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PROJECT PLANNING FOR GEOTHERMAL EXPLORATION DRILLING IN SAINT LUCIA

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ABSTRACT

Several intermittent geothermal exploration efforts have been made in Saint Lucia over the last few decades. However, to date, the commercial viability of the resource has not been determined. In 2014, the Government of Saint Lucia recommenced its efforts at developing the resource by carrying out surface reconnaissance studies. Exploration drilling is the next step in the development of the resource. Experience from drilling projects in other countries prove the importance of project planning for the success of such projects. The peculiarities of the Saint Lucia context must be considered when developing a project plan for exploration drilling. The project plan has many key components, which will guide the project manager and project team through the execution, monitoring, controlling, and closing of the project. Since no geothermal field has been developed on the island to date, uncertainty is high and must be meticulously planned for. The intrinsic high-risk nature of exploration drilling projects provides further premise for careful planning. A comprehensive project plan must be developed by a team, with consultations of industry and other experts. This study provides guidelines on how the plan should be elaborated and highlights areas of special interest in this context in Saint Lucia.

1. INTRODUCTION

1.1 Project overview

The peculiarities and specific context of the '*Saint Lucia Geothermal Resource Development Project*' make project planning a very important exercise towards heightening project success. Project planning conducted after the project initiation stage is normally completed by a project team and through consultations with key interested parties. Uncertainty at this stage of the multi-phased geothermal development project is very high and must be meticulously planned for and managed. As the project proceeds into the pre-feasibility stage or exploration drilling sub-project, a comprehensive plan should outline a roadmap for the project and set baselines which will govern the execution, monitoring and control of the project. This study therefore sets guidelines, specific not only to the planning of geothermal drilling projects, but also for the particular context of the Saint Lucia drilling project. These guidelines will include critical project plan components such as scope, cost, time, stakeholders, procurement, risk and communication. To further illustrate what the integrated project plan could look like, a sample project plan is developed in this study and is presented as an appendix to this report. It is noteworthy that given the impossibility of employing the required team approach, stakeholder engagement and detailed project information required for a comprehensive and detailed project plan, the sample plan is limited to being high-level. However, the guidelines provided in this study, once followed should result in a useful and comprehensive project plan for the drilling project.

1.2 Country context

Saint Lucia is a small island developing state (SIDS) located in the Eastern Caribbean. It has a population of approximately 185,000 people and in 2017 recorded a GDP per capita of 12952 USD (in constant 2011 International USD) (World Bank, 2018). With a surface area of 617 km^2, the island is located at latitude 13º 59' N and Longitude 61º 00' W and is classified as a volcanic island based on its geological formation. The island's main economic activity, source of employment and income remains the tourism sector as is reflected by the sector's high contribution of 82.1% to the total GDP in 2015. The remaining contributions to the GDP are accounted for by 15.3% and 2.7% by the industrial and agricultural sectors, respectively (CIA, 2018).

Against the backdrop of sustainability, it is becoming increasingly important for a SIDS such as Saint Lucia to transition to energy systems which significantly reduce the environmental footprint while at the same time provide cost effective services to the population. The insularity of the energy systems on such islands which have no fossil fuel reserves, along with the vagaries of the international oil market provide an excellent basis for transitioning the energy sector.

Apart from its 30% renewable energy target stated in the National Energy Policy (NEP) of 2010, in 2015 Saint Lucia communicated its commitment to the Paris accord through its Nationally Determined Contributions (NDC). The NDC specify a target of producing 35% of the island's electricity from renewable energy by the year 2025 with an increase to 50% by the year 2030 through a mix of wind, solar and geothermal energy. Considering Saint Lucia's minuscule contribution to global greenhouse gas emissions, it must be noted that achieving a higher level of energy independence and security and lowered electricity prices are more imperative for the SIDS. The cost of electricity in Saint Lucia remains an impediment to economic growth and competitiveness especially within the tourism sector. In 2012, the island recorded an average price of 38 USc/kWh, an amount comparatively higher than electricity prices in other countries in and out of the Caribbean region (GoSL, 2017).

1.3 Saint Lucia's 'Geothermal Energy Resource Development Project' background

The development of the geothermal resource in Saint Lucia is an important part of the island´s energy sector transition to a more sustainable future. One of the main objectives of the geothermal project in Saint Lucia is to contribute to a reduction of electricity prices for the consumers. Consequently, in 2014 the Government of Saint Lucia (GoSL) recommenced its efforts at developing its geothermal resource, following a hiatus from several exploration efforts dating as far back as 1951, which marked the beginning of investigations of the geothermal resource potential.

The Sulphur Springs area (Qualibou caldera area) in the southwestern part of the island had been considered the centre of geothermal potential in Saint Lucia and was therefore the area explored historically. Several exploration exercises and other related works, which contributed to the interpretation of the geothermal resource, were carried out in this area between 1951 and 1970. In particular, studies of local and regional geology were carried out during that period. The first detailed exploration effort took place in the mid 1970's. It consisted of the drilling, logging, and testing of seven shallow exploratory wells, ranging in depths from 116 to 725 m. However, this exploration project did not provide information on the extent of the geothermal reservoir. The most extensive historical exploration work was carried out in 1980 with a series of geoscientific studies including resistivity surveys. The survey results facilitated the development of a preliminary conceptual model of the geothermal system. Five sites for deep exploratory wells were identified but no wells were drilled. A new study was later conducted within the same decade but with a greater emphasis on geology, geochemistry and resistivity measurements along a single survey line. Based on the survey results, three sites for deep exploratory wells were recommended for drilling. In 1987, the first two deep exploratory wells were drilled to depths of 1408 and 2208 m. One well was hot but unproductive due to low flow capacity. The second well was productive but encountered corrosive acidic gases. No further drilling has been carried out since (for location maps see Appendix I).

1.4 Current status of the Saint Lucia Geothermal Resource Development Project

Consequent upon the lack of confirmation of the commercial viability of the resource and the anticipated role of geothermal energy in meeting the island's energy targets, the GoSL sought assistance from the World Bank to provide transactional, regulatory and project management support for the development of the resource for electricity generation. From 2014 to 2016, the GoSL, in collaboration with the World Bank and the Government of New Zealand, therefore recommenced its efforts to evaluate the geothermal potential of the island by launching a new surface exploration campaign. This led to the completion of new surface geoscientific studies within an extended area distinct from the areas previously studied.

In the first quarter of 2018, two parallel studies were completed in preparation for the next phase of the project - the exploration drilling phase. These studies were a prefeasibility study and an Environmental and Social Impact Assessment (ESIA) study for exploration drilling of 3-5 slim wells in three project areas. The studies have identified areas for drilling and have concluded that exploration drilling is a reasonable next step towards the development of Saint Lucia's geothermal resource. Conceptual models were analysed along with all previous studies conducted in past decades.

The World Bank continues to provide support to the GoSL for the development of the geothermal resource. At present, the project approach draws upon the lessons of global good practice, resulting in the use of public sector resources to undergo an exploration drilling programme. The results of the drilling activities will inform future investment decisions in the downstream stages of the project. This approach, it is expected, will de-risk the initial high-risk stages of the project, which would have otherwise been subject to high-risk premium demands of the private sector for upstream project risk compensation.

Recalling that geothermal development projects are multi-phased, the different phases are also treated as sub-projects with a distinct start and end and specific objectives. The pre-feasibility phase characterized by exploration drilling is therefore the next sub-project and will be the focus of this study. This project in summary entails the exploration drilling of 3 slim wells to first confirm the commercial viability of the resource and then to determine the next steps in the development of the resource.

1.5 Justification for project planning in geothermal projects

Geothermal projects are capital and time intensive by nature. Therefore, one of the most important success factors of geothermal projects is proper management. This is more so the case in Saint Lucia because the commercial viability of the resource has not yet been confirmed, resulting in high risk. Inadequate project management is deemed one of the major reasons why projects spin out of control (Discenza and Forman, 2007). According to the channel manager of an online project management software, Maya Lander Gornitzka, "*the main condition for any project to be successful is having a well-thought-out plan before the project is launched*." The inadequacy of project definition and planning is often referred to as the biggest project management mistake and inadequate planning can lead to serious problems during the lifetime of projects (Techrepublic, 2018). For example, it can cause lack of business support later on if the project is not properly defined at the planning stage. It may also lead to overshooting deadlines and budget, poor scope control throughout the project and compromised quality of project deliverables. Moreover, in the worst-case scenario, projects can be terminated prematurely without achieving project goals, should project planning be inadequate.

One major part of geothermal project management is the management of risk, given that they are notorious for the characteristic high level of risk in the prefeasibility phase. Resource and technical risks are described as the one risk which distinguishes geothermal projects from other power projects (Ngugi, 2014). While some risks cannot be avoided, proper project management can assist in managing these risks so that they do not have a significant impact on investments. One key success factor related to approaches in geothermal energy project planning is the phased approach and the importance of the pre-feasibility and feasibility phases. Errors in resource assessments and project design have significant impacts on already sensitive economies related to geothermal projects. These errors have been made in the past as proven by the history of some geothermal projects. One such example is the experience from the Geyser geothermal field in California, USA. This project suffered from an over-estimate of the resource potential, which resulted in over-estimate of approximately 1000 MW (Pálsson, 2017a). The Krafla geothermal field in Iceland offers another example of errors in a geothermal project which yielded catastrophic financial results. The biggest lesson learnt from Krafla is that decisions were made prematurely as insufficient information was available. The resource was proven to be sufficiently large. It was, however, highly complex and the fluid properties were significantly disparate from what was anticipated, resulting in premature and erroneous business decisions. Although the operation has been more successful in recent times, the major lesson from this experience was the importance of managing resource risks particularly with emphasis on the feasibility process. Subsequent projects, for example the Nesjavellir power project, were cautiously planned and managed with a phased approach, drawing on the experiences from the Krafla project (Pálsson, 2017a). According to Pálsson, "*the history of geothermal development shows that geothermal projects can easily go wrong if not all aspects of the geothermal project are addressed adequately*".

2. GEOTHERMAL PROJECT MANAGEMENT AND PLANNING

2.1 Project management in geothermal energy projects

As explained in the PMBOK 5th edition, project management can be defined as a discipline which entails the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements and objectives. This definition encompasses the purpose of the project to meet stakeholder needs and expectations (Burke, 2004). Project management is accomplished through the appropriate application and integration of the several project management processes, logically grouped according to the five stages of a project namely initiation, planning, executing, monitoring and control, and closing (PMI, 2013).

The initial exploration of a geothermal resource towards the development of an operational geothermal power plant is complex and quite expensive. In geothermal projects, the up-front costs, as opposed to the costs of operation and maintenance, determine the economic feasibility of the project. Therefore, the success of the project depends heavily on a sound project management strategy, and consequently efficient and effective project planning and management is essential. Apart from the critical nature of the investment cost of geothermal projects, the peculiarity of geothermal projects is also owed to their characterization by multiple interdependent stages (Rodríguez, 2008). Geothermal energy projects have several generic phases, namely, preliminary geoscientific studies, exploration drilling, appraisal drilling, production drilling, and power plant design and construction. This means that geothermal projects must be developed with a phased developmental approach. Therefore, one of the main project management challenges is the successful harmonization of the geoscientific work, political environment and requirements and geothermal industrial processes for example, drilling, designing, procurement, and environmental requirements, across all development phases (Gíslason, 2008).

