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PROJECT REVIEW OF GEOTHERMAL SPAS´ CONSTRUCTION IN KENYA AND ICELAND

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ABSTRACT

This study reviews the project management approach that was adopted during the construction of the Blue Lagoon, Mývatn Nature Baths and the Olkaria Geothermal Spa, as well as the brine flow system of the three spas. The level of application of a project management approach in a project is dictated by the uncertainties in the outcome of the project, current and emerging risks, threats and opportunities in the business environment, the scope of the project, the stakeholder environment, cost, objective of the project, quality and the phase of the project. Both the Blue Lagoon and Mývatn Nature Baths project outcomes were well known, based on previous knowledge of the popularity of bathing at the Blue Lagoon, and therefore a strict project management approach with no flexibility in schedule, time, resources and scope was adopted. Meanwhile, the Olkaria Geothermal Spa adopted a flexible project management approach that allowed for scope, design and improvement changes. For direct use projects that have no previous baseline data, phased development is recommended because of the uncertainties associated with the outcome of the project. It is also concluded that management of the brine flow system in a geothermal spa is important in ensuring a quality of service that meets customer expectations.

1. INTRODUCTION

Since 1981, the use of geothermal resources in Kenya was mainly confined to electricity generation. Currently, the total installed capacity in geothermal power plants in Kenya stands at 630 MWe. Out of this, the Kenya Electricity Generating Company, Ltd. (KenGen) contributes 513 MWe. In the late 1990s, direct use applications on a commercial scale were adopted by the Oserian Development Company in the form of greenhouses. Before this, Lake Bogoria Resort used warm water from a nearby spring to establish a spa.

To diversify the use of the geothermal resource in the Olkaria geothermal area, KenGen has constructed a geothermal spa. The construction of the spa started in April 2011 and was completed in June 2013. Currently it receives about 14,000 visitors a year. In Iceland, the first and now world acclaimed Blue Lagoon was opened to members of the public in 1987 and later commercialized in 1994. It utilises brine from the Svartsengi geothermal power plant, which is owned by 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, Mývatn Nature Baths was constructed in the northern part of Iceland from October 2003 to June 2004 and currently receives about 200,000 visitors a year.

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

The study objectives are to:

i. Review the level of project management approach that was applied at the Olkaria Geothermal Spa, the Mývatn 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.
ii. Propose a suitable project development approach for similar geothermal direct use projects.
iii. Review the brine flow system of the three geothermal spas and provide a recommendation for improvement of brine flow control at the Olkaria Geothermal spa and for similar projects.

This paper gives an introduction to the study, a 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. It also includes the background of the study, data collection methods used, a 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 ten knowledge areas is rated. These are: 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.

The standards which describe the ten knowledge areas and which have been used for this study include the Project Management Body of Knowledge (PMBOK) guide, ISO 21500 (ISO, 2012) and the International Project Management Association Competence Baseline –ICB (IPMA, 2006). 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 a project management approach as dictated by uncertainties in several areas, including: 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.

Due to the technical nature of the three projects, and in order to understand the project management approach that was adopted, some technical aspects are mentioned within the project management processes. However, specific technical reviews and recommendations, including drawings and technical literature that help to clarify the discussion in the project management approach and which will be used to improve the quality of the Olkaria Geothermal Spa, are referenced and presented in the appendices and do not form the main body of the paper.

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 their quality of life. Today, direct utilisation 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, greenhouses, aquaculture, agricultural drying, industrial uses, cooling, snow melting, space heating, bathing and swimming. The total installed capacity, reported at the end of 2014 for geothermal direct utilisation worldwide is 70,329 MWt, a 45.0% increase from 48,493 MWt since 2010, an annual growth rate of 7.7%. The total annual energy use is 587,786 TJ, indicating a 38.7% increase from the 423,830 TJ/yr in 2010, an 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, 0.21, worldwide. Total installed capacity for direct uses in Iceland as of 2014 was 2,040 MWt. Total energy use for space heating was in total about 26,700 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 global installed direct use geothermal capacity and annual utilisation from 1995 to 2015.

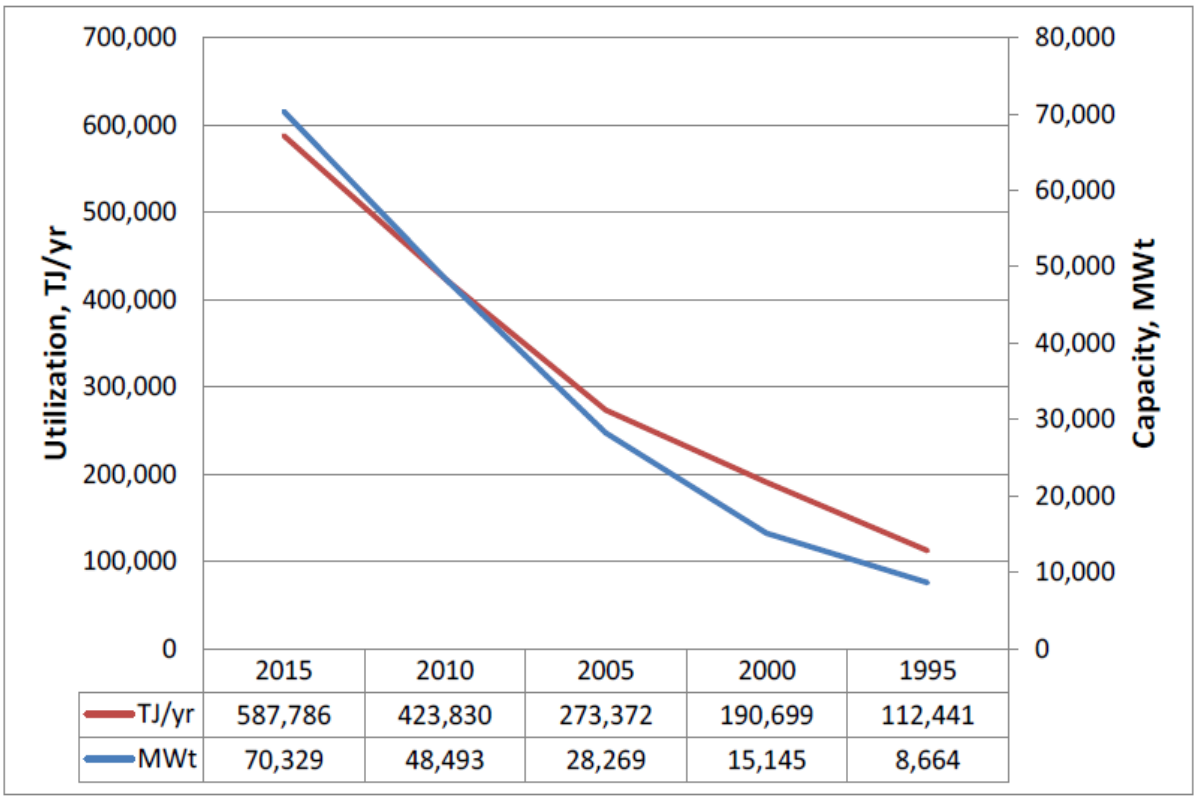

FIGURE 1: Global installed direct-use geothermal capacity and annual utilisation from 1995 to 2015 (Lund and Boyd, 2015)

The above statistics show steady increase in the development of direct use of geothermal energy, and therefore an increase in the number of direct use projects. In Kenya, direct use projects were confined to rudimentary water harvesting from fumaroles for domestic use, mainly in Eburru and to a smaller extent at Olkaria, drying of pyrethrum at Eburru and a spa establishment at Lake Bogoria Resort. In 2003, Oserian Development Company leased a well from KenGen and used geothermal energy to heat their greenhouses at night and as producer of carbon dioxide to increase carbon dioxide levels to further photosynthesis in the plants to promote their growth (Mariita, 2010). To diversify the geothermal utilisation in the Naivasha region, were Olkaria is located, KenGen constructed a geothermal spa in the years 2011-2013, where visitors can enjoy warm bathing and the balneological effects of the brine on their skins.

As the development of direct utilisation of geothermal energy gains momentum, and more and more direct use projects are implemented, there is a need to adopt a project management approach in their

initiation, planning, implementation and closure, so as to increase the number of successful projects. A project management approach reduces the risks, and failure, and increases a timely delivery of project, while at the same time ensuring that quality as well as the project objectives are achieved. 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 a management by projects approach has been used in engineering, construction, aerospace, and now in other disciplines such as medicine, system development, and energy.

According to PMBOK Guide (PMI, 2013), project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet the stakeholders' 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 the management of a project. The ten knowledge areas: integration management, scope management, time management, cost management, quality management, human resource management, communication management, risk management, procurement management, and stakeholder management, are described here below. 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 (PMI, 2013).

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 all the activities and tasks of the project, that are required so as to achieve the deliverables and objectives, are completed. 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 according to 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 completed within budget.

Quality management
Quality is a 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
The human resources deployed should be effectively managed so as to deliver value to the project. Management of human resources involves identification of the appropriate talent and 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 a need to know basis. Communication management consists of communication planning, information distribution, project meetings, progress reporting and administrative closure.

Risk management
This process involves the identification of 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 minimise project failure.

