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Chagaka Kalimbia

FINANCIAL MODELLING AND ANALYSIS OF POWER PROJECT FINANCE: A CASE STUDY OF NGOZI GEOTHERMAL POWER PROJECT, SOUTHWEST TANZANIA

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FINANCIAL MODELLING AND ANALYSIS OF POWER PROJECT FINANCE: A CASE STUDY OF NGOZI GEOTHERMAL POWER PROJECT, SOUTHWEST TANZANIA

MSc thesis
School of Science and Engineering
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INTRODUCTION

The Geothermal Training Programme of the United Nations University (UNU) has operated in Iceland since 1979 with six-month annual courses for professionals from developing countries. The aim is to assist developing countries with significant geothermal potential to build up groups of specialists that cover most aspects of geothermal exploration and development. During 1979-2019, 718 scientists and engineers from 63 developing countries have completed the six month courses, or similar. They have come from Africa (39%), Asia (35%), Latin America (14%), Europe (11%), and Oceania (1%). There is a steady flow of requests from all over the world for the six-month training and we can only meet a portion of the requests. Most of the trainees are awarded UNU Fellowships financed by the Government of Iceland.

Candidates for the six-month specialized training must have at least a BSc degree and a minimum of one-year practical experience in geothermal work in their home countries prior to the training. Many of our trainees have already completed their MSc or PhD degrees when they come to Iceland, but many excellent students with only BSc degrees have made requests to come again to Iceland for a higher academic degree. From 1999, UNU Fellows have also been given the chance to continue their studies and study for MSc degrees in geothermal science or engineering in co-operation with the University of Iceland. An agreement to this effect was signed with the University of Iceland. A similar agreement was also signed with Reykjavik University in 2013. The six-month studies at the UNU Geothermal Training Programme form a part of the graduate programme.

It is a pleasure to introduce the 63rd UNU Fellow to complete MSc studies under a UNU-GTP Fellowship. Chagaka Kalimbia, Mining Engineer by education, from Tanzania Geothermal Development Company (TGDC), completed the six-month specialized training in *Project Management and Finances* at UNU Geothermal Training Programme in October 2016. His research report was entitled: *Business case of Ngozi geothermal power project, Mbeya, SW-Tanzania.* After one year of geothermal work for TGDC in Tanzania, he came back to Iceland for MSc studies at the Iceland School of Energy, Reykjavik University in August 2017. In April 2019, he defended his *MSc thesis* in *Sustainable Energy Engineering* presented here, entitled: *Financial modelling and analysis of power project finance: a case study of Ngozi geothermal power project, Southwest Tanzania*. His studies in Iceland were financed by the Government of Iceland through a UNU-GTP Fellowship from the UNU Geothermal Training Programme. We congratulate Chagaka on the achievements and wish him all the best for the future. We thank the Iceland School of Energy, Reykjavik University for the co-operation, and his supervisor for the dedication.

Finally, I would like to mention that Chagaka's MSc thesis with the figures in colour is available for downloading on our website *www.unugtp.is* (to change to *www.grogtp.org* by January 2020) under publications.

With warmest greetings from Iceland,

Lúdvík S. Georgsson, Director
United Nations University
Geothermal Training Programme

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I must also express my very profound gratitude with love to my wife, Ester Raphael, for unconditional trust, timely encouragement, endless patience and faithful support throughout my years of study. Thanks to my parents for their love as well as spiritual and material continuous support. I feel honoured and blessed to have all of you in my life. To the three of you, I heartily dedicate this thesis.

Last but not of least important, am grateful to God, the Almighty for his unparalleled grace, continuous blessings, superior protection and guidance in all my pursuits. Lord, I am very thankful.

DEDICATION

I dedicate this work to my son, Miles Chagaka, my beloved wife, my father Chaggaka J.A. Kalimbia and my mother Asha Daudi.

ABSTRACT

This study undertook Excel-based financial modelling which entailed construction of an analytical instrument that performs detailed financial and economic analysis for a 30 MW Ngozi geothermal power project investment over its economic useful life. The tool facilitates making the most important financial decisions and solves complex questions about the future performance of an investment. The new bankable project is transacted using project finance structure with a 70% debt share and 6% interest arrangement in long-term debt financing. The model was built to quickly process a comprehensive list of project input assumptions to establish investment key performance indicators (KPIs) from the detailed analysis of projected cash flows. Results of the analysis are useful to the key power project stakeholders namely lenders, sponsors and off-taker in evaluating the attractiveness of the investment and subsequently facilitate making strategic decisions required for the project implementation. The deterministic KPIs results were subjected to the risk analysis to mirror a range of data variations and thus account for future uncertainties of the cash flows. The probabilistic estimation of project CAPEX made with a 90% confidence level amounts to 129 million USD. The project required a total of 21 million USD to meet the lender's fees, interest during construction and initial funding of reserve accounts. The project yielded an equity and project NPV of 24 million USD and 62 million USD respectively. The IRR of the project was 10% > calculated WACC of 6% while the IRR of equity was 17% > 10% of expected return on equity. The model yielded lender’s ADSCR of > 1.4, LLCR of > 2.1 and PLCR of 1.9, all the cover ratios above their minimum requirement, indicating the robustness and ability of project cash flow to service and repay debt. The project produced the LCOE of 60 $/ MWh with the exclusion of the effects of taxes on costs. The risk analysis indicated the price of electricity and energy production to be the most sensitive parameters to the KPIs results. Overall, the model analysis demonstrated the viability of geothermal power project investment to the key project stakeholders.

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1. INTRODUCTION

Over the years financial modelling has demonstrated to be the core task in the critical strategic business decision making across various industries in several projects and fairly considered to be a robust prerequisite for all types of investment appraisal and financial analysis transacted with debt and equity funding structure. Modelling is designed and recognized for solving often complex questions about the future by depicting a real-life situation in numbers to make practical and sound financial decisions in all types of capital projects investment analysis. Ever since an evolvement of public-private partnerships and hence the emergence of innovative financing paradigms particularly project finance in the capital-intensive power projects in emerging economies, modelling demand has been increasing exponentially to adapt the needs. Financial modelling has, therefore, become an essential task for any project finance transaction as it plays an important role in project evaluation.

Although the principal purpose of the study is to undertake financial modelling, it is essential to build-up complete understanding of the fundamental concepts and elements which establish the main inputs or assumptions in the model. The comprehension of these central inputs prior to the actual financial modelling task and subsequently forecast the key outputs of the model over the life of the project substantially influence and establishes robust reliability for project investment feasibility. The robust project financing modelling and analysis depend primarily on the objectives of modelling, project procurement arrangement (also referred to business models), project ownership and financing structures, geothermal resource and costs factors information and lastly the economic and financial key performance indicators required. So before plunge a little deeper into the financial modelling, the thesis first and foremost examines the main objective of modelling task which in this case, undertaking financial modelling of the geothermal power project investment over its economic useful life.

Capital budgeting techniques are used to establish the viability of the project where the project's cash flows are analysed to establish financial and economic feasibility and perform a risk analysis of project's evaluation criteria through the sensitivity, scenarios and simulation analysis. These analyses are of paramount importance to the project capital providers in the decision-making process as demonstrates the ability of the project to provide an adequate rate of return on investment which commensurate with project risk. As it is apparent in the next chapters, PPP project finance source of funds comprises of debts from lenders and equity from the project sponsors. Lenders are concerned about the timeliness of project debt service payments, and equity investors are concerned about the adequacy of their returns. On the other hand, an off-taker/contracting authority is concern about the affordability of project contract payment i.e. the price of electricity for the geothermal power project. The effective project finance model outputs provide adequate information to address all three sets of concerns and subsequently help participants evaluate the attractiveness of a project and make decisions.

This chapter establishes the context of the topic by briefly introducing geothermal power project background, demonstrate the need for a public-private partnership, project finance and financial modelling. Moreover, the summarized research objectives followed by research questions are discussed to effectively undertake the study. Lastly, the thesis outline is presented to illustrate the organisation of the study.

1.1 Background introduction

The financial modelling task is undertaken on the hypothetical geothermal power project to be constructed in SW, Tanzania in the Rungwe Volcanic Province, the area endowed with substantial geothermal resources. Geothermal is mature technology and proved to be low-operating-cost, renewable, affordable and reliable base-load electricity supply. Ngozi geothermal power project is one of the few renewable energy candidate projects chosen to spearhead the Tanzania government's strong impetus and desires to diversify the grid energy matrix through the inclusion of low-cost, environmentally benign and climatic change resilient power generation from the enormous unexploited renewable energy resources in the country.

Once completed the project seeks to meet the growing demand for electricity in the context of dominant unreliable hydropower generation capacity which is currently affected with unreliable rainfall patterns, and more frequent and prolonged droughts due to climatic changes. The geothermal energy is also anticipated to reducing the country's reliance on expensive fossil fuel dominating the national grid. As geothermal projects are characterised with huge geological exploration and resource risks, confirmation of the resource is vital for soliciting the interest of the risk-averse investors to the geothermal power project (Gehringer and Loksha, 2012). For simplicity of modelling task and financing arrangement, the thesis assumes the existence of a geothermal resource with political, technical, environmental and commercial viability to establish a basis to successful reach commercial financial closure.

Despite its demonstrated economic competitiveness, environmentally friendly benefits and technological viability of geothermal energy, geothermal power worldwide still experiences slow, though steady growth over the years in playing a significant role in the energy mix associated with electrical power generation (DiPippo, 2016). This can be partially explained by capital intensiveness of geothermal power projects compared to other large-scale renewable power projects. According to Gehringer and Loksha, (2012) the mid-range estimates for geothermal power project capital cost are close to the US $4 million per MW, this further increases risk since project returns become more sensitive to financing costs. However, once in operation, the higher capital costs of the power plants are offset by relatively lower predictable operation and maintenance costs, but the need to finance high, up-front construction costs in most cases presents a challenge for the host government due to the magnitude of financing requirements and risks involved.

1.2 The need for Public-Private Partnership (PPP) arrangement

With a dearth of public funding in large-scale power projects, private sector involvement is seen as an attractive alternative. In the recent years, there is an observed significant departure from public sector dominance in the finance, ownership, and operation of power generation assets into Public-Private Partnership, a scheme that can bridge the significant financing gap amidst the challenge. The national government partnering with private sector investors to implement public infrastructure using the financial resources and technical expertise of the private sector (World Bank, 2009). This arrangement is critical for satisfying the capital requirement as well as avoidance of financing the projects from the government balance sheet as the mechanism ties up massive volumes of capital that could otherwise be used for a wide array of government pressing purposes. Apart from shifting the financial burden away from government, the PPP scheme assumes some of the project risks including project preparation, implementation and operation.

As the best way to assess and ensure that value for money (VfM) is achieved, which then translates to lower and competitive off-take price of electricity in terms of capacity and energy charges, the public body solicits bids from Independent Power Producers (IPPs) in an international competitive bidding process under Build-Own-Operate-Transfer (BOOT) model. The BOOT is common and by far considered being the most efficient transactional arrangements for geothermal power projects (Gehringer and Loksha, 2012).

Through this model, IPP with a significant proportion of private finance in the form of independent economic unit builds, owns, operates the power plant and finally transfers it back to the government entity at the end of the concession period. The IPP enters into long-term PPP contract referred to as Power Purchase Agreements (PPA) with the contracting governmental authority, a power national utility. The details on the IPP arrangement and its spectrum is expounded in Chapter 2 of the thesis.

1.3 The need for project finance

The private capital flowing into the project through PPP arrangement comes in the form of project finance, a specialised form of finance which entails a consortium of project sponsors mobilizing private capital through long-term debt financing for a new project on the basis of the projected cash flows, rather than an existing corporate balance sheet or other existing assets (Lynch, 2011). The financing technique comprises of equity from project sponsors and debt from the senior lender in return for its principal repayment, interest and fees.

Under the suitable apportionment of transaction risks and well-engineered financing mix, the project finance mechanism provides significant benefits to the host governments as it avoids capacity constraint, government opportunity cost and sovereign balance sheet financing when compared to the conventional direct financing alternatives. The project finance technique is comprehensively covered in detail in Chapter 3.

1.4 The need for financial modelling for project finance

For a project finance transaction where the lender looks primarily on the project's cash flow for debt repayment, whereas the lenders' security and collateral are usually solely on the project's contracts and physical assets. This necessitates a detailed analysis of the project's cash flows tested under a range of assumptions and scenarios to establish the confidence of lenders and equity provider to fund the project. The analysis allows lenders to assess the security of their loans and examine the impact of changing circumstances on project economics.

Therefore, in order to undertake the analysis within a reasonable timescale, the construction of computerised financial model enables to processes a comprehensive list of input assumptions and applies the interactions expected of them in real-life to generate useful output values. Once properly set up, such a model can quickly provide results reflecting a range of data variations and hence allowing the effect of a selection of downside variations from the base case assumptions to be assessed (Lynch, 2011).

The constructed model establishes financial and economic analysis, ratios that measure profitability, credit analysis, and other key performance indicators that aid in decision making. The success of any investment project transacted under project finance principles rests on the well-built and well-understood financial model. Chapter 6 of the study examines financial modelling in details.

1.5 Research objectives

The primary objective of this study is undertaking financial modelling of the geothermal power project over its economic useful life and subsequently establish financial, economic and risk analysis of the investment which is assumed to be transacted under the Public-Private Partnership (PPP) model using the project finance structure.

The objectives can be further divided into the following specific objectives:

i. Reviewing the PPP arrangement and project finance principles for power projects.
ii. Reviewing financial model structures and construction principles.
iii. Establishing a geothermal PPP model and project finance structure.
iv. Establishing Ngozi geothermal resource parameters.
v. Establishing a probabilistic Capital Expenditure (CAPEX) and Operation Expenditure (OPEX) estimations for the geothermal power project.
vi. Reviewing project financial appraisal techniques.
vii. Developing a financial model from available data to facilitate the investment appraisal and risk analysis of the geothermal power project.
viii. Establishing the economic key performance indicators i.e. NPV, IRR, LCOE, WACC, discounted payback periods.
ix. Evaluation of financial key performance indicators i.e. ROE, Debt-Equity (D/E), DSCR, LLCR and PLCR.
x. Undertaking financial risk analysis using sensitivity analysis, break-even analysis, scenario analysis and simulation analysis using @Risk Monte Carlo simulation.

1.6 Research questions

The objectives of the study are summarized in the following corresponding research questions;

i. What are PPPs projects and roles in power projects development?
ii. What are the principles governing power project finance transactions?
iii. How to undertake risks allocation in geothermal power project finance?
iv. How to construct a project finance model for financial and economic analysis?
v. What are key financial and economic performance indicators for project finance deal in the investment appraisal of geothermal power project?
vi. How to undertake financial risk analysis from the constructed project finance model?
vii. What are the Ngozi geothermal resource parameters and assumptions necessary to establish project development costs and modelling task?

1.7 Thesis outline

The thesis is structurally constructed and broken down in two distinct sections to address the aforementioned questions and objectives. The first section includes Chapters 1-6, which explains the underlying theories of the topic whilst the second section consisting of Chapters 8-9 covers the case, results, analysis, discussion and conclusion.

Chapter 2 covers the introduction of PPP projects arrangement, the structure, the payments and type of contracts in generality. The chapter furthermore examines the PPP fundamentals in the power sector, the PPP application in geothermal power projects and lastly the power tariff structures.

Chapter 3 introduces the available power projects financing models and sources for funds with a particular major focus on the unique features of project finance technique, the private finance capital which is the principal financing mechanism for availability-based PPP model in the greenfield power project. The section encyclopaedic highlights the key project finance structure, underlying principles, risks assessment and examine rational risk-sharing arrangements through a rational allocation of risks among the private investors and host governments based on the parties' relative risk management abilities.

Chapter 4 addresses, in great detail, the theoretical background of project investment financial appraisal techniques used in the model to assess the power project investment with regard to their profitability and/or cost-effectiveness to both lenders and project sponsors, taking into account the time value of money. Various assessment formulas and methods of evaluation and performance metrics are examined to establish attractiveness of the investment and establishes project viability over the project's useful life, necessary metrics for both lenders and equity providers. The project financial investment appraisal techniques in the chapter assume the future is known with certainty.

Chapter 5 covers financial risk analysis to incorporate the elements of uncertainty into the project investment evaluation and decisions making. Four techniques for treating project cash flow uncertainty are discussed; sensitivity analysis, break-even analysis, scenario analysis and Monte Carlo simulation analysis using @Risk. The key investment outputs of the project in the constructed model are finally tested against the possible changes in the input parameters.

Chapter 6 describes the financial modelling which covers the roles of project finance model, development phase, modelling design and modular architecture. The individual model components namely dashboard summary, inputs and assumptions, financing and investment, balance sheet, income statement, cash flow statement and profitability modular are discussed. The profitability module covers the calculations of key project performance metrics discussed in chapter four.

Chapter 7 introduces the Ngozi geothermal power project case study. The geothermal energy geology, global progress in the development and utilization of geothermal resources are described. The overview of the electricity supply industry in Tanzania is presented while addressing the position and necessity of geothermal energy technology development in the country's power generation matrix. The chapter also covers the geothermal project business models, geothermal project-specific risks and financing, project development components, power generation technology and project Key Performance Indicators (KPIs). The description of Ngozi geothermal field highlighting the project components, technical resource parameters, project duration, financial and technical parameters are established. The last part covers the estimation of project OPEX and CAPEX.

Chapter 8 explores the results reported in the model and previous chapters. The section covers an in-depth analysis and outlines the key discussions pertaining to the project finance, and financial modelling. A summary of the geothermal power project finance case is established. The key output the financial modelling and risk analysis are discussed.

Chapter 9 concludes the study and recommends on the issues pertains the topic. The section establishes the level of accomplishment of the study in addressing the research objectives, questions and aims. Moreover, the potential avenues for further research on the topic are covered.

2. PUBLIC-PRIVATE PARTNERSHIPS (PPPs)

The term public-private partnership describes a wide variety of arrangements that integrate the commitment of resources from both public and private participants to implement a public infrastructure project. As previously mentioned, the PPPs are mainly driven by the government budgetary constraints for investments in the large-scale infrastructure projects, however the other ultimate purpose of the collaboration between public and private sectors public sectors includes amongst other things; increase efficiency in project delivery and operation, reinforcing competition, access to advanced technology, better accountability and promotion of private sector innovation.

Yescombe, 2007 broadly divided the public infrastructure into categories 1) economic infrastructure which considered essential for day-to-day economic activity; such as transportation facilities and utility networks (for water, sewage, electricity, etc.) and 2) social infrastructure which is considered essential for the structure of society such as schools, hospitals, libraries and prisons.

The thesis focuses on the economic infrastructure which involves building a geothermal power project for electricity generation. Yescombe, 2007 furthermore defined a project-based PPP with the following essential elements:

- A long-term contract (a PPP contract) between a public-sector party and a private sector party;
- for the design, construction, financing, and operation of a public asset by the private-sector party;
- with payments over the life of the PPP contract to the private-sector party for the use of the asset, made either by the public-sector party or by the general public as users of the asset or a combination of the two; and
- with the asset remaining in public-sector ownership or reverting to public-sector ownership at the end of the PPP contract.

Additionally, in some cases, a PPP contract may involve major upgrading and managing of existing infrastructure commonly known as brownfield projects rather than a greenfield construction with significant investment in fixed assets. The main features above seek to clarify and differentiate the PPP approach to other private sector engagement forms i.e. privatization and outsourcing. Under a PPP principle, the public sector retains ultimate accountability to the citizen for the provision of public service and the infrastructure required for their delivery whereas, under privatization and outsourcing, accountability for delivery is transferred to the private party.

Yescombe, 2007 insisted that the relationship between these two parties i.e. public and private is not a partnership in the legal sense, but is contractual, based on the terms of the PPP contract. The word partnership is largely a political slogan in this context.

Under such an arrangement and contract structure, the private sector party usually agrees to undertake the following (World Bank, 2009):

- Design and build or upgrade the public sector infrastructure;
- Assume substantial financial, technical, and operational risks;
- Receive a financial return through payments over the life of the contract from users, from the public sector, or from a combination of the two;
- Return the infrastructure to public sector ownership at the end of the contract (in some cases the private party may retain ownership of the asset).

Finally, it is worth mentioning that, PPP should not be viewed as a project's financing technique, but rather an arrangement that offers alternatives to attract and mobilize new sources of private capital as the public sector faces funding gap from government budgets to develop large-scale infrastructure projects. The private capital only flows into the projects that present adequate potential returns for serving private operator debts and rewarding equity holders (World Bank, 2017).

2.1 PPP versus public-sector procurement

Yescombe, 2007 covered the comprehensive comparison between the two procurement methods and the summary is discussed below. The host governments through their respective public procurement act set out procedures and regulations to all public procurement activities carried by all public bodies in the country.

Literally, the PPP is an alternative to the procurement of the project public assets by the public sector utilizing public fund collected from the from tax revenues or public borrowing. This method of procurement is referred to as public-sector procurement. In a typical public-sector procurement commonly known as design-bid-build, the public authority sets out the specifications and design the project asset, calls for bids on the basis of the detailed design prepared and pays for construction of the asset by a private-sector contractor. The public authority must fund the full cost of construction, including any cost overruns. Operation and maintenance of the asset are entirely handled by the public authority, and the contractor takes no responsibility for the long-term performance of the asset after the relatively short construction-warranty period has expired.

In a PPP, on the other hand, the public authority specifies its requirements in terms of outputs (in case of power project, the net power capacity and generation technology), which set out the public services which the asset is intended to provide, but which do not specify how these are to be provided. The private sector is left to design, finance, build and operate the asset to meet these long-term output specifications. The project company receives payments commonly known as service fees over the long life of the PPP contract on a pre-agreed basis, which is intended to repay the financing costs and give a return to investors. The service fees are subject to deductions for failure to meet output specifications, and there is generally no extra allowance for cost overruns which occur during construction or in operation of the asset.

In Tanzania, these two procurement methodologies are specified in the Public Procurement Act No.7 of 2011 and its Regulations of 2013. Moreover, the detailed procurement and disposal of tender activities under the solicited and unsolicited PPP arrangements are provided under the PPP Act, 2010 and its Regulations of 2011 & 2015 which sets out the procurement procedures, responsibilities of the parties, and the procurement approval process. Using these specified set of acts and regulations, the projects are competitively tendered out to the prospective developers (private sector) in an international competitive bidding process to finance, build, own, operate and possibly transfer the power project.

2.2 Structures of PPP

The infrastructure projects vary depending on the nature of the sector, similarly, the structure of PPP projects take different approaches. The broad nature of the PPP structure is primarily determined by what rights, obligations, and risks that are assumed by the public or private parties within the partnership. In these regards, the PPPs structure is categorised into two common principal structure namely concession and availability-based PPP (World Bank, 2009).

2.2.1 Concession and franchises PPP

Under this category, a public authority grants a private party the right to design, build, finance, and operate an infrastructure asset owned by the public sector. The concession PPP contract is for a fixed period and after the tenor, the private party responsible for operation reverts to the public authority. The private party recoups its investment, operating, and financing costs and its profit by charging members of the public a user fee. In other words, the user pays for using the asset.

Thus, a key feature is that the private party usually assumes the risk of a demand for use of the asset, in addition to the risks of design, finance, construction, and operation. The most common example is toll roads, where payments are made by drivers. However, demand risk may be allocated in various ways, for example, the public authority may share the risk by underwriting a minimum level of usage. User charges may be either prescribed in the PPP contracts or set by the concessionaire.

Franchises are a subset of concession PPPs in which the private sector takes over existing public infrastructure, operating and maintaining it under a fixed-term contract, often with an obligation to upgrade it. Similar to a concession but without the initial construction phase. They are common, for example, in the rail sector. The private party often pays an initial lump sum of money to the public authority to acquire the franchise. Clearly, the dividing line between franchises and concessions is not precise. If a project involves a high level of the initial investment in new or upgraded infrastructure, it may be called a concession, whereas if it involves a limited level of the initial investment (even if there are long-term maintenance requirements), it may be called a franchise.

2.2.2 Availability-based PPP

The availability-based PPP is similar to a concession PPP in such that, it also involves the private party designing, financing, building or rebuilding, and subsequently operating and maintaining the necessary infrastructure. However, in this case, the public authority (as opposed to the user) makes payments to the private party, as, when, and to the extent that public service (not an asset) is made available. Hence the demand or usage risk remains with the public authority.

However, the private sector is responsible for the project completion risks (being on time, to budget) and operating performance of the asset, and if for any reason it is not capable of meeting the agreed level of service committed the availability charge is reduced accordingly. The original form of availability-based PPP is the PPA used in power generation projects where the private investors build a power generation plant and contract to sell the electricity generated to a publicly owned power utility. The public authority assumes the demand risk and makes a minimum payment for availability (or capacity) of the power plant, whether or not its output is required. Energy payment is made for usage, to cover the cost of fuel for the plant.

The PPA structure can be used for any kind of process plant project such as gas converted to electricity or transported in a pipeline. Further development of the PPA structure is also used in social infrastructure projects and other non-self-funding projects such as rural roads. Under both circumstances, the principle of making the service made available is used and payments are based on the availability and not on the volume of usage.

2.3 PPP payment structure

Yescombe, 2017, highlighted the key payments under a PPP contract applicable to whether the project is transacted under the concession and availability-based structures. The project should be able to cover:

- The project’s Operating and Maintenance (O&M) costs;
- The debt service (i.e. interest payments and principal repayments); and
- The investors’ required return on their investment.

As a private party takes the construction and operational risks, failure by the project company to achieve commercial operation by the scheduled Commercial Operations Date (COD) may trigger delay-liquidated damages under the PPP contract. Similarly, failure to achieve minimum project performance as per contract, triggers the performance liquidated damages and worst-case scenarios termination of the contract.

The project performance and liquidated damages have substantial financial consequences to the private investor as they both affect the payments substantially. The PPP contract establishes relevant clauses to address Key Performance Indicators (KPIs) and the levels of deductions for the failures.

2.4 PPP contracts

The PPP arrangement contracts are classified by their nature of legal ownership and control of the project assets by the private sector. The contracts come in various forms, with most depicted with different acronyms. Some of the popular examples are Build-Operate-Transfer (BOT), Build-Own-Operate-Transfer (BOOT), Design-Build-Finance-Operate (DBFO), Build-Own-Operate (BOO) amongst other variants.

Table 1 illustrates the summary of the spectrum of the most common contracts to provide public infrastructure under a long-term contract, the structure lies on a continuum between wholly public-sector projects to wholly private-sector projects privatization (maximum involvement of the private sector).

TABLE 1: PPP contract spectrum (Yescombe, 2007)

	Public project ←					→ Private project
			← Public–Private Partnership			→
Contract Type	**Public-sector procurement**	**Franchise (*Affermage*)**	**Design-Build Finance-Operate (DBFO)***	**Build-Transfer-Operate (BTO)****	**Build-Operate-Transfer (BOT)*****	**Build-Own-Operate (BOO)**

These contracts work with either form of PPP structure i.e. concession or availability-based. The BOT is the most popular PPP arrangement and often used interchangeably with BOOT structure where the private sector entity finances finance the building of the infrastructure asset, own and operate it for a number of years, before transferring control and ownership back to the public sector.

Usually, the infrastructure is transferred back to the public sector at zero cost, or at least at a cost less than the asset's residual value. However, under some other literature, BOT or BTO may not include private finance, whereas BOOT always includes private finance.

2.5 PPP in the power sector

From the discussion of key PPP elements, structures and contracts in the earlier subsections seem vivid that the power projects follow the availability-based structure and in most cases transacted under the BOOT contracts with a specialized project finance arrangement. The availability-based PPP relies on the bankable PPA, a long-term contract referred to as a PPP contract in the key elements of PPP arrangement.

PPP in the power sector, in this case, an IPP design, build, finance, and operates a power plant and contract to sell the electricity generated to a creditworthy publicly owned power utility (off-taker) for a long-term PPA and lastly transfer the plant to the off-taker at the end of the contract period. The PPA contract is structured with sufficient tenor to enable repayment of a debt by providing an adequate and predictable revenue stream. The utility off-taker assumes the demand risk of power and pays an availability charge (also known as a capacity charge) for making the power plant available, whether it uses any power or not. Additionally, the IPP charges a usage charge (also known as energy charge) for the marginal cost of generating power as and when required by the off-taker. The IPP assumes the project completion risks (being on time, to budget) and operating performance of the asset to guarantee the full payments.

Yescombe, 2007, contends that the vital factor which enabled the development of availability-based PPP model is the possibility of the model to attract private finance in the form of project finance technique which transfers a significant share of the financing burden to the private sector and essentially provides a high ratio of long-term debt financing investment necessary to develop the capital-intensive power projects. Lenders typically provide the majority of the funding (capital outlays) required by the power project, hence bears significant credit risk as project debt repayment depends exclusively on the cash flow from the project.

The power project contains only one stream of revenue, that is, payments from the off-taker and if the off-taker fails to pay, it is very difficult for the project to repay its lenders on a timely basis. Lenders, therefore, insists the power project be bankable enough to strongly guarantee repayment of the project debt, the interest rates and the agreed fees. The form of private finance is discussed in Chapter 3.

2.6 PPP in geothermal power project

Geothermal power projects are characterised with special cases among renewable energy sources. This is particularly because of the resource risk associated with the development of the field that does not exist in other technologies. Thus, the host country application of the PPP approach is heavily dependent on whether the field is de-risked to demonstrate the technical and commercial viability of the field. The test drilling phase is considered to be the key to reducing risk to a level that becomes more attractive for private finance.

Gehringer and Loksha, 2012, listed dichotomous PPP approach for geothermal power projects namely:

1) The host country solicits a formal request for proposals (RfP) in form of a competitive procurement process from private developers to develop new geothermal sites through concessions or PPPs. The approach entails the private developer to assume exploration or resource risks. Thus, the developer requires higher compensation for the increased risk through a higher off-take price of electricity or through other means.
2) The host country undertakes projects upstream phases i.e. geothermal exploration and resource confirmation with finances from public funding and official development assistance to advance the project to brownfield status. Similar to the first approach, the host country solicits bids in a formal RfP from the private developers with commercial capital to construction, own and operate and transfer the power project. The RfP amongst other things specifies the capacity (in MW) of geothermal power being sought and the location where the power is needed. From the details in the RfP, power producers bid against each other to highlight amongst other things, technical capacity to carry out the project, experience of the personnel to be involved, experience and performance with similar project, financial capacity to carry out the project utilising the private capital and lastly provision of the competitive tariff to the end-user. It is also anticipated that the RfP package includes the draft PPA for the prospective bidders to respond during submission of the bids.

Given the risky nature of geothermal power investment projects in early phases, the thesis assumes application of the latter approach as it has demonstrated to be viable and effective to both public and private sector players in various parts of the world. The details of the various PPP business models are covered in Chapter 7.

2.7 PPP power tariff structure

As mentioned in Section 2.2.2, the availability-based PPP service prices/payments comprised of two components namely; the capacity charge and energy charge. In the power project context, these forms of payments are referred to as an electricity tariff. CLDP, 2014 categorised tariff structures commonly found in power purchase agreements into; capacity-based and non-capacity-based structure. Furthermore, the application of the tariff structures depends on the dispatch ability of the technologies.

Geothermal being dispatchable technology, the tariff structure can be categorised into:

1) Single energy charge (usually stated in $/kWh) which combines both energy and capacity elements;
2) Single energy charge with a take-or-pay requirement to essentially guarantee a floor to the level of expected dispatch; and
3) Capacity and energy tariff similar to the availability-based PPP payment where the off-taker pays the IPP a capacity charge for the capacity of a generation facility that is made available to the off-

taker, regardless of whether the off-taker actually dispatches the facility while the energy charge is monthly payment ($/kWh) for energy that is dispatched by and actually delivered to the off-taker.

The capacity and energy tariff structure are considered to be advantageous compared to other tariff structures as the payment mechanism is structured to balance the interests of both investors and consumers in an economically efficient. This is achieved by ensuring that the private developer has a reasonable opportunity to earn revenues that are sufficient to:

i. Repay the capital invested in the project plus a reasonable return to the project investors; and
ii. Cover the fixed operating costs of the project, regardless of whether the off-taker dispatches the generation facility or not.

On the other hand, the off-taker's interests are protected because is only obligated to pay for the capacity that is made available to it, plus the energy that is dispatched by the off-taker and actually delivered to the delivery point (CLDP, 2014).

The capacity charge component is established in the PPA to enable the private developer to generate sufficient revenue to:

1) Repay the project debt;
2) Pay the sponsors a return on equity;
3) Pay all corporate and other taxes that are assessed on the private developer and its properties; and
4) Pay for fixed operations and maintenance costs and any other agreed upon project costs that are incurred by the private developer regardless of the dispatch factor.

According to CLDP, 2014, the capacity charge (sometimes referred to as an Hourly Base Capacity Price) is calculated as a price for each MW that is made available over a settlement period (usually a month). Each settlement period is weighted to reflect the importance of the availability of capacity during that hour to the off-taker. The hourly capacity payment for each hour, HCP_i is calculated from the following formula:

$$HCP_i = (BCP_i + FOMC_i) * PWF_i * AvCap_i \quad (1)$$

where BCP_i = The amount of the Base Capacity Price for hour i;
$FOMC_i$ = The amount of the Hourly Fixed Operations & Maintenance Charge for hour i;
PWF_i = The period weighting factor for hour i (a number within a range, for example, 0.65 and 1.5, that reflects the importance of the capacity during that settlement period)
$AvCap_i$ = Capacity declared to be available during hour i by the private developer.

In order to determine the monthly capacity payment (expressed in USD/MW per month) to bill the off-taker, the HCP_i is summed up for the whole month period. Equation 1 incorporates only key elements of the tariff and as illustrated, enables the off-taker to pay only for capacity that is actually made available to it.

Depending on the nature of the PPA, the tariff may contain formulas to address components such as ancillary charges, start-up costs and other supplementary items. Figure 1 summaries the principal components that make up the capacity charge for the geothermal power plant.

The energy payment is structured and calculated to enable the private developer to earn consistent and sufficient revenues to recover the cost of inputs used to generate the net energy output delivered and recovering operations and maintenance costs that vary depending on the quantity of net output generated. EWURA, 2019, established the Energy Payment EP_i for a billing period i in the following formula:

$$EP_i = EP_{nfi} + EP_{fi} + PC_i \quad (2)$$

where EP_{nfi} = Energy payment (non-fuel component);
EP_{fi} = Energy payment (fuel component);
PC_i = Fuel pipeline cost.

As a geothermal power project contains no fuel costs, the equation remains with only one component EP_{nfi} which includes the variable operation and maintenance costs and the net energy output. The EC_{nfi} shall have values expressed in US Dollars / kWh and can be extended further to base energy charge value and sometimes adjusted for the Consumer Price Index (CPI).

The Energy Payment in billing period i, EP_i for geothermal power project can be determined according to the following formula:

$$EP_i = EP_{nfi} = EC_{nfi} * E \tag{3}$$

where EC_{nfi} = Energy charge (non-fuel component) in billing period i;
E = Net energy output.

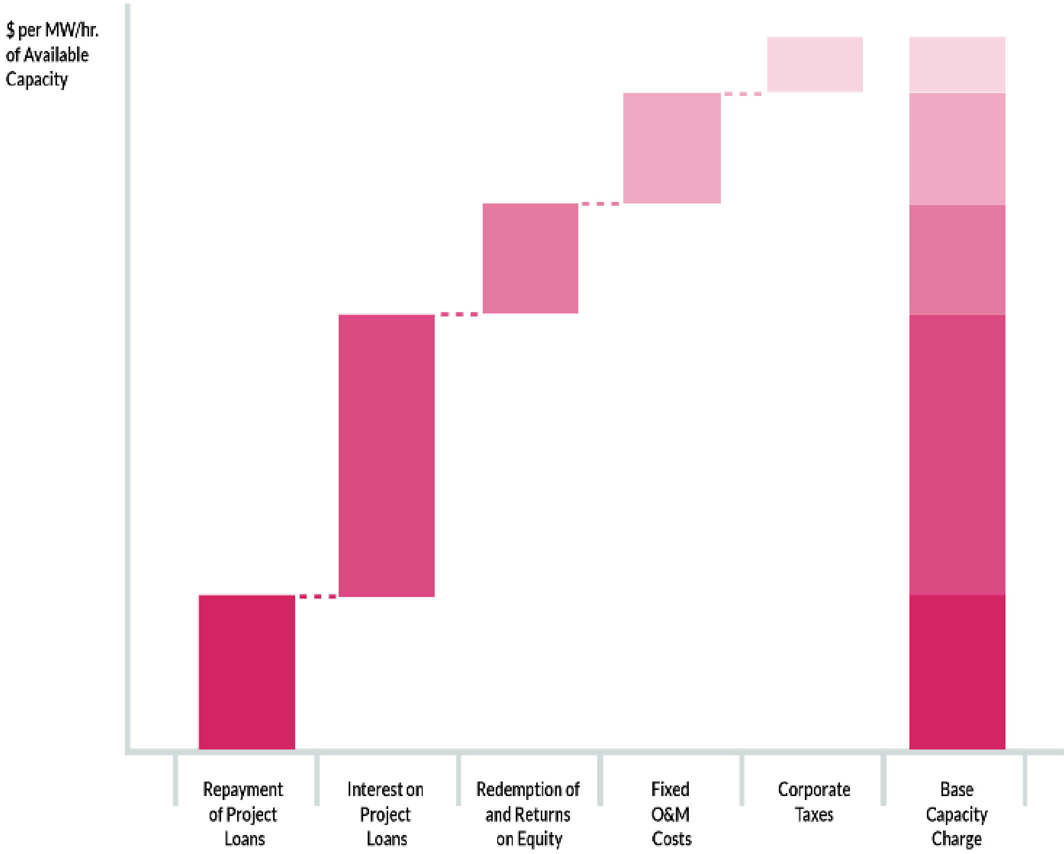

FIGURE 1: Principal components of capacity charge (CLDP, 2014)

Figure 2 illustrates the principal components that make up the energy charge under a capacity-based tariff for a thermal power plant. Since no fuel costs required for the geothermal power plant, therefore, the energy payment constitutes only the variable operations and maintenance cost component only.

The capacity and energy tariff structure provide no incentives for a project developer to charge a risk premium to bear market risk as the project's capital as well as fixed operations and maintenance costs are recovered through the capacity charge payable regardless of the level of dispatch.

As a result, the tariff structure fits the purpose of delivering relatively competitive tariff to the off-taker. The financial model calculates the tariff structure as described in the formulae above while establishing the financial analysis of the project.

