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ECONOMIC AND FINANCIAL ANALYSIS OF REVAMPING THE KAPISYA GEOTHERMAL PROJECT, ZAMBIA

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ABSTRACT

The objective of this study is to carry out an economic and financial assessment for the viability of the Kapisya geothermal power project, with the plant having been non-operational since 1988 when it was installed by Dal.spa of Italy. The economic and financial assessment will also attempt to find the most pragmatic solutions that are also economically viable given the current geothermal parameters at Kapisya geothermal field, which could be implemented once funding is available. In the past, there have been a few studies that have looked at developing the Kapisya geothermal field with the view to carry out new drilling and further field development including a new power plant of up to 2 MW.

The Zambian government´s increasing support for renewable energy aims at diversifying its electricity generation portfolio predominantly from hydroelectricity to other renewable energy sources such as solar, wind, biomass and geothermal. Compared to other renewable energy sources geothermal energy is not only clean energy but is also outstanding as reliable baseload power and thus an alternative to large hydro power for heavy and light industry. Therefore, all the major geothermal systems in Zambia were included in this study with emphasis on sites with the most potential for exploitation.

The approach of the study was from the perspective of installing a small binary Organic Rankine Cycle plant given the current geothermal parameters at Kapisya geothermal field. This was done with the view to produce electricity starting with at least 110 kW and further increasing the power output in a stepwise expansion mode. The most favourable and ideal solutions for the latest small ORC binary plants were analysed and the economic and financial analysis was done to ascertain the viability of electricity generation at the Kapisya geothermal field. This was done considering rural electrification and small industries far from the electricity grid.

Apart from electricity generation there was also the economic perspective of geothermal utilisation for fish drying for the local fish industry, as the Kapisya geothermal field is situated on the shores of Lake Tanganyika. This has potential to boost the local fishing industry.

1. INTRODUCTION

1.1 Overview of Zambia´s geothermal systems

There are over 80 hot springs and other geothermal manifestations in Zambia. In the early 1970s the Government of Zambia commissioned a study to look at possibilities to produce salt from the geothermal brine of the hot springs in order to be self-sufficient in that commodity. Around that time, salt was in short supply. Around 50 hot springs had their geology surveyed and geochemical analyses were conducted. The hot springs in Zambia can be classified into seven main geographical groups (Legg, 1974) listed below:

- Northern group;
- Mansa-copper belt group;
- Western group;
- Eastern group;
- Southeastern group:
- Choma group; and
- Lochnivar group.

Table 1 lists a few of the hot springs which have complete geochemical data. This was used to estimate the reservoir temperatures of these fields, which helps in guiding which hot springs are suitable for further geothermal exploration and development. Figure 1 shows the location of hot springs and geothermal fields in Zambia.

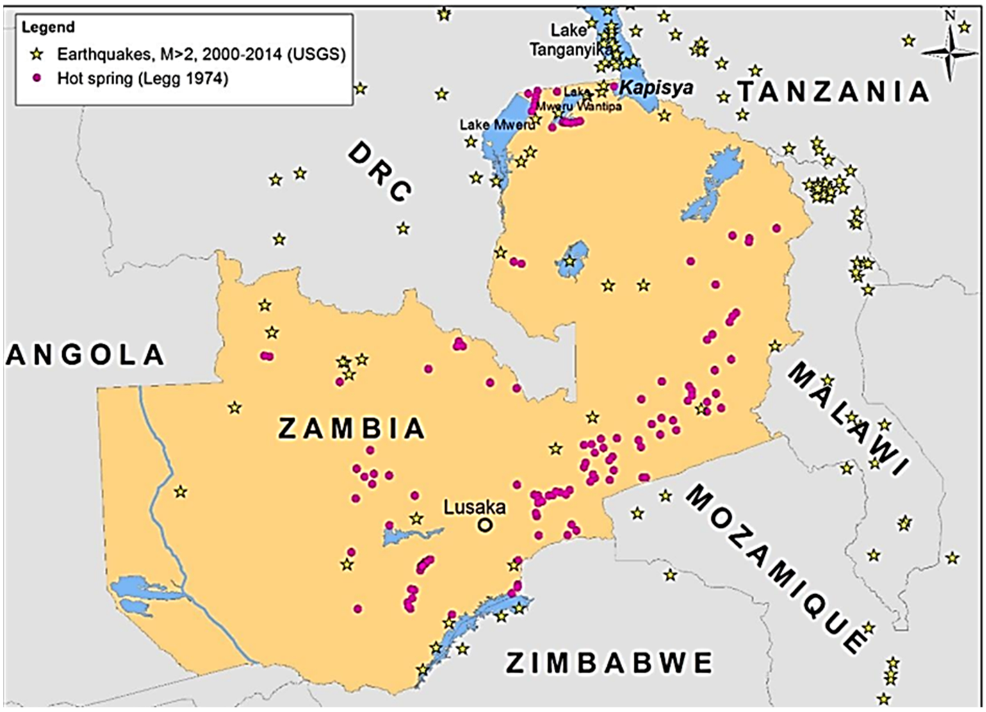

FIGURE 1: Location of geothermal fields in Zambia

The Northern group hosts the Kapisya and Kaleya hot springs which are situated in northern Zambia, close to the shores of Lake Tanganyika. These springs are fairly dilute in their chemical compositions. The other springs in this group are the Kaputa and Chiengi hot springs and are situated near Lake Mweru. The chloride concentrations in these hot springs are quite high. A traditional salt industry thrived around these hot springs where the brine from these hot springs was used to produce salt.

In the *Mansa-copper belt group,* there are the Mansa and Kabinda hot springs both situated in Mansa town. The other hot springs in this group are the Luano, Kafue and Chondwe hot springs, all of which are located in the Copper-Belt region. The Chondwe hot springs have large deposits of calcium carbonate around their periphery.

In the *Western group* there are the Kaimbwe Moshi and Chibemba hot springs in the Northwestern province. The Bilili, Kassip, Kapiamema, Longola, Lubungu and Bilili hot springs are situated around the Kafue national park in central Zambia. It is worth noting that the Kaimbwe hot springs are connected to a salt pan which is probably the largest in Zambia where a traditional salt industry was established and salt is still collected to this day, panned by traditional means.

In the *Eastern group* there are several hot springs namely Sitwe, Shiwa Ng'andu, Kanunshya, Kalamulilo, Chongo, Nabwalya, Kazakaza, and Nsefu, which are situated in the Luangawa trough. The others are Msoro, Mwape amd Kanzi.

The *Southeastern group* has the Mililo, Masaka, Bwingi, Kaligala, Chinyunyu, Mikwa and Kampika. These hot springs have Karoo basement faults and are situated in the Luano valley.

The *Choma Group* of hot springs includes the Mackleneuk, Chibimbi and Mosali springs. These springs are mostly situated on farms and have high levels of fluorine. They are within the Karoo basement rocks.