Procurement management
Procurement in a project involves the procurement of project materials as well as contractors. It involves the 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 the 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 OF THE STUDY

3.1. Olkaria Geothermal Spa

Occupying an area of 4.5 ha, the spa, shown in Figure 2, is located at the Olkaria geothermal field in Naivasha, in the Kenyan Rift Valley, about 120 km from Nairobi and within the Hell's Gate National Park. The Olkaria geothermal field, one of the high-temperature geothermal fields in Kenya as shown in Figure 3, belongs to the Kenya Electricity Generating Company, Ltd. (KenGen), which has a development licence for the field covering a total area of 204 km^2. KenGen owns a part of the land, and obtained a lease from the Kenya Wildlife Service (KWS) for the part of the land that belongs to KWS. To manage the relationship between KWS and the company, a memorandum of understanding (MoU) on the management of the land was signed. Currently, KenGen operates four geothermal power stations in Olkaria, Olkaria I (45

FIGURE 2: Panoramic view of the Olkaria Geothermal Spa

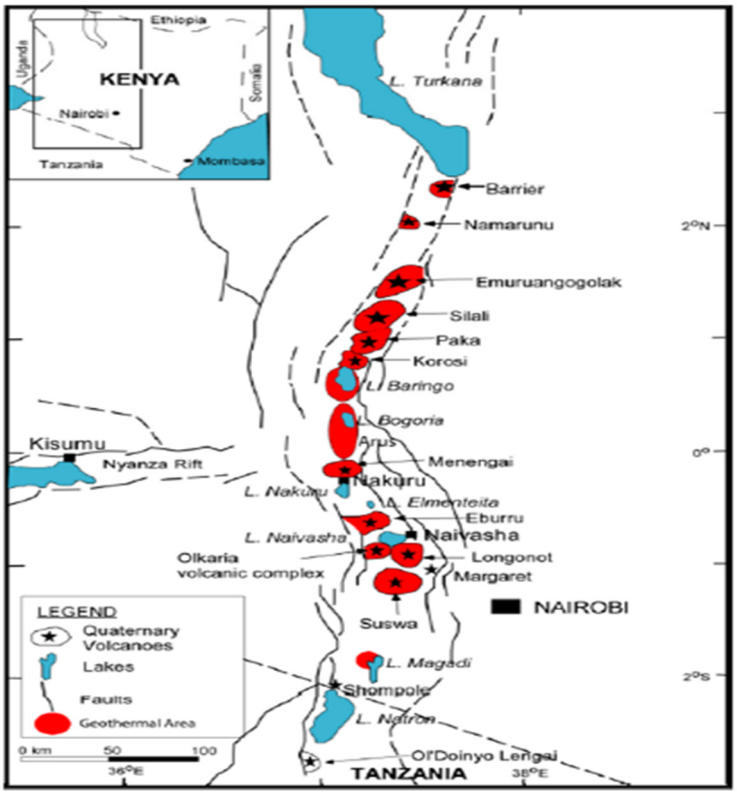

FIGURE 3: Location of Olkaria volcanic complex

MWe), Olkaria II (105 MWe), Olkaria I units 4 & 5 (140 MWe) and Olkaria IV (140 MWe) (Mangi, 2014). In addition to the power plants, KenGen generates a total of 55.6 MWe from nine wellhead units. Alongside the operation of the power plants, KenGen sells steam to Oserian Development Company for the generation of 4 MW from two power plants.

The construction of the geothermal spa is one of the efforts the company is undertaking to diversify the geothermal resource utilisation. The idea to construct the Olkaria Geothermal Spa was first introduced in 2008 and research was thereafter carried out to determine the brine suitability for bathing. Construction of the spa and the facilities started in April 2011 and was completed in July 2013. The construction was undertaken in-house at KenGen and brought together functions across departments that included: civil engineering, reservoir and steamfield 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 modified to 3,500 m^3 and an administration block was added, which has changing rooms, an exhibition room and a restaurant. Later, an additional pool for children was added. Other services planned alongside the spa are a conference facility, a sauna, a steambath, a cable car, a 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, 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 has also become costly due to overtime payments to personnel. 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 for many people to visit the spa.

Design of the brine flow system

The layout of the spa consists of four cascading blue lagoons. The temperature of the brine is manually regulated. The brine is flashed into the first lagoon at 150°C 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, but they are also used to control the flow of the brine. The brine flows into the first lagoon at about 91°C and when it fills up, the brine overflows into the second lagoon at about 85°C through an open tunnel, which is the only entry to the second lagoon. The brine in the second lagoon, which is slightly bigger than the first lagoon, 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 full 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 and 35°C, after the initial fill up of the lagoon, the brine was left to cool to the desired temperature. Later on, to maintain the temperature within the desired range, the valve on the brine line at the first lagoon is opened, while at the same time, part of the brine in the third lagoon is drained to the reinjection well OW-R1 through a drain at the base of the lagoon. The hot brine replaces the cooler brine that is drained and heats up the remaining brine. This process is repeated daily with the valve being opened from 0700 hours to 1600 hours, thus heating up and filling 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 are shown in Appendix I, Figures 1 and 2.

3.2 The Blue Lagoon

The Blue Lagoon, shown in Figure 4, is located on the Reykjanes peninsula in SW-Iceland, which is primarily composed of porous lava (Gudmundsdóttir et al. (2010)). The Blue Lagoon was first created when hot brine from Svartsengi power plant was discharged into the adjacent lava field after the installation of the power plant, around 1980. Soon after the lagoon was formed, its healing effects on psoriasis patients were discovered. The Icelandic Psoriasis Foundation built a primitive shelter to make it possible for its members to change clothes and shower after bathing. Later, the members were given an old mortuary, no longer in use, which served its new purpose shelter for changing clothes at the Blue Lagoon for a number of years. In 1987, the first bathing facilities for public opened. Until then 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 current Blue lagoon.

FIGURE 4: The Blue Lagoon spa facility

The Blue Lagoon, Ltd., was founded in 1992 to develop 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 centre for psoriasis patients in cooperation with the Icelandic health authorities the same year. Scientific studies on the healing power of the Blue Lagoon were conducted in 1992-1996. This research provided data essential for the Blue Lagoon to become recognized by the Icelandic health authorities as an official treatment centre for psoriasis (Gudmundsdóttir et al., 2010). According to Haraldsson and Lloret 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 that 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: the construction of a 5,000 m^3 lagoon as well as a 1,000 m^3 lagoon as part of the treatment centre for psoriasis and other skin ailments which has 35 rooms, the renovation of the existing facilities to include changing rooms, and the construction of the brine flow

system. Other services developed alongside the lagoon were: two cafeterias, a restaurant, laundry services, and a beauty products shop. Blue Lagoon is currently constructing a five-star hotel and expanding the Blue Lagoon by 3,000 m^3, which is the second expansion phase 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.

3.2.1 Design of the brine flow system

At the Blue Lagoon, 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 pipe to the lagoon. The brine pipe is reduced from 10" to 3" and finally to 2", to which 15 mm diameter nozzles are connected, that discharge brine into the lagoon. The pipe is fitted with pneumatic valves, and solenoid valves are fitted on the air control system. The air control system opens the valves along the system so 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°C, or as otherwise set in the control system, the temperature sensors signal the valves to open. Hot brine flows in through the 15 mm diameter nozzles at high pressure and sucks the cold brine from the bottom of the lagoon, creating a convectional current, and mixes with it until temperature reaches 39-40°C at which point the valves close and the flow stops.

In total, there are eight brine inlets into the lagoon. Due to the inflow of brine into the lagoon during the regulation of the temperatures, there is an overflow to the surrounding lava field. A schematic flow diagram of the brine flow is shown in Appendix II, Figure 1. 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 visitors. In the steambath, the brine is pumped through nozzles and temperature sensors regulate the flow of steam through valves. If the temperature drops below the 40-44°C range, or other set temperatures, the sensors signal the valves to open and brine steams out through the nozzles until the temperature range of 40-44°C is achieved, after which the valves close and steam flow is stopped.

3.3 Mývatn Nature Baths

FIGURE 5: Myvatn Nature Baths (Gudmundsson, 2015)

Mývatn Nature Baths, shown in Figure 5, are near the village of Reykjahlíd, which is situated on the shores of Lake Mývatn in N-Iceland. It is far away from Reykjavík (Travelandscape, 2013), and located within the Námafjall 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 realised that it was in the interest of the community if more durable material was used to construct a permanent structure where people could enjoy a steambath. In 1999, an interest group constructed a structure in the area to tap the fumaroles for a steambath and 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 Mývatn

area was commissioned after the interest group obtained a grant from an innovation fund created by the Icelandic government and the local municipality. After the research, the interest group registered a company with the objective of constructing a lagoon to serve the community and visitors. The Mývatn Nature Baths were constructed from October 2003 to June 2004.

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

3.3.1 Design of the brine flow system

Two-phase geothermal fluid from the nearby brine well 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 Mývatn 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 transfer 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 38-40°C or to different 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 38-40°C are achieved after which the flow stops. Due to the inflow of brine into the lagoon during this process, there is an overflow to the reinjection well that takes in the excess brine. A schematic flow diagram of the brine flow is shown in Appendix II, 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 geothermal spas in Kenya and Iceland was collected.
ii. *Observation method:*
   The author visited the Blue Lagoon and the Mývatn Nature Baths on 2nd June 2015 and 9th July 2015, respectively, and later visited the Blue Lagoon again 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 with those who were involved in project management during the construction of the spas. Additionally, for the Blue Lagoon, an interview was conducted with a staff member who is currently involved in the operations of the brine flow system (see interview schedule, Appendix III). 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. A 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.

For 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 poor understanding and/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 Table 1. To rate the main phases, the 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, behavioural and contextual competences.
2	Fair understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences.
3	Good understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences.
4	Very good understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences.
5	Excellent understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences.

Conclusions and recommendations were made on the application of the 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. Specific technical recommendations on the brine flow system and enhancement of usage of the brine for the Olkaria Geothermal Spa are also given (Appendix I, Figure 3).

5. RESULTS AND DISCUSSION

The problems encountered at the Olkaria Geothermal Spa were partly contributed by an 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 and 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 a rating of 3 for Olkaria Geothermal Spa, rating of 4 for Mývatn Nature Baths and rating of 5 for the Blue Lagoon. These results indicate an application of a strict project management approach and project integration at the Blue Lagoon and the Mývatn Nature Baths with no flexibility, or float or buffer provision, for time,

scope and cost. On the other hand, the 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. Details of the application of the project management approach are discussed below in line with the four project life cycles of: concept/initiation, planning, implementation and closure, and the ten knowledge areas as described in PMBOK guide, ISO 21500, and emphasised in ICB. The ratings are presented in Appendix IV.

5.1 Concept and initiation

The Olkaria Geothermal Spa was rated 3 for concept and initiation, Mývatn Nature Baths 4 and Blue Lagoon 4. For both Mývatn Nature Baths and the Olkaria Geothermal Spa, concept development was dictated by necessity while for Blue Lagoon, the concept was driven by a commercial agenda. Mývatn Nature Baths intended to provide a bathing facility for the community while for the Olkaria Geothermal Spa, there was a need to diversify the geothermal resource utilisation. On the other hand, the Blue Lagoon realised an opportunity to expand the bathing facility arising from reports of people getting healed of psoriasis and skin ailments after taking baths in the area.

For the Olkaria Geothermal Spa, the objectives of the construction of the spa were not specific, measurable, achievable, realistic, nor time bound and this affected the rating, while objectives for the Mývatn Nature Baths and the Blue Lagoon objectives were to construct lagoons and were therefore specific to the projects.