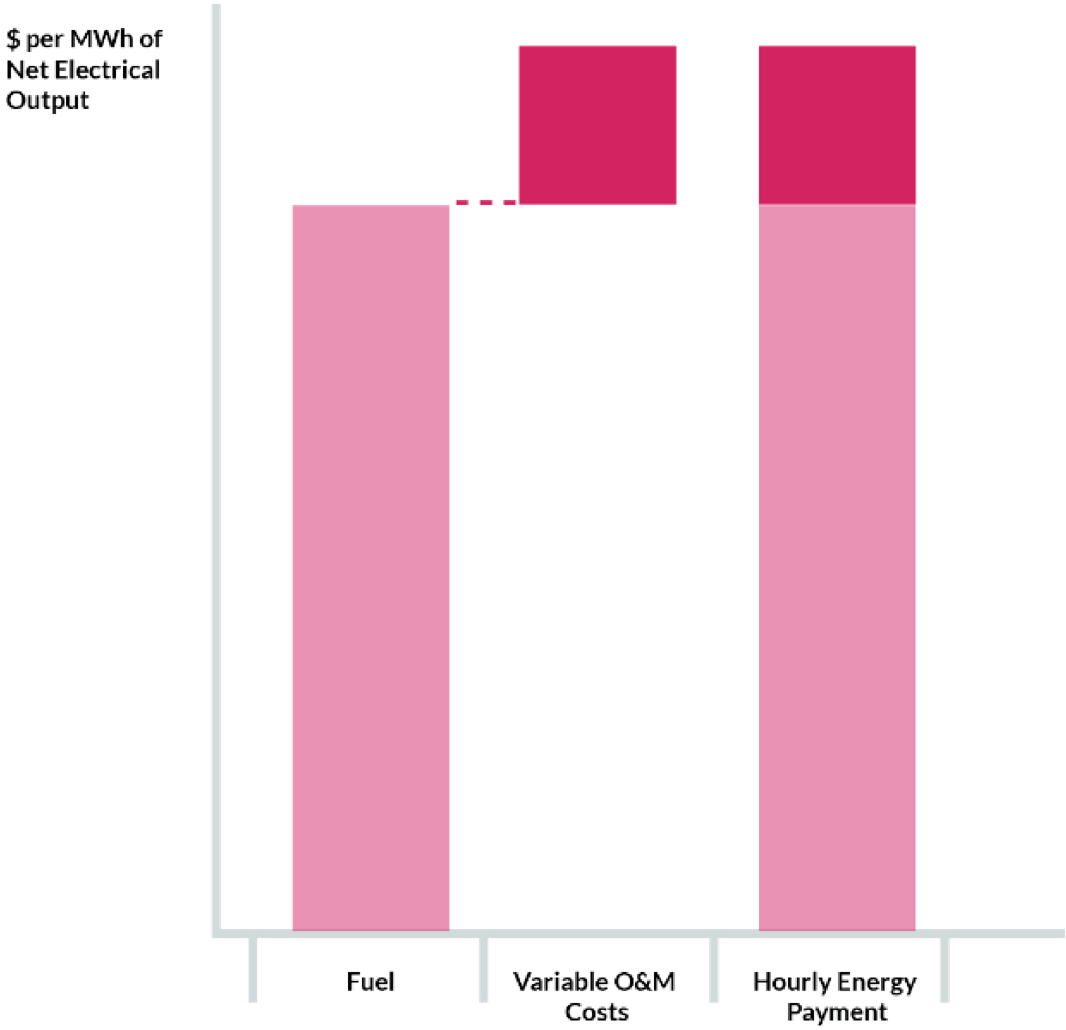

FIGURE 2: Principal components of energy charge (CLDP, 2014)

3. PROJECT FINANCING STRUCTURES

The chapter introduces the financing models available for power projects. The primary projects financing mechanisms are discussed, the pros and cons highlighted, and comparisons drawn between the alternatives is made. The particular focus is then turned to the project finance technique, the private finance capital which is the principal financing mechanism for the power project under the availability-based PPP model discussed in Section 2.5.

3.1 Principal financing models

CLDP, 2016, mentioned four financing structures that are primarily used to raise funds for power projects. The financing models are distinguished by which party or parties bear responsibility for funding the upfront costs of a project. The potential sources of funding and their respectively financing models can have a significant impact on project economics and viability. Therefore, the section covers and assess the advantages and disadvantages of financing structure related to timing, cost and complexity of structuring and implementation.

The four principal financing models comprise of host government financing, developer financing, resource-based infrastructure financing, and project finance. There are exists many variations of sources of project funding and transactions, but the core concepts remain the same. The discussion only covers the three of the more common sources of financing for power projects namely host government financing, developer financing and the main discussion on the project finance technique.

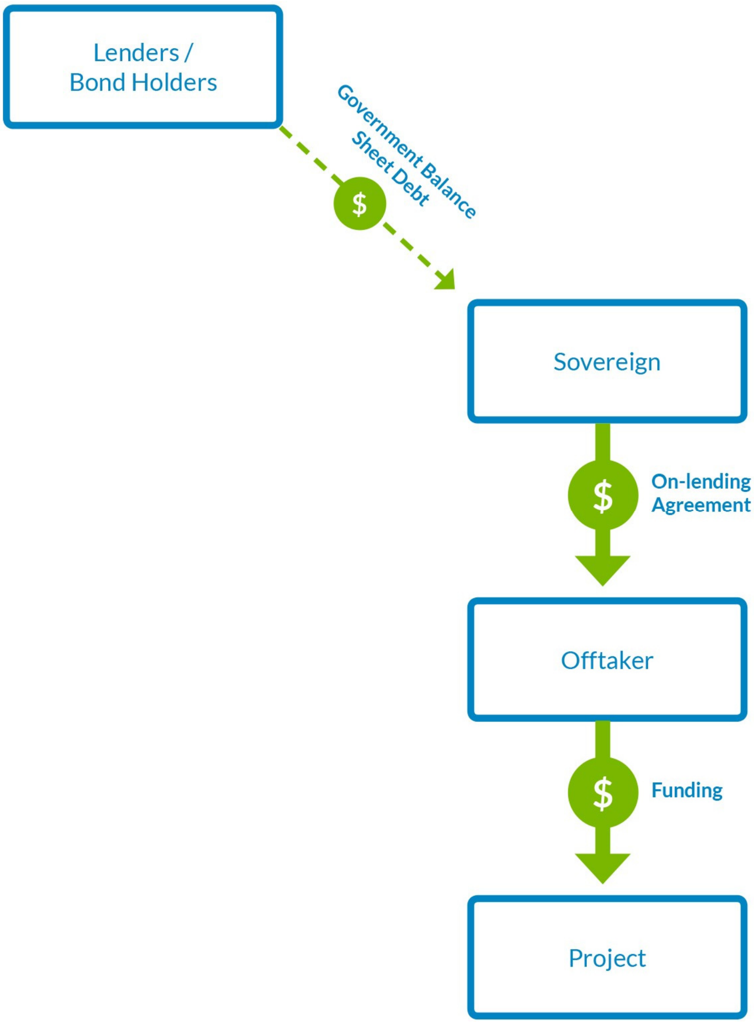

FIGURE 3: Host government financing structure (CLDP, 2016)

3.1.1 Host government financing

This is also referred to as traditional public financing approach where the host government procure large-scale public-sector power assets by utilizing public funds through public-sector procurement method. The host country uses the strength of its balance sheet to supply the off-taker with the necessary capital to undertake a project. The government form of financing to the off-taker can either be through lending funds or contributing additional equity to the project.

The host governments funds are primarily sourced from the sovereign's cash reserves built from tax revenues or from funds that a sovereign borrows from domestic and international institutions i.e. capital markets, multilateral development banks and bilateral institutions. The host government structure is as illustrated in Figure 3.

However, governments are often cash constrained and unable or unwilling to raise funds in the markets due to a variety of factors. These factors include poor credit, restrictive covenants in existing loan documents, or a desire to avoid the opportunity cost due to excessive concentration of resources and risk in a single project hence cutting substantial funding in other country's worthy and needy capital intensive services, competing for scarce fiscal resources like health, water, security and education (Niehuss, 2015).

The financing costs of the technique vary based on the overall source of the funding and the creditworthiness of the sovereign. In case where the government is creditworthy with ample cash reserves and borrowing capacity from lenders at attractive rates and does not have more pressing needs for the funds, the traditional method is the quickest and least complicated ways to fund major projects as the financing approach involves fewer funding parties hence benefits with relaxed transactional structures and fewer coordinations of parties which can be costly (CLDP, 2016).

3.1.2 Developer financing

Developer financing is also referred to as corporate financing technique. The projects undertaken by a private developer can use the strength of the corporation's balance sheets to entirely fund a project in the form of equity. Generally, the project funds come in a combination of corporate own internal cash resources (retained earnings), external borrowing in the financial markets, and sometimes new equity (Niehuss, 2015). Figure 4 depicts a typical developer financing structure.

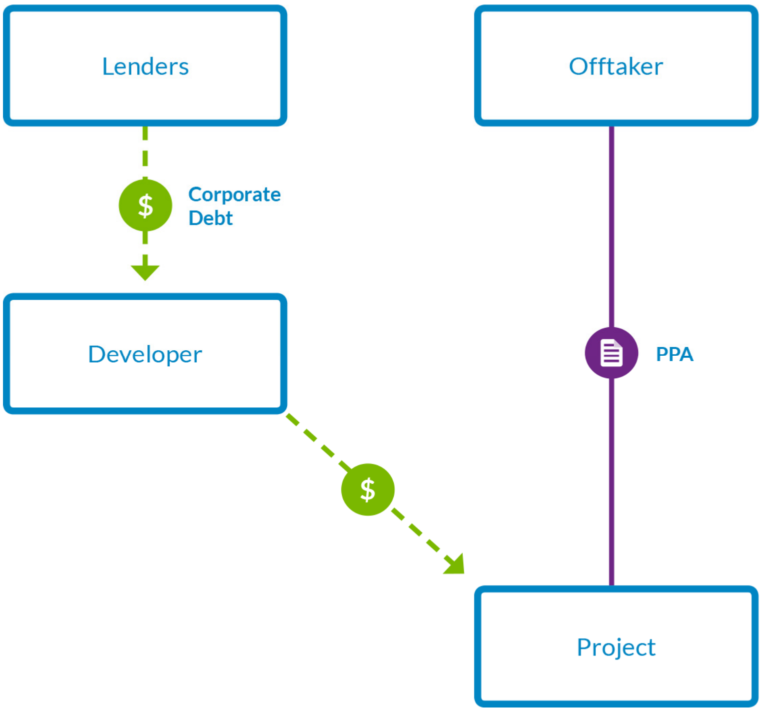

FIGURE 4: Developer financing structure (CLDP, 2016)

Similar to the host government financing, the traditional corporate borrowings are based on the overall financial condition and creditworthiness of the developer and its ability to generate cash from all corporate assets and activities to service the project debt. Few numbers of funding parties involved make the financing mechanism quick, simple and straightforward to fund projects.

However, in many cases, the corporate sponsors are not creditworthy and with significant financial muscles to fund a sizeable project using developer financing alone due to the large investment required and if it does, requires higher returns on the equity and be reflected in a relatively higher electricity tariff. In practice, few utility-scale projects are funded only with developer financing. Moreover, similar to the host government financing, developer financing forces a developer to forego a number of competing investments or other uses of its funds, or its ability to borrow, in order to finance a project (CLDP, 2016).

To summarize, both financing models can only raise projects debt financing depending entirely on the financial capacity or creditworthiness of the host government or corporation. The creditworthiness is established by relying to both on the cash flows from all of the borrower's projects and activities and on all of its assets as security for a debt. The latter are on-balance sheet financings that have full recourse to the government or corporate borrower (Niehuss, 2015).

Given the characteristics of these conventional financing models i.e heavy reliance on the soundness and creditworthiness of the project sponsors, it has proven difficult to raise funds to develop a large-scale capital investment power project. Project finance technique discussed in the next chapter addresses these challenges via the introduction of off-balance sheet financing, a private finance approach transferring a significant share of the financing burden to the private sector.

3.2. Project finance

There is no singular universally accepted precise definition of project finance, however, a large part of the existing literature agrees on some key concepts. Yescombe, 2014 defined project finance as a method of raising long-term debt financing for major projects through financial engineering, based on lending against the cash flow generated by the project alone; it depends on a detailed evaluation of a project's construction, operating and revenue risks, and their allocation between investors, lenders, and other parties through contractual and another arrangement. Project finance is not the same thing as *projects financing*, the loose term that describes a range of financing arrangements for the projects as discussed in Section 3.1.

The ultimate goal in project finance is to arrange a borrowing for a power project which benefits the sponsor and at the same time be completely non-recourse to the sponsor i.e. no substantial impact on the balance sheet or the creditworthiness of the sponsoring entity. However, projects are rarely financed independently on their own merits without credit support from sponsors who are interested as third parties who benefit in some way from the project (Nevitt and Fabozzi, 2000). Hence the terms nonrecourse or limited-recourse financing are frequently used in defining the project finance technique.

World Bank, 1994, defined nonrecourse financing structure of a project happens when lenders are repaid only from the cash flow generated by the project, or in the event of default, liability is largely limited to the value of the project assets. In reality, it is extremely rare for project finance to be 100% non-recourse. On the other hand, the limited recourse happens when lenders have limited recourse to the assets of a parent company sponsoring a project. Lenders may ask the project sponsors to provide some credit support which is limited in amount and/or time i.e. during the construction period only. This is the most widely used form of project finance structure (Niehuss, 2015).

The level of recourse necessary to support financing is determined on the unique risks inherent in the project, and the appetite of the credit markets to accept the risks arising from such elements. For example, if the lenders perceive that a substantial risk exists during the construction phase of a project, they could require that the project sponsor agree to infuse additional equity if the risk actually materializes. The lender would have recourse to the project sponsor's assets until the risk subsides or construction is complete. Thereafter, the loan would be nonrecourse (Hoffman, 2001). Following the nonrecourse or limited-recourse nature of project finance, lenders who supply a large capital to the project bears substantial credit risk hence their paramount concern is for the power project to be solidly bankable to strongly guarantee repayment of the project debt.

The bankability is a very fluid concept and can be defined by two essential building blocks, namely project viability and satisfactory allocation of risks between parties as portrayed in Figure 5. Since the project finance hinges on the project itself, the viability component essentially explains the fact that the project needs to demonstrate the economic, technical, financial, and environmental viability, and that is capable of generating significant cash flow to servicing debt for creditors and provide a sound financial return to project investors. On the other hand, rational allocation of risks among public and private participants based on the parties' relative risk management abilities is indispensable to make project bankable, the allocation is established in accordance with the overall risk structure. This, therefore, requires an in-depth investigation and evaluation of the project and their inherent risks. In the case of PPP project finance, all risks are allocated to two approaches: (i) transferable risks that can be transferred to the private sector (project sponsor) and (ii) retained risks that are retained by the public sector (Weber and Alfen, 2010).

FIGURE 5: Project bankability

As discussed above, the publicly owned power utility (off-taker) solicits bids from IPPs in an international competitive bidding process under BOOT contracts.

Using the project finance structure, the BOOT contract grants certain concession rights to the project sponsor to design, build, finance, and operates a power project and sell the electricity generated to the utility off-taker. The parent company sponsoring a project incorporates a new special purpose vehicle (SPV) or special purpose company (SPC), a legally distinct and ring-fenced entity established specifically for the sole purpose of owning, constructing and operating a project. The SPV has no history and no significant fixed assets of its own. The SPV is usually incorporated in the country in which the project is taking place. The separate incorporation of SPV is deliberately made to guarantee that the SPV is free to concentrate on its task of assuring repayment of the debt as scheduled in timing and in amount and debt obligations are not affected by lines of business that are unrelated to the project but will instead be affected only by the performance of the project.

The separate incorporation of a project in an SPV is seen favourably by lenders for twofold reasons, the first is that setting up an SPV completely isolates the initiative's cash flow from that of the originating companies/project sponsors, giving creditors full control over the vehicle's performance. The second is that financing an SPV allows creditors to concentrate their analysis on the performance of a single project, reducing information asymmetries that could arise in a corporate finance setting (Caselli and Gatti, 2017). The approach, therefore, results in longer loan tenors and lowest-cost financing when compared to the tenors and rates that a large corporate developer would be able to achieve by borrowing using corporate finance techniques (CLDP, 2016).

Significant advantages of project finance packaging are the fact that it avoids capacity constraints, opportunity costs and balance sheet financing by a sovereign hence an attractive financing alternative compared to the previously mentioned. Moreover, multiple parties involved in the financing can facilitate more thorough or comprehensive due diligence as there are multiple sets of eyes and minds focused on project fundamentals. The structuring of project finance transactions facilitates the apportionment of various transaction risks to those best placed, willing and able to assume them.

For all its advantages including high debt levels, long tenors and the limited recourse nature of project finance which are attractive to project sponsors, these characteristics come at a cost coupled with rigorous requirements. On the downside, project finance can be time-consuming, complex and costlier to arrange than conventional direct financing (Clews, 2016). The costly nature of the financing structure is primarily due to the up-front costs incurred due to the coordination of multiple parties involved, preparation of financing documents, legal documents and extensive due diligence required. Hence, coordination can often cause considerable delays for project implementation. (CLDP, 2016).

Figure 6 illustrates a typical project finance arrangement with the arrows showing the direction of cash flows.

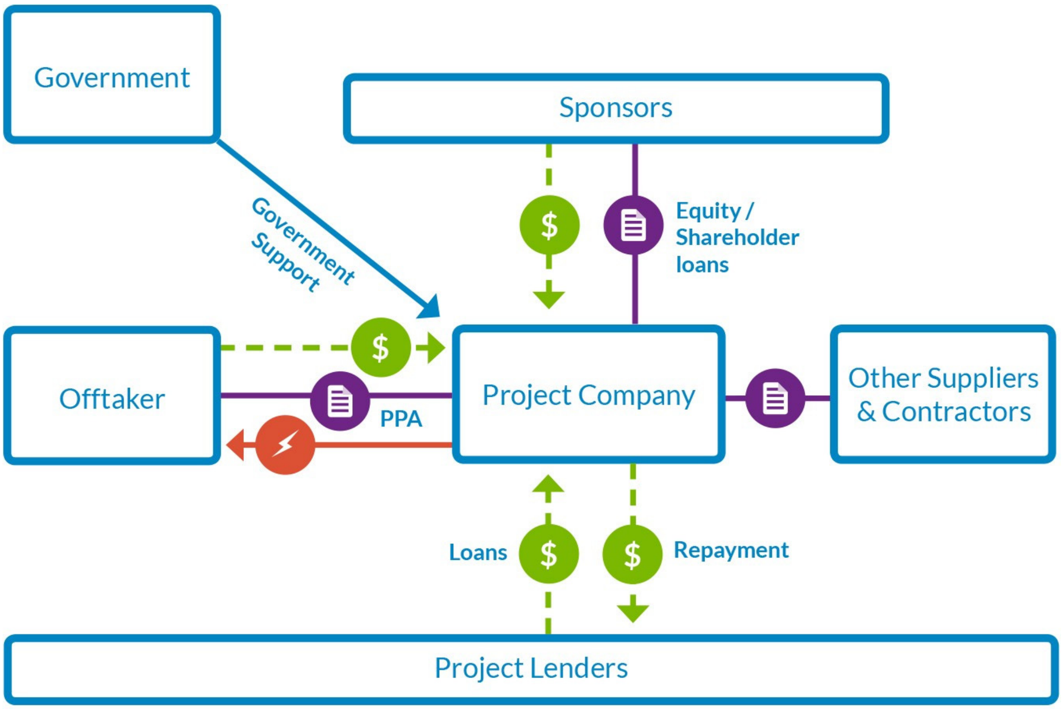

FIGURE 6: Project finance arrangement (CLDP, 2016)

3.2.1 Characteristics of project finance

Different types of projects influence the way project finance is structured and financed. There are however several inter-related features that are common to almost all types of project finance transactions and serves to distinguish it from other types of financing models. Bodnar, 1996, provided the typical preliminary list of basic features of project finance transactions;

a) *Capital-intensive:* Projects finance tends is involved with large-scale projects that require an enormous combination of equity and debt investment.
b) *Highly leveraged:* Project finance projects typically have a large amount of debt relative to equity. The transactions leveraged with debt accounting for usually 65% to 80% of capital in relatively normal cases.
c) *Longer tenor:* The tenor for project finance can easily reach 15 to 20 years. This is however determined primarily by the length of time required for the project asset's cash flow stream to generate enough revenue to pay back investors.
d) *Independent entity with a finite life:* A contemporary project finance frequently relies on a newly established project company, a distinct legal and economic entity with the sole purpose of executing the project and which has a finite life i.e. cannot outlive its original purpose. In many cases, the clearly defined conclusion of the project is the transfer of the project assets. For example in the power project under the BOOT, the project company ceases to exist after the project assets are transferred to the country´s off-taker usually for a nominal or no cost.
e) *Nonrecourse or limited recourse financing:* The project company is the borrower of the debt funds raised for the project, own the project assets and enter into contracts. Since the newly formed entity does not have their own credit or operating histories, project financings rely on the specific project's cash flows and assets of the project company rather than the overall creditworthiness of the sponsor for the repayment of debt.
f) *Many participants:* These transactions frequently demand the participation of numerous international participants. It is not rare to find over ten parties playing major roles in implementing the project. Each participant plays different roles essential to project success The main three participants and decision makers are the host government, the sponsors and the lenders.

g) *Risk allocation:* The risks arising from the project are allocated to the various project partners on the basis of their ability to influence and control the risks. This allocation is achieved and codified in the contractual arrangements between the project company and the other participants. The goal of this process is to match risks and corresponding returns to the parties most capable of successfully managing them. Section 3.4 discusses the risks inherent to typical power project finance and the allocation.
h) *Costly:* Raising capital through project finance is generally costlier than through typical corporate finance avenues or host government financing. The extensive need for due diligence, the involvement of multiple parties, financing documents, and other legal contractual agreements increases the transaction costs.
i) *Controlled dividend policy:* To support a borrower without a credit history in a highly-leveraged project with significant debt service obligations, lenders demand receiving cash flows from the project as they are generated. The project's revenue goes to servicing the debt, covering operating expenses and generating a return on the investors' equity. This arrangement is usually contractually binding. Thus, the reinvestment decision is removed from the management's hands.
j) *Complex documentation and agreements:* Project finances involve extremely complex documentation and different types of agreements with multiple parties to provide the cohesive force in a financing project. A web of inter-related contracts is created between the project company and other project participants to help allocate project risks and to create and protect the revenue stream generated by the project assets. The project finance agreements must be enforceable and have value to the lender as collateral security. The existence of so many contracts means that project finance is sometimes called contract-based financing (Niehuss, 2015).

3.2.2 Structure of project finance

Every project finance structure is characterized by several same basic elements. Figure 7 illustrates the basic elements in a capital investment that is financed on a project basis. At the centre is a discrete asset, a separate facility, or a related set of assets with a specific purpose where in this case, is the generation of electricity from a geothermal power station. As already noted above, the assets must be capable of standing alone as an independent economic unit.

The operations, supported by a variety of contractual arrangements, must be organized so that the project has the unquestioned ability to generate sufficient cash flow to repay its debts. Furthermore, a project must include all the assets that are necessary to constitute an economically independent and viable operating entity (Finnerty, 2013).

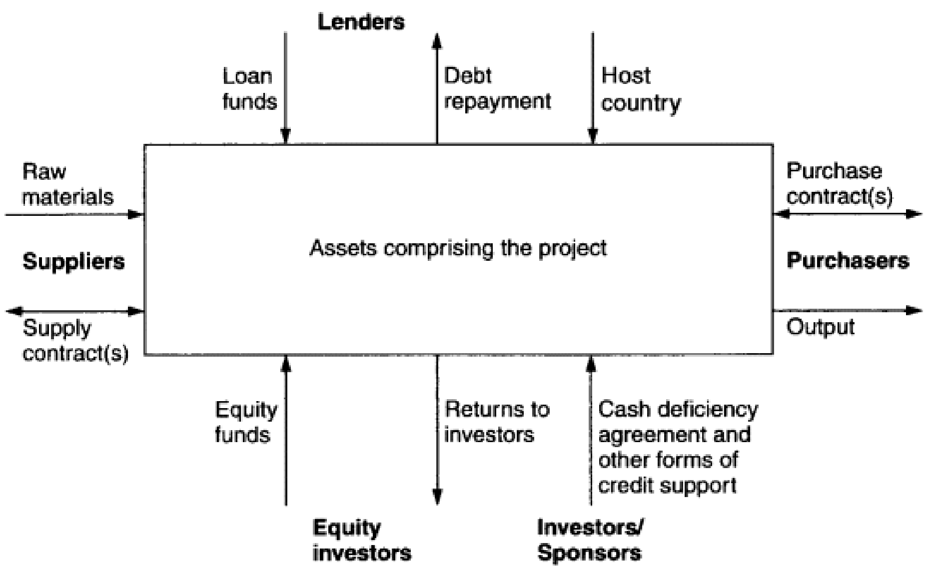

FIGURE 7: Project finance structure (Finnerty, 2013)

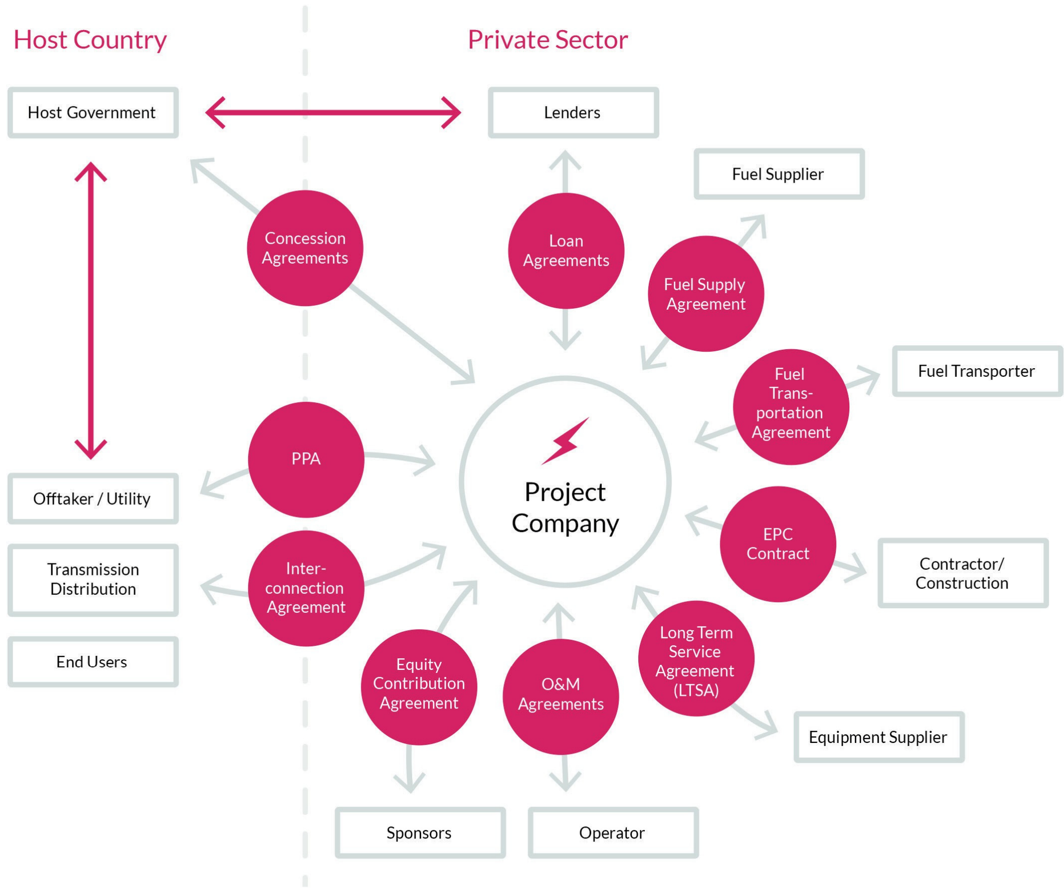

FIGURE 8: Power project finance participants and contractual structure (CLDP, 2016)

3.2.3 Project finance major players

Project finance transactions are complex that often brings together arrays of numerous players, both domestic and foreign in co-dependent relationships and agreements. Figure 8 illustrates the project company in the centre of a complex network of typical contracts and key power project participants.

The section described the key participants, their roles and the nature of agreements in the project finance as follows;

a) *Host government:* The key participant in a PPP project finance transaction. The government has a key role to establish an enabling investment environment in order to maximize the efficiencies of private participation in power markets. This includes a stable, consistent, and investment-friendly framework of laws and regulations in order to attract private investment. As discussed earlier, power procurement through PPP is initiated by the sovereign through a contracting public authority under a competitive tendering process. Furthermore, the host government enters the concession or implementation agreement with the project company to develop, finance, construct and operate the power plant, including the right to sell power to the off-taker. Host governments often provide sovereign guarantees for payment obligations of a state-owned off-takers.

b) *Off-taker:* This a purchaser of the generated power from the project company. PPA governs the sale and purchase of power between the two parties. In the PPP transaction, the off-taker is a power utility which is often a state-owned. The off-taker assumes the ownership of the power plant from the project company at the end of the concession period.

c) *Project sponsors:* These are generally owners of the project with an equity stake. The project sponsor can be for a single company or a consortium to sponsor a project. The sponsors are the primary parties that coordinate the development of the project i.e. initiate the project from the bidding process, performing feasibility studies, obtaining concessions, negotiating with project parties and sourcing the most appropriate mix of equity investors and debt providers for the project.

Where more than one sponsor is involved, a joint-venture structure is agreed between them through the shareholder agreement. In order to obtain project finance debt, the sponsors have to offer priority payment to the lenders, thus accepting that they will only receive their equity return after lenders have been paid their amounts due. Therefore, project sponsors assume the highest financial risk, but at the same time receive the largest share in the project's profit (pro rata to the capital investment at risk) if it goes according to plan (Yescombe, 2014).

d) *Project company:* Owned and controlled by private-sector investors (project sponsors). The project company owns the power project and the seller of power. The project company lies at the centre of a network of all the contractual and financial relationships in the project. The company enters long-term contractual arrangements with lenders, sponsors, host government, operators, contractors, suppliers and off-taker. The heart of any power project finance is the PPA with the off-taker, which explains the project payments based on availability and usage charges as discussed above. The other key agreements include a construction contract with EPC contractor to deliver a completed and fully-equipped ('turnkey') power station to the required specification, at a fixed price and schedule, operation and maintenance agreement with O&M contractor to operate and maintain the plant and fuel supply agreement with fuel supplier to provided fuel for the power station's turbines.

e) *Lenders:* Providers of project finance debt to the project company to build the power project. Due to the size of the power projects investment, the financing may often require the syndication of the financing where several lenders arrange a loan under a single loan agreement. Although lenders share the common goal of being repaid loan principal on time together with a suitable return, the particular objectives of individual lenders may be quite different. Commercial banks have traditionally been the most prominent lenders to project finance. Lenders who are not commercial may have other or differing objectives, for instance, the promotion of exports or the economic development of particular regions (Clews, 2016). Furthermore, since lenders rely on the cash flows of a project to provide investment returns and to service debt, they require detailed risk analysis and due diligence, often supported by independent third-party consultants to assist in evaluating and assessing the viability of the project, validity and accuracy of technical and economic assumptions in the project's business plan and base financial model (CLDP, 2016). Some of the principal debt sources available for project finance are discussed in Section 3.2.6.

3.2.4 Phases of project finance

Although each project finance transaction is unique, the life of a project can be divided into three phases namely development, construction and operation. At the end of the project development phase, the dynamic of operating cash flows in the construction and operation phase for each year of project life is illustrated in Figure 9.

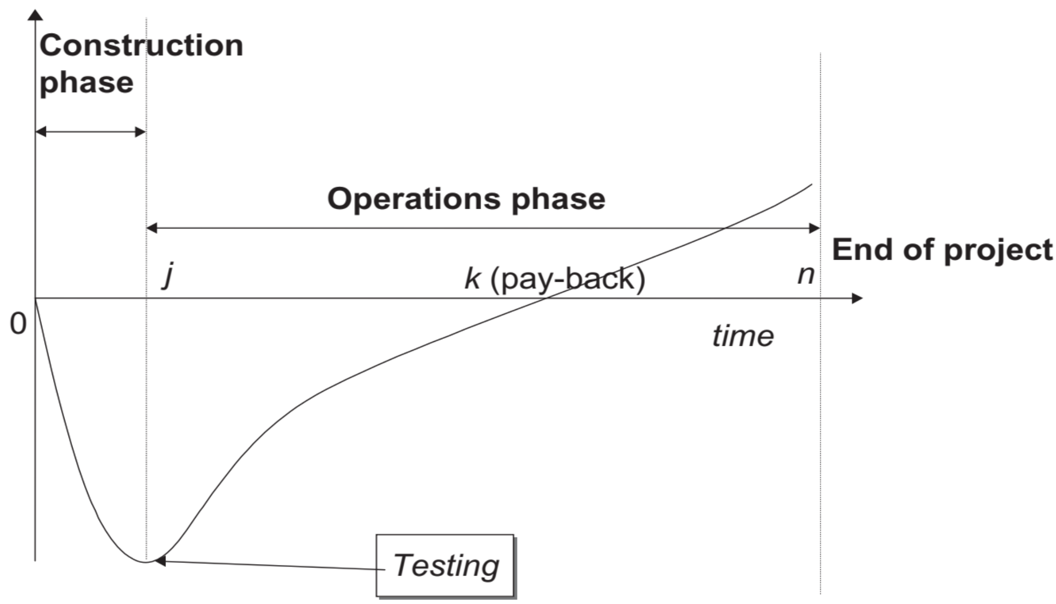

FIGURE 9: Project finance phases with dynamic of cumulative cash flows (Gatti, 2013)

Each phase consists of a complex series of interrelated tasks that requires a systematic and well-organized approach and involves a mixture of well-coordinated disciplines namely; engineering and construction, operation, accounting and tax, financial modeling, financial structuring and most importantly legal covering site acquisition, permits, project contracts and loan documentation (Yescombe, 2014).

a) Development phase
This is the period during which the project is conceived, the project contracts are negotiated, signed, and come into effect, and the equity and project finance debt are put in place and available for drawing. The project sponsors play the primary role in managing this phase of the project and making use of external advisers.

For the geothermal power project, the thesis assumes the project has been partly developed by the off-taker or a public-sector authority before inviting the project sponsors for bidding, developing and managing the project as discussed in Section 2.6. The end of this process is known as financial close and the construction phase can begin upon. This phase is more complex than it might appear at first sight, and can easily run on for several years (Yescombe, 2014).

b) Construction phase
The period during which the project finance begins to flow from the financiers to the project company in order to cover for capital expenditures, interest during construction, working capital, fees and services. The end of this phase is often known as the commercial operation date (COD). In Figure 9, the project construction phase is shown from time *0* to time *j* on the horizontal axis. The project company starts drawing down the loans and equity form the lender and project sponsors respectively. The disbursements of project CAPEX is done over several years which subsequently produce negative operating cash flows.

During this stage, no cash flow is generated from the project and debt service may be postponed, either by rolling-up interest or by allowing further drawdowns to finance interest payments prior to the operation phase. Margins might be higher than during other phases of the project to compensate for the higher risks (Fight, 2006).

The length of this phase can vary from months to several years. The construction phase is the period of which risk is at its highest for lenders due to significant drawdowns to archive the agreed construction milestones. The main risks being (1) delayed construction and/or cost overruns (2) inadequate funding to complete the project and (3) non-completion or abandonment.

c) Operation phase
This is the period during which the plant construction is completed and performance tests are declared to be completed with satisfactory results and all operating permits obtained. The operational phase i.e. the commercial operations of the plant begins. In Figure 9, the phase is shown between point *j* to *n* where after some years of operation, the operating cash flows become positive where *k*, is the break-even point and distance between point *j* and point *k* payback period on the investment. For the BOOT model, the year *n* becomes the last year of the project company to operate the plant before transfer the assets to the off-taker.

During the operation period, the focus of the host government, the sponsor and the permanent lender are on ensuring efficient management and operation of the project in order to create a sufficient revenue stream to pay operating costs, taxes, debt service, and a return on sponsor equity. The operational phase is by far the lengthiest and the stage where renegotiation, restructuring, refinancing, and major disputes are likely to occur (Niehuss, 2014). In this phase, the lenders seek to control the project company's cash flow by stipulating the order of priority in which payments from project revenue can be made commonly referred as a payment water flow or cash flow waterfall or cash-flow cascade. The order of priorities for the use of this cash is regulated in the account agreement (CLDP, 2016). In a typical payment waterfall, dedicated revenues are used to pay operational expenses and debts contributors while the equity contributors wait for several cascaded levels before dividends are released as illustrated in Figure 10.

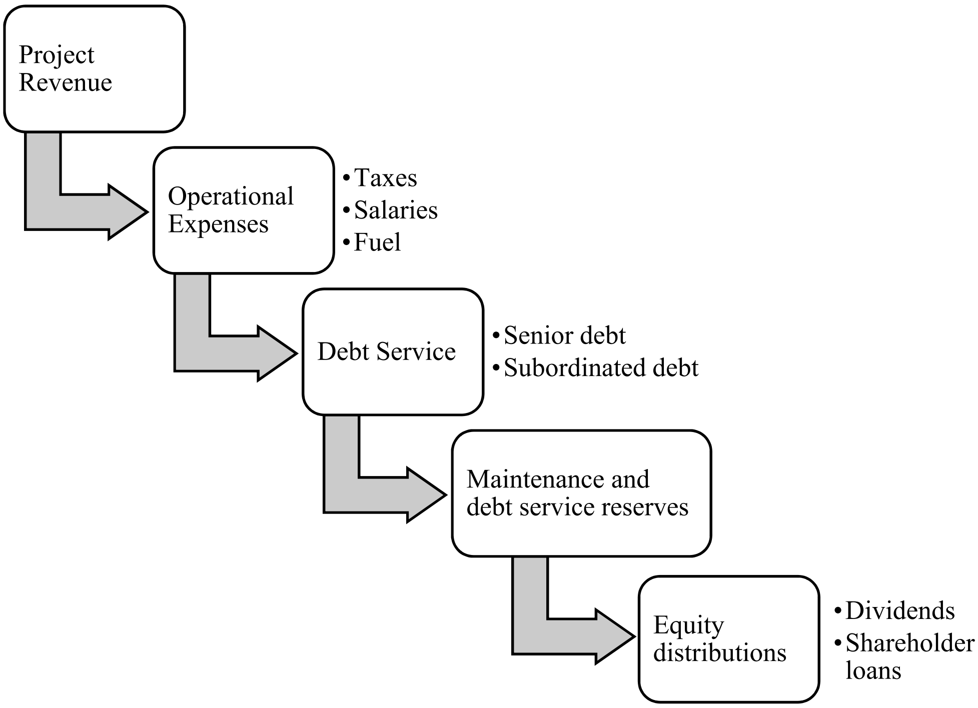

FIGURE 10: Project finance cash flows waterfall

3.2.5 Source of funds for project finance

The source of funds for a PPP project finance consists principally of two components namely equity, provided by the project sponsors and debt provided by one or more groups of lenders. The debt comes in the form of senior debt and equity may sometimes be in the form of junior shareholder loans (European Investment Bank, 2015).

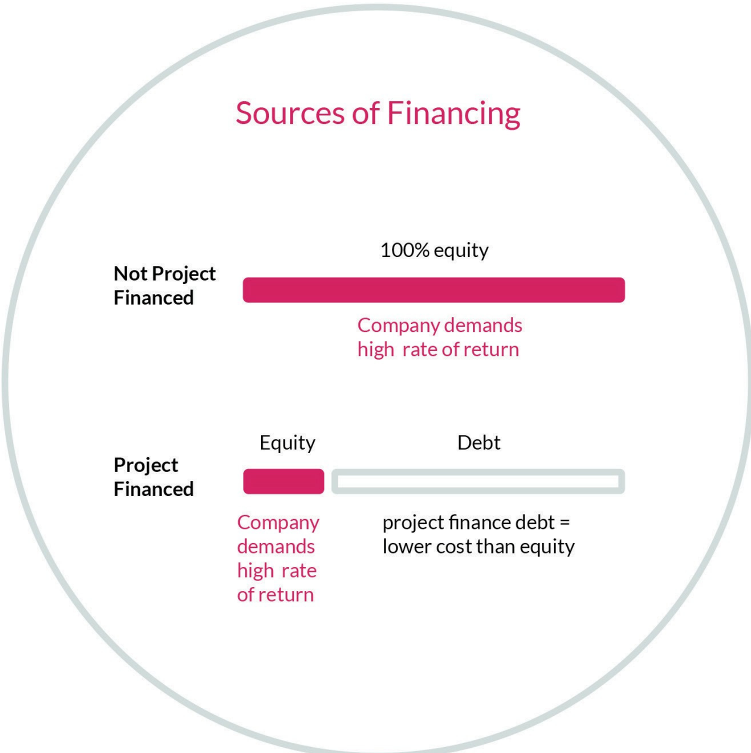

FIGURE 11: Cost project finance versus non-project financing techniques (CLDP, 2014)

The combination of equity and project finance-based debt in the development of a power project provides cheaper financing alternative compared to the projects funded on the balance sheet of large corporate developers as explained in Section 3.1.2. Despite the fact that large creditworthy corporate developers can borrow funds in the capital markets at relatively low interest rates which is essentially much lower than the cost of project finance debt, the developers still consider the borrowed funds as internal funds hence consider it as equity when making investment decisions. Thus, corporate developers seek a high internal rate of return for their equity which translates to relatively a higher off-take price of electricity which may be unaffordable to the off-taker (CLDP, 2014). Figure 11 provides a simplified view of two typical options.

The ratio of senior debt relative to the level of equity in a project is referred to as the level of gearing or leverage. As shown above, the higher the gearing of a project, the lower the likely cost of the overall project's financing as the senior debt is less expensive than other forms of financing (except grants). This is primarily because interest is tax deductible in high leverage investment costs, whereas dividends to shareholders are not, this makes debt even cheaper than the equity. As a practical matter, this may vary depending on how much credit support is required in connection with the project finance since each element of credit support will impose additional costs.

