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BUSINESS CASE OF NGOZI GEOTHERMAL POWER PROJECT, MBEYA, SW-TANZANIA

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ABSTRACT

The objective of the study is to present a preliminary business case of Ngozi high-temperature geothermal field for power generation. The field is ranked as the topmost promising prospect in the country and stands as a flagship project of Tanzania Geothermal Development Company (TGDC). The Ngozi high-temperature field has undergone copious geo-scientific studies since late 1970s at different level, the most recent one being in March 2016 in collaboration with Geothermal Development Company (GDC) of Kenya. Following the vulnerability to hydrology and adverse impacts of climate changes on the hydroelectric power generation, the Government of Tanzania is currently undertaking strong impetus to diversify the energy mix to attain a more robust and resilient modern energy supply to foster the desired socio-economic transformations. Thus, it intends to move the country closer to achieving middle-income status, as envisioned in the National Development Vision 2025. A number of electricity supply industry policies, reforms and implementation strategies are in place to recognise the mandatory requirement of developing geothermal resources and the power is anticipated to contribute up to 200 MW by 2025.

The preliminary preparation of this business case is therefore a humble attempt to highlight rudimentary issues in the development of Ngozi geothermal power project and will be used as a tool to subsequently make sound financial decisions on the further commitment of funds between 22 and 32 million USD in the exploration drilling phase to meet an attractive return on investment during exploitation of resource. The two risks, geological and financing, were seen to be much more prominent and require further mitigation measures in place prior to the execution of the project. The single-flash technology which is considered the mainstay of the geothermal power industry and by far the most installed power technology, was the chosen work cycle with two scenarios of project implementation strategy, namely directly a 50 MW power plant, or first building a 5 MW modular wellhead plant before building a 50 MW conventional power plant. The overall conclusion on the scenarios realised is that a step wise development of 5 MW modular wellhead plant then a 50 MW plant has lower risks, more technical and environmental benefits and reasonable financial returns. This is realised on the Net Present Value of 6 million USD with Internal Rate of Return of 16% on equity, hence a highly recommended sustainable development alternative.

1. INTRODUCTION

1.1 Overview of geothermal energy, development and utilization

Geothermal is derived from two Greek words '*geo*' meaning earth and '*therm'* meaning heat. Geothermal energy is therefore heat derived from the core of the earth as the result of reactions/decays of radioactive materials. On the surface, geothermal energy is usually manifested by the presence of hot springs, calderas, boiling grounds, fumaroles etc. The heat content of the resource usually dictates the type of geothermal resource utilization. Typically, high-temperature resources with temperature >200°C are used to generate electricity whereas low-temperature resources with temperature <150°C are mainly used for providing direct heat for numerous applications, such as space and district heating, water heating, aquaculture, horticulture and industrial processes, among others. Geothermal energy is considered a renewable resource because it exploits the earth's interior heat, which is considered abundant, and water, once used and cooled, is then piped back to the reservoir.

The scope of this project will however only be limited to production of electricity whereby several wells are drilled at a typical depth of 2000–3000 m into the reservoirs after comprehensive geoscientific surface studies to create enough steam and depending on the characteristics of the geothermal reservoirs, one of several geothermal electric production technologies is deployed to power turbines. The first geothermal electricity production is traced back to 1904 where an experimental plant installation was built in Larderello, Tuscany, Italy with a capacity of 15 kW (DiPippo, 2012). Now, 112 years later, a total of 24 countries in the world generate electricity from geothermal resources with a total installed capacity 12,635 MW with overall utilization 73,549 GWh/a **(**Bertani, 2015). The United States of America is by far the world leader in geothermal electricity production with an installed capacity of 3,450 MW while Kenya is the only African country among the world top ten electricity producers and currently holds eighth place with an installed capacity of 594 MW **(**Bertani, 2015).

Contrary to other renewable power generation technologies, geothermal power plants operate at a consistent base load power production level, twenty-four hours a day regardless of changing weather, seasonal variation and climate change impacts and providing a uniquely reliable and continuous source of clean energy. Geothermal power development is however characterized by a high capital investment for exploration, drilling wells, and plant installation, but operations and maintenance cost is relatively low, which makes the levelized cost of energy of geothermal power considerably lower than for other power generation alternatives. According to studies done and contemporary utilisation technology, geothermal energy has been proved to be a renewable, affordable, reliable and environmentally benign ("green") electricity supply. The other imperative advantage worth mentioning is the local cultivation of the geothermal resources of which its development brings significant economic advantages to local economies (Kalimbia, 2016).

1.2 Geothermal energy in Tanzania

Tanzania is one of the East African countries with indications of existence of high potential for geothermal energy resources. Most of the prospects are located in the Tanzanian part of the Eastern African Rift System, which has traversed the country in both eastern and western arms. The prospects are identified by their surface manifestations, mainly thermal springs. About fifty geothermal prospects have been identified in the country with a crude estimated potential of above 5,000 MW according to the National Energy Policy, 2015. The geothermal prospects are localized in four zones, these include:

(i) North-eastern Area: Lake Natron, Lake Manyara and Lake Mason;
(ii) South-eastern coastal area: Kisaki, Utete, Luhoi and Luhombero;
(iii) South-western area: Songwe River, Rukwa Trough, Kasumulo and Mampulo; and
(iv) Rungwe volcanic complex.

Despite this enormous resource base, geothermal energy remains undeveloped to support the desired socio-economic transformation in the country. It is along these lines the Government of Tanzania (GOT), embarked on a strong commitment to increase the country's development and utilization of geothermal power resources to subsequently improve the generation mix and meet increasing power demand through adopting a green growth pathway (Ministry of Energy and Minerals, 2013). In December 2013, GOT through Ministry of Energy and Minerals (MEM) established a 100% state owned agency, Tanzania Geothermal Development Company, Ltd. (TGDC) as a subsidiary company of Tanzania Electric Supply Company (TANESCO) with institutional mandate of expediting geothermal resource development in the country. The company became operational in July 2014. Since its inception, TGDC has acquired a total of eight prospecting licences in the country namely Ngozi, Luhoi, Kisaki, Lake Natron, Mbaka and Kasumulu.

1.3 Late development of geothermal energy in Tanzania

There are many reasons to explain the slow pace of geothermal development in the country. The most significant reason, which is accepted with geothermal experts worldwide, is the high degree of uncertainty at the early stage of exploration, which is accompanied by high upfront costs. Other factors include the previous stable and reliable hydroelectric power generation, which made the country not put emphasis on other renewable energies, discovery of abundant natural gas and later utilization in power generation, inadequate development of human capacity, industry underfunding and long lead times of geothermal power development. In other words, development of a geothermal field from the exploration phase to full conventional power plant operation (excluding wellhead generation) can take time ranging 5 to 9 years, hence doesn't provide a solution to the urgent demand for power. So, the establishment of TGDC has been the most positive initiative towards fast tracking realisation of geothermal development in the country.

2. MEANING OF A BUSINESS CASE

A business case may be defined as a formal, well-structured written document intended to convince a decision maker to approve some kind of action through exploring all feasible approaches to a given problem and enables project owners to select the option that best serves the organization (whatis.com, 2016). It is therefore a fundamental project management decision tool, which weighs all the risks, anticipated commercial benefits and savings to be gained in executing the particular project. The case lastly offers the best recommended option in a pool of alternatives to meet the desired output of the project.

2.1 Usefulness of business case

The usefulness of business case can be categorized in three groups (Pálsson, 2016) namely:

- *For managers and board of directors of the geothermal company* (in this case TGDC) which is typically referred to as business plan and used for internal decision making, prioritizing projects (portfolio management), ensuring that all critical aspects of a project preparation have been fully covered;
- *For financiers*, often referred to as bankable document, to ensure that money put into the geothermal power project is likely to be paid back;
- *For permit providers* (in this case Government of Tanzania), to ensure that the power will be online on time and in the right quantity, and that the resource will be used in a responsible and sustainable way.

2.2 Necessity of business case for TGDC

As a new player in the geothermal industry, TGDC is required to properly strategize utilization of its financial resources on the development and exploitation of geothermal energy to minimize the risks associated with exploration, development and utilisation, through analysing all the available options that will justify the feasibility of developing the resources in a particular way.

The development of a rigorous and comprehensive business case is one important step to engender business changes as well as demonstrate confidence and accountability to GOT and financiers on the ability of the company to meet its financial obligations. Therefore, the preliminary preparation of this business case is an important step to highlight the key project issues that will be used to provide the context for investment decisions in the next phase of exploration drilling in the Ngozi geothermal project and on whether to proceed, modify or abandon the project and in what forms.

3. PROJECT DESCRIPTION AND SCOPE

3.1 Project proponent

Project is being developed by TDGC with close collaboration of TANESCO, MEM and EWURA. For the purpose of co-financing arrangements, several external development partners will be involved in different phases of the project. Figure 1 below shows the position of the project owner in the electricity supply industry in the country.

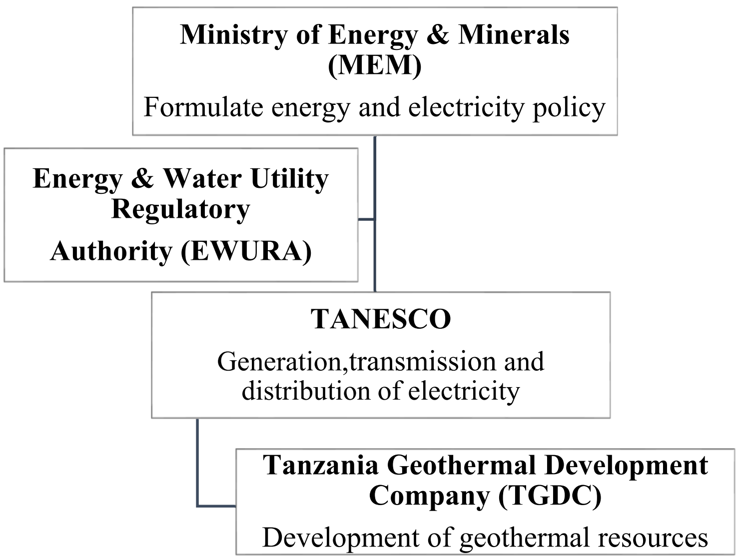


FIGURE 1: Position of TGDC in the country's electricity supply

3.2 Ngozi project location and overview

Ngozi geothermal field belongs to Rungwe Volcanic Province (RVP), situated directly south of Mbeya city with a population of 385,279 (National Bureau of Statistics, 2012), in SW-Tanzania at a triple junction of the East African Rift system as shown in Figure 2. The city is furthermore 822 km (tarmac road) northwest of Dar es Salaam, the country's largest commercial city. Mbeya city is also reached by air (1 hr 25 minutes) or TAZARA railway.

The Ngozi geothermal field is located 18 km from the existing Mwakibete substation with 220 kV transmission and 11 km from the proposed Igawilo substation (land acquisition process is going on and is in advanced stages) with transmission lines 400 kV / 220 kV / 33 kV. The site access requires full operation of a 4WD vehicle as the terrain is hilly and the roads are not paved.

