FRAMEWORK AND MATURITY MODEL TO GUIDE AND EVALUATE CORPORATE CONTRIBUTIONS TO SUSTAINABLE DEVELOPMENT OF NEIGHBOURING COMMUNITIES: SPECIFIC FOCUS ON GEOTHERMAL POWER PROJECTS

by

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Abstract

The goal of this research is to present a new way of thinking (in the form of a framework) about how geothermal power projects can contribute to sustainable development (SD) in a way that harmonizes these projects with SD plans of their neighbouring communities. The research aims to create a SD approach for the greater geothermal power industry that is consistent with the expectations and values of today’s society.

A framework, referred to as the Geothermal Sustainable Development (GSD) framework, is proposed aiming to guide and evaluate the contributions of a geothermal power project to SD in the local and regional communities. After developing the framework, to help companies and other interested parties to track and evaluate the progress of the project with respect to its approach towards SD, an evaluation strategy in the form of a maturity model is proposed. The maturity model aims to highlight the depth and quality of SD-thinking and its influence within a company/project development paradigm.

The research is based on a combination of quantitative and qualitative research approaches to evaluate and test these outcomes. A survey was used that represents the quantitative research approach. This survey set out to assess whether the identified objectives presented in the framework are indeed suitable and effective as tools for the intended purposes of the framework.

A second part of the research consisted of interviews (qualitative research approach) to evaluate the maturity model and its applications. Six case studies were discussed with interviewees.

The developed framework can be used by the industry, communities, NGOs, and government as a starting-point to establish common ground in the development of geothermal power projects to focus the attention of everyone. It also provides the industry with an opportunity to assess their performance and communicate their approaches, contributions, and progress to the stakeholders and (possible) investors consistently and clearly. The combination of a GSD framework and the proposed SD maturity model could be used by any company at project and corporate levels that have already committed or are willing to commit to SD to evaluate their performance.
Lay Summary

Our society faces the growing ecological challenges that are threatening the life of the current and future generation on Earth, such as, climate change, shortage of clean water and energy/power sources, air pollution, and deforestation. In order to overcome these challenges, it is vital that all industries, including the renewable and clean energy sector, recognize the impact that their projects can have on local and international scale on these challenges. They need to identify that the economy, environment, and the future of their host communities are linked. This thesis aims to identify how geothermal power projects can be responsible neighbours of their host society. To this end, a framework has been developed to guide the industry to be socially and environmentally accountable, scientifically and technically updated, and financially viable during the life span of a project and well after during the recovery and closure periods.
Preface

This dissertation is an original intellectual product of the author, N. Arianpoo. All interviews and surveys reported in Chapter 5 were approved by the University of British Columbia’s Research Ethics Board [certificate # H16-01753].
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Abbreviations

- 7Q’s: Seven Questions to Sustainability
- Ave.: Average
- BAT: Best Available Technology
- CanGEA: Canadian Geothermal Association
- CMM: Capacity Maturity Model
- CSR: Corporate Social Responsibility
- DME: Department of Minerals and Energy
- EIA: Environmental Impact Assessment
- GDP: Gross Domestic Product
- GoK: Government of Kenya
- GRC: Geothermal Resources Council
- GRI: Global Reporting Initiative
- GSAP: Sustainability Assessment Protocol for Geothermal Utilization
- GSD Framework: Geothermal Sustainable Development Framework
- HGP: Hawaii Geothermal Project
- HSAF: Hydropower Sustainability Assessment Forum
- ICMM: International Council on Mining and Metals
- IHA: International Hydropower Association
- KenGen: Kenya Electricity Generating Company
- KPLC: Kenya Power and Lighting Company
- kWh: Kilowatt hour
- MCA: Minerals Council of Australia
- MMSSD North America: Mining, Minerals, and Sustainable Development North America
- MoM: Indian Ministry of Mines
- MW: Mega Watt
- MWe: Mega Watt electricity
- MWt: Mega Watt thermal energy
- NGO: non-governmental organization
- O&M: Operation and Maintenance
- OECD: Organization for Economic Co-operation and Development
- P.: Page
- PDAC: Prospectors and Developers Association of Canada
- PGV: Puna Geothermal Venture
- PPA: Power Purchase Agreement
- Q: Question
- R&D: Research and Development
- R&D: Research and Development
- SD: Sustainable development
- SDF: Sustainable Development Framework
- SEA: Strategic Environmental Assessment
- SEI: Software Engineering Institute
- Std.Dev: Standard Deviation
- TSM: Toward Sustainable Mining
- UN: United Nations
- WCED: World Commission on Environmental Development
- WWEA: World Wind Energy Association
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Dedication

To my family, for their endless love and support
Chapter 1

Introduction

Rising environmental and social concerns over fossil fuel consumption have resulted in the general public and governments around the world paying serious attention to the renewable energy sector as an alternative energy option. In 2012, the United Nations recognized the potential of renewable energy sources as a key solution to the environmental challenges that the world currently faces:

“The production and use of energy, however, comes with significant costs, ranging from climate change to energy security and environmental degradation. There are multiple options for addressing these, the most significant of which include the development and widespread penetration of renewable sources and improvements in energy efficiency. Both have seen a huge surge in recent years, aided by new Government programs and significant new investment” (United Nations Secretary-General’s High-level Panel on Global Sustainability, 2012)

This attention provides the renewable energy sector, including the geothermal power industry, with the unique opportunity to raise its share in the energy market. However, the extraction and development of renewable energy resources can also negatively impact their surrounding communities and environment - although in much lower levels than carbon based energy generation. Note that, difficulty in accessing capital (governmental or private) and public acceptance continue to be among the top 10 business risks faced by the power and utilities industries (renewable or non-renewable) during the last decade (Ernst & Young Global Limited, 2011). The rise in public awareness towards SD considerations puts the industry in a place that may negatively impact its reputation and decreases its chance for future financing and growth opportunities. Since the geothermal power industry still has a fragile status within the energy market and struggles to secure its place, the industry needs to take socio-environmental considerations seriously.

Meeting the economic goals while considering the improvement or preservation of the surrounding environment and communities are among the most important business considerations today. The external social pressures on governments and the private sector during the past decade has been a major factor in adopting and developing sustainable development (SD) policies, guidelines, and frameworks. However, the current guidelines and legal obligations implemented worldwide for the
geothermal power industry are limited and fail to address either the social aspects or the integrated attitudes toward socio-economic and environmental considerations in development of such projects. As geothermal power plants are typically located in rural areas with sparse populations, the industry has been growing slowly and quietly under the society’s radar. But as the industry grows, so does the society’s awareness of SD considerations and business responsibilities.

Currently, there are approximately 95 geothermal power projects installed worldwide in both developing and developed countries (Global Energy Observatory, 2016). Studying these projects demonstrates that the industry is, in many cases, failing to meet the expectations of today’s society on integrated approaches toward SD considerations. More typically, the focus of the industry is on environmental and financial aspects of development, while mostly neglecting the broader governance and social considerations necessary for well-balanced sustainable development implementation (explained in greater detail in Chapter 2 of this thesis). Neglecting these elements may at some point along a project’s life cycle trigger social oppositions. Of course, the author does not mean to undermine the voluntary and philanthropic social contributions made by that geothermal power projects to their surrounding communities. However, the current approaches taken by the projects have mostly been focused on short-term impacts or leave a community as independent of the projects’ existence. As a result, the affected communities are not able to maintain or strengthen their capacity in order to achieve sustainable development objectives and vision. The following statement describes this rising concern, which affects the industry’s performance and future growth, adequately:

“Geothermal power projects are widely believed to be an environmentally friendly alternative for electricity generation, in particular because they produce only small amounts of greenhouse gases. However, in practice, some geothermal projects receive very strong opposition from local and environmental groups, to the point where some projects have been held up for years, or sometimes even scrapped altogether. For successful development of a geothermal project to move forward smoothly, the legitimate concerns of the local communities and environmental groups must be addressed to their satisfaction, even though sometimes this means going beyond the mandates of law.” (Rodríguez & de Arévalo, 2007)

“Our business organization need to become conscious of the evolutionary role business plays in the future of our planet and to take responsibility for that role. What we need now is a new metaphor. We
call that metaphor the evolutionary corporation” (Nattrass & Altomare, 2013). Although, only few studies have been conducted on the matter, as a result of rising concerns and oppositions among the public and policymakers, the discussion on more integrated approaches toward sustainable development recently finds its way into the geothermal power literature (for instance in the research and a paper by Shortall, 2014). If the industry hopes to achieve a fair share of the future energy market, it is essential to consider SD values and reduce the widening gap between its perceived performance and the society’s expectations of corporate responsibilities. To the best knowledge of the author, there is no framework to guide and evaluate the performance of geothermal power projects and their contribution towards sustainable development. The issue is not only affecting the industry’s ability to grow, but it also impedes the communication of impacts and contributions to stakeholders and investors. As Böhringer and Jochem (2007) well stated:

“An issue that cannot be clearly measured will be difficult to improve” and “It is meaningless to talk highly (plan) of something that cannot be evaluated” (Böhringer & Jochem, 2007).