The appropriate level of gearing depends essentially on negotiations between the lenders and the project shareholders, however it is primarily determined by the variability of a project's cash flow for debt service, the risks perceived by the lenders in such project, whether the shareholders are actively participating in the project (i.e. as a contractor, operator) and prevailing market conditions.

3.2.6 Debt contributions

Debt is by far the most common and major source of capital for project finance. Project sponsors have a range of available alternatives to obtaining funds for debt contribution in the projects. It can be obtained from sources such as commercial banks, multilateral, Development Finance Institutions (DFIs), Export Credit Agencies (ECAs) and bondholders. The thesis is written on the assumption that debt financing is provided by commercial banks.

The types of debts can range from senior loans, subordinated or mezzanine loans through to bonds and soft loans. Senior debt enjoys priority in terms of repayment over all other forms of finance. The mezzanine debt is subordinated in terms of repayment to senior debt but ranks above equity both for distributions of free cash in the payment waterfall and in the event of liquidation of the project company. Since mezzanine debt's repayment can be affected by the poor performance of the project company, bearing in mind the priority in repayment of senior debt, mezzanine debt typically commands higher returns than senior debt (European Investment Bank, 2015).

As briefly explained in the Section 3.2.4, lenders require project company to set up project accounts also known as control accounts to ensure that, the project's cash flow is allocated as stipulated in the loan documentation which amongst other things seek to ensure timely payment of principal and interest of the loan. These accounts relate to both project revenues and their application to operating and financing costs, as well as to various sums which have to be set aside in reserve accounts. This establishes the lender control and supervision as the project generates revenue (Yescombe, 2014).

Reserve accounts hold various sums of money for twofold reasons 1) providing security against short-term cash flow problems and 2) setting aside funds needed for major expenditure in future. However, this can be a concern to equity providers, as the reserve accounts built up, their return decreases hence prevent or delays distribution of net cash flow. Furthermore, the other sponsors' main concern is for the project company not be left in the position of having insufficient cash to carry on its normal business, while other cash is trapped in reserve accounts.

For geothermal power project, the thesis assumes two essential reserve accounts to be incorporated in the financial modelling task namely Debt Service Reserve Account (DSRA) and Maintenance Reserve Account (MRA). The DSRA account contains sufficient funds to pay the next debt service (principal and interest) instalment, usually six months' worth of debt service. In case the project company cannot pay some or all of the debt service from its normal cash flow, funds are taken out of this account to meet the obligation. The DSRA can be set up in two ways 1) including the DSRA as part of the construction cost budget for the project and 2) funding the DSRA from operating cash flow under the cascade as cash flow comes in from initial operations. The thesis assumes the former.

On the other hand, the MRA is set to ensure that there are always funds available for operation and maintenance (O&M) expenses even when the project has insufficient operation cash flow on a specific period due to lower than expected production, higher cost or both. The size of the reserve account is typically 3 to 6 months of the O&M expenses for both categories of O&M expenses namely major power plant maintenance that incurs after every number of years rather than annually and estimated O&M annual costs. The geothermal power projects major maintenance includes the necessity of makeup wells to capture the expectation of resource degradation over time. The depletion of the project's original wells is established which subsequently establishes the quantity and time period of makeup wells drilling.

3.2.7 Equity contributions

Equity is an effective long-term risk capital invested in the project company provided by the investors who in return receive dividends and capital gains (or losses) based on the projects net earnings in proportion to the amount of equity provided. The equity is provided primarily by main project sponsors and lesser amounts are sometimes provided by a variety of other minority investors. Since shareholders or equity providers typically bear a higher level of risk than the lenders, therefore requires a commensurate return on their investment.

The equity contributions may be a blend of subordinated debt form of ordinary shares capital and subordinated debt or a shareholder loan. Dividends paid to the shareholders are subordinate to all debt and financial obligations of the project, this means that dividends are paid only after debt service and other payments are made, and in the event of loss or bankruptcy, equity is the first to be forfeit (Ndupuechi, 2003).

Lenders frequently require the project sponsor to provide a strong equity base to the project. In lenders perspective, the substantial equity commitment by the main sponsor helps ensure the project's success as (1) makes it expensive for the sponsors to abandon the project, thus encouraging them to take a strong and lasting interest in the project and to seek to remedy difficulties that will arise (2) expedite the decision making, particularly where the sponsor holds a majority share and (3) increases the confidence of other parties in the project (IFC, 1999).

Project finance investors rather than evaluating the return on investment (ROI), use the return on equity investment in the project company as their main measure of project attractiveness. In project finance, the Internal Rate of Return (IRR) of equity is used, the metric measures the growth rate in cash flows after money has been paid to lenders for debt service and government for corporate tax. The IRR of equity is calculated and compared with the investor's hurdle rate for their equity, when the IRR of equity is above the hurdle rate then, the investment is acceptable, and below is rejected (Yescombe, 2014). The theory of the metric is covered in chapter 5.

3.2.8 Financial structure

After the risk of the project been reviewed, the project sponsors who are the drivers of the project, establish negotiations with the commercial lenders on the key elements on the overall financing structure and terms of the debt. As both lenders and equity provider contributes to the total financing of the project, Yescombe, 2014 listed five elements that both lender and borrower need to agree upon. These include; debt-cover ratio, debt-equity ratio, debt-service profile, interest rate, debt fees, length of debt terms and additional costs.

These elements are closely inter-related so that a change in one requirement usually leads to a change in one or more of the others. In power project context, the structuring of these elements can have significant implications for the project's cost of electricity. Financial modelling incorporates the elements and optimize them to produce the most efficient financial structure. The mathematical formulae and interpretation of the cover ratios are expounded in Chapter 4.

3.3 Risk allocation

As previously mentioned in Section 3.2, risk allocation is at the heart of project finance and a fundamental building block of bankability. IFC, 1999 defined risk allocation as the process of identifying and quantifying risks associated with a project, and assigning those risks to the parties. Generally, risks are assigned to the part ablest to bear and control them with the least cost. The parties accepting risks must have both the capability to manage risks and the means to enforce risk management roles legally. In theory, efficient risk allocation leads to the lowest cost, a most financeable commercial structure for the project. In reality, however, parties may deviate from the general principle on which risk allocation between the various contracting parties is also based on the negotiating power of the different parties, leading to a significant impact on project economics.

Yescombe, 2014 divided project finance into three main categories 1) commercial risks (also known as project risks) are those inherent in the project itself, related to technical, financial and other concerns that would face a project irrespective of its country location 2) political risks (also known as country risks) relate to those risks presented by the particular host country and its government. They cover the effects of government action or political force majeure events such as war and civil disturbance (especially, but not exclusively, where the project involves cross-border financing or investment) and 3) macro-economic risks (also known as financial risks) relate to external economic effects not directly related to the project (i.e. inflation, interest rates, and currency exchange rates).

Project finance risk analysis is established by a due-diligence process which intends to ensure the availability of all the necessary information about the project, the process leads to the identification of risks, then appropriately allocates risks to the project parties through an interlocked system of contracts between the project sponsor and other implementing parties.

Lenders' primary or, in some cases, the only source of a debt security is the project cash flow which is subjected to all the three categories of risks. Improper management of these risks places a project's cash flow in jeopardy and hence makes lenders reluctant to provide project finance. Lenders rely on due diligence, risk evaluation and subsequently bankable contractual risk allocation as the cornerstone on the decision to providing debt-finance in project finance transaction.

In PPP power project finance, the host governments (or the off-taker) and project sponsors are two principal risk takers and must agree on the workable risk allocation. In practical, project sponsors are best able to manage the risks that the project is completed within budget and on schedule and that they will perform as technically specified. Sponsors can also manage some foreign exchange and political risks by purchasing political risk insurance which may significantly increase expenses burden to the project. Ultimately, many of these costs get passed through to the end-users.

On the other hand, host governments can better manage economic and political risks. Foreign exchange and inflation risks can be addressed by sovereign fiscal policy and the allocation of foreign exchange to specific projects. Governments can also control the activities and influence the financial condition of the off-taker, typically a government-owned power utility. Sovereign guarantees can provide a way to ensure the performance of off-takers to the satisfaction of lenders. Fuel risks (if applicable) can be shared among the sponsor and public sector participants (Babbar and Schuste, 1998). The geothermal resource risks which are normally not addressed in conventional power projects, require mechanisms to assess and mitigate them. The potential lenders likely require the opinion of an independent technical consultant on the project’s geothermal resources in order to provide the debt (Battocletti and Lawrence, 1999).

The detailed assessment of the individual risks of the three risk categories, their risks mitigation instruments and the allocation of the risks is beyond the scope of this study. However, the thesis assumes a rational risks allocation among the key risk takers is done with no material impacts on the project costs and economics. Babbar and Schuste, 1998 developed a rational model to demonstrate the mechanism of power project risks allocation between the government entities and project sponsors, lenders, and contractors under the general risk allocation principle. The summary is provided in Table 2.

TABLE 2: Risk allocation mechanism (Babbar and Schuste, 1998)

Risks	Sponsors/lenders/contractors	Government/off-taker
Predominont risk assumption by sponsors/lenders/contractors		
Completion	Project ownership/contracts Turnkey EPC contract Development xpertise/resource	Granting of permits/consents
Technical performance	Project ownership/contracts Turnkey O&M contract	None
Financing	Interest rate hedge	Off-taker ability to pass-through finance costs
Predominant risk assumption by host government/off-taker		
Foreign exchange	Hedge foreign exchange rate	Fiscal policy Foreign exchange reserve
Inflation	Indexed contract	Off-taker ability to pass through price increases
Utility performance	None	Control over off-taker Ability to cover the off-taker payment
Political/change in law	Political risk insurance	Domestic policy
Shared risks		
Fuel availability and prices	Control fuel supply for the project Storage/alternative source	Control of local fuel resources, import licenses Off-taker ability to absorb the price increase

4. PROJECTS FINANCIAL APPRAISAL

The project financial appraisal covers the theoretical quantitative background of financial and economic analysis to ascertain whether the expected future cash inflows of the project are sufficient to attract both lenders and project sponsors to invest in the project. The section covers the principles and techniques of project evaluations commonly used as decision-making criteria to appraise or evaluate investment projects in project finance. Furthermore, the relative strengths and weaknesses of each criterion are illustrated.

Project investment appraisal methods are frequently and collectively termed as capital budgeting methods which normally entail sizable and long-term investment projects. The capital budgeting process involves the identification of relevant cash flows, their forecasting, risk analysis and the application of project evaluation concepts, techniques and criteria to assess whether the proposed projects are likely to generate sufficient returns to the capital providers. The result and conclusion of the quantitative project analyses heavily influence the project selection or investment decisions. These decisions clearly affect the success or failure of the project and its future direction. Therefore, project analysis is critically important for a new project (Dayananda, et al.,2002).

The following quantitative investment appraisal techniques are commonly employed in project finance investment analysis to measure the investment attractiveness and establishes project viability. The evaluation techniques cover both discounted cash flow analysis and non-discounted cash flow analysis; 1) payback period (PP) methods 2) NPV method 3) rate of return methods 4) profitability index 5) financial ratio analysis and 6) levelized cost of electricity (LCOE).

Under the conditions typically found in investment projects, Abdel-Aal and Alsahlawi (2014) insisted that no unique one measure is by itself a sufficient basis for financial measures and profitability analysis to accounts for all possible decision factors or dimensions of a project capital investment, in other words no major investment decision should totally be based on a single criterion, so a suitable combination of more than one economic and financial evaluation yardsticks is needed to give a more rounded view of the project to compare, rank, accept, reject or recommend a worth of pursuing a project under consideration.

The discussion of these project financial appraisal techniques assumes the future is known with certainty i.e. in a no-risk situation. In the real world, however, the future cash flows of a project are not certain as cannot be forecasted with absolute accuracy. While the assumption of certainty is not realistic, the appraisal techniques are set to establish to a guide and theoretical correct decision rules only as many unpredictable factors and uncertainties of cash flow cannot be accounted for. The results of these capital investment evaluations need to be subjected to the uncertainty techniques which are essential for any real-world project evaluation that enables making sound investment decisions. The details on the mechanics are covered in Chapter 5.

4.1 Payback Period (PP) method

Park, 2007 defined Payback Period as the length of time required to recover the cost of an investment in the form of cash inflows stream to the project. The payback period is also referred to as the payoff period or the capital recovery period. The method is commonly used to initial screen of investment projects on the basis of how long it takes for a stream of cash flows to cover an investment's cost.

Most investors in high risk, high rewards projects seek to recover most of their capital investments in a short payback period primarily due to unforeseen events in the future over a period of time. This includes rapidly changing in a fiercely competitive environment, macro-economic factors, technology, political environment and tax laws, all potentially affecting the feasibility of investments. For example, geothermal power projects have a long life surviving several political regime changes, this is always a concern to the investors, as for whether the successful regimes maintain the same policy assuring them for their return on investment (Ngugi, 2012). Therefore, a rapid recovering of cash invested in the project i.e. a shorter payback period than some specified period may be a primary requirement in ascertaining the desirability to pursue an investment project.

Therefore, the decision criterions when using PP analysis for project investment decisions is that, for a project to be acceptable, it should have a payback period shorter than the maximum payback period set by the project investors and if two or more mutually exclusive projects with payback periods that are shorter than the maximum payback period, the project with the shorter (or shortest) payback period should be selected. To arrive at the conclusion in the PP analysis, the assumption is cash flows are received at the end of the year hence the payback period is expressed in terms of a whole number of years instead of monthly or weekly, throughout the year. Therefore, the assumption of end-of-period cash flows may be unrealistic in the event that, the calculated PP yield years and number of months (Fabozzi and Peterson, 2003).

Park, 2007 indicated that the payback period takes one of two forms either ignore time-value-of-money considerations or include them. The former case is usually designated as the conventional payback method, the latter case the discounted payback method. Both methods are discussed in detail in the following subsection.

4.1.1 Conventional Payback

The conventional payback period analysis as mentioned does not consider the time value of money which primarily mean the analysis ignores the rule that receiving money sooner is better than later. Computing the payback period depends on whether the net cash inflows are equal each year, or whether they differ over time. For the project with uniform annual cash inflows, the PP analysis is mathematically represented by the following formula;

$$Payback\ Period = \frac{Capital\ Investment}{Uniform\ annual\ cash\ inflow} \tag{4}$$

However, for the non-uniform annual cash flows, Park (2007) stated that the payback period must be determined by comparing the investment outlay with the accumulated cash flow. The approach involves adding the expected cash flows for each year until the sum is equal to or greater than zero. The cumulative cash flow equals zero at the point where cash inflows exactly match, or pay back the cash outflows; thus, the project has reached the payback point. Similarly, if the cumulative cash flows are greater than zero, then the cash inflows exceed the cash outflows, and the project has begun to generate a profit, thus surpassing its payback point.

Fabozzi and Peterson (2003) discussed four primary use of the payback period analysis:

1) favours investments with front-loaded cash flows, an investment looks better in terms of the payback period, the sooner its cash flows are received no matter what its later cash flows look like;
2) Provides the break-even measure of the investment project;
3) Offers some indication of risk, favours projects with higher cash inflows in earlier years and rejects with higher inflows in later year;
4) Provides a rough measure of the liquidity of the investment, favours the project with early recovery of cash flows from the investment, however, does not state the particular payback period that maximizes wealth.

Despite its simplicity and wider application in initial screening and appraising of investment capital projects, the conventional payback period has four key weaknesses:

1) The analysis does not consider all cash flows, hence produces unrealistic results if used as the only decision criterion to analyse investments;
2) The payback period method ignores the timing of cash flows, the projects with late substantial cash inflows may be rejected;
3) For projects with different risk profile, the payback period ignores the risk associated with the cash flows;

4) The method does not indicate wealth maximization and doesn't provide a connection and its profitability.

The method furthermore disregards the cost of capital.

4.1.2 Discounted Payback Period (DPP) method

Park, 2007 defined the discounted payback period as the length of time required to recover the cost of an investment based on discounted cash flows. The DPP is sometimes referred to as the modified payback period. The method is introduced to remedy one of the shortcomings of conventional PP analysis by taking into account the time value of money which essentially explains that the cash received today is worth a lot more than the same amount of cash received in future years, due to its potential earning capacity.

The projects cash flow is discounted back to the beginning of the investment at a rate that reflects both the time value of money and the uncertainty of the future cash flows. The rate is the cost of capital, that is, the return required by the suppliers of capital (lenders and sponsors) to compensate them for the time value of money and the risk associated with the investment. The more uncertain the future cash flows, the greater the cost of capital which is principally the required rate of return for the perspective of the investor (Fabozzi and Peterson, 2003). Being the uneven annual discounted cash flow, the discounted payback period is calculated in exactly the same way as presented in the conventional payback period by comparing the investment outlay with the accumulated cash flow.

The inclusion of discounted cash flow analysis technique in the payback period analysis distinguishes the investments with different timing of cash flows and being to account for the risk associated with the cash flows reflected in the discount rate.

Conclusively, the discounted payback analysis addresses some of the drawbacks of conventional payback period but it does not provide the complete picture of the investment project profitability as it ignores the post payback duration of the project i.e. all the cash flows that happen after the discounted payback period are ignored. The ignored cash flow which can contribute to the present value of investment hence does not indicate wealth maximization.

4.2 Net Present Value (NPV)

NPV refers to the discounted sum of the expected net cash flows utilising the typical discounted cash flow analysis technique, which take into consideration the concept of the time value of money. The discount rate used in calculating NPV takes into account the timing, opportunity cost involved, project equivalent risk on the future cash flows and project's cost of capital, amongst other factors. The rate is often referred to as a required rate of return or hurdle rate or a minimum attractive rate of return (MARR).

In appraising or evaluating investment projects under the NPV, the present value of all cash inflows is compared against the present worth of all cash outflows associated with an investment project. The difference between these present values of the cash flows determines whether the project is an acceptable investment. In this case, a positive NPV value for a given project gives an indication that the project benefits are greater than its costs, and vice versa (Park, 2007).

For project finance structure, the NPV is calculated from the established Free Cash Flow to the Project (FCFP) and Free Cash Flow to Equity (FCFE). The MARR is also defined in different perspectives when evaluating the NPV for both FCFP and FCFE.

The general formula to determine the NPV is as shown:

$$NPV(i) = \frac{A_0}{(1+i)^0} + \frac{A_1}{(1+i)^1} + \cdots + \frac{A_N}{(1+i)^N} = \sum_{n=0}^{N} \frac{A_n}{(1+i)^n} \tag{5}$$

where A_n = Net cash flow at the end of period *n;*
i = MARR;
N = Project economic life.

The NPV formula yields three possible outcomes and hence the NPV investment for an independent project is summarised in the following decision criterion;

If NPV (i) > 0, means the present value of the future cash flows > initial investment hence the investment will earn a rate of return greater than the MARR i.e. more than the minimum needed to give the suppliers of capital their minimum required return (as well as their capital investment back). Therefore, the project should be accepted.

If NPV (i) = 0, The cash flows will provide a rate of return (on the initial investment) exactly equal to the MARR. The investment's net cash flows are just enough to repay the invested capital along with the minimum required rate of return. This is, therefore, the minimum condition for acceptance of a capital investment project.

If NPV (i) < 0, means the present value of the future cash flows < initial investment. The project's net cash flows will not be enough to provide the sources of financing with their full minimum required rate of return (on top of the return of their capital investment). In this case, the investment should be rejected.

In ranking mutually exclusive capital projects with similar MARR and time periods, the NPV metrics are computed for all alternatives and the one which yields the highest NPV to the projects should be selected. Park, 2007, suggested that, when comparing the mutually exclusive alternatives with the same revenues, the projects should be compared on a cost-only basis. This is primarily because the costs are minimised rather than maximizing profits, then project with the smallest or least negative NPV should be chosen.

Despite the theoretical superiority of the NPV criterion in the project investment appraisal, the method is faced with one main practical drawback which is the fact that it implicitly assumes that, the periodic cash flows can and is reinvested at the same discount rate, which is usually not a realistic assumption.

4.2.1 Project NPV

The NPV of a project is found by first discounting the FCFP at the MARR for the project which in this case referred as the Weighted Average Cost of all sources of Capital (WACC) in the project since the FCFP is the cash flow available to all financial investors. The project NPV evaluates the power project investment to demonstrate whether is worth pursuing to both suppliers of debt (lenders) and equity stakeholders.

The $WACC$ includes the required return for each investor and is found by the following expression:

$$WACC = \frac{D}{D+E} * i^* * (1 - T_c) + \frac{E}{D+E} * R_e \tag{6}$$

where $\frac{D}{D+E}$ = The proportion of debt in the project capital
$\frac{E}{D+E}$ = The proportion of equity in the project capital
R_e = The required rate of return on equity or cost of equity
T_c = Corporate tax rate
i^* = Interest rate of the debt or the cost of debt

While the cost of debt or interest rate of the debt, $i^*$is quite easy to measure, the cost of equity, R_e is more complex. The R_e is estimated using the widely used standard Capital Asset Pricing Model, or the CAPM equation which essentially measures the expected rate of return on an asset commensurate with its risk relative to market-wide risk and calculated as the summation of the risk-free cost of debt and a premium for taking a risk as to whether a return is received.

The comprehensive discussion of the CAPM is beyond the scope of this study. The CAPM is governed by the following equation (Higgins, 2016).

$$Re = r_f + \beta(r_M - r_f) \tag{7}$$

where r_f = risk-free interest rate commonly referenced to the U.S. Treasury bond yield, adjusted for inflation;

β = a measure of stock price volatility, the risk premium for the particular company's business compared to the market as a whole; if the project's operating risk profile is considered to have the same risk as the market as a whole, then $\beta = 1$;

r_M = the market rate of return commonly referenced to the average return on the S&P 500 stock index funds, adjusted for inflation.

The calculated WACC is used as a discount rate to discount the future FCFP to determine the project NPV, as shown below:

$$\begin{aligned} NPV\ project &= \frac{FCFP_0}{(1+WACC)^0} + \frac{FCFP_1}{(1+WACC)^1} + \ \dots \ + \frac{FCFP_N}{(1+WACC)^N} \\ &= \sum_{n=0}^{N} \frac{FCFP_n}{(1+WACC)^n} \end{aligned} \tag{8}$$

where $FCFP_n$ = Net cash flow expected at the end of period 0 *through N, N* being the final cash flow in the life of the investment

4.2.2 NPV of Equity

The projected future FCFE is discounted not with WACC but rather by the required return on equity to establish today's value of money and summed to compute the NPV of equity investment in the project. Discounting by Re is consistent with the fact that the annual interest and principal payments for the debt are already made and the entire remaining cash flow belongs to the equity investors only (Gehringer and Loksha, 2012).

The NPV of the cash flow to equity and the respective rate of return takes the perspective of equity investors only. The cash flow used in this calculation is based on the concept of free cash flow to equity (FCFE).

The formula to determine the equity NPV is:

$$NPV\ equity\ = \frac{FCFE_0}{(1+Re)^0} + \frac{FCFE_1}{(1+Re)^1} + \ \dots \ + \frac{FCFE_N}{(1+Re)^N} = \sum_{n=0}^{N} \frac{FCFE_n}{(1+Re)^n} \tag{9}$$

where $FCFE_n$ = Free cash flow to the equity in year n in the project life of N years;

Re = The required return on equity.

The required return on equity generally requires a higher return from this cash flow to compensate for the higher risk associated with being the last in line to receive the payoff. The level of the risk premium and the resulting Re depends strongly on the nature of the project. Gehringer and Loksha, 2012 pointed out that the common equity investors in a geothermal project may require a return between 20 and 30 per cent per year when entering at an early stage which is characterised with resource risk making the greatest contribution to the high-risk premium.

Financing structure is also sensitive to the equity returns, debt financing parameters including the interest rate, maturity period, grace period (if applicable) and debt-to-equity ratio. However, the return can be lowered by proper cost sharing arrangements similar to the PPP structure discussed in the previous chapter where in this case the government funds during the crucial early stages of the project.

4.3 Rate of return methods

The methods analyse the project's annual rate of return on invested capital, or the yield promised by an investment project over its useful life (Park, 2007). The project's rate of return on investment methods discussed under the sub-section covers the methods which consider the time value of money and is also referred to as the discounted cash flow rate of returns.

The two methods covered include the IRR and External Rate of Return (ERR). Both methods can be applied to yearly expected FCFP and FCFE so that the sum of their discounted individual NPV equals zero. The differences between the two project evaluation techniques become apparent in the discussion below.

4.3.1 Internal Rate of Return (IRR)

As stated in Section.3.2.7 above, IRR provides a way to measure the return from an investment per dollar invested which in some other context referred to as an interest rate. Fraser and Jewkes, 2013, pointed out that, the adjective *internal* refers to the fact that the IRR depends only on the cash flows which remain internally invested in the project and being able to pay for itself during the time periods and also provides the project with a return at the end of project life.

A more formal definition of the IRR is stated as follows, the internal rate of return (IRR) on an investment is the interest rate, i^*, such that, when all cash flows associated with the project are discounted at i^*, the present worth of the cash inflows equals the present worth of the cash outflows. That is, the project just breaks even. In other words, the investment has zero $NPV(i^*)$ at this rate of return, i^*. An equation that expresses this statement is:

$$NPV(i^*) = \sum_{n=0}^{N} \frac{A_n}{(1+i^*)^n} = 0 \tag{10}$$

where A_n = Represents FCFP or FCFE.

The IRR is usually positive, but it can be negative as well. A negative IRR implies that the project is losing money rather than earning it hence not able to recover the initial investment. For the evaluation of independent projects, the projects under consideration are evaluated by comparing IRR against the MARR, and that an independent project that has an IRR equal to or exceeding the MARR should be accepted. However, the project investors always require their investment to surpass the breaking even return, therefore the IRR exceeding the MARR is the most preferred investment project.

The summary for IRR accepts–reject decision rule for single project evaluation is as follows;

If IRR ≥ MARR, accept the project
If IRR < MARR, reject the project.

Depending on the cash flow analysis involved namely FCFP and FCFE, the MARR represents the cost of capital for WACC and Re (investor hurdle) rate, respectively. The Equity IRR, cash return on equity investment is calculated based on the FCFE and provides a measure which determines whether a project investment is viable from the sponsors and other investor's perspective. This is the primary output of the project finance model. Thus, equity providers will only invest in the project if IRR ≥ Re while the Project IRR represents rea turn for both investors, in this case, the project will only be attractive if IRR ≥$WACC$. In other words, the the investment is only accepted if IRR ≥ cost of capital.

The above IRR analysis works perfectly well with the simple investment project as explained by Park, 2007 where the initial cash flows are negative and only one sign change occurs in the remaining net cash flow series. On the contrary, when investment in which, more than one sign change occurs in the cash flow series referred to as non-simple projects investment, multiple i^*'s solutions occur, the decision rules for IRR analysis becomes difficult as it fails to provide an acceptable solution for an investment project with multiple rates of return hence no unique sensible decision as to whether the project should be accepted or rejected. This is a strike against the IRR as an evaluation technique.

For comparison of two or more mutually exclusive investment projects of the same economic service life and unequal service lives, Park 2007 suggested that the project with the highest IRR may not be the preferred alternative as in the previous analogy discussed in the NPV analysis. The reason for the conflicting result is due to a phenomenon referred to as switching which occurs when the NPV curves of the two projects intersect one another as illustrated in Figure 12. It could lead to erroneous investment decisions if comparison with MARR of less than 17%, project A would be accepted over project B which yield higher NPV.

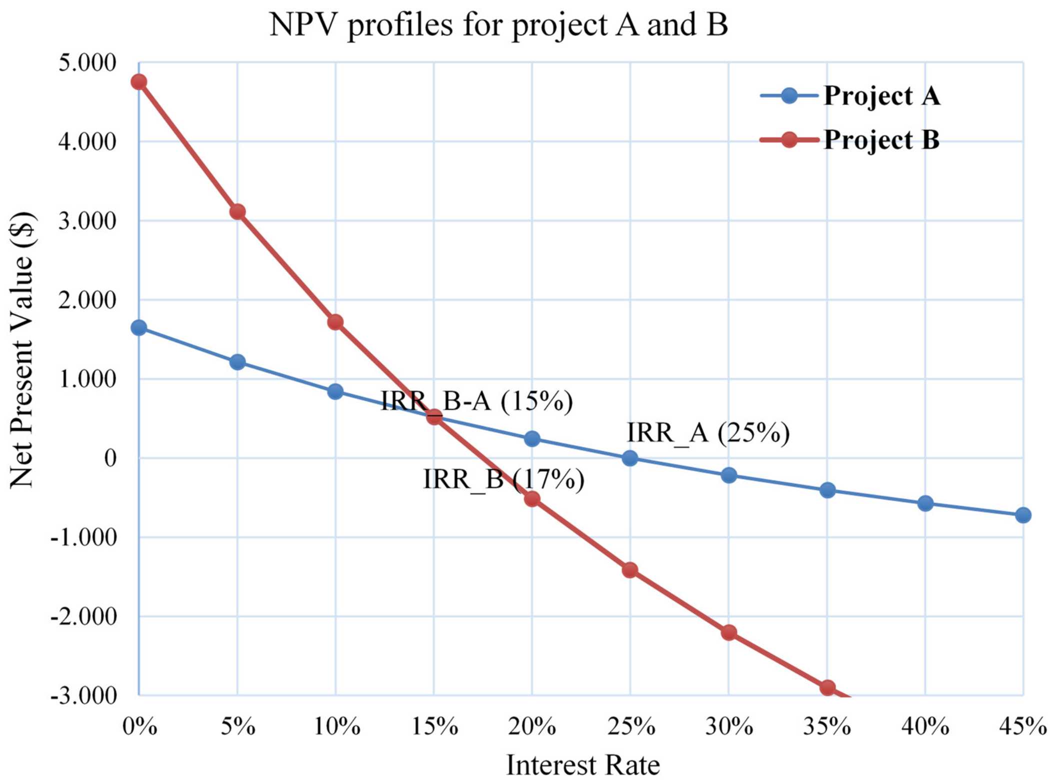

FIGURE 12: NPV profiles

Therefore because of the possibility of switching, it is always safer to use the NPV decision-rule when selecting from among mutually exclusive alternatives because IRR only represents a relative wealth measure expressed as a percentage which ignores the scale of the investment when compared to the NPV analysis which maximises absolute wealth in cash (dollar) measures of investment worth.

To address the drawback of IRR analysis for evaluating the mutually exclusive projects particularly when the IRR decision conflicts with the NPV decision; two methods can be employed:

1) Both NPV and IRR analysis should be carried out between alternatives and the project with higher NPV and lower IRR should be chosen.
2) Another approach is referred to as incremental investment analysis, the IRR is computed on the incremental investment between the projects, and the incremental cash flow between two alternative projects is computed following an investment flow (negative cash outflow following with positive inflow rule). The incremental IRR is computed and compared with the MARR as demonstrated in Figure 12.

Assuming the cash flow for the lower investment cost project (A), the higher investment cost project (B) and B-A is an investment increment, then according to Park, 2007, the decision rule is:

If $IRR_{B\text{-}A} > MARR$	select project B
If $IRR_{B\text{-}A} = MARR$	select either project
If $IRR_{B\text{-}A} < MARR$	select project A

Like NPV analysis, another principle drawback of IRR analysis is the implicit assumption that interim positive cash flows can and is reinvested at the calculated IRR each time which usually an unrealistic scenario. Despite its algebraic flaws, the IRR analysis being expressed in percentage has an intuitive preference for most investors as a decision criterion. The preference for IRR analysis is attributable to the general familiarity of financial decision-makers with rates of return (always expressed in percentage) useful for comparing the profitability of alternative investments rather than with actual dollar returns (Dayananda et al., 2002).

4.3.2 External Rate of Return (ERR)

Similar to IRR analysis, the External Rate of Return (ERR) which also referred to as the modified internal rate of return (MIRR) or the growth rate of return employs the discounted cash flow analysis technique to evaluate projects in terms of their financial attractiveness.

As the name implies, MIRR is a derivative of IRR and as such aims to account for two main previous listed drawbacks of the IRR criterion namely (Kierulff, 2008);

1) The assumption that interim positive cash flows can and is reinvested at the calculated IRR which usually an unrealistic scenario. The NPV calculation employs this assumption and has become one of its weakness.
2) Multiple IRRs project investment results caused by more than one sign change in the cash flow series which makes the decision rules for IRR analysis becoming a difficulty as it fails to provide an acceptable solution for such an investment project due to the confusion and ambiguity.

Despite its unpopular penetration to the industry practitioners and academia, the MIRR computational provides a robust and more realistic percentage measure of financial attractiveness of a project as it avoids the latter inherent weaknesses in NPV and IRR. Upon exploration of the full potential of the MIRR analysis, one can appreciate its superiority over IRR.

In practice, MIRR analysis incorporates the more realistic reinvestment assumption. Kierulff, 2008, mentioned that the idea behind MIRR is simple in computation, but the method may be challenging in practice because of the requirement to determine a discount rate for the investment and a reinvestment rate for cash flows. The MIRR calculation proceeds in three steps;

1) Discount the investment cash outflows committed to the project back to the present at a hurdle rate that fairly represents the investment risk.
2) Compound the cash inflows (excluding investments) forward to a time horizon (a future terminal value) at a chosen reinvestment rate that represents expected future opportunities with risks equal to the investment risk, and
3) Calculate the MIRR that that makes the future value of cash inflows equal to the present value of outflows hence NPV will equal zero.

The three steps can be summarised with the following expression:

$$\sum_{n=1}^{N} \frac{A_n(1+k)^{N-n}}{(1+MIRR)^N} - PV(I_0) = 0 \qquad (11)$$

where; A_n = Cash inflows at the end of period n to calculate the terminal value;
k = Reinvestment rate;

$PV(I_0)$ = Present Value of investment cash outflows;
N = Project economic life.

Fabozzi and Peterson, 2003, listed the decision rules for MIRR, as follows:

If MIRR ≥ cost of capital, the investment project is expected to return more than required, hence the project should be accepted.

If MIRR = cost of capital, the investment project is expected to return what is required investment is expected to return less than required, hence should be indifferent between accepting or rejecting the project.

If MIRR < cost of capital, the investment project is expected to return less than required, hence reject the project as the project does not provide a return commensurate with the amount of risk of the project.

In summary, Kierulff, 2008, contends that the use of MIRR analysis considers drawbacks of the IRR analysis as the MIRR analysis consistently ranks the alternatives in the same order as NPV, the larger the NPV, the larger the MIRR is and in every case less that IRR. This holds true as long as the reinvestment rate equals the cost of capital.

Furthermore, the problem of multiple rates of return is eliminated by the second step of MIRR calculation, where negative cash flows from are usually cancelled out by the positive ones, so only one sign change from negative to positive occurs.

Conclusively, when the investment and reinvestment rates are the same as the NPV discount rate, MIRR is the equivalent of the NPV in percentage terms and when the two are different, MIRR is said to be the better measure because it directly accounts for reinvestment of the cash flows at the different rate.

4.4 Profitability index

Two variations of the profitability index are discussed 1) Profitability Index (PI) and 2) Present Value Index (PVI). Both yardsticks come in a meaningful application when ranking and selecting the mutually exclusive profitable project investments. The projects under considerations have the positive NPV and in the absence of any financial constraint commonly referred to as capital rationing, all the projects should be selected, financed and implemented.

The capital rationing comes in two forms namely; soft capital rationing where the firm's management imposes capital expenditure limits and the other called hard capital rationing when the firm is unable to raise funds to undertake all positive NPV projects (Dayananda et al., 2002). Several reasons can be established as to why hard or soft capital rationing might exist. However, capital rationing is not only the reason for project rejections, others include resource constraints, such as the availability of particular types of labour and raw materials.

The PI analysis deals with decisions associated with only single constraint and involves optimising the positive NPV project investments to ensure that total combined NPV is maximized (completely exhaust the available investment) from the investment decision. In the presence of two or more constraints, mathematical programming techniques such as linear programming become handy.

Mian, 2011, defined the PI as a dimensionless ratio obtained by dividing the present value of future operating cash flows by the present value of the investment. The term PI is commonly used in the private sector while the same metric in the public sector is referred to as benefit-cost analysis which establishes benefits to the public rather than to make a profit hence determines whether the social benefits of a proposed public activity outweigh the social costs (Park, 2007). In this case, the discounted cash inflow and capital investments are the expected benefits and total expected cost, respectively. Mathematically, the PI is given by the following equation:

$$PI = 1 + \frac{Net\ Present\ Value\ (NPV)}{Present\ Value\ of\ Capital\ Investment} \tag{12}$$

The PI analysis measures the relative profitability of an investment or the present value of benefits per the present worth of every dollar invested or on other words the net return for each dollar invested i.e. the higher the PI, the better the investment. From the formula, if the NPV is zero, PI is 1 which indicates the project breaks even. The decision rule for an investment project is to accept the investment project if PI > 1 which means the investment returns more than \$1 in present value for every \$1 invested, rejects a project when PI < 1 and remain indifferent between accepting or rejecting the project when PI = 1 as the investment returns \$1 in present value for every \$1 invested (Fabozzi and Peterson, 2003).

Mian, 2011, listed another variation to the definition of the profitability index which is known as the PVI or investment efficiency. The PVI is defined as the ratio of the NPV to the present value of capital investment rather than the ratio of the PV of future operating cash flows to the PV of capital investment. Mathematically, the PVI is expressed in the following equation:

$$PVI = \frac{Net\ Present\ Value\ (NPV)}{Present\ Value\ of\ Capital\ Investment} \tag{13}$$

Therefore, the PVI measures the net PV dollars generated per the PV of every capital investment dollar where in this case the capital investment is already recovered and the value of the PVR is the net gain over every dollar invested. The decision rule for PVI is accepting all investments with PVI > 0 and reject those with PVI < 0.

From the two formulas of PI and PVI, it can be established that:

$$PI = PVI + 1 \tag{14}$$

Both PI and PVI shares all the advantages of NPV and can be a better evaluation technique than NPV in case of capital rationing.

4.5 Financial ratio analysis

The ratio analysis covers primary analytical tools that provide a coherent view into a primarily project's financial statements and offer a quick shortcut to the understanding of financials which may not be apparent the individual components, thus provides insights into underlying project conditions (Weygandt et al., 2012). The ratio expresses the mathematical relationship between two quantities in the raw data of financial statement and expressed in terms of either a percentage, a rate, or a simple proportion. The calculated ratios must furthermore refer to the relevant information and economically important relation.

A single ratio by itself is not very meaningful, therefore the ratios analysis incorporates a series of ratios to establish a comprehensive evaluation of the project's financial position and performance, and to assess future financial performance. Properly calculated and interpreted ratios identify possible areas that might require further critical investigations. The ratios are interpreted in comparison with:

(1) Prior ratios;
(2) Predetermined standards; and
(3) Ratios of competitors. The variability of a ratio across time is often as important as its trend ratios (Subramanyam, 2014).

The ratio analyses for the prospective projects are established from the projected capital investments, costs and revenue which subsequently facilitates construction of anticipated financial statements. Amongst many usefulness in project financial appraisal, the investors examine various ratios to ascertain whether the project is able to repay the debts lenders and generate commensurate returns to the equity providers. Park, 2007, categorized ratios into five groups namely debt management, liquidity, asset management, profitability and market trend. Only ratios relevant to project finance are discussed in the next section.

4.5.1 Debt management

As project finance structure sources its financing in the combination of long-term debt and equity financing. Debt providers require the project to mandatory repay the loan principal and interest with an agreed-upon interest rate regardless of a project's financial condition. Likewise, equity financing which comes in either preferred stock or common stock requires payment of stated cash dividends to the shareholders. However, the dividend is not a legal liability until the project company declares it (Park, 2007).

Therefore, ratios examine the extent to which a project company uses debt financing in the project operations and demonstrate the long-term project ability to generate cash internally to satisfy operations and repay a debt as they fall due, and with a comfortable margin of safety. In other words, the ratios assess the project's credit risk analysis based on long-term solvency (Revsine et al.,2015). Five essential indexes are discussed to examine the project's capital structure and solvency i.e. ability to pay its long-term liabilities.

a) Debt ratio

The most common and fundamental measure of debt ratio is commonly referred to as gearing or leverage as briefly discussed in Chapter 3. The ratio primary analyses the project capital structure and solvency. The gearing is the ratio of borrowed funds (total liabilities) to total shareholders' equity.

