermal energy generation, several requirements must be met including (Petrolern, 2021):

- Nearby heat demand: Unlike oil and gas, heat is not easily transportable for long distances as it requires costly insulated flowlines.
- Heat resource matching demand, in temperature and flow rate. The flow rate depends on geologic characteristics but can be enhanced by connecting multiple zones or multiple wells in a field. Ideally, wells should provide pressure drive, but downhole pumps can be used to lift the fluids, at some expense in system efficiency.
- Adequate well integrity: Wells at the end of their productive lifetime may be compromised, as casing and cement can deteriorate over time and may require expensive well interventions, and not qualify for conversion.

3. GEOTHERMAL DEVELOPMENT COSTS.

One of the barriers that resulted in lengthy lead times between drilling and the final connection of wells is the financial obstacle. These financial challenges had to do with the economic situation in African states. Over Kenya's experience and in other African countries, several mechanisms were applied to secure funding for exploration, drilling, and development purposes. Experimenting with these has led to a solid understanding of the structuring of project finance.

Public-private partnerships (PPPs) allow African countries' governments to tap into the private sector's expertise, innovativeness, and flexibility toward the timely conclusion of projects, financial efficiency, and quality assurance. In Kenya, the PPP Act 2021 seeks to expand the scope of arrangements to facilitate greater participation by private parties through Annuity-based Design, Build, Finance, and Operate, Strategic Partnerships, and Joint Venture Partnerships (Louise Mathu, 2021). This paper presents a public-private partnership financing approach to developing geothermal power plants in Africa and presents an analogy of its advantages and challenges in our experience.

3.1 Convectional Geothermal Development Cost.

The cost includes:

Exploration costs

Include the cost of drilling exploration wells, desktop data review, detailed surface study (Geophysics, Geology, and Geochemistry surveys), and infrastructure development. (Ngugi, 2013).

Appraisal costs

Appraisal cost involves drilling additional wells and undertaking a feasibility study. In Kenya, it is typical to drill 6 – 9 appraisal wells (Ngugi, 2013). This feasibility study mainly entails a desktop study that would include reservoir simulation and undertaking a preliminary design of the proposed power plant.

Production drilling costs

Production drilling costs entail drilling to provide sufficient steam to operate a specific size of a power plant at full capacity and reinjection wells. The energy output from individual wells is highly variable, depending on the flow rate and the enthalpy (heat content) of the fluid

Power plant construction

The cost of power plants varies even for plants of the same size because they are designed to correspond to the resource attributes in particular turbine inlet pressure (Ngugi, 2013).

Operation and maintenance cost (O&M).

The operation and maintenance costs include staff, administrative and cost of spares, plant inefficiency, reservoir management costs, and cost of capital associated with increased working capital.

O&M costs for geothermal projects are high relative to onshore wind and solar PV, in particular, because over time the reservoir pressure around the production well declines, leading to poorer flow rates. Well, productivity, therefore, reduces over time, and eventually, power generation production falls as well, if remedial actions are not taken. To maintain production at the designed capacity factor, the reservoir and production profile of the geothermal power plants requires agile management, which will also typically mean the need to incorporate additional production wells over the lifetime of the plant.

Plant inefficiency cost

Geothermal power plants suffer failures and breakdowns too. They do not operate at design capacity over their entire life but with time the efficiency decreases and the plants require timeout for inspection, repairs, refurbishment, rehabilitation, and overhauls.

Steam field management cost

Steam fields necessitate close monitoring during steam production to forestall serious steam declines, cold flow invasion, scaling, and other adverse effects. Management and remedial operations may be undertaken including drilling make-up and supplementary re-injection wells, work-overs, tracer injections, and injection of scale inhibitors.

Period	Research & Development Including Surface Exploration & Exploration Drilling	Field Development Including Production Drilling & Surface Equipment	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	8.8	5	0	13.8	0	100
2000-2004	0.125	20	8	194	13	87
2005-2009	1	186	0	195	24	76
2010-2014	16.5	1,004	1.2	1138	21.2	78.9
2015-2019	49.4	294	0.1	576	16	84

Table 1: Total Investments in Geothermal in Kenya by 2019 (US$) (Omenda et al, 2020).