Osborne and Gaebler (1992) described the importance of systematic evaluation and development strategy to win the public support and future growth as:

“What gets measured gets done
If you don’t measure results, you can’t tell success from failure
If you can’t see success, you can’t reward it
If you can’t see success, you probably rewarding failure
If you can’t see success, you can’t learn from it
If you can’t recognize failure, you can’t correct it
If you can demonstrate result, you can win public support” (Osborne & Gaebler, 1992, Chap. 5)
1.1 Research Questions, Scope, and Objectives

The present thesis aims to address the issue (as explained above) by developing a framework to guide geothermal power projects on how to combine sustainable development considerations into their business paradigm. Moreover, this framework provides the industry with a monitoring and evaluating strategy to track their progress in projects with respect to sustainable development considerations. As such the main question this thesis addresses is:

Can the contributions that a geothermal power project makes to sustainable development, in local and regional communities, be evaluated?

To better clarify the scope of the research and better understand what the research exactly aims to achieve, the main question is broken down into smaller sub-questions as follows:

1. How is sustainable development defined in broad terms, for the community and at project level? And what is the preferred terminology to express sustainable development in relation to the geothermal industry?
2. How can a project contribute to SD in a way that harmonizes its approach with SD plans of their neighbouring communities?
3. What approach can be specifically developed for geothermal power projects to guide and evaluate their contributions to SD in local and regional communities?
4. How can the quality of a project’s performance and progress toward SD be evaluated and tracked?

Based on the above question and sub-questions the following objectives are established:

- Objective 1: Demonstrate the need for more integrated approaches toward socio-economic and environmental considerations within the geothermal power arena;
- Objective 2: Provide clarification of what the term “contribution to SD” means for the geothermal power industry and then recognize the broad key essentials of successful
contribution to sustainable development (SD) in local and regional communities where geothermal project development takes place;

- Objective 3: Based on the above, develop a pilot framework to guide and/or test the contributions of a geothermal power project to sustainable development in local and regional communities. This can help in gaining consistency across the industry and within the project’s life cycle by developing an integrated approach toward socio-economic and environmental considerations and;

- Objective 4: Develop an approach to evaluate the performance of geothermal power projects, in terms of compatibility with the concept of sustainable development.

The aim of this research is to present a new way of thinking about the contribution of geothermal power projects towards sustainable development in a way that harmonizes these projects with sustainable development plans in local and regional communities. The research aims to be a catalyst in the implementation of a sustainable development approach for the greater geothermal power industry compatible with the expectations and values of today’s society.
1.2 *Research Roadmap*

This thesis is organized into 8 chapters. The flow and harmony between these chapters is presented in the Roadmap illustrated in Figure 1-1. The thesis is developed in three main stages:

1. Literature review and diagnostic (featured in Figure 1-1, blue coloured parts of the flowchart), as presented in the following chapters:
   - Chapter 2: Provides a literature review on terminology of SD, and its definition and approaches at community and project levels. It also reviews the literature on SD performance evaluation.
   - Chapter 3: Investigates current geothermal power development practices by conducting case studies on three geothermal power projects.
   - Chapter 4: Discusses the outcome of literature review and case studies to establish the needed foundation for the next stage of the research - design and development.
   - Chapter 5: Introduces the research approach and methodology by providing a detailed discussion regarding the methodological approaches used to address the objectives of the research.

2. Design and development (featured in figure 1-1, yellow coloured parts of the flowchart), as presented in the following chapter:
   - Chapter 6: Presents the proposed framework and the SD maturity model developed specifically for the geothermal power industry.

3. Validation, analysis, and expert feedback (featured in Figure 1-1, red coloured parts of the flowchart), as presented in the following chapters:
   - Chapter 7: Explains and discusses the approach taken to validate the developed framework through a survey as well as the approach taken to test the proposed maturity model through 6 case studies.
   - Chapter 8: Delivers the conclusion, contribution, and recommendations for future works.
Chapter 1 - Introduction

Figure 1-1: The research roadmap
Chapter 2

Literature Review

This chapter reviews the definition, terminology, and initiatives toward sustainable development (SD) practices in general, within the geothermal power industry as well as the work of other similar and progressive industries regarding the matter. Due to the interdisciplinary nature of this topic, the first section (2.1) initiates the dialogue on the concept of SD, its definition and components, as defined internationally and within the geothermal power arena. The focus of this section is on the investigation of the variable use and consistency of SD terminology within the geothermal power industry. There is a discussion at the end of the section (2.1.4 Author’s Notes), aiming to establish a common and clear foundation for further communication within the geothermal power arena, including the industry and its stakeholders. Note that establishing consistent/shared terminology opens the door to mutual understanding and further discussion between the parties involved with a geothermal power project.

As the focus of this dissertation is on evaluating the contribution on local and regional communities, Section 2.2 reviews sustainable development practices for communities to determine the ways that a project can contribute to SD of its surrounding communities.

Section 2.3 reviews existing guidelines and frameworks developed within related industries, especially the mining industry which has made significant progress over the last 10 plus years. At the end, Section 2.4 briefly reviews the existing SD performance evaluation strategies.
2.1 TERMINOLOGY OF SUSTAINABLE DEVELOPMENT (SD)

The review of SD terminology as used in geothermal power arena shows that the terms *sustainability*, *sustainable development*, *sustainable energy*, and *sustainable production* are used interchangeably within the industry. The focus of most sustainable development (SD)-related literature within the industry has been on longevity or extended use of the reservoir and there has not been enough attention given to the concept on a broader sense as accepted internationally. Note that using consistent terminology opens the door to further discussion, exchange of ideas, and better understanding between stakeholders and the industry. The stakeholders of a geothermal power project are from various backgrounds, education levels, perspectives, and interests; therefore, consistency in terminology facilitates the communication and reduces misinterpretation among the parties involved. The main intention of this section is to establish the terminology for the rest of the thesis as well as further discussion within the industry. To reach this common foundation on the SD terminology in Section 2.1.4, first the current standard terminology within the geothermal arena and internationally is discussed.

2.1.1 TERMINOLOGY AS USED IN THE GEOTHERMAL POWER INDUSTRY

SD terminology adopted by the geothermal industry seems to indicate that the terms *sustainability*, *sustainable development*, *sustainable energy*, and *sustainable production* has been considered synonymous and therefore applied interchangeably within the industry. In the late 1990’s, SD terms started appearing in the geothermal literature; with the focus on the potential role of the geothermal power industry to help reaching the international sustainable development goals for energy at a global scale (for instance in the papers by Wright, 1998; Méigel & Rybach, 2000; Lovekin, 2000, etc.). The growth of the geothermal power industry (Bertani, 2012) coincided with growing public environmental awareness resulting in increasing corporate behaviour expectations by governments, industries, environmental activists, scholars, and public (Lele, 1991). This also resulted in emerging policies and regulations specifically for geothermal developments (for instance, Government of British Columbia (1996)). These changes caught the attention of the geothermal power industry, as well as others, to explore what SD means for this industry at the project scale.
Today, more typically, the industry refers to the SD concept as a production management and resource longevity model (for instance in the papers by International Geothermal Association, 2001; Axelsson, 2010; Rybach, 2003; Ungemach, Antics, & Papachristou, 2005; etc.). The definition of sustainable development has been tied to resource utilization, often applied as sustainable geothermal resource management, or sustainable production of geothermal reservoir. Geothermal energy has been frequently labeled as a renewable and sustainable energy source, while:

“Renewable describes a property of the energy resource, whereas sustainable describes how the resource is utilized.” (International Geothermal Association, 2001, p. 2)

At first, the industry looked at SD as a development goal for preventing the geothermal reservoir from depletion and keeping the production rate steady for a long time (Axelsson et al, 2001; Rybach, 2003; Rybach & Mongillo, 2006). Perhaps, the following statement effectively summarizes a more broadly held view in the industry:

“In relation to geothermal resources and, especially, to their utilization for energy purposes, sustainability means the ability of the production system to sustain production levels over long periods.” (Rybach, 2003, p. 2)

Used in this form, it therefore does not imply a sustainable development thinking that incorporates economic, environmental, social, and governance dimensions in engaging with stakeholders. There is a wide body of technical work around the matter of sustainable production of geothermal reservoirs. The most referred definition within the industry goes to Axelsson et al (2001) definition for an individual geothermal system, as:

“For each geothermal system, and for each mode of production, there exists a certain level of maximum energy production, $E_0$, below which it will be possible to maintain constant energy production from the system for a very long time (100 – 300 years). If the production rate is greater than $E_0$ it cannot be maintained for this length of time. Geothermal energy production below, or equal to $E_0$, is termed sustainable production while production greater than $E_0$ is termed excessive production.”
At first, $E_0$ is considered to be equal to the natural recharge rate of the reservoir. However, in reality, adjusting the production rate by such a low natural recharge rate is not economically feasible at least for the power industry that requires high upfront capital (Sanyal, 2005). Often, purely for economic reasons, resources are operated to produce at much higher rates resulting in reservoir depletion, which can reduce the reservoir’s profitable longevity to a few decades. However, when the production stops, natural recharge streams eventually may revive the original status of the reservoir. Recovery duration depends on the utilization methods, and the production period and rate (Sanyal & Enedy, 2011; Sanyal, 2005; Yahara, & Tokita, 2010; Rybach & Mongillo, 2006). Sometimes the production rate exceeds the amount of $E_0$ level so much that the reservoir cannot recover for centuries.

Eventually, the above concerns over the economic viability of the projects shifted the adopted terminology of the time to:

“... Sustainability is defined as the ability to economically maintain the installed capacity, over the amortized life of a power plant, by taking practical steps (such as, make-up well drilling) to compensate for resource degradation (pressure drawdown and/or cooling).” (Sanyal, 2005, p. 1)

![Figure 2-1: Examples of different modes of sustainable system utilization for a single geothermal resource (Axelsson, Bjornsson, & Stefansson, 2006)](image)

The economic concerns led the industry to adopt the new utilization strategies so called *sustainable utilization modes* suggested by Axelsson, Bjornsson, and Stefansson in 2006. The suggestions (Figure
were based on the Axelsson et al (2001) definition with the additional considerations over acceptable reservoir recovery duration, and economic concerns (Axelsson, et al, 2010), as:

- **Mode 1**: Constant production for several hundreds of years. This mode is rarely a practical option as the long-lasting production capacity of the reservoir is unknown before a test period and few years of operation.
- **Mode 2**: Stepped production. In this mode, the production rate increases in a few steps until reaching the long lasting potential capacity.
- **Mode 3**: Cyclical (periodic) Production. In this mode, the production exceeds the long-lasting production rate for a few decades (about 30 years) with total breaks in between (about 30 to 50 years). The cycle repeats after the recovery period.
- **Mode 4**: Excessive production followed by a steady, but reduced production rate (overproduction and lower production). Basically, this is a variation of previous mode but instead of a total break down after 30 to 50 years of excessive production, the production rate faces intense but steady reduction. When there is more than one single geothermal resource in the area, all resources together, as one system, could generate electricity continuously for 100-300 years on periodic production mode (mode 3). In this case, when some resources are focused on aggressive productions, the rest are recovering.

In the geothermal power arena, people typically use the term SD and its associated expressions (sustainable, sustainability, sustainable utilization, etc.) to refer to the longevity of the production or reservoir utilization. As the industry engages with a wide range of stakeholders of various backgrounds, it is important to apply the SD terminology as defined and accepted internationally as that will help gain a better understanding and communication among the parties. Establishing consistent and shared terminology opens the door to mutual understanding and further discussion between the involved parties (including companies, the financial sector, shareholders, NGO’s, academia, governments and communities). It is meant to also prevent confusion and misunderstanding along the way as the misuse of sustainable development terminology may result in reducing its potential for creating a new development ethic rather than remaining as an overused phrase. The next sections will explore the definition of sustainable development terminology, as the SD concept, as used in this thesis, is beyond its literal meaning of long lasting.
2.1.2 Broader Use of Sustainable Development Terminology

Sustainable development and sustainability are often used interchangeably. While this may be correct in some cases it can be confusing in others. Confusion mostly comes from the general tendency to shorten the words, using sustainability instead of sustainable development. It is noteworthy to mention that the term sustainability originates from ecology referring “to the potential of ecosystem to subsist over time” (Baker, 2015). Somehow, the term was associated with the ultimate goal of policy - a long-lasting world. While now, sustainability is the ultimate goal; sustainable development refers to many pathways available to help getting there (Baker, 2015).

- Origin and Definition

“Sustainable development is a dynamic concept. It is not about society reaching an end state, nor is it about establishing static structures or about identifying fixed qualities of social, economic or political life” (Baker, 2015). Sustainable development is an ongoing process of learning, adopting, and revising actions (United Nations Secretary-General’s High-level Panel on Global Sustainability, 2012). The process, where the ideal goals can change through time and place reflecting political, social, and cultural context at that moment and that site (Baker, 2015).

Despite the ongoing debate on the meaning of SD, there is a common agreement over dimensions of the concept. Sustainable development is about understanding the complexity of interconnection between environment, society, economic and aiming to integrate socio-economic and environmental considerations into the development paradigm (Baker, 2015; Drexhage & Murphy, 2010).

The concept of sustainable development was a fundamental shift from “what should not be done” to rather emphasizing on “what should be and can be done” (Mitcham, 1995). The best-known definition of SD appeared in the report of the World Commission on Environment and Development (WCED) (Hopwood, Mellor & O’Brien, 2005). This report, Our Common Future (often referred to as the Brundtland report, as the Commission was chaired by Norwegian Prime Minister of the time Gro Harlem Brundtland) was created to address growing concerns over the economic progress path and its socio-environmental consequences (Hopwood, Mellor, & O’Brien, 2005; Drexhage & Murphy, 2010). The Commission defined SD as:
“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs.” (Brundtland, 1987)

At the time of the report, two different approaches of development were advanced by environmentalists and economists. One side believed in putting limits to growth or no-more-growth to save the environment while the other side stressed more industrial growth as a pathway forward for humanity to reduce poverty. “The Brundtland report bridging of these conflicting interests was to propose neither simply limits nor simply development, but sustainable development” (Mitcham, 1995). Sustainable development is about understanding the big picture and clarifying that our actions today should not jeopardize the health and happiness of future generations (United Nations Secretary-General’s High-level Panel on Global Sustainability, 2012). As Carl Frankel (1998) mentioned in his book *In Earth’s Company*, sustainable development is about finding harmony between three dimensions of environment, economic, and society (Nattrass & Altomare, 2013). He describes growth as “to be pursued in a manner consistent with long-term environmental protection and social fairness” (Frankel 1998).

**SD and Lessons Learned from the Mining Industry’s Practice**

The scale of mining developments and their socio-environmental impacts on its surroundings, keeps the mining industry in many cases right in front of socio-political opposition. The significant economical and reputational risks of social conflicts between mining companies and their stakeholders, has forced the industry to revise its corporate behaviour and embrace integrated approaches toward socio-environmental, and economical considerations (Ernst and Young Global Limited, 2015). The shift, however, has been gradually, resulted in better understanding of the SD concept and its implementation challenges.