The *Lochnivar group* includes the Lochnivar, Bwanda, Gwisho and Namulala hot springs. These hot springs are hosted in the Kafue trough. They are some of the hottest hot springs in Zambia with surface temperatures as high as 95°C. They are located along a well-defined fault. Extensive exploration has been done in this area in the recent past, by Kalahari Geothermal Exploration, including the drilling of slim wells with positive results for exploration and production drilling (Maxwell et al., 2018).

2. OPPORTUNITIES IN THE RURAL ELECTRIFICATION MASTER PLAN (REMP)

Zambia's total installed electricity generation capacity was 2,827 MW in 2016. This was composed of hydro 84.5%, coal 10.6%, diesel 3.1%, heavy fuel oil 1.8% (HFO) and solar PV 0.1% (ERB, 2016). Over the years there have not been many investments in electricity generation, especially from the private sector, mainly due to tariffs. Zambia has had some of the lowest electricity tariffs in Sub-Saharan Africa as the tariffs have not been cost reflective at around US$ 0.05 (World Bank, 2017). This has been one of the major hurdles for investments in the power sector. In Figure 2 the electricity tariffs are compared to other Sub-Saharan countries.

However, the Zambian Government resolved to gradually move to cost reflective tariffs by 2019 in accordance with a resolution passed by Southern African Development Community (SADC) (Sikwanda, 2016). This will spur investments in the energy sector, especially from the private sector.

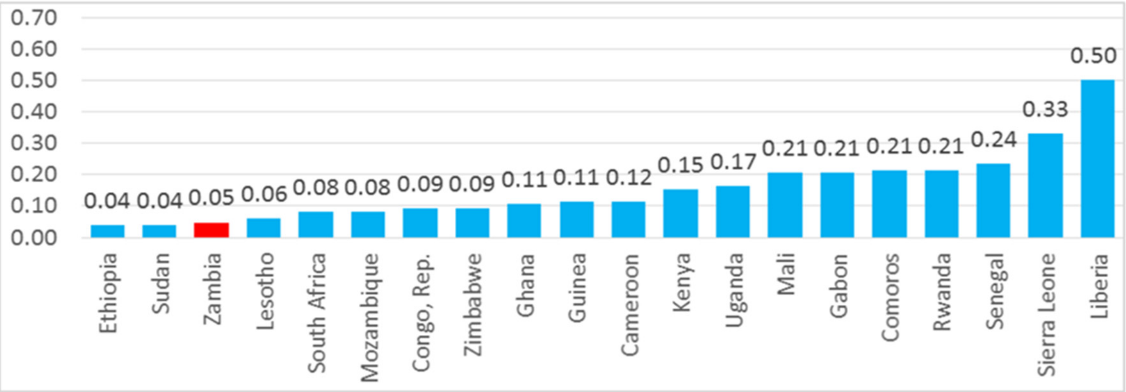

FIGURE 2: Average electricity tarrifs in Sub-Saharan Africa (World Bank, 2017)

TABLE 1: Geothermal fields and hot springs in Zambia
(adapted from Legg, 1974)

	Surface temp. (°C)	**Est. reservoir temperature (°C)**		**Dis-cha. (l/s)**	**Comments**
		Lower range	**Higher range**		
Northern group					
Kalaye	51	118	164	7	Lower value by Truesdell \ higher by Fournier
Kapisya	85	115	123	25	Lower value chalcedo. \ higher by Truesdell
Kaputa	51	71	86	2	Lower value Quartz \ higher by Giggenbach
Mansa group					
Mansa	49	151	188	4	Lower value by Truesdell \ higher by Fournier
Kabunda	42	176	217	3	Lower value by Truesdell \ higher by Fournier
Luano	50	147	184	10	Lower value by Truesdell \ higher by Fournier
Western group					
Kaimbwe	53	120	140	2.5	Lower value by Fournier \ higher by Giggenba.
Lupiamanzi	79	106	149	15	Lower value by Truesdell \ higher by Fournier
Longola	70	106	149	10	Lower value by Truesdell \ higher by Fournier
Lubungu	76	119	167	15	Lower value by Truesdell \ higher by Fournier
Eastern group					
Kanunshya	28	114	175	1	Lower value by Truesdell \ higher by Giggenb.
Kalamulilo	40	125	184	3	Lower value by Truesdell \ higher by Giggenb.
Chongo	12	165	215	11	Lower value by Truesdell \ higher by Giggenb.
Nabwalya South	67	138	195	10	Lower value by Truesdell \ higher by Giggenb.
Kazakaze	55	94	158	2.5	Lower value by Truesdell \ higher by Giggenb.
Nsefu	56	148	185	5	Lower value by Truesdell \ higher by Fournier
Nsefu Spring	30	141	197	5	Lower value by Truesdell \ higher by Fournier
Manze	29	92	113	5	Lower value by Fournier \ higher by Giggenba.
Musaope	74	176	208	7	Lower value by Truesdell \ higher by Fournier
Eastern group					
Malanga	58	72	119	2	Lower value by Truesdell \ higher by Fournier
Chikoa	64	104	148	6	Lower value by Truesdell \ higher by Fournier
Msoro	58	165	199	5	Lower value by Truesdell \ higher by Fournier
Mwape	46	135	155	4	Lower value by Fournier \ higher by Giggenba.
Kanzi	35	93	138	2	Lower value by Truesdell \ higher by Fournier
Southeastern group					
Mililo	65	169	202	-	Lower value by Truesdell \ higher by Fournier
Kalingala River	50	123	164	6	Lower value by Truesdell \ higher by Fournier
Chinyunyu	63	109	115	6	Lower value by Truesdell \ higher by Fournier
Choma group					
Muckleneuk – N	44	-	-	0.3	Low confidence reg. geothemometry
Muckleneuk – main	74	-	-	6.3	Low confidence reg. geothemometry
Chibimbi	58	-	-	0.6	Low confidence reg. geothemometry
Mosali	52	-	-	0.4	Low confidence reg. geothemometry
Lochnivar group					
Lochnivar Park	-			-	
Gwisho	71	151	205		Lower value by Truesdell \ higher by Giggenb.
Bwanda	94	162	211	17	Lower value by Truesdell \ higher by Giggenb.
Namulala	52	-	-	9	Low confidence reg. geothemometry

Truesdell: Truesdell and Fournier, 1976; *Fournier:* Fournier, 1977; *Giggenb.*: Giggenbach, 1981.

2.1 Rural electrification and rural development

The electrification rates in Zambia have been growing over the years. However, the growth rates have been slow due to many factors, which include dependence on grid tied electrification. As of 2015 the electrification rates in Zambia for rural areas were at 4.4% and the urban electrification rates were around 67.3%, according to the living conditions monitoring survey (CSO, 2015). In order to increase the electrification rates the Rural Electrification Authority (REA) was set up in 2003. Subsequently, the Rural Electrification Master Plan (REMP) was also launched in 2008 to be implemented by the REA with the view to boost rural electrification and to manage and implement all rural electrification funds and programmes. In the REMP there were 1,217 Rural growth centres (RGC) across the country as electrification targets for electrification. As defined by the REMP, a RGC is a rural locality with high concentration of residential households and a centre for rural economic activity (JICA, 2008). The RGCs in the REMP were identified for suitability for electrification with solar photovoltaic, wind, diesel and geothermal. The RGCs have a load or electricity demand that can sustain a mini grid and make it economically viable. The RGC concept is demonstrated in Figure 3.