3.2 Geothermal Development Cost from Oil and Gas.

For the Oil and Gas case, Petrolern, 2021 projections, using real-world water production data and a conceptual conversion, indicated repurposing some oil and gas wells to geothermal power production is profitable with IRRs of 7 to 27%. Sample costs of produced electricity are US$0.03–0.05/kWh. These potential values warrant the evaluation of wells before permanent plugging and abandonment.

The primary issues hindering geothermal energy production in sedimentary basin settings seem to be the perceived high risk and high cost of geothermal projects and the necessary expertise to perform a full valuation of existing resources in a cost and time-effective manner. Petrolern screening tool streamlines well evaluation for the oil and gas industry, to facilitate a hydrocarbon-to-geothermal conversion. By providing a cost-effective and efficient evaluation of existing oil and gas wells, it's expected more hydrocarbon-to-geothermal conversion and co-production projects within existing oil and gas producing basins, thereby growing the geothermal industry globally and lowering emissions within the oil patch. Conversion of end-of-life wells to geothermal utilization provides additional monetary value while also providing a pathway to decarbonize existing operations

4. PPP PROCESS OF GEOTHERMAL PROJECTS.

As we look into the PPP process of geothermal project finance, we will look at;

- Legislative framework
- PPP Models
- Structure of PPP projects
- A case study of a geothermal PPP

4.1 Legislative Framework for PPP Geothermal Project Development.

There exist no single, model PPP framework. A government's PPP framework typically evolves over time, often in response to specific challenges facing its PPP program (World Bank, 2017). In the early stages, the emphasis may be on enabling PPPs and creating and promoting PPP opportunities. Once several PPPs have been implemented in different industries in a country, on an ad hoc basis, concern about the level of fiscal risk in the PPP may be revisited for strengthening the PPP framework. In this case, the focus may be on strengthening control over how PPPs are developed or improving public financial management for PPPs, for example in South Africa (Burger 2006).

In Africa, PPP laws and institutions have become increasingly common, but are still in development in many cases (AFDB, 2020). Some African governments have confirmed support of PPPs with specific laws or frameworks. Some countries have frameworks, while others have PPP-specific legal and regulatory frameworks and PPP laws currently undergoing policy discussions (within government bodies) or in the parliamentary process, with some having no clear roadmap towards a functional PPP framework (The Economist, 2015: 12-13). The challenge in these countries, however, is ensuring strong rules and regulations, as well as effective implementation (The African Development Bank Group, 2017:5). A PPP program can only be successful if the legislative framework provides a clear, fair, predictable, and stable legal environment (Chaponda, 2013). African Countries have different arrangements regarding the placement of PPP under their authority. Some countries establish a PPP unit as a focal point for PPPs (World Bank, 2012). In the Southern Africa Development Countries sub-region, for instance, Botswana, Malawi, Mauritius, and South Africa have established PPP units although multiple countries have passed laws mandating their creation (Mfunwa et al, 2015).

4.2 PPP Models

PPP models are classified into five broad groupings. Each of the models is different in terms of ownership of capital assets, responsibility for investment, assumption of risk, and duration of the contract (Karim 2011).

Broad Category	Main Variants	Ownership of Capital Assets	Responsibility of Investment	Assumption Risk	Contract (yr
Supply & management contract	**Outsourcing**	**Public**	**Public**	**Public**	**1-3.**
	Maintenance management	Public	Public / Private	Public / Private	3-5.
	Operational maintenance	Public	Public	Public	3-5.
Turnkey		Public	Public	Public / Private	1-3.
Affermage/ Lease	Affermage	Public	Public	Public / Private	20-May
	Lease*(BLT)	Public	Public	Public / Private	5-20.
Concessions	*BOT, BTO, BOOT, BROT	Public / Private	Public / Private	Public / Private	15-30
Private Ownership of Assets	*BOO/DBFO	Private	Private	Private	Indefinite
	*PFI	Private	Private	Public / Private	15-20
	Divesture	Private	Private	Private	Indefinite

Table 2: PPP Models (Source: UNESCAP 2011)

4.3 Structuring Geothermal PPP Projects in Africa.

Taking advantage of the private sector's capability in the delivery of public infrastructure will result in the achievement and maintenance of a balanced risk-return structure, thereby providing effective services.