A case in point is Kenya, where a distinct project management approach was adopted to ensure proper planning and execution of geothermal projects. A project cycle comprising of four phases and further subdivided into nine steps for geothermal projects implementation has been adopted. The phases are resource exploration, resource assessment, plant construction and operation phases. The exploration phase is further subdivided into three development steps: review of existing information, detailed surface exploration and exploration drilling. Kenya Electricity Generating Company, Ltd. – KenGen, is the leading electric power generation company in Kenya, producing about 75% of electricity capacity installed in the country from hydro, geothermal, thermal and wind (KenGen, 2018). The geothermal project management approach adopted by the company is based on equipping the geothermal unit with experienced and trained staff for all the geotechnical disciplines and drilling processes. The geothermal projects are managed by this unit in their entirety through all steps. Additionally, KenGen hires consultants where specialized capacity does not exist within the company, for example for peer review, feasibility studies and supervision of the power plant construction (Ngugi, 2008).

Geothermal development in Kenya is increasingly becoming regulated and regularized by a more complex legislative framework governed by several national laws. Moreover, these projects are subject to the administrative conditions set by funding institutions. Consequently, a greater focus on project management to meet emerging technological, financial, administrative and legal project requirements is increasingly becoming an urgent need for the success of geothermal projects in Kenya (Ngugi, 2008). The main complexities identified with geothermal projects in Kenya are related to resource exploration and assessment, long development periods, high upfront capital requirements and inability to secure long-term and sustainable development funds, socio-economic and land access issues and environmental conservation (Ngugi, 2008). These intrinsic complexities further justify the importance of effective project management in geothermal projects.

2.2 The fundamentals of project planning in geothermal energy projects

It is important to first discuss the relevance of the differences between a project plan and a project management plan. According to ISO 21500 guidance on project management, project plans normally consist of the project plan and the project management plan while the Project Management Institute (PMI) handbook, PM BOK 5th edition, makes no distinction between the two. The two plans are often combined into one document but may also be separate depending on the nature of the project. The most important requirement of the project plan is that it should reflect the integration of scope, time and cost among other important aspects. In cases that make the distinction between the two, the project management plan is a document or set of documents that defines how the project is undertaken, monitored and controlled. Broadly speaking the project plan therefore defines the "*what*" and related parts of the project while the management plan describes the "*how*". The project plan can be considered the visionary document to define the vision for successful completion of the project and the project management plan defines the system to be used to successfully achieve that vision. In the context of this study, the project plan will be a combination of the two and will provide guidelines for describing both the '*what*' and '*how*' factors of the exploration drilling project in Saint Lucia.

A project plan is understood to be a formal approved document used to broadly guide a project and facilitate communication among stakeholders. Project planning is important because it establishes what has to be done and smoothens the path to enable it to happen (Burke, 2004). An online project management application website, Sinnaps (2018), defines a project plan as "*A formal part of the project that is created by the project manager along with inputs from key stakeholders and team members. It is an approved document that serves as the roadmap for the project and defines the execution of the project and how it will be monitored and controlled"*. Important components of a project plan include a timeline and clear communication methods with stakeholders about the entire project across all its phases, including planning, execution, monitoring control, and closing (PMI, 2013). The project plan is identified as a means to provide a clearer understanding of the project scope and what it will take to reach project goals. The project plan also provides guidelines on how to approach the project. Through communication of the necessary project information to the project team, the project plan commits them to pledge their support. It further obliges the project manager and team to complete the project as planned since they are the ones who draw up these plans. On the contrary, a lack of planning and non-involvement in the planning process may result in misinterpretations, plans being ignored and therefore time delays, among other problems.

The project plan is also used to measure progress. This allows the project manager and team to ensure that they are keeping on track with schedule and are within budget. The plan can be considered an iterative process as it allows the project manager to make the necessary adjustments to the plan to correct any resulting deviations. While the first output of the planning process may be a high-level plan, updates should be made and communicated to appropriate stakeholders throughout the project. The plan is then progressively reworked into more detailed and tightly allocated packages of scope, budget, resource, schedule etc. (ISO 21500).

The standard approaches set by established project management institutions such as the PMI can be applied to geothermal energy projects despite the difficulties posed by its multi-phase nature. In a case study of planning geothermal projects in Central America, planning is identified as a powerful tool to ensure the success of geothermal projects. Geothermal projects consist of several stages and activities, each with its own unique risks and costs. The planning of geothermal projects should therefore take into account this multi-phase nature (Monterrosa, 2009).

To understand the complexity of geothermal projects and to further justify the importance of an effective project plan, it is useful to consider the phases of geothermal projects and the main project activities in each phase. The stage gate diagram for geothermal projects is shown as an example in Figure 1.

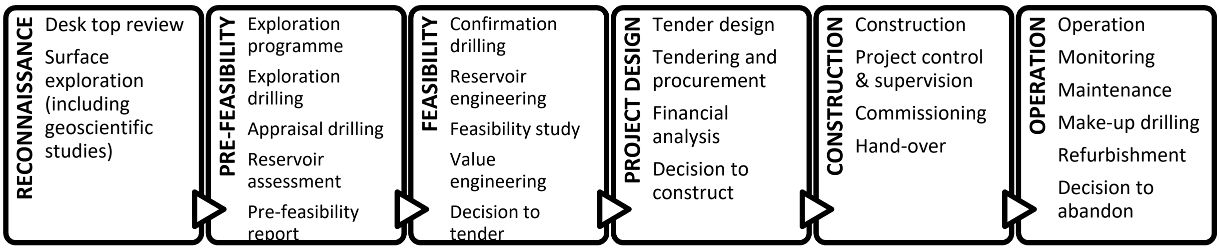

FIGURE 1: Stage gate diagram for geothermal projects (adapted from Pálsson, 2017a)

In geothermal projects, between 20-30% of the total project cost is expended before being able to take a decision on whether or not the field should be developed (Pálsson, 2017a). According to Pálsson, this makes proper project preparation and planning in a systematic and disciplined manner highly important to take the right decisions leading to minimum costs. The stage gate featured in Figure 1 is a slightly modified version of the formal stage gate process developed by Landsvirkjun – the Icelandic National Power Company, to ensure a systematic way of developing geothermal projects in an efficient manner and alludes to the necessity of a project management plan (Pálsson, 2017a).

Particular attention should be focussed on the planning of the drilling stages because drilling is one of the most critical parts of a geothermal project. Geological factors, drilling procurement and contracts are among the main factors, which have a significant impact on a geothermal project, particularly since drilling activities are concentrated within the earlier higher risk stages of the project. For example, it is estimated that between 50 and 70% of total project costs are due to drilling works. It is therefore important to focus on the planning of drilling works during the preparation of geothermal projects as it is one of the determining factors for the success of the project (Pálsson, 2017b). Experience from several geothermal projects shows that deviations occur, influencing the success of drilling projects, and causing them to depart from the critical path. The consequences of these deviations range from non-productive time to catastrophic wellbore failure or even loss of well control (Pritchard, 2011). This makes planning for all components of the project, including risk, crucial to project success. Moreover, due to the small scale of the Saint Lucia project, focus should be placed on proper project management and project planning in particular since there is no room for correcting major errors committed in the development of the possibly sole geothermal field.

2.3 Project plan overview

Recalling that this study will narrow in on the upcoming exploration drilling stage of the project, it is important to establish product specifications and project success definitions for exploration drilling as a sub-project. A generic definition of drilling success refers to the timely and cost-effective completion of fit-for use wells using the suitable and available technology in a safe manner (Okwiri, 2013). All planning guidelines will therefore be presented cognitive of these requirements.

The focus of the project plan in this study will lie in defining roles, responsibilities, organization and procedures for the management of risk, schedule, cost, communication, stakeholders and procurement. It will also focus on the establishment of baselines related to scope, quality, schedule, costs, resources and risks. The structure of the project management plan discussed in this study will therefore contain the components described briefly in the following sections. Descriptions are widely based on definitions given in both the PM BOK 5th edition and the ISO 21500 guidance on project management.

Project scope
The project scope can be thought of as a high-level description of what the project will tackle. It should cover the project objectives, goals, specifications, description and should state the main deliverables tied to the project. This element of the project management plan is essential to identify the reason for the project. In turn it gives the overall direction of the project. The excepted result of defining the project scope should be a scope management plan to manage and preserve the scope of the project by defining and controlling what is and is not included in the project. According to PMI, the scope management plan, a subsidiary of the project management plan also includes a work break-down structure (WBS). A WBS is essentially a deliverable-oriented hierarchical decomposition of the work to be executed by the project team to accomplish the project objectives (PMI, 2013).

Schedule
This component of the project plan allows the planning of the time element of the project. Time is one of the three major project constraints (the other two being cost and quality). A project is made up of tasks, each with a beginning and an end, and each task has a time element, which must be planned. Project completion is dependent upon deliverables, which are in turn dependent upon task completion, making time planning crucial.

Cost
Cost is one of the three constraints of projects and must be managed to ensure meeting project objectives. Cost is closely linked to project tasks and deliverables. The main purpose of planning this component of the project is to estimate costs and develop a budget, which is distributed to the various levels of the WBS. It also entails setting a framework for controlling costs during the execution of the project to ensure that the project is completed within budget. Planning the cost element of any project, and in particular the Saint Lucia geothermal project ensures that the project is effectively managed to the cost baseline and that cost variances are managed.

Stakeholders
Stakeholders are identified during the project initiation stage. During planning, a stakeholder management plan is created which describes the development of appropriate and effective strategies for engagement of stakeholders throughout the project life cycle. This component of a project plan is essential to manage stakeholder impacts on project success based on their needs and interests. It should result in a succinct actionable plan to interact with project stakeholders in order to support the project's interests.

Communication
The communications planning component is a process of developing an appropriate approach and plan for the timely collection, distribution, management and control of project information. Planning this project component is based on stakeholder's needs and requirements, and available organizational

assets. The purpose of planning communications is to determine and manage the information and communication needs of the stakeholders.

Risk
Risk can be either threats or opportunities, which can have either a negative or a positive effect on project constraints and objectives. Planning of risk entails identifying and analysing risks and planning for risk responses. A risk response plan is important to enhance opportunities and to reduce threats to project objectives. Stakeholders are an important aspect of risk identification and the stakeholder register developed during the previous project initiation stage should be an input to the planning for risks.

Procurement
Planning the procurement component of the project plan entails specifying the procurement approach, documenting project procurement decisions, and identifying potential sellers. The key benefit of its inclusion in the project plan is that it determines what support needs to be outsourced. It also gives a clear idea of how to acquire goods and services, how much is needed, and when to acquire it.

3. DEVELOPING THE PROJECT PLAN

3.1 Project context and environment

The distinct nature and unique conditions associated with the Saint Lucia geothermal project emphasizes the importance of the project management plan, as previously discussed. Firstly, this would be the first project of its type in Saint Lucia. Despite the long history and numerous efforts to explore the country's resources in the past, no geothermal field development has taken place. Secondly, due to the aforementioned approach of using public financing upstream, funding from non-private sources can cause an extended schedule, as decision making is invariably more time-consuming. This approach is quite different from countries such as Iceland and Kenya which have years of experience in geothermal development and it is therefore more critical to apply helpful project management processes such as planning.

The consequences of the small scale of the Saint Lucia project is the third premise for developing a comprehensive project management plan. With a peak demand of 61.7 MW in 2017 (LUCELEC, 2018), the electricity sector has a notable limited scale for power generation. Given this relatively small scale of the opportunity in Saint Lucia, potential private sector interest can be limited, making it difficult to attract experienced project developers in Saint Lucia, as evidenced by experiences in neighbouring islands. Moreover, the GoSL has limited experience with renewables and in attracting independent power producers (IPPs) to the sector. The fourth unique condition of this project which makes planning essential are the gaps in the institutional capacity for implementation, notwithstanding the fact that implementation institutional arrangements are presently being made. Lastly, the legal and regulatory framework is a very important consideration in the planning of the geothermal project. A revised version of the Electricity Supply Act, which governs the generation, transmission and distribution of electricity, allows for limited competition in renewable energy generation including geothermal power. This is in the context of the monopoly on generation held by the Utility Company, Saint Lucia Electricity Services, Ltd. (LUCELEC), prior to the revision of the act. Transmission and distribution of electricity remain solely under their responsibility. However, the specific legislation and regulations that govern the exploration for geothermal resources and the production of geothermal power have not been implemented. This is very critical to successful project planning as matters related to issuing development permits, concessions, etc., must be taken into account. This can severely affect time and schedule and ultimately the successful completion of the geothermal project. Apart from the aforementioned premises, the major risks which can be classified as environmental, social, or technical risks support the premises which justify the need for a comprehensive project management plan. Risk management as a key component to the project plan will be discussed in subsequent sections of this report.