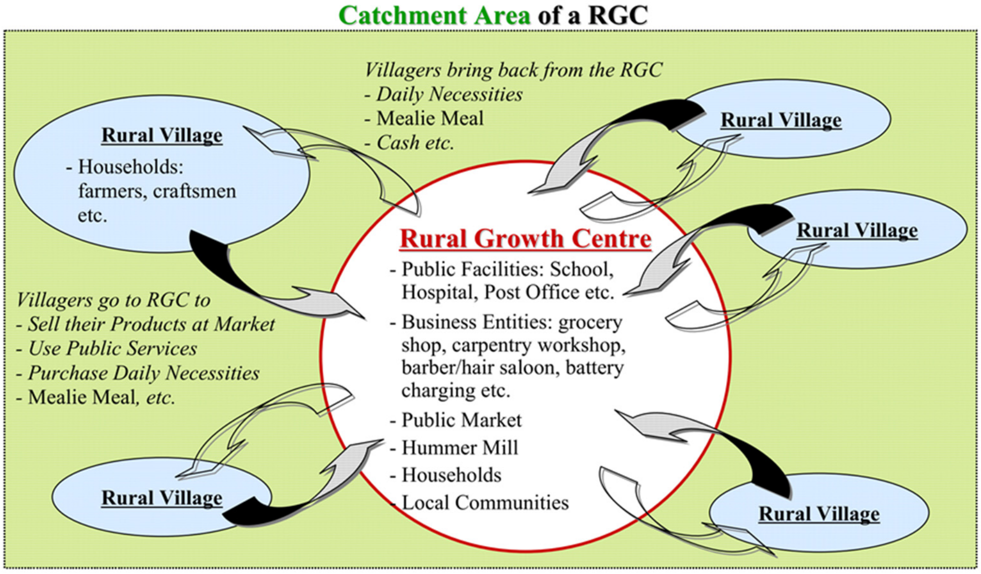

FIGURE 3: Rural growth centre – RGC (JICA, 2008)

According to the World Bank (World Bank, 2017) there are two major challenges for rural electrification in Zambia:

I. Low population densities in rural areas which have insufficient loads for electrification;
II. The network extension choices for electrification, such as using standard three phase technology, lead to over-specified medium voltage and low voltage for rural areas and making it prohibitively expensive for on-grid access.

The average cost of grid extension is 10,000-22,000 USD/ km, depending on the terrain. With these challenges there are many opportunities for rural electrification with off-grid solutions such as mini grids using solar photovoltaic, wind, geothermal and diesel.

3. BACKGROUND OF KAPISYA GEOTHERMAL PROJECT

In the 1980s, the Zambian and Italian Governments signed a bilateral agreement to explore and develop geothermal resources in Zambia with the view of producing electricity. In this agreement the Italian government was to conduct geothermal exploration in Zambia and install a power plant at a suitable site according the results of the exploration. The Zambian government was to construct power lines and grid distribution from a power plant at Kapisya geothermal field to a load centre which was close to the field, but at the same time far from the national grid. DAL S.p.A. of Italy was contracted by the Italian Government to carry out the geothermal exploration, development and power plant installation. Geothermal exploration commenced in 1986 and once it was completed by the contractor through drilling of fourteen shallow wells it was recommended that an Organic Rankine Cycle (ORC) binary power plant be installed at the Kapisya geothermal field. Two ORC generators were installed each with a nominal rating of 120 kW and a net output of 100 kW, bringing the total nominal installed power to 220kw and total rated output to 200 kW (Dominico and Liguori, 1986).

The full commissioning of the power plant for power transmission required the construction of power lines to the load centre by the Zambian Government. However, the power lines were not constructed and the power plant was subsequently handed over to the Geological Survey Department (GSD) in 1988. Since then not much activity has been undertaken at the site and the plant was eventually handed over to the national power utility company ZESCO Ltd. in 1999 to facilitate the power lines construction (Sikazwe and Musonda, 2005).

From the time the power plant was handed over to ZESCO Ltd. a few studies have been conducted on the Kapisya geothermal field. Since there was no full commissioning of the power plant, a full commissioning report was unavailable and there was incomplete documentation at the time of the hand over to ZESCO Ltd. Hence, the studies conducted focused on the exploration stage of geothermal development with the view to establish the actual potential of the Kapisya geothermal field for electricity production. KenGen of Kenya was contracted to carry out geothermal exploration at the Kapisya geothermal field as well as the Chinyunyu geothermal field which is located close to the capital city of Lusaka (Kombe, 2009). According to Omenda et al. (2007) the reservoir temperatures of Kapisya are around 125°C, estimated from geothermometers. Geophysical surveys were also conducted using TEM and MT measurements. Based on this a conceptual geothermal model was built. In establishing the possible power that could be generated from Kapisya field, a Monte Carlo simulation was conducted and the results indicated that the field could produce 2 MW of power. Deeper drilling to the highest temperatures of the field was recommended (Omenda et al., 2007).

A few years later, another study was conducted in order to establish Kapisya' s geothermal energy potential (Óskarsson et al., 2014), including geochemical analyses and geophysical magnetic surveys. The estimated reservoir temperatures were assessed to be up to 115°C. This was somewhat lower than the previous estimate of the geothermal reservoir temperature to be around 125°C. To achieve the highest possible temperature, deeper drilling was also recommended (Óskarsson et al., 2014).

The ORC binary power plant at Kapisya geothermal field is shown in Figure 4. Considering the history outlined above, this study's focus is to find a pragmatic and economically viable solution to generate electricity from Kapisya geothermal field.

FIGURE 4: The Kapisya binary plant (Kombe, 2009)

4. ORC UNITS ON THE MARKET

4.1 Brief description of small ORC units

There are several types of ORC binary units available on the market today. The power output ranges from as small as 35 kW up to 5 MW, using different ranges of temperatures as minimum temperatures, starting from 70 up to 130°C. The small ORC units have drawbacks in terms of output compared to the large ORC binary units. The pumps of the small ORC units may consume as much as 30% of the power produced (Zhai et al., 2016). However, with technological advances small ORC units have significantly increased in efficiency. The introduction of screw expander technology has made the small ORC units competitive at similar capacities with turbine technology ORC units. These screw expander units are even 30% cheaper than comparable units with turbine driven systems (Smith et al., 2005). Figure 5 shows a diagram of a binary ORC screw expander.