As the private sector is known to possess good mobility, this will offer cost savings to the aspects of the projects such as planning, design, construction, and eventually the operation.

The typical PPP process is as follows;

a) Development phase

The contracting authority intending to implement a project through a public-private partnership under the PPP law shall be responsible for conceptualizing or identifying potential projects and undertaking the preparatory and tendering process of the project. A contracting authority shall then, constitute a project implementation team for overseeing the structuring and implementation phases of the project.

b) Procurement phase

Three kinds of procurement methods for PPPs are known to exist – direct procurement, privately initiated proposals (PIIP), and competitive bidding.

The PPP law in different countries also allows for negotiations between the negotiating committee, constituted by the Contracting Authority, and the first-ranked bidder. These discussions cover the technical, commercial, legal, social, environmental, local content, and financial terms of the project agreement.

c) Contracting phase

The PPP law determines the criteria that a Contracting authority would use in determining the duration of a public-private partnership agreement example; (a) the life span of the technology to be employed under the agreement; (b) the investment standards that are required to be maintained by each party to the project agreement throughout (c) the duration of the public-private partnership agreement; (d) the economic and financial viability of the project and the economic life of the facilities to be provided.

Project finance is a risk transfer process whereby the public sector transfers the risk of construction of an asset to the private sector which in turn will obtain financing for the asset and in so doing defer the government's obligation to make payment to the post-construction period.

