Presented at "Short Course VI on Utilization of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilization", organized by UNU-GTP and LaGeo, in Santa Tecla, El Salvador, March 23-29, 2014.

UNITED NATIONS UNIVERSITY
GEOTHERMAL TRAINING PROGRAMME

LaGeo S.A. de C.V.

RISKS AND RISK MITIGATION IN GEOTHERMAL DEVELOPMENT

Paul K. Ngugi
Geothermal Development Company Limited
Nairobi
KENYA
pngugi@gdc.co.ke

ABSTRACT

Geothermal projects are designed to be within time, budget, planned specification and legal and regulatory provisions while meeting the project objectives. The geothermal development is exposed to various risks of varying degrees throughout all its phases and stages of development. The resource risk distinguishes geothermal projects from others projects. This persists through all phases and stages of development. It takes several forms including resource existence and size, suitability, sustainability and utilization challenges. Other risks include way leaves, market, financing, commercial and macro-economic risks.

Comprehensive and detailed surface studies, numerical simulation and interference tests during resource utilization are cheaper ways that inform the possibilities of occurrence of various forms of resource risk and provide information for formulation of resource risk mitigation strategies. Coupled with reservoir monitoring and incremental development, resource risk can be managed effectively. Undertaking a baseline environmental and social studies can avoid project disruption and law suits against the project. Deliberate engagement of the host community can bring about the positive understanding of the project and buy in.

Conservative assumptions and use of time and financial contingencies are essential in deriving a tariff that safeguards investors' interest, use of generation tax credit, concessional financing such as green funds and carbon credit help improve project financial competitiveness, power purchase agreement shield the investor from the market risk inflation and foreign exchange risks.

1. INTRODUCTION

The objective of undertaking a geothermal power project is to generate power for consumers on a value for money basis, generate return for the investor over the hurdle rate and service debts from lenders and suppliers when they become due, while still making sufficient funds to meet operational and maintenance cost. For these goals to be met, a demand for the power must exist, a resource characteristics are suitable and can sustainably be exploited for the economic life of the project within the legal and environmental framework has to be identified, a matching proven technology to develop and exploit the resource must exist at a competitive price, investors, lenders, off-takers and technologists must be available for the project to take effect. The probability that the project will be implemented according to plan and meet the desired goals without a hitch or glitch is highly unlikely. Therefore forestalling risks, estimating impacts and defining responses to emerging issues is an essential aspect of project management. Risk may be defined as the chance that an investment's actual return will be different than expected.

Risk involves a state of uncertainty where some of the possible outcomes are undesirable (Hadi et al., 2010). Figure 1 (red) shows the resource uncertainty versus investment cost (blue) for the various geothermal development phases and stages. The figure show that the uncertainty decreases overtime and as the project progress. However, the uncertainty is not totally eliminated. On the other hand the investment cost progressively increases as the project progresses.

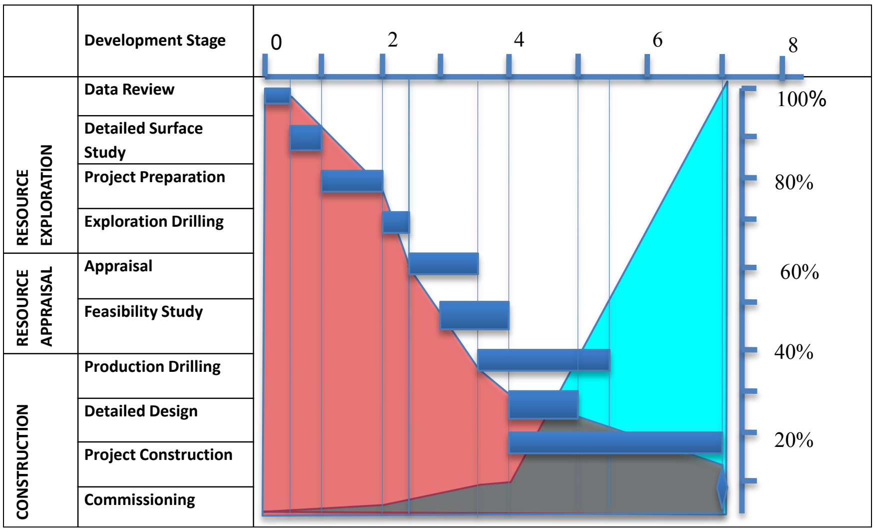

FIGURE 1: Development resource uncertainty and investment cost against project progress