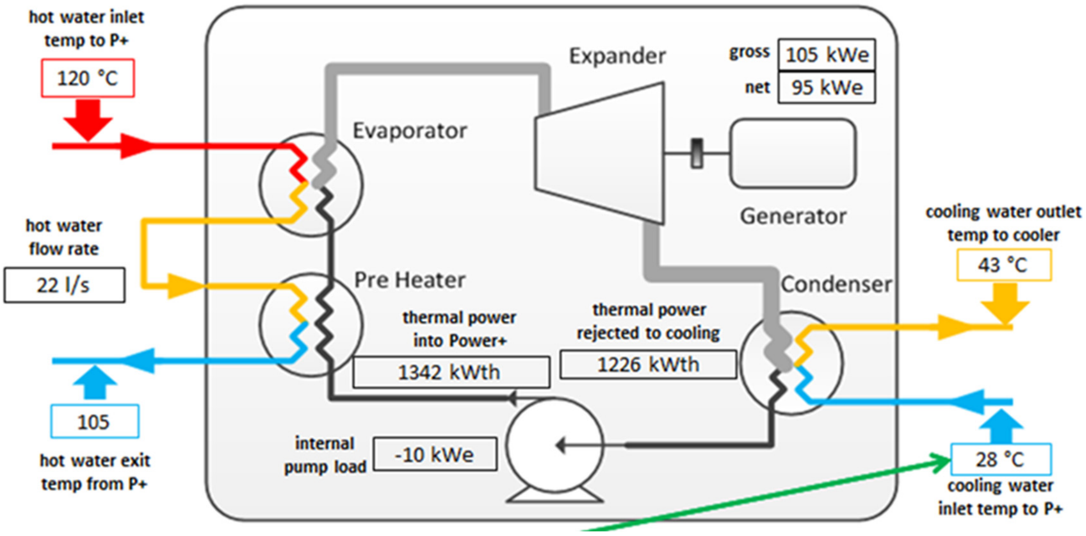

FIGURE 5: Screw expander for a binary ORC (ElectraTherm, 2018)

4.2 Case examples of installations of small ORC units

4.2.1 Maguarichic - Mexico

This is an ORC binary power plant with an installed capacity of 300 kW. This was installed in rural Mexico for the purpose of rural electrification. The input temperatures are around 105°C and the net output is around 200 kW (Sánchez Velasco, 2005).

4.2.2 Romania

There is a 50 kW ORC binary plant in Romania using screw expander technology instead of turbine technology. It operates with an input temperature of 105°C and average flow rates of 10.1 l/s (ElectraTherm, personal comm.).

4.2.3 Japan

The ElectraTherm company utilizes Organic Rankine Cycle (ORC) and proprietary technologies to generate up to 110 kWe of electricity from low-temperature water ranging from 77 to 122°C. At this site, located in Beppu in Japan, the *onsen* (Japanese for bath-pool) provides varying flows of geothermal steam at approximately 110°C. Unlike other renewable sources, geothermal heat is baseload, providing a continuous hot water flow with power generation capabilities. Hot geothermal water is the fuel used to create a high pressure vapour that expands through the patented twin screw power block, spinning an electric generator to produce clean electricity while simultaneously cooling the water by 20°C (ElectraTherm, personal comm.).

4.2.3 Chena Hot Springs, Alaska, USA

This binary plant utilizes R134a, a fluid to flash to vapour, which then drives the turbine to produce electricity. The binary system at Chena involves several steps. First the 74°C geothermal fluid enters the evaporator which is a large heat exchanger. Here the hot geothermal fluid transfers its energy to the R134a fluid converting it to gas. The R134a gas is then routed to the turbine which is connected to a generator to produce electricity. After passing through the turbine, the gas is routed to a condenser where natural cold water, with a temperature of 2.8-7.2°C, is used to convert the R134a gas back to a liquid. In both the evaporator and the condenser, the R134a fluid is not in direct contact or mixed with the geothermal water or the cold water so the working fluid remains pure. The geothermal water is then routed through the buildings before being re-injected back into the thermal reservoir. The 400 kWe binary system produces 100% of the electric power needed by the Chena Hot Springs Resort, and because the system is a closed loop, nothing is emitted to the atmosphere. The power unit at Chena utilizes geothermal fluids at 74°C to produce the 400 kWe of power for the resort, the lowest geothermal temperature producing power in the world (Leeland et al., 2015).

5. VENDORS AND MANUFACTURERS OF SMALL ORC UNITS ON THE MARKET

In the preparation of this report several vendors and manufactures of small ORC units were contacted. This was done to obtain updated information on the prices, performances and required maintenance cost to be encountered when running a small ORC binary plant. The inquiry to the vendors and manufactures also included the actual geothermal parameters for Kapisya geothermal field such as the flow rates of the springs and wells, the geochemical composition and temperatures. Below is a list of vendors and manufactures that were contacted:

- Climeon;
- Enorgia;
- ElectraTherm;
- Triogen;
- Infinity Turbine;
- Mattei;
- Pratt and Whitney;
- Zucatto Energy;
- Clean Power; and
- Exergy.

There were many vendors who responded and gave their conditions and specifications for their ORC units and recommendations regarding Kapisya geothermal plant. Of the contacted vendors and manufacturers, a meeting was held with representatives from Electra, as ElectraTherm had the best solutions and most pragmatic recommendations given the geothermal conditions known at Kapisya (ElectraTherm, personal comm.). ElectraTherm has already installed small binary ORC units using a screw expander technology in several places, such as a 75 kW unit Florida Canyon in Nevada, USA, the 110 kW unit in Beppu, Japan and the 75 kW unit in Romania. This was suitable for Kapisya which is a low-enthalpy system. The available sizes of small ORC units offered by ElectraTherm were 35 kW, 75 kW and 110 kW (ElectraTherm, 2018). The options given by ElectraTherm were water cooled and air cooled ORC units.

For Kapisya geothermal project a water cooled unit was chosen as the better option despite it costing more than the air cooled unit. This was a complex decision. There are several reasons to be taken into consideration when choosing the cooling system. Since Kapisya geothermal field is situated in a subtropical location, cooling can significantly affect the net power output. With this fact it is imperative that the project has the option with the more optimum or higher output considering that the plant is small and every kilowatt gained to the system can affect the long term profitability of the project. According to Astolfi et al. (2017), in higher ambient temperature conditions, in this case sub-tropical conditions, the water cooled system is preferred to the air cooled system. This is because in higher temperature conditions there is an increase in cycle condensing temperature which penalises the air cooling system compared to the water cooled system. This results in more net power output for the water cooled system compared to the air cooled system, despite the fact that the water cooled system also involves an extra pump for water pumping. For the Kapisya project water cooling system is also easier to set up as the project is located on the shores of Lake Tanganyika which provides a readily available source of cooling water. This would have to involve a small cooling pond to be excavated close to the plant for the cooling water.