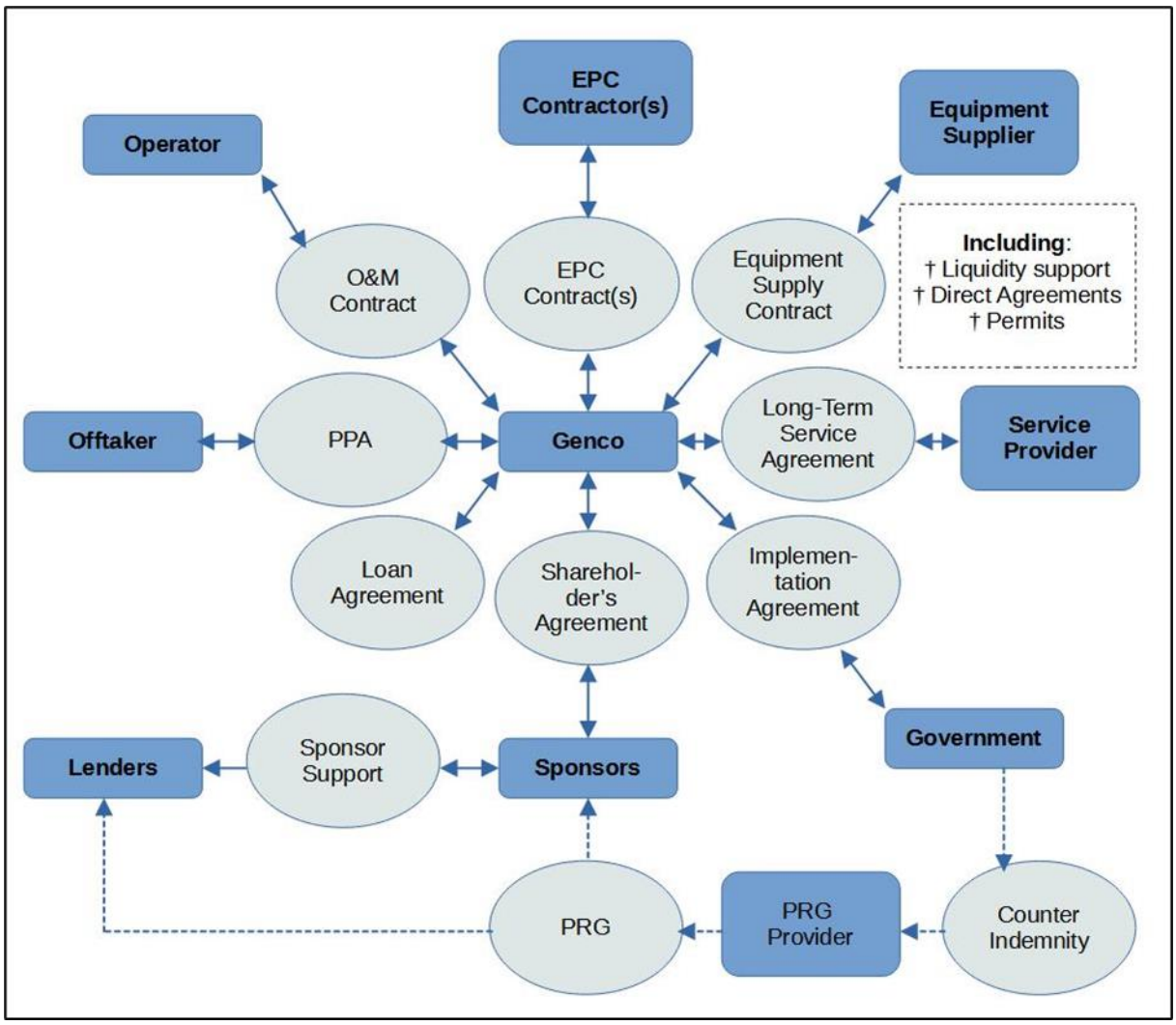

Figure 3. PPP Structure Diagram. UNECE PPP standards for grid-connected renewable energy (2016).

Genco: Power Generating and selling entity.

PPA: Power Purchase Agreement.

EPC: Engineering, Procurement, and Construction.

PRG: Partial Risk Guarantee

Some of the risks that a geothermal PPP project would face are;

- Availability Capacity –the requirement to generate the amount of electricity at agreed-upon levels throughout the concession term
- Development of Steam wells and Steam Availability – the requirement to ensure the agreed-upon steam is available throughout the concession period to enable the generation of power.
- Financing - the responsibility for obtaining the funds to develop and maintain the plant
- Design and Construction – the responsibility for the design and construction of the plant and bears all the cost and time overruns during construction
- Tariff restructuring – remains the responsibility of the public sector
- Transmission line failure -the requirement to ensure that the lines are in place and adequate to offtake the electricity that will be generated before the commissioning of the plant
- Deemed generated energy - if the government fails to dispatch electricity, then the public sector will have to bear the risk.

4.4. A case study of a geothermal PPP in Kenya.

In the Menengai geothermal 105MW project, Geothermal Development Company (GDC) is the steam supplier, Kenya Power (KPLC) is the off-taker, and Kenya Transmission Company (KETRACO) is in charge of the evacuation facilities while three IPPs are to build three power plants generating 35 MW each. Below is a breakdown of the risk transfer in the project.

RISK	GDC	IPP	KPLC	GOK
Fuel Risk (Steam)	Deemed Payment Obligation To The IPP/Termination Payment	N/A	N/A	N/A
Market Risk	N/A	N/A	Deemed Payment Obligation To The IPP/Termination Payment	N/A
Foreign Exchange Risk	N/A	N/A	Pass-Through Cost To Consumer	N/A
Financing Risk Due To The Long Lead Time (Time Lag) Between The Initial Investment And The Start Of Revenues	Exploration, Drilling, And Steam Gathering System	Development Costs And Investment During Construction	N/A	N/A
Termination Risk Before Financial Close	Cost Incurred	Cost Incurred	Cost Incurred	N/A
Termination Risk After Financial Close	Related To Fuel	Related To Generation	Related To Evacuation/ Demand	Termination Due To A Political Event
Short Term Payment Delay	GDC Operations Security/ PRG	IPP Operations Security	Partial Risk Guarantee	Partial Risk Guarantee
Permits And Authorization	Related To Steam Field	Related To Power Plant	Related To Power Offtake	Related To Timely Issuance
Construction Delay	Steam Gathering	Power Plant	Evacuation Facilities	N/A
Technology Risk	Steam Gathering	Power Plant	Evacuation Facilities	N/A
Operation And Maintenance	Steam Gathering	Power Plant	Evacuation Facilities	N/A