The formula is:

$$Gearing = \frac{Total\ liabilities}{Shareholders'\ equity} \tag{15}$$

The project capital structure with a very high gearing ratio illustrates being financed with a significant amount of debt whereas one with low gearing indicates a large proportion of project financing is in the form of equity capital. The gearing ratio measures the scale of project risk i.e. projects with lower gearing ratios are generally less risky than those with higher gearing ratios.

The unity gearing ratio implies that a project is equally financed by both lenders and equity providers. As with most ratios, the good gearing ratio depends on the industry. Certainly, most project finance gearing ratio in power project has considerably larger than 1 which translated to having more debt than equity. This is mainly due to difficulties in raising sizable investments required from shareholders and most importantly, the interest on the debt is the deductible expense from a project's taxable income whereas dividends are not hence a cheaper form of financing.

However, the higher the proportion of debt, the larger the fixed charges of interest and debt repayment, and the greater the likelihood of long-term insolvency risk during periods of earnings decline or hardship (Subramanyam, 2014).

b) Interest coverage ratio

The interest coverage is also commonly known as times interest earned. The ratio is calculated by dividing EBIT by the yearly interest charges that must be met.

The formula is:

$$Interest\ coverage = \frac{Operating\ income\ (EBIT)}{Annual\ interest\ expense} \tag{16}$$

The ratio shows the interest exposure and indicates the project's ability to pay interest on its outstanding debt and to what extent operating income can decline before the project is unable to meet its annual interest expenses. Hence the metric reflects the cushion between operating profit inflows and required interest expenses (Park, 2007). In some other cases, the periodic principal payments are included in the calculation.

The interest coverage of 1:1 shows that operating income is equal to the annual interest expenses hence very thin cushion for project lenders particularly when the debt principal payment is not factored. Therefore, the lower the ratio, the higher the likelihood that the project will not be able to pay interest expenses. The higher the ratio, a substantial cushion for the lender, the better. If the interest coverage ratio is less than 1, then the project not generating enough income, hence failure to meet this obligation and possibly resulting in default.

A major drawback of the traditional interest coverage ratio is that it uses operating income rather than cash flow from operating activities which is considered to represent the inclusive measure of cash generation. Furthermore, project finance, unlike in corporate loans, both EBIT and the cash flow cover ratio for annual interest (as opposed to total debt service) are not generally considered to be significant measurements. This is because corporate loans are often renewed from year to year, whereas project finance loans have to be repaid because the project has a finite life. Therefore, the project company must be able to reduce its debt each year as scheduled and payment of interest alone is generally not adequate (Yescombe, 2014).

c) Annual Debt Service Cover Ratio (ADSCR)

The ADSCR is the ratio between the annual cash flow available for debt service to the required interest payment and principal repayment for each year of the loan term. The ADSCR shows the buffer of cash flow relative to debt service, thus a more significant measure of a project company's ability to service its debt as it falls due with payment from the annual generated cash flow from operating activities.

The formula is:

$$ADSCR = \frac{Cash\ flow\ after\ tax}{Interest\ and\ principal} \tag{17}$$

Lenders compare the project ADSCR with their initial project base case projections throughout the term of the loan and ensure does not fall below their required minimum at any time. The ADSCR is usually calculated semi-annually on a rolling annual basis.

If the ADSCR is less than 1 for any particular year, then the project is not generating sufficient cash flow to pay the lender, creating a risk of default. The minimum ADSCR requirement obviously varies between projects, but very approximate levels for standard projects could be 1.3:1 for a power plant project with a PPA while 2:1 for a merchant power plant project with no PPA or price hedging (Yescombe, 2014).

d) Loan Life Coverage Ratio (LLCR)

The LLCR is the ratio between NPV of all projected cash flows available from the year on which the project is projected to begin operations, to the year on which the loan is repaid and the outstanding debt on the calculated year (the remaining principal amount). The interest rate as that assumed for the debt is used as the discount factor for the available cash flow instead of the WACC (Yescombe, 2014).

The formula is:

$$LLCR = \frac{NPV\ of\ cash\ flow\ after\ tax\ (debt\ payment\ term)}{Outstanding\ principal} \tag{18}$$

From the formula, can be seen that the LLCR is based on a similar calculation as ADSCR, but the difference is that, the LLCR considers the whole term of the loan i.e. from the date on which the project is projected to begin operations, to the last date on which the loan is repaid. The assessment rule for the projected LLCR is similar to that of ADSCR where, if the ratio is less than 1, then there is default risk.

In practice, however, lenders require the minimum initial LLCR in their base case projections for a standard project to be around 10% higher than the figures for minimum ADSCR.

According to Yescombe, 2014 LLCR is a useful measure for the initial assessment of a project's ability to service its debt as a whole and for continuing to look at it over its remaining life, but clearly, it is not so useful if there are likely to be significant cash flow fluctuations from year to year. ADSCR is thus a more significant measure of a project company's ability to service its debt as it falls due.

e) Project Life Coverage Ratio (PLCR)
The PLCR is the ratio between NPV of all projected cash flows available for debt service for the whole life of the project (not just the term of the debt as for the LLCR) and the debt outstanding (i.e. the remaining principal amount). The interest rate is used as the discount factor for the projected cash flows available for debt service.

The formula is:

$$PLCR = \frac{NPV\ of\ cash\ flow\ after\ tax\ (for\ whole\ life\ of\ the\ project)}{Outstanding\ principal} \tag{19}$$

The ratio helps lenders to check whether the project has the capacity to make repayments even after the original final maturity of the debt, in case there have been difficulties in repaying all of the debt in time. The lenders refer this extra debt service capacity ratio as the tail which primarily means as the ratio expects at least a year or two of cash flow cover. In natural resources projects, the PLCR usually known as the reserve cover ratio. The tail can be based on;

- The general ability of the project company to keep operating and so generating cash after the loan term whereas anticipated the technical life of the project is significantly longer than the loan term.
- The existence of input supply and offtake contracts, or a concession agreement, which specifically ensures that the project company will continue to operate.

From a mathematical standpoint, the PLCR is higher than the LLCR, and the lenders anticipate the PLCR to be in a range of 15–20% higher than the minimum ADSCR (Yescombe, 2014).

4.5.2 Liquidity analysis

The liquidity analysis measures the project's short-term ability to generate cash for immediate debt repayment needs as they fall due. Short-term liquidity problems arise when operating cash inflows don't match outflows.

The most important ratios in this category are the following;

a) Current ratio
This is the ratio between all current assets and all current liabilities. The ratio measures a project's ability to use all current assets to cover all its current liabilities. A current ratio of 1:1 means that a project has a dollar in current assets to cover each dollar in current liabilities which is considered to be the absolute minimum level of acceptable liquidity. The formula is:

$$Current\ ratio = \frac{Current\ assets}{Current\ liabilities} \tag{20}$$

The current ratio of less than 1 means the project runs of cash to cover current liability sometime during the next year. The acceptable current ratio depends on the nature of the industry.

The general rule of thumb calls for a current ratio as close to 2:1. This rule, of course, a subject of many exceptions as depends heavily on the composition of the assets involved (Park, 2007). On the other hand, a very high current ratio suggests to shareholders that the project company is sitting on its cash. One problem with the current ratio is that it ignores the timing of cash received and paid out.

b) Quick ratio

The quick ratio is similar to the current ratio but a more stringent measure. The ratio is between the current asset less inventories and current liabilities. The quick ratio measures the ability of the project to immediate pay current liabilities without relying heavily on the sale of inventory. The formula is:

$$Quick\ ratio = \frac{Current\ assets - Inventories}{Current\ liabilities} \tag{21}$$

The current inventory is excluded primary due to being illiquid which primarily means cannot instantaneously be converted into cash (difficult to liquidate in the short term). Significant time is required to sell the inventories, collect the receivables and subsequently have the cash.

The quick ratio of 1:1 means a project has $1 of quick assets to pay each $1 of current liabilities. The acceptable current ratio depends on the nature of the industry, however in general, the ratio of 1:1 is considered safe and relatively strong liquidity position. Although a little better than the current ratio, the quick ratio still ignores the timing of receipts and payments.

c) Cash ratio

This is the most conservative measure of project's liquidity, can be used where the current ratio or quick ratio are not considered to be evidence of a project's very short-term ability to pay off its current liabilities. The ratio is between the cash and cash equivalent and current liability. The formula is:

$$Cash\ ratio = \frac{Cash\ and\ cash\ equivalent}{Current\ liabilities} \tag{22}$$

The cash ratio, therefore, refines both the current ratio and the quick ratio by measuring only the amount of cash and cash equivalents available in current assets to cover current liabilities. The calculated ratio can be compared to industry averages or other projects on the liquidity level. The ratio of 1:1 provides a measure of very immediate liquidity, where $1 of cash is available to cover $1 of current liabilities hence demonstrates reasonable evidence of liquidity.

4.5.3 Asset management

The ratios under asset management measure how effectively the project manages its assets. The ratios that relate to the project's asset management include inventory turnover ratio, day's sales outstanding ratio and total asset turnover ratio (Park, 2007). Only the total asset turnover ratio which is relevant to power project finance is covered.

a) Total asset turnover

This is the ratio of revenue to all the project's assets. The ratio measures how effectively the project uses its total assets in generating its revenues. The formula is:

$$Total\ asset\ turnover = \frac{Revenues}{Total\ assets} \tag{23}$$

The rate of 1:1 means that for every dollar invested in assets, the project generates $1 from the revenue. The total asset turnover gauges not just efficiency in the use of fixed assets, but efficiency in the use of all assets. The higher the ratio, the more productive the project is at generating sales from the use of its assets. However, depending on the nature of the industry, the ratio can have significantly different average levels. Therefore, the ratio becomes particularly useful when compared to the industry average for the project in the same industry.

4.5.4 Profitability

Profitability ratio analysis involves the evaluation of a project's return on investment. The analysis focuses on a project company's sources and levels of profits which involve identifying and measuring the impact of various profitability drivers. The ratios evaluate the two major sources of profitability namely the operating performance margins and aspects of return on investment (Subramanyam, 2014).

a) Operating performance margins

The ratios evaluate profit margins from operating activities. The analyses ratio typically links income statement line items to the projected revenue.

Operating profit margin. The ratio measures the percentage of profit generated by operating activities. In other words, the operating margin ratio demonstrates how much revenues are left over after all the variable or operating costs have been paid. Conversely, the ratio shows what proportion of revenue is available to cover non-operating costs like interest expense.

$$Operating\ magin = \frac{Operation\ profit(EBIT)}{Revenue} \tag{24}$$

The higher operating margin is more favourable as it shows that the project is generating sufficient revenue from ongoing operations to pay for both variable costs and fixed costs.

Net profit margin ratio. The net profit margin ratio measures a dollar a project keeps out of revenue after payment of all expenses. In other words, the profitability measures how much net income a project makes from each dollar of revenue generated.

$$Profit\ margin = \frac{Net\ income}{Revenue} \tag{25}$$

The higher net profit margin is more favourable as it shows that the project is generating sufficient revenue from ongoing project operations to pay for both operating and non-operating expenses. The metric furthermore expresses the percentage to pay shareholders.

b) Return on investment ratios

The ratios assess financial rewards to the suppliers of equity and debt financing. Two ratios namely Return on Investment (RoI) and Return on Equity (RoE) are covered.

Return on Investment (RoI). The RoI is the ratio between EBIT and invested capital in the project. It measures how effectively the capital invested in the project (both shareholder's equity and debt) is used to generate a return.

The ratio is a widely recognized measure of project performance. In some other cases, it is referred to as Return on Capital Employed (RoCE) or Return on Invested Capital (RoIC). Several kinds of literature might define RoI differently depending on the forms of numerator used in the analysis.

The ROI also allows to assess a project's return relative to its capital investment risk and can be compared to the return on invested capital to returns of alternative investments (Subramanyam, 2014). The formula is:

$$RoI = \frac{Operation\ income(EBIT)}{Shareholders'\ equity + Total\ liabilities} \tag{26}$$

The rationale for using operating income in the numerator is the fact that, the project performance is evaluated on the operational based only and such that the changes in the rates of corporate tax or level of interest rates from the lenders do not affect the metric hence becomes an important indicator of a project's long-term financial strength.

Return on Equity (ROE). The ROE is a ratio of net income to the shareholder's equity. The ratio measures net income per dollar of invested equity capital or, equivalently, of the percentage return to shareholders on their investment. ROE is by far the most popular yardstick of financial performance among investors (Higgin, 2016). The formula is:

$$ROE = \frac{Net\ Income}{Shareholders'Equity} \tag{27}$$

The higher ROE indicates the efficient use of shareholders equity and the more return for investors. On the other hand, the ROE expresses whether the project is generating enough of a profit to compensate for the risk of being a shareholder.

In order to critically analyses ROE, the three principal components can be studied for controlling the ROE project metric as shown in the formula:

$$ROE = \frac{Net\ income}{Revenue} * \frac{Revenue}{Total\ Asset} * \frac{Total\ Asset}{Shareholders'Equity} \tag{28}$$

Denoting the last three ratios as the profit margin, asset turnover, and financial leverage, respectively, the expression can be written as:

$$ROE = Profit\ margin * Asset\ turnover * Financial\ leverage \tag{29}$$

From the three determinants of ROE, the project has only three levers for controlling ROE (Higgin, 2016) namely; the earnings squeezed out of each dollar of sales, or the profit margin, the revenue generated from each dollar of assets employed, or the asset turnover and the amount of equity used to finance the assets, or financial leverage.

4.6 Levelized Cost of Electricity (LCOE)

The USEIA, 2019, cited LCOE as a convenient summary measure of the overall completeness of different generating technologies and has become a very decisive parameter in the power industry. The metric represents the USD/kWh cost (in discounted real dollars) of building and operating a generating plant over an assumed financial life and duty cycle. The key inputs to calculating LCOE include capital costs, fuel costs, fixed and variable operations and maintenance (O&M) costs, financing costs, and an assumed utilization rate for each plant technology. This is one primary targeted output of the financial modelling task as determines the tariff i.e. price of electricity that off-taker is required to pay.

Upon setting electricity tariff equal to project's LCOE, the project breaks even and indicates the USD/kWh expected price necessary for the project to sufficiently cover the cost of the project (including debt and equity costs). The LCOE would also be a measure for the required feed-in tariff or tariffs to be charged to the end-user in order for the project to be economically feasible. (IRENA, 2017; 2018). In PPP project finance model, the LCOE is one of the contract payment components that an off-taker/contracting authority is interested to know.

The LCOE allows alternative technologies to be compared when different scales of operation, different investment and operating time periods, or both exist. For example, the LCOE could be used to compare the cost of energy generated by a renewable resource with that of a standard fossil fuelled generating unit. The geothermal power project might be required to be compared with other alternatives of power generating technologies to demonstrate its economic feasibility. The project finance model calculates the LCOE metric and compares the proposed geothermal power project with the other alternative resources. The LCOE is recommended for use when ranking alternatives given a limited budget simply because the measure will provide a proper ordering of alternatives which may then be selected until the budget is expended.

The LCOE formula is established from the basic definition of LCOE that it is a cost, if assigned to every unit of energy produced by the system over the analysis period, is equal the total life cycle cost (TLCC) when discounted back to the base year. TLCC include all the costs incurred through the ownership of an asset over the asset's life span or the period of interest to the investor (Short et al., 1995).

By definition, a project´s equivalent annual cost C_n is the product of the LCOE and the quantity of electricity generated by the system in the year n, donated as Q_n is calculated in the formula:

$$C_n = Q_n * LCOE \tag{30}$$

where the C_n includes investment costs, fuel costs, fixed and variable operation and maintenance costs.

As investment starts in year 0 and power production starts in year 1, the definition of the TLCC formula:

$$TLCC = \sum_{n=0}^{N} \frac{C_n}{(1+d)^n} \tag{31}$$

Substituting the Equation 30 into Equation 31 provides;

$$TLCC = \sum_{n=1}^{N} \frac{Q_n * LCOE}{(1+d)^n} \tag{32}$$

Equating Equations (31) and (32) establish the fundamental formula for the power project's LCOE as follows:

$$LCOE = \frac{\sum_{n=0}^{N} \frac{C_n}{(1+d)^n}}{\sum_{n=1}^{N} \frac{Q_n}{(1+d)^n}} \tag{33}$$

where C_n = Project cost in period n;
Q_n = System annual generated quantity of electricity in period n;
N = Project lifetime (analysis period);
d = Annual discount rate.

5. FINANCIAL RISK ANALYSIS

The financial risk analysis describes the use of financial and statistical analysis tools in apportioning the uncertainty of a model's output to the uncertainty of the assumptions and input values. As for any typical investment project, the project evaluation requires future projections and assumptions of the input variables which subsequently produces the project's future cash flows over the life of a project and when evaluated in the model, yields project outputs that form an integral part of investment decision analysis.

As the future is uncertain, the estimates of the few variables can be determined with relative confidence while other estimates used in the analysis are subject to substantial uncertainty. Since the projects are evaluated with the deterministic evaluation approaches i.e. single-point estimate for each of the uncertain factors, produces uncertain future cash flows which are then used to calculate measures of profitability, the approach may be very detrimental to the evaluation and decision-making analysis of any capital investment project (Mian, 2002).

Park, 2007 listed two drawbacks of single-number or best estimates approach in the input parameters that generate the project's future cash flows namely 1) no guarantee that the best estimates match actual values and 2) no provision to measure the risk associated with an investment, or the project risk, on other words the approach provides no means of determining the probability of success or failure in generating the project anticipated returns.

In order to incorporate the risks and uncertainty of input parameters and establish the expected reliable project's cash flows for project evaluation, as parameter estimates can be so hard to determine, a range of possible values for uncertain components of a project cash flow need to be established to create a more realistic picture of the future which subsequently produces a range of profitability metric values output for a project under evaluation. This addresses the two registered pitfalls and becomes possible to establish probability and reliability of individual expected project cash flows which in turn establishes the level of certainty which is essential and meaningful for any real-world project investment evaluation.

Whilst there are a variety of approaches with a varying degree of sophistication used to undertake a project's risk analysis or incorporation of the elements of uncertainty into the project investment evaluation and decisions making. Four techniques for treating uncertainty is covered namely sensitivity analysis, break-even analysis, scenario analysis and Monte Carlo simulation analysis using @Risk.

5.1 Sensitivity analysis

The sensitivity analysis seeks to discover the uncertain input variables or underlying key assumptions that may have the greatest impact or more sensitive on the possible project's outcome. The analysis, on the other hand, examines whether or not the results of the project performance indicators are sensitive given a change in only one of the input parameters throughout the life of a project. The sensitivity analysis is sometimes referred to as what-if analysis.

Park, 2007 explains the procedure of performing a sensitivity analysis. The analysis begins with a base-case scenario, which is developed by using the most likely values for each input variable. The specific variables of interest are varied by several specified percentage points above and below the base case one at a time while holding other variables constant. The new performance measure is calculated for each of the values obtained.

The results of the sensitivity analysis are summarized and presented through a plot of sensitivity graph also known as a spider diagram as schematically shown in Figure 13. The evaluation criterion is plotted on the vertical axis and the per cent deviation on the horizontal axis. Sensitivity graphs illustrate the sensitivity of a particular measure to one-at-a-time changes in the uncertain parameters of a project. The slopes of the lines show how sensitive the relevant performance measure is to changes in each of the inputs i.e. the steeper the slope, the more sensitive the evaluation criteria is to a change in a particular variable and vice versa.

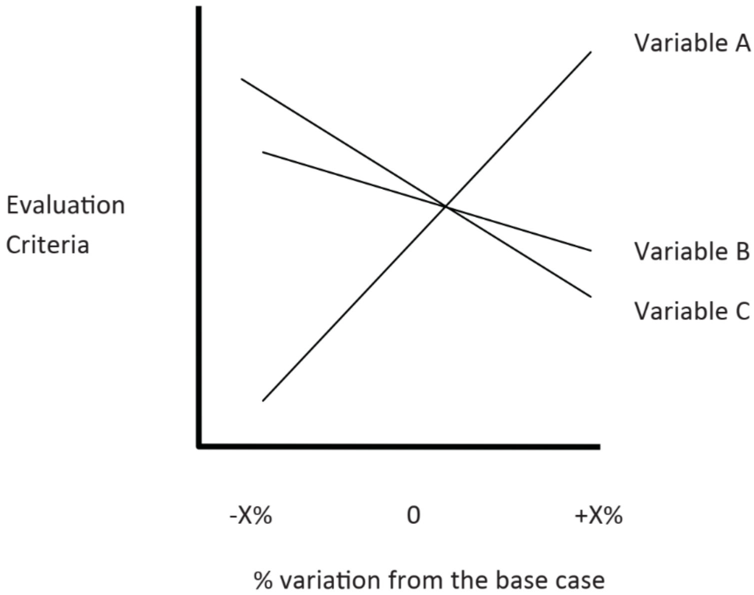

FIGURE 13: Sample sensitivity spider plot (Whitman and Terry, 2012)

As illustrated in Figure 13 of sample sensitivity plot, input variable A has the greatest effect on the evaluation criteria, followed by B and A being the least sensitive variable. The sensitivity graphs make easier to reveal key parameters that have a significant impact on the performance measures of interest, and which do not. The project should then be particularly careful to get good estimates for the most sensitive key parameters or plan for more detailed management of the variables as the project unfolds (Fraser and Jewkes, 2013).

In summary, the sensitivity analysis is easy to understand and provide a useful means to communicate a lot of information in a single diagram. The graphs can be used to select the key sensitive parameters, determine the sensitivity and robustness of the economic viability of a project investment decision analysis.

However, there are exists two primary drawbacks of sensitivity analysis 1) the analysis does not contain any information about the likelihood of the project evaluation criteria to deviate from the base case 2) the analysis assumes that the input variables are independent of one another, thus ignores the all possible interaction between two or more variables to produce an interaction effect when allowed to change at a time (Whitman and Terry, 2012).

The sensitivity analysis of NPV and IRR of Equity is carried out in the project finance model to a given change in an input variable from the geothermal power project. The detailed discussion of the project sensitivity analysis is covered in Chapter 8.

5.2 Break-even analysis

Park, 2007 defined break-even analysis as a technique for examining the impact of variations in output on a project's evaluation criteria. The analysis responds to the question of how much variability can an individual parameter have before the project breaks even at which the project's NPV is zero. For example, the project investors may be interested to understand how low the unit selling price of electricity (USD/kWh) can fall before the power project stops generating sufficient returns. Therefore, breakeven analysis can be viewed as a special application of sensitivity analysis.

As opposed to the most widely used measure of accounting break-even point which focuses on the revenue level that yields in a zero-project accounting net income, in other words, the total revenue is equal to total costs. The approach of break-even analysis in an investment project analysis is based on the project's cash flows which are considered to be a more powerful representation.

Illustrating the procedure of break-even analysis based on NPV, the PV of cash inflows is computed as a function of an unknown variable x (any project parameter of observation) and PV of cash outflows as a function of x therefore;

$$PV\ of\ cash\ inflows = f(x)_1 \tag{34}$$

Then, the PV of cash outflows is computed as a function of x;

$$PV\ of\ cash\ outflows = f(x)_2 \quad (35)$$

Lastly, from the definition, the project NPV is calculated from Equations 34 and 35:

$$PV\ of\ cash\ inflows - PV\ of\ cash\ outflows = 0 \quad (36)$$

This yields to:

$$f(x)_1 = f(x)_2 \quad (37)$$

The calculated x indicates the break-even value, which in many cases represents the cut-off or threshold value at which a choice change. The x futhermore indicates its sensitivity to the project evaluation and values of particular variables that give the project a break-even net present value (NPV) of zero.

The break-even value calculations may also be carried out using the Goal Seek Function in the Excel tools. The Goal Seek Function alters one cell (any project parameter of observation) to accord with the desired outcome in the target cell. Since the target is the NPV not falling below zero, then NPV cell value is set to zero while allowing the input parameter in the changing cell to alter.

The break-even analysis provides a strong pessimistic case of a project investment decision analysis, however just like sensitivity analysis, the technique has limitation in the scope 1) does not describe the likelihood of occurrence of cut-off value 2) capable of altering only one variable at a time, while all other variables are held at their most likely values. This may not be the true representation of a project dynamic world where many variables are changing in different directions at the same time throughout the life of a project (Dayananda, et al.,2002).

5.3 Scenario analysis

Scenario analysis is a what-if analysis technique that considers the sensitivity of investment's evaluation criteria to changes in key variables and the range of likely variable values (Mian, 2002). The analysis addresses the major drawback of both the break-even and sensitivity analysis, i.e. only one input variable is allowed to change at a time while holding other variables constant and no interdependencies can be explained amongst the variables.

The analysis begins with establishing the various key project input variables and examines the possible scenarios that might happen at the input variable extremes cases. The three most common scenarios are; the most likely (base-case), most optimistic (best-case) and the most pessimistic (worst-case) cases. The analysis then calculates the project investment's evaluation criteria based on the scenarios by varying several inputs simultaneously. The project evaluation criteria under the worst and the best conditions are then compared with the expected, or base-case (Park, 2007).

The scenario analysis provides a robust measure of the extreme cases of the project under consideration and provides an indication of which conditions can the project returns never be realised hence very useful analysis in the project decision making. However, similar to break-even and sensitivity analysis, the analysis does not contain any information about the specific probabilities or likelihood of the project evaluation criteria to fall on the worst case, the best case, the base case and all the other possibilities.

The thesis covers the scenario analysis of NPV and IRR of equity in the project finance model by varying several inputs at a time from the geothermal power project. The detailed discussion of the project scenario analysis is covered in Chapter 8.

5.4 Simulation analysis

The simulation analysis is the most comprehensive and powerful technique for project risk analysis. The analysis is implemented by identifying the project's investment random variables then assigning a probability distribution for the variables to develop the probability distribution profile for the project's evaluation criterion outputs, by stochastically aggregating the individual variable values associated with the criterion at the same time. Probability distributions are a much more realistic way of describing uncertainty in variables of a risk analysis.

The probability distribution takes the description of uncertainty one level beyond that used in the sensitivity analysis and scenario analysis where the variable's uncertainties are described purely in terms of the range of possible values. The probability distribution does this, but it also describes the likelihood of occurrence of values (random variables) within the given range, such that when the probability of an event approaches 0, the event becomes increasingly less likely to occur and certain to occur when has a probability of 1.0. When only a finite (isolated) number of values can occur, the probability distribution is described as discrete, and when any value within the range can occur it is continuous (Campbell and Brown, 2003).

As project analysis assumes the availability of the probabilities of future events, thus, for the discrete random variable, the probability of each random event needs to be assessed while for a continuous random variable, the probability function needs to be assessed, as the event takes place over a continuous domain. In either case, a range of probabilities for each feasible outcome must exist which together make up a probability distribution. For the discrete random variable, the probabilities are based on reasonable set of past similar project observations or historical data if the trends that characterised the past are expected to prevail in the future, however, in many real investment situations, no reliable historical data are available to consider, this requires to assign subjective probabilities appropriate to explain the possible states of nature.

On the other hand, for the continuous random variable, the range of values are established to characterize the variability of project random variables, and in absence of objective data, a triangular probability distribution can be used where the minimum, most likely, and maximum values with their probabilities are determined. Values around the most likely are more likely to occur. In case the assumptions of triangular probability distributions become unreasonable i.e no one value is any more likely to occur than any other, the variables can be described as a uniform distribution with minimum and maximum only (Park, 2007). The other common probability distributions include normal or bell curve, lognormal, PERT and discrete.

The thesis utilises the computer simulation where project investment decisions on the project's evaluation criterion outputs are tested. The general approach involves assigning a subjective (or objective) probability distribution to each unknown factor and to combine all these distributions into a probability distribution for the project's profitability as a whole. Park, 2007, listed the following suggested logical steps for any computer program that simulates risky investment scenarios;

Step 1: Identify all the variables that affect the measure of investment evaluation criteria.

Step 2: Identify the relationships among all the variables. The relationships of interest are expressed by the equations or the series of numerical computations of which the project's evaluation criteria is computed. These equations construct the spreadsheet model that is analysed.

Step 3: Classify the variables into two groups: the parameters whose values are known with certainty and the random variables for which exact values cannot be specified at the time of decision making.

Step 4: Define distributions for all the random variables.

Step 5: Perform simulation sampling and describe the resulting evaluation criteria distribution.

Step 6: Compute the distribution parameters and prepare graphic displays of the results of the simulation.

The Monte Carlo simulation is a very powerful computerized mathematical algorithm for simulating the behaviour of various physical and conceptual systems to account for risk in quantitative analysis and decision making. The method furnishes the decision-maker with a range of all the possible outcomes and the probabilities of their occurrence for any choice of action hence allow better decision making under uncertainty, ambiguity, and variability (Palisade, 2019).

Several commercial software packages are available to perform the Monte Carlo simulation, where each package with a different level of advancement. The thesis conducts the project Monte Carlo simulation using an @Risk package, a Microsoft Excel-based program (add-ins) which is considered to be the most advanced package in the market. The @Risk primarily follows the same procedures as listed above with some other few specifics. After the deterministic project finance model establishes the investment evaluation criteria, the project random variables are identified.

The @Risk allows the modeller to choose amongst the variety of probability distributions that best describes the characteristics of random variables of interest. Then, the Monte Carlo simulation calculates results repeatedly, each time sampling a different set of random values from the predefined probability distribution. Each set of samples is called an iteration, and the resulting outcome from that sample is recorded. Depending upon the number of uncertainties and the ranges specified for them, the Monte Carlo simulation could involve thousands or tens of thousands of recalculations before it is completed. Finally, the Monte Carlo simulation produces a probability distribution of possible outcome values which provides a much more comprehensive view of what may happen and how likely it is to happen (Palisade, 2019).

Therefore, the thesis performs Monte Carlo simulation to develop the probability distribution profile for the two project's evaluation criterions namely NPV and IRR of equity from the deterministic project finance model by introducing probability distributions of projects random variables from the geothermal power project. The overall presentation and interpretation of the simulation results from the @Risk graphs and statistical reports are covered in Chapter 8 to provide a comprehensive spectrum of possible project outcomes and the likelihood of their occurrence for better project investment decision analysis under uncertainty.

6. FINANCIAL MODELLING

There is no generally accepted or standardised definition of financial modelling, but can be loosely explained as the task of development analytical financial model, an instrument that is used in performing detailed financial analysis and subsequently facilitates making the most important financial decisions in solving often complex questions about the future performance of an investment. More broadly, a financial model is the most fundamental and effective risk assessment tool (Bodmer, 2015).

The model is typically built in spreadsheets (Microsoft Excel is by far the most dominant package) for the flexible manipulation of data. The thesis chose Excel for modelling task for a twofold reason, first, Excel is very flexible, as the most of the anything can be constructed and analysed, and secondly, Excel communicates very well with other systems. As not all, an Excel spreadsheet can qualify to be a financial model (Fairhurst, 2017), with defined features that make a financial model distinct from a garden-variety spreadsheet. A sound financial model is characterised being:

a) More structured; A financial model contains a set of variable assumptions i.e. inputs, outputs, calculations, and scenarios with a set of standard financial forecasts based on those assumptions.
b) Dynamic; financial model contains inputs that, when changed, impacts the calculations and, therefore, the output. Built-in flexibility to display different outcomes based on changing a few key inputs.
c) Using relationships between several variables i.e. the change of any of the input assumptions, a chain reaction often occurs in the dependent variable.
d) Showing forecasts; mainly displaying the possible future financial projections.
e) Contains scenarios (hypothetical outcomes) i.e. since a model is forward-looking instead of backward, a well-built financial model can be easily used to perform scenario and sensitivity analysis.

In practice, building a good and quality financial model to can effectively be used by various parties is a daunting task and time-consuming. Rees, 2018 listed the three typical characteristics of a good model that can be often be used to judge a model once it has been built;

a) Minimal time to understand, audit or validate. The model requires a clear logical flow (usually left-to-right, top-to-bottom), manageable components with each logical step shown explicitly and being clear on showing the inputs and key aspects of the model.
b) Objectives-driven. A good model should support the user or decision-maker requirement in providing insight into a range of financial questions related to the transaction under scrutiny. It uses a set of input variables and outputs that are appropriate to the situation and be built at a level of detail that is appropriate, excluding unimportant variables.
c) Free from errors. Generally, modelling errors can be grouped into three broad categories, formula errors, assumptions or input errors, and logic errors. The model should contain none of those. As previously stated above, a good model will need to correctly capture the dependency relationships between all variables and be designed so that it can be calibrated with relative ease. This enables the inputs and outputs compared with historical data, expert opinion, judgement or common sense. The best practice is always being vigilant enough looking for errors as the model is being built.

While every financial modelling task is driven by several objectives, Bodmer, 2015, listed three general objectives of any financial modelling task; (1) coming up with the expected value of an investment (2) assessing the risk of the investment and (3) developing the financial structure of a transaction given its risk.

According to Bodmer, 2015 the variety of financial models can be categorised depending on their objectives and to a large extent on the type of investment being assessed. Therefore, most financial models can be classified into six general categories namely; corporate models, project finance models, acquisition models, merger integration models, financial institution models and real estate models. Because of different data sources and alternative evaluation techniques, the layout is somewhat different for each of these model types.

The thesis covers project finance modelling task which incorporates the principles of project finance in the designing of a financial model. As per the general financial model design, the next chapter comprises of the organisation of model inputs, formulation of mathematical calculations and effectively presenting outputs.

6.1 Project finance model

For project finance transaction, where everyone's financial security rests on the future performance of a new undertaking, a thorough analysis of the project's cash flows under a range of assumptions is a prerequisite for arranging debt and equity funding. This is done with the help of a computer finance model. The model is constructed to process a comprehensive list of input assumptions and scenarios, and perform the detailed analysis of cash flow to determine whether a project is sound enough to pursue (Lynch, 2011).

Once properly set up, such a model can quickly provide results reflecting a range of data variations and hence allowing the effect of a selection of downside variations from the base case assumptions to be assessed. The results from the project finance model can be used to determine the following (Operis, 2018):

a) The rate of return of the project, which indicates whether it is worth doing the project at all. The project internal rate of return (IRR) metric measures this.
b) Establish debt service cover ratios which indicate whether the project produces a sufficient buffer of cash flow relative to debt service hence quantify how safe it would be to participate as a lender.
c) The rate of return for the shareholders, which measures whether it would be attractive to participate as an investor. In this case, the equity internal rate of return (IRR) which is strongly influenced by the amount of long-debt financing, the method and timing of the debt repayment, and the tenor of the debt.

Additionally, according to Lynch (2011), the project finance model also aid in quantifying the robustness of the deal under a range of downside assumptions and establishing a optimum financing structure that is supportable for the project i.e. the amount debt and equity that is issued in the transaction, including the size of the debt, the tenor of the debt, and the debt repayment profile.

As explained in Section 3.2, project finance transactions involve numerous participants and documentation, quite often the agreements are constructed and negotiated differently, the financial model that details the long-term financial projections of the analysis power project becomes the only platform where all agreements and project participants meet, and the only place in which the combined economic effect of their contributions is visible.

As a project progresses from the development to operation phase, the role of the financial model evolves over the life of a project finance transaction and it is essential that model functions as required from the initial feasibility stages all the way through to final debt repayment. The models are constructed to assess the economic and financial performance of projects investment throughout the phases of a project finance transaction. In the initial stages, financial models are used to determine project feasibility and approximate funding requirements. The models are then used to structure the financing and subsequently to monitor the project performance (Clews, 2016).

The illustrative financial analysis of a hypothetical geothermal power project is established in the study and undertaken from the project finance model. Also, for simplicity, the model assumes an annual periodicity set for the fiscal year ending on December 31.

6.2 Purpose and uses of the model

As project finance evolves in phases, modelling process changes and develop to adopt the same manner from feasibility study to the financial close and subsequently drawing of funds. The contribution made by the model changes and develops. Lynch, 2011 established a wide range of purposes that project finance model can be typically served in various stages of the project. This includes:

a) Initial assessment of project feasibility;
b) Determining financing structure and facility amounts;
c) Reflection of developing documentation;
d) Establishing critical and sensitive project variables;
e) Support for ongoing negotiations;
f) Provision of figures for bid submission;
g) Provision of information memorandum figures;
h) Preparation of sensitivity analyses for potential lenders/investors;
i) Use as part of the loan agreement; and
j) Use as part of project documentation.

In a PPP project, the financial model involves three parties namely the public authority, the sponsors and the lenders. Yescombe, 2007 mentioned instead of having three parallel financial models for each participant, it is often more efficient for a single model to be developed jointly. The off-taker model is constructed for evaluation of the project and bids from prospective sponsors. The bidders (project sponsor) models are calibrated against the off-takers shadow financial model to ensure that the results are the same (given the same assumptions). Lenders then use the same model developed by the project sponsors in the ways listed above.

Conclusively, the usage of the model as demonstrated from the list above makes it multidisciplinary important as it interacts with different disciplines which include but not limited to lenders, financiers, lawyers and commercial bid managers. Therefore, it is important for the model to be easily understood by all parties, accurate and adaptable in order to be a reliable decision-making tool.

6.3 Model development phase

As previously stated, the role of financial model evolves over the life of a project finance transaction. Each phase of the model fulfils several of the roles listed in Section 6.2. The PPP project finance model progression can be divided into two distinct phases i.e. pre-financial close and post-financial close. Each category varies in terms of the details and data available at the time.

The question of how much details in each stage is dictated mainly on the stage of a project and data availability which is attained progressively over time. The pre-financial close model is prepared from project feasibility to the financial close where the level of inputs increases significantly in the same proportional.

With the limited data and assumptions during the feasibility study, the off-taker seeks to determine whether the project outcomes are favourable from the eyes of public sector i.e. confirming the financial viability and affordability of the project. The sponsor model contains more sophisticated inputs and details that primary establish the competitive tariff of electricity that covers both project and finance cost. The lender uses this model for the due-diligence process, and with significant incorporation of lender's critical inputs data and secured contracts, the final project finance model with agreed structure is developed to reach financial close. The model establishes the base case, optimistic and pessimistic scenarios.

The role of the model continues beyond the financial close. The post-financial closure model is used as a budgeting tool for the project company, a basis for lenders to review the changing long-term prospects for the project and thus their continuing risk exposure; and enabling investors to calculate the value of their investment.

For the off-taker, the post-financial close model is used to calculate compensation-event payments, calculate any refinancing gain and calculating the termination sum for some early-termination scenarios (Yescombe, 2014). The summary of the pre-financial close and post-financial close is illustrated in Figure 14.

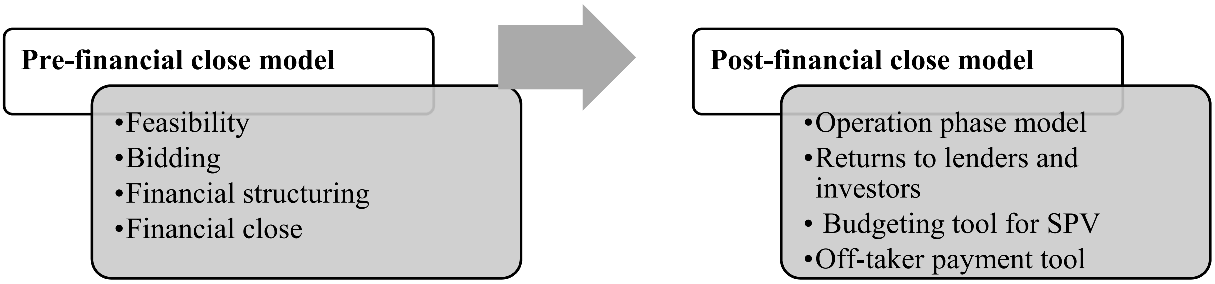

FIGURE 14: Model stage development flow chart

Therefore, the model development phases underscore the importance of the model to be as dynamic as possible to easily accommodate the changes as it passes through several stages, this enables easy manipulation and update of inputs and assumptions. More importantly, the model structure should be developed in such a way that it allows easy onward development of the later stages models until the final version is attained.

6.4 Steps in building a financial model

The building is the process of designing and developing a new financial model with a logical flow and structural compactness to the point that it can transform a given set of assumptions into trustworthy projections that describe and illustrate a deal in a quantitative manner. Furthermore, the model constructed must represent in mathematical terms the relationships among the variables of a financial problem so that it can be used to answer "what if" questions or make projections.