Additionally, the business case for initiation of the geothermal project surrounds the economic feasibility of the development of the resource. Under the assumption that a commercially viable resource can be exploited to develop in the first instance a 15 MW geothermal plant, an economic analysis results in a positive net present value (NPV) of the total capital to the amount of USD 30 million and an internal rate of return on equity of 21%. A payback period of 15 years is estimated with an assumed PPA price of USD 0.15/kWh. A concessional loan with an interest rate of 3%, a discount rate of 6.0% and a loan maturity of 15 years were assumed. This suggests a very economically viable resource given the aforementioned assumptions, making the exploration drilling justifiable to confirm the resource.

3.2 Project scope

As already described in the previous section, the definition of the project scope should include a description of the result or service that the project seeks to bring about. The geothermal project in Saint Lucia can have a significant impact on the socio-economic setting and the environment and therefore the goals and objectives must be clearly stated during planning as quantifiable criteria for project success. Since geothermal projects are complex, long in duration and based on sequential phases, planning for scope management will prevent scope creep as the project proceeds. The project scope and its aforementioned elements form the foundation upon which the project will be built. A strong foundation is likely to result in a successful project. It is important to determine the deliverables of each of the stages listed in Figure 1. The interdependency of each stage on the previous is tied to the deliverables of each stage. Project completion and success are closely linked to the completion of deliverables. Therefore, deliverables of the project should be clearly defined during planning. For the drilling project in focus, drilling success for number of wells must be defined at this stage.

Project goals and objectives
Goals and objectives set boundaries for action within a project by providing a clear strategy. They also provide a framework for measuring an organization's performance and success in achieving clearly defined targets. The project goals are intrinsically linked to the products and deliverables. The end-result of a successful geothermal project in the Saint Lucia context is a functioning power plant completed within budget and schedule. Recalling that geothermal energy is a multi-stage development process, describing the end-products of each stage is also important. For example, the end-result of the exploration drilling project would be a firm decision on whether further investments should be made towards the development of the resource for power generation. The main goal would be to confirm whether the geothermal resource in Saint Lucia is suitable for electricity generation. However, the strategic objectives to which the entire geothermal project will contribute are listed below. The development of geothermal energy in Saint Lucia will:

- Contribute towards the fiscal sustainability of the island nation by providing lower and more stable electricity prices. This will in turn contribute to a more dynamic private sector as lower electricity prices translate to increased competitiveness.
- Reduce fossil fuel imports thus enhancing climate resilience through lower probabilities of supply disruptions consequent upon adverse weather events.
- Increase energy security and independence.
- Enhance the regulatory and institutional environment for the introduction of indigenous renewable energy sources into the energy mix in general.

More detailed and specific objectives should also be determined during planning. Product specifications should be incorporated into determining the specific objectives. Targets, years and capacity of the power plant should all be included as objectives. This not only enables the project team to determine what needs to be done but also gives insight into how it should be done. As an example, the specific objectives for the Saint Lucia Geothermal Development Project can include, but are not limited to the following:

- To carry out a detailed exploration of the geothermal field to confirm the existence and extent of a geothermal reservoir through the drilling of 3-4 slim holes in three different community locations.

- To develop a 15-30 MW geothermal power plant with a phased approach by 2023.
- To contribute to Saint Lucia meeting its NDC commitment of generating 35% of the island's electricity from renewable energy.
- To develop a legal framework which supports the continued incorporation of IPPs in Saint Lucia.

Work breakdown structure (WBS)
The WBS is a subdivision of the major project deliverables and project work into smaller, more manageable components. The resulting lower level work packages in the hierarchy become input into several other planning processes such as resource, time, cost and risk planning. These work packages can be cost estimated, scheduled, monitored and controlled. The WBS makes risk more identifiable and manageable.

In complex projects such as geothermal projects, converting items, which are complex to manage into a set of smaller more manageable and simpler activities can contribute to a higher level of project success. This set of simple tasks can achieve the project goals when combined. It is suggested that the WBS for the Saint Lucia project is elaborated for each stage of the project. A starting point is to identify summary tasks, which are a summarization of the subordinate work packages. Summary tasks are not on their own, they are accompanied by executed tasks. They are then broken down into work packages, which contain the actual tasks to be performed. Using a WBS code system, a unique number can be assigned to each deliverable and/or task in the WBS as seen in Table 1 in Appendix II, which is a high-level example of a WBS for the *Saint Lucia Geothermal Exploration Drilling Project*. Various layouts may also be used to present a WBS, including the tabular format and tree structure.

3.3 Schedule

Planning the time component is necessary to guide the management of the timely completion of the project. Project tasks are limited by the time constraints of their goals or deliverables. Therefore, as the time element is planned in iterations, it will be possible to improve time assumptions. There are many methods of determining a schedule for projects during planning. Estimating activity duration is one of the most popular methods. Decomposing the deliverables or work packages at the lowest level of the WBS into more detailed activities allows the scheduling of these activities in a way that ensures that the project objectives are met. It may increase the degree of confidence of estimates. Once all identified, these activities should be sequenced since all activities have an intrinsic logical relationship with its predecessor or successor. Lead times and lag times should also be considered when determining dependencies between activities. The main objective is to get a realistic estimate of the time involved in the project, which is a major input into the process of developing the schedule.

Bottom-up estimating of project duration, the most common tool used in project scheduling, entails aggregating the estimates of the components of the lower-levels of the WBS. The key benefit of this process is that it provides the amount of time each activity will take to be completed. To improve duration estimates additional tools include expert judgement and historical data or experiences from former projects (PMI, 2013).

For complex projects such as geothermal projects, it is important to consider particularities when estimating durations. Some important considerations include geographical, political, environmental and even social reserves. For example, the duration of drilling activities in geothermal projects in Iceland compared to the Saint Lucia project could be significantly different due to mobilization of drill rigs and materials. Specific processes such as permits and other official approvals differ widely across different countries and must be taken into account when estimating durations. This also requires input from the risk component of the plan, which will assist in determining cases in which estimates should be base according to risk mitigation actions.

Project schedules can be elaborated using various scheduling tools, one of which is the popular and effective Gantt chart. This tool can also allow one to see the interdependencies of different activities. An example of a Gantt chart developed for the drilling project is shown in Figure 1 in Appendix II of this report.

3.4 Cost

When planning for costs, similarly to planning the time component, estimating is the technique used to arrive at an established authorized cost baseline. This planning process includes the approximation of the monetary resources needed to complete the project activities. These estimated costs of the individual work packages are then aggregated to establish a cost baseline. It is important to refine and update the estimates throughout the project life cycle. Accuracy is expected to increase as the project advances. Estimated costs charged to the entire project are built up from the costs for all resources that will be used to complete the project. These include costs for equipment, services, labour, and materials among others. Special categories such as inflation, cost of financing, and discount rates should also be taken into account when planning costs.

A detailed cost estimate at the planning stage for exploration drilling, in the absence of specific details on well locations and related quotations for more critical items, can yield unreliable estimates. Large discrepancies may occur based on rig costs, labour costs and access roads, among other items. According to the *Geothermal Handbook Planning and Financing Power Generation Report*, slim hole drilling incurs a cost of between USD 0.5 and 1.5 million (Gehringer and Loksha, 2012). This cost depends largely on particular details such as location, depth of drilling and even contract types. The 2017 pre-feasibility study for the proposed geothermal project in Saint Lucia confirms the possible discrepancies in estimated costs for drilling, but has provided a reasonable estimate of USD 2 million for each slim hole considering a total drilling depth of 2 km. Despite these risks associated with planning the cost component, a general cost estimate is useful for initial budgeting purposes. As planning becomes more detailed, a cost analysis can help to better understand where certain local costs may be significantly different from that expected. There the cost component must be progressively updated and should include cost impacts of risk mitigation plans. In consideration of this, each slim well was estimated at USD 3 million for the sample plan elaborated in this study. Other major items considered in the cost estimate were the work packages and activities established in the WBS as discussed previously. Additional overhead costs, licensing, financing management fees, contract management fees, public awareness and contingency allocations were included. The latter is particularly important as a buffer and to ensure successful project implementation within budget despite the high risk of this project. Table 3 in Appendix II shows a sample high-level costs estimate elaborated according to level two of the WBS and considering the additional aforementioned items.

3.5 Stakeholders

Stakeholders, also referred to as interested parties, are essential to project success. Project management success is determined by the appreciation of the project management results by relevant stakeholders. This makes the identification of individuals, groups or organizations that could impact or be impacted by a project outcome a very important aspect of project planning. Their influence, interest and dependencies must be documented and managed resulting in the major benefit of early identification of the appropriate focus for each group of stakeholders.

Identifying the role of stakeholders begins with their classification according to the level of involvement in the project or relationship with the organization. Therefore, stakeholders can be classified as primary or secondary, and external or internal. Primary stakeholders are usually those most directly involved in the project, for example the project team and sponsor. Secondary stakeholders are less obvious and are not directly involved in the project but can influence and can be influenced by the project. External stakeholders are usually those outside the project organizational structure, while those within, including the sponsor and clients are considered internal stakeholders.

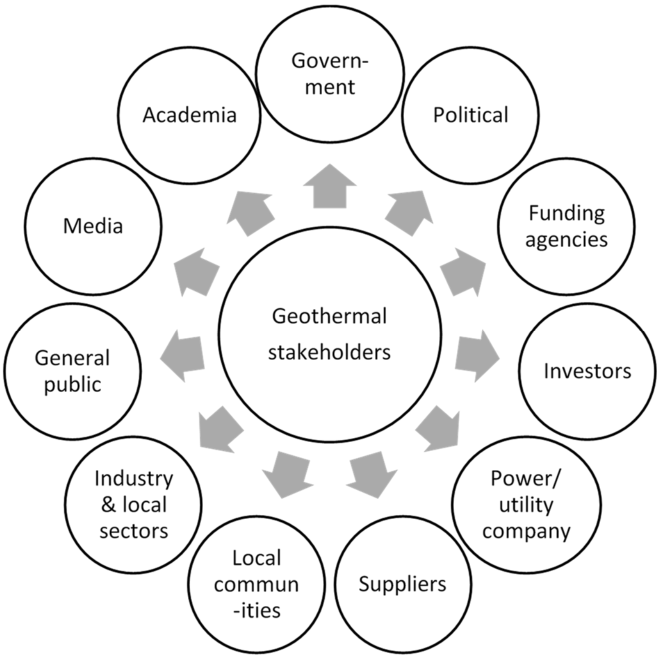

FIGURE 2: Stakeholder categories in the Saint Lucia geothermal project

As uncertainty comes in the form of both threats and opportunities, stakeholder identification can also lead to identifying potential supporters of geothermal power generation and garner a sense of workforce potential, in the Saint Lucia context. One such example is the opportunity for stakeholders in the services and agricultural sector to benefit from direct utilization of geothermal energy; an option that has not been considered for the island yet. In general, the most important categories of stakeholders in geothermal energy projects (and tailored to the Saint Lucia context) can be classified as shown in Figure 2. They are further discussed briefly below.