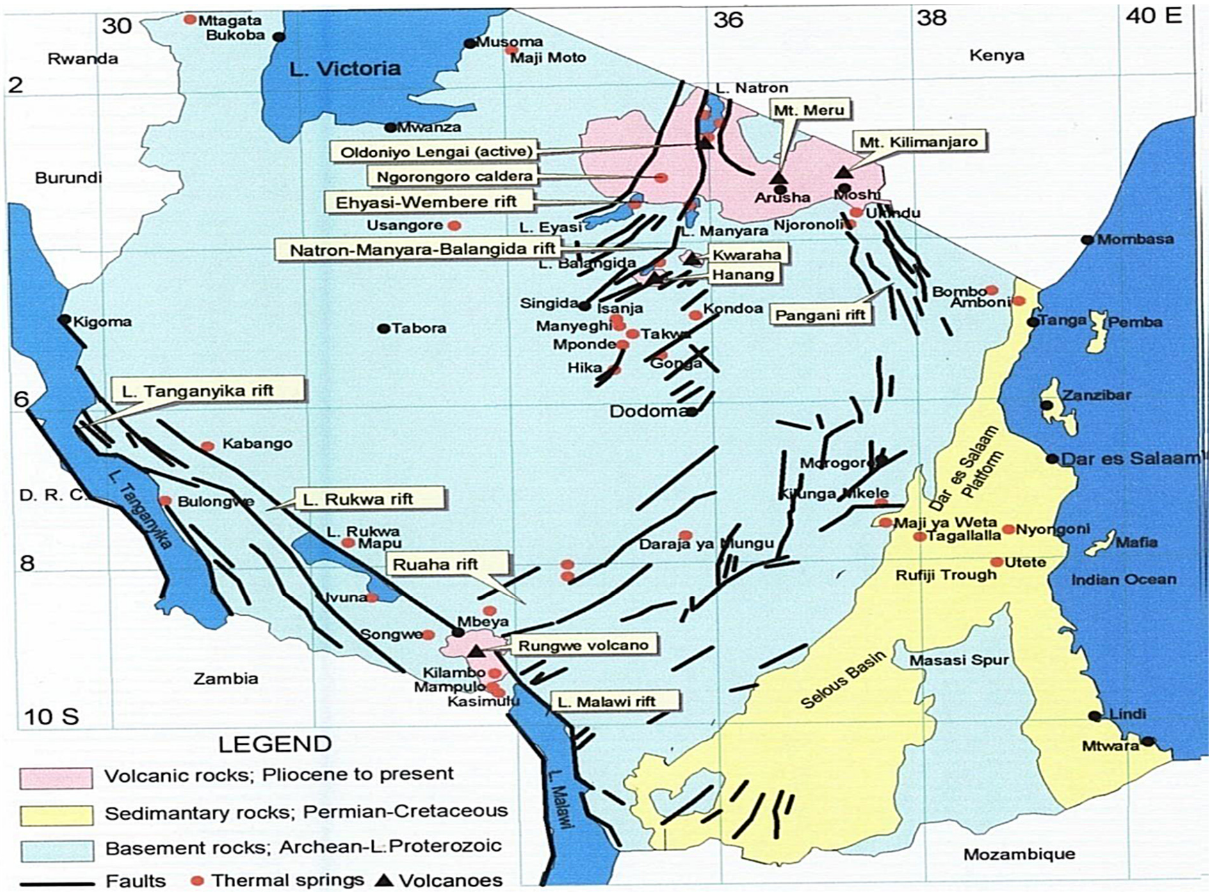


FIGURE 2: Location of Ngozi geothermal field, SW-Tanzania (MEM, 2014a)

3.3 Ngozi topmost geothermal field

Ngozi geothermal field is ranked as the most promising in the country and stands as a flagship project of TGDC. The field, as will be shortly explained below, has undergone copious geo-scientific studies since late 1970s at different levels. The most recent one was in March 2016 in collaboration with Geothermal Development Company (GDC) of Kenya, financed by Icelandic International Development Agency and United Nations Environmental Programme (UNEP).

The preliminary geo-scientific studies have indicated the magma chamber of the Ngozi volcano acting as a heat source for a high-temperature geothermal system with reservoir temperatures of more than 250°C, at >2,000 m depth. The active NW-SE trending faults are responsible for fluid flow in a north-westerly direction and based on fracture permeability. However, based on geology it is suggested that many structures in this region could be covered by the thick pyroclastic material, which is more than 250 m thick, and hence are not expressed on the surface.

Drilling of three exploratory wells is anticipated to start in the last quarter of 2017 and based on the results of flow tests from the exploration wells, the exact potential of the resource will be assessed to fully develop the resource. Table 1 describes competitive advantages of Ngozi geothermal field with respect to other geothermal prospects in the country, hence the *topmost project*.

TABLE 1: Ngozi geothermal field competitive advantages

S/N	Reason	Advantage
1.	Presence of adequate geo-scientific information from numerous previous studies.	Provide a baseline to commence detailed surface studies at medium cost.
2.	Geologically located in volcanic setting.	Possibly a high-temperature resource.
3.	Adequate source of drilling waters.	Easier drilling operations.
4.	Located close to the existing Mwakibete substation with 220kV transmission.	Low power evacuation cost.
5.	Presence of excellent infrastructure system, i.e. roads, airport, railway.	Easy to transport equipment and materials.
6.	Proximity of the prospect to Mbeya city.	Easy to access support services.
7.	Positive social acceptance of geothermal energy.	Slightly high level of awareness of geothermal energy development.
8.	Cold climatic conditions.	Suitable for numerous direct utilisations of geothermal heat.

3.4 Previous geoscientific studies

Ngozi geothermal prospect, like many other prospects in the country, has been actively subjected to preliminary reconnaissance and multidisciplinary surface exploration studies from different government agencies, development partners and private companies to precisely establish its geothermal potential. All of the studies carried out indicated the presence of a scientifically viable resource with additional recommendation of various geoscientific studies. The following are some of the documented exploration studies done in the prospect;

a) Swedish consultant group (SWECO) between 1976 and 79 in collaboration with VIRKIR, Iceland carried out geothermal exploration under financial support from the Swedish International Development Cooperation Agency (SIDA). The objective of the study was finding possibilities of exploiting geothermal recourses in Tanzania. The results were favourable, indicating good possibility of encountering high-temperature resources. However, the studies recommended further studies (Ministry of Energy and Minerals, 2014a).
b) Between 2004 and 2005, Tanzanian Rural Electrification Study (TRES) was conducted by the German company Deutsche Energie-Consult Ingenieurgesellschaft mbH (DECON), SWECO and InterConsult. Tanzania Electric Supply Company (TANESCO) was the implementing institution on the client's side. The African Development Bank (ADB) was the funding organisation of TRES. The study involved geophysical surveying (magnetic, gravity and resistivity surveys). In the study, geothermal energy, among others, was regarded as an indigenous, renewable energy source suitable for future electricity supply in Tanzania and recommended detailed assessment of Ngozi prospect in Mbeya (Mjokava, 2008).
c) GEOTHERM (Phase I, 2009 and Phase II, 2013) conducted a project titled "Geothermal as an alternative Source of Energy for Tanzania" in Ngozi prospect, Mbeya with the overall objective of locating geothermal areas favourable for development and to locate the drilling site. The project is part of GEOTHERM programme, which is a technical cooperation programme of the German government. The field campaign to Lake Ngozi-Songwe prospect involved geological mapping as well as geochemical and geophysical surveys. Based on the combined data evaluation from geological, geochemical and geophysical findings, locations of three temperature gradient wells were identified. The intention of these wells was to acquire better understanding the hydrothermal characteristics of the resource. However, the wells were not drilled.
d) Geothermal Power Tanzania (GPT), Ltd., a private company registered in 2012 in Tanzania, among others was licensed to explore and develop Ngozi geothermal resources. GPT was 70% owned by Geothermal Power Limited (GPL – registered in Mauritius), Interstate Mining & Minerals, Ltd. (Interstate, 25%) and National Development Corporation (NDC, 5%) (Geothermal Power, 2016).

Based on the previous GEOTHERM programme phase I and II, GPT planned supplementary fieldwork mainly for finding the best located and accessible drill sites and subsequently producing power depending on reservoir characteristics. However, the prospecting licenses were revoked one year later. In the eyes of the licensing authority, the license holder was found in default as the result of failing to meet obligations as stipulated in the country's Mining Act 2010.

e) Japan International Cooperation Agency (JICA) conducted reconnaissance satellite-based geothermal resource characterization study meant to assist in identifying promising geothermal sites to obtain fundamental information to consider the future contribution by JICA to geothermal development in Tanzania. Through utilisation of Monte Carlo analysis with 50% probability, the Ngozi geothermal resource potential was estimated to be 359 MW (JICA, 2014).

3.5 Ngozi preliminary resource assessment

The numerous previous geoscientific works had established preliminary resource capacity of the field, however, the most recent resource potential of 270 MW using the simple power density method within the delineated area of 18 km^2 northwest of the field has been established as shown in the Figure 3. The northwest area has been studied in detail and is so far considered as the most suitable area for exploration drilling and three wells were sited. On the other hand, little has been done on the southeast part of the field which provides the greater confidence of enlarging the resource of the field upon full completion of the detailed surface studies. Upon completion of drilling and obtaining results of flow tests from the exploration wells, the comprehensive characteristics of the reservoir and final estimate will be established.

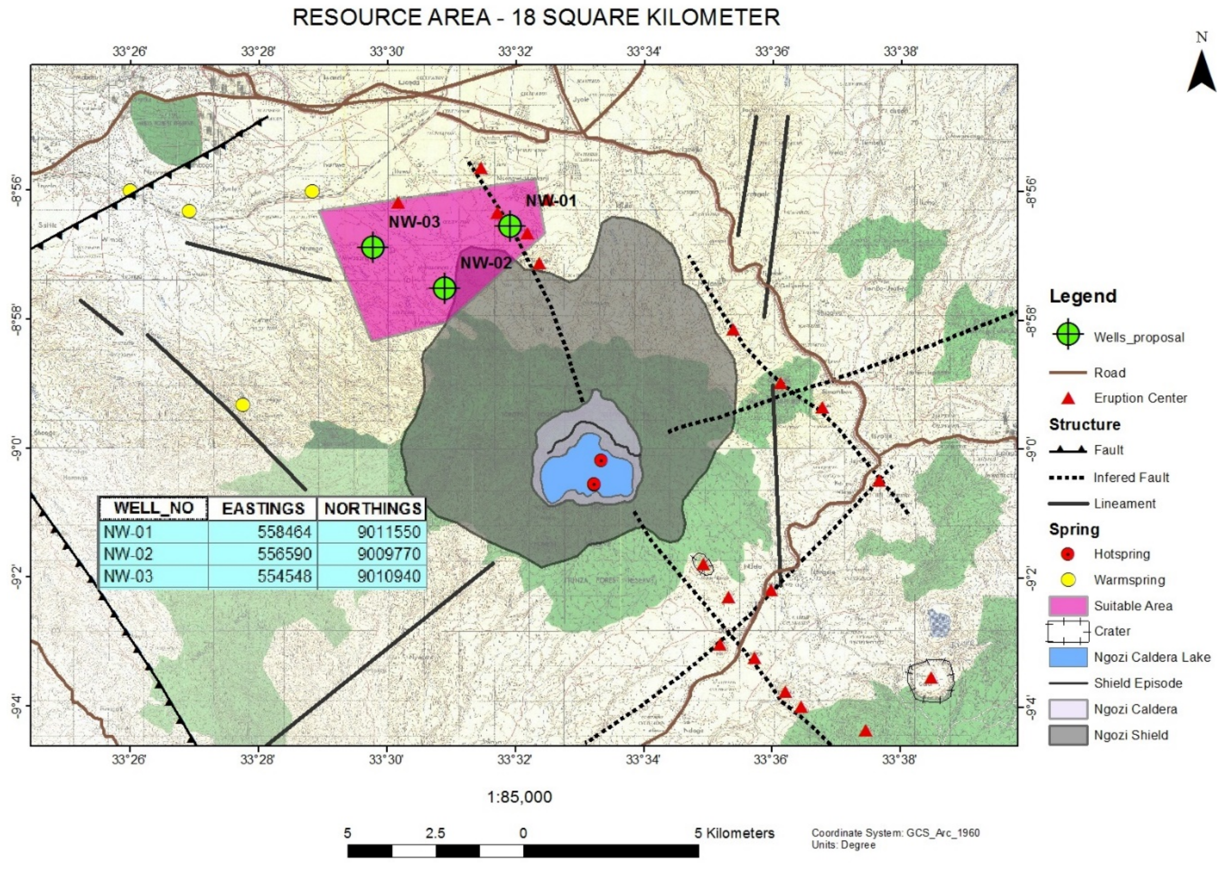


FIGURE 3: Resource estimates and preliminary drilling sites

3.6 Scope of the study

The scope of this project will be comprised of the technical, economic, financial and environmental viability of the project while assessing and managing potential risks associated with power development of Ngozi geothermal project. For the simplicity of this business case, single-flash power plant technology will be utilised under the following development scenarios:

- *Scenario 1* - building of a 50 MW power plant;
- *Scenario 2* - installation of a 5 MW modular wellhead plant, and thereafter building of 50 MW conventional power plant.

4. BUSINESS OUTCOME

Ngozi geothermal power project is aligned with a number of key social and economic governmental issues as well as the electricity supply industry policies that are expected to radically increase power demand in the country, which is also in parallel with the intention of embracing green energy growth and hence promoting environmental protection. The business outcomes are categorised into the groups and discussed below;

4.1 Key country issues and rationales

4.1.1 Social-economic issues

Tanzania has a total land area of about 945,203 km^2, with a total estimated population of 44.9 million. The current rate of population growth is 2.9% per year and it is estimated to reach 64 million by 2025 and 83 million by 2035 (National Bureau of Statistics, 2012). Today, about three quarters of Tanzanians live in rural areas, by 2035 it is projected that urban population will have increased, although rural residents will still constitute the majority of population. Along those lines, the government has put in place an action plan to accelerate access to electricity in rural areas implemented by both Tanzania Electric Supply Company (TANESCO) and the Rural Energy Agency (REA). These plans will significantly record a fast growth in demand of electricity in the rural areas. The country has furthermore registered a significant development in harnessing mineral resources amongst other planned developments, the move will contribute significantly to economic growth and increased energy demand.

