PROJECT REVIEW OF THE GEOTHERMAL SPAS CONSTRUCTION IN KENYA AND ICELAND

Peketsa Mangi
Kenya Electricity Generating Company Ltd
P.O. Box 785-20117
NAIVASHA, KENYA
pmangi@kengen.co.ke

ABSTRACT

Development of geothermal energy faces many challenges ranging from finances to inadequate expertise. These challenges have always been the focus for most geothermal projects. However, with growth of size of geothermal projects, coupled with the need for efficiency and timely delivery of these projects as dictated by stakeholders, there is need to adopt project management approaches before, during implementation and project closure. This is critical not only for electricity generation projects but also for direct use projects. Adoption of project management approach in geothermal projects has the net effect of reducing project failure and enhancing project success, minimizing risks, reducing the cost of construction of the project, satisfying interested parties or stakeholders to the project thus contributing to the overall success of the project, reducing the cost of power or cost of the anticipated services, encouraging professional development and enhancing best practices within an organization. This paper reviews the level of adoption of project management approach that was adopted during the construction of the Geothermal Spa at the Olkaria Geothermal Project, Kenya, and the Myvatn Nature Baths and the Blue Lagoon in Iceland during conception, initiation, planning, implementation and closure of the projects.

Key words: Project management; geothermal spa, initiation, planning; implementation; project closure, project cost, interested parties, project success; Olkaria geothermal Project; Myvatn Nature Baths; Blue lagoon

1. INTRODUCTION

Since 1981, the use of geothermal resources in Kenya was mainly confined to electricity generation. Total installed capacity in geothermal power stands at 685.5 MWe. Out of this, the Kenya Electricity Generating Company Limited (KenGen) contributes 533.5 MWe while 148 Mwe and 4 MWe are contributed by Olkaria III and Oserian Development Company . In the late 1990’s, direct use applications on a commercial scale was adopted by Oserian Development Company in the green houses. Before this, Lake Bogoria Resort used warm water from a nearby spring to establish a spa. To diversify use of the geothermal resource, KenGen has constructed a geothermal spa. The construction of the spa started in April 2011 and was completed in June 2013 and currently receives about 14,000 visitors per year. In Iceland, the first and now world acclaimed Blue Lagoon was opened to members of the public in 1987 and later commercialised in 1994. It utilizes brine from the Svartsengi geothermal power plant (HS Orka hf). Today, it is one of the greatest tourist attractions in Iceland, with over 700,000 visitors recorded in 2014 (Ragnarsson, 2015). A second lagoon, Myvatn Nature Baths was constructed in the northern part of Iceland from October 2003 to June 2004 and currently receives about 200,000 visitors per year.

During the construction of the spa in Kenya, project management challenges were experienced which contributed to the delay in completion of the project. In addition, technical challenges in the design of the brine flow system from the reinjection line through the spa to the reinjection well were experienced. This created a challenge in the management of the temperature of the brine.

The study objectives were to review the level of project management approach that was applied at the Olkaria Geothermal Spa, the Myvatn Nature Baths and the Blue Lagoon during the initiation, planning, implementation and closure in relation to project management processes of scope, quality, cost, and time control, communication management, stakeholder management, human resource management, risk assessment, procurement and the integration of these areas and propose suitable project development approach for similar geothermal direct use projects

This paper, therefore, gives an introduction to the study; review of literature on direct uses of geothermal energy in order to provide an understanding of the project environment as well as a review of literature on project management principles and techniques; background to the study; data collection methods used; presentation and discussion of the results; and conclusions and recommendations. In the discussion of the results, the level of understanding of project management principles and application or adoption of the ten knowledge areas of integration management, scope management, time management, cost management, quality management, human resource management, communication management, risk management, procurement management, and stakeholder management during the initiation, planning, implementation and closure of the three projects is rated.

The standards which describe the ten knowledge areas and which have been used for this study include Project Management Body of Knowledge (PMBOK) guide, ISO 21500 and the International Project Management Association Competence Baseline (ICB). A rating of 1 to 5 is used where 1 represents least understanding of project management principles and application or adoption of the ten knowledge areas while 5 represents excellent understanding of project management principles and application or adoption of the ten knowledge areas. Conclusions and recommendations are made on the level and applicability of project management approach as dictated by uncertainties in project outcomes, emerging opportunities and threats, risks, and stakeholder influence and control; suitable project development approach for direct use projects; and the brine flow system of the three geothermal spas.