2. LAND ACCESS AND WAY LEAVES

Like all other physical projects, land is a required for the geothermal project to establish the wells, road infrastructure, the power plant and the power evacuation system. As human populations increase, land which is a constant production factor continues to become scarce and precious. Geothermal development therefore is in competition with other land uses. Land access and way leaves is one of the most sensitive aspects of the geothermal project especially because it causes the project to results in resettling people out of the project area.

Land negotiation can be protracted stalling or delaying the project. Implementing an attractive resettlement package, providing adequate time to procure land and deliberate strategic stakeholder communication programs are vital for the success of the project. Ultimately, government support may be necessary when a need arises for compulsory acquisition of land (Government of Kenya, 1982).

3. RESOURCE RISKS

The one risk that distinguishes a geothermal project from all other power projects is the resource risk. All other risks are generally well understood, can be quantified and therefore addressed. Every geothermal field is unique. In addition, sections of a geothermal field may exhibit different characteristics and or different development challenges. In Kenya for instance, the three geothermal fields so far drilled do not bear similar reservoir characteristics. In particular, the greater Olkaria geothermal field, has different section of the fields have exhibited different characteristics and within the same sections it has been observed that some wells have different chemistry, well output, temperature, pressure, enthalpy and drilling challenges. The resource risk is not only confined to the resource exploration and appraisal development stage but in general persists throughout the entire economic life of the project although of varying degrees. The resource risk falls into several categories some of which are existence, resource size, suitability, and utilization challenges.

3.1 Existence

It is not sufficient that a geothermal prospect possesses magnificent surface manifestations such as geysers, fumaroles, hot springs, steaming and altered grounds or mud pools. To prove commercial viability of a resource, drilling of deep wells is required. Infrastructure such as roads, water system and other supporting facilities are required for drilling of exploration wells. Further, funds are required for drilling of wells, mobilization and demobilization of drilling equipment. The mobilization and demobilization costs may be sizable. This is the first stage of the project that requires significant funds. At this stage, uncertainty of the outcome is highest. To increase the probability of successfully drilling a discharging well, various studies are undertaken. The studies are aimed at estimating or predicting the existence of a heat source, reservoir temperature, existence of reservoir fluids and recharge mechanism and geological structures to support evolution of a geothermal reservoir and depth of the reservoir.

The studies that are undertaken include geological and hydrogeological studies, gravity measurement, resistivity measurement, sampling of fumaroles gas seepages, chemistry of borehole fluids and temperature measurement. The encountering magmatic gases indicate possible existence of a heat source, geothermometry analysis undertaken with the chemistry of the sampled fluids provides insight to the possible reservoir temperature, micro-seismic activities may indicate where the fluid movement exists (target for drilling) and the possible reservoir depth and resistivity anomalies may indicate the possible areal size of the resource. High seepage of reservoir gases may indicate possible high permeability a precursor for large output wells and chemistry of the sampled fluids indicate the upflow within the system or possible development problems such as scaling. Temperature gradient measurements are used to estimate top of the reservoir. Geophysical measurements also help indicate the top of the reservoir thus aid in designing well casing programs.

It is the strength of convincing detailed surface studies tha exploration wells are sited. In the event that none of the three wells typically drilled at this stage are productive, then further development is halted until a review of the data is undertaken. On the other hand, if one well discharges fluid, the resource is said to be proven. It is common practice to assume a low success rate for the exploration wells to reflect the level of risk in a financial model.

To motivate privates sector and governments to invest in this stage of development, the African Union Commission with the support of donor community have devised a grant termed Geothermal Risk Mitigation Fund (GRMF) available only to a few countries in Eastern Africa. The grant is designed to meet part of the infrastructure cost as well as the cost for the drilling of exploration well. An additional component may be available to the investors if the project progresses to appraisal drilling.