4.1.2 Tanzania Development Vision (TDV) 2025

The TDV 2025 came into effect in 1999 with the aim of transforming Tanzania into a globally competitive, newly industrialized, prosperous and middle-income country with an economy achieving an annual per capita income of at least US$3,000 by 2025, from an income per capita of USD 640 (2014). It furthermore seeks to ensure a high quality of life to all citizens in a clean and secure environment by 2025. The vision recognises access to modern energy as the one fundamental prerequisite for proper functioning of the economy and other social settings. Socio-economic transformation can only be realised under the presence of adequate, affordable, reliable and environmentally friendly electricity supply.

4.1.3 The National Energy Policy, 2015 (NEP, 2015)

The policy provides a comprehensive legal and regulatory framework and institutional set up aimed at improving energy sector governance and performance. The policy recognises the fundamental role that the huge potential of renewable energy in the country can play. Among others, the policy has set an objective of enhancing geothermal resources governance and mitigating exploration and development risks. Among other things, the Government has guaranteed to establish institutional, legal and regulatory frameworks for geothermal development, encourage private sector investment in geothermal development, facilitate the availability of infrastructure for deployment of geothermal and develop a mechanism for public-private partnership in geothermal development.

4.1.4 International initiative for green energy

Presence of many initiatives from various development partners and international organisations in the world of green energy. Tanzania is not left behind on this, geothermal, being one of the environmentally friendly energy types, plays a greater role in demonstrating the country commitment in moving to this direction. The United Nations Sustainable Development Goal 7 (SDG7) is designed to ensure access to affordable, reliable, sustainable and modern energy for all. Developing the geothermal energy in the country is aligned with this goal and demonstrates the strong commitment of the Government of Tanzania towards turning the goal into reality. The presence of international financing windows to finance the risk party of geothermal industry in forms of grants and concessional loans and in-kind support provides an outstanding opportunity to accelerate development of the resource.

4.1.5 Electricity sector issues

- *Traditional dependence on hydropower, not healthy for achieving the desired socio-economic transformations:*
  As of May 2014, the grid installed capacity was 1583 MW composed of hydro 561 MW (35%), natural gas power plants of 527 MW (34%) and liquid fuel power plants of 495 MW (31%). TANESCO also imports power from Uganda (10 MW), Zambia (5 MW) and Kenya (1 MW) (Ministry of Energy and Minerals, 2014b). In the past two decades, the country has observed a dramatic disturbance in traditional hydropower generation caused by persistent and frequent droughts, hence extensive load shedding in the whole country. The situation forced TANESCO to enter into short term contracts with diesel based generation emergency power producers (EPPs) which have relatively rapid installation time, however are accompanied with a higher tariff per kWh and are environmentally unfriendly, hence bad for the country's economy. For instance, in 2013, TANESCO contracted EPPs which in total installed 317 MW capacity at a cost of 30-35 USc/kWh. The power crisis has accentuated the high risk of reliance on hydropower and consequently the fundamental need of diversifying power generation sources to mitigate the results of climate change.
- *Electricity supply and demand:*
  At present, only 24% of the Tanzanian population are connected to electricity whereby only about 11% of the rural population are connected to electricity services. Under this situation, the energy balance in Tanzania is dominated by traditional use of biomass in the form of charcoal and firewood. The government plans to increase the connectivity level to 50% by 2025 and at least 75% by 2033. On average, demand for electricity is growing at 10-15% per annum. The current peak demand is 935 MW which occurred on 12th December 2014 and it is projected to grow to 7,644.8 MW by the year 2025 according to the Power System Master Plan (2012 update). The low accessibility and affordable energy services is consistently identified as a major constraint in achieving desired socio-economic transformation in Tanzania, hence to foster the desired socio-economic transformation, universal access to modern energy services in an affordable, reliable, sustainable and environmentally-friendly manner is inevitable.

4.2 Strategic alignment

TGDC in close collaboration with the Government of Tanzania and TANESCO has made sectorial plans and reforms to develop geothermal power to meet the targets mentioned in Section 4.1 of this report. TGDC aims at developing geothermal projects and Ngozi has been prioritised as the first project. The company has furthermore aimed at strengthening the institution and building strong capacity in science, engineering, social and environmental know-how, and for that purpose, step wise phase development is preferred. The following are the two strategic alignments in developing the Ngozi project;

4.2.1 Additional 200 MW of geothermal power by 2025

As of June 2014, Ministry of Energy and Minerals (MEM) has developed the Electricity Supply Industry (ESI) reform strategy and roadmap, which proposes a rationale and a framework for the reform of Tanzania's electricity sub-sector in governance and performance for supporting the desired economic transformation, while protecting the environment. It aims at meeting the current and future demand for electricity, reducing public expenditure on ESI for operational activities, attracting private capital, and increasing electricity connection and access levels. The reform highlighted the optimistic commitment and deliberate move towards increasing the installed power capacity from 1,583 MW (April 2014) to at least 10,000 MW by 2025 as shown in Table 2 below, while the transmission and distribution systems are to be expanded. Renewable energy, geothermal of particular interest, has to inject 200 MW of geothermal power by 2025. Ngozi geothermal power project is anticipated to inject up to 100 MW.

TABLE 2: Present and projected installed capacity by year 2025
(Ministry of Energy and Minerals, 2014b)

Source	Current capacity	Additional capacity (2015 -25)	Capacity by 2025
Hydro (MW)	561	1,529.00	2,090.84
Natural Gas (MW)	527	3,968.00	4,469.00
HFO/GO/diesel (MW)	495	-	438.40
Coal (MW)	-	2,900.00	2,900.00
Wind (MW)	-	200.00	200.00
Solar (MW)	-	100.00	100.00
Geothermal (MW)	**-**	**200.00**	**200.00**
Interconnector (MW)	-	400.00	400.00
Total (MW)	**1,583**	**9,297.00**	**10,798.24**

4.2.2 Power System Master Plan (PSMP), 2012 update

TANESCO in collaboration with the Ministry of Energy and Minerals (MEM) is currently undertaking review of the PMSP 2012, among other reasons to tentatively reflect the future power demand and supply while considering all the available options to generate electricity in the country and moreover to increase the share of renewable energy in the national energy mix. Ngozi geothermal power project was the first power project to be considered in the plan to meet the future power demand in the country.

5. PROJECT PLANNING AND EXECUTION STRATEGY (HIGH LEVEL)

5.1 Project milestones

Tanzania Geothermal Development Company Limited (TGDC) in collaboration with geothermal exploration experts around the world is currently carrying out additional geo-scientific studies to fill in the gaps that remain so far. Upon results of the studies, the exploratory drilling decision to intersect the geothermal reservoir will be made. Drilling is expected to start in the last quarter of 2017. Based on the power production strategy, a power plant will be constructed and the timeline will be established. An overview of the proposed timeframe for project phases and major decision points are shown in Table 3 (mainly for scenario 2).

TABLE 3: Timeframe for each phase of the project

Project phase	Commencement	Completion	Remarks/status
Project preparation (surface studies & land acquisition)	July, 2014	May, 2017	On -going
Environment.& Social Impact Assessment (ESIA) study	May, 2014	June,2017	On -going
Major decision point			
Exploration drilling - mobilisation, site preparation, well construction, drilling and well testing	Q4, 2017	Q2, 2018	Projected (Scenario 2)
Major decision point			
Installation of well head power plant	Q2, 2018	Q4, 2018	Projected (Scenario 2)
Major decision point			
Additional surface exploration and reservoir study	Q1, 2019	Q4, 2019	Projected (Scenario 2)
Appraisal drilling and well testing	Q1,2020	Q4,2023	Projected (Scenario 2)
Feasibility study - evaluate geothermal resource	Q1, 2022	Q1,2023	Projected (Scenario 2)
Major decision point			
Steam gathering system construction	Q1, 2023	Q1, 2025	Projected (Scenario 2)
Power plant development construction	Q1, 2022	Q1, 2025	Projected (Scenario 2)
Power plant operation and maintenance	Q1, 2026	Q4, 2050	Projected (Scenario 2)

5.2 Project dependencies

Ngozi prospect is located in a very mountainous area with heavy rainfalls and slippery ground. It is, therefore anticipated that drilling will start during the dry season of the year i.e. from September 2017.

5.3 Project team

Apart from utilizing in-house experts, TGDC will deploy various experienced consultancies in the geothermal industry in the areas of surface studies. These include drilling supervision consultancies and drilling contractors, who will undertake drilling and testing of the wells, as well as Engineering, Procurement and Construction (EPC) contractor in power plant construction activities. Figure 4 shows the anticipated Ngozi project organogram for the drilling programme.

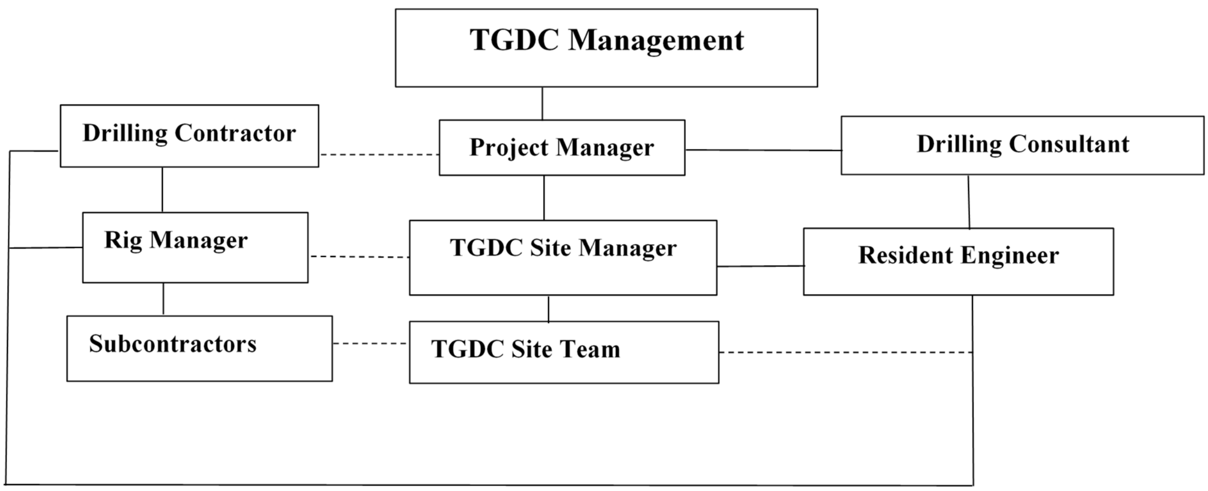


FIGURE 4: Proposed Ngozi organogram for the drilling phase

6. RESOURCE ASSESSMENT

6.1 Exploration strategy

TGDC in collaboration with consultancies undertook a review of available geophysical, geochemical and geological data and focused on analysing the quality of previous work and reports. The review report was then used as a baseline for additional survey plans for Ngozi geothermal prospect.

Following the completion of the above, TGDC has carried out additional studies to appraise the site and precisely locate the drilling sites. A combination of geo-scientific methods (geological, geochemical and geophysical) will be employed to gather information on the subsurface for better understanding the prerequisite characteristic of geothermal system (i.e. heat source, permeability, recharge mechanism and cap-rock). TGDC in collaboration with consultants will carry out additional studies in the following areas:

- **Geophysical studies**
  Additional geophysical studies with Transient Electromagnetic (TEM) and magnetotelluric (MT) methods to further reveal the existence of hidden structures and sub-surface resistivity anomalies. Both MT and TEM soundings are carried out at the same locality for static shift correction at shallow depth.
- **Geochemistry studies**
  Geochemical studies carried out involve the measurement of ground radon (Rn) and carbon dioxide (CO_2) radioactivity in numerous areas in the prospect. It will be furthermore include sampling of steam and gaseous discharge from geothermal manifestations, analysis of chemical parameters, rare earth elements (REEs) and isotopes. The analytical and isotopic results will be used to improve details of the underlying geothermal reservoirs.
- **Geological studies**
  Geological studies include additional lithological and stratigraphic studies, the volcanological evolutions, structural mapping, mapping of the manifestations and hydrogeological surveys.
- **Environmental and social baseline studies**
  An environmental social and impact assessment study shall be conducted to collect baseline information and assess potential environmental impacts and suggest mitigation measures that may arise from geothermal development.

6.2 Anticipated cost

Following the available data and previous geoscientific exploration, the anticipated cost of the activities is estimated to be 2 million USD. The cost has taken into consideration both previous level of geoscientific studies and ongoing studies.

7. DEVELOPMENT STRATEGY

7.1 Geothermal business model assumption

This is an approach on how the geothermal development can be undertaken and primarily involves deciding at which stage if suitable the private sector is engaged. There are numerous geothermal development models in the world, all variants lying between purely state-owned model, purely private owned or the participation of both parts under a Public-Private Partnership (PPP) or Joint Venturing (JV) arrangements. Options are not mutually exclusive, the decision is based on a balance of many factors including, but not limited to (i) development speed; (ii) price, cost and risk allocation; (iii) availability of funding; (iv) public entity development capability; (v) public entity cost recovery compared with risk profile; (vi) and the available private sector incentives (EAGER, 2015).