2. LITERATURE REVIEW

For centuries, swimming in warm water from hot springs was the widely known direct use of geothermal energy. This provided recreation to many people and improved quality of life. Today, direct utilization of geothermal energy is gaining momentum and total installed capacity has increased over the years. Some of the direct uses of geothermal energy today are geothermal heat pumps, greenhouse heating, aquaculture pond heating, agricultural drying, industrial uses, cooling and snow melting, space heating, bathing and swimming. The total installed capacity, reported through the end of 2014 for geothermal direct utilization worldwide is 70,329 MWt, a 45.0% increase from 48,493 MWt since 2010, growing at an annual compound rate of 7.7%. The total annual energy use is 587,786 TJ (163,287 GWh), indicating a 38.7% increase 423,830 TJ/yr (117,740 GWh/yr) since 2010, and a compound annual growth rate of 6.8%. The worldwide capacity factor is 0.265 (equivalent to 2,321 full load operating hours per year), down from 0.28 in 2010, 0.31 in 2005 and 0.40 in 2000. The lower capacity factor and growth rate for annual energy use is due to the increase in geothermal heat pump installations which have a low capacity factor of 0.21 worldwide. Total installed capacity for direct uses in Iceland as at 2014 was 2,040 MWt. Total energy use for space heating was in total about 26,700 terajoules (TJ), which corresponds to 7,417 GWh. Total installed capacity for direct use in Kenya is 82.40 MWt with energy use of 182.62 TJ, corresponding to 50.73 GWh (Lund and Boyd, 2015). Figure 1 shows the installed direct use geothermal capacity and annual utilization from 1995 to 2015.