6. ECONOMIC AND FINANCIAL ANALYSIS OF KAPISYA GEOTHERMAL PROJECT

From a project management stand point, economic and financial analysis is very important and one of the major determinants as to whether a project should be undertaken or not. With the results from the economic and financial analysis, a bankable project document can be prepared. This is essential when reaching project bankability and project financing from banks and cooperating partners. In the case of revamping the Kapisya geothermal plant, the sustainability of the project to produce power is important. Demonstrating that the project is feasible with the available ORC binary technology and supported by an economic and financial analysis is essential before funds can be availed to develop the project. In this case, after extensive consultations with vendors and manufacturers of small ORC binary plants considering the temperatures and fluid chemistry at Kapisya geothermal field, a financial model was used based on Jensson (2016). The results of the financial calculations are presented in Appendix I.

6.1 Project assumptions

For the Kapisya geothermal project the assumptions are that there is no further drilling required as drilling was already conducted by DAL S.p.A. of Italy in 1988 (Sikazwe and Musonda, 2005). There are already fourteen wells drilled in the field. However, since the wells have not been used for some time well tests are required to ascertain which wells have the best flow, as a small binary ORC of 110 kW requires at least a flow rate of 22 l/s of hot fluid to attain maximum output. The Kapisya field has flow rates of at least 25 l/s according to Table.1. Pumps can be installed in wells to get fluid with higher temperature than the surface temperature. According to the manufacture ElectraTherm, there is no need to have a separate housing for the specified small binary plant since the design of the power plant is such that it does not need a separate base such as concrete floors as large binary plants need, because of its small scale and robust design (Electra Therm, pers. comm.). Other assumptions for this project have been obtained from lecture notes, consultations and other publications and case studies of similar projects.

TABLE 2: Project assumptions

Project parameters	Unit
Power plant type	Binary ORC (Screw expander)
Rated electricity output	110 kW
Construction duration	12 months
Planning horizon	20 years
Grant funding	500,000 USD
Operating and maintenance costs	10,000 USD
Sales quantity	0.7 GWh/year
Depreciation equipment	10%
Discount rate	10%

In estimating the expected revenues for the power plant, a capacity factor is used. The net power of the plant produced in a year is multiplied by the capacity factor as shown in Equation 1:

$$\text{Revenue / Year} = 365 \times 24 \times P_{Net} \times C \times P_{\$} \qquad (1)$$

where 365 = Number of days in a year;
24 = Number of hours in a day;
P_{Net} = Net power output;
$P_{\$}$ = Electricity price (USD 0.15 as project threshold electricity price); and
C = Capacity factor.

7. RESULTS OF PROFITABILITY MODEL

The profitability model analyses the investments, capital requirements of the project, the internal rate of return, the net present value and the performance of future revenues and operations once the project is implemented and is described in this section.

7.1 Marginal Attractive Rate of Return (MARR)

The Marginal Attractive Rate of Return (MARR) is defined by Salas (2012) as the discount rate that the investor in the project appreciates compared to other financial investments of an equivalent risk. The most preferred investment alternatives are provided by the rate of return and MARR for equity is the investor´s cost of capital. In this project the minimum acceptable rate of return is 10%.

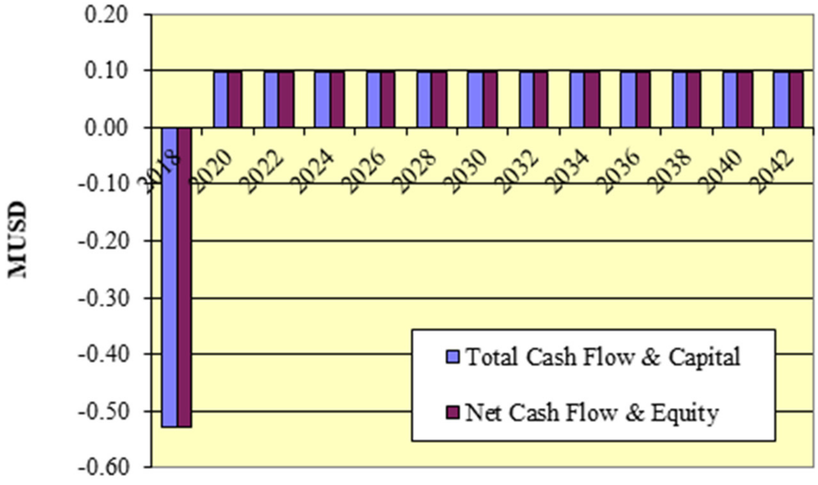

FIGURE 6: Net cash flows

7.2 Net cash flows

From Figure 6, it is shown that the cash flow in the first year is negative. The high cost at this stage is due to logistics, power plant assembly and well installations. The cash flow becomes positive in year 2019, a year after the assembly and installation of the power plant, and the electricity generation commences and revenue starts being generated from electricity sales. The net cash flow and capital after the year of construction is equal to net cash flow and equity. This is due to the fact that the project is wholly funded by a grant and no loans are involved.

7.3 Net Present Value (NPV)

The Net Present Value (NPV) is the difference between the present value of all incoming cash flows and the outgoing cash flows related to an investment project. The NPV determines whether the investment project is acceptable given the investor´s expected rate of return from the investment (Jensson, 2016). The formula for NPV is represented as:

$$NPV(i) = \frac{A_0}{(1+i)^0} + \frac{A_1}{(1+i)^1} + \cdots + \frac{A_n}{(1+i)^n}$$

$$= \sum_{n=0}^{N} \frac{A}{(1+i)^0} \tag{2}$$

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

If the NPV is positive for a single project, then the project should be accepted and this means that the project has a greater equivalent value of inflows to outflows and is therefore profitable.

According to Jensson (2006) in deciding to invest in a project the following should apply:

If NPV (i) > 0, accept the investment;
If NPV (i) = 0, remain indifferent to the investment; and
If NPV (i) < 0, reject the investment.

In Figure 7, the accumulated NPV for the total capital at a 10% discount rate is 0.34 M USD while the accumulated NPV of equity at a discount rate of 10% is 0.34 M USD. The NPV of total cash flows turns positive after 8 years of operations while the NPV of net cash flows turns positive after 7 years of operations. For this project the NPV turns positive so the project is viable and economically acceptable.