TGDC has not yet acquired a geothermal development business model, however, for the purpose of developing this business case, it is assumed that the company will be the power producer, that is to say, TGDC will undertake whole geothermal development value chain phases from reconnaissance to power plant construction and operation, hence carrying all resource risk. TGDC will have the entire control of the resource with the obligation of committing the large investment required to have the power online. The GOT anticipate to co-finance the project components in collaboration with development partners and other financing windows under which TGDC is eligible.

7.2 Power plant technology

There are mainly three types of power plant technology (work cycles) that are applied in electricity production in geothermal power plants. The work cycles are referred to as condensing (single-flash), back-pressure (atmospheric exhaust) and binary or twin-fluid system (organic Rankin cycle - ORC). For all suggested technologies, the spent geothermal fluid geothermal liquid is assumed to be reinjected into the reservoir through reinjection wells. However, out of the three work cycles, two technologies are the most common, namely, condensing cycle which utilises fluid from reservoirs with temperatures in the range of 200–320°C, and binary cycle which utilises fluid with temperatures as low as 120°C (Elíasson et al., 2011).

For development of this business case, the single-flash technology power plant technology, as shown in Figure 5, was considered in the development of two scenarios. The choice was merely due to two reasons, one being within the range of Ngozi anticipated reservoir temperature and secondly being by far the most common geothermal power plant work cycle employed in the world, as of 2015 a total installed capacity of 5079 MW has been observed (Bertani, 2015).

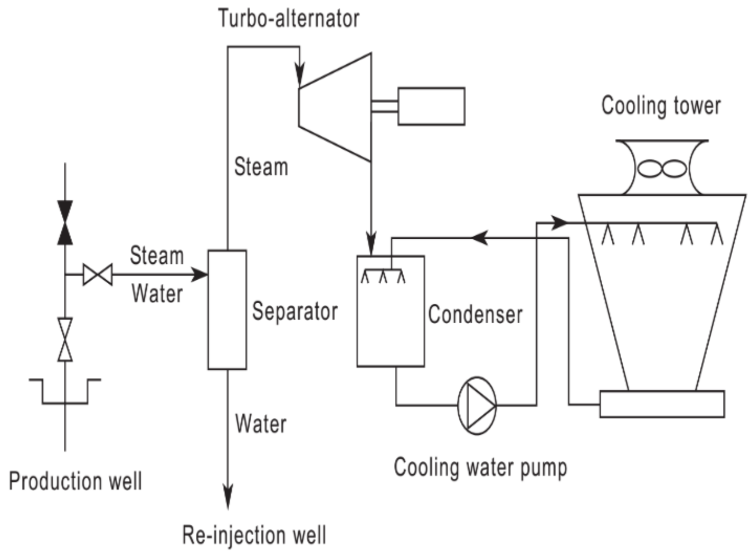


FIGURE 5: Simplified schematic diagram of single flash power plant (Hudson, 2003)

The technology is furthermore the most economical choice for high-enthalpy liquid-dominated resources. The single-flash technology is essentially thermodynamic improvement on the back-pressure design where before the steam from the turbine is being discharged to the atmosphere, it is discharged to a condensing chamber (Hudson, 2003). The two-phase flow of a geothermal fluid (a mixture of steam and liquid) is piped from the production well to the separator, where the fluid is separated from the steam. The liquid is disposed of into the reservoir through a reinjection well, the steam flows from the separator through a turbine and electrical power is generated in the generator, coupled to the turbine. The steam then enters the condenser, where it is condensed at sub atmospheric pressure. This condenser provides cooling with cooling water circulating through a cooling tower. The condensate is used as make-up water for the cooling tower to make up for losses due to evaporation and blowdown.

7.3 Power development strategy

Stepwise exploitation of a geothermal resource has proven to be a successful model of development in various part of the world. Power plants as small as a few tens of megawatts can be economically built and provide substantial understanding of the resource, hence sustainable extraction. Ngozi geothermal field is still not a very well-known site as no wells have been drilled. It is along these lines, the following stepwise power generation methodologies can be deployed.

7.3.1 Scenario 1 – a direct 50 MW power plant

This is the long term solution of power generation, upon successful drilling and testing of the first three exploration wells, drilling of appraisal wells shall be done followed by feasibility studies. A positive feasibility study will lead to drilling of production and reinjection wells to supply enough steam to generate 50 MW. A total of 15 wells are anticipated to be drilled and later a steam gathering system is to be constructed where the costs for the construction on a turnkey basis are estimated to be 0.4 million USD per MW (confidential communication). Under this scenario, the project is scheduled to commence operations in 2023. The power plant capital cost (excluding the wells) under EPC contractor ranges between 1.8 and 2.5 million USD per MW (Hallgrímsdóttir and Gudmundsson, 2016).

7.3.2 Scenario 2 – First a 5 MW wellhead plant then a 50 MW conventional power plant

This is the hybrid strategy made to generate early revenue from a wellhead unit before the construction of a 50 MW conventional power plant. The revenue will be directly reinvested during the construction period of the large plant. The wellhead units are positioned next to a production well pad and are supplied with steam from one the production wells. The units are installed after each well is drilled and tested. For TGDC to comprehend early power generation and first unlock the geothermal potential in the country, wellhead generation is anticipated to be one of the options as the plant can be installed in a matter of months, providing early return on investment and relieve the company from the long wait for the large conventional power plant development period.

Upon a successful drilling of full sized exploration wells and testing, a 5 MW portable wellhead unit will be installed. This will involve utilising one production well (one of the exploration wells), one reinjection well and utilization of single-flash technology to generate electricity. The steam gathering system shall be designed so that the well will be connected to the large power plant in the future. For a standard size power plant, a fixed price EPC turnkey budgetary pricing excluding wells is estimated to be 1.75 – 2.4 million USD per MW (Hallgrímsdóttir and Gudmundsson, 2016). Under this scenario, the project is scheduled to commence operations in 2019 with regards to the well head unit and thereafter the 50 MW power plant is anticipated to be online in the year 2026 hence totalling 55 MW of electricity.

8. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT

8.1 Potential environmental impacts in geothermal development

Geothermal power projects compared to other conventional power generation projects has proven to have less impacts on the environment. However, the phases of exploration and production drilling as well as power production may result in possible physical impact on the environment that surrounds the resource area, hence requiring mitigation measures. The impacts during drilling phase include flora, fauna, ecosystems and biodiversity disturbance – as a result of clearing vegetation, levelling of land surface, excavated materials and drainage requirements. During power production the main registered impacts are observed due to emission of *g*reenhouse gases *(*GHG) together with other minor rare possible impacts, including subsidence and induced seismicity. The established global weighted average of GHG for geothermal power plant is 122 g/kWh, which is still significantly lower than from fossil fuel plants (ESMAP, 2016). The implementation will furthermore have a significant social impact due to land acquisition, which will result in loss of ownership of agricultural land and relocation of people.

8.1.1 Overview of environment acts and requirements

Tanzania Environmental Management Act (2004) and the Environmental Impact Assessment and Audit Regulations of 2005 require mandatory EIA before the implementation of any development project. The regulation defines Environmental Impact Assessment (EIA) as a systematic examination conducted to determine, whether or not, a programme, activity or project will have any adverse impacts on the environment. In accordance with the law, Ngozi geothermal project falls under the projects, which require a full Environmental and Social Impact Assessment study.

The geothermal power development falls under clause 7 and 16 of energy and extractive industry, respectively, and requires mandatory undertaking of EIA studies. It furthermore requires TGDC as a project developer to undertake EIA at their own cost prior to major decisions and commitments on the financing of project or actual project execution in two phases of exploration and production drilling as well as power plant construction. National Environment Management Council (NEMC) is the main EIA authority in the country with institutional mandate to undertake the review, monitoring, enforcement and compliance activities for EIA and facilitates public participation. The environmental impact assessment and audit regulation has highlighted key steps to embark on and satisfy the awarding of an environmental certificate. TGDC shall in the first place register the project to NEMC for screening, undertake scooping exercises, and conduct impact analysis and finally implementation of mitigation and impact management. Upon finishing, the comprehensive report is submitted to NEMC for decision.

8.1.2 Overview of land acquisition and resettlement

Project development will involve a significant amount of land for operations, therefore resettlement will be necessary and hence composition will be involved. The entire process is guided by Tanzania Land Acquisition Act 1967 and Land Act number 4 & 5 of 1999.

8.2 Current status on Ngozi environmental impact assessment

As per law requirements, TGDC has initiated a process to acquire the EIA certificate to successfully undertake exploratory drilling at the last quarter of 2017. NEMC registered Ngozi geothermal project with number 4711. The hired local contractor in collaboration with TGDC technical, environmental and social experts undertook the scoping exercise and the comprehensive report was submitted to NEMC. The report a.o.t. provides decision makers with useful information towards predicting the impact severity and determines the level of ESIA required. Upon reviewing NEMC recommended further Environmental and Social Impact Assessment, which is anticipated to take place as soon as precise final drilling sites locations have been established. The environmental certificate will enable TDGC to proceed with drilling of exploratory wells and further the construction of power plants.

9. STAKEHOLDERS AND COMMUNICATIONS

Geothermal energy is not among the more known sources of energy in Tanzania, despite significant economic and environmental benefits from developing geothermal energy, a low level of awareness of industry is observed across all stakeholders. It is along these lines, that TGDC is obliged to map all the project stakeholders to comprehensively understand their connections and interest to the project, hence helping in identification of the key objectives of engagement or communication to raise awareness of geothermal energy exploration, development, utilisation as well as environmental benefit of the energy. This is important as the implementation of the project will be associated with direct social impacts on indigenous people, such as acquisition of their agricultural land and resettlement of some communities. The proper handling of project stakeholders will have reputational risk for TGDC, financiers and development partners.

9.1 Geothermal stakeholder analysis

Geothermal projects, like many other energy projects, crosscut a number of interested parties. The diverse range of stakeholders include people, groups, or organizations interested in the performance and/or success of the project, or who are constrained by the project or perceive to be affected by the project. Stakeholders are typically classified into two groups of primary and secondary stakeholders. Primary are project members executing the project while secondary stakeholders are generally outside of the project, they usually receive the project information provided from the project team or through indirect information. Table 4 below shows the compiled preliminary mapping up of stakeholders as well as the scale of the power or influence and interest in the Ngozi geothermal project.

TABLE 4: Stakeholder mapping

S/N	Group	Category	Power/Influence	Interest
1.	TGDC	Primary	Low	High
2.	Project team members - EPC contractors, sub-contractors advisors and others working in the project	Primary	Low	High
3.	TANESCO	Primary	Low	High
4.	MEM and EWURA	Primary	Low	High
5.	Financiers - lenders and investors	Primary	High	Low
6.	Local community	Secondary	High	Low
7.	Politicians	Secondary	High	Low
8.	International communities	Secondary	Low	Low
9.	Development partners	Secondary	Low	Low
10.	Public at large (Tanzanian community)	Secondary	Low	Low
11.	Competitors	Secondary	Low	High
12.	Suppliers	Primary	Low	High
13.	Perceived to be stakeholders	Secondary	High	High

9.2 Communication plan

The communication plan was developed depending on scale of power, influence and interest in the project. This was deliberately made to ensure that stakeholders receive the precise level of information on the understanding of the project and its benefits at the right time and from the right source and the right quantity. Table 5 shows the developed grid of power/interest for stakeholder prioritization and communication strategy.

TABLE 5: Grid of power/interest

Power/Influence		Interest: Low	Interest: High
	High	**Keep satisfied**	**Manage closely**
	Low	**Monitor (minimum effort)**	**Keep informed**

From the above grid, the communication strategy to the stakeholders can be made under the following guidelines;

- High influence, highly interested people/groups: The group shall be fully engaged and make the greatest efforts to satisfy, e.g. perceived to be stakeholders;
- High influence, less interested people/groups: The group shall be provided with sufficient information to ensure that they are up to date but not overwhelmed with information, e.g. local communities;
- Low influence, interested people/group: The group shall be adequately informed to ensure that no major issues arise. This group can often be very helpful with the detail of the project, e.g. project team members;
- Low influence, less interested people/group: The group shall be monitored, providing them with minimal communication to prevent boredom, e.g. public at large (Tanzanian community).

The forms of communication ranges from public meetings, internal and external presentations and local media visits. TGDC has so far made deliberate efforts to reach all interested and affected parties of a project, including but not limited to local people closer to the project, region and district leaders, politicians, local community leaders and the general public. From July 2015, TGDC undertook a geothermal awareness campaign in Mbeya region, particularly to the areas surrounding Ngozi geothermal prospect to raise awareness, prepare the community and win their acceptance of the proposed project. The strategy was mainly dissemination of the benefits of geothermal energy as a clean, renewable, reliable and affordable source of energy. Among many concerns of the stakeholders was land compensations and project employment policy.