In the early 1990s, as a result of public pressures, mining companies started improving their environmental performances, and establishing few voluntary activities for their surrounding communities (exactly similar to the geothermal industry’s situation right now). “However, in almost every case, it was not the environmental aspect that was the stumbling block. The fundamental downfall was the failure to obtain backing of the stakeholders, particularly the residents of the area and region, by carefully understanding and dealing with their underlying environmental and social
issues before battle lines were drawn” (James, 1999. p. 91). Although the society was not satisfied, the industry’s practices resulted in developing strategies to minimize environmental impacts of mining activities as well as inspiring many environmental regulatory frameworks (Thomson, 2016).

“As an industry, we will gradually find ourselves unable to operate anywhere we turn if we are incapable, or reluctant to effectively combine economic, environmental and social goals everywhere we do business.” (James, 1999. p. 90)

“Mineral products are essential to contemporary societies and economies. Many basic needs cannot be met without them. But simply meeting market demand for mineral commodities falls far short of meeting society’s expectations of industry.” (MMSD North America, 2002. p. xiv)

To bring the social consideration into the traditional environmental and economical approach, mining companies realized a need for going beyond their regulatory responsibilities to gain the trust and consent of communities. Meanwhile, affected communities started demanding more involvement in decision making from local mining companies. “These trends have been spurred by the growth of the sustainable development paradigm” (Prno, 2013).

“One of the greatest challenges facing the world today is integrating economic activity with environmental integrity, social concerns, and effective governance systems. The goal of that integration can be seen as ‘sustainable development’.” (MMSD North America, 2002. p. xvi)

The mining industry’s journey toward acceptance and implementation of sustainable development has led to better understanding and improvement of the concept’s dimensions: environment integrity, economic stability, social equity, and equitable governance. Mining industry practice has resulted in the development of several SD frameworks by the industry and scholars providing step-by-step guideline toward the better implementation of the concept, for instance the publication “Seven Questions to Sustainability” (MMSD North America, 2002), ICMM 10 Principles (ICMM, 2003), Towards Sustainable Mining (TSM) (Mining Association Canada, 2013), etc. An important learning from mining experience is the inclusion of governance (both legal jurisdictional as well as corporate capacity) in the dimensions of SD.
The general tendency toward shortening the terms can often be misleading or create misunderstanding. The term sustainable mining is one example. “Sustainable mining means different things to different people. To some it means mining carried out in a manner consistent with sustainable development. In particular, it is mining in a way that preserves the environment, protects indigenous cultures, and promotes the welfare of local communities. To others, sustainable mining implies the extraction of mineral resources from the earth in a manner that permits this activity—that is, extracting minerals resources from the earth—to continue indefinitely” (Tilton, 2009). The confusion often sparks some allegation that the mining industry tries to mislead society, for instance:

“The deployment of corporate oxymorons like sustainable mining is one of the key strategies corporations use to conceal harm and neutralize critique” (Kirsch, 2010).

As a result of resource exhaustion, all mining production will have an end. It is important though to emphasize here that sustainable development is not about sustaining each and every project forever; but it is about making a positive contribution to the wellbeing of the society and environment.

The tendency toward shortening SD terminology can be seen in energy industries including the geothermal power industry. The terms sustainable energy and sustainable energy system are often used in the energy sector. While a sustainable energy system is more appropriately defined as “a cost-efficient, reliable, and environmentally friendly energy system that effectively utilizes local resources and networks” (Hepbasli, 2008), sustainable energy is often used to refer to renewable energies (Lemaire, 2012) in regard to their supposedly long-lasting lifespan. Stefansson (2000) stated “in order to obtain sustainable exploitation of an energy resource, the resource has to be renewable”. But in reality, even among renewable energy sources, it is hard to find the energy sources that can provide energy forever despite the extraction rate, weather condition, etc. It is also debatable whether the development of all renewable energy sources contributes to sustainable development. In other word, the nature of a reservoir (renewable or non-renewable) by itself is not a guarantee to a positive contribution of a project to the journey of the community toward SD, as SD is more a reflection of project’s utilization and community engagement strategies.


2.1.3 **CONTRIBUTION TO SUSTAINABLE DEVELOPMENT**

Worldwide acceptance of the sustainable development concept was an important step forward, but moving from theory to practice has proven to be much more difficult (Drexhage & Murphy, 2010). At the beginning the focus of sustainable development concept was more on the challenges in the international and national scales. However, gradually, people have realized that sustainable development can only be gained by a collective teamwork by all members of the community rather than an integration of uncoordinated and inharmonious individual’s action toward individually defined-SD paths. The term *contribution to sustainable development* is used to indicate the impact that each individual person, community, company, government, projects, or any sector of society leaves on the SD journey of a society.

2.1.4 **AUTHOR’S NOTES**

As discussed above, people in the geothermal power arena has focused most of their attention and research on sustainable production of the reservoir, rather than sustainable development as an important development ethic - the broader concept in which the economic, environment, society, and governance dimensions of a project integrates into the development paradigm. The Author doesn’t imply that the current viewpoint of the geothermal power industry is wrong, but encouraging the industry to broaden their horizon to the expectations of the society about corporate responsibilities. As a starter, to prevent misunderstanding, the author encourages using the appropriate and clear SD terminology as accepted internationally and avoids shortening when it is possible to prevent misunderstanding.

As discussed in Section 2.1.2.2, the miscommunication has even affected the mining industry as people have two different perspectives on SD approach in the industry. As Tilton (2009) explained, on one hand, some look at the concept from the point of view of an ore body, and the others from the community point of view and integrated SD approach. The former has led to the appearance of terms such as sustainable mining, which seems to contradict itself and reduce the effectiveness of the concept as a development ethic for both the industry and for its stakeholders. As such, the geothermal power industry should focus on the broader sense in which SD implies to integrate environmental, economic, societal, and governance dimensions of development. The following notes are suggested:
The terms sustainability and sustainable development are not consistently interchangeable.

Using SD terminology as a well-defined and accepted development ethic to only refer to the level of production and utilization can be misleading.

It is possible to have a long-lasting project with a negative contribution to sustainable development by failing to address and integrate environmental, social, economic, and governance considerations.

Energy/power is a fundamental need of a functioning society (Tester, 2005). It is vital for society to have access to energy/power at all times. It is not necessary for each individual energy/power project to last forever as long as there are alternative sources in place or the project serves sustainable development dimensions in ways that build viable long-term capacities, strengthen communities and recover damaged ecosystems as a result of the project. After all, the key factor is the positive contribution of an economic activity that integrates environmental integrity, social concerns, and effective governance systems into its development paradigm (MMSD North America, 2002).

So, does this mean that the lifespan of a geothermal power project is not important at all? The mining industry experience shows that it is essential for affected communities that the production last long enough to allow the increased flow of income from the project to expand their local economics, and their societal infrastructure wellbeing (Gibson, 2006). This should also be considered in geothermal power projects. However, having a long-lasting project by itself is not enough and the joint planning with the community to get there will be essential (Gibson, 2006).

**Author suggestion**: The author would suggest that a clear distinction be made between the terms *sustainability*, *sustainable production* and *sustainable development*. Also, when it is possible, substitute the term production longevity or long lasting/stable/steady production rather than sustainable production to capture the same context without leading to assigning any broader meaning to the term sustainable.
2.2 SD AT COMMUNITY LEVEL: TOWARD SUSTAINABLE DEVELOPMENT PRACTICES FOR COMMUNITIES

For any industry including geothermal power, to positively contribute to a society’s journey toward SD, the journey itself should first be understood - its objectives, long-term goals, visions, and its main components. The aims of this section are to investigate what sustainable development means in community planning by reviewing some of the leading practices/frameworks that has been developed over the past decades toward sustainable development practices for communities such as Eco-Municipality Movement, Agenda 21, and the Natural Step.

Due to higher environmental awareness, cities and communities around the word have often tried to embrace more eco-friendly practices to create livable communities with higher standards, such as recycling programs, energy-efficient buildings (e.g. green buildings), better public transportation system and health care, etc. However, the single-issue approach to handling environmental and human’s wellbeing, lack of consideration for the bigger picture and long-term vision in local and global scale, and lack of cooperation and harmony between different sectors of communities, create more conflicts than solutions. A great example of the single-issue approach was the well-intended effort of creating energy-efficient buildings after the 1970s oil crises. The buildings were so airtight and insulated that they also sealed all volatile compounds, dirt, and moles inside them, the phenomena that is known as sick building syndrome (James & Lahti, 2004).