Concept and initiation of the Olkaria Geothermal Spa took two years of research while it took five years for the Mývatn Nature Baths and more than five years for the Blue Lagoon. To avoid project failure, adequate planning is necessary. All aspects of a project must be taken into account, including the project risks and viability. In the case of a direct use project like geothermal spas, assessment of brine availability and suitability is critical because unavailability or unsuitability of the brine may kill the project. Adequate time must be provided for research.

Olkaria Geothermal Spa rated poor at 1 on ethics analysis because no ethics analysis was done, nor were project rules and regulations made clear to the project team. The Mývatn Nature Baths and the Blue Lagoon rated fair at 2, because project rules and regulations were made clear to the project team. The importance of ethics analysis is best described by Jónasson and Ingason (2013), who argue that ethics govern the conduct of the individual, the team, and the organisation in a project, define the relationships, and sets out behaviour and expectations. Definition of project ethics helps to reduce conflict, and where it arises, helps the project manager to deal with conflict without prejudice or bias.

Project charter
For the Olkaria Geothermal Spa, a proposal based on a payback period financial model was submitted and therefore it rates fair at 2, while the Blue Lagoon prepared a project charter and therefore rates excellent at 5. Mývatn Nature Baths rates good at 3 because while no project charter was done, a business plan that captured aspects of a charter such as the risks, stakeholders, project costs and business focus was done. A project charter presents a refining of the business case for a project on which the board or management of the company makes a decision on whether to proceed with the project or not. A project charter also provides the project plan in terms of: project team composition, refined design and a simulation of options, refined quality management plan and refined objectives in view of any changes in the market, refined stakeholder management plan, refined project controls, schedules, and resource requirements including cost. Without a project charter, the project becomes exposed to risk of being no longer relevant due to a changing business environment.

Project team
The Olkaria Geothermal Spa rated 4 for project team while both Mývatn Nature Baths and the Blue Lagoon rated 5. The Olkaria Geothermal Spa had a project manager who supervised three subproject

managers in charge of lagoon construction, building construction and the brine line. For Mývatn Nature Baths, the project had an overall project manager with three subproject managers in charge of lagoon, brine line and outside works; groundwork; and construction of the building. The project manager had authority to make decisions except those that entailed additional costs. For the Blue Lagoon, the project manager had authority to make decisions except those that involved large additional costs, and supervised contractors who were responsible for construction of the lagoon, construction of the treatment centre and renovation of the building; and the brine line.

Identification of stakeholders
Olkaria geothermal Spa rated 2 for stakeholder identification while both Mývatn Nature Baths and the Blue Lagoon rated 5. Olkaria Geothermal Spa did not identify and list the stakeholders but only made an assumption. Some of the stakeholders like Kenya Wildlife Service (KWS), senior management, staff, customers, local authorities, Ministry of Health and NEMA were only assumed. On the other hand, the Blue Lagoon identified contractors, HS Orka, Grindavík municipality, the Chief Executive Officer of the Blue Lagoon, members of the public, and environmental activists as stakeholders. Stakeholders for Mývatn nature Baths included Landsvirkjun - National Power Company, shareholders, landowners, environmentalists, members of the public, tourists, and local authorities.

5.2 Planning

Planning for the Olkaria Geothermal Spa was rated at 3 while both Mývatn Nature Baths and the Blue Lagoon were rated at 4. Ratings of processes under planning are presented below.

Time, scope, work breakdown structure, and activities
All the three projects identified the scope, work breakdown structure and carried out scheduling and determined the time that would be required. They all rated excellent at 5. According to schedule, the construction of the Olkaria Geothermal Spa was to take 4 months (see Table 2).

Meanwhile the construction time for the Mývatn Nature Baths was 7 months and 1½ years for the Blue Lagoon. The initial scope of the Olkaria Geothermal Spa included three cascading lagoons, an administration block and the brine line. The administration block has changing rooms, exhibition room and a restaurant and the brine line and reinjection system. Later, a fourth lagoon for children was added. Other services planned alongside the spa were a conference facility, sauna, steambath, cable car, a children's park, and a picnic area. The project was broken down into the construction of the lagoon, the building and the brine line and reinjection system.

Mývatn Nature Baths consist of a 2,550 m^3 lagoon, an administration block that has changing rooms, and the brine flow system. The building has a museum, a cafeteria and laundry. The project was broken down into three main functions, namely groundworks, lagoon and outside works, and the construction of the building. For the Blue Lagoon, the works were also broken down into three areas, namely, construction of the lagoon, construction of the treatment centre and renovation of the building, and construction of the brine line. All three projects sequenced, scheduled activities and estimated durations using MS project.

Resource estimation and project organisation
For Olkaria Geothermal Spa, 100 workers were required for the three components of the projects, and the project implementation team consisted of 16 staff from various departments of KenGen. Rough estimation of the requirements, both financial and labour, was done and for human resources, relevant competences were identified and deployed. For the Mývatn Nature Baths and the Blue Lagoon, detailed bills of quantities were done and cost estimated and the contractors provided personnel for the project. The projects were divided into functional areas that were headed by subproject managers. In addition,

the subproject managers had supervisory role over the individual sub project implementation team (PIT). In all the three projects, there was an overall project manager who had an overseeing role.

TABLE 2: Activities and schedules at Olkaria Geothermal Spa

Task name	Duration	Start	Finish	Prede-cessors	Resource names
Lagoons	**76 days**	**12.4.11**	**25.7.11**		
Excavations	50 days	12.4.11	17.6.11		Civil Technician (1)
Hardcore Fills	20 days	27.4.11	23.5.11		Unskilled Labour (7); Masons (2)
Concrete Works	20 days	24.5.11	20.6.11	4	Unskilled Labour (7); Masons (2); Carpenter (1)
Footpaths & Parking	20 days	21.6.11	18.7.11	5	Unskilled Labour (7); Masons (2)
Finishes	25 days	21.6.11	25.7.11	5	Unskilled Labour (4); Masons (2)
Building	**125 days**	**18.4.11**	**5.10.11**		
Substructure	**25 days**	**18.4.11**	**19.5.11**		
Excavations for Foundations	5 days	18.4.11	22.4.11		Unskilled Labour (8); Masons (2); Carpenter (1)
Foundation concrete works	10 days	7.5.11	19.5.11	10	Masons (2); Unskilled Labour (8); Carpenter (1)
Superstructure	**100 days**	**20.5.11**	**5.10.11**	**9**	
Walling	30 days	20.5.11	30.6.11		Masons (2); Carpenter (2); Unskilled Labour (8)
Roofing	20 days	1.7.11	28.7.11	13	Masons (2); Carpenter (2); Unskilled Labour (8)
Fitting & Fixtures	20 days	29.7.11	25.8.11	14	Masons (2); Carpenter (2); Unskilled Labour (8)
Finishes	30 days	26.8.11	5.10.11	15	Masons (2); Carpenter (2); Unskilled Labour (8)
Services	**102 days**	**7.5.11**	**25.9.11**		
Mechanical	**90 days**	**24.5.11**	**25.9.11**		**Mechanical technician (1); Plumbers (2)**
Plumbing & drain. for Lagoon	30 days	24.5.11	4.7.11		Mechanical technician (1); Plumbers (2)
Plumbing & drain. for Building	90 days	24.5.11	25.9.11		Mechanical technician (1); Plumbers (2)
Mechanical ventilat.	14 days	29.7.11	17.8.11		Mechanical technician (1); Plumbers (2)
Electrical	**90 days**	**7.5.11**	**8.9.11**		
Conduiting	40 days	7.5.11	30.6.11		Electrical Technician (1); Electrician (1)
Wiring & Fit-Out	30 days	29.7.11	8.9.11	14	Electrical Technician (1); Electrician (1)
External Lighting	20 days	19.7.11	15.8.11	6	Electrical Technician (1); Electrician (1)

Cost

Initial project cost for the Olkaria Geothermal Spa was estimated at US$300,000 but increased to US$500,000. No detailed bill of quantity was done. This cost excludes additional US$500,000 that was spent on equipment and electrical works. The project was fully funded by KenGen. Financing of the project was planned in line with the annual budgeting cycle of the company.

Both Mývatn Nature Baths and the Blue lagoon prepared detailed bills of quantities and the cost was US$1,000,000 for Mývatn Nature Baths. The two projects were financed by shareholders.

Risk identification and assessment

In risk analysis, both Mývatn Nature Baths and Blue Lagoon rate very good at 4. Olkaria Geothermal Spa rates fair at 2 because risks were not adequately addressed through a comprehensive business plan and the risk analysis that was undertaken was not exhaustive. Some of the risks that were identified were brine availability, reinjection system, brine chemical composition, safety risks, and approvals. The chemical composition of the brine was analysed and found to be suitable for bathing. Regarding safety, the spa is 1-1.5 m deep and warning signs were erected and rules and regulations published. Lifeguards are on site and visitors are not allowed into the spa past 18:00 hours. There are first aid kits and fire

extinguishers available in the building. Financial risk, customer availability and sustainability were not analysed and this exposed the project to financial loss.

For Mývatn Nature Baths, risk analysis was undertaken on the financial success, brine availability, reinjection system, brine chemical composition, and safety. A detailed financial and business plan was done which provided an assessment of the viability of the project. The brine is obtained from one of the wells drilled in the area, initially meant for a diatomite factory. The brine was analysed and found to be suitable for bathing. No reinjection system was designed for the project until 2014 when a 100 m depth reinjection well was drilled. Some of the safety measures taken include recruitment of lifeguards, limiting depth of the lagoon to a maximum of 1.5 m, availability of first aid and life-saving equipment and erecting warning signs. Environmental scoping licence and building designs approvals were obtained. However, Mývatn Nature Baths get inadequate brine to heat up the entire baths uniformly because the heat exchanger is not able to supply enough brine at the desired exit temperature of 130°C.

Some of the risks analysed for the Blue Lagoon project included financial risk and profitability, brine availability, and brine chemical composition. A lot of time was spent on designing a temperature management system that ensured the visitors' safety, since from previous experience, visitors to the lagoon got burnt during bathing when the brine from the separator flowed into the lagoon without notice. The brine was analysed and found to be suitable for bathing. Some of the safety measures taken were recruitment of lifeguards, lagoon depth limited to maximum of 1.5 m, availability of first aid and life-saving equipment and erecting warning signs. No environmental scoping was done because it was not required at that time. Approvals were obtained for the building designs and the use of brine for treatment of psoriasis and other skin ailments.