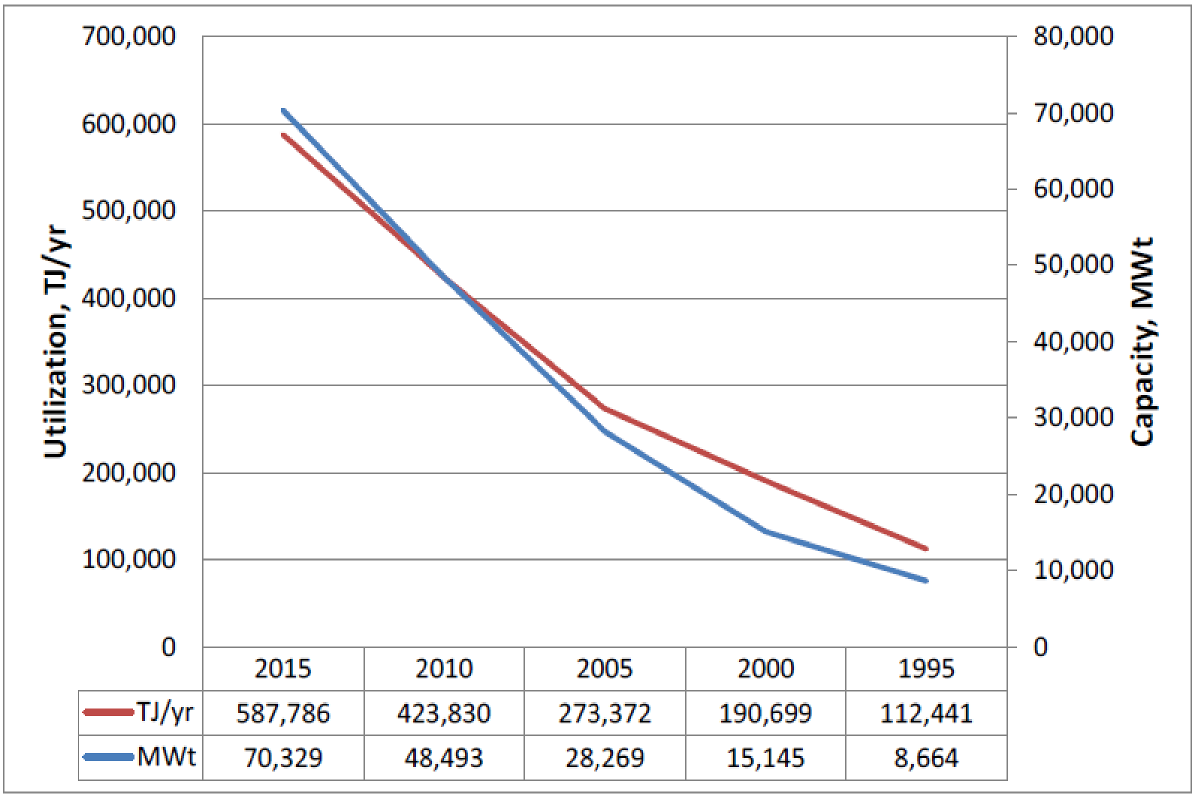

FIGURE 1: The installed direct-use geothermal capacity and annual utilisation from 1995 to 2015 (Source: Lundi and Boyd, 2015)

The above statistics show an increase in development of geothermal direct uses and therefore increase in the number of direct use projects. In Kenya, direct uses were only confined to rudimentary water harvesting from fumeroles for domestic use mainly in Eburru and to a smaller extent at Olkaria, drying of pyrethrum at Eburru and Spa establishment at Lake Bogoria Resort. Lately in 2003, Oserian Development Company leased a well from KenGen and used geothermal energy to heat their greenhouses at night and carbon dioxide to enrich carbon dioxide levels for synthesis (Mariita, 2010). To diversify geothermal utilisation, KenGen constructed a geothermal spa from 2011 to 2013, where visitors enjoy warm bathing and balneological effects of the brine on their skins.

As the development of direct utilization of geothermal energy gains momentum, and more and more direct use projects are implemented, there is need to adopt project management approach in their initiation, planning, implementation and closure so as to enhance project success. Project management approach reduces risks, failure, and increases timely delivery of project while at the same time ensuring that quality is achieved and projects objectives are delivered. This creates a positive impact on the project teams and the client. (Burke, 2004), argues that more and more organisations are accomplishing their businesses through projects and that management by projects approach has been used in engineering, construction, aerospace, and now in other disciplines such as medical, system development, and energy.

According to PMBOK Guide, 2013, project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet stakeholder´s needs and expectations from a project. (Reiss, 2007), on the other hand, defines project management as a collection of loosely connected techniques, some of which are useful in bringing projects to a successful conclusion. PMBOK identifies ten knowledge areas that are critical in management of a project. The ten knowledge areas described below include integration management, scope management, time management, cost management, quality management, human resource management, communication management, risk management, procurement management, and stakeholder management. ICB reinforces the importance of the ten knowledge areas in its description of forty six competence elements that are crucial for a project manager to be able to effectively apply the knowledge, skills, tools and techniques as advocated by PMBOK.

Project integration

This process integrates the four main project management processes of initiation, planning, implementation and closure. It involves bringing together inputs from several knowledge areas and ensuring that the inputs are deployed for the success of the project.

Scope management

This includes all the processes that are required to ensure that the project all the activities and tasks that are required so as to achieve the deliverables and objectives. The project Manager may be required to identify the activities and tasks that constitute the scope but also those that are not part of the scope. Scope management constitutes scope planning, definition, scope change management and scope verification, normally determined during initiation and also during implementation and closure.

Time management

This is the management process that ensures that the project is delivered within the stipulated time and as per schedule. This process is affected by a number of factors which include scope variations, availability of finances, supplier or contractor management, and poor management of tasks and deliverables. Time management therefore consists of activity definition, activity sequencing, duration estimation, schedule development and time control.

Cost management

This consists of resource planning, cost estimating, cost budgeting, cash flow and cost control. The objective of cost management is to ensure that the project is delivered within budget.

Quality management

Quality is constituent of the inherent characteristics of the project deliverable that meets the expectation of the user or customer or client. The project, therefore, should satisfy the needs for which it was intended. The quality of the project is tied to the design of the project in line with customer requirements. Quality management includes quality planning, quality assurance, and quality control.

Human resource management

Human resource deployed to a project should effectively be managed so as to deliver value to the project. Management of human resource involves identification of appropriate talent, skills and deployment of these skills to specific areas of the project. It also involves ensuring that the human resource remains motivated during the project. The process involves organisation planning, staff acquisition, and team development.