Table 3: Risk Allocation for Menengai 105MW Project (Adrian, 2016)

5. FINANCING OF GEOTHERMAL POWER PROJECTS

The earlier phases of greenfield geothermal project development comprising surface-based exploration, discovery, and exploration drilling to confirm the availability and viability of the resource are typically associated with the highest risks. These phases also require significant financial investment which private parties may not be in a position to or be willing to invest in given the risk that findings of the initial phases could show that the resource is inadequate and/or unviable. Financial resources expended in this phase would therefore be sunk costs that cannot be recovered and these costs can be quite significant. Test drilling alone can account for up to 15% of the overall capital cost. It is for these reasons that the upstream phases of geothermal project development tend to rely heavily on investment by the public sector, while private investors tend to enter the project at more mature phases (Gehringer and Loksha, 2012).

Studies reveal that the African continent has 14 regions with high geothermal potential which could be used for further geothermal reconnaissance, investigation, and development. Most geothermal project development has however largely taken place within the East African Rift System (EARS) and most notably in Kenya, which then also provides good examples of how various geothermal projects have been financed. There are several options available for geothermal projects ranging from public sources to grants and concessional finance. These are in some instances complemented by technical assistance from support programs (IRENA, 2020).

5.1 Public funding

Public finance has played an important role in successful geothermal project development, which has contributed to Kenya's ranking as the African leader in geothermal. The exploration phase for the country's first privately funded and developed geothermal power plant on the continent, Olkaria III, was undertaken by the Government of Kenya before the construction of the power plant. Concessional loans from the China Exim Bank facilitated the appraisal and production drilling at Olkaria I, II, IV, and V. The Geothermal Development Company (GDC) which is mandated to undertake early-stage geothermal development to allow for the entry of private investors, was established in 2008 with funding provided by the Government of Kenya.

Tanzania established the Tanzania Geothermal Development Company (TGDC) in 2013 with funding largely from its government and undertakes exploration drilling to enable the harnessing of geothermal resources. In Djibouti, the Djibouti Office for Development of Geothermal Energy (ODDEG) is involved in surface studies and confirmatory drilling. It is an agency of the Djibouti government and its activities are funded using concessionary loans from the Arab Fund for Economic and Social Development and Kuwait Fund for Arab Economic Development, all of which are guaranteed by the Djibouti government. Exploration and drilling activities in Ethiopia, Eritrea, Uganda, and Rwanda have also been financed by their respective governments (IRENA, 2020).

5.2 Private Finance

The instances in which private investors developed geothermal resources using their funds have been those in respect of which the resource has been largely harnessed for its use. Examples are a geothermal heated dryer in Eburru, Kenya which was developed in 1939, and a 0.2MWpower plant in Kiabukwa in the Democratic Republic of the Congo which was used to supply electricity to a mine. In recent years, Ethiopia, Kenya, and Uganda have issued licenses to private investors to develop greenfield projects. In Kenya, 14 licenses were issued to greenfield prospectors between 2008 and 2019 to undertake surface studies and drill exploratory wells (IRENA, 2020).

5.3 Financing Arrangements in Geothermal Public-Private Partnerships

The various experiences with public and private financing in geothermal development as captured indicate that to attract private investors, involvement of the public sector is important, particularly if the latter contributes financial resources in the upstream phases which carry greater risk. PPPs have been successfully adopted around the world to develop power projects using different generation technologies. The PPP model has been noted to be particularly effective for geothermal projects if it covers all major project phases including test drilling, field development, and power plant construction. In such an arrangement, the public sector could concentrate its contribution of financing resources in the riskier upstream development phases while the private partner finances the bulk of the capital costs in the more advanced phases which involve the construction of the power plant and its subsequent operation (Gehringer and Loksha, 2012).