Quality
Olkaria Geothermal Spa rated 1 because there was no quality plan put in place while Mývatn nature Baths and the Blue Lagoon rated 4 and 5, respectively, because of developed quality plans. Methods used in the quality planning included regular inspection of works as per design and regular meetings.

Procurement
Olkaria Geothermal Spa rated poor at 1 on procurement plan while Mývatn Nature Baths and Blue Lagoon rated excellent at 5. The delay in completion of the Olkaria Geothermal Spa was mainly caused by procurement hiccups, scope change that impacted procurement and human resource unavailability. Such delays were not experienced at the Mývatn Nature Baths and the Blue Lagoon because contractors who were selected through restricted tendering were responsible for the supply of materials and labour. For Mývatn Nature Baths, 5% of the contract amount was levied to a contractor for every day of non-delivery or delay.

Communications
Olkaria Geothermal Spa rated poor at 1 on communication plan because no communication plan was developed. However, during the implementation of the project, the project manager was the point of communication. Mývatn Nature Baths and the Blue Lagoon rated at 5 because they had comprehensive communication plans and the project managers were the contacts for the projects. All the three projects used emails, status and progress reports, and verbal communication through telephones, telephone texts, as well as daily, weekly and monthly meetings.

Design of the brine flow system
The initial designs of the brine flow at the Olkaria Geothermal Spa and the Mývatn Nature Baths provided for manual control of temperature. This caused difficulty in managing the temperature of the brine to the required range of between 38 and 40°C for Mývatn Nature Baths and between 30 and 35°C for the Olkaria Geothermal Spa. Mývatn Nature Baths later automated the temperature control system when funds became available. Manual temperature control at the Olkaria Geothermal Spa is becoming expensive and untenable and this necessitates the need to install an automatic temperature control system.

Brine at Mývatn Nature Baths is being reinjected into a 100 m depth well. At the Blue Lagoon, there is no effective reinjection system for the used brine and brine overflows to the surrounding lava.

5.3 Implementation

Project management approach on implementation rated 4, 3, and 5 for Mývatn Nature Baths, Olkaria Geothermal Spa and Blue Lagoon, respectively. The ratings were affected by the level of application of the various knowledge areas or processes as described below.

During implementation, close supervision was required. Some project components ran concurrently and these required to be supervised, monitored, controlled and delivered within schedule and in adequate quality. Some of the methods that were used to monitor and control the scope and time included: regular meetings with supervisors and teams, daily, weekly, and monthly progress reports that were submitted to senior management, proper stage management, and identifying the need for and obtaining approvals for variations in good time.

Stakeholder management
Stakeholder management was rated fair at 2 for the Olkaria Geothermal Spa, and 4 and 5 for Mývatn Nature Baths and Blue Lagoon, respectively.

Olkaria Geothermal Spa rates at 2 on stakeholder management because there was no stakeholder management plan. Both Blue Lagoon and Mývatn Nature Baths had stakeholder management plans and this enabled them to obtain most of the initial funding of the projects from shareholders. They, therefore, rate 5 and 4 respectively. For the Olkaria Geothermal Spa, lack of stakeholder management plan resulted in inadequate engagement with stakeholders such as KWS, especially on visitors' entry charges. This has continued to be a problem as visitors are charged at the KWS-gate for entry into the Hell's Gate National Park as well as for entry at the spa.

Mývatn Nature Baths and Blue Lagoon had stakeholder management plans that enabled the companies to get initial financing for the projects. The importance of having a stakeholder management plan is best explained by PMBOK Guide (PMI, 2013), which states that identifying stakeholders, understanding their relative degree of influence on a project, and balancing their demands, needs, and expectations are critical to the success of the project. Failure to do so can lead to delays, cost increases, unexpected issues, and other negative consequences including project cancellation. Example of an unexpected issue that ought to have been resolved earlier is that visitors to the Olkaria Geothermal Spa pay entry fees at the KWS gate and also at the spa, which is costly.

Project team development
Before the start of a project, it is important to have a team building session during which project expectations, ethics, rules and regulations, and project objectives are made clear to the team. The team should also be trained on how to conduct quality inspections and supervision, so that the project is delivered to the client's expectations and within schedule. The PIT at Olkaria Geothermal Spa was not trained on interpersonal skills, supervisory skills, project scheduling, project controls, and quality auditing. No team building sessions were held nor were ground rules set. However, staff were given Key Performance Indicators (KPIs) upon which they were evaluated based on delivery and timelines. Olkaria Geothermal Spa, therefore, rates at 2 while PITs at Mývatn Nature Baths and the Blue Lagoon rated 4 because the various subproject managers had experience in project management.

Risk treatment and control
On risk treatment and control, Olkaria Geothermal Spa rated 2 while both Mývatn nature Baths and Blue lagoon rated 3. Risks identified during the implementation of the projects were addressed. For example, during the construction of the Olkaria Geothermal Spa, coarse finishing was done on the floor of the lagoon to make it less slippery. Stairs into the lagoon were modified to 4" to make them less deep. For

the Blue Lagoon, no reinjection system was designed for the project. However, shallow wells were later drilled to take in the brine. These got easily clogged up with silica and so as to the date of publication there is no effective brine reinjection system and the used brine is spreading into the lava field surrounding the lagoon. This is becoming untenable to the environment and can have an impact on stakeholder relationships.

Quality control
Olkaria Geothermal Spa rates at 3, Mývatn Nature Baths 4 and Blue Lagoon 5 on quality control. For Olkaria Geothermal Spa, the rating was affected by, among others, inadequate control of scope due to lack of change request forms despite the significant changes witnessed, and quality control on inadequate specifications especially on the brine flow system. This resulted in a manual temperature control system, while the Mývatn Nature Baths and the Blue Lagoon use automatic temperature control systems. However, all the three projects implemented quality control in line with specifications through on-site inspections, quality checks against design, consultations and regular meetings. Schedule and time control methods adopted by the three projects included regular meetings, taking daily records of the activities, and review of schedules against work delivered. Any corrective actions needed were recorded in notebooks and carried out so as to ensure quality as per design. Regular meetings were also held to identify areas of focus or corrections. At the Olkaria Geothermal Spa, time and schedule control was affected by poor selection of suppliers and a change of scope and this delayed the project by 1 year and 11 months. This was not the case for Mývatn Nature Baths and the Blue Lagoon where scope changes were minimal and contractors supplied the materials and a strict project management approach was adopted.

Supplier selection
The Blue Lagoon and Mývatn Nature Baths rated 5 on supplier selection because both projects procured contractors through restricted tendering. The contractors were responsible for supply of materials and labour during construction. On the other hand, Olkaria Geothermal Spa rated fair at 2. Suppliers of project materials were selected based on specifications and cost. Delay in procurement of materials delayed the construction of the Olkaria Geothermal Spa by 1¾ years. Some of the suppliers did not deliver materials, while obtaining approval for procurement of some of the items was sometimes deferred. Any deferment or non-delivery of materials increased the procurement timeline for any single item by six months which is the normal procurement cycle.

Information distribution
All the three projects rated 4 on information distribution. Information was distributed on a need to know basis. Methods used to distribute information included meetings, memos, letters, emails, mobile texts, verbal communication, and status reporting.

Scope control
On scope management, Olkaria Geothermal Spa and Mývatn Nature Baths rated at 3 and 4, respectively, while Blue Lagoon rated at 5. For both the Mývatn Nature Baths and the Blue Lagoon, no major changes were made to the original designs. Mývatn Nature Baths and Olkaria Geothermal Spa did not develop change request forms while the Blue Lagoon had change request forms which are critical for managing scope, cost, scheduling and accountability.

During the construction of the Olkaria Geothermal Spa, the source of the brine was changed. Initially, brine was tapped from the reinjection line from well OW-710 that connects to the main reinjection line to well OW-708. The construction was done from 1st June 2013 to 6th June 2013. After tapping the brine from the reinjection line from well OW-710, it was realised that the brine flow was cyclic and not adequate. A new brine line was constructed from 10th June to 30th June 2013 to tap brine from the main reinjection line to well OW-708. Furthermore, an additional lagoon for children was constructed. Changes at the Olkaria Geothermal Spa represent a flexible project management approach because the outcomes were not certain. If scope control was strictly adhered to, the children's lagoon would not have been added, nor would the size of the largest lagoon have been increased from 1,500 m^3 to 3,500 m^3.

Time control
On schedule and time control, Mývatn Nature Baths and Blue Lagoon rated excellent at 5 and Olkaria Geothermal Spa fair at 2. Construction of Mývatn Nature Baths took 7 months, the Blue Lagoon 1 ½ years, and Olkaria Geothermal Spa 2¼ years, while the original schedule was 125 days. For the Olkaria Geothermal Spa, this delay was caused mainly by procurement bureaucracy and non-delivery of some critical materials and occasional human resource unavailability. Supervisors ensured that work was assigned to teams as per the schedule and stage of works, with measured targets in terms of time and quality expectations, and getting concurrence from the supervisors and the foremen regarding the daily Key Performance Indicators (KPI). Alongside the KPIs, resource requirements were provided (if available) to ensure that no team stopped work due to lack of resources. The foremen, through their supervisors, submitted daily reports of their KPIs and these were reviewed against the schedule and required quality. For the Mývatn Nature Baths and the Blue Lagoon, construction was done by contractors as per the initial design and no major changes were done. The project management approach adopted at the Olkaria Geothermal Spa was flexible so as to accommodate any changes in scope or delays caused by quality improvement and procurement hiccups.

Cost control
Olkaria geothermal Spa rates 3 on cost control while Mývatn Nature Baths and Blue Lagoon rate excellent at 5. For the Olkaria Geothermal Spa, the cost was controlled through the recording of daily activities, daily material movements and inventory control, and review of actual costs against budget provision for specific components of the project. Inventory of the materials was reviewed daily to ensure no materials were lost or to determine if there was any additional requirement that needed to be provided for. At Mývatn Nature Baths and the Blue Lagoon, the contractors were directly responsible for the construction and the work was evaluated per deliverables to ensure that there was no cost overrun.