Having these primary objectives in mind, the model should be structured to capture as many of the interdependencies among the variables of the model as possible and making the model easy to ask "what if" questions, that is, change the values of the independent variables and observe how they affect the values of the key dependent variables (Sengupta, 2004).

Sengupta, 2004, insisted on the systematic approach in creating the model which involves planning ahead before undertaking the actual construction of the model, and this takes some time. However, the systematic approach prevents wasting time and frustrations to the modeller. The approach involves modelling in steps and the details vary somewhat depending on the spreadsheet package. Figure 15 illustrates the key steps suggested to be followed during the building of a new model.

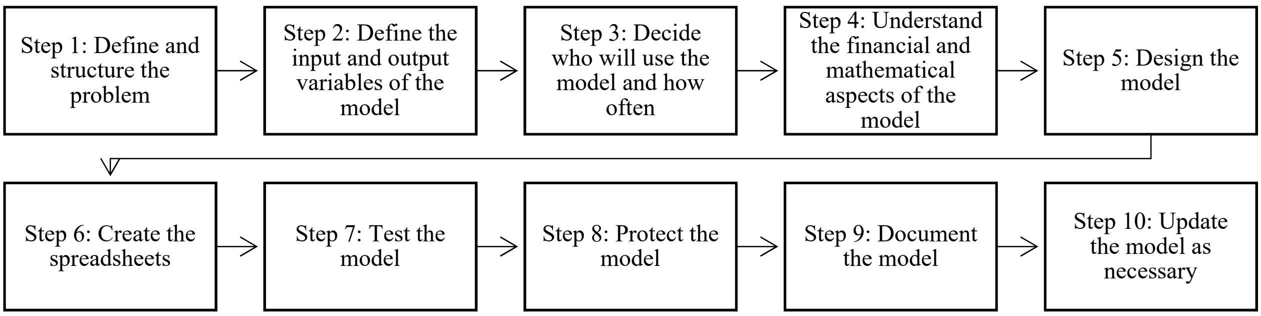

FIGURE 15: Steps in building a financial model (Sengupta, 2004)

However, one does not in practice need to follow the steps strictly in this order, nor to finish one completely before going onto the next one. Most of the time one needs to go back and forth to some extent and this entirely depends on the circumstances.

As seen from the ten steps above, prior to the designing and building of a model, it is imperative to comprehend the model principal function, not only in terms of the analysis to be performed and the results produced but also who uses the model, how often and under what expectations. All of these characteristics make a lot of difference during construction. Creating the model for the third party involves much more work and details to make it understandable rather different than would be required by the modeller themselves.

6.5 Model design principles, layout and components

While every project has unique features, and each spreadsheet package its own special techniques, certain design principles apply generally to the construction of project finance models. Lynch, 2011 documented six critical golden rules in financial modelling;

- One model for each project;
- Data in one place;
- Any value calculated only once in the model;
- Consistent formula across any given row;
- The consistent timeline on all calculation sheets;
- No circular code.

The principal aims of golden rules are to make the modelling process quicker and easier whilst minimising the risk of errors and to create a model which is as flexible, robust and understandable as possible. The rules are applied in the model structure and layout, making it easy to structure the model, check and audit the model later.

The underlying layout of the model provides the essential framework, overall structure and the logic flow through the model. The layout is furthermore broken down into the organisation of various sections, rows, columns and pages of the model within the spreadsheet. Proper guidelines can ensure that these elements are best arranged to support the development, use and presentation of the model.

The sections, rows, columns and pages and pages can be group into blocks or modules of formulas that perform discrete operations within them and enable the logic flow through the model i.e. as a block completes its tasks, it passes the results to the next block hence information flows from the data to all subsequent sections. The separation of distinct blocks in the model layout is referred to as a modular approach and is by far considered to be the most effective way to build a model successful (Tjia, 2009).

The layout of any project finance model can be broken down into three basic categories namely inputs, calculations and reports as illustrated in Figure 16.

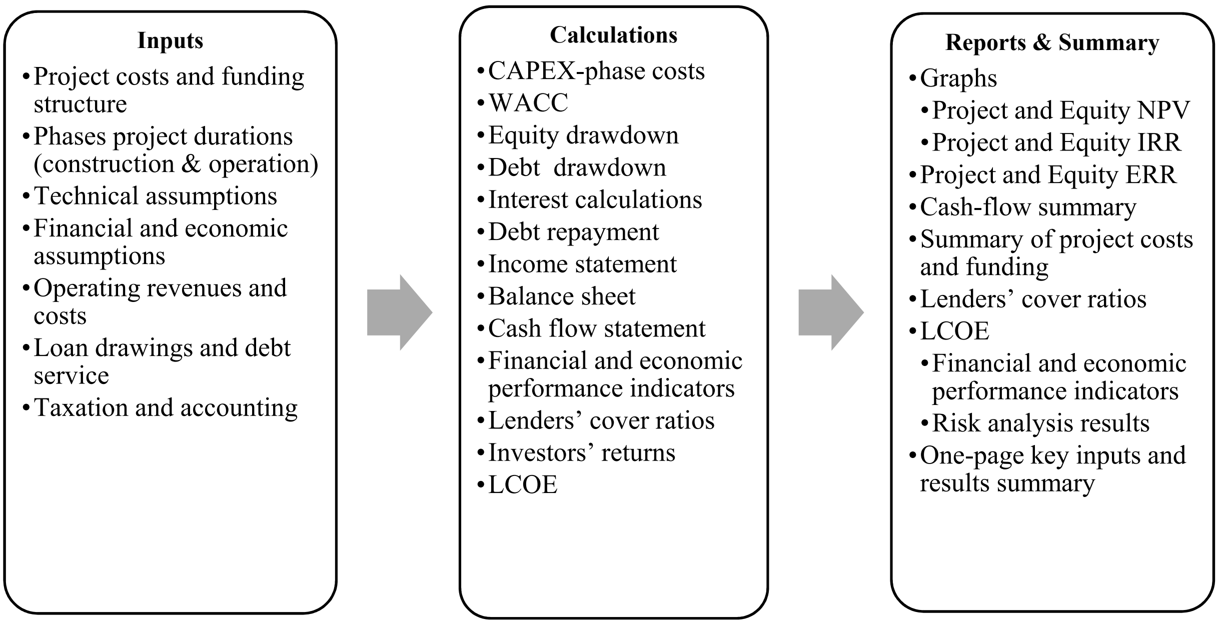

FIGURE 16: Typical project finance model layout and components

These categories are kept with a clear separation to enable the model to be read from left to right. The inputs, usually comprising one worksheet, accommodates all input variables of the project finance deal i.e technical, economic, and financial variables.

The calculation sheets comprise the sections that process the data in line with the assumptions applicable to the project. Calculation sections are organised primarily for ease of use by the modeller and for clarity of the calculations, although each should give a useable printout to support a detailed audit of the figures in due course. Lastly, the results sheets are the presentation sheets where values from the data and calculation sections are collected and organised into the format required for output summaries and reports.

Using the modular approach described above, the model is further divided into several interrelated Excel worksheets, where the components interact and establish the logic flow of data between them. Each modular is implemented in a separate worksheet in the same Excel workbook. The model is structured based on an Excel profitability analysis paper from Jensson, (2006) as illustrated in Figure 17.

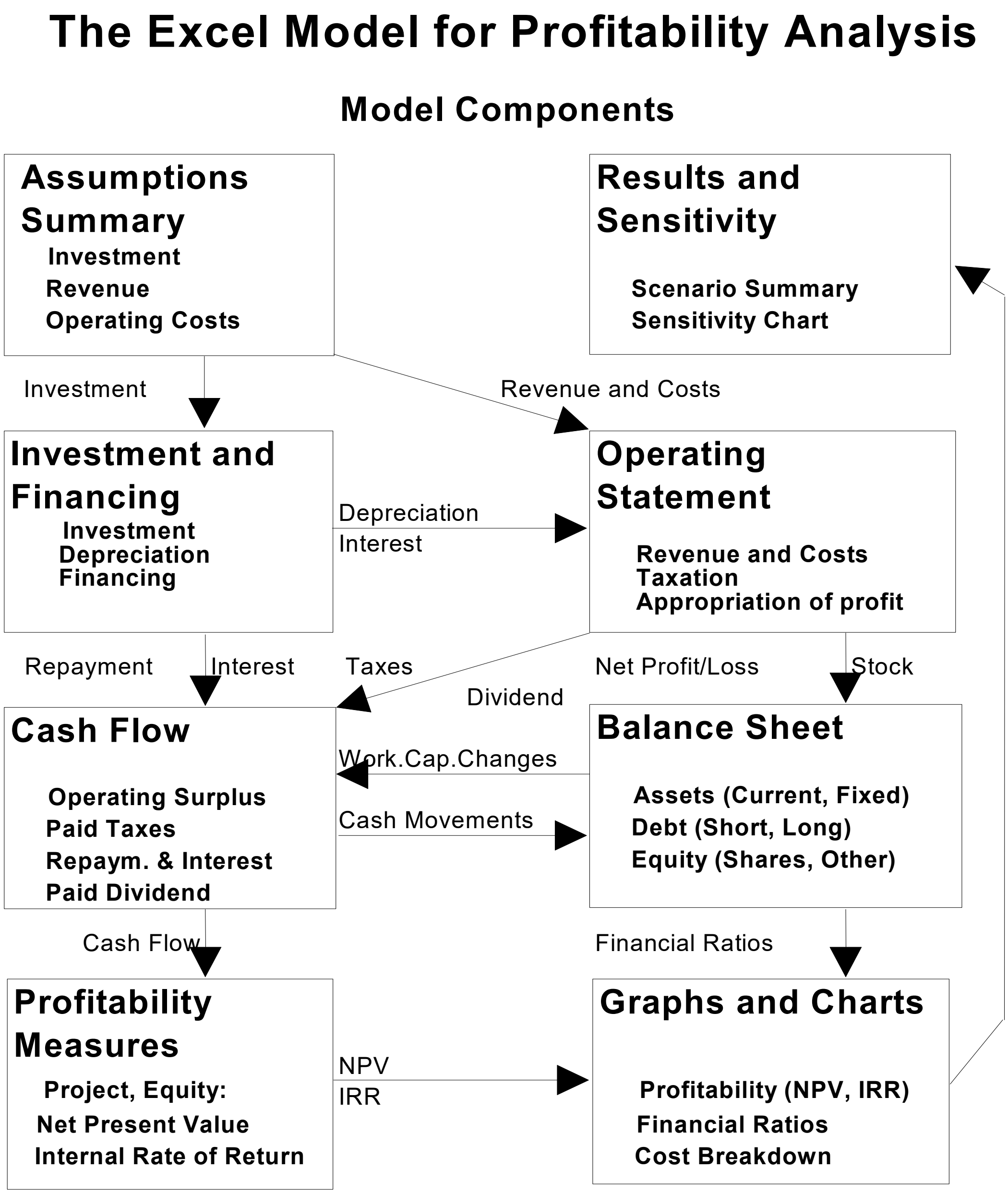

FIGURE 17: Model components and their relationships (Jensson, 2006)

6.6 Model components

This section unpacks the components of the model as shown in Figure 17. The model is built in a way that components are linked together in a workbook so that if one component in any worksheet changes, the others change as well.

6.6.1 Assumptions and result

This worksheet contains all the main variables needed to automatically compile the consecutive worksheets. They are also referred to as the independent variables of the model as can be changed independently, at the user's choice or on other words are not calculated by the model. In the worksheets, the cells for independent variables have only input numbers or text and not any formula. Most importantly, these are the variables that change to ask "what if" questions (Sengupta, 2004).

The best practice is always to cluster and colour code all the input cells of a model and protect and hide everything else in the workbook against accidental or unauthorized changes of formulas and links between cells. Colour coding allows the modeller and third-party users to immediately know what can be changed (assumptions) and what should not be altered (formulas). This is an important practice as tweaking the input assumptions by just a few dollars, either way can have a huge impact on cash flow, profitability, and the downright viability of a project.

The sheet also displays a summary of the key outputs of the financial model. The WACC, IRR, ERR, NPV, lenders cover ratios, payback periods and LCOE metrics are displayed here. These metrics are used in the worksheet to perform sensitivity, scenario and Monte Carlo simulation analyses to capture the uncertainties of future performance of the project.

6.6.2 Investment and financing

The investment and financing worksheet establishes the total project CAPEX, project finance structure and depreciation of project fixed assets.

a) Investment

The project investment is established from the CAPEX with figures broken down into buildings, equipment and miscellaneous. Furthermore, the total magnitude of the project investment cost required for the project is a summation of the calculated CAPEX, lender's fees, interest during construction costs and initial funding of reserve accounts. These figures are imported from the assumptions and result worksheet.

b) Financing

Since the project is transacted by the project finance technique, the assumed project's finance structure at the financial close is used. The following terms are specified in this worksheet i.e. amount debt, the size of equity, the tenor of debt, interest rates and calculations during phases, debt repayment, grace period and loan fees.

c) Depreciation

Depreciation attempts to measure a portion of the cost (or fair value) of a fixed asset that has been used up in generating the revenue recognized during a particular period. Put in other words, depreciation takes care of the gradual conversion of fixed assets into expenses. With the exception of land, most fixed assets have a limited useful life. The depreciation distributes the fixed asset's cost to match asset expense over its useful life to account the loss of value of fixed assets due to deterioration and obsolescence (Atrill and McLaney, 2017). The depreciation is relevant both to tangible fixed assets and to intangible fixed assets. Whereas, in the case of intangibles, the depreciation expense is referred to as amortisation.

In order to determine the amount of depreciation to take on a particular asset, four estimates are required; 1) capitalized cost (or fair value) of the asset 2) the estimated useful life of the asset 3) the estimated residual or salvage value of the asset and 4) the depreciation method to be employed These estimates are based on economic and engineering information, experience, and any other objective data about the asset's likely performance.

Broadly speaking, there are three methods that are commonly used to calculate the depreciation charges, namely the straight-line method, accelerated method and the unit-of-production method. The thesis uses the straight-line method to calculate the periodic depreciation expenses, $D_n$which can be expressed by the relation (Park, 2007);

$$D_n = \frac{(C - S)}{N} \tag{38}$$

where D_n = Depreciation expense during the year, n;
C = Capitalized cost (or fair value) of the asset;
S = Salvage value;
N = Asset useful life.

The depreciation expenses, D_n in Equation 38 establishes the book value of the asset at the end of n years, B_n which is calculated by substracting the total depreciation charges made to date from the cost of fixed assets as shown in the equation.

$$B_n = C - (D_1 + D_2 + D_3 + \cdots D_n) \tag{39}$$

The straight-line method derives its name from the fact that when the B_n is plotted against time, it results in a straight line. The straight-line method simply allocates the amount to be depreciated evenly over the useful life of the asset. In other words, an equal amount of depreciation is charged for each year that the asset is held. The annual depreciation charge appears in the income statement as an expense.

Although depreciation expenses are not actual cash flows, it has an important impact on cash flows by reducing taxable income and thus determining the total actual project income taxes. In the model, different depreciation categories are defined, and the project company fixed assets i.e. buildings, equipment and miscellaneous are depreciated in accordance with the host country's regulations.

6.6.3 Balance sheet statement

This worksheet in the model describes the components and functions of balance sheet statement. The purpose of the balance sheet is simply to describe the financial position of a project company as of a particular date i.e. not valid for the previous day or the day after. Due to its purpose, the balance sheet statement is sometimes referred to as the statement of financial position describing the sources of project funding equivalent to the total assets acquired by the project company. The statement can also be described to show a financial snapshot taken at any given point of time of all the assets the project company owns and all the claims against those assets i.e. liabilities and stockholders' equity.

Assets are arranged in order of liquidity or the length of time it takes to convert them to cash. The most liquid assets appear at the top of the page, the least liquid assets at the bottom of the page, cash is the most liquid of all assets, and it is always listed first. Similarly, on the liabilities side, liabilities are arranged in order of payment, the most pressing at the top of the list, the least pressing at the bottom i.e. accounts payable are always toward the top, while shareholders' equity is at the bottom (Park, 2007). The main three items i.e. assets, liabilities and shareholders' equity are governed and related by the fundamental accounting Equation 40;

$$Asset = Liabilities + Shareholders'\ Equity \tag{40}$$

The model utilises the equation in the balance sheet to establish the correctness of the financial statements.

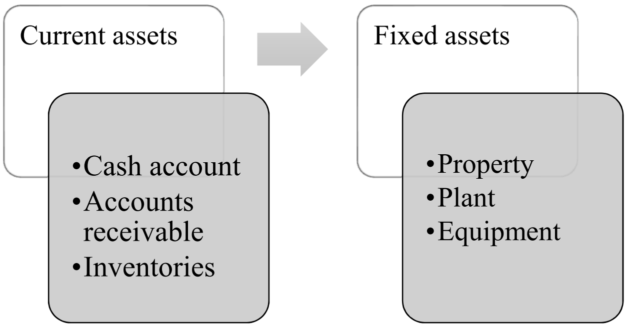

FIGURE 18: Balance sheet assets components

a) Assets

Assets in the balance sheet represent a dollar amount of how much a project company owns at the time at a particular period. The assets are predominantly made of two main components namely current asset and fixed assets as shown in Figure 18.

Current assets are basically assets that are held for sale or consumption during the projects' normal operating cycle i.e. the time between buying and/or creating a product or service and receiving the cash on its sale. For most businesses, this is less than a year. In the balance sheet, current assets are critical, that they are separately broken out and totalled. Current assets generally include three major accounts:

Cash account: explains the funds at the bank needed to conduct day-to-day project business. Although all assets are always stated in terms of dollars, only cash represents actual money.

Accounts receivable: explains the dollar amount that customers owe the project company for services billed but not paid for i.e. the money that is supposed to be paid by customers within one financial year period. For example, when a project company dispatch electricity to the off-taker, the electricity bill is not paid instant. The project company prepare an invoice for payment. This unpaid bill immediately falls into the accounts' receivable category. When the bill is paid, it is deducted from the accounts receivable account and placed into the cash category. It is important that a project company establishes the strict days sales outstanding to improve its cash position, the shorter days the better position. The PPA is anticipated to establish a reasonable billing period from the off-taker to the producer to minimize the level of unpaid energy and ensure that the schedule of debt service payments adheres.

Inventories account: shows the dollar amount that the project has invested in raw materials, work in process, and finished goods and other supplies needed for production, or goods waiting to be sold. In the geothermal power plant, an insignificant number of inventories are made available, it is, therefore, reasonable to assume that the account contains zero-dollar amount in the model.

Fixed assets are relatively permanent assets and take time to convert into cash. The assets reflect the amount of money the project company paid for the buildings, equipment and miscellaneous when it acquired those assets. Generally defined as any long-term asset used for production and often called gross plant, property and equipment. As previously discussed in the depreciation section above, the portion of the usefulness of these assets expires and recognised as depreciation expenses. Therefore, the fixed assets account in the model represents the current book value of these assets after deducting depreciation expenses.

b) Liabilities and shareholders' equity

As shown in Equation 40, the liabilities and shareholders' equity are the two claims against the assets of a project company. The liabilities of a project company indicate where the company obtained the funds to acquire its assets to operate the project. Therefore, liability is money the project company owes. On the other hand, stockholders' equity is that portion of the assets of a company which is provided by the project sponsors (owners). Therefore, stockholders' equity is the liability of a project company to its owners (Park, 2007).

Current liabilities represent debts which must be paid by the project company in the near future (normally, within one year). This includes the amounts project company owes its vendors on the date of the balance sheet for products or services that it has purchased (Figure 19). Like current assets, current liabilities are so critical that they are separately broken out and totalled. The longer a project company can delay in paying off the suppliers, the longer it holds on to free money. The major current liabilities include accounts and notes payable within a year. Also includes the accrued expenses (next year's loan

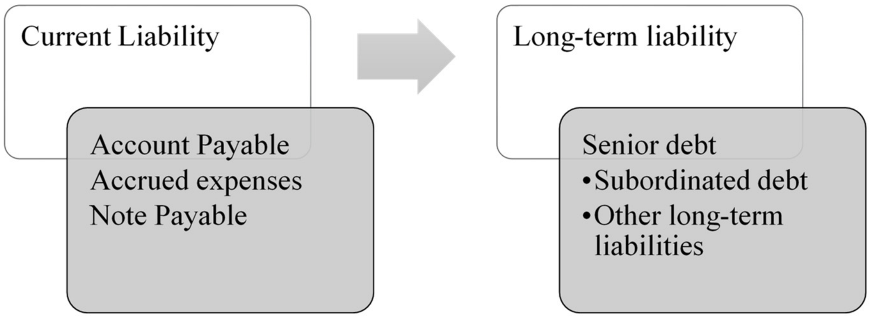

FIGURE 19: Balance sheet liabilities components

repayments, loan interest, taxes payable, dividends payable owed, but not yet due for payment), and advance payments and deposits from customers.

Long-term liabilities are any other obligations that are non-current. They include senior debt, subordinated debt, long-term notes and other long-term liabilities that are due and payable more than one year in the future. In this case, these are long-term commercial debt taken from the lenders to fund the project.

Shareholders' equity represents the value of the shareholders' investment in the project after all other debts have been paid. Generally, consists of preferred and common stock, treasury stock, capital surplus, and retained earnings.

In the model, the accounts receivable account is expressed as a per cent of the projected revenue while that of accounts payable is estimated at the per cent of operating and maintenance expenses.

6.6.4 Income statement

This worksheet in the model workbook describes the components and functions of an income statement. The income statement is an ongoing record of the revenues and operating expenses through a particular period. The records are done at regular intervals and this model builds the statements on an annual basis.

The statement furthermore shows the financial performance of the project company by indicating whether the investment project is making or losing money during a stated period, hence the other name Profit-and-Loss (P&L) statement. Unlike the balance sheet statement where there is a carry over the amount from the previous period, in the income statement, each period starts from scratch. The basic income statement equation is as follows;

$$Revenue - Expenses = Net\ Income \tag{41}$$

The layout and basic elements of the income statement are as described in Table 3:

TABLE 3: Income statement format

	Revenue
-	Operating expenses
=	Operating income or Earnings Before Interest, Tax, Depreciation and Amortization (EBITDA)
-	Depreciation and amortization
=	Earnings before Interest and Tax (EBIT)
-	Interest
=	Earnings before Tax (EBT)
-	Corporate tax
-	Dividends
=	**Net Income**

Revenue is the sales arising from the activities of a business venture. For a power project, revenue is the product of the net exported power and the agreed tariff between off-taker and project company as stipulated in the PPA.

The revenue generated from the project deducts the operating expenses to calculate the operating profit or EBITDA (Earnings Before Interests, Taxes, Depreciation and Amortization). The power project operating expenses encompass all cost directly and indirectly associated with the generation of the sold energy. These include staff cost, spares, oils, cooling water where applicable, security and other administrative costs. The cost also includes reservoir maintenance costs such as undertaking a steam status report, scaling management measures, well interference testing using tracers and pressure monitoring as well as maintenance of road and steam gathering systems. Often, costs of drilling and connection of makeup wells are included as operating expenses rather than capital hence reduces the tax payment and improves the project cash flow (Ngugi, 2012).

As depreciation and amortization are non-cash expenses (no actual cash that the project company pays out-out), EBITDA becomes an important indicator to show the amount of cash a project company can generate from its operations and absolute ability to pay its interest costs. Creditors would examine this metric very closely. Additionally, EBITDA can be useful for project valuations, analyse and compare the profitability between different projects in the same industry as it eliminates the effects of many of the factors that differentiate projects in different sectors, such as interest (from different financing profiles), depreciation (from different fixed asset bases), amortization (from different holdings of intangibles), and taxes (from different tax treatments). A zero EBITDA, on the other hand, means that there is absolutely no cash coming from the revenue-generating activities (Tjia, 2004).

The EBITDA less depreciation and amortization establishes Earnings before Interest and Tax (EBIT), also referred to as operating profit or operating income, a number that defines a project company's ability to generate operating earnings before interest expense (a cost related to financing decisions, not operating decisions) and taxes (a cost related to running a business in a regulated economy). Concisely, The EBIT metric measures the earnings related to the main operations of a project company outside of other non-operating expenses on the items that are incapable to control (Tjia, 2004).

After debt interest being deducted from the EBIT metric, the Earnings Before Tax (EBT) is attained which reflects how much operating profit is realized before accounting for taxes. The tax is computed on a fixed tax rate. However, the magnitude of tax payable varies depending on the host country's existing tax incentives to encourage investment and growth. This incentivize measure may improve the project's financial viability and allowing a lower end-user tariff that benefits consumers. These incentives can take the forms of tax holidays or carry forward losses. In this case, the model assumes tax losses are carried forward between years, hence the model calculates the taxable profit which is essentially the EBT less loss transfer. The rates of tax are levied on the project company's taxable income and established from the fiscal regime in the particular jurisdiction. The model calculates the payable income tax as a multiplication of taxable profit by a percentage rate of corporate tax. The rate is imported from the assumption and results worksheet. This calculation yields the profit after tax metric and dividend is calculated as a percentage of the metric. Lastly, the net income, or net profit, is calculated. The net income is the proverbial bottom line or accounting income, determined by subtracting the income taxes from the taxable income. This metric is a primary measure of project performance and the final output of the income statement.

Conclusively, the income statement relies on accrual accounting principles, as a result, the revenues and expenses are not synonymous with cash inflow and outflows. The income statement uses issued bills to show the performance of the project for the period rather than cash receipts and cash payments since not all invoices have been paid at the end of a period. Therefore, the profit (or loss) may have little or no relation to the cash generated during the reporting period. Furthermore, the statement focuses only on determining the net income of the project for supporting its operating activities and ignores two other important business activities for the period i.e. financing and investing activities (Park, 2007).

Therefore, to address all these drawbacks of the income statement, the third major component of the financial statement is required i.e. the cash flow statement which provides a detailed look at how much cash is moving in and out of the project during the reporting period.

6.6.5 Cash flow statement

This worksheet in the model workbook describes the components and functions of the cash flows statement. The statement of cash flows describes the actual project cash flows i.e. the cash and cash equivalents to and from the project that occurs in a particular period from operations, investments and financing activities. The cash includes currency on hand and demand deposits while cash equivalents are short-term, highly liquid investments that are readily convertible to cash (Atrill and McLaney, 2017).

The focus of the cash flow statement is solvency, having enough cash in the bank to pay bills as they come due. The cash flow statement primarily summaries the information regarding a project's cash receipts and cash payments over the period concerned. The statement gleans much of the information from the careful study of a project's income statement and the balance sheet and adjusts for all transactions for the non-cash item. Higgins, 2016 described cash flow production cycle as illustrated in Figure 20 which demonstrates the simplified close interplay between project company operations and finances.

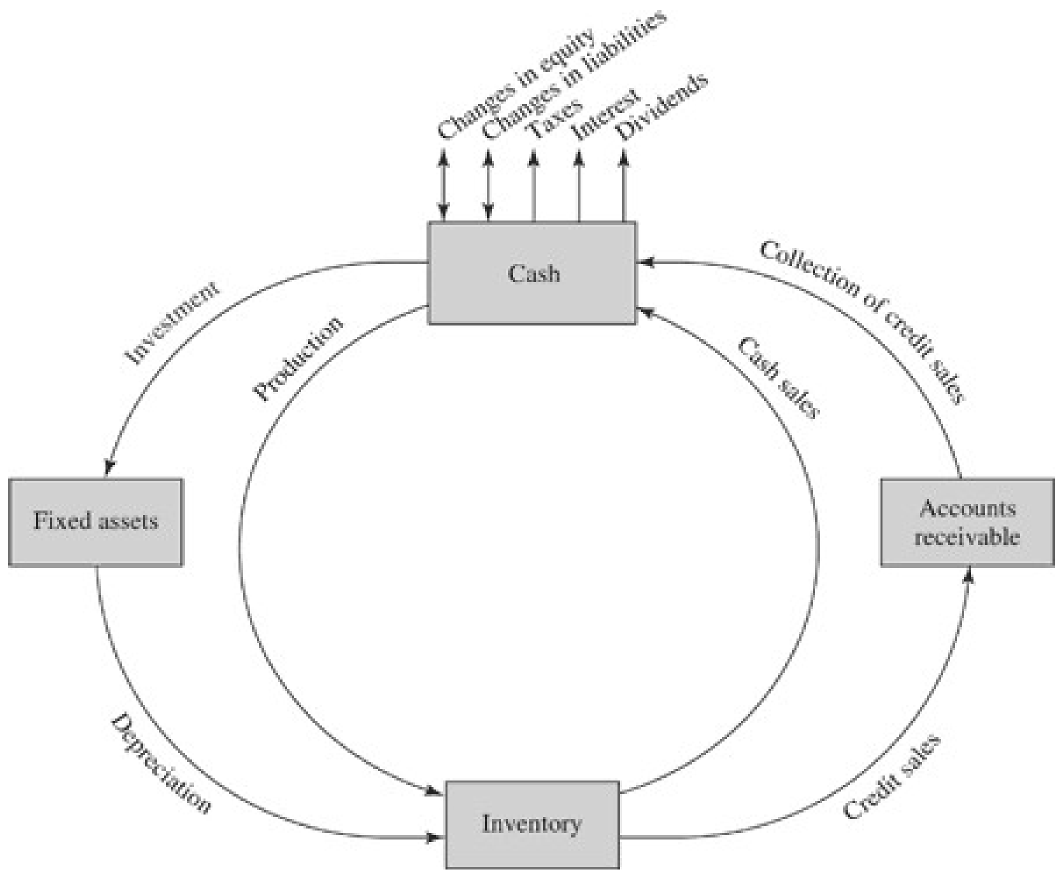

FIGURE 20: Cash flow production cycle (Higgins, 2016)

The cash from the lenders and equity providers purchases productive assets and begins operations. Depending on the nature of the business, the manufactured product is stored temporality in inventory, therefore, what began as cash is now physical inventory. If the sale is for cash, this occurs immediately, otherwise, cash is not realized until some later time when the account receivable is collected. The movement of cash to inventory, to accounts receivable, and back to cash is referred to as the project's operating or working capital cycle.

On the other hand, reinvestment of fixed asset is exercised as the assets are consumed, or worn out, in the creation of products. Depreciation of the fixed assets as explained in the previous chapter takes the latter into consideration hence increasing the value of merchandise flowing into inventory. The outflow of cash is seen in the form of dividends, interests, taxes, changes in liabilities and changes in equity, but the last two also generate an inflow of cash. The object of this whole exercise is to ensure that the cash returning from the working capital cycle and the investment cycle exceeds the amount that started the journey (Higgins, 2016).

The cycle gives two basic principles 1) financial statements are an important window on reality as it provides linkage between a project company's operations and its finances 2) there is a difference between the income statement and the cash flow statement i.e. profits do not equal cash flow, cash and the timely conversion of cash into inventories, accounts receivable, and back into cash is the lifeblood of any company. If this cash flow is severed or significantly interrupted, insolvency can occur as the project has insufficient cash to pay its maturing obligations and therefore, this is one main focus of cash flow statement, ensuring project solvency i.e. having enough cash in the bank to pay bills as they come due (Higgins, 2016).

Atrill and McLaney (2017) provided the standard layout of the cash flow statement as summarized in Figure 21. In the reporting format, the sources and uses of cash in the project are categorised into three business activities namely cash provided or consumed by operating activities, by investing activities, and by financing activities. The detail of each activity is explained in details below.

Cash flow from operating activities primarily eliminate the effects of accrual accounting on net income through:

1) Adding back to the net income, the non-cash expenses, such as depreciation and amortization, since it entailed no any cash outlay; and
2) Adding the changes in current assets and current liabilities to the net income to account for unpaid bills and invoices.

The net cash provided by operating activities is considered to be a more reliable indicator of project performance than net income. This is because net income depends on myriad estimates, allocations, and approximations, easily manipulatable while the net cash provided by operating activities record the actual cash, thus seen to be more objective measures of performance. Despite the certain merit on the strength of the cash flow from operating activities the performance metric may wrongly indicate the real performance of the project (Higgins, 2016).

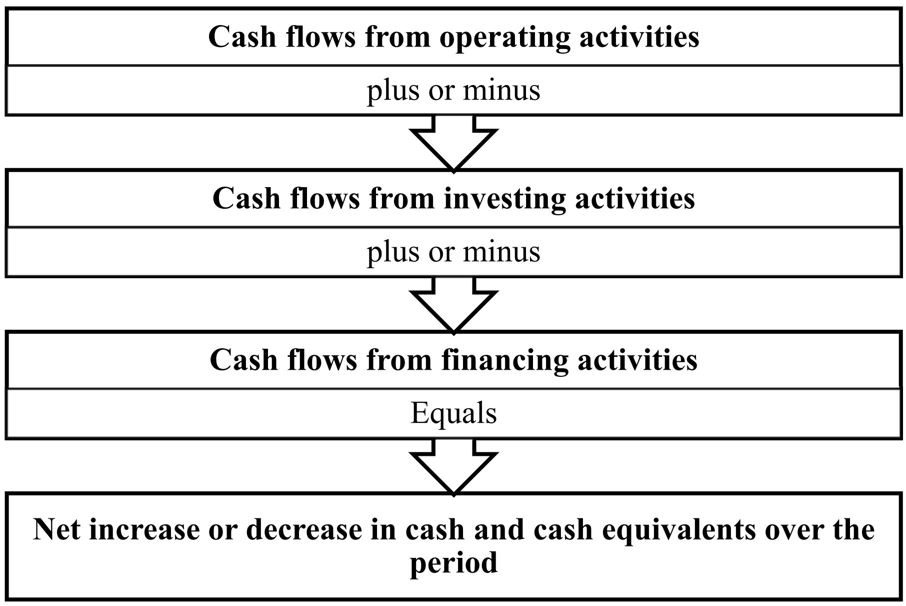

FIGURE 21: Standard presentation for the statement of cash flows
(Atrill and McLaney, 2017)

Cash flow from investing activities consists of cash flow transactions related to investment activities which comprise of purchasing new fixed assets (cash outflow), reselling old equipment (cash inflow), and buying and selling financial assets.

Cash flow from financing activities consists of cash transactions related to financing any capital used in the project i.e. repayments of existing loans results in cash outflows while borrowing or selling more stock, results in cash inflows.

Lastly, net increase or decrease in cash and cash equivalents over the period becomes the cash flow position of the project company, which is a summary of cash inflows and outflows from three activities for a given accounting period.

Cash flow statement is considered to be a powerful tool in undertaking project financial and economic feasibility analysis. When performing the analysis, various forms of cash flows and other metrics establish the proper assessment of project performance. Higgins, 2016 stated the four common types of cash flow in practice;

a) Net cash flow

This is the cash earnings intended to measure the cash the project generates which is distinct from the earnings to test a laudable objective. The net cash flow is calculated as shown in the Equation 42 where the net income (form the bottom of the income statement) adds back any non-cash items i.e. depreciation and amortization, and if applicable, all other non-cash items like stock-based compensation, unrealized gains or losses, or write-downs are also added:

$$Net\ cash\ flow = Net\ income + Noncash\ items \tag{42}$$

However, net cash flow as a measure of cash generation implicitly assumes the project's current assets and liabilities are either unrelated to operations or do not change over time, which is not always the case.

b) Cash flow from operating activities (CFO)

As stated in the prior section, the project operating cash flow is a more inclusive measure of cash generation as the metric addresses the change of current asset and current liability in the net cash flow as:

$$CFO = Net\ cash\ flow\ \pm \Delta\, Working\ Capital \tag{43}$$

However, the CFO in the Equation 43 does not include capital expenditures (the investment required to maintain capital assets).

c) Free Cash Flow to the Project (FCFP)

The cash flow establishes the amount of cash available after payment of all project operational expenses, but before any payments to all debt and equity stakeholders or grow the business (if applicable). In other words, the metric elaborates the cash available in the project regardless of the project's capital structure.

The FCFP measures the ability of the project to generate cash flows to exceed all its capital expenditures (CAPEX). The CFO is adjusted in calculating FCFP to exclude any cash outflows from interest expense.

The positive and growing free cash flow signifies outstanding project's financial performance and health. The FCFP is a fundamental determinant of the value of any project investment and represented in Equation 44:

$$FCFP = CFO + [(Interest\ expense * (1 - tax\ rate)] - CAPEX \tag{44}$$

The discounted cash flow analysis technique described in Chapter four establishes the expected future FCFP into today's present value of project investment to demonstrate whether the project is worth pursuing to both lenders and project sponsors.

d) Free Cash Flow to Equity (FCFE)

The FCFE establishes the cash flow available for equity shareholders of the project company after it has met all its obligations which includes CAPEX, working capital and debt financing requirements. The FCFE is distributed as per equity providers' agreement which sets forward the dividend's payment under the discretionary of management/shareholders. The FCFE is calculated in the Equation 45:

$$FCFE = FCFP - [(Interest\ expense * (1 - Tc)] + net\ borrowing \tag{45}$$

Similar to FCFP, the projected future FCFE is discounted to establish today's value of money. The metric establishes the analysis of equity investment in the project.

6.6.6 Profitability measures

The profitability worksheet calculates the project financial appraisal metrics as theoretically presented in Chapter 4. The following are covered;

a) Economic key performance indicators i.e. NPV, IRR, MIRR, LCOE, and DPP;
b) Financial key performance indicators i.e. Equity NPV, Equity IRR, ERR, DSCR, LLCR, PLC.

6.6.7 Graphs and charts

The worksheet consists of graphs and charts that illustrate trends of key performance indicators, cumulative cash flows, a summary of project costs breakdown and funding, and the geothermal resource potential and production profile.

7. A CASE STUDY OF THE GEOTHERMAL FIELD

This chapter covers the case study of hypothetical Ngozi geothermal power project development in southwest Tanzania. The financial modelling task is undertaken based on the data and assumptions developed from the geothermal field case.

The chapter begins with a large-scale picture of geothermal energy technology, describing the meaning and geological aspects of geothermal energy, global progress in the development and utilization of geothermal resources. The overview of the electricity supply industry in Tanzania is presented while addressing the position and necessity of geothermal energy technology development in the country's power generation matrix. The chapter also covers the geothermal project business models, geothermal project-specific risks and financing, project development components, power generation technology and project KPIs.

The description of Ngozi geothermal field is provided and covers the location, size of the field, development status, field existing infrastructure, and nearest point to connect to transmission lines. The project components, technical resource parameters, project duration, financial and technical parameters are established. Lastly, project OPEX and CAPEX are presented.

7.1 Geothermal energy, development and utilization

The word geothermal comes from the two Greek words “Geo” means earth and “Therme” means heat. Geothermal energy is, therefore, the heat derived from the deep inside centre of the Earth, the core as a result of radioactive reactions/decays of naturally occurring radioactive isotopes. The breaking down of these radioactive materials in the solid core makes the temperatures incredibly higher, ranging between 4300°C and 6660°C. The section provides insights on geothermal energy geology, utilization and geothermal energy in Tanzania.

7.1.1 Geothermal energy geology

The high temperatures from this part of the core are powerful enough to melt rocks in the outer core into a hot liquid called magma. Most of the time, the magma stays below the Earth’s crust, where it heats surrounding rocks and remains hot for the period between five thousand and a million years. In some cases, however, the hot magma reaches the earth’s surface as lava and forms volcanoes.

The heat from magma can rise through the mantle to the Earth’s surface. The temperatures at the base of the crust are about 1100 °C, assuming the temperature at the surface of 10 °C, the gradient between the surface and the bottom of the crust is calculated to be 31.1 °C /km or about 3.1°C /100 m. This conductive temperature gradient rate is typical in normal areas. The anomalous regions with good geothermal fields, the thermal gradient is several times greater than these normal values. For example, at Larderello, Italy where the first geothermal steam plant was built, the gradient is 10-30 times higher than normal (DiPippo, 2016).

That heat is sufficient to power plate tectonics, which is the slow movement of the continents and the ocean floor that make up earth’s crust, and the upper mantle (Glassley, 2015). The relative motion of the tectonic plates i.e. continental areas and oceanic crusts, of any size, gives rise to several possible interactions as illustrated in Figure 22. Most of these responses cause the rise of pressurised magma from the core through the faults generated during the movements.

When a plate is under compression can lead to the four responses shown in Figure 22, however, the trenching or subduction is one of the most important mechanisms that give rise to high-temperature geothermal regions. On another hand, when a plate is subjected to tension forces, it can relieve the stress with the responses shown in Figure 22 which all leads to anomalous geothermal regions that may be conducive to exploitation.