3.2 Suitability

It is not uncommon for wells that have discharged fluid to be plugged because the fluids they produced are corrosive, or remain idle due to temperature inversion or cyclic discharge as well scaling. There are generally three technologies employed in the exploitation of the geothermal resource for electric power generation namely steam turbine/ flush technology, binary technology and a hybrid model.

Temperature, pressure, enthalpy and permeability are the major criteria for suitability of a resource. The higher the temperature/pressure, the better is the resource. Low yielding wells with low temperature increases capital investment because a larger number of wells would be required for a particular plant size. Permeability influences the well capacity which is a product of fluid mass and enthalpy. High mass flow and enthalpy results in wells with high potential power potential. Large amounts of non-condensable gases, corrosive nature of fluids and potential to develop scaling reduces the value of the resource.

The cost of drilling accounts for the greater resource development cost and is further influenced by the depth of the resource. Deep seated resource or high drilling costs can inhibit the development of a resource.

Investing in studies which lead to siting of high yielding wells with high temperature/ pressure and avoiding drilling in areas with potential for scaling improves financial performance for the project. Conservative assumptions on well productivity are essential when projecting capital cost and tariff.

3.3 Size

After drilling a successful discovery well, there remains a great uncertainty as to what resource area exists with exploitable fluid characteristics (Sanyal and Koenig, 1995). Resistivity measurements used to make initial resource size estimates are known to deviate from reality (Hadi et al., April 2010). Figure 2 shows a typical resistivity profile used for siting wells. Further appraisal wells are drilled in order to delineate the areal area of the resource and to confirm suitability of the resource. Conceptual models updated using data from exploration wells can greatly improve the success of siting subsequent wells. However, the risk of drilling unsuccessful well remains significantly high. Provision for failed wells in the financial models is necessary to accommodate this risk.

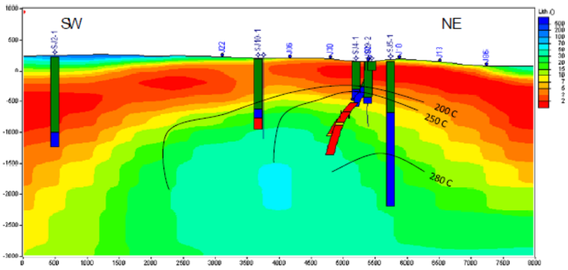

FIGURE 2: Resistivity profile used for siting wells (Hadi et al., 2010)

3.4 Sustainability

The economic life for geothermal power projects is typically 20 to 30 years. For the entire period, steam/ brine has to be guaranteed. Ordinarily, the steam pressure and or well yields decline slightly before stabilizing. Potentially all fields can degenerate significantly by way of decline in pressure/ well yield, adverse fluid chemistry change (Sanyal and Koenig, 1995), or incursion by cooler fluids. Together, these factors either require additional capital investment to make-up for steam/ brine decline or increase operational costs.

Selection of turbine inlet pressure versus wellhead pressure is essential to provide allowance for decline. Development of well calibrated numerical reservoir model to tract well output, resource quality and reservoir response under various exploitation scenarios will provide great insight to the probability of adverse reservoir occurrences. Undertaking incremental development will limit capital exposure to loss arising from these types of risk while providing adequate time to study and understand the resource response to utilization. Integration of hot and cold reinjection as informed by the numerical simulation can greatly help to avert pressure decline and check well yield decline. A reservoir monitoring program that includes well productivity testing, downhole temperature measurement, enthalpy measurement and fluid chemistry analysis is a must during resource utilization.

The financial model used for project evaluation and approval should include make-up wells, and undertake a sensitivity analysis on profitability under various development scenarios.

3.5 Development and utilization challenges

Even after a commercial resource has been discovered through drilling and delineated, some production wells within the delineated area will have dismal performance. Some will have cold inversion, cyclic pressure regime and below average yields. Others may show scaling tendency.

Experience has shown that there is a learning curve required in optimally developing a resource. In Kenya, Olkaria greater geothermal field has been under development for the last 60 years since the drilling of the first two well in 1956 – 1958. Over this period, observations have shown different sections of the greater Olkaria geothermal system to have very attractive characteristics while others with non-commercial characteristics. In the early stages of Olkaria development, the field was drilled to the shallow steam dominated reservoir section. These wells over time have shown noticeable decline in yield. On the other hand, it has become apparent that deeper wells have demonstrated better yields.