5.4 Closure

Project management approach on closure was rated excellent at 5 for the Mývatn Nature Baths, the Olkaria Geothermal Spa and the Blue Lagoon. The Olkaria Geothermal Spa is still being tested and therefore has not yet been closed. The project has now been handed over to a management board and an operations committee. The management board is responsible for resource mobilisation, marketing, talent management, and strategic planning for the facility, including any improvements to the spa operation, while the operations committee is responsible for the day to day running of the spa. Outstanding works include a conference facility, cottages and a cable car, as well as remedial works on the brine flow system and temperature management. After the construction of the spa and the administration building was completed, the PIT was retained but with minimum activity as it awaits the next phase of development. In line with partial closure of the project, all the documentation related to the project was collated and kept and a final project report was prepared, detailing the total cost of the project and outstanding works. During the test run, a number of challenges have been experienced that need to be addressed. These include: inadequate business planning resulting in fewer visitors now at 14,000 per year, and inadequate stakeholder management. Lessons learnt in the three projects include the following:

i. Documentation of all aspects of a project. This is normally overlooked and it can become a subject of auditing. All transactions including procurement and payments must be recorded and evidence kept.
ii. Projects of such magnitude should be contracted out. This will reduce time wasting on obtaining approvals for every single purchase which delays project delivery.
iii. All members of the project team must be officially released from their day to day duties so as to focus on the project.
iv. The project leader should learn to motivate teams to be able to perform under difficult circumstances.
v. Open communication by the project manager to the teams and other interested parties is essential for project success.
vi. Support from senior management is important for the success of any project.

vii. Regular updates to management are important so that the stakeholder does not lose interest in the project.
viii. A project that takes a long time to be completed can fatigue management and runs the risk of being abandoned.

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, the objective of the project, quality and the current phase of the project. These factors and their level of influence on the project management approach in relation to the type of project are discussed below and appropriate recommendations made.

Risk analysis
Where the viability of the project, risks and opportunities are not clear, as in the case of the Olkaria Geothermal Spa, it is recommended that the project starts small and expands later, depending on the business growth. This, therefore, requires a different project management approach that allows scope change, more focus on stakeholder management, a communication plan and business strategy, review of business environment, continuous review and assessment of risks and opportunities, and development and execution of marketing strategy. On the other hand, Mývatn Nature Baths had a fairly clear indication of the visitors' numbers and the popularity of bathing in the brine arising from the experiences at the Blue Lagoon, and therefore they could start with a big project. For the Blue Lagoon, there was a clear indication of the number of visitors, based on previous use of the lagoon and this formed a benchmark from which the Blue Lagoon could expand with a clear and strict project management approach that provided little change for scope change, cost and schedule variations. The application of project management approach for the Blue Lagoon was thus different from the Mývatn Nature Baths and the Olkaria Geothermal Spa.

Marketing strategy
For a project with uncertain immediate outcome, opportunities and risks like the Olkaria Geothermal Spa, it is recommended that a marketing strategy be developed during the planning stage but executed only when adequate data has been collected on the potential opportunities, risks and threats available as well as quality of services. This requires that the project starts in small phases and uses trial and error as the quality of service is improved. A one-year test run period is thus recommended during which baseline data is collected about the customers, the usability and usage of the brine, improvement of the services is undertaken and stakeholders are managed. Olkaria Geothermal Spa is still on a test run although it was opened to the public in August 2014. A marketing strategy will be developed and executed once all required services have been established. Mývatn Nature Baths launched a marketing strategy after it was ensured that the quality of the service had been improved, mainly through installation of an automatic temperature control system. The test run and corrective action period took nine months.

Cost and scope
Due to the uncertainty of the project requirements and how the project would evolve, being the first project of its kind ever undertaken by the KenGen company, it was difficult to obtain a near actual cost estimate for the Olkaria Geothermal Spa. The scope changed during project implementation and this increased the cost. Strict cost and scope control could not be applied because the outcome and requirements were not clear and therefore could not be established accurately. It is, therefore, recommended that a strict scope and cost control as a project management approach should only be applied in a project where the outcomes are certain, for example, a power plant, or any expansion project that already has information on business viability and known requirements for the project. This means

the financing and scope plans should have a buffer or float provision that allows changes, provided the project is still under control.

Quality
For projects with uncertain outcomes and whose risks or opportunities are difficult to ascertain, the quality is impaired by little information on design, arising from a lack of adequate knowledge as well as little knowledge about customer expectations. Quality, though managed through the design specifications, cannot easily be guaranteed because the design could be based on inadequate consideration of customer needs or a lack of adequate knowledge. It is recommended that for such projects, the quality plan be flexible so as to allow some aspects of quality to be addressed as the project progresses. The quality plan should allow for trials and test runs to determine the functionality of the product. Due to the uncertainty of the functionality of the lagoons, the first lagoon that was constructed at Olkaria Geothermal Spa was test run and it was realised that it could not hold the brine as intended and thus had to be reconstructed. A strict project management approach that does not allow for cost variation and rescheduling is not applicable in such a project.

Time
During the construction of the Olkaria Geothermal Spa, time could not be managed in a strict project management sense although this was the initial intention. The completion time was delayed due to unanticipated procurement delays and non-delivery of items. Time control is difficult in a project that has uncertain processes controlled by other factors beyond the direct authority of the project manager. During scheduling, the plan should provide flexibility so that issues are addressed as they arise. This can be applied for trial and experimental projects whose outcomes, risks and opportunities are uncertain. However, for projects that are to be delivered within an inflexible timeframe, it is recommended that processes which are not in direct authority of the project manager, and which can impact the completion time of the project, be outsourced. In such a case, a contractor should be procured to undertake the construction.

Procurement plan
For projects that have strict timelines, especially those that have been tested and proved viable such as expansion projects, it is recommended that contractors be procured to undertake the construction. This will ensure that the project is delivered within time and as per specification. For pilot or small direct use projects, however, in-house capacity, if available, can be used to initiate, plan and implement the project.

Stakeholder management
A comprehensive stakeholder management plan that allows for constant engagement with the stakeholders is required for a project that has uncertain outcomes, opportunities or risks. This is true of the Olkaria Geothermal Spa that required a comprehensive stakeholder management plan to manage stakeholders such as KWS. Inadequate engagement of KWS is, at the time of writing, posing a threat to the number of visitors to the spa because of what visitors think is a double charge as they pay entry fees at both the KWS-gate and the spa. Engagement with KWS can provide additional opportunity for increasing the number of visitors to the spa through waiver of entry fees and also by making the spa one of the destinations while visiting the park.

Choice of project development approach
It is recommended that due to the uncertainties associated with the risks and outcomes, as well as emerging opportunities and threats, direct use projects adopt a phased development approach. This allows a review of the functionality of the project, and reassessment of opportunities and threats which change as the project is being implemented. Table 3 shows a proposed two-phased development of a geothermal spa or another direct use project. During phase one, the project is developed small and test run for one year. The test run period is used to collect baseline data about the customers, as well as a constant review of the risks and opportunities and stakeholder environment. During this period, the marketing strategy is executed once it is clear that the project is functioning as per design expectations. Any improvements to the project that enhance use of the brine are noted and executed during phase one

and lessons learnt recorded. Phase two is an expansion phase that is premised on adequate data and therefore strict project management approach on scope, quality and cost control is adopted.

TABLE 3: Proposed phased development of geothermal spa or direct use project

	Duration (Years)													
PHASE 1	**1**		**2**		**3**		**4**		**5**		**6→**			
Concept/ Initiation														
Research on brine availability and suitability														
Project charter														
Stakeholder identification														
Planning														
Define scope														
Work breakdown structure														
Define and sequence activities														
Define project organisat.														
Estimate costs														
Develop budget														
Approvals														
Internal														
Abridged business plan														
Environmental scoping/ EIA														
Financing plan														
Develop market. strategy														
Risks identification and assessment														
Plan quality														
Plan procurements														
Plan communication														
Design Approvals														
Implementation														
Procurement of contractor														
Construction of lagoons														
Test run														
Execution market. strategy														
PHASE 2: REDEVE-LOPMENT														
Planning														
Implementation														
Closure														
Operations														

In line with these recommendations, the Olkaria Geothermal Spa should spend about 7½ months developing and executing a marketing strategy, as well as analysing opportunities in enhancing and increasing services from the geothermal fluid as shown in Table 4 and further described in Appendix I, Figure 3 and in Appendix V.

As part of stakeholder and communication management, Mývatn Nature Baths should drill a deeper reinjection well, obtain adequate supply of brine especially during winter and provide safety briefs to visitors. Similarly, the Blue Lagoon should find ways of disposing the used brine and also provide safety briefs to visitors.

TABLE 4: Schedule of activities for Olkaria Geothermal Spa

	Duration (months)															
	1		**2**		**3**		**4**		**5**		**6**		**7**		**8**	
Activity																
Research on algae																
Algae composition and management																
Partnership with Ministry of Health																
Contact ministry																
Research on health benefits of brine																
Research on beautification products																
Use of products																
Business plan development																
Marketing strategy developm.																
Marketing strategy execution																
Other services																
Steambaths																
Swim suits for hire																
Restaurant services																
Massage services																
Installation of hot water system																
Procurement of steel coil, pipes and connections																
Installation																
Automatic temp.control system																
Specifications																
Procurement of contractor																
Design of the system																
Installation of the system																
Closure																

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REFERENCES

Burke, R., 2004: *Project management: Planning and control techniques* (4th ed.). John Wiley & Sons, West Sussex, 509 pp.

Gudmundsson, Á., 2015: *Námafjall high temperature area*. UNU-GTP, Iceland, unpublished lecture notes.

Gudmundsdóttir M., Brynjólfsdóttir Á., Albertsson A., 2010: The history of the Blue Lagoon in Svartsengi. *Proceedings of the World Geothermal Congress 2010. Bali, Indonesia,* 6 pp.

Travelandescape, 2013: *Location of Mývatn Nature Baths in North Iceland*. Travelandescape, webpage: *www.travelandescape.ca/2013/09/blue-lagoon-vs-Mývatn-baths/.*

Haraldsson, I.G., and Lloret Cordero, A., 2014: Geothermal baths, swimming pools and spas: Examples from Ecuador and Iceland. *Paper presented at 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,* 14 pp.

IPMA, 2006: *Competence baseline* (version 3). International Project Management Association, Nijkerk, The Netherlands, 212 pp.