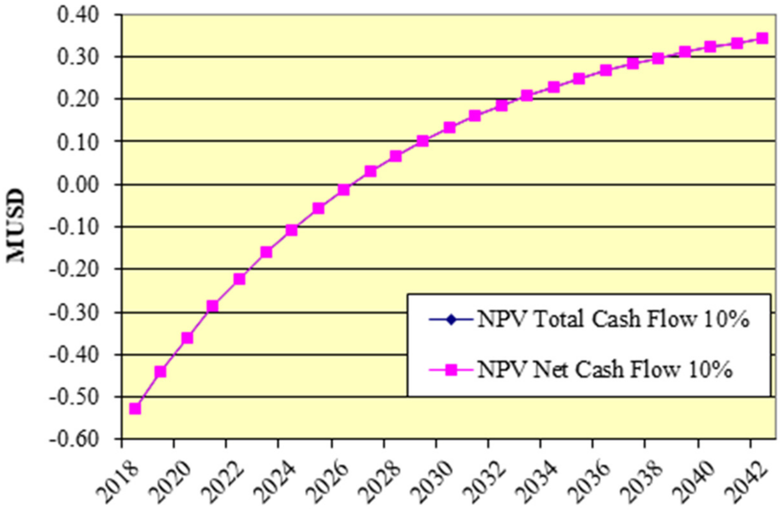

FIGURE 7: Net Present Value (NPV)

7.4 Internal Rate of Return (IRR)

The internal Rate of Return is the discount rate where the NPV of the cash flow of an investment is equal to zero. The IRR is therefore equal to the rate of return for which the following function is equal to zero:

$$\sum_{n=0}^{N} \frac{A_n}{(1+i)^0} = 0 \tag{3}$$

According to Jensson (2006), investors desire to excel beyond the breakeven point when deciding to make investments. The investor´s investment policy defines the MARR and the MARR and IRR are used to determine whether the project is feasible or not feasible. The rule for deciding the project feasibility is as follows:

If IRR > MARR – Accept project;
If IRR = MARR - Remain indifferent; and
If IRR < MARR - Reject project.

In Figure 8, the IRR of net cash flows and the IRR of total cash flows are both 18%. The reason why the graph of the IRR of net cash flow and the IRR of total cash flows are super imposed on each other is because there are no loans involved in the project. Therefore, since the IRR of 18% is greater than the MARR or discount rate which is 10%, this entails that the project is viable and it is acceptable to invest in this project according to the rule above.

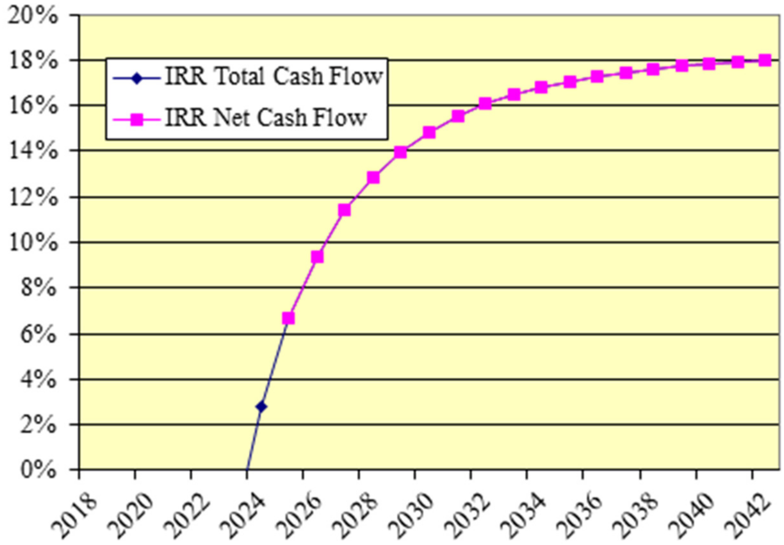

FIGURE 8: Internal Rate of Return (IRR)

7.5 Risk assessment analysis

The impact assessment analysis helps to assess which of the variables affect and influence the cost of the project and the benefits of the project stream. This includes the operation and maintenance of the power plant, the equipment cost and the sales price of electricity.

A sensitivity analysis is carried out to determine how much the IRR is influenced and changes with respect to the given parameters and in this case the parameters are the operation and maintenance of the power plant, the equipment cost and the sales price of electricity. A base case scenario is defined from the most likely values for each of the variables, i.e. pessimistic, most likely and optimistic. The variables are changed one at a time for a given percentage which is specified. The values used in this project's sensitivity analysis range from -50% to +50%, while keeping other values constant at the base case value. For the new value the output is then calculated. For this project the IRR is significantly affected by sales price and sales quantity of electricity. The output is the IRR of equity and the results are shown below in Table 3.

TABLE 3: Sensitivity analysis

		Price		**Sales quantity**		**Equipment**		**O&M**
		18%		**18%**		**18%**		**18%**
-50%	50%	8%	50%	7%	50%	18%	50%	18%
-40%	60%	10%	60%	9%	60%	18%	60%	18%
-30%	70%	12%	70%	11%	70%	18%	70%	18%
-20%	80%	14%	80%	14%	80%	18%	80%	18%
-10%	90%	16%	90%	16%	90%	18%	90%	18%
0%	100%	18%	100%	18%	100%	18%	100%	18%
10%	110%	20%	110%	20%	110%	18%	110%	18%
20%	120%	22%	120%	22%	120%	18%	120%	18%
30%	130%	24%	130%	24%	130%	18%	130%	18%
40%	140%	25%	140%	26%	140%	18%	140%	18%
50%	150%	27%	150%	28%	150%	18%	150%	18%

8. FISH DRYING – THE OTHER POTENTIAL FOR GEOTHERMAL UTILISATION

Kapisya geothermal field is situated on the shores of Lake Tanganyika where there is also a fishing industry. The fish caught locally is sometimes smoked with wood gathered from the area. Gathering wood for fish drying is one of the contributors to deforestation. Refrigeration for the local fish industry is not available due to the lack of electricity to the area. Fish drying using geothermal resources can significantly contribute to the growth of the fish industry near Kapisya geothermal field.

Iceland is renowned for utilisation of geothermal resources which also include fish drying. There are over twenty companies that use geothermal resources for commercial fish drying (Arason, 2018). Geothermal fish drying as in Iceland can be used by the local fish industry at the Kapisya geothermal field. Sun drying of fish is predominantly used for fish preservation by the local fish industry in Kapisya. There are some challenges with sun drying of fish that are experienced during the rainy season as the fish is dried out in the open. However, with geothermal drying indoors, the wind or rain do not affect the drying process and there are no interruptions to the it. This is not the case when the fish is dried in the open in the sun, and in the case where the rainfall activity is high during the rainy season the drying process is frequently interrupted. According to Arason (2018), the following disadvantages are experienced in sun drying of fish:

- Sun drying makes the fish prone to contamination by dust;
- It is very dependent on the prevailing weather conditions;
- There are slow drying rates in sun drying and this increases the chances of mould; and
- Drying of fish in the sun may not reduce the moisture content of the fish, thereby increasing the risk of mould as well as making it difficult to prevent mould growth.

The local fish industry in Kapisya and others localities along the shores of Lake Tanganyika encounter the challenges mentioned above regularly. According to Arason, 2018, fish drying using geothermal resources has many advantages, such as:

- It has a shorter drying time compared to sun drying;
- The drying can be done all year round and is not dependent on prevailing weather conditions;
- Contamination of the fish from flies and insects is controlled and prevented;
- The water content is consistent and the product quality is high; and
- This is a utilisation of local clean renewable resource compared to smoking fish as means of preservation using fire wood.

With the foregoing benefits the fish industry near Kapisya geothermal field can expand and exploit the potential of the geothermal resources in their region. This is very advantageous especially as there is no commercial refrigeration currently available, due to the non-electrification of the region.