Communication management

This process ensures that project information is collected and disseminated without putting the project in jeopardy. Some information may be sensitive and only to be shared among certain personnel. That means the information dissemination should be based on a clear policy of need to know basis.

Communication management consists of communication planning, information distribution, project meetings, progress reporting and administrative closure.

Risk management

This process involves identifying risks, risk quantifying and impact, and risk control. In a project, risks exist before a project but can also emerge as the project is in progress. A risk control process must be activated during the project so as to minimize project failure.

Procurement management

Procurement in a project involves procurement of project materials and also contractors. It involves procurement of goods and services from outside the project team and constitutes procurement planning, source selection, contract administration and contract closeout.

Stakeholder management

This includes the process required to identify and manage the project sponsor, customers and other interested parties that may have impact on or are impacted by the project, either positively or negatively. Before start of a project, it is important that all the stakeholders of the project are identified and their impact or influence to the project mapped. A stakeholder management plan should then be developed based on their degree of influence or impact.

3. BACKGROUND TO THE STUDY

Olkaria Geothermal Spa

Occupying an area of 4.5 ha, the spa, shown in Figure 2, is located at the Olkaria Geothermal field, Naivasha, Rift Valley about 120 km from Nairobi and within the Hell's Gate National Park. The Olkaria Geothermal field, one of the known geothermal sites in Kenya as shown in Figure 3, belongs to the Kenya Electricity Generating Company Ltd (KenGen) that has a development license for the field covering a total area of 204 km^2. In addition to the license, the Company obtained lease from the Kenya Wildlife Service (KWS) for part of the land that belongs to KWS while it owns the rest of it. To manage relationship between KWS and the company, a memorandum of understanding (MoU) on the management of the park was signed. Currently, the Company operates four geothermal power stations, Olkaria I (45 MWe), Olkaria II (105 MWe), Olkaria I units 4 & 5 (140 MWe) and Olkaria IV (140 MWe) (Mangi, 2014). In addition to the large power plants, the Company generates a total of 81.1 MWe from 15 wellhead units. Alongside the operation of the power plants, the Company sells steam to Oserian Development Company for generation of 4 MW from two power plants.

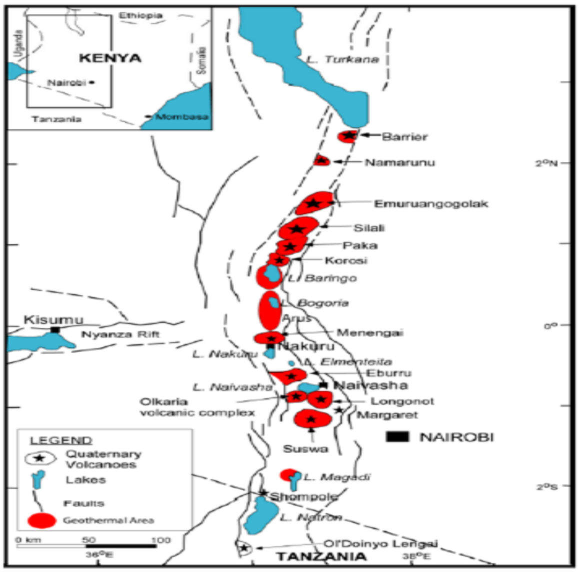

Figure 3: Location of Olkaria

The construction of the geothermal spa is one of the efforts the Company is undertaking to diversify geothermal resource utilization. The idea to construct the Olkaria Geothermal Spa was first introduced in 2008. Research was thereafter carried out to determine brine suitability for bathing. Construction of the spa and the building started in April 2011 and was completed in July 2013. The construction was undertaken in-house and it brought together functions across departments that included civil engineering, Reservoir and steam field and Research and Consultancy. Initially, the spa was to consist of small size lagoons with the largest being 1,500 m^3 but as the project progressed, the size of the large lagoon was revised to 3,500 m^3 and an administration block which has changing rooms, exhibition room and a restaurant. Later, a fourth lagoon for children was added. Other services planned alongside the spa were a conference facility, sauna, steam bath, cable car, children´s park, and a picnic area.