ISO, 2012: *ISO 21500:2012. Guidance on project management*. International Organization for Standardization, Geneva, 36 pp.

Jónasson, H.I., and Ingason, H.Th., 2013: *Project ethics*. Gower Publishing Ltd., Surrey, 142 pp.

Lund, J.W., and Boyd, T.L., 2015: Direct utilisation of geothermal energy 2015, worldwide review. *Proceedings of the World Geothermal Congress 2015, Melbourne, Australia,* 31 pp.

Mangi, P., 2014: Geothermal direct use application: A case of the Geothermal Spa and Demonstration Centre at the Olkaria geothermal project, Kenya. *Paper presented at Short course IX for Geothermal Exploration, organized by UNU-GTP, KenGen and GDC, Naivasha, Kenya,* 12 pp.

Mariita, N., 2010: An update on applications to direct-uses of geothermal energy development in Kenya. *Proceedings of the World Geothermal Congress 2010, Bali, Indonesia, 5* pp.

PMI, 2013: *A guide to the project management body of knowledge* (5th ed.). Project Management Institute, 5 pp.

Ragnarsson, Á., 2015: Geothermal development in Iceland 2010-2014. *Proceedings of the World Geothermal Congress 2015, Melbourne, Australia,* 15 pp.

Reiss, G., 2007: *Project management demystified* (3rd ed.) Taylor & Francis, London, 210 pp.

APPENDIX I: Lagoon layout and brine flow system at the Olkaria Geothermal Spa

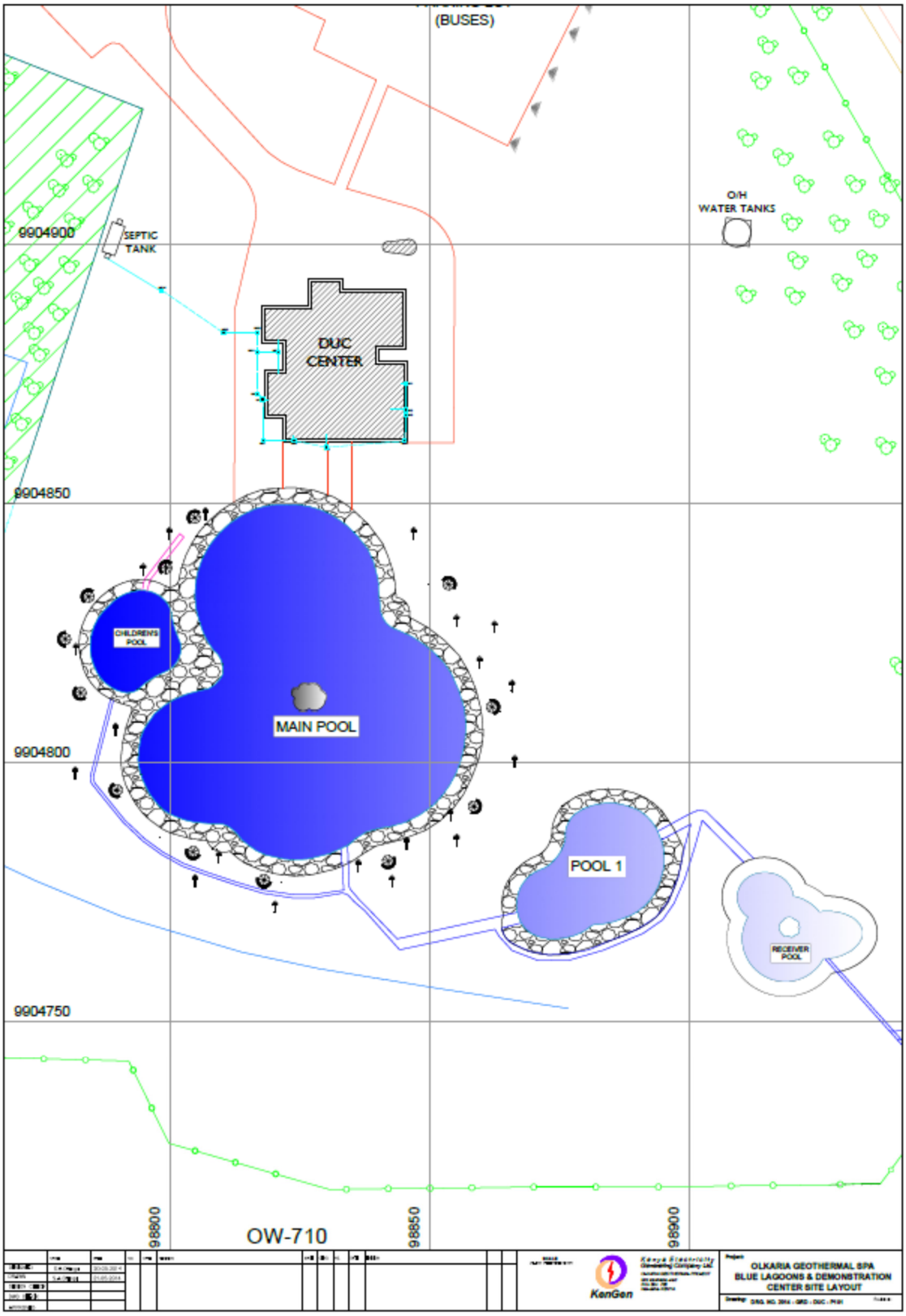

FIGURE 1: Lagoon layout

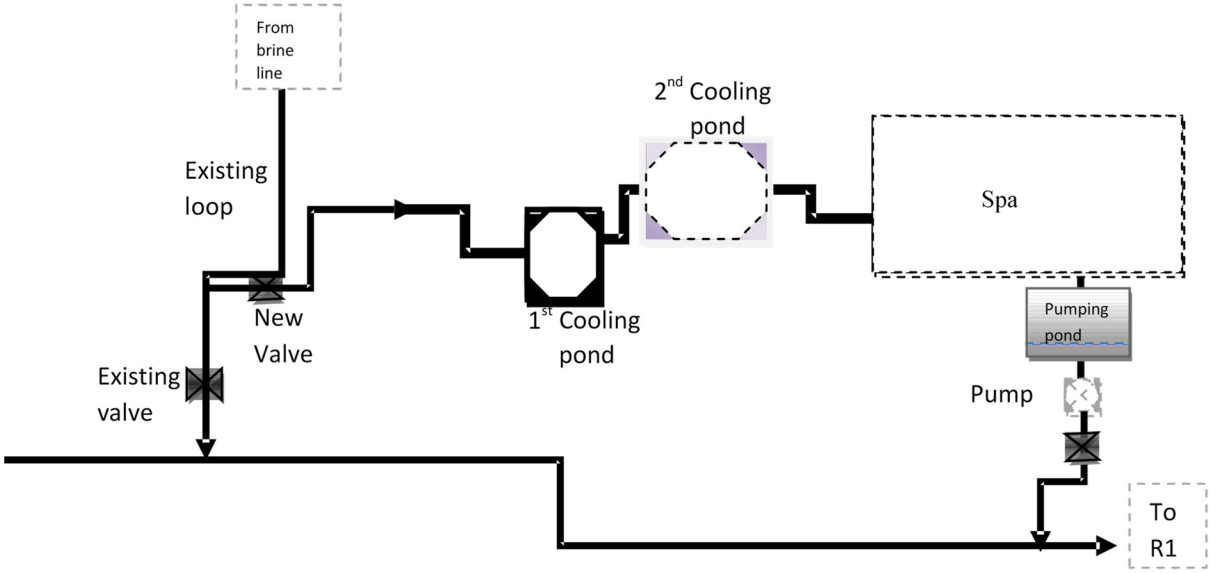

FIGURE 2: Brine flow system

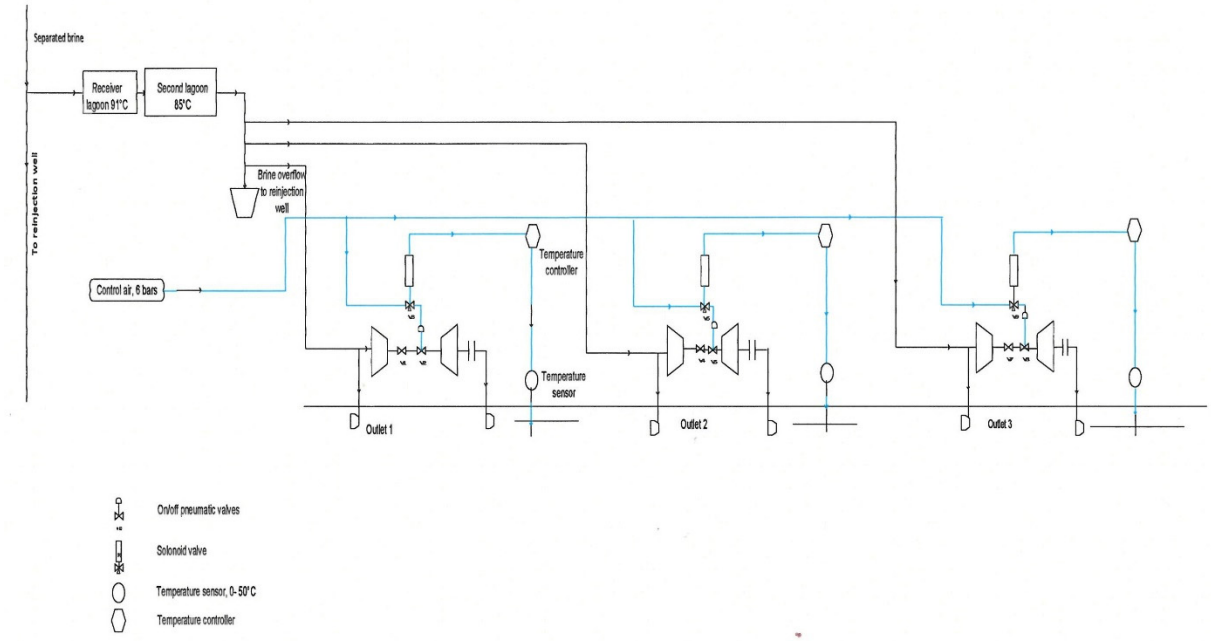

FIGURE 3: Proposed brine flow and temperature control system for Olkaria Geothermal Spa