Government institutions

Government institutions and departments are key stakeholders in the Saint Lucia geothermal project. Some are primary and internal project stakeholders, for example the Ministry with responsibility for Energy and Public Utilities (Ministry of Infrastructure, Ports, Energy and Labour). Others may be considered as secondary and external stakeholders. They include but are not limited to the ministries with responsibility for development planning approval, land-use, agriculture, water resource management, tourism, economic development and labour.

Political stakeholders

While this grouping of stakeholders may overlap with government institutions, there are very important distinctions. Political interest in geothermal projects varies widely across countries and political systems. The long lifecycle of geothermal projects has already been mentioned several times as an important reason for effective project management. Therefore, an associated risk factor is the 5-year office term of government administrations between successive elections. This could be a major risk if political interests in the geothermal project vary widely from one administration to another. In Saint Lucia, like in any other country, geothermal energy is on the political agenda because of its long-term potential. If geothermal projects are in an advanced stage, it is unlikely that they are removed from political agendas. The latter is not the case of Saint Lucia, because the project remains in the high-risk pre-feasibility stage. At first glance without a systematic stakeholder assessment, it can be gleaned that the political stakeholders in Saint Lucia are therefore critical to project success. Drawing from the experiences of other countries, geothermal "champions" have been effective in developing geothermal energy. These champions are usually political champions who put or keep geothermal energy on the agenda (Minder and Siddiqi, 2013). It is therefore important to consider both the incumbent and opposition parties as important stakeholders, whose interests should be managed.

Funding agencies

These stakeholders are among the most important stakeholders or interested parties for this project, particularly because of its approach in using public financing in the higher risk stages, as previously discussed. According to the ICB - IPMA Competence Baseline Version 3.0 booklet, "*Project management success is the appreciation of the project management results by the relevant interested* *parties*". Funding agencies are key interested parties and this statement largely applies to them as stakeholders. These agencies have specific guidelines and requirements which must be met by recipient countries or agencies. In the case of Saint Lucia, the World Bank provides transaction, project management and regulatory support in this upstream development stage of the project. The bank is therefore a major primary stakeholder in this project.

Investors & developers
With the approach decided upon by the GoSL, it is important to begin early with the engagement of investors and reputable developers despite their later entry into the project at the downstream phases. Particular attention needs to be placed on attracting investors in this particular project in light of the possible effects of this small amount of power according to the island´s electricity demand. This group of stakeholders would have to be subjected to meeting legal and regulatory requirements related to geothermal power production. One such example is their close involvement in the PPA process. However, at this stage in the project the role or requirements of investors and developers are limited.

Utility company
The sole utility company, LUCELEC, which provides transmission and distribution of electricity services to the Saint Lucian public is a key stakeholder in this project. Uptake of the electricity produced from a geothermal power plant must be guaranteed to justify the business case for developing the resource. LUCELEC is the only possible customer for the electricity produced. Therefore, PPA negotiations are inevitable, should the resource be confirmed as commercially viable and LUCELEC is a key party in these negotiations. The agreed price is significant in determining the economic viability of the project. The importance of LUCELEC as an interested party also lies in its role as the main generator of electricity and its integrated resource planning of the future mix of technologies to meet the current 61.7 MW peak demand on the island. Therefore, early engagement with LUCELEC is very important.

Suppliers
Suppliers refer not only to providers of goods but also services. Therefore, this includes consultants and specialists who may be part of the project throughout its lifecycle. Saint Lucia does not have a cadre of trained professionals in the area of geothermal energy and therefore it is anticipated that services will have to be sought from the international market. One such example is the contracting of an ´exploration management contractor (EMC)´ who will be hired to conduct the exploration drilling programme. This would require a contract with the EMC for fulfilment of the works. Also bearing in mind that many suppliers of products and services related to geothermal energy drilling are based out of the island, this stakeholder group must be specially considered in the communication plan.

Local communities
These refer to communities which are located in or near the project areas or may be affected by access to the project site. Three communities have been identified under the current project design based on the location for the drilling of slim wells. They include Belle Plaine, Fond St. Jacques, and Mondesir-Saltibus. Community members in these areas could benefit and/or be affected by project constraints and therefore engagement with them must be planned and included in a stakeholder management plan. High priority should be placed on landowners with whom any agreement needs to be entered for the attainment of land areas within the project locations. Previous community engagement activities related to the development of the geothermal resource has recorded some concerns by members of the local communities. For this reason, they remain key interested parties and can influence the success of the project.

Industry and local sectors
While focus has been placed on the exploitation of the geothermal for electricity generation, no consideration has been given to the direct use of the resource. Experiences from other countries suggest that geothermal energy is increasingly being used for direct utilization applications. These include agricultural and recreational applications such as greenhouses and bathing, among others. Direct

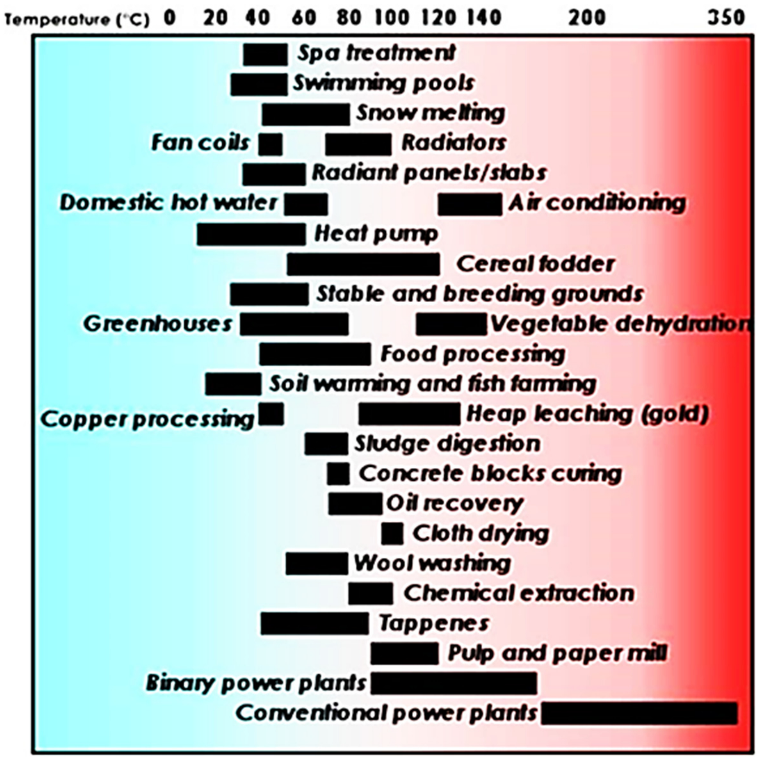

FIGURE 3: Lindal diagram (Kwaya et al., 2016)

utilization is widely used for space and water district heating in temperate countries and this would not apply to the Caribbean region. However, geothermal energy direct use can be applied to several other applications. Figure 3 shows the Lindal diagram which can be broadly defined as a proposed diagram of geothermal energy use with different fluid temperatures. The diagram shows the different applications of geothermal fluids according to specific temperatures. Some apply to Saint Lucia and are related to the agriculture, tourism, fishing, wastewater, and construction sectors and sub-sectors. However, these possibilities can only be explored when more information about the nature of the resource is made available through exploration drilling activities. The aforementioned stakeholders consequently have a limited interest at this point in the project.

Furthermore, hoteliers and other related service providers in the tourism sector are affected by volatile and comparatively high electricity prices, making the tourism sector a future beneficiary in the event of a successful power plant project. The project location is within a touristic area and provides a second basis for identifying the sector as a stakeholder because this group takes an active interest in the project execution and outcomes.

General public

The geothermal project is being funded using public financing in the upstream phase, therefore it is of national interest. Additionally, the anticipated benefits of enjoying lower and more stable electricity prices make the general populace key stakeholders. Moreover, political influence on the citizens must be managed by proper information dissemination to the public. This is especially important against the backdrop of the political risks which could become associated with the project.

Media

Dissemination of the correct information is of extreme importance to geothermal projects. Members of the media can be influential when sharing the information, in particular controversial project subject matters, since they interface directly with the public. Media is also important for recruitment of labour and to facilitate procurement processes. Local radio and television stations in Saint Lucia have conventionally been very involved in such national projects and are important in getting the correct information to both community members of project areas and the general public. Historically, talk shows have also been used to engage the Saint Lucian public on the geothermal project. In particular, it is noted that some media companies have a larger followership. Some media personalities are very influential and their views can sway the views of the public and therefore affect the support and acceptance of the project. It is therefore very important to apprise media personalities on certain aspects of the projects and major milestones in particular. Engagement with the media is also very important at the stage gates between project phases.

Academia
This group of interested parties should be considered and can most likely be linked to opportunities presented by the project for capacity building of its members. This is not limited to Saint Lucia since the island does currently not have a range of university institutions or geothermal training institutions. The Sir Arthur Lewis Community College, a tertiary education institution, is an intermediary step between secondary education and university education for many Saint Lucian students. Including this institution in the communication plan for this project could generate interest among aspiring university students to further studies in subject areas related to geothermal energy, thus building capacity at a national level.

Other stakeholders
Similar to Japan, the location of part of the geothermal resource coincides with a UNESCO world heritage site. Careful development of the geothermal resource for electricity and other uses must therefore be ensured, as it is desired by the government that the heritage status is not threatened by the development. In light of this, other organizations have an interest in the project. For example, the Saint Lucia National Trust is a conventionally active organisation concerned with the preservation of the island´s heritage. Another such organisation is the Soufriere Development Foundation and the Soufriere Marine Management Association. Other stakeholders may include other professional associations associated with the project, labour unions and prospective employees.

Prioritising stakeholders by risk
Apart from stakeholder identification, planning for the stakeholder component should also include prioritising the stakeholders and their interests and developing a strategy to cope with their requirements and interests. One important basis for applying this to a project plan for the Saint Lucia project is the scarcity of resources to communicate all information to all stakeholders. Prioritizing the stakeholders by risk enables the project team to focus the resources on communication with higher risk stakeholders. When identifying stakeholders and rating their level of impact and involvement in the project, the use of a tool that comprises a rating scale should be used. One example of a simple tool uses the assignment of a score for the possibility of involvement and for impact on the project. The product of the two is calculated. Both involvement and impact can be assigned a number scale for example from 1 to 5, with 5 being the highest level of involvement and highest level of impact on the project. This would make the maximum score 25 and the minimum score 1. It is important to establish a definition for each value within the scale to make it more objective when administered by the project team. For example, a score of 1 for the possibility of involvement can be defined as '*less than 10% involvement throughout the project lifecycle*' and a score of 5 for the impact can be defined as '*the stakeholder´s role and actions can cause project termination*'. Table 1 shows an example of this ranking. A more detailed example is presented in the sample project plan in Appendix II. When completed for all stakeholders, this tool results in a ranking of the stakeholders by project risk.

TABLE 1: Example of a tool for ranking stakeholders by risk

Stakeholder	**Possibility of involvement (A = 1-5)**	**Impact on project (B = 1-5)**	**Score A×B**
National government	5	5	25
Academia	1	2	2

Planning the stakeholder component of the project is also closely knit with the communication plan. This feeds into the communication plan which will outline when and how project information is shared with key stakeholders. Documenting the needs and expectations of the stakeholders is also an important planning task. The relationship between risk management and stakeholder management is clear. Stakeholder engagement can lower risk and also provide opportunities. It is consequently important to identify all links.

3.6 Communication

Planning for the communication component of a project cannot be done in isolation from the other components of the plan. For example, stakeholder planning is closely linked to communication planning. As mentioned in previous sections, the needs and methods of communication with stakeholders, and in particular high interest stakeholders, must be included in the communication plan. The process of developing an appropriate approach and plan for project communications is also based on available organizational assets. The communication plan should reflect timely and appropriate collection, distribution, storage and disposition of project information (PMI, 2013).