The spa is located near the main reinjection line to reinjection well OW-708. Total brine flow to well OW-708 is 300 tonnes/hr out of which 140 tonnes/hr is available for the spa. The brine flow system through the spa and to the reinjection well is manually controlled. This has created a challenge in the management of the temperature to the required range. It is also becoming costly due to overtime being incurred. The brine availability and proximity to the reinjection line are some of the factors that determined the location of the spa. Another factor was the topography of the area that allowed gravity flow of the brine from the receiver lagoon. Due to its location in the park and near the geothermal power plants, the spa was expected to benefit from the tourists who visit the park and the many visitors and students who visit the power plants. The short distance of about 120 km from Nairobi, 80 km from Nakuru town and 35 km from Naivasha town was also expected to provide convenience to many people to visit the spa.

Design of brine flow system

The layout of the spa consisted of four cascading lagoons. Temperature of the brine is manually regulated. The brine at 150°C is flashed into the first lagoon through a pipe designed and constructed to collect the brine as it bubbles out. A silencer in the first lagoon muffles the noise during the flashing of the brine. The hot water pipe to the first lagoon has two valves for safety reasons. These valves are also used to control the flow of the brine. The brine flows into the first lagoon at about 91°C. When the first lagoon fills up, the brine overflows into the second lagoon at about 85°C through an open tunnel. It enters the second lagoon on one entry. The brine in the second lagoon, which is slightly bigger, cools to about 84°C before exiting into the third and largest lagoon at about 69°C through a single entry. The outlet temperature in the largest lagoon is 46°C. These values assume a total flow rate of 140 tonnes/hr in an 8´´ pipe.

At total flow, the three lagoons, assuming that they were empty at the start, fill up in 23 hours. To manage the temperatures in the large lagoon to between 30°C and 35°C, after the initial fill up of the lagoon, the brine was left to cool to between 30°C to 35°C. Later on, to maintain the temperatures to between 30°C and 35°C, the valve on the brine line at the first lagoon was opened while at the same time, part of the brine that was cooler in the third lagoon was drained to the reinjection well OW-R1 through a drain at the base of the lagoon. The hot brine replaced the cooler brine that was drained and heated up the remaining brine. This process is now repeated daily with the valve being opened from 0700 hours to 1600 hours thus heating up and filling up the largest lagoon which is used for bathing. The layout of the lagoons and the brine flow system from the reinjection line through the lagoons to the reinjection well is shown in Appendix 2, Figure 1 and Appendix 5, Figure 3.

Blue Lagoon

According to Guðmundsdóttir et al, 2010, the Blue Lagoon, shown in Figure 4, is located on the Reykjanes peninsula in south-western Iceland that is primarily composed of porous lava. he Blue Lagoon was first created when hot brine from Svartsengi power plant was discharged into the adjacent lava field. Soon after the lagoon had been formed, its healing effects on psoriasis patients were discovered. Members of the Icelandic Psoriasis foundation built a primitive shelter to make it possible for the members to change clothes and

FIGURE 4: Blue Lagoon

shower after bathing. Later, the members were given a mortuary that was no longer in use and which served its new purpose at the Blue Lagoon for a number of years. In 1987, the first bathing facilities for the public opened. Until then, both the public and people with psoriasis had been bathing in the lagoon and using the primitive available housing. An idea to construct a lagoon on a commercial scale developed and this formed the main objective of constructing the Blue lagoon.

The Blue Lagoon Ltd., was founded in 1992 to lead health-related tourism related to the Blue Lagoon. The company took over the operation of the Blue Lagoon facilities in 1994 and opened a treatment center for psoriasis patients in cooperation with Icelandic Health authorities the same year. Scientific studies on the healing power of the Blue Lagoon was conducted in 1992-1996 and this research provided data essential for the Blue Lagoon to become recognized by the Icelandic Health Authorities as an official treatment center for psoriasis (Guðmundsdóttir et al., 2010). According to Haraldsson and Cordero, 2014, the Blue Lagoon contains about 6 million litres of brine and the hydraulic retention time is about 40 hours. The salt content is 2.5%, close to 70% of sea water.