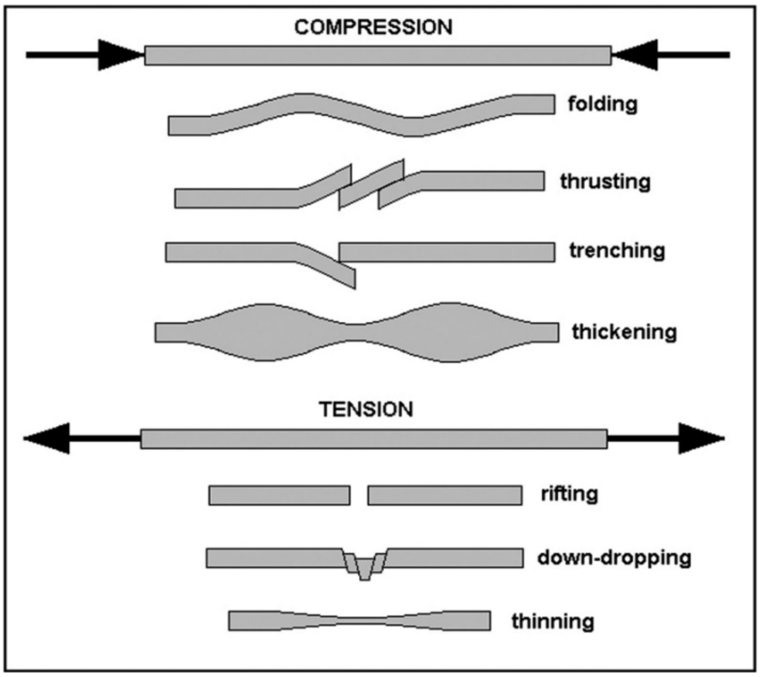

FIGURE 22: Response of plates to compression and tension (DiPippo, 2016)

Figure 23 illustrates the five features that are essential to making a typical hydrothermal (i.e., steam or water-based) volcanic-related geothermal resource commercially viable. These include 1) a large heat source 2) permeable reservoir 3) a supply of water 4) an overlying layer of impervious rock and 5) a reliable recharge. If the field lacks any one of these features, the hydrothermal resource is considered not commercially viable hence not worth exploiting (DiPippo, 2016).

From Figure 23, the cold recharge water enters in the geothermal system as rain (point A) and percolating through faults and fractures deep into the formation where it comes in contact with heated rocks. The permeable layer offers a path of lower resistance (point B) and as the liquid heats, it becomes less dense and tends to rise within the formation. If it encounters a major fault (point C), the liquid ascends toward the surface, losing pressure as it rises until it reaches the boiling point for its temperature (point D). There it flashes into steam which emerges as a fumarole, a hot spring, a mud pot, or a steam-heated pool (point E). Lastly, the magmatic intrusion also referred to as a hot body (point F) continuously transfers heat through conduction mechanism between rocks to reach the permeable rock.

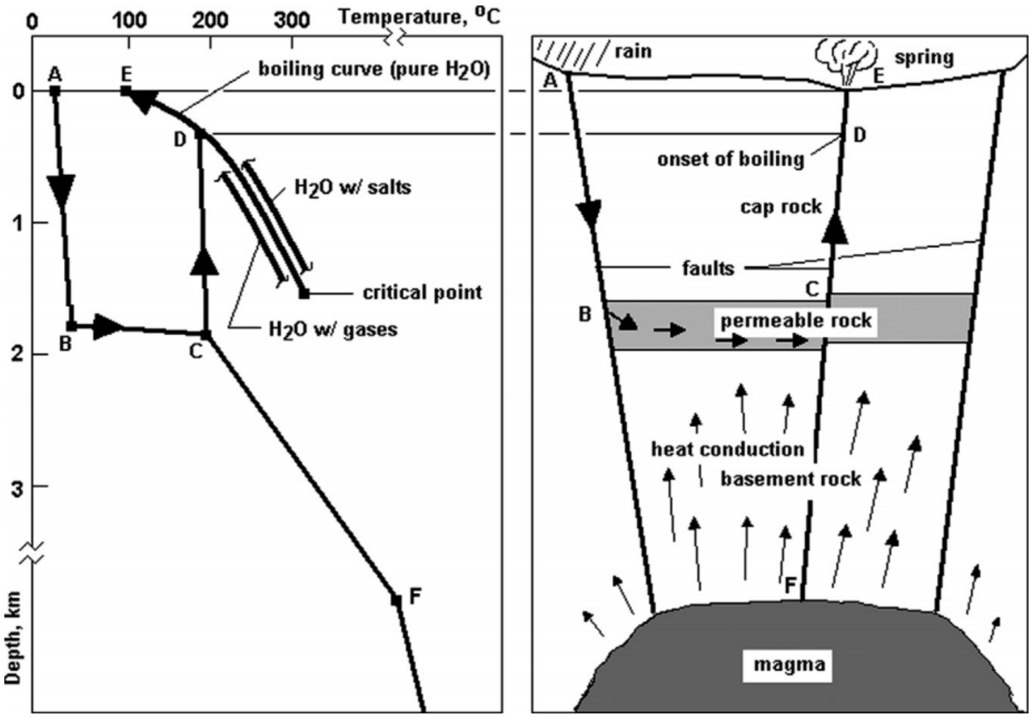

FIGURE 23: Schematic model of a hydrothermal geothermal system (DiPippo, 2016)

7.1.2 Geothermal energy utilisation

The wide spectrum use of geothermal resources is strongly influenced by the total energy content (enthalpy) or temperatures of the geothermal fluids and steam. Generally, the resources of high temperature or high-enthalpy systems are utilized primarily for electric power generation, whereas the resources of lower temperature or low-enthalpy systems are utilized mostly for space heating and other potential direct uses. Lindal diagram shown in Figure 24 provides a comprehensive spectrum of applications of geothermal fluids and steam depending on their temperature range.

The scope of this study is primarily limited to the higher-temperature end of the spectrum of geothermal resource i.e. electric power generation as shown in Figure 24. Therefore, to achieve this, the previously described high-temperature commercially viable hydrothermal geothermal resource required to be located and accessed to extract the hot geofluids to the surface to energize the power plant (Gehringer and Loksha, 2012).

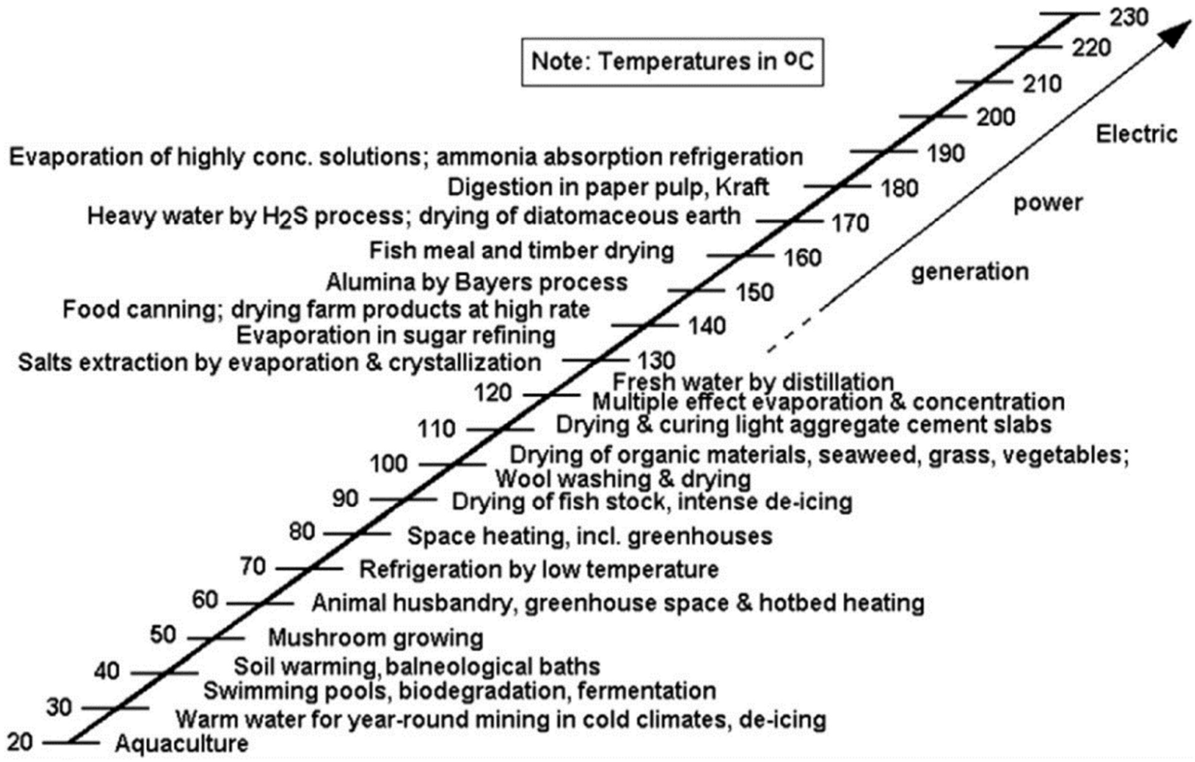

FIGURE 24: Modified Lindal diagram showing applications for geothermal fluids (DiPippo, 2016)

The currently available technologies employed to meet this requirement is through using geo-scientific methods and drilling of wells at a typical economical depth of between 2,000-3,000 m to extract a geothermal reservoir. The drilled conventional full-size production well (>8" diameter) penetrates into the subsurface, providing a flow path for the reservoir fluid to ascend from the depth and then connected to a power facility. In order to prevent the resource from becoming depleted (and to mitigate possible environmental impacts from the discharge of waste fluids), such condensed geothermal fluids are usually recycled by being re-injected into the reservoir through additional wells called injection wells (IFC, 2013).

Most of the world's geothermal fields exploited today are associated with volcanic and/or recent tectonic activity. Most geothermal power-plant developments are therefore located close to tectonic plate boundaries such as the Pacific Rim, the East Africa Rift Valley, and the Mid-Atlantic Ridge resulted from the tension and compression forces. These areas are commonly discovered through thermal surface expressions, such as hot springs, calderas, boiling grounds and fumaroles amongst many other signatures.

Typically, springs and fumaroles are sampled, and geochemical analyses are used to estimate the maximum temperatures of fluids in the subsurface. The areas with highest geochemically derived temperatures are further explored in detail and eventually developed. Some geothermal fields have been found even though there were no obvious surface manifestations; generally, by exploration drilling for some other resource.

Geothermal energy is a mature technology, exploited for electric power production for more than a century and has proved to be low-operating-cost, renewable, affordable, uniquely reliable base-load and environmentally benign electricity supply. Once the geothermal plant begins operation, produces a steady output twenty-four hours a day regardless of changing the weather, seasonal variation and climate change, and the plant can economically perform satisfactorily for at least 25-30 years at a relatively low and competitive cost of electricity. Moreover, the operating plant can incorporate the cascading direct uses of the brine to improve the project's overall economics. The other imperative advantage worth mentioning is that the local cultivation of the geothermal resources brings significant economic advantages to local economies (Kalimbia, 2016).

The first geothermal electricity production is traced back in 1904 where the demonstration project of the small steam generator was built in Larderello, Tuscany, Italy with a capacity of 15 kW that lighted four light bulbs. The commercial generating capacity of 2500 kW dry-steam geothermal plant was installed in 1916. Now, 115 years later, a total of 24 countries in the world generate electricity from geothermal resources (Figure 25). As at year-end-2018, globe registered a total installed capacity 14,600 MW (ThinkGeoEnergy, 2019). The United States of America is by far the world leader in geothermal power electricity production with an installed capacity 3,639 MW whereby Kenya is the only African country and holds a ninth place in the world's top ten geothermal power producers with an installed capacity of 676 MW.

Despite the many significant benefits of developing geothermal power, there are also key considerations to be made in terms of the drawbacks of pursuing the exploration and exploitation of this energy source. Some of these include:

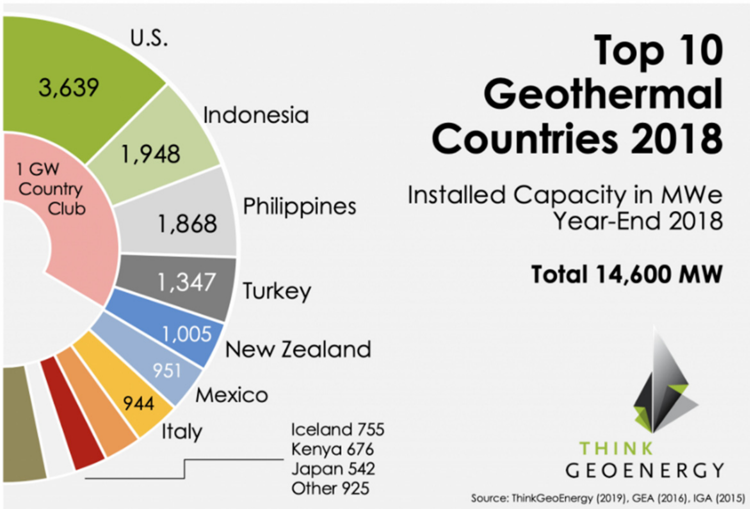

FIGURE 25: Geothermal worldwide Installed Capacity (ThinkGeoEnergy, 2019)

a) Commercial geothermal power projects are expensive i.e. the exploration and drilling of new reservoirs come with a steep price tag. According to Gehringer and Loksha, 2012 mid-range estimates for geothermal power project capital cost are close to US $4 million per MW

b) High upfront costs and the risks particularly for test drilling phase, drilling of one full-size geothermal well could cost around 1-7 million USD (with an average of 50 per cent success rate for the first well drilled) and field needs at least three wells to confirm the existence of the resource. The drilling costs, therefore, encompass between 35 and 40% of the total CAPEX of a geothermal power project, most of which is incurred in determining the size, location, and power capacity of the geothermal resource. This investment is, of course, lost if no commercial resource is found (IFC, 2013).

c) Relatively long lead time from conception to the power production, most guidelines and literature assumes 5 to 9 years to develop the conventional power plant project. Thus, geothermal power is not suited to provide emergency power solutions for the country's power problems.

d) Geothermal resources are location specific, as is characterised with uneven distribution of commercial resources. Outside of those areas, geothermal energy is often not available or economical. In the presence of commercial geothermal resource, the extracted hot geofluids cannot be transported long distances as they lose their inherent thermodynamic value through the effort, which is also costly if successful, thus not commercially viable.

7.1.3 Geothermal energy in Tanzania

Tanzania belongs to East African regions with indications of high abundance geothermal energy resources. Similar to other countries, the geothermal activities in Tanzania lies within the great and longest Eastern African Rift System (EARS) where most of the prospects are located. These prospects are identified by their surface manifestations, mainly thermal springs. About fifty (50) geothermal prospects have been identified in the country.

Unlike other countries in the region, the EARS traversed Tanzania with both eastern and western arms as shown in Figure 26. Kenya exploits the eastern branch to generate the aforesaid capacity, on the other hand, the western arm of the rift is unproductive as yet. According to the geoscientific analysis of data points and available technologies, Tanzania geothermal resource is crudely estimated with a potential of above 5,000 MW of electricity (MEM, 2015). Despite this enormous resource base, geothermal energy remains undeveloped, presently there is no geothermal power plant installed in the country.

The country's four broad potential target prospects for geothermal exploration are categorised into four regions namely (a) Natron region near the Kenyan border in the North; and (b) Mbeya region between Lake Rukwa and Lake Nyasa in the southwest and (c) Rufiji basin in the east and (d) central Tanzania region all shown in Figure 26.

In northern Tanzania, geothermal activity occurs mainly along with the southern extension of the Kenya rift into Lake Eyasi, Ngorongoro, Lake Natron, Ol'doinyo Lengai and Arusha areas. The prospects in the Mbeya region are associated with the Rungwe volcanic complex and include Ngozi, Songwe, and Kiejo-Mbaka geothermal areas. In the Rufiji basin in eastern Tanzania occur Luhoi, Kisaki and Utete sites. Other geothermal areas are in central Tanzania and include Singida, Kondoa, Dodoma and Shinyanga areas (TGDC, 2017).

The study focus area is the Ngozi prospect situated in the Rungwe

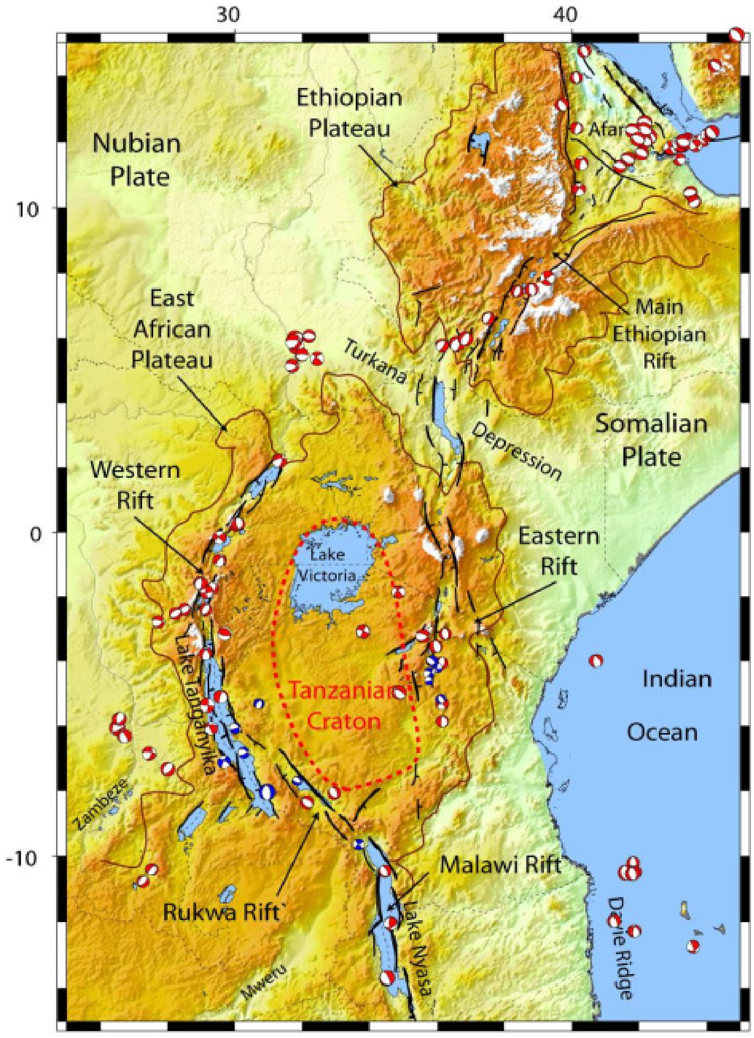

FIGURE 26: Tectonic map of Eastern Africa
(Source: TGDC, 2017)

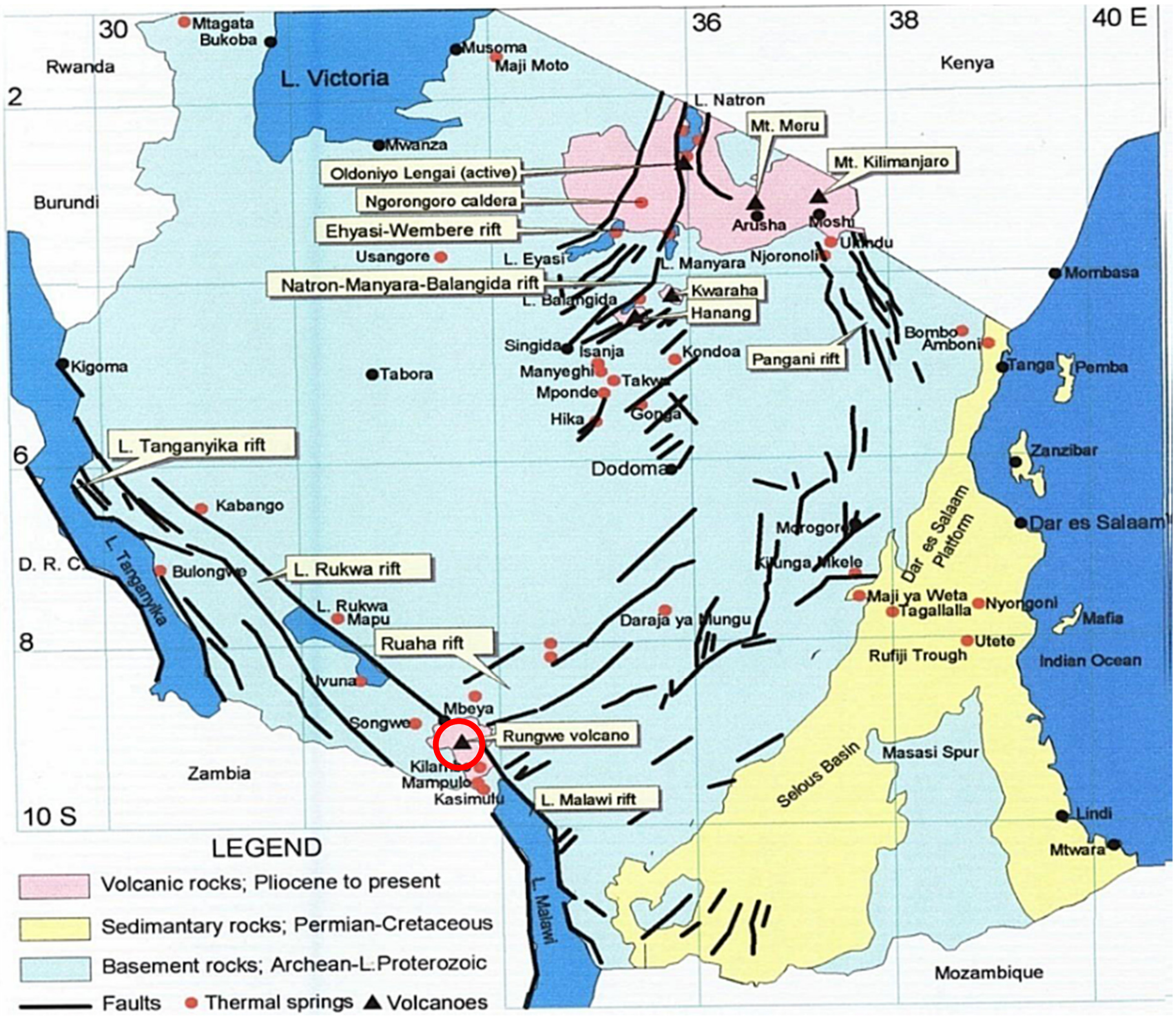

FIGURE 27: Geothermal fields in Tanzania and the location of Ngozi geothermal field, SW-Tanzania (MEM, 2012)

volcanic complex in the Mbeya region (Figure 27). The project salient features are extensively covered in the next chapter.

7.2 Project description

The section describes the key features of project development that provides critical inputs in the financial modelling exercise described in the previous chapter. The section covers; project location, project objectives, the rationale to undertake the project, field resource assessment, project business model, project phases, power cycles, project components, project cost estimates and project key performance indicators.

7.2.1 Project location

Ngozi geothermal field belongs to Rungwe Volcanic Province (RVP), situated directly south of Mbeya city in southwestern Tanzania at a triple junction of the East African rift and is about 2.5 km long and 1.6 km as shown in Figure 27 cycled with red. The Mbeya city, with a population of 385,279 (NBS, 2012) is located 822 kilometres (tarmac road) Northeast of Dar es Salaam, the country's largest commercial city. The city is also reached by air (1 hr. 25 minutes) or TAZARA railway from Dar es Salaam.

Given that, the power generated by the project is feed into the national grid, the closest feeding point to the national grid needs to be established. Two alternatives are considered, 1) the existing 220 kV Substation at Mwakibete in Mbeya city located 8 km from the field 2) the proposed new 400kV/220kV/33kV substation at Itanji Street in Igawilo ward located 11 km from the geothermal field. The site access requires the full operation of a 4WD vehicle as the terrain is hilly and the roads are not paved.

7.2.2 Project strategic thrust and rationale

As a result of climate change, Tanzania has witnessed increasingly unreliable rainfall patterns and more frequent and prolonged extreme droughts over the past two decades. These, in turn, have affected the country's power sector due to over-reliance on hydropower as the major source of electricity. During the period, the power industry recorded a radical drop of hydropower generation as several hydropower dams are forced to shut down in dry seasons as water levels fall below the minimum required to run turbines. In December 2015 the Thomson Reuters Foundation, 2015, reported that the utility suffered a daily loss of about $230,000 due to hydropower shortfall following the shutdown of two hydropower dams for three weeks.

This forced the state-run power utility firm to use extensive load shedding, the thermal power plant for base load, and hire emergency generation capacity while having the advantage of relatively rapid installation time, emergency capacity uses environmentally polluting fossil fuels at a considerable financial cost (AfDBG, 2015). For instance, in 2015, the fuel oil-based emergence power producers installed 317 MW capacity at a cost of between 30 to 35 USc/kWh.

As of December 2016, Tanzania's total installed grid capacity was 1,357.69 MW (TanzaniaInvest, 2016). The electricity generation matrix composed of hydro 566.79 MW (42%), natural gas 607 MW (45%) and liquid fuel (HFO and diesel) 173.40 MW (13%) as illustrated in Figure 28. The country's per capita electricity consumption was estimated to be 101 kWh per year (MEM, 2012).

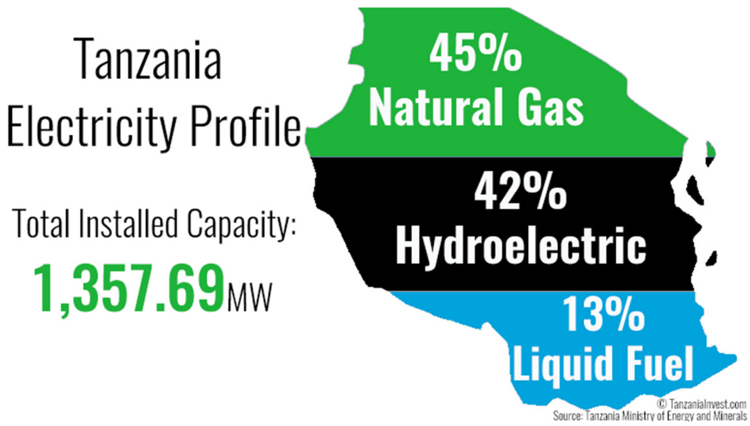

FIGURE 28: Tanzania power installed capacity (TanzaniaInvest, 2016)

According to the NBS, 2016 energy access situation report, only 67.5 per cent of the Tanzania population at community level had access to national grid electricity with 49.3 per cent rural and 97.3 per cent urban areas. Therefore, the majority of Tanzanian particularly in rural areas still lack access to modern and sustainable energy services to due inability to access the central grid electricity.

Following the challenges, the Government of Tanzania made a supreme decision to prioritize the development of a grid diversified generation portfolio to including the indigenous and low-cost power generation from the untapped renewable energy potential sources for which geothermal is one of the most important. Development of the geothermal resources in Tanzania is anticipated to provide a robust and resilient energy supply that is not subjected to oil price shocks and weather patterns. The geothermal power also addresses the growing demand for electricity in the context of unreliable hydropower generation capacity which is estimated growing between 10 per cent and 15 per cent per annum (MEM, 2014).

Ngozi geothermal field was chosen as candidate project to accelerate the diversification and meet the future power demand and subsequently included in country's most authoritative technical power document i.e. Power System Master Plan update, 2016 and anticipated to inject up to 100 MW of electricity by 2025. The project is also anticipated to generate clean low-cost energy and significantly contribute to meet the rising demand for electricity.

7.2.3 Project objectives

The primary objective of the project is to generate electricity from Ngozi field geothermal resources located in Mbeya region southwest Tanzania. The project is anticipated to meet the host government's desire to diversify the national grid electrical energy mix away from the dominance of hydro sources and increase the share of reliable, low-cost renewable power to meet the country's electricity growing demand.

7.2.4 Project resource assessment

Ngozi geothermal field is ranked as the topmost promising field in the country and stands as a flagship project of the country's geothermal development company. The field has undergone copious geo-scientific studies since the late 1970s at different levels, the most recent one being in the year 2015/2016 in collaboration with high-level United Nations Environmental Programme technical consultants and Geothermal Development Company (GDC) of Kenya.

A number of pre-existing and new geoscientific study and data were compiled to present the findings of the comprehensive geothermal resource assessment of the Ngozi prospects. The integrated resource conceptual models as illustrated in Figure 29, indicates the presence of a typical commercially viable hydrothermal resource comprising of all five essential features previously discussed in the previous in Section 7.1.

The Ngozi prospect belongs to the active Ngozi volcano which is part of the Rungwe Volcanic Province (RVP) located at the Mbeya triple rift intersection of the western and eastern branches of the EARS. The primary geothermal features are thermal water discharges (up to 89°C) on the bottom of the Ngozi crater lake. The deep geothermal reservoir beneath Ngozi has an estimated temperature of 232 ± 13°C,

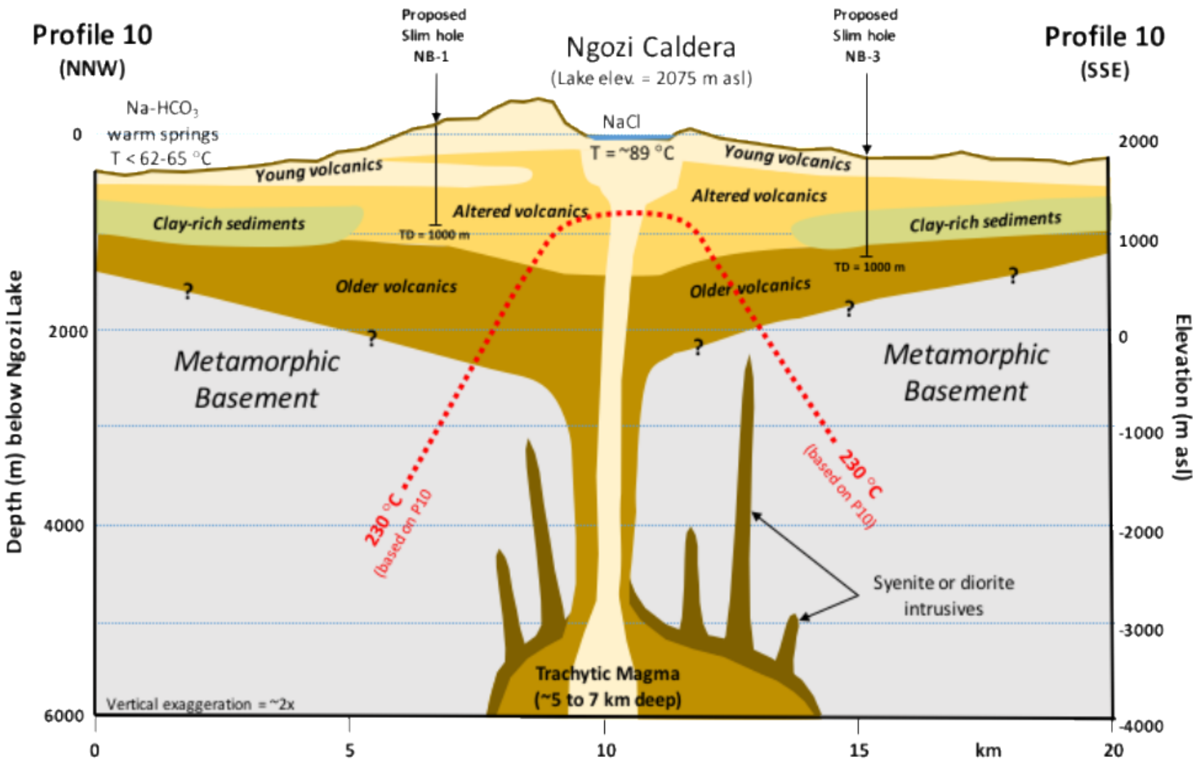

FIGURE 29: Schematic geological conceptual model for Ngozi volcano (Alexander et al., 2016)

TDS of 15,800 ± 2300 mg/kg (Na-Cl composition) and a P-CO_2 of 15 ± 4 bar. The geothermal reservoir is recharged by both meteoric waters (50-70% approximately) and primary magmatic waters (Alexander et al., 2016). Thus, according to the Lindal diagram, the Ngozi geothermal resource is primarily categorised as a higher-temperature resource which qualifies for electric power generation.

Based on the geothermal resource parameters such as resource area, thickness, porosity and temperature. The resource capacity was established using two methods namely log normal power density (then Cumming power capacity estimate) and Monte Carlo stored heat assessment. The methods yielded a P50 (50% probability of exceeding, or 50% confidence) of 2.9 km^2 of 33 MWe and 36 MWe for Cumming and Monte Carlo stored heat assessment, respectively. The scope of this study is primarily limited to the higher-temperature end of the spectrum of geothermal resource i.e. electric power generation as shown in the Lindal diagram. Based on the results, the study assumes a power project with a reservoir of 30 MWe capacity.

The resource parameters and capacity estimated above are solely based on the available geo-scientific data developed using the above-ground surveying techniques which may include magnetic, resistivity, and gravity surveys, as well as geochemical and geological analysis. While these techniques provide essential inputs to the construction of a reservoir model, accurate targeting of production wells and subsequent location of reinjection wells, the drilling of the geothermal well is the only guarantee and critical element to the success and technical viability of any geothermal power project.

The geothermal PPP power project is not considered bankable to attract private capital until test drilling has been performed and feasibility study was undertaken to prove beyond a doubt the existence of commercial geothermal reserves. This is primarily due to the potential mismatch risk that may result between the established reservoir properties using subsurface above-ground techniques and actual geothermal reservoir characteristics from the exploratory or confirmation deep-drilling program which may significantly affect the quality and quantity of production and hence the commercial viability of a project (IFC, 2013).

Since no exploratory or confirmation deep-drilling program done in the field, there are exists significant geological exploration and resource risks for soliciting the interest of the risk-averse investors funding. In order to surmount this hurdle for simplicity of using project finance mechanism and subsequently modelling task, the thesis assumes the existence of a geothermal resource with political, technical, environmental and commercial viability to establish a basis to successful reach commercial financial closure. The thesis assumes off-taker de-risking the field and invite the off-taker for power production.

7.2.5 Project phase, risks and financing

Geothermal phases can be broadly categorised into six phases namely; preliminary surveys, exploration, test drilling, wellfield development, power plant construction and operation phase. Each phase indicates the inherent risk level and magnitude of investments required. Figure 30 extracted from Gehringer and Loksha, 2012, summarises the combination and relationships between phases of the geothermal power project, level of the capital cost required and the overall project bankability.

As illustrated in the graph, the geothermal power project requires significant investments prior to demonstrate the viability of the project that subsequently attracting commercial capital. For instance, in order to undertake test drilling and feasibility study, a point considered suitable for financial closure, the project developer requires to cover up to 20% of the total project CAPEX and still the project risk is closer to 50%.

Therefore, the first three phases of geothermal power projects rely heavily on the risk capital mainly equity, grants and soft loans. This is due to high uncertainty and resultant project risk which proves difficult to acquire funds and if it does, might be in an expensive in the commercial term (IRENA, 2017). The host governments are therefore required to play a key role in de-risking the field to attract cheaper private finance.

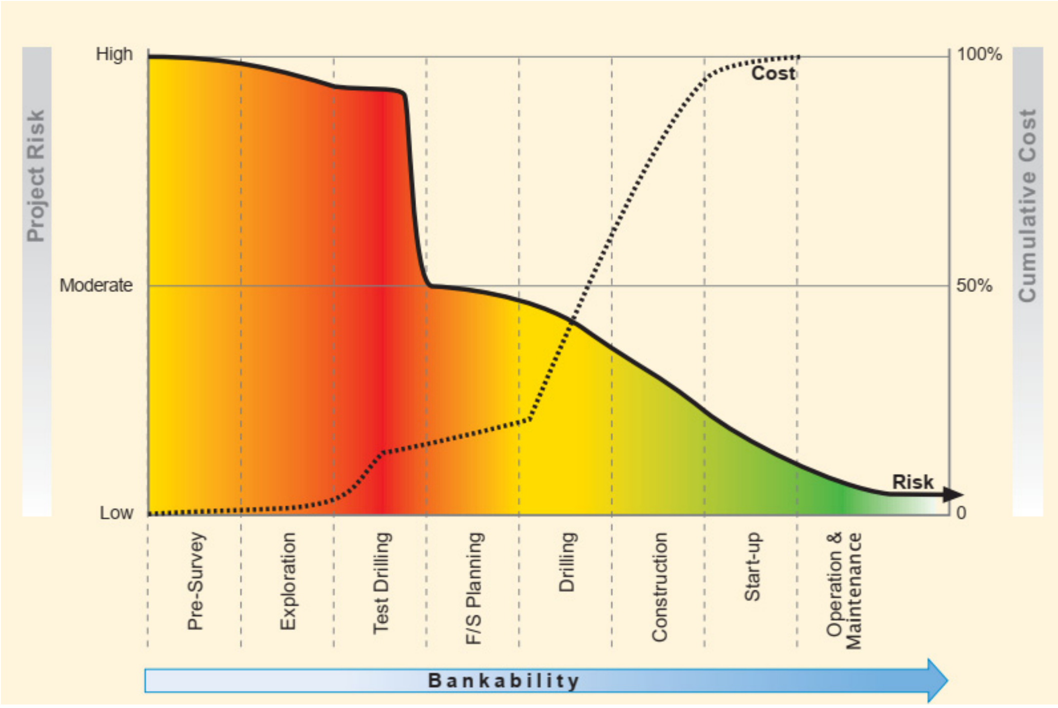

FIGURE 30: Project phases, costs, risk profile and bankability
(Gehringer and Loksha, 2012)

7.2.6 Project business model

Clark, et al.,2012 defined business model as the logic by which an enterprise sustains itself financially or simply, the logic by which an enterprise earns its livelihood. The geothermal industry just like enterprises is developed and operated in differing business models. The categorisation of geothermal business models varies depending on which party (public/private) funds which phase of the project.

International experience shows that varieties of operational models have been used around the world, and demonstrated that there is no single model for the development of geothermal resources. Gehringer and Loksha, 2012, indicated in Figure 31 eight different business models commonly employed in international geothermal power projects development.

As illustrated, the business models range from the fully private development, where the geothermal power project relies entirely on an independent power producer (model 8), to fully public, where only state-owned power utility /off-taker is involved (model 1). Any business model between the two extreme parties is referred to as the PPP arrangement covered in Chapter 2.

The study assumes Ngozi geothermal power project is transacted with the model 6, a PPP arrangement where an off-taker/contracting public authority de-risk the project through undertaking preliminary surveys, exploration and test drilling. Then, the private developer using private capital finances wellfield development, power plant design and construction, and operation of the wellfield and power plant. The model is very attractive to the investors as assumes little resource risk, however, the model raises the key concerns to the ownership and control of reservoir management.

In this case, the BOOT contract is used where the private sector entity finances the wellfield development, power plant design and construction, own and operate the plant and wellfield for a number of years, before transferring control and ownership back to the public sector.