Project management consists largely of communication among team members and both external and internal project stakeholders. Effective communication is important in diminishing the gaps in expertise as well as cultural and organizational backgrounds that may exist among diverse stakeholders. Communication planning is also important to manage different perspectives and interests of the stakeholders which would influence the project execution or outcome.

The communications planning process entails defining the type of information that must be delivered, who it will be delivered to, the format for delivery, and the timing and frequency of its dissemination. It is estimated that 90% of a project manager's job is spent on communication so it is important that information is shared with the right people at the right time (Watt, 2014). This is very applicable to complex and high-risk projects such as geothermal energy projects. The risk of insufficient communication planning could result in failure to accomplish key project objectives, duplication of effort, and reduced stakeholder confidence.

The first step in defining the communication plan is conducting a communications requirements analysis to determine what kind of communication your stakeholders need from the project to enable them to make good decisions. The geothermal project is expected to produce a large volume of information and the requirements analysis will assist in avoiding overwhelming stakeholders with unnecessary information. Other considerations in elaborating the communication plan include communication technology, models and methods. The communication vehicles should be specified according to groups of stakeholders and the type of information which will be shared with them. Special attention should be given to planning of meetings with the project team and stakeholders throughout the project. To accomplish this a project stakeholder analysis is first completed (Table 2 in Appendix II). A communication matrix is then elaborated. The matrix outlines details regarding the communication activities that are used during the course of the project. It is developed jointly and maintained by the project manager and the integrated project team. Planning the communication component can be done at each phase or can be further detailed and planned around each project milestone. A sample of the communication component of the project plan can be found in Tables 4 and 5 in Appendix II.

3.7 Risk

Risk management

Although not a panacea for project success, risk management as a part of any project is a key factor for meeting project goals and specifications within budget and on time. Planning for the risk component of a project involves defining how risk management activities will be structured and performed and outlining the tools and approaches. Noteworthy, is the interdependency between risk and other components of the project plan. For example, the cost, schedule, procurement, stakeholders, communication and scope components of the project plans, among others, are inputs to the risk planning process. Therefore, risk management is an iterative process and though defined in the planning stage of a project it should be updated throughout the lifecycle of the project. Once risk management is planned, the results are also used to update the other aforementioned components of the plan. For example, risk management activities should be reflected in the project schedule and budget. A risk management plan entails the processes of risk identification, risk analyses, and risk response planning.

Risk identification
The purpose of the process of identifying is to determine potential risk events and their characteristics that may positively or negatively affect project objectives. This process is a frequentative one since identified risks may change or new risks may arise as the project progresses throughout its lifecycle. Risks can be classified as either threats or opportunities. Threats bear a negative impact on the project and opportunities bear a positive impact on the project. Identifying risks should involve various participants, including the project manager and team, project owner, project sponsor, project product or services users, risk management experts, and subject matter experts (ISO 21500). By identifying the risks and determining their characteristics, the project team is equipped to anticipate events that may affect the project outcomes. Risk identification is a predecessor to performing risk analyses in order to prioritise the risks based on their importance by assessing and combining their probability of occurrence and impact (PMI, 2013).

Risk analysis
The process of ´Risk analysis´ examines and measures the effect of the identified risks in terms of probability of occurrence and level of impact on the project. Analysing the risks is also necessary for prioritizing the risks for further action. Risk analyses can be performed through qualitative and quantitative methods. Quantitative risk assessment methods are generally laborious and complex and are based on numerical estimations to determine the probability and impact of risks. These methods require sophisticated software and experienced personnel. In the qualitative method, risks are ranked and organized according to their probability of occurrence and severity using a predefined scoring system. This ranking is then used to determine a risk response plan by determining what strategy should be applied to deal with each risk. A hybrid method of semi-quantitative risk characterisation can also be used in this process. It is described by FAO/WHO (2009) as a means to “provide an intermediary level between the textual evaluation of qualitative risk assessment and the numerical evaluation of quantitative risk assessment, by evaluating risks with a score.” This method avoids the vagueness which may result from a qualitative risk assessment while in tandem avoiding the complex mathematical treatments necessary with a qualitative assessment. For the purposes of this study, the latter method will be further expounded and used in the sample plan.

Parameters of the semi-quantitative analysis
Likelihood of occurrence or probability is one of two main parameters and gives the uncertainty dimension of the risk. It measures whether the risk is likely to occur. A broad range from impossibility to certainty is used as the standard of measurement. The definition of this range is project specific and varies from one project to another. Severity of risks is the other parameter used in this assessment and defines the magnitude of the effect and consequences, which the occurrence of the risk will have on the project. The risk ratings are calculated by finding the product of the two aforementioned parameters. Tables 2 and 3 show general probability and categories, respectively. These should be further defined according to the particular project.

TABLE 2: Example of probability categories

Scale value	**1**	**2**	**3**	**4**	**5**	**6**
Description	Very unlikely	Unlikely	Remote	Occasional	Likely	Very likely

TABLE 3: Example of scale for severity

Scale value	**1**	**2**	**3**	**4**
Description	Minor	Moderate	Critical	Catastrophic

Risk register and matrix
A systematic approach to planning the risk component of the project requires the use of a tool that serves as a risk register and permits the carrying out of the risk assessment as described above. The tool used

in this study also includes the defining of a suggested risk treatment plan for each risk, followed by a repeat of the qualitative risk analysis, giving a rating of a final residual risk.

A risk register facilitates the planning of risk management in an auditable manner allowing a sustainable process for updating throughout the project lifecycle. Risk registers may be constructed in many different formats and are customized to suit each individual project. Figure 4 shows an example of the risk register tool used in the sample project plan. The second column is characterised by a drop down menu for selection of the risk categories that will be described further in subsequent sections of this report. The third column requires the input of the risk description. The likelihood of occurrence and impact consequence of each risk are inputs into the next two columns. The scales of each as used in the sample plan for this study are subsequently described and defined. It is recommended that these ratings are decided upon within focus groups and should be based on opinions and experiences of industry experts. The risk priority ranking results in column 6 and is the combination of the likelihood and impact consequence (product of the two). In the next column, the risk treatment plan or strategy for each corresponding risk is recorded as determined by the risk assessment team. New likelihood and impact ratings are then reassigned taking into account the expected effect of the treatment. It is expected that these risk ratings are reduced, especially the likelihood of occurrence. This gives rise to the final risk ranking referred to as residual risk. Modifications to this tool may be used as the need arises and according to the information available. For example, the cost of risks and risk response actions may be included if available.

Risk No.	Risk Category	Risk and Description	Risk Chance Likelihood	Risk Impact Consequence	Risk Priority (initial)	Risk Treament	Risk Chance Likelihood	Risk Impact Consequence	Residual risk
1					0				0
2					0				0
3					0				0

FIGURE 4: Example of a risk register tool

The risk matrix shown in Figure 5 is the graphical representation of the ranking and prioritization of the risks identified and assessed in the risk table above. Risk matrixes are usually applied in decision-making to evaluate how much risk is acceptable and prioritize the risk according to which risks need to be addressed with urgency. A 6 × 4 matrix was used in this study as seen in Figure 5. The resulting ranking classifies the risks as high risk, critical risk, low risk or marginal.

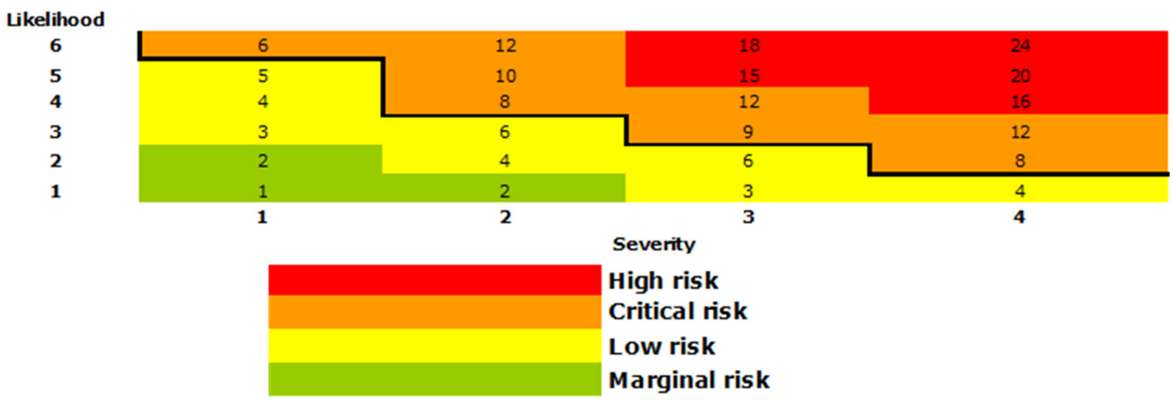

FIGURE 5: Risk matrix used in the sample plan

Risk in geothermal energy drilling projects

In the case of the Saint Lucia geothermal project a risk management plan should be completed at a high level for the entire lifecycle of the project. However, as done in this study, it is also important to focus on the risk plan for the up-coming pre-feasibility phase of the project which primarily entails exploration drilling. This stage of the geothermal project is reputed as being the highest risk and most capital-intensive stage of the project. This makes planning for the risk component of the project even more justifiable.

Risk associated with exploration drilling can be defined as the uncertainty associated with disruptions in the drilling project timeline, economic performance, project completion, environment, health safety and even professional reputation, that drilling challenges may cause (Okwiri, 2017). Effective risk management is therefore crucial in ensuring safe and timely delivery of geothermal projects within budget. This requires the application of specific risk mitigation strategies. Although the entire pre-feasibility phase of geothermal projects can be considered as one project, it is important to plan for risk management for each well. This is primarily because the experiences and lessons learned from one well can be inputs into the risk management process of subsequent wells.

Risk categories in geothermal drilling projects
Categorizing risk aids by generating a thorough risk register is crucial to avoid omissions of important risks. For geothermal projects in general and in the case of the Saint Lucia project, the following categories are suggested based on the country and project context:

- Resource and technical;
- Legislative;
- Financial or economical;
- Organizational, administrative or project management;
- Political;
- Health and safety; and
- Environmental and social.

Resource and technical risks
Resource risks make geothermal projects unique from other power projects. Other risks are generally considered standard and well known (Ngugi, 2014). Therefore, addressing these risks is done by using standard risk mitigation procedures. The characteristics of each geothermal field are unique. The characteristics of the geothermal reservoir in the Saint Lucia remain obscure despite surface exploration studies. While the resource risks persist throughout the lifetime of the project, the uncertainty of the existence and/or nature of the resource is at its highest during the pre-feasibility or exploration drilling stage of the project. The resource risk can be related to the existence, size, physical and chemical characteristics of the resource.

Technical risks form another category of risks which frequently affect geothermal drilling projects. These risks mainly refer to the integrity and conditions associated with the geological formation and the supply, delivery, and use of equipment and materials. According to Okiwri (2017), the occurrence of risks in this category often results in a ripple or domino effect if not adequately handled. This reiterates the importance of planning the risk component to sufficiently manage risks throughout the project.

Apart from the literature consulted, the experiences of previous exploration drilling projects in Saint Lucia point to the occurrence of technical risks mainly. One such example is the historic drilling of the two deep wells, one of which produced corrosive steam with a high gas content. The other was non-productive. The pre-feasibility study completed in 2017 points to a number of uncertainties in the resource, including the hypothesis surrounding the modelled resistivity structure. The study notes that other hypotheses could explain the model and that several features argue against the inferences made thus far. Frequently occurring resource and technical risks in geothermal drilling projects can be further categorised as geological risks, casing and cementing, equipment and tools challenges, drilling materials and consumables, force majeure and well success.