The Blue Lagoon also produces skin care products that contain unique natural ingredients, silica, minerals and algae. The number of Blue Lagoon visitors has increased rapidly during the past years and reached 700,000 in 2014, making it one of Iceland's most popular tourist attractions (Ragnarsson, 2015). The initial scope of the project included construction of a 5,000 m^3 lagoon, a 1,000 m^3 lagoon as part of the treatment centre for psoriasis and other skin ailments which has 35 rooms, renovation of the then existing building to have changing rooms, and construction of the brine flow system. Other services developed alongside the lagoon were two cafeterias, restaurant, laundry services, and beauty products shop. Blue Lagoon is currently constructing a five star hotel and expanding the Blue Lagoon by 3,000 m^3, being an expansion phase two of the project. The expansion will cover an area of 8,500 m^2, in addition to the current areal occupation of 7,500 m^2. The second phase of the Blue Lagoon project will cost about US $47,000,000.

Design of the brine flow system

Brine used in the lagoons is obtained from the separator station serving the Svartsengi power plant. Part of the separated brine (152°C, 5.5 bars) that goes to a reinjection well flows into a 250 mm (10'') diameter brine line to the lagoon. The brine line is reduced from 10 ‘’ to 3'' and finally to 2'' to which 15 mm diameter nozzles that discharge brine into the lagoon are connected. The line is fitted with pneumatic valves. Solenoid valves are fitted on the air control system. The air control system opens the valves along the system. There is a provision for an overflow of the brine in case there is a problem with the reinjection system to the well. Temperature sensors are located in the brine along the edge of the lagoon. When temperatures fall below 40^{o}C or as may have been set in the control system, the temperature sensors signal the valves to open. Brine flows in through the 15 mm diameter nozzles at high pressure and sucks the cold brine from the bottom of the lagoon, creates a convectional current, and mixes with it until temperature reaches 39^{o}C to 40°C after which the valves close and the flow stops.

In total, there are 8 brine inlets into the lagoon. Due to the inflow of brine into the lagoon during regulation of the temperatures, there is an overflow to the surrounding lava field. A schematic flow diagram of the brine flow is as shown in Figure 5 in Appendix 7. Along the edge of the lagoon is a ´waterfall area´ where the brine is pumped through overhead showers and jutes out in moderated quantity and at certain pressure to ´massage´ the muscles of those taking bath. For steam bath, the brine is pumped through nozzles. Temperature sensors regulate the flow of steam through valves. If temperature drops below 40°C and 44^{o}C or the set temperature, the sensors signal the valves to open and brine steams out through the nozzles until temperature of 40^{o}C to 44°C is achieved after which the valves close and steam flow is stopped.

Myvatn Nature Baths in North Iceland

FIGURE 5:Myvatn Nature Baths
(Source: Ludvik´s lecture on Námafjall High Temperature area, 2015)

Myvatn Nature Baths shown in Figure 5 are near the village of Reykjahlíð, which is situated on the shores of Lake Myvatn in the far north of Iceland. It is much more difficult to reach, unless you are flying into nearby Akureyri or will be driving the Ring Road (http://www.travelandescape.ca/2013/09/blue-lagoon-vs-myvatn-baths/). It is within the hot temperature Namafjall geothermal field.

According to an interview with Jóhann F. Kristjánsson, 2015, before 1998, people constructed makeshift structures on fumaroles coming out of cracks on the ground. It was later realized that it was in the interest of the community if more durable material was used to construct a permanent structure where people could have steambaths. In 1999, an interest group constructed a structure on the cracks to tap the fumaroles for steam bath. An idea to construct nature baths for the area was conceived. A five year research on the temperatures and chemistry of hot springs in the Myvatn area was commissioned after the interest group obtained a grant from an innovation fund created by the Government and the municipality. After the research, the interest group registered a company with the objective of constructing a lagoon to serve the community and visitors. The Myvatn Nature Baths were constructed from October 2003 to June 2004.

The Myvatn Nature Baths use brine from one of the nearby wells drilled in 1976 meant for steam generation for a diatomite factory. The scope of the project included construction of a 2,550 m^3 lagoon, an administration block that had changing rooms, and the brine flow system. Other services planned alongside the lagoon included a souvenir shop, a cafeteria and laundry. The Myvatn Nature Baths were constructed from October 2003 to June 2004. Construction was done by contractors as per the initial design. No major changes were done. Initially, the brine flow was managed manually but automatic temperature controls were introduced during operations.