During power plant operation, TGDC will establish programs to promote corporate social responsibility, which will provide additional benefits for project affected persons and other residents of the project area with the purpose of uplifting the lives of people through providing better education, health, water and electricity supply along with a cleaner environment.

10. RISKS ASSESSMENT AND MANAGEMENT

Geothermal development like many other power investments, is associated with numerous risks. These range from exploration to power plant operations. The greener the field, the more the risk. Ngozi field being virgin and first of its kind in the country is anticipated to weigh much higher compared to brown fields in other parts of the world. The upfront activities, particularly exploratory drilling, bears greater risk and is the second largest investment after the power plant construction. The risk magnitude goes down as the project reaches operations phases. The intention of this case is to highlight and analyse both resource and non-resource risks in detail, examining threats and opportunities that could prevent the project from realising its objectives in terms of sustainability, schedule, cost, quality and performance. The content of this business case will involve highlighting key project risks, and its management will be utilising a probability impact matrix as a qualitative risk analysis method and finally providing risk reporting and control.

10.1 Risks identification

The recognition of potential geothermal power project risks was done based on various geothermal power projects and author experience through observing all the stages and phases of a project life cycle. Predominantly, the risk profile varies depending on the existing development phase of the project, development setup and social and environment concerns. The development risk factors of Ngozi geothermal power development are summarized below.

10.1.1 Resource risks

- *Exploration risks/geological risk*
  This is explained as the probability of the prospect not yielding the anticipated resource production characteristics. Geothermal development depends on two factors which both define the amount of energy that can be extracted from the subsurface, namely temperature and flow rate. Prior to drilling, there is very little knowledge on the resource characteristics, such as the existence of adequate flow rate, temperature, system inherent permeability, the chemical components of the geothermal fluids and size of resource. The geological risk is reduced with every well drilled and with the time they flow but it is still present during all phases of the geothermal project development and throughout the lifetime of the power plant;
- *Operational risks*
  The risks are observed during actual power production phase of a project, often happen when the field is not well maintained as per set standards. The involved risks comprise reservoir depletion, mechanical failure or plant breakdown, industrial and environmental accidents, plant and equipment chemical scaling from geothermal fluids, corrosion, earthquakes during reinjection, delays in drilling and connecting make-up wells, unexpected shortages or increases in the costs of consumables and spare parts.

10.1.2 Non-resource risks

- *Legal and regulatory risk*
  Geothermal power development in Tanzania falls under Mining Act 2010, Energy and Water Utilities Regulatory Authority (EWURA) Act of 2001 (2006), Environmental Management Act 2004, Rural Energy Agency and Rural Energy Fund Act No.8 of 2005, Electricity Act No. 10 of 2008 and Petroleum Act No.10 of 2008. These provide conducive environment for independent power producers to invest in the energy sector. However, most of these regulations and others are not well coordinated as there exists no geothermal policy, legislation or regulatory framework that can link together all the existing structure. For example, the mining law does not communicate with the EWURA and electricity acts. This is one of the major risks to the

development of Ngozi geothermal project as it will not only repel the participation of private developers, but also will increase hardship in securing financing for power development.

- *Drilling delays and cost overrun*
  The project has set average number of days a rig has to spend drilling one well. However, during drilling operation, there is a risk of spending more days than anticipated. The delays tend to have a multiplying effect on other phases of the project, and would therefore lead to cost overrun. For example, each day in geothermal drilling typically costs \$25,000-\$50,000 so a 30-day delay due to e.g. permits, road, drill pad or water supply not being ready or delay in delivery of casing, wellhead valve, etc., could cost around \$1 million.
- *Health and safety issues*
  Drilling operations, construction and power plant operation area are associated with complex processes and therefore pose great risk to the health and safety of personnel and equipment.
- *Environmental and social risk*
  This is a critical risk that may lead to delay or cancellation of the project as a result of non-attendance of social and environmental issues, and hence a delay/denial of financing from the government or possible financiers. Ngozi project area is partly surrounded with environmentally sensitive areas such as Poroto Ridge Forest Reserve, Itunza Forest Reserve and other miner forests. The project is furthermore located in small and medium scale agricultural areas, the implementation of the project in the above settings might raise concerns if little consultation is done, lack of direct benefits as well as land acquisitions problems.
- *TGDC capability risk*
  TGDC, being a new company with an operational history of less than 2 years, might suffer through inadequate experienced geothermal professionals providing expertise in executing various phases of the project.
- *Economic risk*
  These include overall economic conditions, movements in interest, inflation rates, currency exchange rates as well as expansion or increase in taxes and royalties after the power purchase agreement. These might have an adverse effect on the exploration, development and production activities.
- *Financing risk*
  Deficiency or unavailability of funds from the government and other financing partners will subsequently lead to delay in executing the project.
- *Development and construction delay risk*
  There is a risk of delay during construction of the steam gathering systems, power plant and power evacuation facilities that is always caused by incoordination of the construction activities.
- *Change in political regime*
  The geothermal development phases as well as the economical conventional power plant life are subject to various political regimes change (Ngugi, 2012). Within the time range, the government energy policies might change the focus on geothermal power development and concentrate on other forms of energy or other investment priorities. These policies may have a material impact on the development of Ngozi power project.

10.2 Risk analysis and assessment

The above registered potential risks require a comprehensive risk management plan, which assesses the vulnerability of critical assets to specific threats, determines the risk (expected likelihood and consequences of specific attacks on specific assets) and identify ways to reduce risk and prioritize risk reduction measures based on strategy. This is done by establishing a risk matrix, which is also referred to as a probability and impact matrix. The content of this business case will involve highlighting a theoretical form of the key project risks and its management will be utilising the probability impact matrix as a qualitative risk analysis method.

Probability impact matrix

The method involves defining risks in a two dimensional approach, namely uncertainty occurrence (probability) and the outcome effect (impact) of risk chance likelihood and risk impact consequence. Likelihood is derived from uncertainty of risk occurrence and the impact is the effect of the contingency. Potential event of loss designating risk (R) is translated in mathematical terms as a result of the product of the size of the impact (I) and likelihood of (P) (Dumbravă and Iacob, 2013):

$$R = I * P$$

The project probability of risk occurrence was set between 1 and 6, while the impacts on a scale of 1 to 4 were established as shown in Tables 6 and 7, respectively. Moreover, the risk exposure was calculated as shown in Table 8 below.

TABLE 6: Likelihood score risk

Score	**1**	**2**	**3**	**4**	**5**	**6**
Likelihood level	Almost impossible	Unlikely	Remote	Occasional	Moderate	Frequent

TABLE 7: Impact analysis

Score	**1**	**2**	**3**	**4**
Magnitude of impact	Minor	Moderate	Critical	Catastrophic

TABLE 8: Calculation of the exposure risk score

Likelihood					
6	6	12	18	24	
5	5	10	15	20	
4	4	8	12	16	
3	3	6	9	12	
2	2	4	6	8	
1	1	2	3	4	
	1	**2**	**3**	**4**	**Severity**

The project probability impact matrix was developed in Table 9, with risk categorised. The details of the risk are found in Appendix I.

TABLE 9: Probability impact matrix

Likelihood				
6	6	12	18	24
5	5	10	15	20
4	4	8	12	16
3	3	6	9	12
2	2	4	6	8
1	1	2	3	4
	1	**2**	**3**	**4**	**Severity**

High risk
Critical risk
Low risk
Marginal risk

10.3 Risk escalation and reporting

Table 10 below shows the risk escalation and reporting. It defines who must be informed and has the authority to accept risk based on its magnitude.

TABLE 10: Risk escalation and reporting

	Risk escalation and reporting levels for each level of risk
High risk	TGDC board members
Critical risk	TGDC Chief Executive office
Low risk	Project team senior leadership
Marginal risk	Project manager

10.4 Risk treatment and control

Several risk mitigation measures were put in place to minimize the severity of the key risks as shown in Appendix I. Despite the risk treatment and control measures in place, the exploration and financing risks were seen as dominant and requiring further measures.

11. PROJECT FINANCING

This explains a range of funding arrangements available to execute the project and therefore stands as the most critical part of the project development. Geothermal resource development, like many other power development projects, is critically dependent on access to financing under attractive conditions to earn a return commensurate with the risk at that particular phase of the project (NREL, 2011).

Regardless of the significant technical competitive advantages of geothermal power to other forms of energy technologies, securing funds for geothermal power projects has proven to be a great challenge in the early stages of exploration as most financiers have limited appetite for geologically risky projects, especially on green fields. The substantial initial investment is related to the drilling cost and to the need to cover the geological risk at the beginning of the exploration.

However, TGDC has ensured the access of adequate funding to successfully implement various phases of the project. In this case, TGDC has to secure loans, then the Government of Tanzania will be the borrower and Ministry of Energy and Minerals will serve as a beneficiary executing agency and beneficiary of the proposed loan, and TGDC will serve as the implementing agency. For the development of this case, the following financing windows are considered in the development of Ngozi geothermal power project.

11.1 Financing of surface exploration

For development of this case, TGDC is anticipated to finance the surface exploration to precisely locate the drilling sites. This is currently done through funding from GOT and the available financing windows both in monetary and in-kind forms, e.g. Geothermal Risk Mitigation Facility (GRMF) grant, The United Nations Environment Programme (UNEP), Iceland Directorate for International Development Cooperation (ICEIDA), Japan International Cooperation Agency (JICA), etc.

11.2 Financing of exploration and appraisal drilling

As stated above, drilling is the highest risk development phase for geothermal projects and requires a substantial amount of funding, hence it is the most difficult phase to mobilise capital as well as the greatest uncertainty to meet the return on the investment. TGDC might utilize the available financing sources at this phase including GOT, public support investment climate funds and geothermal risk mitigation facility grants. This includes GRMF grant, Scaling-up renewable energy programme (SREP), grant part of the Climate Fund Framework, SREP grant and loan through World Bank etc.

11.3 Financing of power plant construction

Depending on the development strategy in this case, GOT with the available partners will fund the wellhead units plant while the conventional power plant and associated infrastructure will be co-financed with other international agencies and institutional lenders. The possible financing windows include, but are not limited to, JICA, African Development Bank, European Investment Bank, World Bank, Agence Française de Développent (AFD), SREP grant, TOSHIBA (MoU with TGDC), etc.

12. PROJECT ECONOMICS

To fully understand the financial and economic analysis of various options, the field development costs shall be assessed on a green field basis, that is taking into account all costs incurred from initial surface exploration, exploration and development drilling, steam field and power plant development, construction and commissioning, operation and maintenance. The cost estimates were done based on the ESMAP 2012 handbook (Gehringer and Lokhsa, 2012), unpublished lecture notes as developed by (Pálsson, 2016) and presentation from Hallgrímsdóttir and Gudmundsson (2016) as well as considerations of Ngozi site specific factors.

12.1 Assumptions

The assumptions are shown in Table 11 for general project assumptions, Table 12 for specific cost assumptions and Table 13 for financial assumptions that were used to assess the financial viability of project;

TABLE 11: General project assumptions

Parameter	Unit	Value
Average well output	MW	5
Exploration drilling success rate	%	50%
Appraisal wells drilling success rate	%	75%
Production drilling success rate	%	90%
Ratio of reinjection to production wells	Ratio	1/5
Well drilling days	Days	90

TABLE 12: Specific cost assumptions

Item	Unit	Amount (M USD)
Well drilling (hired rigs)	USD/Well	4
Drilling materials	USD/Well	1
Steam gathering system	USD/MW	0.4

TABLE 13: Financial assumptions

Parameter	Value
Plant capacity factor	95%
Planning horizon (operations)	25 years
Equity share in cap. ex	30%
Loans	70%
Loan interest rate (no inflation)	5%
Electricity price	100 $/MWh
Loan management fee	1%
Income tax rate	30% of profit
Loan repayment	20 years
Depreciation buildings	20%
Depreciation equipment	25%
Depreciation other	20%

12.2 Financial viability

The net present value (NPV), internal rate of return (IRR) and discounted payback period (PB) methods are the three most popular decision rules used to assess the viability of many investment planning problems. The financial viability was done using a modified Microsoft Excel-based profitability assessment model developed by (Jensson, 2016) which is made up of different spread sheets including investment, operations, cash flows and profitability. The three methods will be used in this case to conclude the profitability of the chosen project scenarios. Appendix II shows screenshots from the probability model.

12.2.1 The Net Present Value (NPV)

The net present value (NPV) of a project is the sum of the present value of all its cash flows in each year of the project's implementation, both inflows and outflows, discounted at a rate consistent with the project. Mathematically, NPV is presented as:

$$NPV(i) = \frac{A_0}{(1+i)^0} + \frac{A_1}{(1+i)^1} + \dots + \frac{A_N}{(1+i)^N}$$

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

where A_n = Net cash flow at the end of period *n;*
i = MARR (Minimal Attractive Rate of Return);
N = Service life of the project.