Legal risks
Various legal risks could affect a geothermal drilling project. However, at this stage in the Saint Lucia project not many legal risks are anticipated since it is mainly exploration drilling. However, common legal risks involve the breaching of contracts and changes in law, among others.

Financial and economic risk
Financial and economic risks in exploration drilling are closely tied to the duration of the drilling

activities and the risks involved in the process. Additionally, few may be attributed to interactions with financiers. Consequently, many drilling projects experience cost overruns. Some items under this risk category which may apply to the Saint Lucia project include the high cost of drilling, fluctuations in interest and exchange rates, delays in disbursement of funds from financiers and unforeseen changes in bank regulations and formalities. Noteworthy is the approach used by the GoSL to access concessional financing to help in making the project attractive for further financing.

Organizational, administrative or project management risk
Constant changes within or outside of organizations and project teams have the potential to affect projects. Some items under this category of risks include complicated bureaucratic requirements, sudden changes in governmental regulations, unfounded or politically influenced project management decisions, insufficient focus and attention to project needs, ambiguous contract specifications, insufficient expertise and capacity in workforce.

Political risks
The economic lifetime of a geothermal project is 25 years on average. Throughout this period, changes in government administrations can pose risks to the success of the overall project. However, this is not a risk for the current exploration drilling project in Saint Lucia. Some commonly occurring risk items in this category include insufficient budgetary allocations, fluctuations in costs due to changes in government policies and complex procurement policies, losses due to bureaucracy and late approvals.

Health and safety risks
These refer to risks that impact personnel, property and the environment of operation. Geothermal drilling can result in several hazards which can potentially cause harm to both personnel and property. Moreover, when these risks occur, they could result in irreversible damage and bad reputations for key interested parties. Some common examples include the release of toxic gases such as CO_2 and H_2S, severe noise pollution, improper use and malfunctioning of equipment, improper disposal of drilling cuttings, and thermal and chemical pollution.

Environmental and social risks
Geothermal energy projects in general can produce changes to people's way of life and standard of living. Physical environmental risks must be identified and mitigation planned in the planning stage of the project. Failure to do this effectively can result in delays in the project and in the most extreme cases it can cause termination of the project. Some common opportunities and threats under this category include capacity building and job creation, livelihood support and development, lowered cost of electricity and therefore improved standard of living, impacts on water supply, impacts on heritage sites, negative visual impacts on landscape, noise pollution, and seismic activity.

One particular risk that exists in the Saint Lucia project is the existence of the resource in or near protected or developmentally sensitive areas. This is however not unique to Saint Lucia and it is important to draw from the experiences of other countries. In Japan for example, several geothermal companies have been prevented from carrying out studies towards geothermal development in or near national parks. In Saint Lucia, surface manifestations and therefore part of the geothermal resource is predicted to exist within the Pitons Management Area (PMA). The PMA consists of the Sulphur Springs and two dramatic twin mountains, which are major tourist attractions and contributes significantly to the Saint Lucia economy through tourism. In 2004, the PMA was declared a World Heritage Site by United Nations Educational, Scientific and Cultural Organization (UNESCO). To ensure maintenance of this status, the GoSL established development limits and criteria for areas of the PMA by commissioning the 'Limits of Acceptable Change' (LAC) study. Consequently, some areas of the PMA fall within a classified 'Policy Area 2,' which are areas within which development is excluded and non-permissible to prevent environmental degradation. This limits further exploration within these areas and limits exploration drilling to areas outside of this area. Figure 2 in Appendix I shows the prospective drilling areas identified through surface reconnaissance studies in relation to the PMA. The risk of affecting the world heritage status or receiving opposition to the exploration drilling by related key interested parties must therefore be managed.

Constructing the risk management plan for the Saint Lucia project
For the purposes of this project, a sample risk plan was constructed. However, for a full risk management plan, all associated risks under each of the aforementioned categories should be listed and a short description provided for each. The scales used in this sample plan for the Saint Lucia exploration drilling project are described in Tables 4 and 5.

TABLE 4**:** Scale and description for likelihood of risk occurrence

Scale number	**Scale for likelihood**	**Description**
1	Very unlikely	Almost impossible that this event occurs during the pre-feasibility phase (exploration drilling phase)
2	Unlikely	Very rare, little chance that the event occurs during the pre-feasibility phase
3	Remote	Low probability that the event occurs during the pre-feasibility phase
4	Occasional	Event will probably occur during the prefeasibility phase
5	Likely/moderate	Event is likely to occur at least once during the pre-feasibility phase
6	Very likely/frequent	Event will occur more than once during the pre-feasibility phase

TABLE 5: Scale for impact consequence of risks

	1: Minor	**2: Moderate**	**3: Critical**	**4: Catastrophic**
Organizational, administrative or Project Management	Causes minor to no delays in project phase	Causes some delay in project phase	Causes major delays in project phase	Causes project termination
Political	Causes minor to no delays in proj. phase	Causes some delay in project phase	Causes major delays in project phase	Causes project termination
Legal	Leads to minor delays (no law suits probable)	Leads to some delays in comple-ting the exploration drilling programme (law suits unlikely)	Leads to major delays in comple-ting the exploration drilling programme (may inv. law suits)	Leads to premature project termination (law suits highly likely)
Technical	Leads to very few delays of short duration	Leads to a few delays of moderate duration	Leads to several and long delays and increase in budget	Leads to an abandoned drilling programme and resource commer-cial viability unconfirmed
Environmental	Minor damage within confined area	Temporary harm	Extensive damage, more limited area	Massive irreversible damage, wide area
Financial or economical	Less than 1% of capital cost involv.	1-5% of capital cost involved	5-10% of capital cost involved	More than 10% of capital cost involv.
Health and safety	Minor accident, no first aid required	First aid required Person not at work up to 1 week	External medical help. Person not at work up to 3 mo.	Fatal accident/ permanent incapacity
Social	< 10% of the population against the project. 10-30% of community members negatively affected by the proj.	10-30% of population against project. 10-30% of community members negatively affected by the proj.	About 50% of population against project. About 50% of community members negatively affected by the proj.	> 50% of population against project. > 50% of community members negatively affected by the proj.

Six risks were assessed for the Saint Lucia geothermal exploration drilling project in the sample plan. They include a resource project management, legal, environmental, organizational, administrative or project management risks. The resource risk is based on the low permeability reported in the results of the surface exploration studies. There is no guarantee that this will affect flow capacity of the wells in the exact areas chosen for drilling. However, it is anticipated with reasonable assurance that flow capacity of wells is largely related to the permeability. Therefore, a likelihood of 5 was chosen and a risk impact consequence of 3 chosen. The latter was chosen because the impact may mean that at least 1 out of 3 wells could be unproductive. This would affect the following phases of the project and may lead to more wells being required. The red coloured box indicates a high risk. The treatment plan suggested financial provisions for failed wells in the financial models to accommodate this risk. The effect which this mitigation action has is a reduction in the impact consequence. No change is anticipated with the likelihood of occurrence through this mitigation action.

A project management risk which could occur in this project is ambiguity in contract specifications. With the project management and transaction support from the World Bank, the likelihood of occurrence is, however, low. In addition, contract matters are being handled by the Project Coordinating Unit, a specialized and highly skilled unit within the GoSL. But the risk impact consequence is expected to be fairly high and can lead to several days of delay, and consequently an increase in budget. The combination of the likelihood and impact consequence results in a low risk to the project. As a mitigation action it is suggested that PCU and World Bank procedures are followed closely and that due diligence is exercised when contracts are being developed and negotiated. The residual risk remains low.

Loss of livelihoods, which falls under the category of environmental and social risks, is assessed as being a marginal risk to the exploration drilling project. The pre-feasibility and ESIA studies have both indicated the unlikelihood of disturbance to agricultural lands surrounding the targeted drilling areas. Therefore, as shown in the risk register table, both a low likelihood of occurrence of this risk and a low impact consequence result in a low risk priority. This risk is therefore not a priority for mitigation.

3.8 Procurement

There are different procurement strategies which may apply to geothermal drilling projects. In the Saint Lucia project context, it is understood that the role of the World Bank as transaction managers will influence the particulars of procurement. However, the works, services and materials that must be procured for exploration drilling are standard and do not vary widely from one project to another. They include procurement of engineering design (design of well and wellhead), civil works (roads and drilling platforms construction, water supply, cuttings handling among others), drilling services and works, drilling supervision, procurement of rig, crew and drilling tools, wellhead procurement and installation, mechanical works, casing pipes and equipment procurement, well logging services, casing installation, cementing, and mud logging a.o. (Pálsson, 2017a).

Regardless of the procurement policy associated with a geothermal drilling project, the aforementioned services and goods must be included in the procurement plan. In the case of the Saint Lucia project, it is understood that the GoSL plans to contract an Exploration Management Consultant (EMC) to carry out final planning, procurement, and overall day-to-day management of the exploration drilling programme. It is therefore assumed that the EMC will be responsible for procurement of the other individual works, goods, and services. This is a reasonable approach for the island given the lack of experience and capacity in geothermal energy.

4. PROJECT PLAN IMPLEMENTATION

4.1 Executing the plan

Once carefully planned, the project can move to the execution stage. This third phase (following initiation and planning) involves putting into action the project plan, which is essentially a roadmap for the execution team. It entails the performing of all processes necessary to fulfil the work defined in the project plan in a manner which meets the project specifications. Project execution widely involves integration of all project plan components through coordination of personnel and resources. One key activity in project implementation is the management of interested parties through the strategy described in the project plan. Most of the project's budget is expended during the implementation stage. Additionally, the relatively high-risk nature of geothermal exploration projects requires that, for the project to be successful, a well-constructed plan must be followed meticulously during project execution to increase the chances of project success. However, as the project is executed, it will become necessary to update both the project plan and the baselines set by it which may for example surface from unforeseen risks changes in resource availability. Detailed analyses of the arising deviations may be prescribed depending on their degree of impact. This would prompt the use of change management process towards seeking approval to modify the project plan and the baselines contained in it.

4.2 Monitoring and control

The project plan serves as an instrument of project monitoring and control. Monitoring and control processes are executed in order to measure project performance and other special events and conditions that experience, as a consequence, variances from the project plan. Monitoring processes involve progress tracking, reviewing and reporting to monitor the entire project effort carried out to meet project requirements identified during initiation and planning. A fundamental benefit of the monitoring is that it permits the understanding by key interested parties about the current state of the project and project forecasts. In particular, the scope, budget, and schedule are tracked and forecasted. Milestones set in the project plan are an important means of tracking and monitoring project progress, identifying areas in which changes are required (PMI, 2013).

The controlling of the project relates closely to responding to the identified areas of discrepancy and initiating the process for approved changes to steer the project back toward compliance of the project plan. It involves recommending changes to the project plan and subsequently securing their approval. This control process is defined more closely in an integrated change control process. Particular attention is placed on budget and schedule when monitoring and controlling a project.

4.3 Change control

Despite a risk assessment and mitigation plan, unanticipated risk events may surface during projects and in particular drilling projects especially given resource and technical risks. This is also linked to changes that may occur during the project. Change control procedures are therefore important and include steps by which standards, policies, plans and project documents are formally approved and validated (PMI, 2013). It is important that the change control process include the recording of change in a register. The changes should then be analysed by a cost-benefit approach. Other important parameters which should be considered include scope resources, quality and risk. The impact assessment helps to decide whether the change is modified, cancelled or approved. The decision of the approval process should be communicated to key project stakeholders.

4.4 Project performance measurement

A common and effective performance measurement technique used in project evaluation is earned value measurement techniques. Schedule and cost variances along with schedule and cost performance indices are common in earned value calculations. These techniques are useful for determining the degree variance as it relates to the cost and schedule baselines defined in the project plan. This provides insight into whether corrective or preventive action is required. Other variance analysis tools and techniques are also available for use in project monitoring and control processes.