Design of the brine flow system

Two phase geothermal fluid from one of the wells nearby enters a separator where brine is separated from steam. The separated brine at 180°C with a flow rate of 40 l/s flows into a heat exchanger where it heats fresh water for district heating. It exits the heat exchanger at 130°C with a flow rate of 20 l/s. This brine is collected in a reservoir and maintains a top temperature of 98°C. Inside the reservoir, a coil (heat exchanger) carrying fresh water runs through, which heats water that is used in the Nature Baths buildings. The reservoir has an overflow which drains excess brine to a reinjection well. The brine from the reservoir flows by gravity to the lagoon and enters at about 80°C. To reduce this temperature to between 38° and 40°C, circulating pumps behind rock formations within the lagoon suck the cold brine at the bottom of the lagoon and create convectional currents. This mixes the hot and cold brine and thus reduces the temperature to 38°C- 40°C or to the desired temperature.

The brine from the main reservoir enters the lagoon at five points with automatic temperature controls. When temperatures drop, the thermostats signal the valves to open up and allow in more brine from the main reservoir until temperatures of 38°C- 40°C are achieved after which the flow stops. Due to the inflow of brine into the lagoon during regulation of the temperatures, there is an overflow to the reinjection well that takes in the excess brine. A schematic flow diagram of the brine flow is as shown in Appendix 3, Figure 2. Along the edge of the lagoon is a ´waterfall´ where the brine is pumped through overhead showers and jutes out in moderated quantity and at a certain pressure thus ´massaging´ the muscles of those under the ´waterfall´.

4. METHODOLOGY

The following data collection methods were used:

i. Documentary sources

Information available on direct uses of geothermal energy, the concept/ initiation, planning, construction and closure of the geothermal spas in Kenya and Iceland was used.

ii. Observation method

The author used observation method to collect data during the visit to the Blue Lagoon and the Myvatn Nature Baths on 2nd June 2015 and 9th July 2015 respectively and later a revisit to the Blue Lagoon on 22nd September 2015.

iii. Interviews

Interviews were conducted with staff who were involved in the design of the brine flow system for the three geothermal spas and those who were involved in project management during the construction of the spas. Additionally, for the Blue Lagoon, interview was conducted with a staff who is currently involved in the operations of the brine flow system. For the Olkaria Geothermal Spa, the information presented is based on personal experiences by the author who was the project manager during the initiation, planning, and construction.

iv. Data analysis and presentation

The data collected was analysed and presented focusing on the project management approach that was adopted during the initiation, planning, implementation and closure of the three projects. The analysis of the level of project management applied is based on the project manager´s understanding and application of the ten knowledge areas as described in PMBOK guidelines and ISO 21500 and elaborated in ICB. Review of the design of the brine flow from the well/s, power plant or reinjection line to the geothermal spas and into the reinjection well or disposal system is also presented.

In the discussion of the level of application of project management approach, a rating was determined based on the application of the ten knowledge areas as defined in PMBOK guidelines and ISO 21500 as well as application of the competences as described in the ICB. A rating of 1-5 was adopted, where 1 represents least or poor understanding or lack of application of one or more of the ten knowledge areas and or competences as described in ICB while 5 is the highest as described in summary Table 1. To rate the main phases, average of the ratings of the knowledge areas or competences was calculated and rounded off to the nearest number. The author, through an objective analysis of the data, determined the rating.

TABLE 1: Rating of project management approach

Grade	Description
1	Poor understanding and adoption of project management techniques, poor application of knowledge areas or technical, behavioral and contextual competences
2	Fair understanding and adoption of project management techniques, knowledge areas or technical, behavioral and contextual competences
3	Good understanding and adoption of project management techniques, knowledge areas or technical, behavioral and contextual competences
4	Very good understanding and adoption of project management techniques, knowledge areas or technical, behavioral and contextual competences
5	Excellent understanding and adoption of project management techniques, knowledge areas or technical, behavioral and contextual competences

Conclusions and recommendations were made on application of project management approach as dictated by risks associated with the project, emerging opportunities and threats in the business environment, the size of the project, the objective of the project, the stakeholder environment, cost, business environment, quality and the current phase of the project. In line with this, further recommendation is given on the development approach for direct use projects. These recommendations are useful for future direct use projects. Specific technical recommendations on brine flow system and enhancement of usage of the brine for the Olkaria Geothermal Spa is given in Appendix 9.