The figure below provides a representation of the models that have been adopted by different African countries with a key feature being the involvement of the public sector in the upstream phases.

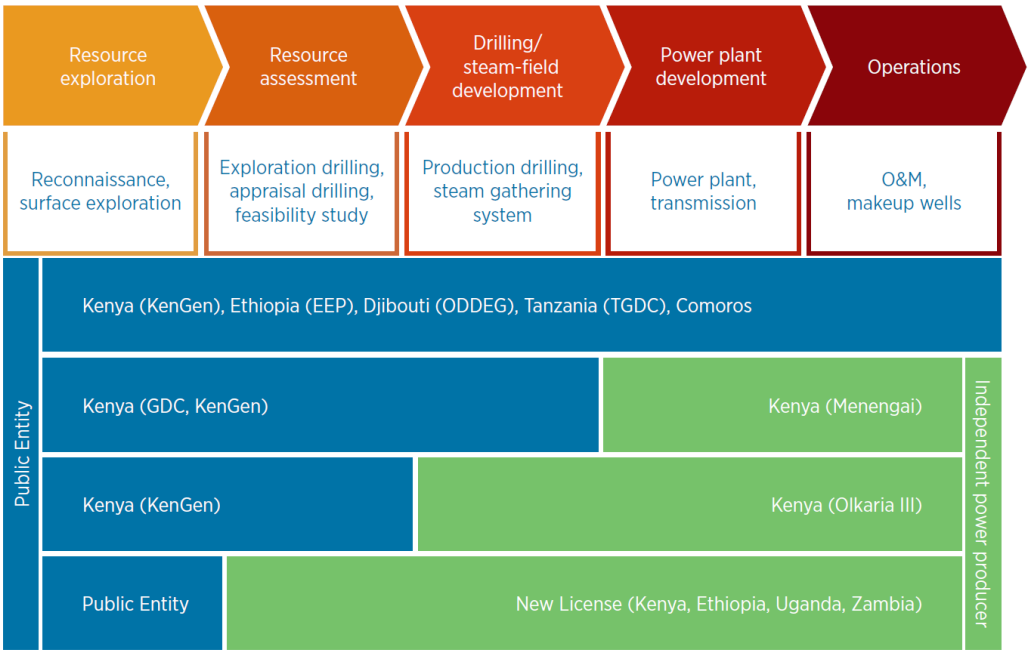

Figure 4: a representation of the models that have been adopted by different African countries (IRENA, 2020).

Two PPP models have been used in Kenya. The first is where public funds were used for the development of the field following exploration and/or exploration and a private entity is licensed to drill appraisal and production wells, construct a power plant and operate and maintain it, a Build-Own-Operate structure. This was the model adopted for the Olkaria III 150MW (KPLC, 2021) geothermal project which was developed by OrPower 4. Development of the project was done in phases commencing in the 1990s expanding the plant's capacity gradually from an initial 8MW to its current capacity. Ormat Technologies provided equity financing with an initial commitment of USD 40 million for the first phase. The project secured debt financing eleven years later in 2009. This debt financing was enabled by the renegotiation of the power purchase agreement with the off-taker, KPLC, and the provision of a government security package, as well as Political Risk Insurance (PRI) provided by the Multilateral Investment Guarantee Agency (MIGA). Various development finance institutions (DFIs) provided the required financing – a consortium of Deutsche Investitions- und Entwicklungsgesellschaft mbH (DEG) and KFW Development Bank led by the Overseas Private Investment Corporation (OPIC) (Micale et al, 2015). It is instructive to note that the construction of the Olkaria III geothermal power plant began well before Kenya adopted its first PPP Act of 2013 (now replaced by the PPP Act of 2021).