Traditionally, cities and communities’ economic growth has relied on the concept of more and more consumption, and transitions takes much professional involvements, careful planning, and cooperation between all sectors (municipality, industries, residents, NGO’s, etc.). The goal of sustainable development practices for communities is that “Humanity must rediscover its ancient ability to recognize and live within the cycles of the natural world” (Nattrass & Altomare, 2013). As Flint (2012) defined in his book, Practice of Sustainable Community Development, “a sustainable community is one that moves beyond subsistence, to the capability for making choices that promote resilience and long-term benefits. And thinking long term is one of the real distinctions of sustainable communities in contrast to livable communities”. As a result, a community should only invest and
pursue those short-term practices and opportunities that serve as a foundation to future progress (James & Lahti, 2004).

### 2.2.1 **ECO-MUNICIPALITY MOVEMENT**

In the mid 1980s, the small Swedish town of Overtornea initiated a new approach toward community development practice to overcome the economic recession that hit Nordic countries at the time (Honkapohja, 2009). During the recession, the town of barely 6,000 residents lost 25% of its population and its trust of a bright future. The municipal government changed this seemingly hopeless situation by developing possible future scenarios and positive long-term opportunities for their community. The vision was seeking win-win-win relationship between society, nature, and humans. At a time, such ideas of collaborative community planning, cooperation between various sectors of the community, and taking into account the local cultural and traditional extents were not common (James & Lahti, 2004). Six years later, 200 new enterprises developed within the various fields of organic farming, fish farming, eco-tourism, beekeeping, etc. The municipal government shifted its incentives and investments to ecological friendly developments and public health. They called their approach *eco-municipality*. Their success relied heavily on the widespread community participation and cooperation between various sectors of the society. In the early 1990s, Overtornea’s story persuaded many other Swedish cities to embrace the eco-municipality approach as well as many others in Norway, Denmark, and Finland. The terms like eco-municipality, eco-cities, and eco-communities/towns gained a lot of attention in Nordic countries. The success of eco-municipality efforts influenced the United Nations (UN) Conference on Environment and Development, known as 1992 Rio Earth Summit, in the development of an action plan named Agenda 21. Chapter 28 of this agenda was dedicated to the local sustainable development reflecting Nordic communities experience (James & Lahti, 2004; International Council for Local Environmental Initiatives, International Development Research Centre (Canada), & United Nations Environment Program, 1996).

### 2.2.2 **THE LOCAL AGENDA 21 PLANNING GUIDE**

In 1992, 179 countries leaders gathered at the United Nations Earth Summit in Rio to prepare a global action plan as the first step forward to move the sustainable development concept from theory to action. The outcome is called Agenda 21. While preparing the documents, Participants recognized
that “because so many of the problems and solutions being addressed by Agenda 21 have their roots in local activities, the participation and cooperation of local authorities will be a determining factor in fulfilling its objectives. Local authorities construct, operate and maintain economic, social and environmental infrastructure, oversee planning processes, establish local environmental policies and regulations, and assist in implementing national and subnational environmental policies. As the level of governance closest to the people, they play a vital role in educating, mobilizing and responding to the public to promote sustainable development” (United Nations, 1992).

As a result, Agenda 21, in Chapter 28 (the Local Agenda 21) called upon local authorities in every country, in a period of 4 years:

- To increase cooperation between local authorities on the national and international scales
- To enhance the level of transferring and exchanging information and experience
- To achieve consensus from their populations on implementing of a Local Agenda 21 in their communities
- To encourage and ensure the participation of women and youth in this process

Upon release of the Agenda 21 action plan, there was little information available on putting sustainable development theory in action for communities. However, at the end of the above mandate in 1996, 1,300 local authorities from 31 countries shared their progress in developing of their own Local Agenda 21 version of the action plan. These real-life experiences were used in the preparation of the Local Agenda 21 Planning Guide in 1996. The following planning guidelines were defined for communities:

- “Equally factor economic, community, and environmental condition into the design of development projects and service strategies;
- Fully engage relevant interest groups and, in particular, service users in the development of service strategies that meet their needs; and,
- Create service strategies that can be sustained because they focus on underlying systemic problems rather than problem symptoms, and because they consider long-term trends and
2.2.3 Habitat III - United Nations Goals for Cities and Human Settlements

In 2015, the United Nations (2016) released 17 sustainable development goals known as “Transferring our world: the 2030 Agenda for Sustainable Development” to guide governments toward that ultimate goal of sustainable development (Figure 5). Goals such as, no poverty, zero hunger, gender equality, affordable and clean energy, etc. were included in the agenda. Consequently, many governments initiated national SD strategies and policies aligning with the United Nations recommendations.

Figure 2-2: Sustainable development goals to transfer our world (Source: United Nations, 2016)

In 2016, the UN held a global summit on urbanization in Quito, Ecuador with the focus of defining an action plan known as Habitat III to identify and discuss the key challenges facing cities and towns around the world to fulfill and implement SD and climate change goals and agreements. The discussion resulted in development of 11 goals to “make cities inclusive, safe, resilient and sustainable” (United Nations, 2016) as following:
“By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums

By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons

By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries

Strengthen efforts to protect and safeguard the world’s cultural and natural heritage

By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations

By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning

By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and implement, in line with the Sendai Framework for Disaster Risk Reduction 2015-2030, holistic disaster risk management at all levels

Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials” (United Nations, 2016)
2.2.4 The Natural Step for Communities

Lack of systematic approaches in handling environmental challenges (single-issue approach to interrelated matters) and growing concerns and confusions in Swedish communities motivated Dr. Karl-Henrik Robert, a cancer research specialist, to call other Swedish scientist and environmental groups to participate in an open dialogue in a hope of establishing some ground rules for human-environment relationship (sustainable development practice) at community level in 1988. As the dialogue received an overwhelming number of responses, more groups joined the dialogue from governments, NGOs, unions, various industries, and eventually the King and Queen of Sweden in a year after the first initiative. Their efforts resulted in creation of educational manuscript including basis principles for societal cooperation on the matter, TV shows, and tape-and-booklet mailing to every resident in Sweden (James & Lahti, 2004).

The outcome of the dialogue and collaboration between Dr. Robert, Dr. Karl-Erik Eriksson and John Holmberg (a physics professor and his PhD student at the Chalmers University in Sweden) resulted in development of the Natural Step framework for sustainable development of communities in 1989 (Nattrass & Altomare, 2013; The Natural Step, 2016). Their approach was initiated around identification of those human activities that jeopardized long-term sustainability of societies. They argued that the human-environment relationship within a society is a key in walking toward or away from sustainable development. As a result, they developed four non-overlapping system conditions that are necessary for ensuring a successful journey toward SD, as follows:

“In a sustainable society, nature is not subject to systematically increasing

- concentrations of substances from the earth’s crust (such as fossil CO2 and heavy metals),
- concentrations of substances produced by society (such as antibiotics and endocrine disruptors),
- degradation by physical means (such as deforestation and draining of groundwater tables),

And in that society,
there are no structural obstacles to people’s health, influence, competence, impartiality and meaning.” (The Natural Step, 2016)

The Natural Step framework was a result of the above system conditions. Table 2-2 shows the four defined guiding objectives by the framework for systematic and smooth transformation of societies toward SD with local scale decision-making.