APPENDIX II: Blue Lagoon and Mývatn Nature Baths brine flow systems

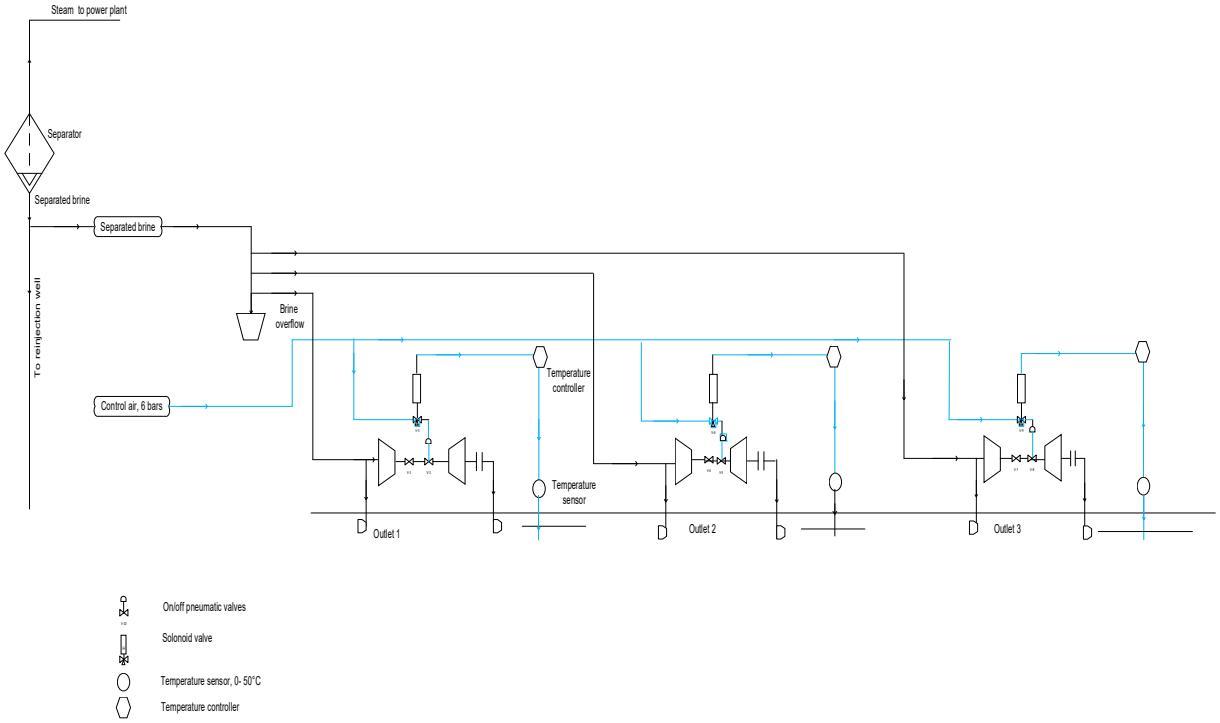

FIGURE 1: Brine flow and temperature control system at Blue Lagoon

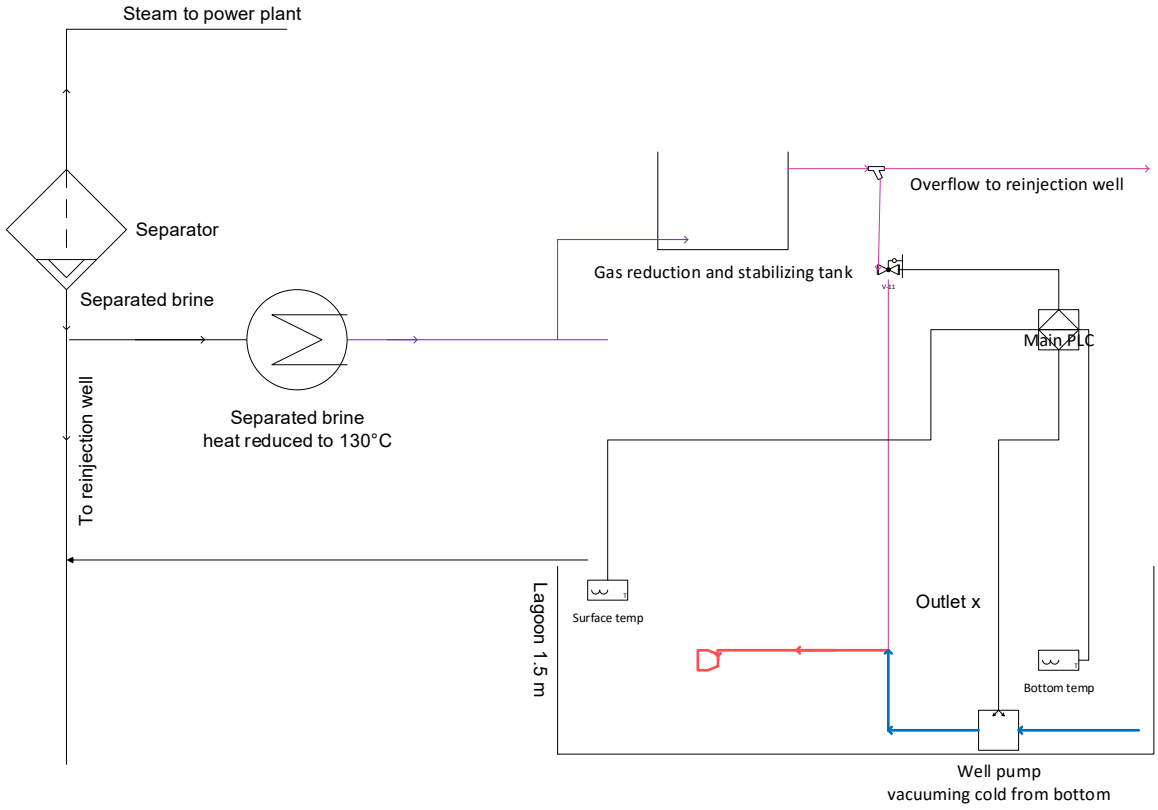

FIGURE 2: Mývatn Nature Baths brine flow system

APPENDIX III: Interview schedule

Introduction
Name of Interviewer: Peketsa Mangi
Pursuing Geothermal Project Management and Finances course at UNU-GTP
Purpose: Undertaking project as part of requirement for award of certificate in geothermal technology
Confidentiality: Information will be treated with confidentiality
Interviewee: Identified as one of the officers involved in the initial design of the Blue Lagoon
Thanking interviewee for time and agreeing to be interviewed

Introduction by Interviewee:

Name:
Position in organisation
Areas of interviews

DESIGN OF THE BRINE FLOW SYSTEM

What is the source of the brine?

What is the minimum and maximum depths of the lagoon?
Minimum depth _____ Maximum depth _____

How is the brine flow from the separator to the lagoon controlled?
Use of automatic valves; Controlled manually using valves; Brine flows into a reservoir

Temperature of the brine from the source?

How is temperature regulated to the desired temperature in the lagoon?

Where is the brine overflow from the lagoon disposed?
In the nearby lava formation; In a reinjection well; Flows to the sea through a pipe

How many brine entry points are there in the lagoon?

Please indicate if brine flow is automatic or manual
Manually controlled; Automatic controlled by use of thermostat

What is the average temperature of the brine in the lagoon?

PROJECT MANAGEMENT

Project initiation

During construction of a project with such complexity as the Blue Lagoon, project management techniques are deployed so as to ensure success of the project.

What was the objective of constructing the Blue Lagoon?

Was a project manager appointed for the project?

If a project implementation team was appointed, was it released officially to undertake the project work?

If yes, was the project manager involved in the appointment of the project team?

Was the project manager granted authority to make decisions regarding the project

Before project kick off, one of the requirements is production of a Project Initiation Document (PID) that summarises project viability, and refines the scope, duration, resources and project team composition and business environment review. Was a PID issued before start of the project?

Project ethics analysis and agreement on the project ethics is useful in managing teams and creating a moral standing for the project. Did you undertake a project ethics analysis before start of the project?

Did you prepare a project charter that captured the costs, tasks, schedules, and deliverables of the project with the team?

During the initiation, did you identify all the stakeholders of the project?

Please tick if the following were some of your stakeholders
HS Orka; Grindavik town; The CEO of Blue Lagoon; Tourists; Members of the public; Environmental activists; Any other?

If yes, who among these posed risk to the project?
HS Orka; Grindavik; The CEO of Blue Lagoon; Tourists; Members of the public; Environmental activists; Any other?

Who among these presented the biggest opportunities to the project?
HS Orka; Grindavik; The CEO of Blue Lagoon; Tourists; Members of the public; Environmental activists; Any other?

Was a business case developed for the project?

PLANNING

Project plan

Did you develop an overall project plan for the project?

Scope and work breakdown structure

What was the scope of the Blue Lagoon during the initial implementation?
Lagoon; Washrooms; Restaurant; Administration building; Cafeteria; Souvenir shops; Steambaths; Sauna.

Was a work breakdown structure that gives the main works done for the project?

How many contractors were involved in the construction of the project, if any?

How many workers in total were involved in the construction of the Blue Lagoon?

Sequence of activities, Activity duration and schedule

What planning tools did you use to schedule activities?
MS project; Excel sheet; MS Word; Any other

What time estimation did you make for the entire project?

How long did you take to complete the project?

Based on the total time taken to complete the project, how would you apportion the time taken:
During planning stage; During construction; During closure of the project

Cost estimates and budget
What budget estimate was done for the initial scope of the project?

Projects have different components that may require financing at different times. Please indicate the breakdown of the budget in line with the various components
Blue Lagoons; Buildings; Electrical installations; Equipment and furniture.

Finances for the project were provided by
Owner; Loans; Shareholders; Any other

What was the total cost of the project?

Identification and assessment of risks
During the planning of the project, project risks have to be considered. Please indicate if risk assessment was undertaken regarding the following and indicate the action taken as a risk mitigation:
Brine disposal system; financial risk; Brine availability; Brine chemical composition; Environmental Impact assessment; Safety; Any other risks not mentioned above.

Indicate if the following approvals were required for the project:
Building designs; Brine chemical composition; Environmental impact assessment licence; Safety standards; Health certificate for restaurant services; Provision of health products; Provision of health services for psoriasis.

Did you develop a quality plan for the project?

If yes, please tick if any of the following was part of your quality plan
Regular inspection in line with standards; Quality review meetings; Review of construction in line with specifications and design; Project audits; Assigning personnel for quality review; Correction Action plans; Any other/s.