The second model involved the adoption of a Project Implementation and Steam Supply Agreement (PISSA) under the Menengai Phase I project. The Menengai Geothermal Development Project is to be developed by GDC in five phases with the long-term goal of developing 465MW of geothermal steam equivalent. The first phase of this project involves the development of three power plants by three independent power producers - QPEA GT Menengai Limited, Sosian Menengai Geothermal Power Limited, and Orpower Twenty-Two Limited, all special purpose vehicles (SPVs) incorporated in Kenya as required under the PPP Act. Each plant is to have a generation capacity of 35MW making an overall total capacity of 105MW. The project is being undertaken through a steam sales business model where GDC supplies the steam to the power plants for conversion to electricity (through the PISSA) under a Build-Own-Operate arrangement. GDC as the state-owned entity is responsible for financing the early phases of steam resource development in the geothermal field, drilling activities, and development of the steam gathering system which collates the steam produced and conveys it to the power plants. The IPPs were to finance the construction and operation of the power plants and buy the steam supplied by GDC under a Project Implementation and Steam Supply Agreement (PISSA). The IPPs signed a Power Purchase Agreement with KPLC as the single off-taker of all the electricity to be generated by the three power plants.

The third kind of PPP model is being implemented in the Corbetti and Tulu Moye projects in Ethiopia. This structure has an independent power producer (IPP) entering into an agreement with the state or state agency for the development of the geothermal field. Under this arrangement, the licensee will drill exploration and production wells, construct a power plant, and operate and maintain it under a Build-Own-Operate-Transfer (BOOT) arrangement (IRENA, 2020).

Sharing of risks and costs between the public and private sectors through a PPP structure can contribute to de-risking of projects thereby potentially attracting more financing from debt markets at favorable rates. Other benefits that can flow from adopting PPPs include achieving financial close faster because the project is significantly de-risked and expertise from both the public and private sectors can be efficiently allocated and utilized.

5.4 Risk Mitigation Facilities Supporting Financing of Geothermal PPPs

The potential of geothermal energy as a renewable energy resource continues to attract interest in the African continent where the resource is found. Several facilities are now available to mitigate the risks associated with geothermal project development. The Geothermal Risk Mitigation Facility is one such program that was established in 2012 by The African Union Commission and partner development finance institutions such as the German Federal Ministry for Economic Cooperation and Development (BMZ) and the EU-Africa Infrastructure Trust Fund (EU ITF).

The overall objective of the GRMF is to encourage public and private sector investment in geothermal power generation. This is achieved by providing financial support to mitigate the early-stage exploration risk associated with geothermal power projects to improve project bankability and secure external financing.

Political risks can be mitigated through political risk insurance and can be offered together with credit enhancement guarantees through MIGA. Facilities such as the Regional Liquidity Support Facility provides short-term liquidity support to IPPs to cover non-payment risk by off-takers.

6. CHALLENGES OF FINANCING GEOTHERMAL PROJECTS IN KENYA THROUGH PUBLIC-PRIVATE PARTNERSHIPS.

Project finance is a relatively longer-term financing mechanism whereby the lenders have recourse primarily to the future revenue streams and assets of the project/s they are financing. Unlike in the traditional corporate financing model whereby the borrowing entity's historical track record will be used to evaluate its ability to repay, in project financing, the focus is on the predictability and ability of the future cash flows to sufficiently and sustainably meet debt servicing requirements. As such, the structure and size of the financing facility are hugely influenced by the structure of the cash flow envelope of the project.

Due to its longer-term nature, project finance is the most suitable methodology for financing Public-Private Partnerships (PPPs), especially in the energy sector. Challenges include:

6.1 Undeveloped financial markets.

Project finance has been widely used in developed countries due to the advancement of their financial markets among other factors. On the contrary, Africa and other emerging markets are still lagging. There is very slow adoption and use of project finance in Africa, thus limiting the flow of capital into infrastructure PPP projects.

For PPPs to thrive in the energy sector, African countries must develop financial markets that can provide sustainable and long-term finance that understands the limitations and dynamics of the geothermal sector in the country.