5. CONCLUSIONS

Guidelines for developing a project plan for the exploration drilling project in Saint Lucia were developed in this study. The approach was centred on establishing the necessary steps by considering the different components that make up a comprehensive plan. These components included scope, cost, schedule, stakeholders, risk and procurement. While standardized methodologies were employed drawing from the expert views of international project management bodies such as PMI, the peculiarities of geothermal exploration drilling projects add some uniqueness. This is particularly the case for a small island like Saint Lucia considering its long history with geothermal resource development among other limitations and constraints. This study concludes that there are many areas which stand out and require special attention when planning this particular project. Worth mentioning is risk management, stakeholders, cost, and schedule planning. It is not guaranteed that a project plan is a panacea for success of the exploration drilling project. However, this study bears strong evidence that a well elaborated project plan will assist in meeting project objectives, prevent scope creep, cost over runs and detrimental delays. The study briefly pointed out the lessons learnt from past geothermal projects which suffered from inadequate planning, giving strong justifications for ensuring high levels of effort in planning prior to the execution of the exploration drilling project.

The project plan guidelines developed in this study will produce a road map for the execution of the project once followed. This would remove ambiguities in project execution and will set baselines for effective monitoring and control. The study also iterates the necessity to perform iterations on the project plan, updating it regularly as the project proceeds. The project plan is also found to be an important link between the project manager, the project team, project sponsor and project owner.

One main recommendation emanating from the study is the need to carefully build a team for the elaboration of the plan, including the governmental agencies, the World Bank and the utility company. Expert advice from the international geothermal stage should also be consulted to register all possible risks and approach a high level of estimations for cost and time. Outstanding leadership, ethics and openness should be applied during the project planning process in order to motivate team member to effectively share opinions, experiences and expert advice.

It is concluded that this study provides a foundation for building an effective project plan for the exploration drilling project, given the adequate tools and conditions. The components described in the study once integrated into a holistic plan will certainly enhance the project management efforts of this project.

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APPENDIX I: The active volcanic area and location maps

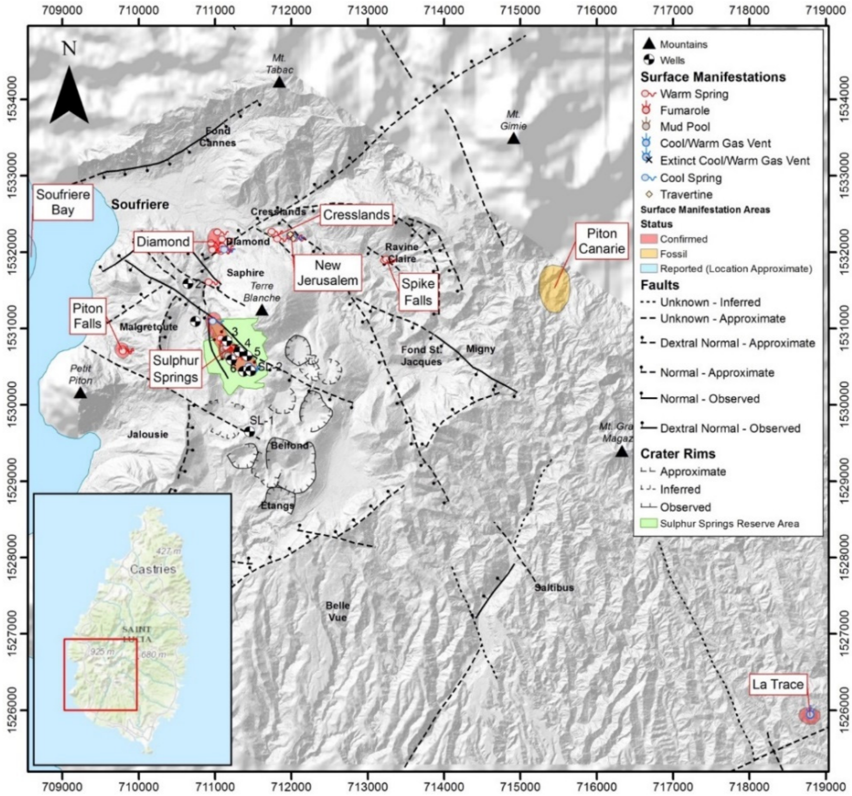

FIGURE 1: Location map showing wells, thermal manifestations, and faults within the volcanic area and Qualibou depression (GoSL, 2016)

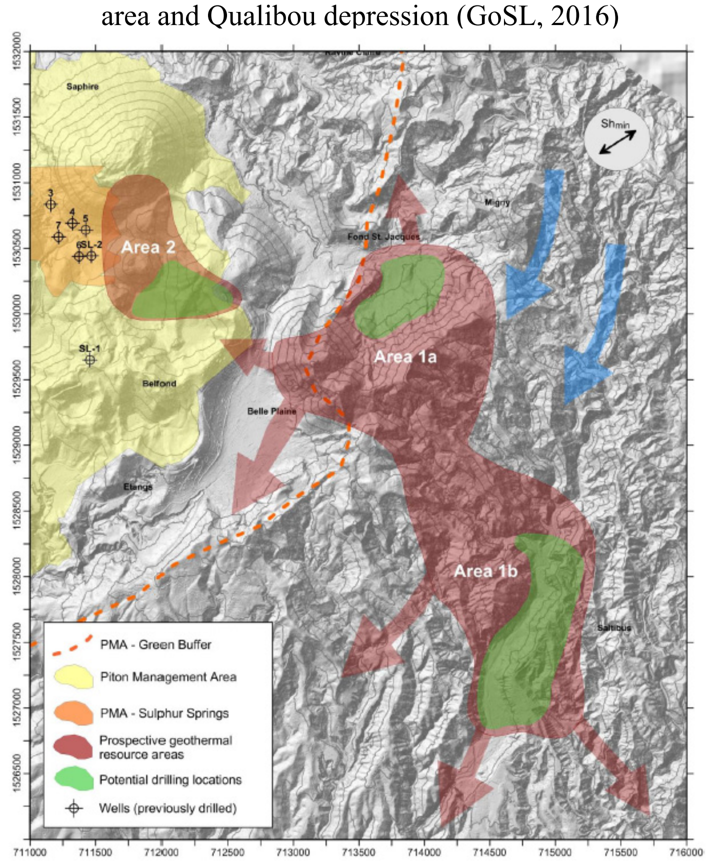

FIGURE 2: PMA and potential resource areas (GoSL, 2016)

APPENDIX II: Sample project plan for the Saint Lucia geothermal exploration drilling project

Project plan overview

Despite decades of intermittent geothermal exploration efforts, the commercial viability of the geothermal resource in Saint Lucia remains unconfirmed, for both applications of electricity generation and direct utilization. Surface exploration studies have been completed for the Saint Lucia project and the prefeasibility study confirms that sub-surface exploration is a reasonable next step. Therefore, this project plan plan will provide a definition of the exploration drilling project, or the prefeasibility phase as it is also known. The project plan will outline the following:

- Critical assumptions;
- Project goals and objectives;
- Project specifications;
- Project work plan;
- Project stakeholders;
- Project budget;
- Project schedule; and
- Project communication plan.

Critical assumptions

- The goals of the project support the vision and mission of the Ministry with responsibility for Energy, contributing in the long run to help Saint Lucia reach its energy targets, become energy independent and maintain a stable electricity grid.
- The data used in creating estimates are reasonable and historic and have been applied in similar jurisdictions.
- The necessary access to land required for the exploration drilling activities will be secured by the GoSL in a responsible manner within a reasonable time frame.
- Effective communication will exist between the project owner (GoSL), the project sponsor (the World Bank) and the project team. Adequate support will be rendered to the project team by the aforementioned interested parties.
- Geothermal energy as part of the future energy mix of Saint Lucia has been assessed and included in the 2018 endorsed National Energy Transition Strategy.
- The information provided by previous surface exploration surveys, pre-feasibility and environmental social impact assessments, have been accepted by the World Bank and the GoSL, with the assurance that exploration drilling is a reasonable next step.
- The outcome of this project will provide the GoSL with adequate and reliable information on the commercial viability of the geothermal resource to make a go, no-go decision to proceed to production drilling.

Project goals and objectives

The exploration drilling project is essentially one phase of the wider geothermal resource development project in Saint Lucia. It is impossible to predict if the project will advance through all phases to deliver a geothermal power plant without undertaking sub-surface testing. Therefore, the outcome of this exploration project will result in much value to the overall project as it removes uncertainty and allows energy planning to move forward at a more informed level. Nevertheless, in the event that a geothermal power plant is successful, the overarching strategic goals of the project owner and sponsor are as follows:

- Contribute towards the fiscal sustainability of the island nation by providing lower and more stable electricity prices. This will in turn contribute to a more dynamic private sector as lower electricity prices translate to increased competitiveness.
- Reduce fossil fuel imports thus enhancing climate resilience through lower probabilities of supply disruptions consequent upon adverse weather events.
- Increase energy security and independence.
- Enhance the regulatory and institutional environment for the introduction of indigenous renewable energy sources into the energy mix in general.

In order to fulfil the aforementioned strategic goals, the drilling project must be undertaken. Therefore, the specific objectives of the exploration drilling project are as follows:

- Adequately investigate, evaluate and compare multiple sites towards the selection of the most attractive options for proceeding with the resource development towards electricity generation.
- For each well, reliably measure temperatures to the full depth of the well, towards determining whether hydrothermal circulation is present.
- Collect information to determine the distribution and magnitude of permeable zones in the areas drilled.
- Collect other relevant technical data, including information on the lithology and hydrothermal alteration in each well.
- Perform well testing, including injection and production testing to evaluate subsurface conditions and reservoir properties.
- Use the well testing results to update the conceptual model.
- Determine whether an exploitable geothermal resource exists and if so to plan for further development.

Project specifications

This project is expected to deliver the drilling of 3 to 4 slim holes in the communities of Belle Plaine, Fond St. Jacques, and Mondesir-Saltibus each to a depth of 2000 m. Each drilled exploration well should be logged to obtain multiple temperature and pressure logs during and after well completion. Flow tests and basic injection tests should also be carried out. Production tests should be conducted in the event that a well is capable of production. It is estimated that the drilling of each well should be complete within 50 days. However, in this project plan, an additional contingency period of 10 days were considered per well, in response to initial risk management. Lastly, a full pre-feasibility report must be produced explaining the pertinent results of the drilling programme and should contain updated conceptual models. Cost analysis and pre-engineering designs must be included where applicable. The report should provide definitive recommendations for the next steps, i.e. it should indicate the feasibility of proceeding to the next stage of the project – production drilling.

Project work plan: Work Breakdown Structure (WBS)

The WBS for the prefeasibility, or exploration drilling project is shown in Table 1 below. Major work packages are further broken down into smaller work packages through 3 levels. It must be noted that the work packages in level 3 can be further broken down into activities.