Geothermal resources are by nature fractured. Fractured systems are good for well yields but result in increased drilling cost. Major loss of drilling fluid circulation causes problematic drilling due to poor hole cleaning and extended cementing jobs. Sloughing formation can significantly increase drilling cost thereby compromising project profitability or leading to abandonment. Experience in drilling serves to reduce drilling challenges and costs.

Scaling increases the operational cost due to use of chemical inhibitors or mechanical cleaning. Entrained solids within steam can create challenges of deposits on steam turbine members, non-condensable gases can create stress related cracking or premature failure of equipment. Selection of materials for the construction of the plant and its accessories is therefore very important.

4. TECHNICAL RISKS

Financiers are risk averse and they would be cautious when faced with untested technology that may jeopardize recovery of their credit/investment. Technology is used to explore, access by drilling and utilize geothermal resource in power generation. Geothermal conventional steam turbines and binary technology are now fully reliable. Selection of manufacturers who have a successful history and long term business outlook is a prerequisite. Experienced geoscientists and drilling personnel are essential for success of the project. Use of experts is useful for peer review. Warrants and guarantees are instruments used to shield investors.

5. SOCIAL AND ENVIRONMENTAL RISKS

Environment and social economic issues (Naito, 1995) are very sensitive and can lead to a viable project not being approved, being denied financing and disbursement of funds. It is one area that many world governments control and regulate through legislation and have governmental bodies monitoring on a continuous basis. For electricity generation projects in Kenya, an environmental permit must be issued by National Environmental Management Authority (NEMA). Further, most financial institutions will require an environmental audit during project appraisal and implementation with a requirement to meet certain standards. Most financial institutions have employed specialists with environmental and social expertise for this purpose.

It is customary to carry out baseline environmental and social studies alongside detailed surface exploration studies. Upon successful surface exploration, a social environmental impact assessment study would be carried out before commencement of any site development. Prior to project ground breaking and during the life of the project investor representatives will engage host communities on a continuous basis by holding open gatherings to build project awareness, receive concerns, complaints and community based proposals for corporate social responsibility. In addition, weather stations are erected within and outside of the project area to monitor various factors of the project that could affect the environment. In addition, various environmental audits are carried out regularly to establish data and basis for corrections where standards are not met. Incorporating mechanism to comply with environmental regulations benchmarked to international standards is the best way to mitigate this risk.

6. MARKET RISK

Ultimately except where government provides subsidies, the end user pays for all the costs arising from electricity provision and therefore their need for power, willingness and ability to pay are influencing factors for a successful project. Besides demand, access to the market may be curtailed by lack of the necessary infrastructure including transmission and distribution network. It is the demand for affordable electricity that drive developments and in the absence of this demand the project assets will be without any return.

The feasibility study includes undertaking electricity supply and demand analysis and forecast as a basis for justifying further development. In addition, a long term power supply contract (Power Purchase Agreement) on a take or pay basis transfers the market risk from the investors and lenders to the off taker.

7. FINANCING RISK

All other types of risk eventually translate to financial risks. Investors and debt providers therefore have to identify and evaluate risk before they can commit financial resource to the project.

Additionally, project implementers have to be aware of and contend with the risk associated with their choice of debt providers. Kenya has largely relied on bilateral and multilateral financial institutions for financing its power projects. In a number of cases, this financing has disaster. In point from the 1990's, is where a geothermal project stalled for 10 years essentially because the government then was perceived as not subscribing to various political ideologies acceptable to the financier's sponsors. Even though the steam was available and tendering documents had been prepared, the Country could not raise funding from its traditional partners leading to the prolonged delay. In another instance, a project solely financed from a bilateral arrangement with only one financier on board stalled. Disbursements of funds to the project were stopped midstream, while all contractors and consultants were on site, simply because there was social agitation fronted by some non-governmental organization. The ensuing uncertainty lasted several years and during that period, the project accrued huge standby costs. Consequently, project became a loss making venture. A classical case was where the project capital cost tripled and the projected implementation time went from about two year to seven years. This arose from the financier demand that a study be made to ascertain steam which was already availability at the wellhead. The financier declined to allow an award for building an additional unit to the contractor who had constructed the previous two units, yet they were on site waiting to demobilize. The financier directed that a fresh competitive bid be undertaken and opportunity of constructing the third unit at a cheaper price lost and the project rendered loss making. In one other case, a financial delayed disbursed until the project had progressed 70% thereby inconveniencing the borrower.