Procurement
Was a procurement plan for the project developed?

What procurement methods were used to procure the contractor or materials?
International competitive tendering; National competitive tendering; Selective tendering; Direct procurement.

Who was responsible for procurement of materials for the project?

What procurement bottlenecks did you experience, if any?
Delay in delivery of materials; Unavailability of materials; Lack of finances; Substandard materials; Change of prices; Any other, please specify.

Please give the methods of marketing you adopted (many can apply)
Linkage with local tour agents; Attending local Travel fairs; Attending international travel fairs; Incentives to local tour guides; Linkage and incentives to local hotels; Linkage and incentives to local tour bus drivers; Incentives to bus drivers; Schools visits; Brochures; Coupons distribution to hotels, travel agents, excursion companies; Distribution of brochures to schools, tour agencies, trade fairs, excursion buses, Advertisement in the media; Any other?

Did you develop a communication plan for the project, i.e. who will be responsible for communication and methods of communication?

If yes, which methods were used?
Daily meetings; Weekly meetings; Monthly meetings; Emails; Progress reports; Verbal – telephone, face to face; Memos and letters; Any other, please specify.

IMPLEMENTATION, MONITORING AND CONTROL

Directing and controlling the project
What project control activities were undertaken?
Regular meetings with the supervisors; Regular progress reports; Recording of daily activities; Daily materials movements control as part of cost management; Taking inventory of materials on a daily basis; Scheduling of activities; Daily scheduling of activities; Review of schedules against deliverables; Regular inspection of works; Any other, please specify.

During project implementation, the scope of the project may change. Please indicate if any of these actions were put in place.
Change request forms prepared; Approval required for any change; Scope definition done.

Manage stakeholders
What methods were used to manage the stakeholders?
Profiled stakeholder according to level of influence, level of impact to the project; Meetings with stakeholders were held; Regular updates were sent to stakeholders; The project sponsor was regularly updated on the progress of project; Quality reviewed in line with expectations of customers and project sponsor; Shareholders updated on progress of construction

Develop project team
Was the project team trained on quality assessment, project control techniques, and supervision?

If no, was that because the know-how was already in place within the team?

Risk treatment
Were risks identified during the project?

Were corrective actions put into place and acted upon to deal with project risk?

Quality assurance
What methods were used to ensure quality?
Regular inspections of works at site undertaken; Regular meetings were held with supervisors; Construction was reviewed against design; Any other method?

Information distribution
What methods were used to distribute information to the project team, stakeholders and contractors?
Daily meetings; Weekly meetings; Monthly meetings; Emails; Progress reports; Verbal – telephone, face to face; Memos and letters; Any other, please specify.

Was information distributed on the need to know basis?

Team management
Indicate which of the methods best describes how conflict was managed in the project team
Stage management with supervisors; Discussion with teams; Removal of non-complying team members; Counselling; Negotiation with members.

How would you describe the morale of the team during implementation of the project?

Manage stakeholders
Did you have a plan of how to manage the various stakeholders?

CLOSURE OF THE PROJECT

During handing over of the project, what are some of the activities that you undertook so as to bring the project to a closure?
Meeting held; Documentation done; Final project report written; Lessons learnt recorded; Database of lessons learnt kept; Project handed over.

APPENDIX IV: Rating of project management approach in geothermal spas construction

On a scale of 1-5, rating how best the items in the matrix were addressed during the planning and execution of the project. 1- Poor and 5 is best						
Grade	**Description**					
1	Poor understanding and adoption of project management techniques, poor application of knowledge areas or poor application of technical, behavioural and contextual competences					
2	Fair understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences					
3	Good understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences					
4	Very good understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences					
5	Excellent understanding and adoption of project management techniques, knowledge areas or technical, behavioural and contextual competences					
REVIEW OF PROJECT MANAGEMENT APPROACH						
Phases and subjects	**Olkaria Geothermal Spa**	**Rating**	**Blue Lagoon**	**Rating**	**Mývatn Nature Baths**	**Rating**
Concept/ initiation		**2**		**4**		**4**
Clarity of objectives	Not project objective but corporate objective. Objectives clear to team.	3	Objective clear to team	5	Objective clear to team	5
Project charter	Not prepared. Simple payback period done in a proposal	2	Prepared	5	Not prepared. Business plan done	3
Project ethics analysis	Not done	1	Rules and regulations were made clear	2	Rules and regulations were made clear	2
Stakeholder identification	Stakeholders not listed	2	Stakeholders identified	5	Stakeholders identified	5
Establish project team	PIT established with project manager. Team not officially released	4	PIT established with project manager	5	PIT established with project manager	5
Planning		3		5		5
Project plan						
Scope, WBS, Define activities	Scope identified, WBS done and activities defined	5	Scope identified, WBS done and activities defined	5	Scope identified, WBS done and activities defined	5
Resource estimate, project organisation	Resource estimate done. Casual labour restrictions	3	Resource estimates done. Contractor labour	5	Resource esti-mates done. Contract. labour	5
Sequence activities, activity duration, schedule	Done on MS Project	5	Done on MS Project	5	Done on MS Project	5
Cost estimate, budget	Done	3	Done	5	Done	5
Identify and assess risk	Not all risks identified and assessed	2	Risks identified and assessed	3	Risks identified and assessed	3
Plan Quality	No plan done	1		**5**		4
Procurement plan	No plan done	1		**5**	**Plan done**	5
Plan communication	No plan done	1	Plan done	5	Plan done	5
Implementation		**3**		**5**		**4**
Direct project work	Done		Done		Done	

Manage stakeholders	No stakeholder management plan. Management on ad hoc basis	2	Identified as HS Orka, the CEO, Grindavik	5	No stakeholder management plan. Management on ad hoc basis	4
Develop project team	Team not trained on project controls, supervision. Meetings used	2	Team trained on project management aspects	4	Team trained on project management aspects	4
Treat risk	Risks mitigation identified and applied	2	Risks mitigation identified and applied	3	Risks mitigation identified and applied	3
Quality assurance	Quality requirements reviewed against controls	4	Quality requirements reviewed against controls	5	Quality requirements reviewed against controls	4
Select suppliers	Suppliers selected. Procurement beaurocracy delayed delivery of project materials	2	Contractors procured. Procurement of materials by contractors	5	Contractors procured. Procurement of materials by ontractors	5
Distribute information	Need to know basis	4	Need to know basis	4	Need to know basis	4
Team morale & motivat.	Team morale high and low	3	Team morale was high	4	Team morale was high	4
Leadership style adopted	Participatory	4	Participatory	4	Participatory	4
Monitoring and control						
Control project work and project changes	Done				Done	
Control scope	No change requests forms. Significant changes	2	Change request forms. No major change	5	No change request forms. No major change	3
Control resources, manage team	Done - inventories and stock control, cost versus deliverables, team supervised	3	Contractor role. Consultation	5	Contractor role. Consultation	5
Control schedule	Poorly executed. No adequate materials and labour	2	Done	5	Done	5
Control cost	Done	3	Done	5	Done	5
Control risk	Risks mitigated. Financial and stakeholder risks mitigation not done	3	Risks mitigated except brine reinjection	4	Risks mitigated except for inadequate brine during winter	4
Quality control	Continuous inspection was done by supervisors per specificat.	3	Continuous inspection was done by supervisors	5	Done	4
Administration	Done	4	Done	4	Done	4
Manage communications	Done through meetings, reports, emails on a need to know basis	4	Done through meetings, reports, emails on a need to know basis	5	Done through meetings, reports, emails on a need to know basis	5
Closure		5		5		5
Close project phase or project	Done	5	Done	5	Done	5
Lessons learned	Project success and failures were recorded	4	Project success and failures were recorded	5	Project success and failures were recorded	5
SUMMARY RESULTS	**Olkaria Geothermal Spa**	**3**	**Blue Lagoon**	**5**	**Mývatn Nature Baths**	**4**

APPENDIX V: Activities for Olkaria Geothermal Spa

i. *Installation of automatic temperature control system*
Olkaria Geothermal Spa can adopt the design of the temperature control system that was installed at the Mývatn Nature Baths. At least five entries for the brine should be created at the Olkaria Geothermal Spa, controlled by valves and temperature sensors that allow brine flow when the temperature drops below 30°C or as may be desired (a proposed design layout is shown in Appendix I, Figure 3)

ii. *Hot water supply to the building*
This system can adopt the Mývatn Nature Baths method that has a coil carrying cold fresh water running through the hot reservoir and onwards to the building. At the Olkaria Geothermal Spa, the receiver lagoon that has temperature of between 91 and 86°C can be used to heat the fresh water. The heated fresh water can then be supplied to the building.

iii. *Business plan and a marketing strategy development*
The business plan should assess the project plans in terms of visitors, identify project risks, define a marketing strategy, review the products and services range, define the business environment, market trends, competitors, strengths and weakness, opportunities and threats.

iv. *Silica mining*
Use of silica for beautification of the skin has become popular at the Blue Lagoon. This product can also be used to popularise the Olkaria Geothermal Spa.

v. *Research on algae*
Green algae grow at the Olkaria Geothermal Spa after months of use. Algae growth was once experienced at some portion of the Mývatn Nature Baths where fresh water used to drip. This problem at the Mývatn Nature Baths stopped when the fresh water line was removed. The algae growth at the Olkaria Geothermal Spa needs to be investigated in line with the existence of a certain microalgae species at the Blue Lagoon that is partly attributed to skin beautification effects.

vi. *Establishment of linkage with Ministry of health officials on the health benefits of the brine*
The Blue Lagoon has gained prominence and is recognised as an alternative treatment centre for psoriasis due to the brine chemical composition. This has helped to market the lagoon. Possibility of linkage with the Ministry of Health should be explored and pursued.

vii. *Manage stakeholders*
The relationship with Kenyan Wildlife Service (KWS) who are one of the stakeholders should be managed adequately. A better managed relationship will ensure that tourists visiting the park will also visit the spa. Fees charged to visitors when they visit the spa may also be waived.

viii. *Introduce additional services such as steambath, massage, restaurant, and swim suits for hire*

ix. *Undertake the tasks shown in Table 3 within a period of 7½ months*
This will enhance quality of service, guarantee increased number of visitors, and enhance project viability and sustainability. This should be initiated immediately so as to leverage on the advantage of being the only geothermal spa in Africa and therefore a special tourist destination.