TABLE 1: Work breakdown structure – WBS

<table>
<tr><th>Level 1</th><th>Level 2</th><th>Level 3</th></tr>
<tr><td rowspan="4">1. Pre-feasibility/exploration drilling</td><td>1.1 Drilling programme and procurement</td><td>1.1.1 Define the drilling programme
1.1.2 Define the drill rig specifications for the 3 sites
1.1.3 Tender and procure EMC
1.1.4 Tender and procure other services</td></tr>
<tr><td>1.2 Preparation work</td><td>1.2.1 Access roads
1.2.2 Build necessary infrastructure
1.2.3 Access to water supply</td></tr>
<tr><td>1.3 Owner’s representation on site</td><td>1.3.1 Liaise with drilling contractor
1.3.2 Liaise with geoscientists</td></tr>
<tr><td>1.4 Well 1</td><td>1.4.1 Site preparation I
1.4.2 Rig installation and set-up I
1.4.3 Drill slim hole I
1.4.4 Demobilization of drill rig and equipment I
1.4.5 Site restoration I</td></tr>
</table>

Level 1	Level 2	Level 3
	1.5 Well 2	1.5.1 Site preparation II 1.5.2 Rig installation and set-up II 1.5.3 Drill slim hole II 1.5.4 Demobilization of drill rig and equipment II 1.5.5 Site restoration II
	1.6 Well 3	1.6.1 Site preparation III 1.6.2 Rig installation and set-up III 1.6.3 Drill slim hole III 1.6.4 Demobilization of drill rig and equipment III 1.6.5 Site restoration III
	1.7 Well testing and reservoir assessment	1.7.1 Conduct (well)completion tests 1.7.2 Record and document results
	1.8 Pre-feasibility study report for power plant	1.8.1 Update conceptual model 1.8.2 Pre-engineering/Technical feasibility 1.8.3 Financial & Risk analysis 1.8.4 Income / Market assessment 1.8.5 Reasonable next steps

Project stakeholders

The following stakeholder groups (Table 2) are identified as the relevant stakeholders associated with the drilling project and will be affected by the constraints of the project or have the potential to affect the project outcomes. Each stakeholder group is assigned a risk rating in function of the possibility of involvement and impact on the project. According to this register, the most critical stakeholders include some government organizations, the World Bank, the suppliers, contractors and landowners. Attention is placed on these stakeholders in the communication component of this plan to ensure effective management of the stakeholder requirements.

TABLE 2: Stakeholder priority by risk register

Stakeholder group	Examples	Possibility of involvement (A = 1-5)	Impact on project (B = 1-5)	Score A×B
(Departments of) National Government	Energy and infrastructure	5	5	25
	Economic development	4	4	16
	Planning	2	4	8
	Tourism	1	2	2
	Piton management office	4	4	16
Political stakeholders	Imcumbent and opposition leaders	2	4	8
Funding agencies	World Bank	5	5	25
Investors	Preferred private developer	2	3	6
Utility company	Lucelec	2	2	4
Suppliers	Drilling contractor	5	5	25
	Drill rig supplier	4	5	20
Local communities	Land owners	4	5	20
	Farmers	3	4	12
	Schools	1	1	1
Tourism	Hoteliers and accommodation providers	1	2	2
	Tour operators	1	1	1
Regulatory bodies	National Utilities Regulatory Commission	2	2	4

Stakeholder group	Examples	Possibility of involvement (A = 1-5)	Impact on project (B = 1-5)	Score A×B
Interest groups/ organisations	St. Lucia National Trust	1	2	2
	Soufriere Development Foundation	3	3	9
	Soufriere Marine Management Agency	2	3	6
	Organisation of the Eastern Caribbean States (OECS)	1	2	2
General public		2	3	6
Media	Print and digital media	2	3	6
Academia	Potential university research students	2	2	4
	Sir Arthur Lewis Community College	2	2	4

Project budget
A project cost baseline is established through the estimation of cost breakdowns. The total estimated budget is 22.5 MUSD. The disaggregated costs according to work packages and which make up this amount are shown in Table 3 below.

TABLE 3: Cost breakdown

Item	MUSD
Drilling programme and procurement	0.5
Preparation work	1.5
Owner's representation on site	0.5
Well 1	3.5
Well 2	3.5
Well 3	3.5
Well testing and reservoir assessment	0.5
Pre-feasibility study report for power plant	1
Overhead costs	1
Licensing, financing and contract management fees	0.5
Public awareness	0.5
Contingency	6
Total cost estimate	**22.5**

Project schedule
The project timeline is done based on level 2 of the WBS (Figure 1). Estimated durations of these work packages are used in the elaboration of this WBS. It should be noted that a more detailed timeline can be constructed using level 3 work packages.

Project communication plan:
The objectives of the communication plan are to:

- Keep the project team and sponsor informed of project timelines, budget, and project requirements.
- Provide structured opportunities for feedback from project team, sponsors and other stakeholders.
- Provide accurate and regular information to the three relevant communities, including residents and businesses, throughout the project.
- Identify and address any stakeholder, community and industry concerns or opposition to the project.
- To mitigate resistance to the development of the geothermal resource from key stakeholders.

- Address the specific concerns of communities close to the project sites, addressing matters of access and environmental issues.
- To provide factual information towards fostering transparency and trust among parties.

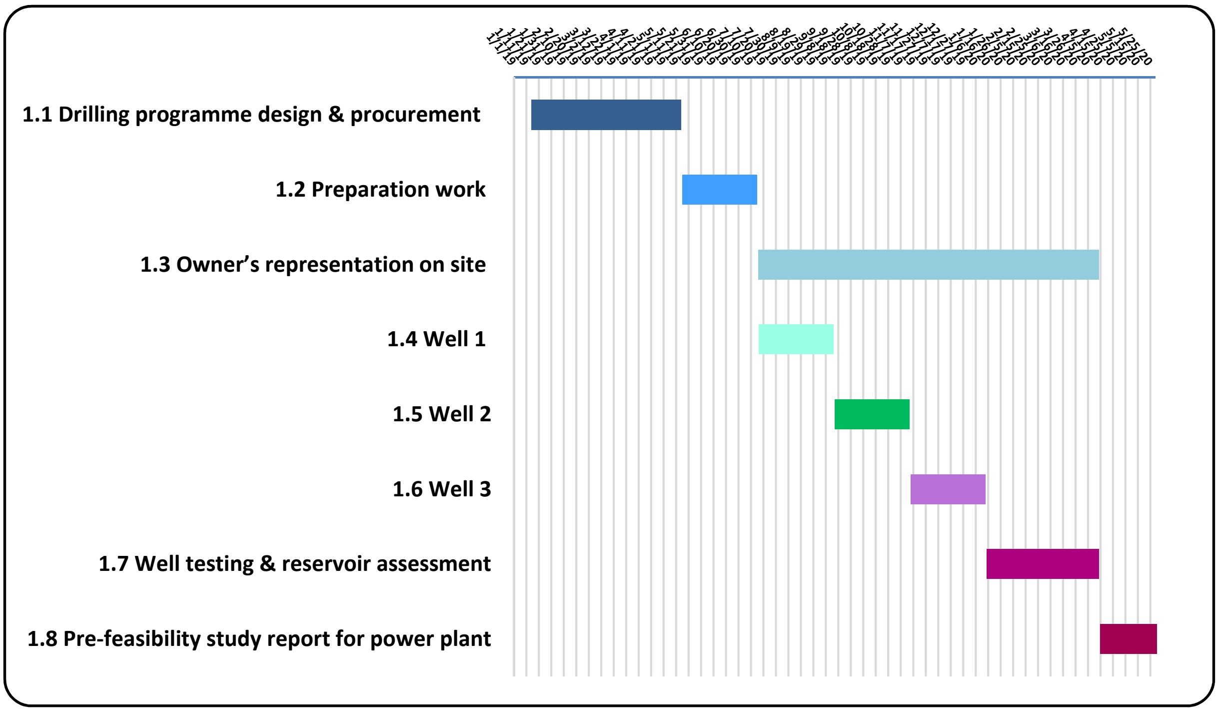

FIGURE 1: Project schedule

The communication strategy

The communication plan for the Saint Lucia geothermal project is elaborated in order to set goals and aims for the general communication of the project (Table 4). The main strategic direction of the communication plan is towards identification of stakeholder groups by their classifications as primary or secondary stakeholders, and specific communication goals for each group are determined. The strategy also describes the instruments, tools, resources and events that will be used in order to reach the communication objectives of the Saint Lucia geothermal project. A framework for measuring the impact and impact and effectiveness of the project's communication activities is also included. Lastly, the communication plan defines how to reach the target groups by specifying communication vehicles both according to communication activity and target stakeholders.

Dissemination of information for the project (Table 5) should firstly target the intended audience of the communication plan itself. That target audience should include the project team, the Ministry with responsibility for Energy as the implementing line ministry, the World Bank which offers transaction, and project management support to the project, and the Project Coordinating unit of the Ministry of Economic Development, which is presently responsible for procurement and transactional activities under the project. This audience should generally include any other stakeholders whose support is needed to carry out the Saint Lucia geothermal project. It is also intended that information dissemination under this project will target the media, environmental and other lobbying organizations, and the scientific community as an indirect means of reaching the general public.

TABLE 4: Stakeholder communication register

Stakeholder group	Contact name	Contact information	Communication vehicles	Feedback mechanisms	Comments
Internal stakeholders					
Ministry of Energy		Email address, Mailing address, Office location Telephone No.	Meetings, reports, emails, memos	Memos, meetings approval processes	
Ministry of Economic Development		Email address, Mailing address, Office location Telephone No.	Meetings, reports, emails, memos	Memos, meetings, approval processes	
World Bank		Email address, Mailing address, Office location Telephone No.	Meetings, reports, emails, memos	Feedback reports, meetings, approval processes	
LUCELEC		Email address, Mailing address, Office location Telephone No.	Meetings, reports, emails, memos	Meetings, emails, letters	
Developer			Meetings, reports, emails, memos	Meetings, emails, letters	
External stakeholders					
Ministry of Tourism		Mailing address, Email	Memos, meetings	Meetings	

TABLE 5: Information dissemination plan

Information	Target	Description purpose	Frequency	Owner	Distribution vehicle	Internal/ external	Comments
Status report	Project Sponsor	1-2 page summarizing project progress and deliverable status	Bi-weekly	Ministry of Energy (Geothermal Project Implementing Unit, PIU)	Email	Internal	Should be submitted ahead of bi-weekly meet-ings with all internal stake-holders.
Team Meeting	Internal stake-holders	A 1-2 hour long convening of project team and internal stakeholders to discuss project progress and deliverables status	Bi-weekly	Ministry of Energy	Meeting	Internal	-
Information booklets	General public		Bi-annually	Geothermal PIU	Print media, Social media	External	
Document-aries	General Public	Short informative and entertaining documentaries on the project, with a simplified technical information, and benefits of geothermal energy	Updated bi-annually Aired weekly	Geothermal PIU	Broadcast media, social media, internet	External	

Information	Target	Description purpose	Frequency	Owner	Distribution vehicle	Internal/ external	Comments
Community meetings	Local communities	2-3 hour long meetings within communities in or near project areas to discuss project status, address concerns and outline next steps	As required/ major milestones	Geothermal PIU	Community meetings	External	This is especially important at the stage gates of the project phases.

Risk plan

The sample risk assessment includes one risk from each risk category. The risk treatment plans are outlined and its impact on risk is assessed giving rise to a residual risk (see Figure 2).

Ref.	Risk Category	Risk and Description	Risk Chance Likelihood	Risk Impact	Risk Priority (initial)	Risk treament plan	Risk Owner	Risk Chance Likelihood	Risk Impact	Residual Risk
1	Resource	Non Flowing Wells	5	3	15	Provisions for failed wells in financial model	EMC, GoSL	5	2	10
2	Political	Political changes having an effect the exploration drilling project	1	3	3	Inclusion in stakeholder plan/Build awareness at the political level	EMC, GoSL	1	2	2
3	Organizational, Administrative or Project Management	Ambiguity in contract specifications	2	3	6	Refer to professional capacity of the Project Coordinating Unit (PCU) and continue to follow World Bank Procedures for contract finalizations	GoSL, EMC	1	3	3
4	Legal	Breach of contract	3	4	12	Ensure legal review of contracts before finalized	GoSL	1	4	4
5	Environmental & Social	Seismicity	2	3	6	Monitoring	GoSL, EMC	2	2	4
6	Environmental & Social	Loss of livelihoods	1	2	2	No major action required	GoSL	1	2	2

FIGURE 2: Sample risk assessment matrix