Keen interest that certain financiers place on social resettlement programs can attract unjust enrichment from undeserved compensation. In one project in Kenya, certain people migrated into the project area, when they became aware that an appraisal program had successfully been carried out, and that the lender would require their full compensation for resettlement as a condition for funding.

About 25 years ago, arising from perceived corruption within the government, along with the unexplained murder of the a senior government official, a key lender declined to serve as principal financier for further geothermal development in Kenya and refused to negotiate a new credit until action was taken. As a result the geothermal development suffered delays (Geothermex Inc., 2010).

Typically geothermal projects have long lead times and the capital outlay is largely upstream. Further, the earlier stages of development are mainly financed using equity which is expensive as compared to debt. The high upfront costs combined with long lead times can influence cost of financing in a manner not favorable the project (Gehringer and Loksha, 2012). Further, capital budgeting tools used to compare projects namely IRR and payback period may show that geothermal projects are unfavorable.

Matching your financers' lending criteria vis-à-vis your project and country issues as the foregoing shows is crucial for the success of a project. Pooling lenders rather than using one lender spreads the risk of financiers' failures. It is important to have contingent measures to meet financing gaps in the absence of lenders or delay in disbursement.

Concessional financing through cheap loans from governments, green funds, carbon credits, tax holidays and generation tax credit where available help to improve the competiveness of geothermal projects thus making them attractive to financing.

8. OFF-TAKER DEFAULT RISK

Figure 3 shows the transaction model for the first 100 MW Menengai Project in Kenya used by Geothermal Development Company (GDC). The model shows the various key parties involved in the transaction. Off-take risk encompasses the risk of failure by the off-taker to take power due to reasons concerning dispatch, transmission line congestion, line failure and the risk that the off-taker may be unable to make the agreed payment in a timely fashion (Gehringer and Loksha, 2012).

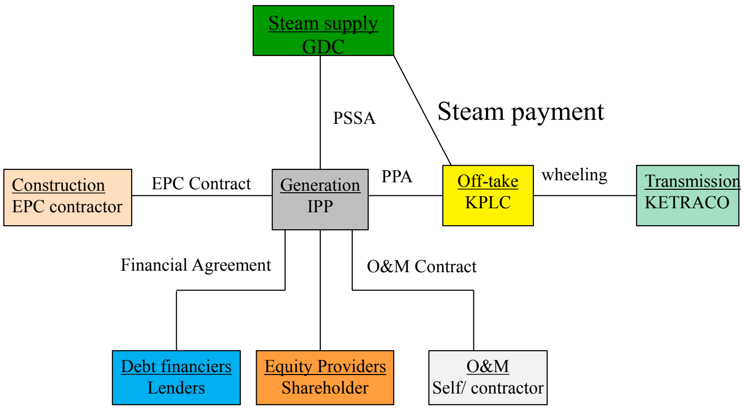

FIGURE 3: Transaction model used by Geothermal Development Company of Kenya

This risk is borne by the off taker in addition to the market risk. The off-taker through the power purchase agreement is obligated to procure a form of guarantee to safeguard against its failures. The guarantee may be in the form of bank guarantee, letter of credit or for government agencies they may procure partial risk guarantees. The power purchase agreements in Kenya are structure on a take or pay basis. Further, the off-taker is tasked to procure a sovereign guarantee or letter of comfort that becomes applicable should the off-takers default result in termination of the power purchase agreement.

9. POWER GENERATOR DEFAULT RISK

The obligation of the power generator falls into two categories, the fuel supply and energy conversion or power generation. Fuel supply entails availing steam or brine by way of prospecting, assessing and drilling while energy conversion entails designing and construction of the power plant, operating and maintaining it over the power purchase agreement period. As it were, the generator bears the resource risk, construction, operations and maintenance risks. In addition, by entering in a power purchase agreement, the generator is liable for liquidated damages in the event they do not meet their obligation as stipulated in the power purchase agreement.