<table>
<thead>
<tr>
<th>Guiding Objective</th>
<th>Type of Practices</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Eliminate our community’s contribution to fossil fuel dependence and to wasteful use of scarce metals and minerals</td>
<td>Transit and pedestrian-oriented development; development heated and powered by renewable energy; mixed-use development; public transit, alternatively fuelled municipal fleets; incentives for organic agriculture that minimizes phosphorus and petrochemical fertilizers and herbicides.</td>
</tr>
<tr>
<td>2. Eliminate our community’s contribution to dependence upon persistent chemicals, and wasteful use of synthetic materials.</td>
<td>Healthy building design and contraction that reduces or eliminated use of toxic building materials; landscape design and park maintenance that uses alternatives to chemical pesticides and herbicides; municipal purchasing guidelines that encourage low- or non-chemical product use.</td>
</tr>
<tr>
<td>3. Eliminate our community’s contributions to encroachments upon nature (e.g. water, land, wildlife, forests, soil, ecosystems)</td>
<td>Redevelopment of existing sites and buildings before building new ones; building “from the inside out” development and infrastructure policies; open space, forest, and habitat preservation; reduced water use and recycling of wash water; sewage treatment by plants.</td>
</tr>
<tr>
<td>4. Meet human needs fairly and efficiently.</td>
<td>Affordable housing for a diversity of residents; locally based business and food production; using waste as a resource; eco-industrial development; participatory community planning and decision making.” (James &amp; Lahti, 2004)</td>
</tr>
</tbody>
</table>

The Natural Step objectives can be applied to various scales and topics within a society, from policies, project development to running a single household. In other word, it provides a shared vision and helps the various sectors of a society demonstrate a collective action. The framework introduced a method named A-B-C-D to help communities transform and monitor their progress.
The A-B-C-D Method Toward the Change

The A-B-C-D method (Figure 2-3) is a back-casting strategy, starting from the final objectives/goals of a society/business and going backward to design the change process needed to guide the various sectors:

A = Awareness and Visioning

The first step for any community or company is to align all parties around a common understanding, shared vision, and playing roles; to establish what the organization or community would look like in future considering the Natural Step principles to SD (The Natural Step Canada, 2016).

B = Baseline Mapping

This step is for mapping the current state of the community/business. Finding what action is moving the system toward or away from the objectives defined by the Natural Step or where are the gaps and limitations (The Natural Step Canada, 2016).

C = Creative Solutions

The creative solutions are vital to address today challenges as well as lead future improvements in the right direction. As so, involved parties are asked here to back-cast from the objectives to the baseline situation in order to brainstorm on opportunities and potential solutions and possibilities (The Natural Step Canada, 2016).

D = Decide on Priorities

"After identifying the opportunities and potential solutions in the ‘C’ step, the group prioritize the measures that move the organization toward sustainability fastest, while optimizing flexibility as well as maximizing social, ecological and economic returns. This step supports effective, step-by-step implementation and action planning. At this stage,
organizations can pick the 'low-hanging fruit' - actions that are fairly easy to implement and offer a rapid return on investment in order to build internal support and excitement for the planning process” (The Natural Step Canada, 2016).

To reach the sustainable development goals planned for a community, change needs to occur within all levels of the community from municipal operations to all practices and decisions made by citizens, businesses, and households.
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2.3 SD AT CORPORATE LEVEL: SD FRAMEWORKS AND PRACTICES FOR BUSINESSES

The rapid transformation in corporate-related environmental and social regulations and the rising expectations during the last decades has stirred companies in the direction of adopting a new development ethic called sustainable development. “The companies recognize that the economy and the environment are integrally linked and that nature's limits have both significant economic consequences and opportunities for their businesses. They use this knowledge to guide their company's planning and investment strategies and to increase their long-term viability and competitive advantage. They understand that important economic benefits can be gained by learning to operate in harmony with nature and by guarding against a collision with the limits imposed by natural laws or by society's reactions to negative environmental effects” (Nattrass & Altomare, 2013). Accordingly, companies and businesses should recognize their important role in overcoming the current global challenges and take responsible actions.

During the past decade, there have been ongoing efforts on bringing the SD concept from the scale of the national/international policy down to the project and corporation levels by various industries. These efforts have resulted in significant improvement and produced various protocols, frameworks, and guidelines. Each reflects their particular organization/industry viewpoints (Thomson, 2016). However, the results share a similar foundation as many of the current sustainability assessments that are actually derived from similar impact assessment tools (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007) such as the Environmental Impact Assessment (EIA). However, they have been extended in their considerations and coverage to meet growing demands for including social concerns (Pope, Annandale, & Morrison-Saunders, 2004). In his book, In Earth’s Company, Frankel (1998) suggested the following common goals for companies who are interested in adopting the SD concept in their businesses:

- “Progress toward zero waste: rather than seeking to reduce waste, companies will come as close as possible to eliminating it altogether.”
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- Whole systems thinking: addressing problems at the level of the entire system, rather than the parts, using a design approach that allows strategists to conceive something completely new rather than simply to extrapolate the future from the present.

- Looking beyond internal operational sustainability and making the world's problems the company's problems.

- Moving beyond the focus on environmental issues to a focus on sustainable development.” (Nattrass & Altomare, 2013)

The United Nations has a number of recommendations to industries on SD approaches, such as reducing greenhouse gases emissions during the operation, improving operational efficiency by adopting and identifying new technologies, and establishing multi-stakeholder partnership and collaboration. Dyllick and Hockerts (2002) defined the sustainable development at a project/corporate level as “meeting the needs of a firm’s direct and indirect stakeholders (such as shareholders, employees, clients, pressure groups, communities etc.), without compromising its ability to meet the need of future stakeholders as well.” To implement the idea, they recommended three key factors to the companies; integrating the economic, environmental, and social considerations during the lifespan of a project, developing the short-term and long-term goals, and consuming the income and not the capital (natural and social) (Dyllick & Hockerts, 2002).

Because there is no holistic SD framework or guideline yet developed specifically for the geothermal power industry, to the best knowledge of the author, the focus of this section is to review the existing guidelines and frameworks developed for related industries. Using SD approaches and initiations taken in other industries may benefits the sustainable development efforts for geothermal energy. This includes available framework/guidelines for other renewable energies as well as the mining industry as a one of the pioneers in implementing SD concepts at the project level. Besides, when it comes to socio-environmental concerns, the geothermal power industry is facing similar challenges as mining although with fewer detrimental effects for the environment, such as air and water pollution, noise pollution, cultural disturbance, health and safety concerns, relocation of dwellings, environmental footprints, etc. (Kubo, 2003).
In the following sub-sections, first, the Sustainability Assessment Protocol for Geothermal Utilization (GSAP) is reviewed which is a set of indicators specific to geothermal energy utilization in Icelandic context developed by Shortall in 2010 (and in a later publication Shortall, Davidsdottir, & Axelsson, 2015). Then some of the highlighted SD frameworks developed by the mining industry are reviewed for inspiration of the SD approaches for geothermal power plants. The highlighted SD frameworks presented here are Seven Questions to Sustainability, Sustainable Development Framework (SDF) for Indian Mining Sector, A Strategic Framework for Implementing Sustainable Development in the South African Minerals Sector, and Enduring Value: the Australian Minerals Industry Framework for Sustainable development.

2.3.1 A SUSTAINABILITY ASSESSMENT PROTOCOL FOR GEOTHERMAL UTILIZATION (GSAP)

In 2010, Shortall developed a list of indicators for geothermal energy utilization in the Icelandic context called a Sustainability Assessment Protocol for Geothermal Utilization (GSAP) as part of her Master’s thesis. After holding a series of discussions on the indicators with stakeholders, Shortall, Davidsdottir, and Axelsson (2015) extended their research and introduced a set of 10 goals (themes) and 21 common indicators for geothermal energy utilization. To the best of the author’s knowledge, GSAP is the first and only sustainable development protocol for geothermal utilization so far. The indicators have been developed through workshops (Delphi method) held in Iceland, Kenya, and New Zealand. The participants were asked to rate the proposed goals and indicators to indicate their priorities (Dewulf, De Meester, & Alvarenga, 2015). Although the protocol intended to be at a project-based level, the social elements of the protocol are a mix of the national and project scale. The attempt has brought more clarification and one step forward toward better understanding and implementation of SD concept for the geothermal arena. Table 2-2 shows the defined goals and samples of proposed indicators.

2.3.2 THE HYDROPOWER SUSTAINABILITY ASSESSMENT FORUM (HSAF)

The Hydropower Sustainability Assessment Forum (HSAF) is a collaborative group of various hydropower sectors’ representatives. The forum published two documents: IHA (International
Hydropower Association) Sustainability Guidelines and IHA Sustainability Assessment Protocol in 2004 and 2006 respectively to help assessing social, economic, and environmental performance of hydropower projects. Their latest work, IHA Sustainability Assessment Protocol, is divided into four sections based on the four stages of hydropower project lifecycle known as strategic assessment, project preparation, project implementation, and project operation (International Hydropower Association, 2009). Each section is developed as an independent tool for the development stage of a project. For each section, there is a list of main aspects separated for each stage of a project and each dimension of SD.