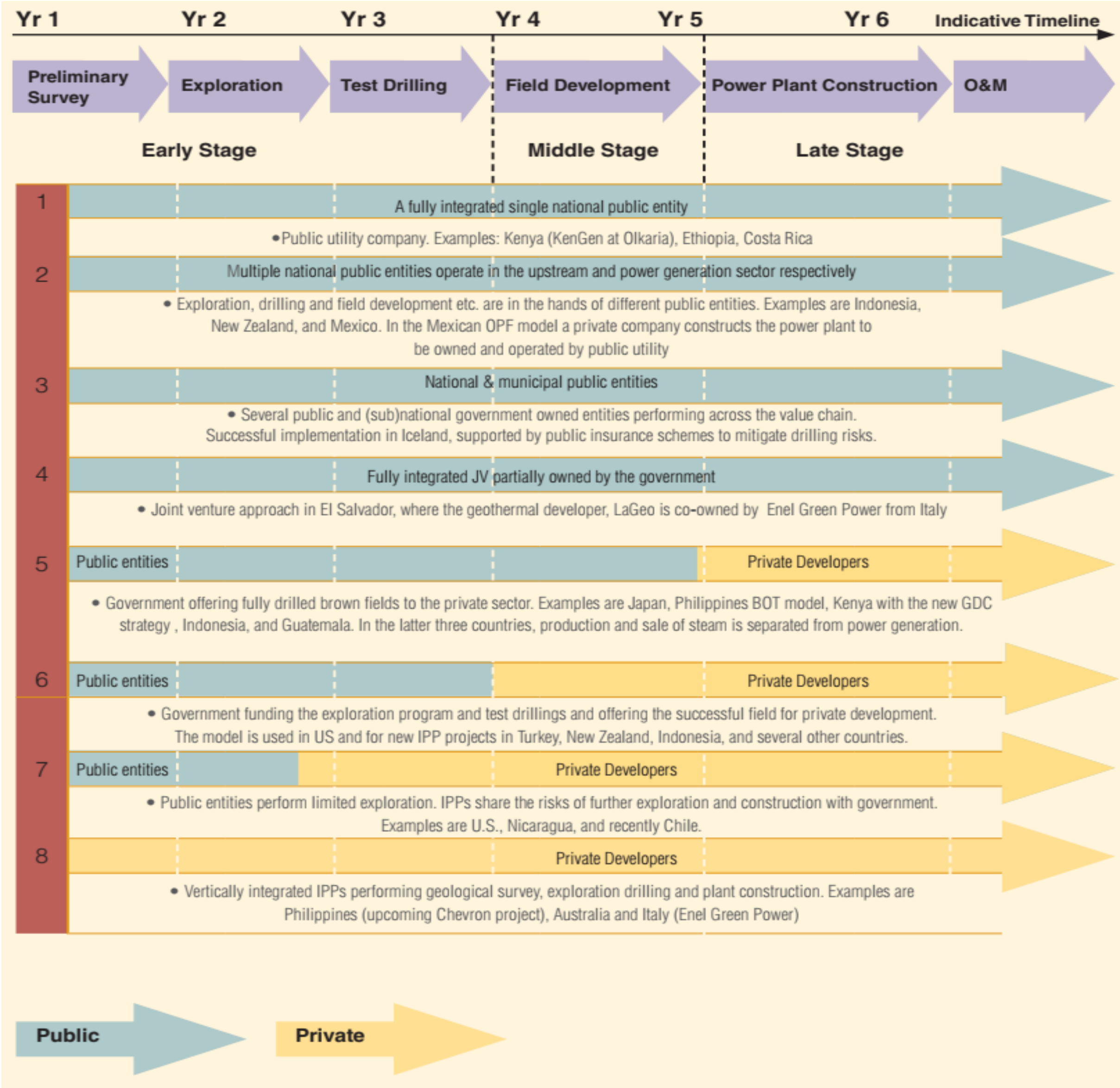

FIGURE 31: Models of geothermal power development in the world
(Gehringer and Loksha, 2012)

7.2.7 Geothermal power generating technologies

Based on the reservoir parameters established in Section 7.2.4, Ngozi prospect is classified as high temperature liquid-dominated geothermal field, thus the single-flash steam plant is suitable for geothermal energy conversion into electricity and is by far considered to be the mainstay of the geothermal power industry (DiPippo, 2016). The terminology *single-flash system* indicates that the geofluid undergoes a single flashing process, i.e. a process of transitioning from a pressurized liquid to a mixture of liquid and vapour as a result of lowering the geofluid pressure below the saturation pressure corresponding to the fluid temperature.

Figure 32 illustrates the main components of a single-flash steam plant and energy conversion systems where the geothermal fluids are extracted from the production wells, is directed into a separator, where the steam is separated from the liquid, the steam is expanded through a turbine process to produce electricity, and finally together with the separated brine, reinjected back into the reservoir in an effective and environmentally benign manner using the injection wells (Gehringer And Loksha, 2012).

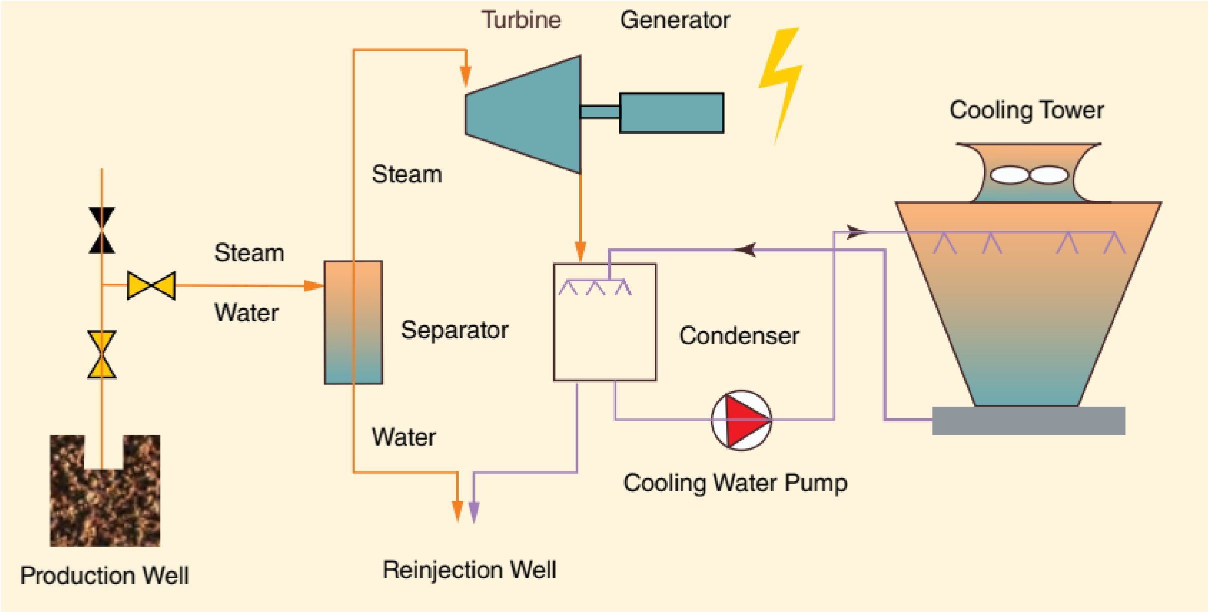

FIGURE 32: Simplified single-flash power plant schematic (Gehringer and Loksha, 2012)

7.2.8 Project components

The project business model in Section 7.2.6 establishes key project components which are used in project CAPEX estimation. The following key project components transacted with model 6 are shown in Table 4.

TABLE 4: Project components

No	Component name	Component description
1.	Field infrastructure	Construction of access roads and water reticulation system.
2.	Mobilization and demobilization	Deploying the contractor's drilling rig equipment, supplies and personnel to the project site and disbandment of the contractor to the place of origin.
3.	Wells drilling	Appraisal, production and injection wells drilling. The component also includes rig moves between pads and testing wells.
4.	Feasibility study	The hiring of third-party consultants to undertake the final assessment of the field.
5.	Steam Gathering Systems	Engineering, procurement and construction of steam pipelines and the separators.
6.	Power plant	Engineering, procurement and construction of a power plant with the turbine, generator, and the cold end, which consists of a condenser and needs either air (fan cooling) or water cooling (direct or by cooling tower).
7.	ESIA for drilling and power plant	Undertaking full ESIA for drilling programme and power plant construction.
8.	Annual permits	Covers all permits necessary to undertake the project from infrastructure development to power plant operation. i.e. generation license, health, safety & environment permit, water use and concession lease.
9.	Project management	All project development and consultancy work.
10.	Interconnection	Includes all components relating to connecting to the grid, such as the construction of transmission lines, costs at the substation, permitting costs with the utility and start-up costs.

The cost estimation of the key project components listed in Table 4 are established using a Monte Carlo simulation using @Risk package discussed in Section 5.4. The estimation technique helps to establish the project costs with all possible outcomes and the likelihood of occurrence.

7.2.9 Project Key Performance Indicators (KPIs)

The PPP project finance model extensively covered in Chapter 6 establishes the financial analysis of geothermal power project. Two types of KPIs are calculated in the model to establish the economic feasibility of a project namely economic KPI and financial KPI. As four different primary stakeholders are involved in PPP power projects, each different participant has different interests and therefore each focus on different KPIs (IRENA, 2017).

Further defining the KPIs, economic KPIs are used to assess the overall economic feasibility of the project. They are not impacted by financing structure and loan repayment schemes while the financial KPIs are used to assess more detailed financial risks and impacts on specific stakeholders, taking financing structure and loan repayment schemes into account.

IRENA, 2017 provided a KPIs overview related to the interests of different stakeholder groups as illustrated in Table 5. The colour code was used to highlight a focus of the stakeholder on the particular KPI. The deep red indicated the stronger focus of the group, lighter red indicates a more indirect interest and the white indicates no direct interest in the KPI under observation.

TABLE 5: KPIs and main stakeholder interests (modified from IRENA, 2017)

KPIs	Project sponsors	Lender	Off-taker	End user
Economic KPIs				
Project NPV				
Project IRR, ERR				
LCOE				
PP				
PI/CBR				
Financial KPIs				
Equity NPV				
Equity IRR, ERR				
ADSCR				
LLCR				
PLCR				

7.3 Summary of model project parameters

The summary of the project duration, financial, technical and OPEX parameters covered in Table 6 provide necessary inputs to the estimation of project capital expenditure (CAPEX) and the building of the project finance model.

Three-point costs estimation with a range of input cost parameters of optimistic, most likely and pessimistic are established in Table 7. The parameters are subsequently utilised in the Monte Carlo simulation and using PERT distribution the probabilistic costs of individual project components are established. The project CAPEX is calculated with a 90% confidence level.

TABLE 6: Project parameters (Ngugi, 2012; Gifford and Grace, 2013; Kalimbia, 2016)

Summary of key project parameters Date: June, 2019				
No.	**Categories**	**Component**	**Unit**	**Input Value**
1.	Project duration	Planning and construction phase (P&C)	years	5
		Operating phase (OP)	years	25
2.	Financial	Equity share	%	30%
		Debt share	%	70%
		Annual debt interest rate	%	6%
		Annual expected return on equity	%	10%
		WACC	%	6%
		Debt commitment fee	%	1%
		Debt up-front fee	%	2%
		Debt repayment period	years	20
		Grace period	years	2
		Price of electricity	\$/MWh	130
3.	Technical	Net electric power	MW	30
		Capacity factor	%	90%
		Operational hours per day	hours	24
		Operational days per year	days	365
		Annual production, Yr 1	MWh	236,520
		Annual plant production degradation	%	0.5%
		Ratio of plant capacity to thermal potential	ratio	0.9
		Thermal Resource Potential, Yr 1 (kW-electric equivalent)	MW	33
		Annual degradation of the thermal resource	%	3%
		Estimated well productivity	MW/well	5
		Total wells required for thermal resource potential	No.	7
		Ratio of injection to production wells	ratio	0.25
		Injection wells	No.	2
		Total wells required for 30 MWe power plant	No.	8
4.	OPEX	Steam field Fixed O&M Expense	\$/MW-yr	0.002
		Steam field Variable O&M Expense	\$/MWh	10
		Plant Fixed O&M Expense	\$/MW-yr	0.04
		Plant Variable O&M Expense	\$/MWh	22.5
		Royalties (% of revenue)	%	2.5%
		Insurance (% of Total Cost)	%	0.5%
		Project Management	\$/yr	50,000
		Reinvestment I (make-up wells) at year 9th	Million USD	5
		Reinvestment I (make-up wells) at year 17th	Million USD	5

TABLE 7: Range of CAPEX for probabilistic cost estimation
(TGDC, 2017; Ngugi, 2012; Kalimbia, 2016; Gehringer and Loksha, 2012)

Summary of three-point CAPEX estimation for PERT distribution - date: June 2019				
No.	**Component name**	**Range of input Parameters (Million USD)**		
		Optimistic	**Most Likely**	**Pessimistic**
1.	Field infrastructure	1.0	1.2	1.5
2.	Mobilization and demobilization	0.8	1.0	1.5
3.	Wells drilling	29.2	37.5	58.3
4.	Feasibility study	0.8	1.0	1.5
5.	EPC SGS	10.5	12.0	18.0
6.	EPC Power plant	45.0	54.0	75.0
7.	Interconnection for 8 km transmission line (approx.. 0.25 M$/km)	1.8	2.0	2.4
8.	ESIA full for drilling and power plant	0.2	0.4	0.8
9.	Annual permits	0.2	0.3	0.5
10.	Project management	3.0	4.0	8.0
Total CAPEX		**92.4**	**113.4**	**167.5**

8. DISCUSSION

The section covers the detailed individual analysis of the three building blocks of the project finance model namely key project inputs and assumptions, calculations performed in the model, and the model results which analyses the key findings from the investment project analysis. Furthermore, the project finance structure is summarised in accordance with the discussion of the three building blocks.

8.1 Model inputs and assumptions

The project capital structure with 30% of equity from shareholders and 70% of debt from the commercial bank was assumed to undertake the Ngozi geothermal power project. The lender required an interest rate of 6% per annum which is assumed to remain the same both during the 5 years of project construction and thereafter in the operation phase. The debt repayment tenor of 20 years with a grace period of 2 years was assumed for a 25 years project life. The debt repayment is furthermore assumed to be equally distributed throughout the debt tenor and the interest is calculated based on the remaining loan principal.

From the total debt commitment of 105 million USD, the one-time debt up-front fee of 1% and a debt commitment fee of 2% are calculated. The latter is charged for the debt committed but not drawn during construction as from the lender perspective, the commitment that is not funded represents a risky asset and must receive compensation with some kind of fee (Bodmer, 2015). Lastly, the lender's minimum DSCR, LLCR and PLCR of 1.3, 1.43 and 1.56, respectively, were specified.

The project CAPEX was established from Monte Carlo simulation whereas 10,000 iterations yielded a mean project CAPEX of 118.9 million USD as depicted in Figure 33. In order to proceed with a confidence level of 90%, the total project CAPEX yielded a total cost of 129.39 million USD which translates a project risk cost/contingency of 10.5 Million USD.

From the cost estimation above, the project generated a reasonable investment cost of 4.3 million USD per MW which fits within the industry range. The IRENA, 2017 report, estimated the range to fall between 2 and 5 Million USD/MW. The overall CAPEX as categorised in Table 7 is also expressed into a percentage of the overall installed costs of a geothermal power projects cost for each component.

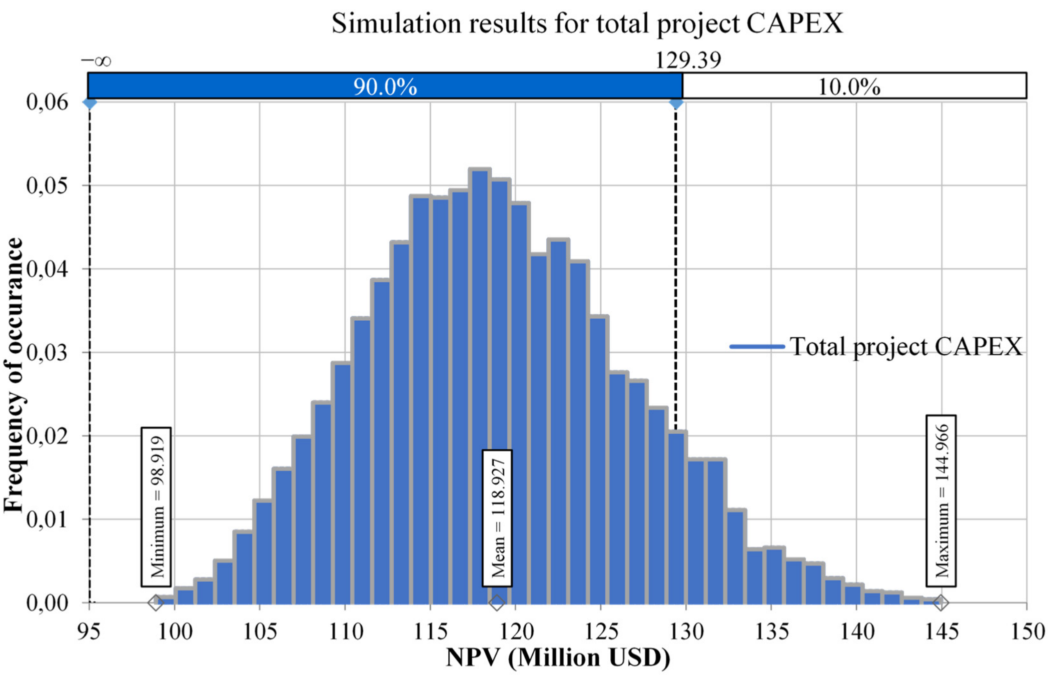

FIGURE 33: Histogram simulation results for total project CAPEX

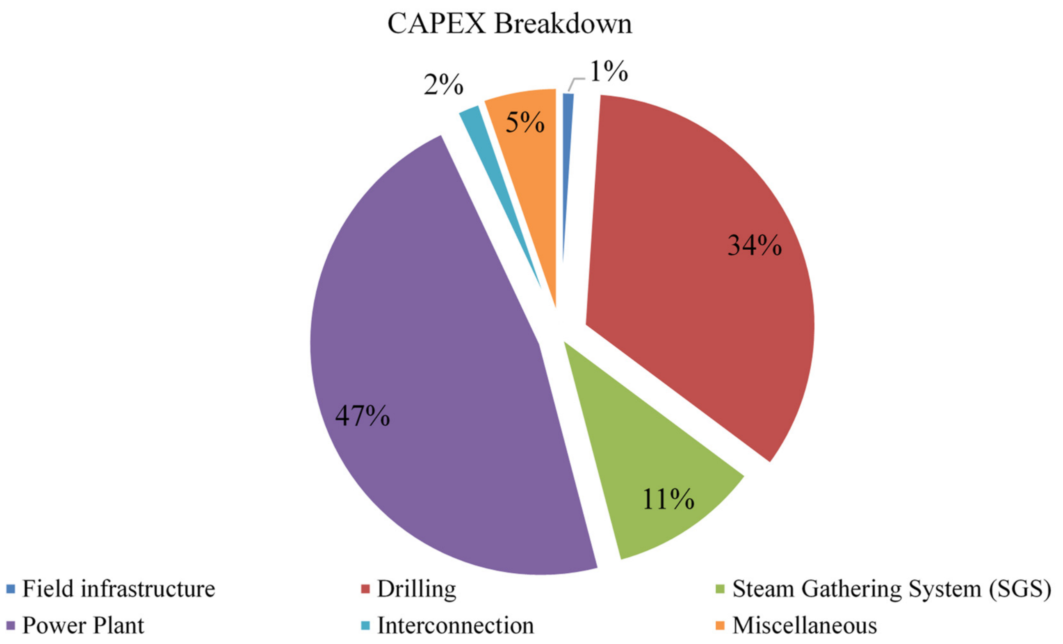

FIGURE 34: CAPEX breakdown

As illustrated in Figure 34, the power plant construction and wells drilling constitute the largest share to the overall cost of the project, where in this case more than 80% of the costs were used to fund the two components. This is a typical cost structure distribution for any geothermal power project where the power plant and drilling are the two largest components in terms of cost or value added (Gehringer and Loksha, 2012).

In order to be used in the model, the CAPEX components were categorised into buildings, equipment and miscellaneous costs. The CAPEX categorisation and their respective costs components are as shown in Table 8.

TABLE 8: Model project CAPEX categorization

CAPEX categorization	Components	Cost (Million USD)
Buildings	EPC Steam Gathering Systems (SGS), EPC power plant construction and interconnection costs.	70.8
Equipment	Field infrastructure, mobilization and demobilization, and wells drilling costs.	41.8
Miscellaneous	ESIA, annual permits, project management, project risk cost and feasibility study costs.	16.8
	Total	**129.4**

The project financing costs were optimized in the Excel workbook through cash account to meet the lender's fees, interest during construction costs and initial funding of reserve accounts. As per general rule, lenders typically require the establishment of DSRA, and MRA and working capital reserve account prior to the commencement of operations to ensure that loan repayments and all O&M expenses are met respectively.

The size of both reserve accounts were 6 months of debt service obligation and O&M expenses and working capital required. This together with the other costs established a total cost of 21 Million USD. The total project cost inclusive of financing costs totalled 150 Million USD.

In order to establish the annual expected power plant electrical energy output, the 90% capacity factor of a geothermal power plant in the year 1 was estimated to capture the maximum possible electrical energy output against the 30 MW nameplate capacity. Furthermore, an annual potential power plant degradation of 0.5% during the life of a project was assumed to account for the decrease of plant efficiency due to the ageing of equipment and other power plant infrastructure.

The geothermal power plant is sized to capture less than the maximum thermal potential available from the drilled wells. The 0.95 ratio of plant capacity to thermal potential was assumed. Therefore, with a power plant nameplate installed capacity of 30 MW, the ratio established a resource capacity electric equivalent of 33 MW to maximize the use of plant capacity as thermal resource potential degrades over time.

As geothermal resources degrade over time, the project assumed 3% of an annual degradation of thermal resource which initially estimated to be 33 MW electric equivalent in the year 1 of operation. The foreseeable depletion of the resource from the initial wells over time establishes the necessity of make-up wells to replace the lost thermal potential of the resource.

Figure 35 illustrates the resource potential and production profile where two make-up wells were drilled to boost the theoretical thermal resource potential and allow the power plant to produce within the stated capacity during the project's useful life. The make-up wells have a significant impact on the overall project cash flows.

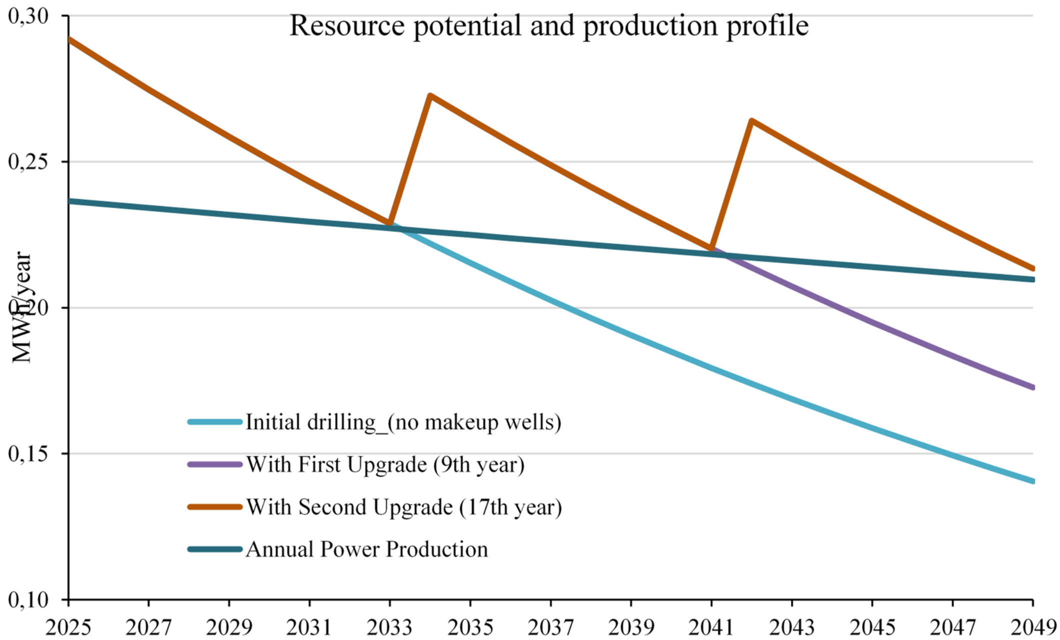

FIGURE 35: Resource potential and production profile

The other key financial input parameters used in the model are tabulated and briefly explained in Table 9.

8.2 Model calculations

The calculations in the model were performed in the separate worksheet in the same Excel workbook. The CAPEX and OPEX worksheet, investment and financing worksheet, three financial statements worksheets and profitability worksheets completed comprehensive calculations in the model. The details on the calculations are presented in the model itself. However, snapshots of the worksheets are shown in Appendices I – VI.

TABLE 9: Financial parameters

Financial inputs and assumptions	Input value	Explanation
Debtors (Accounts Receivable)	5%	Assumed percentage of days in a year where project revenue remained unpaid from the power utility i.e. from when an invoice is issued until it is paid.
Creditors (Account Payable)	10%	Assumed percentage of days in a year where operating costs remained unpaid to suppliers i.e. from when a receipt is received until it is paid.
Dividend	50%	The proportion of profits paid to project sponsors.
Depreciation	%	Depreciation rate established with accordance to Tanzania laws, 25% for building, 10% for equipment and 5% for miscellaneous assets.
Corporate Income tax	30%	Tanzania income tax rate.
Loss transfer	-	The model assumed allowance of loss transfer in corporate tax computation.

8.3 Model results and graphs

The free cash flows that are used in establishing most of the key performance indicators are calculated in the profitability worksheet in the model and the results of the analysis are presented graphically in the charts and graphs worksheet. Figure 36 depicts the calculated FCFP, FCFE and some of the key performance indicators in the model. The next subsections analyse the graphical results of KPIs in the model to establish the economic feasibility of a project for lenders, project sponsors and off-taker.

Project Key Performance Indicators(KPIs)		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029
Cash Flow after Taxes		3.0	2.0	5.0	5.0	6.0	19.9	20.5	20.5	20.5	20.4
Total project financing		32.0	35.3	30.4	26.8	25.6					
Free Cash Flow to the Project (FCFP)		-29.0	-33.3	-25.4	-21.8	-19.6	19.9	20.5	20.5	20.5	20.4
Cumulative FCFP	0	-29.0	-62.3	-87.8	-109.6	-129.2	-109.3	-88.8	-68.3	-47.8	-27.4
NPV of Project	6%	-29.0	-60.5	-83.2	-101.5	-117.1	-102.1	-87.6	-73.9	-61.0	-48.9
IRR of Project		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
ERR of Project		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Free (Net) Cash Flow		0.5	0.1	1.8	0.7	0.8	13.6	14.2	8.9	9.2	9.5
Total Equity		9.6	10.6	9.1	8.0	7.7					
Free Cash Flow to Equity (FCFE)		-9.1	-10.5	-7.3	-7.3	-6.9	13.6	14.2	8.9	9.2	9.5
Cumulative FCFP	0	-9.1	-19.6	-26.9	-34.3	-41.2	-27.6	-13.4	-4.4	4.8	14.3
NPV of Equity	10%	-9.1	-18.7	-24.7	-30.2	-34.9	-26.5	-18.5	-13.9	-9.6	-5.6
IRR of Equity		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
ERR of Equity		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1

FIGURE 36: Snapshot of calculated FCFP, FCFE and KPIs

8.3.1 Free project and equity cash flows

Figure 37 illustrates the cash flows of the investment project i.e. Free Cash Flow to the Project (FCFP) and Free Cash Flow to Equity (FCFE). The project cash outflows (with negative values) are observed in the five years of planning and construction phase.

Thereafter, the project begins to generate positive cash inflows as the project enters the operation phase in the year 2025. The project produces steady FCFP with a slight reduction due to degradation of power plant facilities till the year 2032. The significant decline is observed in the year 2033 and 2041 due to substantial reinvestment required to drill make-up wells. The decline of cash flows is also explained by corporate income tax payment which came in effect in the year 2035 to the end of the project life.

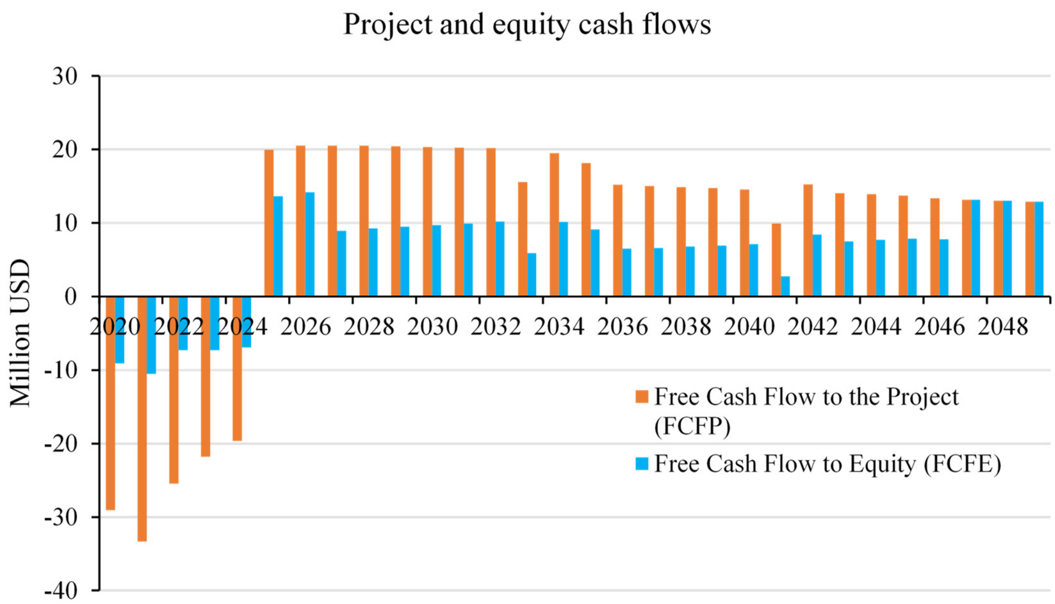

FIGURE 37: Project and equity cash flows

Similarly, the FCFE began generating positive cash flow in the year 2025, the sharp decline of FCFE is observed two years after the COD in the year 2027. The unique reason for the decline of FCFE was the expire of grace period which required commencement of debt repayment. As the debt become full repaid in the year 2046, the FCFE increased in the same proportional.

8.3.2 Accumulated NPV of project and equity

Figure 38 illustrates the accumulated NPV of the project and equity during construction and operation phases of the project. The graph shows the sharp increase of NPVs soon after the COD. As positive NPV demonstrates the viability of the project, the NPV equity became positive in the year 2031 with 1.4 million USD while that of the project in the year 2035 with 6.7 million USD. As the project reaches the last year of the operation in 2049, the NPV of the project becomes 62 million USD while that of equity amounts to 24 million USD which demonstrates that the power project is an economically viable project to undertake for both lenders and project sponsor.

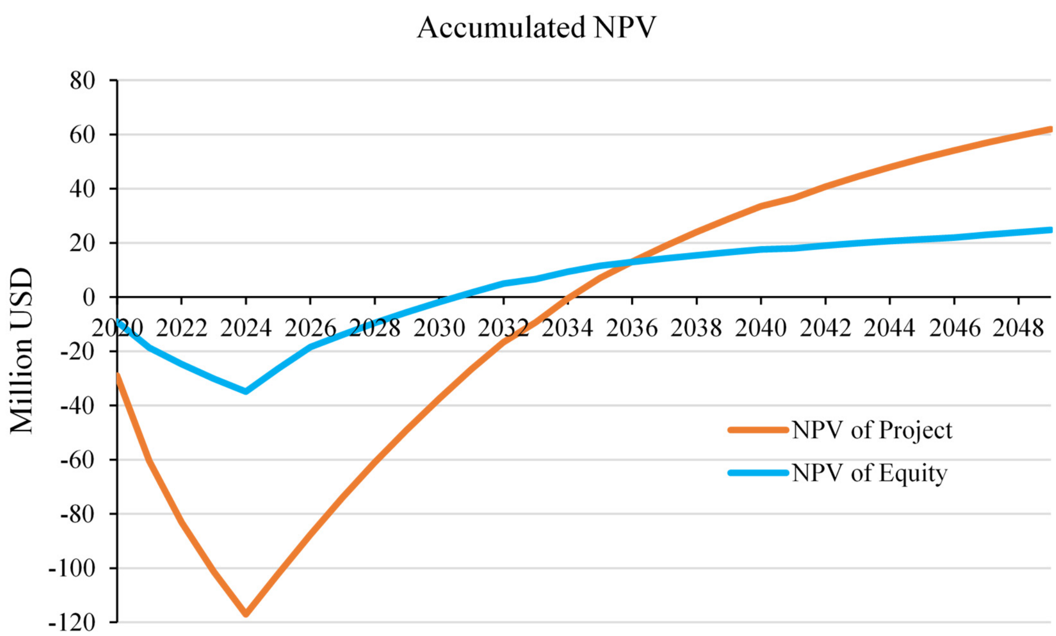

FIGURE 38: Accumulated NPV

8.3.3 IRR of the project and equity

Figure 39 shows the IRR of the project and equity during construction and operation phases of the project. The IRR of equity increased steadily from 2% in the year 2028 to 17% in 2049 whereas that of the project grew from 2% in 2031 to 10% in the last year of the operation in 2049.

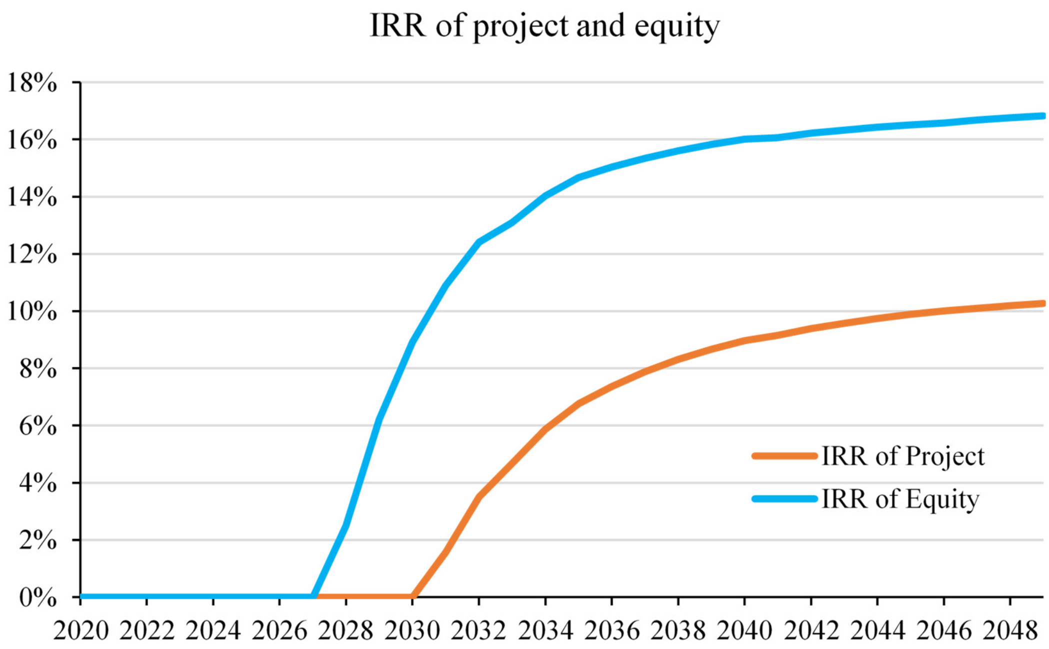

FIGURE 39: IRR of project and equity

The IRR of project and equity are compared with the WACC and an expected return on equity respectively to demonstrate the attractiveness of the investment project. Since the IRR of the project in the year, 2049 is greater than calculated WACC of 6% and the IRR of equity in the year 2049 is greater than the return on equity of 10%, the project investment is proven viable to both project sponsors and lenders.

8.3.4 ERR of the project and equity

Figure 40 depicts the ERR of the project and equity during construction and operation phases of the project. The ERR of the project rose marginally from 2% in 2030 to 8% in the last year of the operation in 2049. On the other hand, the ERR of equity, increased from 1% in 2027 and kept steady rise to 10% in the year 2034 and remained constant up until the year 2045 where it decreased to 9% in the last year of operation.

Similar to the IRR, the ERR metrics of project and equity are compared with WACC and an expected return on equity respectively to demonstrate the attractiveness of the investment project. Since the ERR of the project in the year 2049 is greater than calculated WACC of 6%, the project is attractive to the capital providers.

On the other hand, the ERR of equity in the year 2049 is less than the return on equity of 10%, hence as per decision rule, the project investment for project sponsors is not worth pursuing. However, the results are due to the underlying principle assumption of ERR calculation where cash flows are not reinvested with the same rate.

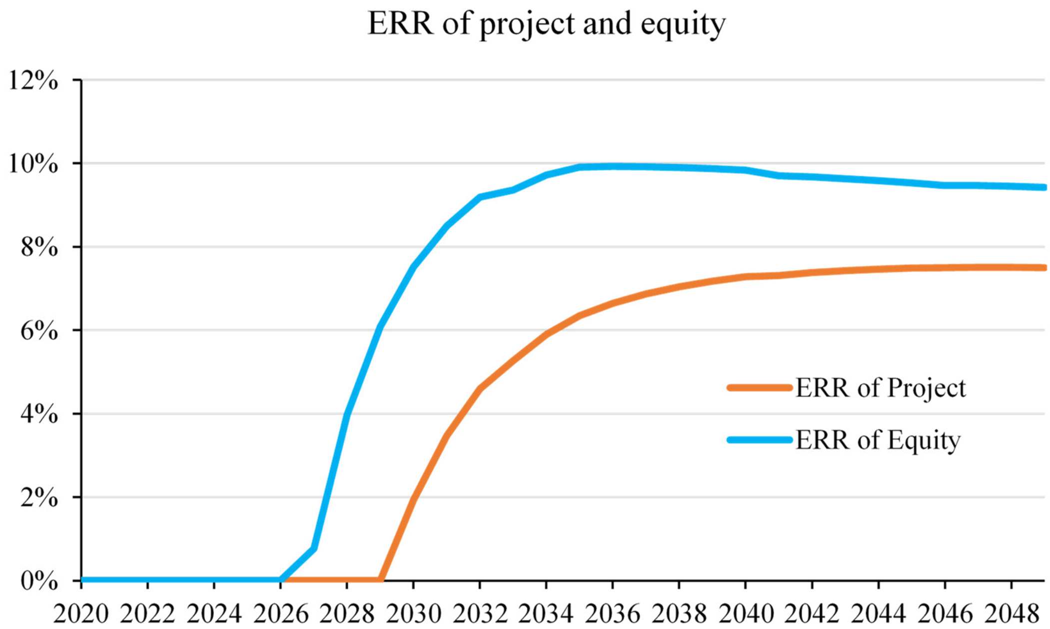

FIGURE 40: ERR of project and equity

8.3.5 Discounted payback period

Figure 41 displays the discounted payback periods determined for non-uniform annual cash flows of the project and equity. The payback periods were determined by comparing the investment outlay with the accumulated discounted cash flow. The cash flows for each year were added until the sum is equal to or greater than zero. The discounted cash flow to equity was 6.52 years (mid of 2030) and that of the project was 10.1 years (early 2034).

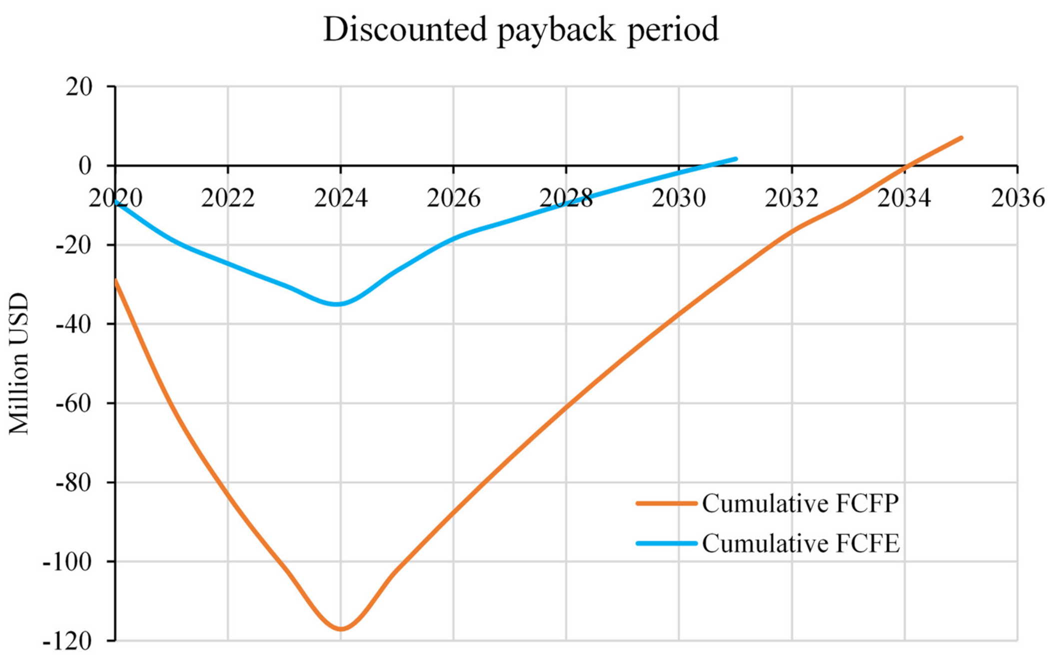

FIGURE 41: Project and equity discounted pay payback periods

8.3.6 Levelized Cost of Electricity (LCOE)

Table 10 illustrates calculations of the LCOE in the model. The project CAPEX, financing cost, and fixed and variable operations and maintenance (O&M) costs were incorporated in establishing the annual total cost of the project. On the other hand, the plant capacity factor and degradation of the power plant was integrated into establishing the annual energy production.