The construction risks can be in the form of delays or time overruns, budget overrun or plant underperformance or malfunctions during commissioning. Time overruns and plant underperformance attract penalties while budget overrun strain the project capital needs and erode profitability. The plant design, construction delays and underperformance risks are passed over by the generator to a qualified engineer-procure- construct (EPC) contractor through a lump-sum, time based and turnkey contract. Time and budget overruns are also mitigated by providing contingencies.

The investors risk paying penalties during periods of plant downtime. Proper operations of power plant ensures revenues for all. However, prolonged breakdown and other downtime can compromise a return on investment and the ability of the plant to service its loan and generate sufficient funds to keep it in good operating conditions. The risk of operation and maintenance is therefore real and lasts for a long time. To mitigate the risk, adequate budgets and stock of spares and consumables are required. Proper preventive and maintenance schedules undertaken in time are essential. Outsourcing overhauls can help reduce risks and attractive personnel benefits can help recruit competent staff and retain them.

The generator will employ various insurance instruments to transfer risks related to their default.

10. FORCE MAJEURE

Force majeure are event that occur without being caused by any action or inaction by any of the contracting parties or there agents which prevent one or all parties from fulfilling their obligations under the contract. These events include war, strikes, crime, hurricane, flooding, earthquake and volcanic eruptions. For such events to be declared an act of forced majeure, the cause must not be as a result of a failure of the party declaring it, nor must it be predictable or preventable.

The effects can be temporary and possible to remedy without serious erosion of projected economic benefits. In this case each party involved takes liability of the losses arising from the force majeure. Certain obligations are waived especially relating to time aspects but the parties continue with the project. Where possible the parties insure such risks. Where the project can be remedied but the economic conditions of the project have been adversely eroded, the aggrieved party may seek buyout. Abandonment is an option where the project cannot be rescued.

11. INSTITUTIONAL RISKS

Both investors and the financiers will be concerned with the capacity of the institutions in the entire electricity generation and distribution value chain including contractors and lenders. Figure 3 shows the value chain for the Menengai first 100 MW project. GDC will avail steam which the independent power producer (IPP) will convert to electricity. The IPP will further contract an EPC contractor to construct the plant for them and seek funding from prospective lenders. The electricity will be sold to

Kenya Power and Lighting Company Limited (KPLC), the off take power, and power will be evacuated using Kenya Electricity Transmission Company Limited (KETRACO) transmission infrastructure. Any of these organizations can cause the failure of the project. The key concern in evaluating the organization's risk includes the experience of the organization to undertake its role, the financial capacity to undertake the projects and to endure financial shock that may arise during the project implementation and the human resource capacity to undertake, manage and operate the projects. Use of joint venture partnerships and consultants can alleviate financial and human capacity deficits.

12. MICRO-ECONOMIC RISKS

In Kenya, generation costs are pegged to the US dollar in order to shield both the power off taker and the generator from currency exchange risks. However, the consumers pay for the electricity in the local currency. The cost of the exchange rate variation is assessed on a monthly basis which is then billed to the consumers directly.

Over time inflation erodes money value such that a fixed amount of money will buy fewer goods in the future. If left unaddressed, inflation can erode the investors return on investment and may lead to poor management and maintenance of the power plants. In Kenya, the cost of inflation is an aspect of the power purchase agreement and is adjusted on an annual basis.

13. CHANGE IN LAW RISK

Imposition of legal requirements such as expansion or increase in taxes and royalties after the power purchase agreement has been signed whose compliance would result into material difference in the investors return can compromise the project financial integrity. Provisions are provided in the power purchase agreement that should such events occur the investor shall qualify for a review of the tariff.

14. LEGAL AND REGULATORY RISKS

All investments will result in various business transaction and contractual relationships. Potentially all these transactions and relationships could give rise to disputes necessitating arbitration and or court adjudication. Therefore investors and financiers would be concerned whether justice can be served and be enforced by evaluating institutions and national policies.