5. RESULTS AND DISCUSSIONS

The problems encountered at the Olkaria Geothermal Spa were partly contributed by inadequate project management approach that resulted in some key steps in the process being overlooked. This included the design aspects of the brine flow system during planning as well as adequate planning for procurement or identification of alternatives.

The level of application, however, differed from one project to another. From the review and analysis of the information gathered, overall project management approach was adopted at 3 for Olkaria Geothermal Spa. Myvatn Nature Baths 4 and 5 for Blue Lagoon. These results indicate application of strict project management approach and project integration at the Blue Lagoon and the Myvatn Nature Baths with no flexibility or float or buffer provision for time, scope and cost. On the other hand, project management approach at the Olkaria Geothermal Spa was more flexible and did not adhere to strict project management approach as advocated by PMBOK guide and ISO 21500.

6. CONCLUSIONS AND RECOMMENDATIONS

From the discussion of the results, it can be concluded that the type and level of project management approach in projects depends on the risks associated with the project, the size of the project, the stakeholder environment, cost, business environment, opportunities and threats in the business environment, the objective of the project, quality and the current phase of the project.

REFERENCES

Burke, Rory, 2004: Project management: Planning and control techniques, 4th ed. John Wiley & Sons, West Sussex, ISBN 0470851244, 509 p.

Guðmundsson, Ásgrímur, 2015: *Namafjall high temperature area*. UNU-GTP, Iceland, unpublished lecture notes

Guðmundsdóttir M., Brynjólfsdóttir Á., Albertsson A, 2010: The history of the Blue Lagoon in Svartsengi. *Proceedings of the World Geothermal Congress 2010. Bali, Indonesia, 25-29 April 2010.*

Location of Blue Lagoon in north Iceland. Source: (http://www.travelandescape.ca/2013/09/blue-lagoon-vs-myvatn-baths/

Haraldsson, I.G., and Cordero, L.C.: Geothermal baths, swimming pools and spas: Examples from Ecuador and Iceland. Short Course VI on Utilisation of Low- and Medium-Enthalpy Geothermal Resources and Financial Aspects of Utilisation, organized by UNU-GTP and LaGeo, in Santa Tecla, El Salvador, March 23-29, (2014).

IPMA Competence Baseline version 3: Published by International Management Association, ISBN 0-9553213-0-1, 2006

ISO 21500. (2012). Guidance on Project Management. Geneva: International Organization for Standardization, 2012

Jonasson, Haukur I. and Ingason, Helgi T., 2013: Project ethics. Gower Publishing Limited, Surrey, ISBN 9781409410966, 142 p.

Lundi, John W. and Boyd, Tonya L., 2015: Direct Utilisation of Geothermal Energy 2015 Worldwide Review. *Proceedings World Geothermal Congress 2015. Melbourne, Australia, 19-25 April 2015*

Mangi, P, 2014: Geothermal direct use application: A case of the Geothermal Spa and Demonstration Centre at the Olkaria Geothermal Project, Kenya: A paper presented during the UNU- GTP-KENGEN- GDC Short course IX, Lake Naivasha Country Club, Kenya, 2-23 November 2014

Mariita, N., 2010: An update on applications to direct-uses of geothermal energy development in Kenya. *Proceedings World Geothermal Congress 2010. Bali, Indonesia, 25-29 April 2010*

PMI, 2013: A guide to the project management body of knowledge (*PMBOK® guide*). -- Fifth edition, 2013. Project Management Institute, ISBN: 978-1-935589-67-9, Published by: Project Management Institute, Inc, P. 5

Ragnarsson, Árni, 2015: Geothermal Development in Iceland 2010-2014. *Proceedings of the World Geothermal Congress 2015. Melbourne, Australia, 19-25 April 2015.*

Reis, G., 2007: Project Management demystified, 3rd ed. Taylor & Francis, London, ISBN 978-0-415-42163-8, 210 p