If the NPV($\underline{i}$) is positive for a single project, the project should be accepted, since a positive NPV means that the project has greater equivalent value of inflows than outflows and therefore makes a profit. According to the decision rule for NPV:

If $NPV(i) > 0$ Accept the investment;
If $NPV(i) = 0$ Remain indifferent to the investment;
If $NPV(i) < 0$ Reject the investment.

12.2.2 Internal Rate of Return (IRR)

An internal rate of return (or IRR) for an investment is typically defined as a discount rate that makes the net present value of the investment cash flows equal to zero. The IRR is equal to the rate of return for which the following function is zero:

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

Investors usually want to do better than breaking even in their investments. Their investment policy usually defines a MARR (Minimal Attractive Rate of Return), in which case the IRR and the MARR can be used to decide whether a project is feasible or not. The decision rule for a simple project is as follows:

If $IRR > MARR$ Accept the project;
If $IRR = MARR$ Remain indifferent;
If $IRR < MARR$ Reject the project.

12.2.3 Discounted Payback Period (PB)

The discounted payback period of a project shows the time it takes the project to recover investment outlays. The project with discounted payback period in the desired time frame is considered feasible. However, the method does not measure profitability, as it only measures the time it takes to recover the initial investment outlay but not the profit that is made after paying back the initial investment. Hence, it doesn't allow for the possible advantages of a project with a longer economic life.

12.3 Sensitivity analysis

This is the process of determining to what extent the project financial viability results can be affected with changes in the input parameters. The values of input parameters are often associated with a degree of uncertainty; it is therefore crucial to examine the project's financial viability results given a change in these parameters. The business case has determined how much IRR and NPV change relative to a given change in input parameters of sales price, sales quantity, and investment cost of equipment and operation and maintenance expenses.

12.4 Discussion on project economics in Scenario 1

12.4.1 Project assumptions

The assumptions on the financial feasibility analysis of Scenario 1:

- Three exploration wells will be drilled with 50% success rate, 4 appraisal wells at 75% success rate and 9 production wells at 90% success rate to supply steam to power the turbine. Upon careful reservoir study, some of the unsuccessful wells will be used as reinjection wells, however, one reinjection well will be drilled.
- TGDC/GOT will partly finance the project's total investment at the arrangement of 30% equity and 70% loan at an interest of 5%.

12.4.2 Project cost estimates

The investment cost items are classified as:

- Buildings-power plants cost (EPC package), workshop (electrical, mechanical and carpentry), civil works, access road construction, water supply infrastructures and power evacuation facilities (transmission line and substation). The total investment cost for the 7 years of construction period was 149 million USD.
- Equipment-exploration drilling, appraisal drilling, production drilling, rig mobilisation and demobilisation, transfer of rig between pads, project management drilling consultant. The total investment cost for the 7 years of construction period was estimated to be 91 million USD.
- Other-detailed surface studies, environmental studies, feasibility study, water and environmental project permit, state concession fee, land purchase and resettlement. The total investment cost for the 7 years of construction period was estimated to be 9 million USD.
- The project will require a total working capital of 18 million USD.

12.4.3 Summary of results

From the three financial viability analysis methods and sensitivity analysis, the following results were observed:

- *The Net Present Value (NPV)*
  The NPV at 15% MARR for the total equity of 80 million USD at the 25th year of operation was calculated to be 15 million USD, while the NPV at 10% MARR for the total project investment of 266 million USD was calculated to be 5 million USD. Since the NPV in both cases > 0, the project is considered feasible. The accumulated NPV graph is as shown in Figure 6.

- *Internal Rate of Return (IRR)*
  The IRR at was calculated to be 20% for the total equity of 80 MUSD at the 25th year of operation, while the IRR for the total project investment of 266 million USD was calculated to be 10%. Since the IRR>MARR for the equity, then project is accepted meanwhile the MARR = IRR for the total project investment, then the project viability decision becomes indifferent. The IRR graph is as shown in the Figure 7.

- *Discounted Payback Period (PB)*
  The PB period of the project is reached at the 8th year of project operation for equity, i.e. 2029/2030, while in the 22nd year for the total project, i.e. 2044. This can be read from the NPV graph in Figure 6.

- *Sensitivity analysis*
  The sensitivity analysis was done to find out how sensitive the NPV and IRR are against the cost of equipment, price of electricity, sales quantity of electricity, loan interest and operation and maintenance. From Figure 8, the four parameters of equipment, price of electricity, sales quantity

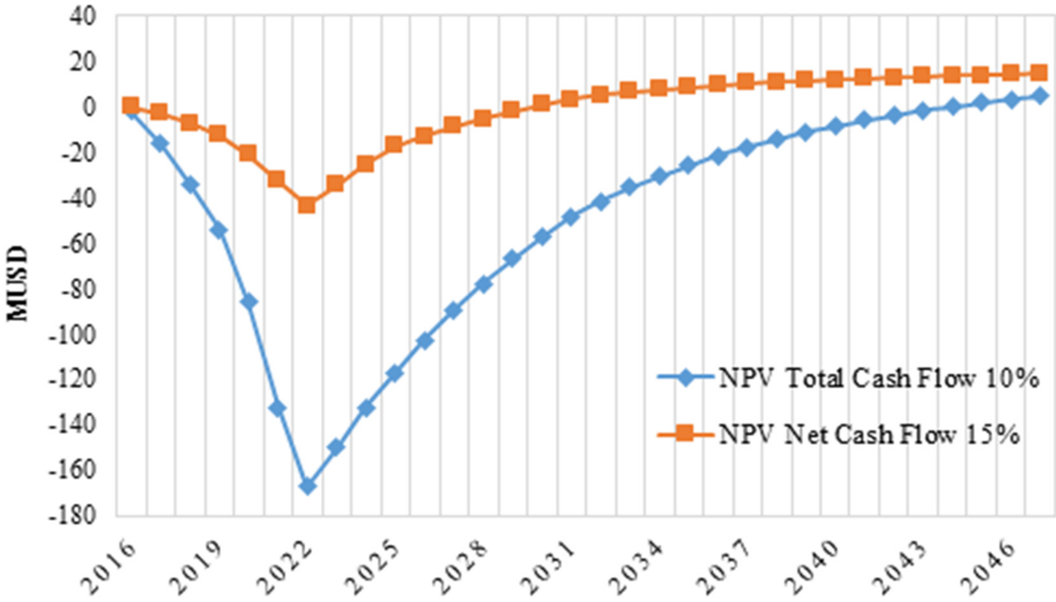


FIGURE 6: Accumulated Net Present Value

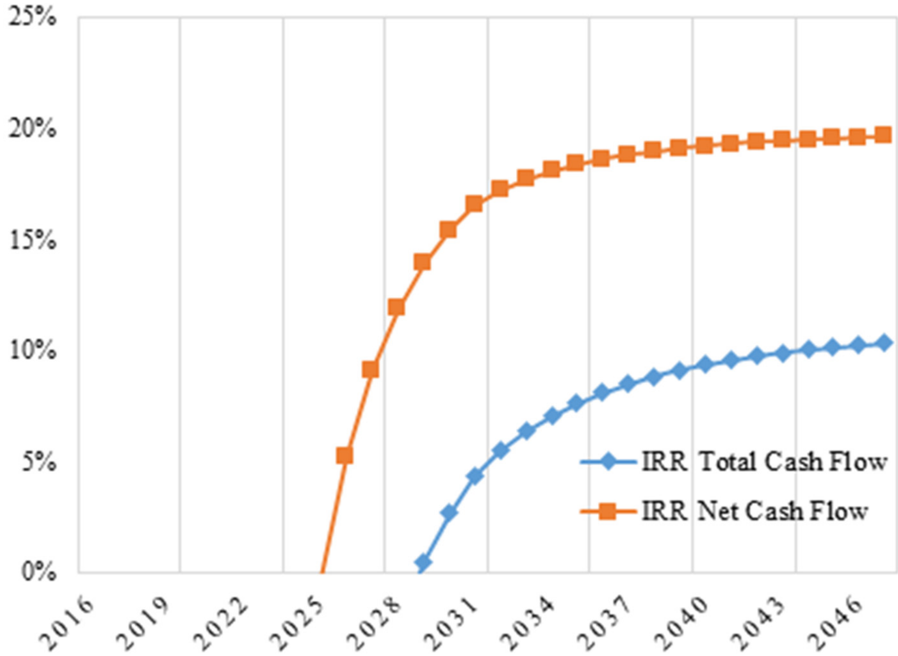
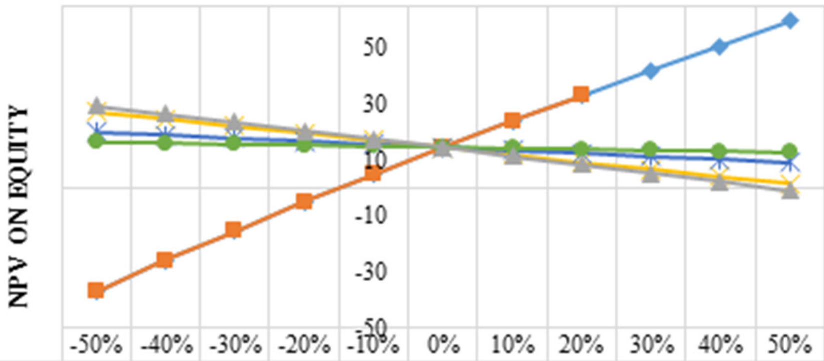


FIGURE 7: Internal Rate of Return (IRR)

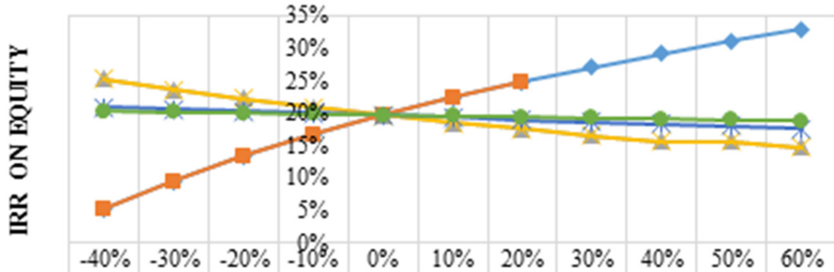
of electricity and loan interest were very sensitive on the NPV of Equity. For example, a 20% decrease in price and quantity of electricity to be sold will make the project not feasible while a 50% increase in the price of equipment will make the project not viable. The other parameters of loan interest, operation and maintenance cost as well as the cost of others will have no significant impact on the NPV of the equity. For example, the 50% increase of all costs will still make the project feasible.

The same parameters were checked on the IRR of the equity, from Figure 9. The analysis showed that with the decrease of the price and sales quantity of electricity by 10% the project becomes not feasible as the IRR becomes 13%, less than the MARR of 15%, whereas a 60% increase of the cost of equipment and loan interest will still make the project feasible. The cost operation and



	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
Price	-37	-26	-15	-5	5	15	24	33	42	51	60
Sales Quantity	-37	-26	-15	-5	5	15	24	33			
Loan interest	27	25	22	20	17	15	12	9	7	4	1
O+M	20	19	18	17	16	15	13	12	11	10	9
Others	16	16	16	15	15	15	14	14	13	13	13
Equipment	29	26	23	21	18	15	11	8	5	2	-1

FIGURE 8: Sensitivity analysis on the NPV of equity



	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%	60%
Price	5%	9%	13%	17%	20%	22%	25%	27%	29%	31%	33%
Sales Quantity	5%	9%	13%	17%	20%	22%	25%				
Equipment	25%	24%	22%	21%	20%	19%	17%	17%	16%	16%	15%
Loan interest	25%	24%	22%	21%	20%	19%	17%	17%	16%	16%	15%
O+M	21%	21%	20%	20%	20%	19%	19%	19%	18%	18%	18%
Others	20%	20%	20%	20%	20%	19%	19%	19%	19%	19%	19%

FIGURE 9: Sensitivity analysis on the IRR of equity

maintenance as well as the cost of others will have no significant effect on the changes on the IRR of the equity.

12.5 Discussion on project economics on Scenario 2

12.5.1 Project assumption

The assumptions on the financial feasibility analysis of Scenario 2:

- Three exploration wells will be drilled with 50% success rate and one of the wells will be used to supply steam to power the turbine in the wellhead unit. The unsuccessful wells will be used as reinjection wells.
- GOT will finance the exploration drilling and installation of 5 a MW well head unit.
- Following the successful installation of a wellhead unit, the 50 MW power plant field development activities will be undertaken i.e. surface studies, drilling of appraisal, production and reinjection wells.