TABLE 10: LCOE calculation in the model

Levelized cost $/MWh		2020	2021	2022	2023	2024	2025	2026
Investment cost (Million $)		32.1	35.4	30.5	26.8	25.7		
Annual operating expenses							10.3	10.1
Depreciation							22.7	22.7
Project cost		**32.1**	**35.4**	**30.5**	**26.8**	**25.7**	**-12.4**	**-12.6**
NPV of project cost	6%	175.86						
Annual energy production (MWh)							0.237	0.235
NPV energy production	6%	2.9						
LCOE ($/MWh)		**60**						

The calculation ignored the effects of taxes on costs and yielded the LCOE of 60 $/MWh. Therefore, for this project to be economically feasible, the electricity tariff should always be higher than the calculated LCOE as the metric only provides an indication on the ability of the project to sufficiently cover the cost of the project. For this reason, the model PPA tariff was assumed higher than the LCOE. The off-taker in the PPP project requires this metric to establish sustainable tariff to charge the end-user.

8.3.7 Financial ratio analysis

a) Debt management ratio

The ratios establish the ability of a project to generate enough cash flow to repay a debt as falls due hence analysing the project's credit risk based on long-term solvency. The lender's minimum ADSCR, LLCR, and PLCR of 1.3, 1.43 and 1.56 respectively were specified.

Figure 42 illustrates the ADSCR > 1.4 and LLCR > 2.1 registered throughout the life of the project. Furthermore, the model calculated the PLCR of 1.9. All the three metrics indicated a strong capacity of cash flows to service the debt even after the original final maturity of the debt.

On the other hand, gearing, the ratio of borrowed funds to total shareholders' equity decreased from the initial project capital structure of 2.3 in 2024 to 0.3 in the last year of operation. This indicates a significant decrease in project default risk. The remaining small portion of the debt is due to the current liabilities.

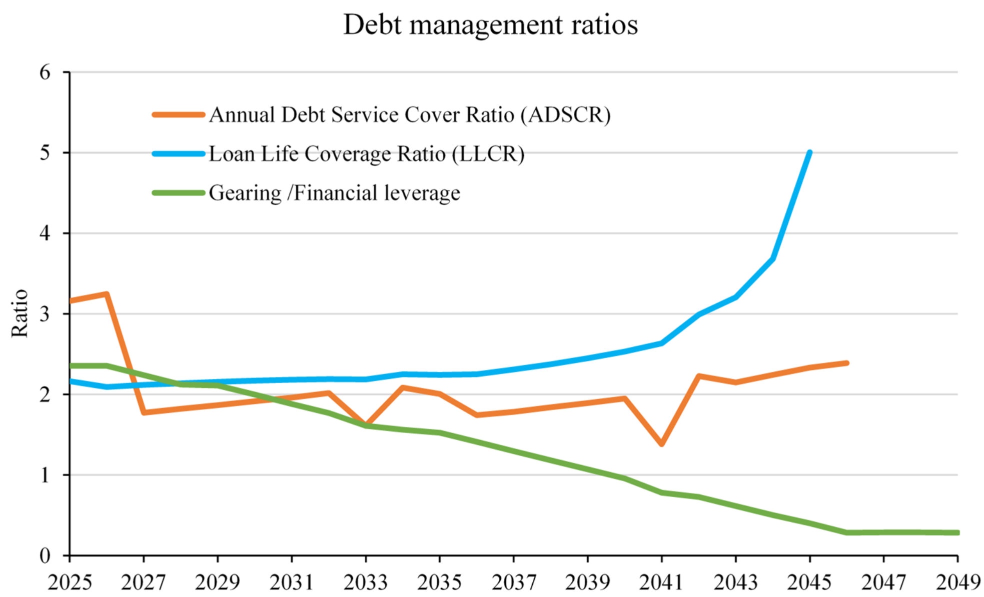

FIGURE 42: Debt management ratios

b) Liquidity ratios

Figure 43 illustrates two liquidity ratios i.e. cash and current ratios. As a geothermal power project assumes no existence of inventories, the quick ratio was not considered in the liquidity analysis.

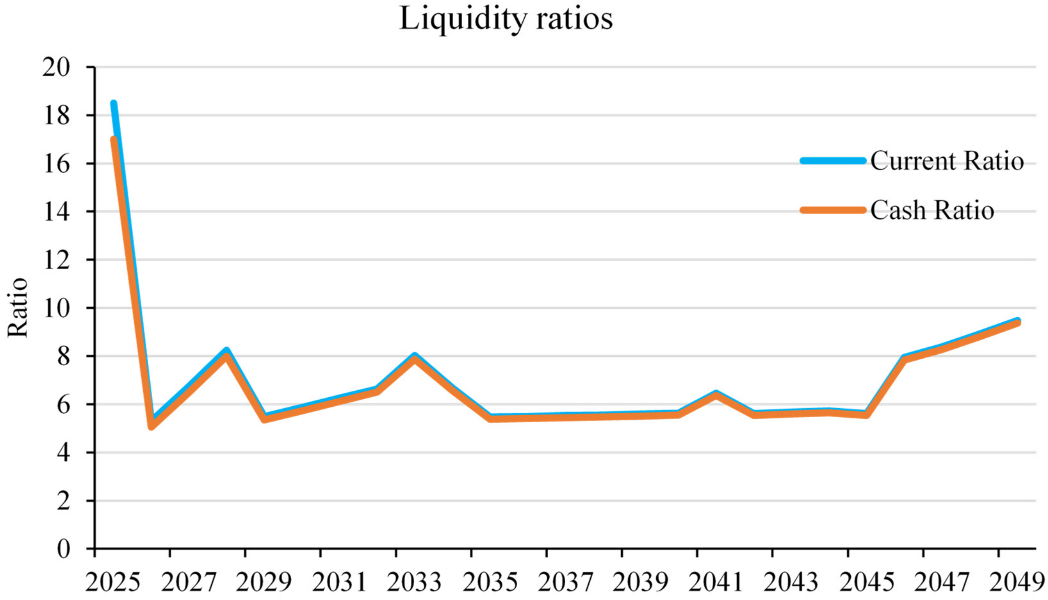

FIGURE 43: Liquidity ratios

Both ratios indicated sufficient current assets to meet the project's short-term liabilities as they fall due. The sharp decline of the ratios at the beginning of the project is primarily due to expire of grace period hence the requirement to pay for next year debt repayment. However, throughout the life of a project, ratios stood above the ratio of 5. Last three years, the ratios increased as the debt repayment is completed.

c) Profitability ratios

The ROI, ROE, net profit margins and operating profit margins demonstrated a similar trend on the project operating performance and returns on investment as shown in Figure 44. Similar to the project cash flows, the wells replacement drilling is vividly seen to negatively impact the profitability drivers. However, from the year 2029 to last year of operation, the project profitability metric demonstrated strong project performances and return on investment.

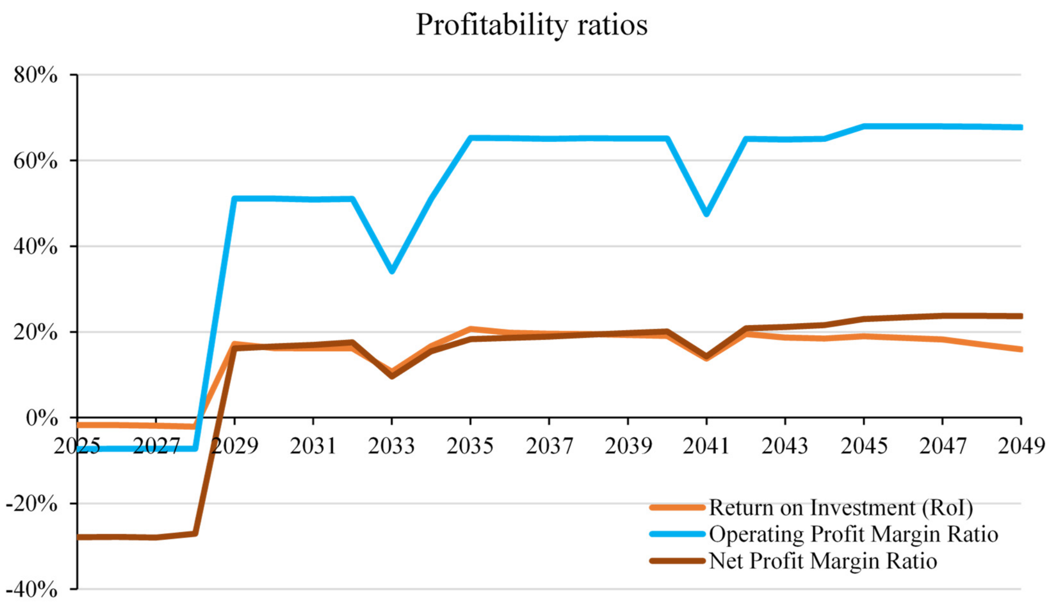

FIGURE 44: Profitability ratios

8.4 Project risk analysis

8.4.1 Sensitivity analysis

The project and equity NPV, and IRR of equity outputs were analysed against the likely changes of the key uncertain project input variables and underlying key assumptions namely buildings CAPEX, equipment CAPEX, electricity price, power production, plant variable O&M expenses and debt share. While the model established the whole analysis, this section discusses NPV and IRR of equity as the two evaluation criteria can have substantial impacts on the project sponsor's returns.

Figure 45 illustrates the analysis of NPV of equity where the price of electricity and power production are the two most sensitive parameters in the project. The decrease in the two parameters by nearly 20% makes the project infeasible.

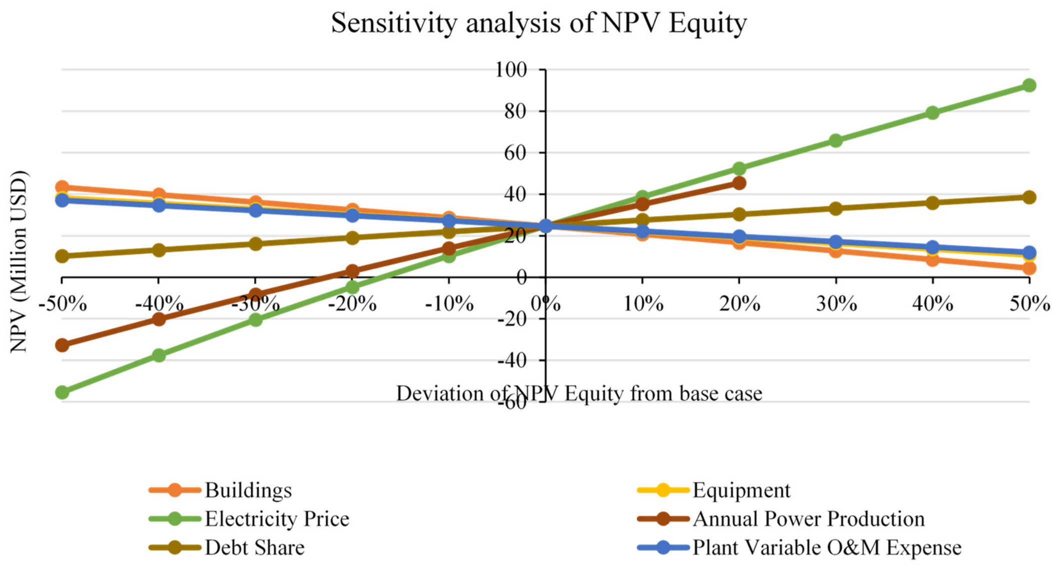

FIGURE 45: Equity NPV sensitivity analysis

The CAPEX of buildings and equipment followed by being sensitive however no significant impact on the NPV, as shown in the graph, even with a 50% increase of the CAPEX, the project produces positive NPV. Furthermore, the debt share and plant variable O&M expenses are the least sensitive inputs, the deviation of NPV by 50% both increase and decrease makes the project viable as NPV > 0.

Similar to Equity NPV, the sensitivity analysis of Equity IRR as shown in Figure 46 demonstrated the price of electricity and power production to be the most sensitive parameters. The decrease of two parameters by nearly 20% makes the project infeasible as produces Equity IRR of < 10%. The other parameters of buildings CAPEX, equipment CAPEX, plant variable O&M expenses and debt share are the least sensitive as the decrease or increase produces the desirable Equity IRR of > 10%.

8.4.2 Scenario analysis

The scenario analysis was performed on the project most sensitive parameters delivered from the sensitivity analysis i.e. buildings CAPEX, power production and electricity price. The model outputs tested involved of NPV project, NPV equity, IRR equity, ERR equity, ERR equity and ADSCR. The base case was of the model outputs were tested against the input variable extremes cases i.e. optimistic (best-case) and pessimistic (worst-case) scenarios.

As shown in Table 11, the pessimistic case makes the project infeasible for all the metrics under evaluation. Moreover, the ADSCR of 0.7 in the pessimistic case demonstrates the inability of cash flows available to service the debt. The optimistic scenario, on the other hand, produced positive desirable results of evaluation metrics to undertake the project.

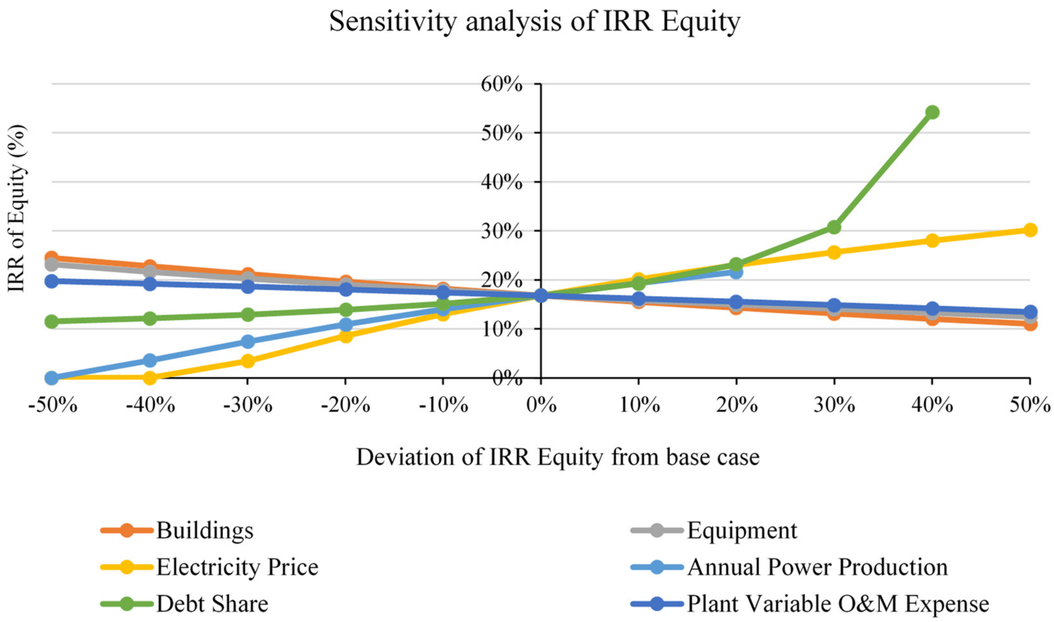

FIGURE 46: Equity IRR sensitivity analysis

TABLE 11: Scenario analysis summary

Scenario summary		Pessimistic	Base case	Optimistic
Changing cells:				
	Buildings CAPEX	110%	100%	90%
	Power production	90%	100%	105%
	Electricity price	77%	100%	115%
Result cells:				
	NPV equity	-22	25	56
	IRR equity	3%	17%	24%
	ERR equity	5%	9%	11%
	ADSCR	0.7	1.4	1.8

8.4.3 Monte Carlo simulation

The Monte Carlo simulations for NPV and IRR of equity were performed using @Risk package using the constructed deterministic project finance model. The probability distribution of the most sensitive project random variable was established from the completed sensitivity analysis. In this case, the study undertook the Monte Carlo simulation with the price of electricity on both the NPV and IRR of equity. Figure 47 depicts the histogram of simulation results for the NPV of Equity whereas 10,000 iterations of the price of electricity defined by the PERT probability distribution were sampled and recorded. The Monte Carlo simulation indicated a probability of 1.5% for the NPV of Equity to be ≤ 0, as per decision rule for the NPV, the results demonstrate to the project sponsors that there is 98.5% for the project to be financially feasible. Moreover, the histogram shows a 54.8% probability that the project meets the calculated deterministic Equity NPV of 24.4 million USD.

On the other hand, the histogram of Monte Carlo simulation results for the IRR of Equity is presented in Figure 48. Similar to NPV of Equity, 10,000 iterations of the price of electricity defined by the PERT probability distribution were sampled and recorded. The results demonstrated a probability of 58.5% that project attains the pre-calculated equity IRR of 17%. Similarly, the results demonstrate a 98.5% for the project to generate IRR of Equity ≥ 10% which is the project sponsors minimum required rate of return to demonstrate the financial feasibility of the project.

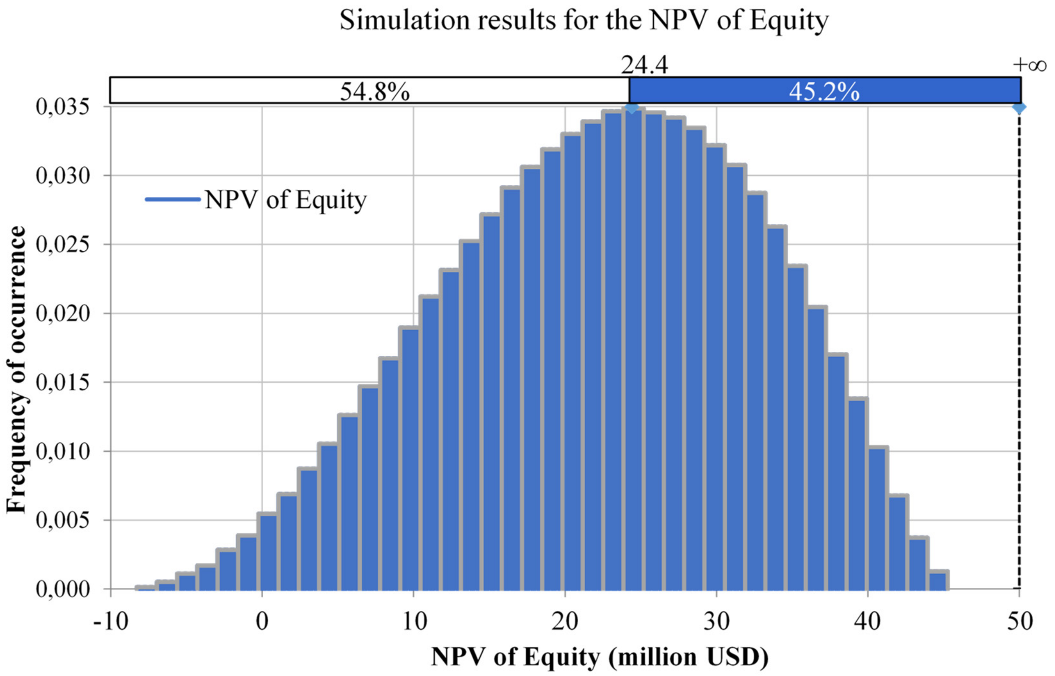

FIGURE 47: Histogram simulation results for the NPV of Equity

Conclusively, the Monte Carlo simulation results for both IRR and NPV of Equity demonstrated the robust feasibility of the investment project as both metrics indicated a 98.5% probability to meet the metrics decision rules. On the other hand, the results indicated a probability of > 50% to meet the pre-calculated IRR and NPV of Equity. In overall, the results demonstrate a greater likelihood of the project to generate sufficient cash flows under uncertainty of the price of electricity to meet sponsors commensurate returns.

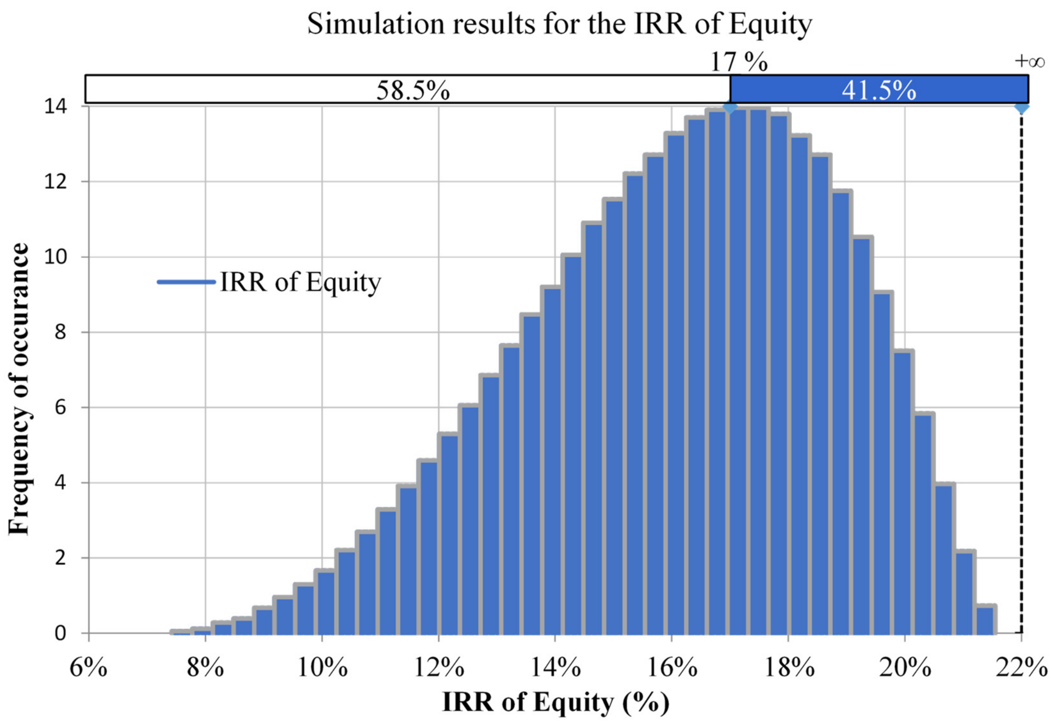

FIGURE 48: Histogram simulation results for the IRR of Equity

8.5 Project finance deal summary

To summarise, the project company in the power project finance generated total revenue of 724.3 Million USD from a $130 per MWh sale of 5.57 GWh of electricity to the off-taker for 25 years of project life. The breakdown of project funds to various project participants ranging from host government (in form of corporate tax), local government (royalty), project sponsor (cash account and dividend), project lenders (fees, interest and principal) and, suppliers and O& M contractors are shown in Figure 49.

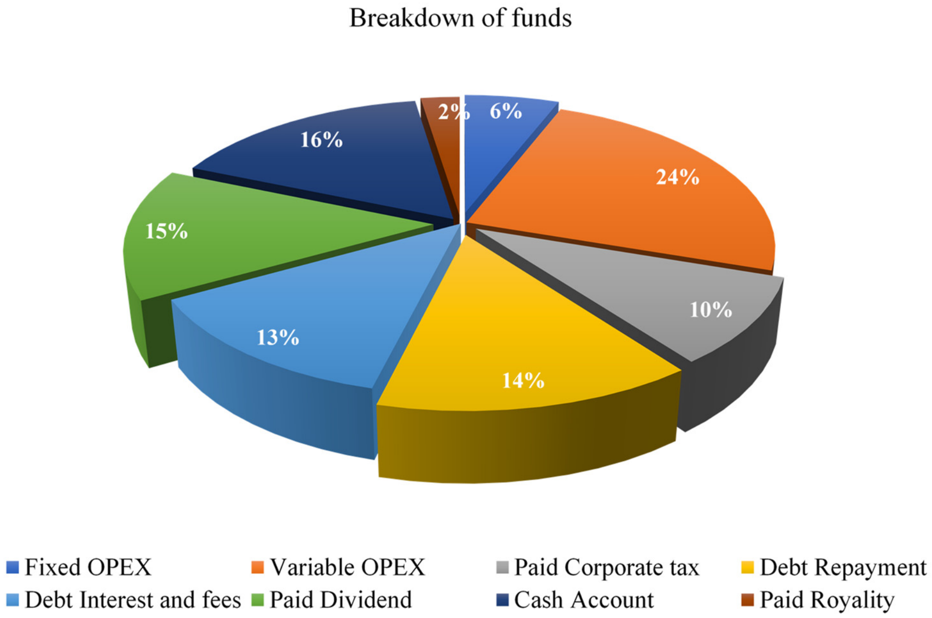

FIGURE 49: Breakdown of project revenue

Furthermore, the project cash allocation for the 30 years of project construction and operation is as shown in Figure 50. Throughout the phases the project generated sufficient cash flow to meet the financial costs obligation (fees and interest), repayment of the debt, corporate tax and payment of dividends to the shareholders. The chart also shows the cash movement change over the years.

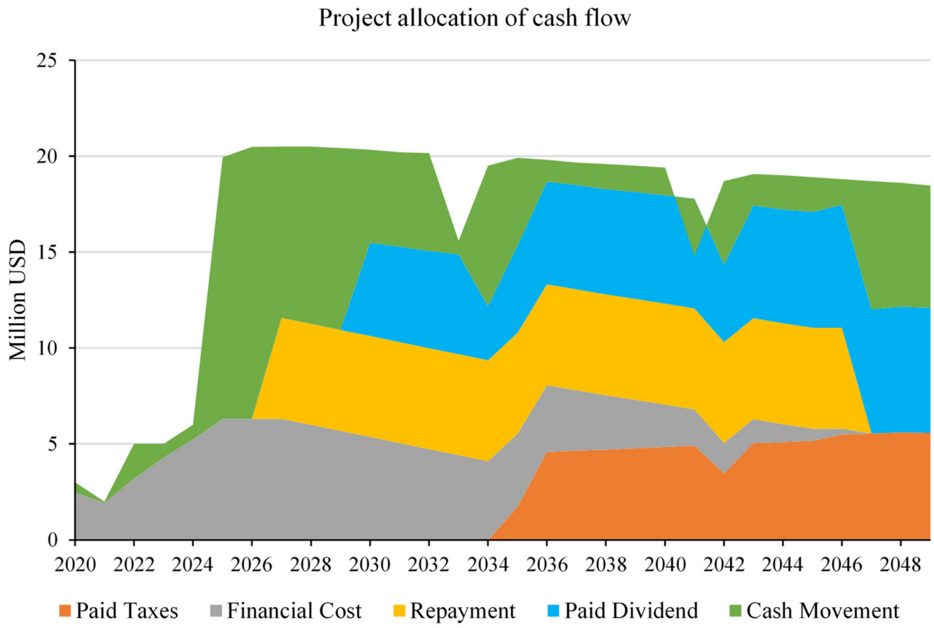

FIGURE 50: Project allocation of cash flow

9. CONCLUSION

Financial modelling is an indispensable task when undertaking a project transacted with project finance technique which entails the nonrecourse or limited-recourse nature of the financing where the capital suppliers are repaid only from the cash flow generated by the project. The project finance model constructed in this study provides a quick detailed analysis of the cash flow, subjected the analysis under a range of assumptions and scenarios to capture the risk associated with the model output. For a PPP power project, the model analysis amongst other things computed the key performance indicators that aid in decision making amongst the lenders, project sponsors and the country's off-taker. The geothermal PPP model involved public authority to de-risk the project through undertaking preliminary surveys, exploration and test drilling. The approach attracts private capital and generates lower CAPEX of the power project.

Notably, the model results in the discussion chapter demonstrated that Ngozi geothermal power project to be both economic and financially feasible project to implement as it generates sufficient returns to the project sponsors, demonstrated strong ability of the project to service debt payments from the cash flows and most importantly, a project provided an affordable price of electricity to the off-taker. The implementation of the power project is anticipated to realise Tanzania's desire to diversify the national grid electrical energy matrix away from the dominance of hydro sources and increase the share of reliable, low-cost renewable power to meet the country's electricity growing demand.

The primary objective of the thesis entailed building a project finance model and analysis of geothermal power project investment over its economic useful life was accomplished. The specific objectives were met through the pre-defined research questions summarized at the beginning of the study;

Question 1: What are PPPs projects and roles in power projects development?
PPP project involves an arrangement that integrates the commitment of resources from both public and private participants to implement a public infrastructure project. PPP plays a substantial role in attracting large-scale private capital in the power project investments in the form of project finance. In geothermal power project, PPP model is an attractive approach to power project sponsors particularly upon confirmation of the existence of the commercially viable resource. This is achieved through test drilling followed with undertaking a third-party feasibility study all financed with the contracting public authority. The de-risking of geothermal field is a compulsory step towards private capital financial close.

Question 2: What are the principles governing power project finance transactions?
The project finance provides commercial capital in the PPP power project under the nonrecourse or limited-recourse basis, off balance sheeting financing where lenders are repaid only from the project's future cash flows, or in the event of default, liability is largely limited to the value of the project assets. The bankability of the project plays a key role in attracting project finance funding for a new project. The bankability is loosely defined by two essential building blocks namely project viability and satisfactory allocation of risks between parties. The viability of the project explains the projectability to generate significant cash flows to servicing debt for creditors and provide a sound financial return to project investors. Furthermore, the rational risk allocation among public and private participants is in the heart of any bankable project finance deal. A new special purpose vehicle (SPV) with no previous history is incorporated for the sole purpose of owning, constructing and operating a project in the defined lifetime of a project. The SPV contracts third parties to perform construction and operation, and mostly importantly enters into long-term contractual arrangements with lenders, sponsors, host government and off-taker for lifetime implementation of the project.

Question 3: How to undertake risks allocation in geothermal power project finance?
Although not intensively covered in the thesis, risk allocation in the power project finance deal requires risks to be assigned to the party able to bear and control with the least cost. For example, in PPP power project finance, the host governments (or the off-taker) and project sponsors agrees on the workable risk allocation whereas project sponsors are best able to manage the risks that project is completed within budget and on schedule and that they will perform as technically specified and while the host governments manage economic and political risks. The violation of this general risk allocation principle

leads to a significant impact on project economics. The study assumed a rational risks allocation among the key risk takers.

Question 4: How to construct a project finance model for financial and economic analysis?
The project finance model is built based on the overall objective of an investment being analysed. For a power project investment analysis, the inputs are technology specifics and vary considerably, however, the model results desired, irrespective of technology being evaluated are the same. The model is constructed to be dynamic and structured in modular approach such that, formulas in the modules perform discrete operations within them and enable the logic flow through the model. This architecture makes the model understandable, easy to audit, robust and most importantly minimising the risk of errors model during the financial and economic analysis of the project.

Question 5: What are key financial and economic performance indicators for project finance deal in the investment appraisal of geothermal power?
The key performance indicators in a project finance deal covered both economic and financial KPIs which analysed the investment of geothermal power project. The economic KPIs calculated in the model include project NPV, project IRR, project ERR, LCOE, payback period and profitability index. These metrics are not impacted by the financing structure and loan repayment schemes. On the other hand, the financial KPIs included Equity NPV, Equity IRR, Equity ERR and the lender's ratios i.e. ADSCR, LLCR and PLCR.

Question 6: How to undertake financial risk analysis from the constructed project finance model?
The risk analysis in the model was performed using sensitivity analysis, scenario analysis and Monte Carlo simulation using @Risk. The analysis is carried to capture the uncertainty of the model's outputs to the possible variations set of assumptions and input values of the project. The results of sensitivity and scenarios analyses establish the downside variation of the project evaluation criteria output to the base case assumptions. The Monte Carlo simulation, on the other hand, produces a probability distribution of possible project outcomes and the likelihood of their occurrence. All three methods provide a sound project investment decision analysis under uncertainty.

Question 7: What are Ngozi field geothermal resource parameters and assumptions necessary to establish project development costs and modelling task?
Ngozi geothermal resource parameters are covered in Chapter 7. The primary geothermal features are thermal water discharges (up to 89°C) on the bottom of the Ngozi crater lake with the deep geothermal reservoir beneath with an estimated temperature of 232 ± 13°C. The P50 resource capacity was established using two methods namely log normal power density (then Cumming power capacity estimate) and Monte Carlo stored heat assessment with 33 MWe and 36 MWe respectively. The high-temperature liquid-dominated resource qualified for electric power generation and subsequently single-flash steam power plant technology suitable for geothermal energy conversion into electricity. These parameters together with the PPP transactional model establish project development costs, fundamental inputs to the financial modelling exercise.

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APPENDIX A: Optimization of financing costs

Investment costs:	Million USD	2020	2021	2022	2023	2024
Buildings	**70.8**	0.0	13.8	22.3	18.6	16.1
Equipment	**41.8**	25.0	16.1	0.1	0.1	0.5
Miscellaneous	**16.8**	4.1	3.5	3.1	3.1	3.1
Total Project CAPEX	**129**	29.1	33.4	25.5	21.8	19.7
Financing costs*:*						
Reserve Accounts costs, lenders fees and IDC	**21**	3	2	5	5	6
Total Project Financing:	**150**	**32**	**35**	**30**	**27**	**26**

APPENDIX B: Resource potential and power plant production (MWh)

		2025	2026	2027	2028
Resource Potential					
Resource potential degradation		0%	3%	3%	3%
Initial Drilling (no upgrades)		0.292	0.2832	0.2747	0.2665
With First Upgrade (9th year)					
Resulting Increase in thermal resource Potential (well productivity)	0.0438	0.292	0.2832	0.2747	0.2665
With Second Upgrade (17th year)					
Resulting Increase in thermal resource Potential (well productivity)	0.0438	0.2920	0.2832	0.2747	0.2665
Plant Capacity					
Production degradation		0.0%	0.5%	0.5%	0.5%
Plant capacity factor by year (%)		90%	89.6%	89.1%	88.7%
Annual Power Production (GWh)		0.2365	0.2353	0.2342	0.2330

APPENDIX C: Investment and financing worksheet

Investment and financing (Million USD)		2020	2021	2022	2023	2024	2025
Investment:							
Buildings		0.0	13.8	22.3	18.6	16.1	0.0
Equipment		25.0	16.1	0.1	0.1	0.5	0.0
Miscellaneous		4.1	3.5	3.1	3.1	3.1	0.0
Total investment		**29.1**	**33.4**	**25.5**	**21.8**	**19.7**	**0.0**
Booked Value of Fixed Assets:							
Buildings		0.0	13.8	36.1	54.7	70.8	53.1
Equipment		25.0	41.1	41.2	41.3	41.8	37.7
Miscellaneous		4.1	7.6	10.7	13.7	16.8	15.9
Total Booked Value		**29.1**	**62.4**	**87.9**	**109.7**	**129.4**	**106.7**
Depreciation expense:							
Depreciation Buildings	25%						17.7
Depreciation Equipment	10%						4.2
Depreciation Miscellaneous	5%						0.8
Total Depreciation expenses		**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**22.7**
Financing:							
Equity drawdown	30%	9.6	10.6	9.1	8.0	7.7	**45**
Debt drawdown	70%	22.4	24.7	21.3	18.8	18.0	**105**
Total		**32.1**	**35.4**	**30.5**	**26.8**	**25.7**	
Debt:							
Drawdown		22.4	24.7	21.3	18.8	18.0	
Repayment	20						
Grace Period	2						
Principal repayment	0	22.4	47.2	68.5	87.3	105.3	105.3
Interest	6%	0.0	1.3	2.8	4.1	5.2	6.3
Debt commitment fee	1%	0.8	0.6	0.4	0.2		
Debt up-front fee	2%	1.7					

APPENDIX D: Income statement worksheet

Income statement (Million USD)		2020	2021	2022	2023	2024	2025	2026
Annual power production							0.237	0.235
Electricity price							130	130
Revenue							**30.75**	**30.59**
Fixed OPEX_ Steam Field ($/MW-yr)	0.002						0.06	0.06
Variable OPEX_Steam Field ($/MWh)	10						2.37	2.35
Fixed OPEX_ Power Plant ($/MW-yr)	0.04						1.20	1.20
Variable OPEX_Power Plant ($/MWh)	22.5						5.32	5.30
Main Reinvestment makeup wells	5						0.00	0.00
Royalties (% of revenue)	2.5%						0.77	0.76
Insurance (% of total cost)	0.5%						0.53	0.42
Project Management	0.05						0.05	0.05
Total operating expenses							**10.30**	**10.14**
Operating Income (EBITDA)							**20.45**	**20.45**
Depreciation and Amortization							22.72	22.72
Earnings before Interest and Tax (EBIT)							-2.27	-2.27
Financial costs (Debt Interest and fees)		2.5	1.9	3.2	4.3	5.2	6.32	6.32
Profit before Tax (EBT)		-2.5	-1.9	-3.2	-4.3	-5.2	-8.59	-8.58
Loss Transfer		-2.5	-4.4	-7.6	-11.9	-17.1	-25.7	-34.3
Taxable Profit		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corporate Income Tax	30%	0.0	0.0	0.0	0.0	0.0	0.0	0.00
Profit after Tax		**-2.5**	**-1.9**	**-3.2**	**-4.3**	**-5.2**	**-8.6**	**-8.6**
Dividend	50%	0.0	0.0	0.0	0.0	0.0	0.00	0.00
Net Income		**-2.49**	**-1.93**	**-3.20**	**-4.29**	**-5.24**	**-8.59**	**-8.58**

APPENDIX E: Balance sheet statement

Statement of financial position (Million USD)		2020	2021	2022	2023	2024	2025	2026
Assets:								
Cash Account	0	0.51	0.59	2.39	3.10	3.86	17.48	31.61
Accounts receivable (debtors)	5%						1.54	1.53
Current Assets		0.51	0.59	2.39	3.10	3.86	19.02	33.14
Long Term Fixed Assets		29.06	62.41	87.89	109.71	129.39	106.68	83.96
Total Assets		**29.57**	**63.00**	**90.28**	**112.81**	**133.25**	**125.70**	**117.10**
Liabilities:								
Next Taxes Payable		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Next Year Dividend Payable		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Next Year Debt Repayment		0.00	0.00	0.00	0.00	0.00	0.00	5.26
Account Payable (creditors)	10%	0.00	0.00	0.00	0.00	0.00	1.03	1.01
Current Liabilities		0.00	0.00	0.00	0.00	0.00	1.03	6.28
Long Term Liabilities		22.44	47.19	68.53	87.30	105.27	105.27	100.01
Total Liabilities		22.44	47.19	68.53	87.30	105.27	106.30	106.29
Equity:								
Accumulated Shareholders' Equity	0	9.62	20.22	29.37	37.41	45.12	45.12	45.12
Accumulated Net Income	0	-2.49	-4.41	-7.61	-11.90	-17.14	-25.73	-34.31
Total Capital		7.13	15.81	21.76	25.51	27.98	19.39	10.81
Liabilities and Shareholders' Equity:		29.57	63.00	90.28	112.81	133.25	125.70	117.10
Error Check		0.00	0.00	0.00	0.00	0.00	0.00	0.00

APPENDIX F: Cash flow statement

Cash flow statement Million US$		2020	2021	2022	2023	2024	2025	2026
EBITDA		0.0	0.0	0.0	0.0	0.0	20.4	20.5
Accounts receivable change		0.0	0.0	0.0	0.0	0.0	1.5	0.0
Account payable change		0.0	0.0	0.0	0.0	0.0	1.0	0.0
Financing expenditure		3.0	2.0	5.0	5.0	6.0		
Cash Flow before Tax		**3.0**	**2.0**	**5.0**	**5.0**	**6.0**	**19.9**	**20.4**
Paid Taxes								0.00
Cash Flow after Tax		**3.0**	**2.0**	**5.0**	**5.0**	**6.0**	**19.9**	**20.4**
Financial cost		2.5	1.9	3.2	4.3	5.2	6.3	6.3
Repayment		0.0	0.0	0.0	0.0	0.0	0.0	0.0
Free (Net) Cash Flow		**0.51**	**0.07**	**1.80**	**0.71**	**0.76**	**13.62**	**14.13**
Paid Dividend								0.0
Cash Movement		**0.51**	**0.07**	**1.80**	**0.71**	**0.76**	**13.62**	**14.13**