Kenya as an example, despite having a robust capital market the country has not been able to develop innovative solutions that will help crowd capital for specific infrastructure projects like geothermal projects. Players like the Nairobi Securities Exchange are still perceived to be a reserve for the middle- and higher-class citizens thus not tapping from the masses in the lower classes.

Commercial banks are also hesitant to lend for long tenures, especially for complex infrastructure projects like geothermal projects. It is practically impossible to access financing facilities with tenures of more than 10 years in most African countries' markets. Energy projects like geothermal projects are capital intensive and as such require longer-term financing arrangements to be financially viable.

Additionally, most of the players in the African financial market are hesitant to lend on a project financing arrangement. They insist on collateral-based lending making it impossible for project sponsors who do not have sufficient balance sheets to guarantee the heavy borrowing required for geothermal projects.

Owing to these limitations, project sponsors have been forced to borrow offshore. Unfortunately, offshore borrowing comes with some conditions and costs. When the borrowing is in a foreign currency different from the revenue streams of the project, borrowers will have to incur additional hedging costs making the financing expensive. Offshore lenders would also demand higher returns to be compensated against the real and perceived risks of the country and project.

6.2 Poor risk allocation

Proper and efficient risk allocation is at the core of the success of any PPP project. There is a misconception in the public sector especially in Africa that risk should be transferred to the private sector, putting off the private sector from investing in the region.

Just like any capital-intensive project, there are numerous risks to investing in geothermal projects in Africa. There is a need to map out all the risks during the preparation stage and reasonably allocate them to the party that is best placed to manage them.

Providers of finance would want risks to be allocated and shared optimally to guarantee repayment of their investment and a return on their investment in the project.

Africa still needs to build a consistent track record to attract more sustainable financing to geothermal projects. For this to happen, the government needs to make a deliberate decision to take up key risks in geothermal projects to attract a wider pool of private investors for geothermal projects.

6.3 Capacity challenges

Structuring and managing PPPs for large and complex geothermal projects requires advanced skills and experience which might not be available locally. As such public bodies might have to contract foreign consultants who might be very expensive limiting the commissioning of feasibility studies to inform investment decisions in the geothermal sector. Providers of finance for geothermal PPP projects would require very robust and competent feasibility studies which are costly to conduct.

As much as public bodies would have the technical experience, they lack teams that can blend the technical experience with project finance and PPPs to unlock financing for their projects. There is insufficient capacity in the structuring, procurement, financing, and management of PPP agreements in those bodies. As a result, private sector investors are hesitant to invest in geothermal projects through PPPs.

6.4 Negative publicity

There has been quite some negative publicity in Africa putting off investors who have chosen to invest in other countries. This negative publicity erodes investor confidence thus limiting private sector interest in geothermal projects and other energy projects that are sounded in the market.

Inadequate transparency in the procurement processes is a major challenge. Some of the decisions made by the government are skewed pushing away investors. This makes it difficult to finance geothermal and other energy projects through PPPs.

6.5 Inconsistent decision-making in Africa's energy sector

Inconsistent decisions made by the African government officials in the energy sector deter private sector investors. Investment in geothermal energy is long-term and requires consistent policies to win the confidence of the lenders. An example is a recent push by the Kenyan government to renegotiate Power Purchase Agreements for contracts that had been entered between the government and the Independent Power Producers.

6.6 Changes in the tax laws.

Any changes in the tax laws in the country with no protection for private investors who have invested for a long time in the energy sector could be counterproductive. Some of these changes could alter the entire dynamics of financing arrangements entered for energy projects making it difficult for investors to earn a fair return on their investment.

7. CONCLUSION.

This paper presents a preliminary perspective of how institutionalized PPPs can be applied to geothermal power plants, in Africa. There are still some barriers to the development of the geothermal sector as shown in this paper. All-embracing, the adoption of PPPs appears to be a positive effort to accelerate geothermal development in Africa. While not conclusive, there is the opportunity that PPPs can improve operational efficiency in regulatory regimes and contractual specificities.

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