Table 2-2: GSAP outline (Shortall, 2015)

<table>
<thead>
<tr>
<th>Defined goals</th>
<th>Samples of proposed indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.  Renewability</td>
<td>• Air quality in the surrounds of the geothermal power plant</td>
</tr>
<tr>
<td>2.  Water resource usage</td>
<td>• Average income levels in project-affected communities</td>
</tr>
<tr>
<td>3.  Environmental management</td>
<td>• Direct and indirect local job creation over lifetime of project</td>
</tr>
<tr>
<td>4.  Efficiency</td>
<td>• Duration of plant power outages per year</td>
</tr>
<tr>
<td>5.  Economic management and profitability</td>
<td>• Estimated productive lifetime of geothermal resource</td>
</tr>
<tr>
<td>6.  Energy equity</td>
<td>• Expenditure on heat and electricity as a percentage of household income</td>
</tr>
<tr>
<td>7.  Energy security and reliability</td>
<td>• Impact on important or vulnerable geothermal features</td>
</tr>
<tr>
<td>8.  Community responsibility</td>
<td>• Imported energy as a percentage of total (national level)</td>
</tr>
<tr>
<td>9.  Research and innovation</td>
<td>• Income-to-expenditure ratio for project-affected municipalities</td>
</tr>
<tr>
<td>10. Dissemination of knowledge</td>
<td>• Level of induced seismicity per year</td>
</tr>
<tr>
<td></td>
<td>• Noise levels</td>
</tr>
<tr>
<td></td>
<td>• Number of accidents leading to work absence in the energy company per year</td>
</tr>
<tr>
<td></td>
<td>• Percentage of community residents that must be relocated due to energy project</td>
</tr>
<tr>
<td></td>
<td>• Percentage of energy company expenditure given to R&amp;D per year</td>
</tr>
<tr>
<td></td>
<td>• Percentage of renewables in total energy supply nationally (metric)</td>
</tr>
<tr>
<td></td>
<td>• Water quality of water bodies impacted by geothermal power plant operations</td>
</tr>
</tbody>
</table>

The table below shows the overall outline of the defined protocol and sample of proposed considerations. Each aspect (shown below) accompanies a list of process and performance attributes/indicators for consideration. Table 2-3 demonstrates HSAF principles and proposed aspects.
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Table 2-3: HSAF outline (International Hydropower Association, 2009)

<table>
<thead>
<tr>
<th>Defined Principle</th>
<th>Samples of proposed aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles:</td>
<td></td>
</tr>
<tr>
<td>1. “Hydropower, developed and managed sustainably, can provide national, regional, and local benefits, and has the potential to play an important role in enabling communities to meet sustainable development objectives.” (International Hydropower Association, 2009)</td>
<td>Section I – Strategic Assessment</td>
</tr>
<tr>
<td>2. Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.</td>
<td>• Demonstrate needs</td>
</tr>
<tr>
<td>3. Sustainable development embodies reducing poverty, respecting human rights, changing unsustainable patterns of production and consumption, protecting and managing the natural resource base, responsible environmental management, long-term economic viability, financial stability including participation of private sector parties, and ethical business practices.</td>
<td>• Regional and national policies and plan</td>
</tr>
<tr>
<td>4. Sustainable development calls for a balancing of economic, social and environmental values informed but not dictated by financial benefits to private interests. This balance should be achieved and ensured in a transparent, interactive and accountable manner, taking advantage of expanding knowledge, multiple perspectives, and innovation.” (International Hydropower Association, 2009)</td>
<td>• Political risks</td>
</tr>
<tr>
<td></td>
<td>• Institutional capacity</td>
</tr>
<tr>
<td></td>
<td>Section II – Project Preparation</td>
</tr>
<tr>
<td></td>
<td>• Economic/technical/governance aspects</td>
</tr>
<tr>
<td></td>
<td>• Public Sector Governance</td>
</tr>
<tr>
<td></td>
<td>• Regulatory Approval</td>
</tr>
<tr>
<td></td>
<td>• Site Selection and Design Optimization</td>
</tr>
<tr>
<td></td>
<td>• Corporate Governance</td>
</tr>
<tr>
<td></td>
<td>• Economic Viability</td>
</tr>
<tr>
<td></td>
<td>• Management of the Hydrological Resource</td>
</tr>
<tr>
<td></td>
<td>• Social aspects</td>
</tr>
<tr>
<td></td>
<td>• Indigenous Peoples and Ethnic Minorities</td>
</tr>
<tr>
<td></td>
<td>• Resettlement</td>
</tr>
<tr>
<td></td>
<td>• Community Acceptance</td>
</tr>
<tr>
<td></td>
<td>• Communications</td>
</tr>
<tr>
<td></td>
<td>• Project Benefits</td>
</tr>
<tr>
<td></td>
<td>• Environmental aspects</td>
</tr>
<tr>
<td></td>
<td>• Environmental Impact Assessment</td>
</tr>
<tr>
<td></td>
<td>• Reservoir Management</td>
</tr>
<tr>
<td></td>
<td>• Pest and Invasive Species</td>
</tr>
<tr>
<td></td>
<td>• Biodiversity, Habitats and Protected Areas</td>
</tr>
<tr>
<td></td>
<td>Section III – Project Implementation</td>
</tr>
<tr>
<td></td>
<td>• Same as Section II</td>
</tr>
<tr>
<td></td>
<td>Section IV – Project Operation</td>
</tr>
<tr>
<td></td>
<td>• Same as Section II</td>
</tr>
</tbody>
</table>

2.3.3 **Sustainability and Due Diligence Guideline (for Wind Power)**

In 2004, the World Wind Energy Association (WWEA) published a Sustainability and Due Diligence Guideline aiming to assist wind power developer and producer with the management and assessment
of their actions toward SD. The focus of the guideline was to promote greater considerations of SD dimensions mostly in the new projects. The guideline provides a list of sustainability aspects and their main considerations. Table 2-4 shows the outline of this guideline.

Table 2-4: Outline of the sustainability and Due Diligence Guideline (World Wind Energy Association, 2004)

<table>
<thead>
<tr>
<th>Sustainability aspects</th>
<th>Samples of considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>5. “Demonstrated need for the project.”</td>
<td>The Role of Governments and Regulatory Frameworks</td>
</tr>
<tr>
<td>6. Economic viability and planned monitoring of economic performance.</td>
<td>• Governments and sustainability</td>
</tr>
<tr>
<td>7. Availability and cost of resources over the projected life of the facility</td>
<td>• National and regional energy policies</td>
</tr>
<tr>
<td>8. Appropriateness of the technology, levels of efficiency and service required.</td>
<td>• Strategic assessment</td>
</tr>
<tr>
<td>9. Energy payback ratio.</td>
<td>• Promoting wind power in energy production</td>
</tr>
<tr>
<td>10. Distribution and sustainability of economic benefits.</td>
<td></td>
</tr>
<tr>
<td>11. Additional or multiple use benefits</td>
<td><strong>Managing Environmental Outcomes</strong></td>
</tr>
<tr>
<td>12. Poverty reduction through flow on benefits to local communities via employment, skills development, investment opportunities and technology transfer.</td>
<td>• Optimizing environmental outcomes for wind power schemes</td>
</tr>
<tr>
<td>13. Maximize opportunities and benefits for, and not posing significant unsolvable threats to, vulnerable social groups.</td>
<td>• Environmental assessment (EA) principles</td>
</tr>
<tr>
<td>14. Community support and/or lack of community opposition.</td>
<td>• Environmental management systems (EMS)</td>
</tr>
<tr>
<td>15. Safety issues and hazards</td>
<td><strong>Managing Social Outcomes</strong></td>
</tr>
<tr>
<td>16. Environmental impact assessment.</td>
<td>• The role for stakeholder and community consultation</td>
</tr>
<tr>
<td>17. Carbon intensity and greenhouse gas emissions.</td>
<td>• Gaining community acceptance – managing social impacts</td>
</tr>
<tr>
<td>18. Waste products (emissions or discharges to air, water and land).</td>
<td>• Gaining community acceptance – proposed strategies</td>
</tr>
<tr>
<td>19. Extent of land or marine area affected (environmental footprint) and associated aquatic and terrestrial ecological impact.</td>
<td><strong>Managing Economic Outcomes</strong></td>
</tr>
<tr>
<td>20. Avoidance of exceptional natural and human heritage sites.</td>
<td>• Institutional framework</td>
</tr>
<tr>
<td>21. Level of impacts on rare, vulnerable or threatened species, maximizing habitat restoration and protecting high quality habitats.</td>
<td>• Identifying costs and benefits</td>
</tr>
<tr>
<td>22. Environmental management plans</td>
<td>• Allocation of benefits</td>
</tr>
<tr>
<td>23. Environmental management system.</td>
<td></td>
</tr>
</tbody>
</table>
2.3.4 **Seven Questions to Sustainability (7Qs)**