9. DISCUSSION

The Kapisya geothermal project has been inactive since 1988 when it was installed by Dal S.p.A. of Italy and handed over to the Geological Survey Department of Zambia. The subsequent stage where the power lines were to be constructed by the Zambian Government was not covered in the bilateral agreement and the power lines were never constructed (Sikazwe and Musonda, 2005). This is the major reason why the plant was not fully commissioned. The increase in population and economic activity has increased the electricity load from the area which has surpassed the currently installed capacity of 220 kW. Previously the electricity load in the area was small, hence the need to build power lines to the nearest load centre.

The current Turboden turbine power plant has a lot of component which have not been used and exposed to the elements. The cost of replacing the old components is high as some of the parts are no longer manufactured. Installing a new plant with updated technology is more feasible. Turbine technology ORC is more efficient than screw expander ORC but more expensive for small power generation in the kW-range. Therefore, screw expander ORC is cheaper and more cost effective for power generation here (Smith et al., 2005). Therefore, revamping the Kapisya geothermal project through installing a screw expander is economically more feasible as shown by the financial model used where the IRR is 18% and greater than the MARR. The advantage for implementing this project is that the electricity load is not very far from the power plant, thereby reducing the expected cost of power lines significantly. The screw expander ORC unit also has the advantage of generating power with temperature as low as 70°C.

The other opportunity for Kapisya geothermal field is fish drying. There is a small fishing industry in the region of Kapisya geothermal field and the reliance on power from diesel generation is not economically sustainable to enable reliable baseload power for commercial refrigeration. With fish drying using geothermal resources the output from the fishing industry can be sustainably expanded creating more economic opportunities for the region.

10. CONCLUSION

From this study there are three main conclusions reached in the economic and financial analysis of revamping the Kapisya geothermal plant:

- Refurbishing the old Turboden binary turbine power plant is not economically viable for electricity power output below 1 MW compared to the alternative options.
- Installing a ORC binary screw expander power plant is economical and viable for the low-enthalpy system at Kapisya. This should be started with the installation of 110 kW and then increased stepwise.
- The Kapisya geothermal field has great possibilities to be used for fish drying as the field is located at the shores of Lake Tanganyika where the local fish industry has easy access to the geothermal resources and can easily exploit the local resources for fish processing and preservation.

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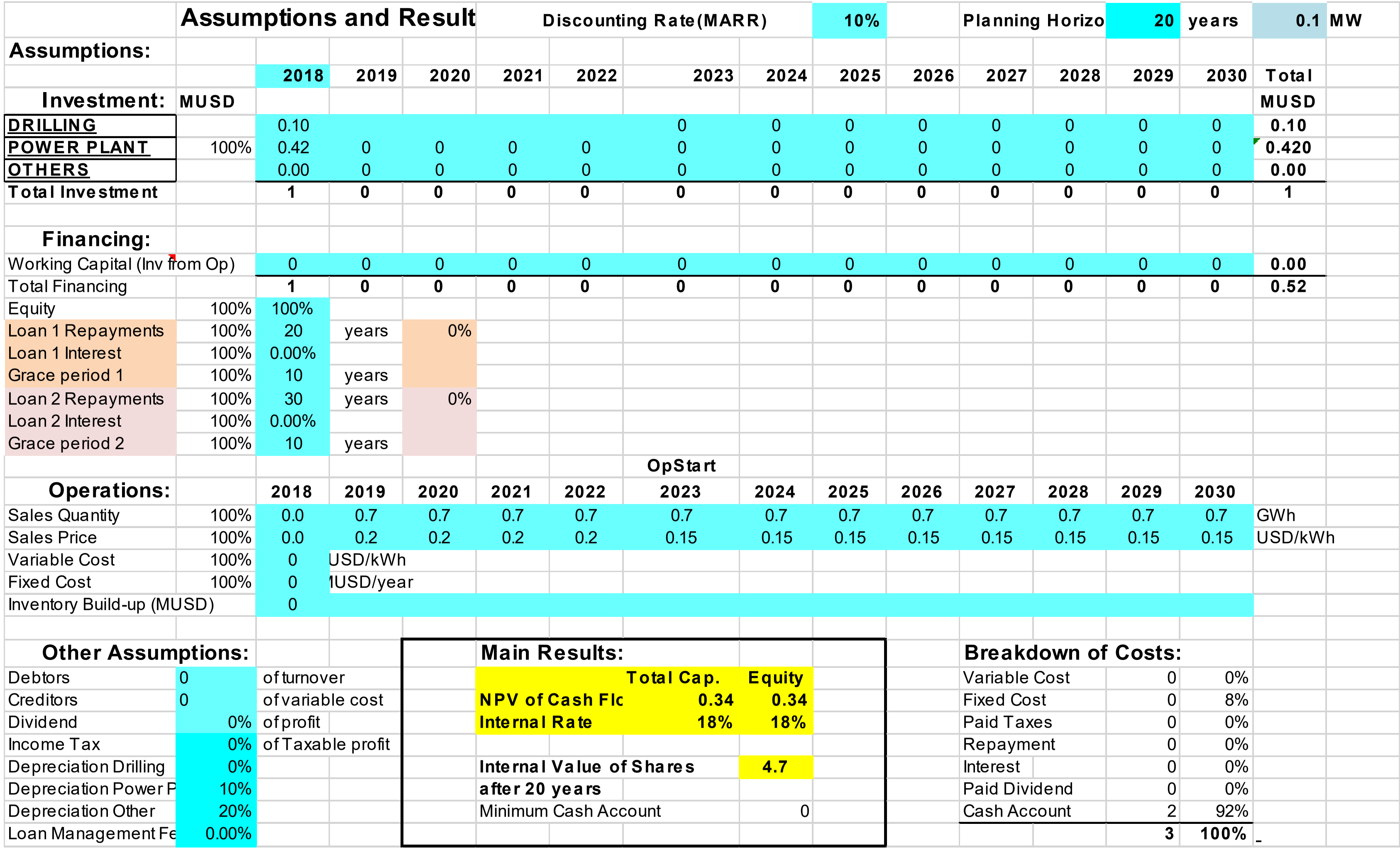
Appendix I: Results of financial calculations

Summary results:



	Assumptions and Result				**Discounting Rate(MARR)**				**10%**		**Planning Horizo**		**20**	**years**	**0.1**	**MW**
Assumptions:																
		2018	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**Total**	
Investment:	**MUSD**														**MUSD**	
DRILLING		0.10					0	0	0	0	0	0	0	0	**0.10**	
POWER PLANT	100%	0.42	0	0	0	0	0	0	0	0	0	0	0	0	**0.420**	
OTHERS		0.00	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**	
Total Investment		**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	
Financing:																
Working Capital (Inv from Op)		0	0	0	0	0	0	0	0	0	0	0	0	0	**0.00**	
Total Financing		**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.52**	
Equity	100%	100%														
Loan 1 Repayments	100%	20	years	0%												
Loan 1 Interest	100%	0.00%														
Grace period 1	100%	10	years													
Loan 2 Repayments	100%	30	years	0%												
Loan 2 Interest	100%	0.00%														
Grace period 2	100%	10	years													
							OpStart									
Operations:		**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**		
Sales Quantity	100%	0.0	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	GWh	
Sales Price	100%	0.0	0.2	0.2	0.2	0.2	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	USD/kWh	
Variable Cost	100%	0	USD/kWh													
Fixed Cost	100%	0	USD/year													
Inventory Build-up (MUSD)		0														
Other Assumptions:					**Main Results:**						**Breakdown of Costs:**					
Debtors	0	of turnover					**Total Cap.**	**Equity**			Variable Cost		0	0%		
Creditors	0	of variable cost			**NPV of Cash Flc**		**0.34**	**0.34**			Fixed Cost		0	8%		
Dividend	0%	of profit			**Internal Rate**		**18%**	**18%**			Paid Taxes		0	0%		
Income Tax	0%	of Taxable profit									Repayment		0	0%		
Depreciation Drilling	0%				**Internal Value of Shares**			**4.7**			Interest		0	0%		
Depreciation Power P	10%				**after 20 years**						Paid Dividend		0	0%		
Depreciation Other	20%				Minimum Cash Account			0			Cash Account		2	92%		
Loan Management Fe	0.00%												3	**100%**	-	

Investments:

Investment

		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	Total
Investm and Financing		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	
Investment:																											
DRILLING		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.10**
POWER PLANT		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.420**
OTHERS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.0**
		1	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**
Booked Value of Fixed Assets																											
DRILLING		0.10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000	0.000	
POWER PLANT		0.420	0.420	0.378	0.336	0.294	0.252	0.210	0.168	0.126	0.084	0.042	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	
OTHERS		0.000	0.000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Total Booked Value		**0.52**	**0.420**	**0.378**	**0.34**	**0.294**	**0.252**	**0.210**	**0.1680**	**0.1260**	**0.084**	**0.042**	**0.000**	**0.000**	**0.00**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.00**	
Depreciation:																											
Depreciation DRILLING	0%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Depreciation POWER P	10%	0	0.00000	0.0420	0.0420	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0.378**
Depreciation OTHERS	20%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Total Depreciation		**0**	**0**	**0.042**	**0.042**	**0.042**	**0.042**	**0.042**	**0.042**	**0.042**	**0.042**	**0.042**	**0.042**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.378**
Financing:																											
Equity	100%	0.52	0.000	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.52**
Loan1	0%	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
Loan 2	0%	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
Total		**0.52**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.52**

Operations:

Operations

		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	Total
Operations Statement																											
Sales		0	0.70	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	**16.8**
Price		0	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	
Revenue		**0**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**0.105**	**3**
Variable Cost	0	0.001	0.00	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Fixed Cost	0.008	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080	0	0	0	0	0	0	0	0	0	0	0	0	**0.2000**
Diverse Taxes																											
Operating Surplus (EBITDA)		**-0.01**	**0.097**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0.10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**2**
Inventory Movement		0.001	0	0	0																						
Depreciation		0	0	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0	0	0	0	0	0	0	0	0	0	0	0	0	**0**
Operating Gain/Loss (EBIT)		**-0.01**	**0.10**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1.90**
Financial Costs		0.0000	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
Profit before Tax		**-0.01**	**0.10**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.10**	**0.10**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**2**
Loss Transfer	0	-0.008	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Taxable Profit		0.000	0.089	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.055	0.097	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	
Income Tax	0%	0.000	0.000	0.000	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0.00**
Profit after Tax		**-0.01**	**0.10**	**0.055**	**0.055**	**0.055**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.06**	**0.097**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**2**
Dividend	0%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	**0**
Net Profit/Loss		**0.0**	**0.097**	**0.055**	**0.055**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.055**	**0.097**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**2**

Cash flows:

Cash Flow

		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	Total
Cash Flow																											
Operating Surplus (EBITDA)		-0.009	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	2
Debtors	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Debtor Changes			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Greditors	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Creditor Changes			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Financing - Expenditure		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
Cash Flow before Tax		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Paid Taxes			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Cash Flow after Tax		0.0	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	2
Interest & Loan Man Fee		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Repayment		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Net Cash Flow		-0.01	0.10	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2
Paid Dividend			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
																											0
Cash Movement		-0.01	0.097	0.10	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	2.32

Balance:

Balance

		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042
Balance Sheet																										
Assets																										
Cash Account	0	-0.01	0.088	0.19	0.28	0.38	0.48	0.57	0.67	0.77	0.86	0.96	1.06	1.16	1.25	1.35	1.45	1.54	1.64	1.74	1.83	1.93	2.03	2.13	2.22	2.32
Debtors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Stock	0	0.001	0.0010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Current Assets		0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2
Fixed Assets		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Assets		0.512	0.509	0.564	0.619	0.674	0.729	0.784	0.839	0.894	0.949	1.004	1.059	1.156	1.253	1.350	1.447	1.544	1.641	1.738	1.835	1.932	2.029	2.126	2.223	2.320
Debts																										
Dividend Payable		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Taxes Payable		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Creditors		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Next Year Repayment		0	0	0	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Current Liabilities		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Long Term Loans		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Debt		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Equity	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Profit & Loss Balanc	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2
Total Capital		0.512	0.609	0.664	0.719	0.774	0.829	0.884	0.939	0.994	1.049	1.104	1.159	1.256	1.353	1.450	1.547	1.644	1.741	1.838	1.935	2.032	2.129	2.226	2.323	2.420
Debts and Capital		0.512	0.609	0.664	0.719	0.774	0.829	0.884	0.939	0.994	1.049	1.104	1.159	1.256	1.353	1.450	1.547	1.644	1.741	1.838	1.935	2.032	2.129	2.226	2.323	2.420

Profitability:

Profitability

		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	Total
Profitability Measurements																											
NPV and IRR of Total Cash Flow																											
Cash Flow after Taxes		-0.01	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	2.319
Total Capital		-0.520	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.52
Total Cash Flow & Capita		-0.529	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	0.097	1.799
NPV Total Cash Flow	10%	-0.529	-0.441	-0.361	-0.288	-0.222	-0.161	-0.107	####	####	0.030	0.067	0.101	0.132	0.160	0.186	0.209	0.230	0.249	0.267	0.282	0.297	0.310	0.322	0.333	0.343	
IRR Total Cash Flow			-82%	-47%	-25%	-11%	-3%	3%	7%	9%	11%	13%	14%	15%	16%	16%	16%	17%	17%	17%	17%	18%	18%	18%	18%	18%	
NPV and IRR of Net Cash Flow																											
Net Cash Flow		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Equity		-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	-1
Net Cash Flow & Equity		-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
NPV Net Cash Flow	10%	-1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
IRR Net Cash Flow									7%	9%	11%	13%	14%	15%	16%	16%	16%	17%	17%	17%	17%	18%	18%	18%	18%	18%	
Financial Ratios																											