12.5.2 Project cost estimates

The investment cost items are classified as shown below:

- *Buildings standard size wellhead power plants cost (EPC package),* workshop (electrical and mechanical and carpentry), civil works, access road construction, water supply infrastructures and power evacuation facilities (transmission line and substation). The total investment cost for the 3 years of construction period was estimated to be 12 million USD.
- *Equipment* – exploration drilling, rig mobilisation and demobilisation, transfer of rig between pads, wellheads, well silencers and connections to steam system, project management drilling consultant. The total investment cost for the 3 years of construction period was estimated to be 16 million USD.
- *Other-detailed surface studies*, environmental studies, feasibility study, water and environmental project permit, state concession fee and land purchase and resettlement. The total investment cost for the 3 years of construction period was estimated to be 3 million USD.
- *This scenario* utilised same cost estimates as in 50 MW power plant above with exclusion of the field development costs that were previously covered from the 5 MW plant. The total investment cost for the large power plant was estimated to be 214 million USD.

12.5.3 Summary of results

From the three financial viability analysis methods and sensitivity analysis, the following results were observed:

- *The net present value (NPV)*
  The NPV at 15% MARR for the total equity of 94 MUSD at the 35th year of operation was calculated to be 6 MUSD. Since the NPV > 0, the project is feasible meanwhile the NPV at 10% MARR the total project was calculated to be 24 MUSD at the 35th year of operation with a total investment of 240 MUSD. Since the NPV > 0, the project is feasible. The accumulated NPV graph is as shown in the Figure 10.

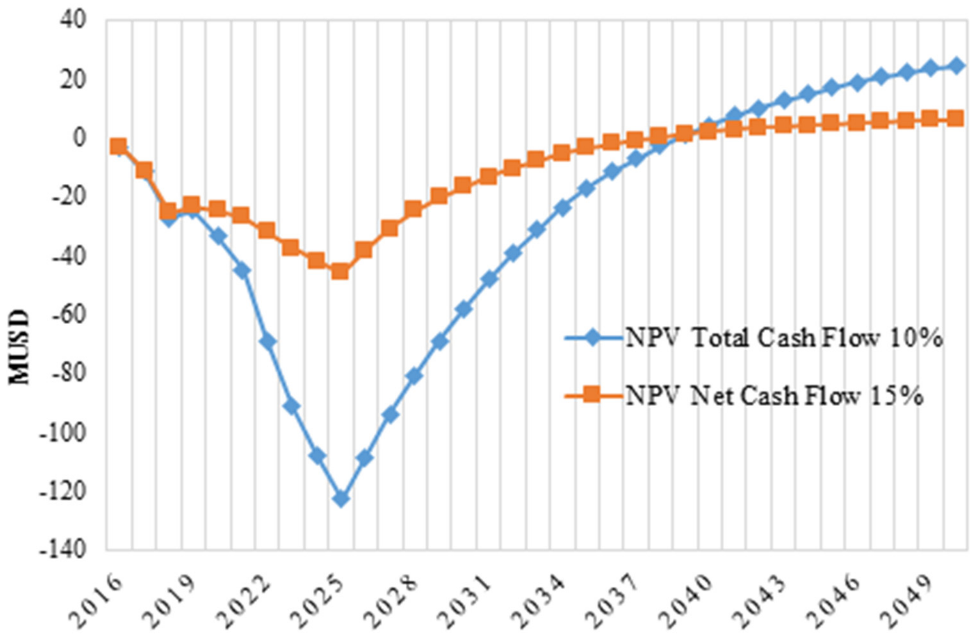


FIGURE 10: Accumulated Net Present Value

- *Internal Rate of Return (IRR)*
  The IRR was calculated to be 16% for the total equity of 94 MUSD at the 35th year of operation, since the IRR > MARR then the project is accepted. The IRR for the total project was calculated

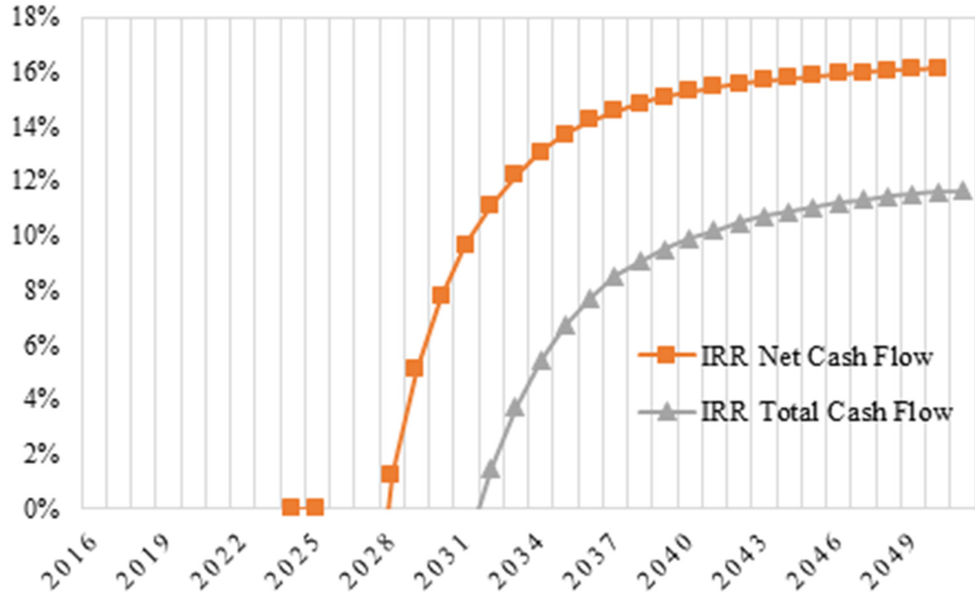


FIGURE 11: Internal Rate of Return (IRR)

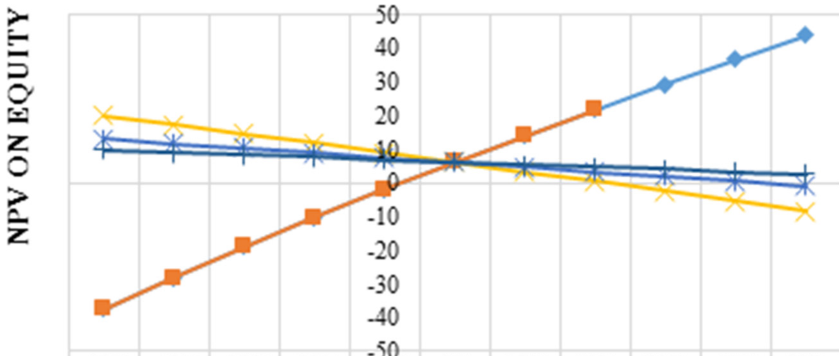
to be 12%. Since the IRR>MARR then the project is accepted. The IRR graph is as shown in Figure 11.

- *Discounted Payback Period (PB)*
  The discounted PB of the project was attained at the 22nd year of project operation, i.e. 2038/2039 for both equity and the total project. This can be read from the NPV graph in Figure 10.
- *Sensitivity analysis*
  The sensitivity analysis was done to find out how sensitive the NPV and IRR are against the equipment, price of electricity, sales quantity of electricity, loan interest and operation and maintenance. From Figure 12, the three parameters of equipment, price of electricity and sales quantity of electricity sales were very sensitive for the NPV of Equity. For example, a 10% decrease of price of electricity and quantity of electricity to be sold will make the project not feasible while a 20% increase in the price of equipment will make the project not feasible. The loan interest has little significance as 40% increase in the loan interest will make the project still feasible. The operation and maintenance costs will have no significant impact on the NPV of the equity. For example, a 50% increase in the operation and maintenance costs will still make the project feasible.

  The same parameters were checked on the IRR and the equity, however the IRR of the equity is not adversely affected by any of the parameters, Figure 13 shows that even with a decrease of the price and sales quantity of electricity of 50% the project becomes feasible. The same is seen on the cost of equipment and operation and maintenance, the increase of these factors by 50% will still make the project feasible.

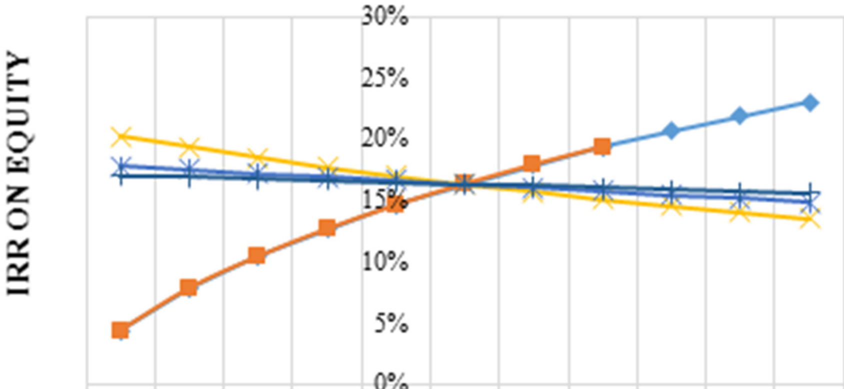
12.3 Overall summary of results

Both scenarios were sensitive to the price of electricity, sale quantity and the cost of equipment. A significant sensitivity was also observed on the loan interest in Scenario 1, as the slight increase in loan interest could make the project not viable, this is explained by the large amount of loans needed to develop this scenario. Again, Scenario 2 provides a substantial amount of revenue from the wellhead unit, or close to 29 million in 7 years of operations with the initial investment of close to 15 million USD (for well head unit), hence saving the company from requesting working capital from the financier.



	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
Price	-37	-28	-19	-10	-2	6	14	22	29	37	44
Sales Quantity	-37	-28	-19	-10	-2	6	14	22			
Equipment	20	17	15	12	9	6	3	0	-2	-5	-8
Loan interest	13	12	10	9	8	6	5	3	2	1	-1
O & M	10	9	8	8	7	6	5	5	4	3	3

FIGURE 12: Sensitivity analysis of the NPV on equity



	-50%	-40%	-30%	-20%	-10%	0%	10%	20%	30%	40%	50%
Price	4%	8%	10%	13%	15%	16%	18%	19%	21%	22%	23%
Sales Quantity	4%	8%	10%	13%	15%	16%	18%	19%			
Equipment	20%	19%	18%	18%	17%	16%	16%	15%	15%	14%	13%
Loan interest	18%	17%	17%	17%	17%	16%	16%	16%	15%	15%	15%
O+M	17%	17%	17%	17%	16%	16%	16%	16%	16%	16%	16%

FIGURE 13: Sensitivity analysis of the IRR on equity

13. CONCLUSIONS AND BUSINESS RECOMMENDATIONS

The preliminary build-up of this business case is one crucial step for various interested parties to provide justifications for the investment in the exploratory wells drilling in Ngozi geothermal field and, subsequently, the installation of the first geothermal power plant in the country. The case has covered all the essential social-economical project benefits, identified key project risks, identified possible project financing arrangements, project implementation scenarios, project social and environmental issues, stakeholder management and communication plan and, finally, financial viability analysis. Table 14 shows a snapshot of the business case parameters with the two project implementation scenarios.

TABLE 14: Snapshot of the two options of business cases

Factors	50 MW flash plant	5 MW WH unit + 50 MW flash plant
Strategic alignment	Aggressive approach towards including geothermal as a part of Tanzania's energy mix.	Careful approach in developing local skills and experience in utilising geothermal resources in Tanzania.
Environmental	The scenarios will attract significant environmental impacts to the area, particularly during drilling and operation phase.	Limited impacts will be produced from this strategy, if there are to occur, the 5 MW wellhead unit will be an excellent prototype to properly mitigate the problems for the 50 MW power plant.
Stakeholder impact	Significant number of stakeholders will be involved hence a large impact.	The 5 MW plant will attract few stakeholders at first hence it is easier to properly map the number of interested parties during the construction and operation of the large power plant.
Risk:		
Resource risk	The risk is higher due to little understanding of the reservoir.	Stepwise development of the 5 MW unit will offer the best knowledge of the reservoir and reduce the risk.
Operation. risk	May require significant support from outside Tanzania for the start-up of a 50 MW unit.	More experience in handling geothermal wells and turbines when starting operation of a 50 MW unit.
Risk of cost overrun	In case of risk of cost overrun, the risk will be much pronounced as it involves drilling of many wells at the beginning.	Few wells will be drilled, the risk will not be significant.
ESIA risk	Large area will be covered hence significant social and environmental shock.	The 5 MW WHP will occupy a small area, providing room for community acceptance and understanding on response to the environment. The latter 50 MW plant will utilize both environmental and social concerns raised during the 5 MW unit construction and operation.
Financing	More difficult to finance a 50 MW power plant with limited understanding of the reservoir as well as limited institutional capacity.	Easier to finance a 5 MW wellhead unit and also to finance the 50 MW plant with multidisciplinary experience gained from the 7 years of experience in exploration and exploitation of the reservoir from the 5 MW plant.
Economy:		
Cost	266 Million USD	245 Million USD
NPV	15 Million USD	6 Million USD
IRR	20%	16%
Pay-back period	15 years	23 years

The financial viability of the two scenarios indicate a positive financial viability on equity, whereby Scenario 1 yielded a NPV of 15 million USD with IRR of 20% while Scenario 2 generated a NPV of 6 million USD with IRR of 16%,. Under financial rationalization, Scenario 2 seems to be more profitable. However, the strategy is associated with a large investment close to 80 million USD, higher degree of uncertainty following the limited technical understanding of the Ngozi geothermal reservoir and limited TGDC capability. Scenario 2 is less profitable but associated with a significantly lower risk profile, the strategy of installing a wellhead unit after successful drilling and testing of exploration wells reduces both technical and financial risks as only 31 million USD will be spent. The strategy will generate early revenue for the company, which will be reinvested in development of a large 50 MW power plant and reduces bulky project financing obligations as well as building a strong capacity in the TGDC workforce on the geoscientific, social, environmental and technical expertise on development and exploitation of geothermal resources. It is along these lines, that Scenario 2 is recommended as the best strategy to undertake for the project.