Countries that uphold independent judiciaries, enter into varies treaties and memberships of international bodies provide comfort to investors and lenders. Investors may avoid investing in countries where the risk is very high.

15. POLITICAL RISKS

The 25 year economic life of a geothermal project will see several changes of government. Elections particularly in Africa often times result in civil disobedience and may at times degenerate to civil war. Incoming governments are likely to formulate new policies if only to make political statements or may altogether vary policies seriously impacting existing and future developments. Investors and financiers seriously worry over whether they will be able to repatriate their investment to their country of origin, convertibility of the local currency to other currencies without making serious exchange losses or restriction and whether investment owned by foreigners will not be expropriated by rogue governments. Investors and financiers would require transparent and fair taxation policies. Further these policies should be long term and predictable.

Countries that seek political stability and put in place transparent systems for decision with checks and balances reduce the political risk. Partial risk guarantees and political risk insurance are used to safeguard against this risk.

16. CONCLUSIONS

The overarching goal of a geothermal development is the successful implementation of the project that will generate a good return to its owners as well as meeting its other financial obligations. The geothermal development is exposed to various risks of varying degrees throughout all its phases and stages of development. The resource risk is one of the major risks in a geothermal development. It persists through all phases and stages of development and takes the form of resource existence and size, suitability, sustainability and utilization challenges. Other risks include way leaves, market, financing, commercial and macro-economic risks.

Studies, in particular comprehensive detailed surface studies, numerical simulation and interference tests are very useful for informing the possibilities of occurrence of the various forms of resource risk. This enables formulation of resource risk management strategies. Incremental development and reservoir monitoring are highly recommended to ensure resource sustainability. A deliberate and purposeful baseline environmental and social studies, host community engagement and diligent environmental management program are essential for reducing project interruption. Incorporating green funds, resource risk mitigation grants and carbon credit help the project to be financially competitive against other sources of energy. The feasibility study includes establishing electricity supply and demand. Insurance, partial risk guarantee, sovereign guarantee and letter of comfort are some of the instruments used to mitigate against some of the development risks. Power purchase agreement help shield the investors from the market risk, inflation and foreign exchange risk.

ACKNOWLEDGEMENTS

The author thanks United Nations University – Geothermal Training Program, Management of Geothermal Development Company Limited (GDC) for providing the opportunity to write this paper and the GDC's Corporate Planning Team who critically reviewed the manuscript.

REFERENCES

Gehringer, M., and Loksha, V., 2012: *Geothermal handbook: Planning and financing power generation*. The International Bank for Reconstruction and Development / The World Bank Group, Washington DC, United States, Energy Sector Management Assistance Program technical report 002/12, 164 pp. Web: http://www.esmap.org/Geothermal_Handbook

Geothermex Inc., 2010: *An Assessment of Geothermal Resource Risks in Indonesia*. Report prepared for the World Bank, 2-18. Web: http://www.ppiaf.org/sites/ppiaf.org/files/publication/REPORT_Risk_Mitigation_Options_Indonesia.pdf

Government of Kenya, 1982: Geothermal Act. *Laws of Kenya*. Website: http://www.kenyalaw.org:8181/exist/kenyalex/actview.xql?actid=CAP.%20314A

Hadi, J., Quinlivan, P., Ussher, G., Alamsyah, O., Pramono, B., and Masri, A., 2010: Resource risk assessment in geothermal greenfield development; An economic implications. *Proceedings World Geothermal Congress 2010, Bali, Indonesia*, 5 pp. Web: http://www.geothermal-energy.org/pdf/IGA standard/WGC/2010/0709.pdf

Naito, T., 1995: Project finance for geothermal power projects. *Proceedings World Geothermal Congress 1995, Firenze, Italy*, 2883-2887. Web: http://www.geothermal-energy.org/pdf/IGAstandard/ WGC/1995/4-Naito.pdf

Sanyal, S.K., and Koenig, J. B., 1995: Resource risk and its mitigation for the financing of geothermal projects. *Proceedings World Geothermal Congress 1995, Firenze, Italy*, 2911-2915. Web: http:// www.geothermal-energy.org/pdf/IGAstandard/WGC/1995/4-Sanyal2.pdf