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APPENDIX I: Risk identification, treatment and control

Ref.	Risk category	Risk and description	Risk chance likelihood	Risk Impact consequence	Risk priority (initial)	Risk treatment plan	Risk owner	Due	Risk chance likelihood	Risk impact consequence	Residual risk
1	Exploration /Geological	Unfavourable characteristics of reservoir such existence of inadequate flow rate, low temperature, poor system inherent permeability and the chemical components of the geothermal fluids hence hitting dry wells	3	4	12	Comprehensive geoscientific studies to preciously establish the drilling targets	TGDC	10.10.2016	2	2	4
2	Operational and Maintenance	Reservoir depletion, mechanical failure or plant breakdown, environmental accidents, plant and equipment chemical scaling from geothermal fluids, corrosion, earth quake during reinjection, delays in drilling and connecting make-up wells, unexpected shortages or increases in the costs of consumables, spare parts.	2	3	6	Periodic maintained of power plant and associated infrastructures as per set standards	TGDC	10.10.2016	1	2	2
3	Legal and regulatory	Miscommunication of existing legal and regulatory framework in relation to geothermal development	3	2	6	Establishment of geothermal policy, legislation and regulatory framework to link with available framework.	GOT	10.10.2016	2	1	2
4	Environmental and Social	Flora, fauna, ecosystems and biodiversity disturbance, GHG emission as well as land acquisition and resettlement area may cause rejection of project	2	4	8	Undertaking detailed ESIA study,preparate strategic and time plans to mitigate the challenges	TGDC	10.10.2016	2	1	2
5	Drilling delays and cost overrun	Geological formation, mechanical problems and unforeseen problems may lead to the delays and cost overrun	2	2	4	Comprehensive geological studies to establish the formation parameters as well as having the cost contingency.	TGDC	10.10.2016	1	1	1
6	Economic	Higher return on invetsment,unclear tax incentives, High interest rate, Delay in PPA	2	3	6	Early preparation of Business case outlying all the possible economic sensitive factors	TGDC	10.10.2016	1	2	2
7	Financing	Non-availability or insufficient funds from GOT and the project counterpart	3	4	12	Early preparation and submission request of project financing plan to the possible project financier	TGDC	10.10.2016	2	2	4
8	Development and Construction Delay	Delay during construction of steam gathering systems, power plant and power evacuation facilities	2	3	6	Undertaking detailed feasibility study while outlying various options	TGDC	10.10.2016	1	1	1
9	Political	Shift in project political support due to change in government regime	2	2	4	Comprehensive awareness campaign to publicize the importance of geothermal energy as renewable, reliable and environmentally friendly source of electricity generation.	TGDC, GOT	10.10.2016	1	1	1
10	Healthy and Safety	Drilling, construction and power plant operation pose great risks to health and safety of personnel and equipment's	2	3	6	Preparation of healthy and safety plan prior the commencement of activities as well as strict implementation strategy	TGDC, Contractors	10.10.2016	1	2	2
11	TGDC Capability	TGDC is new company with limited geothermal experts	3	2	6	Engaging geothermal experienced implementation consultancies and contractors in various phases of the project	TGDC	10.10.2016	1	1	1

FIGURE 1: Identification of risks, treatment and control measures

APPENDIX II: Screen shots from profitability model

	Assumptions and Results						**MARR**	**Equity**	**15%**		**Planning Horizo**		**25**	**years**	
Assumptions:							**MARR**	**Project**	**10%**						
		2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**Total**
Investment:	**MUSD**														**USD**
Buildings	100%	0	9	0	1	25	58	57	0	0	0	0	0	0	**149**
Equipment	100%	0	6	21	21	21	17	5	0	0	0	0	0	0	**91**
Other	100%	2	1	0	5	0	0	0	0	0	0	0	0	0	**9**
Total Investment		**2**	**16**	**21**	**27**	**46**	**75**	**62**	**0**	**0**	**0**	**0**	**0**	**0**	**248**
Financing:															
Working Capital		1	2	2	3	3	6	1	0	0	0	0	0	0	**18**
Total Financing		**3**	**18**	**23**	**30**	**49**	**81**	**63**	**0**	**0**	**0**	**0**	**0**	**0**	**266**
Equity	100%	30%													
Loan Repayments	100%	20	years												
Loan Interest	100%	5%													
Operations:		**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	
Sales Quantity	100%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.4	0.4	0.4	0.4	0.4	MWh/year
Sales Price	100%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100$/MWh
Variable Cost	100%	0	MUSD/MW												
Operation and Maintenance	100%	5	MUSD/year												
Inventory Build-up															
Other Assumptions:					**Main Results:**										
Debtors	1/12	of turnover (revenue)					**Total Cap.**	**Equity**							
Creditors	1/12	of variable cost			**NPV of Cash Flow**		**5**	**15**							
Dividend	0%	of profit			**Internal Rate**		**10%**	**20%**							
Income Tax	30%	of taxable profit													
Depreciation Buildings	20%	Tanzania Investment Act, 1997			**Internal Value of Shares**			**6**							
Depreciation Equipment	25%	Tanzania Investment Act, 1997			**After 25 Years**										
Depreciation Other	20%	Tanzania Investment Act, 1997													
Loan Management Fee	1%														

FIGURE 1: Assumptions and results for Scenario 1

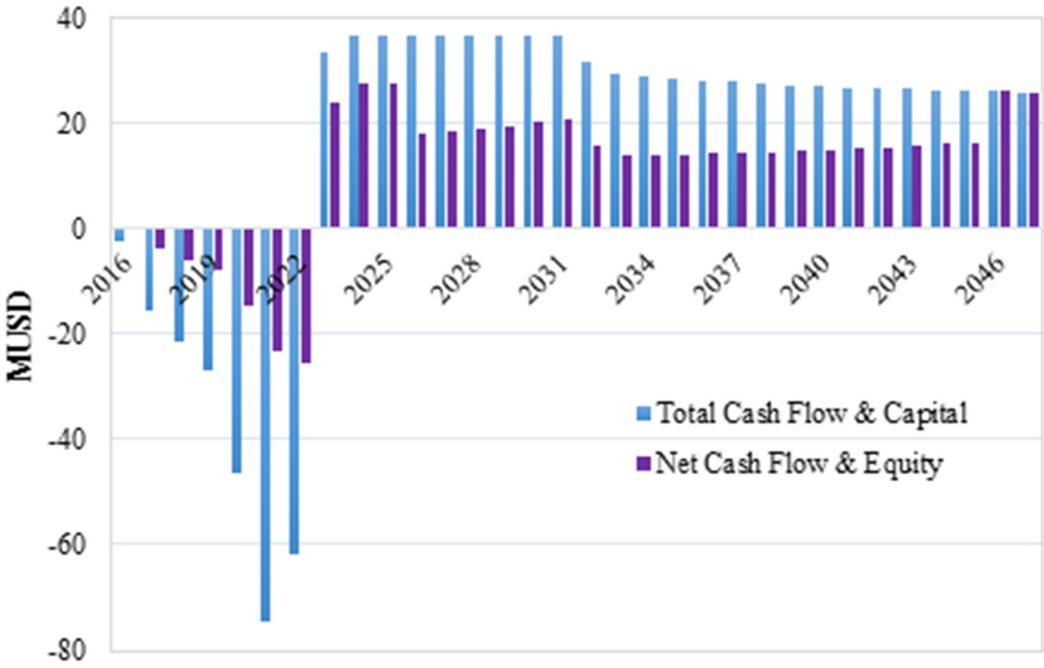

FIGURE 2: Cash flow to be generated from Scenario 1

	Assumptions and Results							**MARR (Equity)**	**15%**		**Planning Horizon**		**7**	**5 MW**
Assumptions:								**MARR (Project)**	**10%**		**Planning Horizon**		**25**	**50 MW**
		2016	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
Investment:	**MUSD**													
Buildings	100%	0	2	10	0	0	0	22	35	39	39	0	0	0
Equipment	100%	1	6	9	1	15	20	20	16	0	0	0	0	0
Other	100%	3	1	0	1	0	0	3	1	0	0	0	0	0
Total Investment		**3**	**9**	**19**	**2**	**16**	**21**	**45**	**52**	**39**	**39**	**0**	**0**	**0**
Financing:														
Working Capital		0	0	0	0	0	0	0	0	0	0	0	0	0
Total Financing		**3**	**9**	**19**	**2**	**16**	**21**	**45**	**52**	**39**	**39**	**0**	**0**	**0**
		5 MW	**50 MW**											
Equity	100%	100%	30.0%											
Loan Repayments	100%	0	20	years										
Loan Interest	100%	0%	5%											
Operations:		**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**
Sales Quantity	100%	0.0	0.0	0.0	0.04	0.04	0.04	0.04	0.04	0.04	0.04	0.46	0.46	0.46
Sales Price	100%	0.0	0.0	0.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Variable Cost - 5 MW	100%	0.0	MUSD/MWh/year											
Variable Cost - 50 MW	100%	0.0	MUSD/MWh/year											
Operation & Maintenance - 5 MW	100%	0.3	MUSD/MWh/year											
Operation & Maintenance - 50 MW	100%	5	MUSD/MWh/year											
Inventory Build-up	100%	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Assumptions:					**Main Results:**									
Debtors	1/12	of turnover (revenue)					**Total Cap.**	**Equity**						
Creditors	1/12	of variable cost			**NPV of Cash Flow**		**23**	**6**						
Dividend	0%	of profit			**Internal Rate**		**12%**	**16%**						
Income Tax	30%	of taxable profit												
Depreciation Buildings	20%	Tanzania Investment Act, 1997			**Internal Value of Shares**			**5**	**(Exit Policy)**					
Depreciation Equipment	25%	Tanzania Investment Act, 1997			**After 35 Years**									
Depreciation Other	20%	Tanzania Investment Act, 1997												
Loan Management Fee	1%													

FIGURE 3: Assumptions and results for Scenario 2

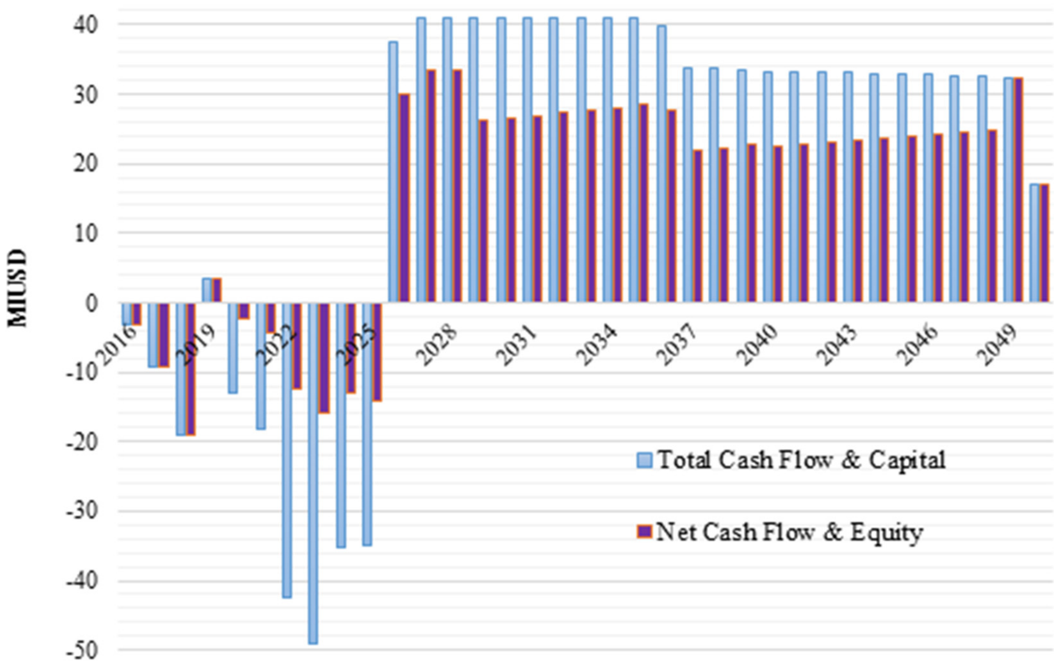

FIGURE 4: Cash flow to be generated from Scenario 2