“Over the past decade the mining industry has attempted to strengthen their corporate policies, increase their engagement with government, civil society and community actors, and improve their professional capability to respond to environmental and social challenges” (Junior, Franks, & Ali, 2015). “If the minerals sector is to contribute positively to sustainable development, it needs to demonstrate continuous improvement of its social, economic, and environmental contribution, with new and evolving governance systems. The sector needs a framework within which it should judge and pursue any development” (MMSD North America, 2002. p. 24). During the past decade, the mining sector has invested widely within the matter. This section, as well as sections 2.3.5 to 2.3.8 is a glance at some of these attempts.

In 1999, an initiative was taken by nine of the world’s largest mining companies in response to the growing concern for the disconnection that emerged between mining activities and the values of society (Hodge, 2004). As a result, the industry leaders established the Mining, Minerals and Sustainable Development (MMSD) project. The main objective of MMSD work was the development of a framework, practical principles, and indicators for assessing the compatibility of mining activities with sustainability objectives (International Institute for Sustainable Development, 2004). One of the manifestations of MMSD over the past decades was the development of an integrated, dynamic assessment framework called ‘Seven Questions to Sustainability’ (MMSD North America, 2002). The framework is defined specifically for mining activities at the project level. “The framework emerged in response to the realization that if ideas of sustainability cannot be brought to bear in a way that is meaningful for people working on the ground in real projects, they will be of little use. It is the result of a year-long effort of a multi-interest group involving companies (small to large), government regulators, First Nations/Native Americans, community representatives, organized labour, non-government organizations, teachers and students” (International Sustainability Indicators Network, 2002). The outcome resulted in the identification of seven essential topics/questions for the contribution of mining activities toward SD (International Sustainability Indicators Network, 2002).
### Table 2-5: Summary of 7Qs (MMSD North America, 2002)

<table>
<thead>
<tr>
<th>Defined Objectives/questions</th>
<th>Samples of proposed sub-objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Questions</strong></td>
<td><strong>Engagement</strong></td>
</tr>
<tr>
<td>1. “Are engagement processes in place and working effectively?”</td>
<td>• Engagement process</td>
</tr>
<tr>
<td>2. Will people’s wellbeing be maintained or improved?</td>
<td>• Dispute resolution mechanism</td>
</tr>
<tr>
<td>3. Is the integrity of the environment assured over the long term?</td>
<td>• Reporting and verification</td>
</tr>
<tr>
<td>4. Is the economic viability of the project or operation assured, and will the economy of the community and beyond be better off as a result?</td>
<td>• Adequate resources</td>
</tr>
<tr>
<td>5. Are traditional and non-market activities in the community and surrounding area accounted for in a way that is acceptable to the local people?</td>
<td>• Informed voluntary consent</td>
</tr>
<tr>
<td>6. Are rules, incentives, programs and capacities in place to address project or operational consequences?</td>
<td><strong>People</strong></td>
</tr>
<tr>
<td>7. Does a full synthesis show that the net result will be positive or negative in the long term and will there be periodic reassessments?”</td>
<td>• Community organization and capacity</td>
</tr>
<tr>
<td>(MMSD North America, 2002)</td>
<td>• Social/cultural integrity</td>
</tr>
<tr>
<td></td>
<td>• Worker and population health</td>
</tr>
<tr>
<td></td>
<td>• Availability of basic infrastructure</td>
</tr>
<tr>
<td></td>
<td>• Direct, indirect effects</td>
</tr>
<tr>
<td></td>
<td>• Full social/cultural risks, costs, and benefits</td>
</tr>
<tr>
<td></td>
<td>• Responsibilities and sureties</td>
</tr>
<tr>
<td></td>
<td>• Distribution of cost, benefits, risks</td>
</tr>
<tr>
<td></td>
<td>• Social/cultural stress and restoration</td>
</tr>
<tr>
<td><strong>Environment</strong></td>
<td><strong>Economic</strong></td>
</tr>
<tr>
<td>• Ecosystem function, resilience, and capacity</td>
<td>• Project economic</td>
</tr>
<tr>
<td>• Ecological entitlement</td>
<td>• Economic contributions</td>
</tr>
<tr>
<td>• Full ecosystem cost, risks, and benefits</td>
<td>• Community/regional economics</td>
</tr>
<tr>
<td>• Responsibilities and sureties</td>
<td>• Operational efficiencies</td>
</tr>
<tr>
<td><strong>Traditional and non-market activities</strong></td>
<td><strong>Institutional arrangement and governance</strong></td>
</tr>
<tr>
<td>• Activities/use level</td>
<td>• Effectiveness of legislation, etc.</td>
</tr>
<tr>
<td>• Traditional cultural attributes</td>
<td>• Capacity to address operational consequences</td>
</tr>
<tr>
<td><strong>Overall integrated assessment and continuous learning</strong></td>
<td>• Bridging to post-closure</td>
</tr>
<tr>
<td>• Project level alternatives</td>
<td>• Overall confidence that commitments made will be fulfilled</td>
</tr>
<tr>
<td>• Strategic level alternatives</td>
<td><strong>Overall synthesis</strong></td>
</tr>
<tr>
<td>• Overall synthesis</td>
<td>• Continuous learning</td>
</tr>
</tbody>
</table>

(MMSD North America, 2002)
In the framework, each question accompanies an ideal answer, objectives, indicators, and specific metrics. However, in practice, there is not necessarily a unique or right answer to these questions. In fact, the details of these indicators and metrics are site and time specific and highly dependent on the phase of a project (MMSD North America, 2002). Since what is believed to be today’s ideal answer may shift over time, continuous learning and updating of the indicators, ideal answers, and sustainability objects is a vital part of the assessment (Question 7). Table 2-5 provides the outline of the 7Qs framework with details.

### 2.3.5 Sustainable Development Framework for the Indian Mining Sector

In 2011, the Indian Ministry of Mines (MoM) commissioned EMR India Private Limited to develop a sustainable development framework specific to the need of the Indian mining sector. The attempt was a response to severe criticism that the Indian mining sector was facing due to neglect for social and environmental considerations in their development plans as well as the existing gaps in the available policies and regulations. The framework proposed 7 principles with a review of the current gaps, limitations, and issues around the topic as well as a list of suggestions and considerations to overcome the situation in the context of Indian society (ERM India Private Limited, 2011). Table 2-6 provides the outline of this framework in more details.

<table>
<thead>
<tr>
<th>Defined principles</th>
<th>Samples of proposed considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principles:</td>
<td></td>
</tr>
<tr>
<td>1. Incorporating environmental and social sensitivities in decision on leases</td>
<td>Environmental aspects</td>
</tr>
<tr>
<td>2. Strategic assessment in key mining regions</td>
<td>• Biodiversity</td>
</tr>
<tr>
<td>3. Managing impact at the mine level through sound management systems</td>
<td>• Water</td>
</tr>
<tr>
<td>4. Addressing land, resettlement and other social impacts</td>
<td>• Environment</td>
</tr>
<tr>
<td>5. Community engagement, benefit sharing and contribution to socio-economic development</td>
<td>Social aspects</td>
</tr>
<tr>
<td>6. Mine closure and post-closure</td>
<td>• Land and resettlement</td>
</tr>
<tr>
<td></td>
<td>• Human rights aspects</td>
</tr>
<tr>
<td></td>
<td>• Community engagement, benefit sharing</td>
</tr>
<tr>
<td></td>
<td>• Human resources</td>
</tr>
<tr>
<td></td>
<td>• Contribution to local economy</td>
</tr>
<tr>
<td></td>
<td>Mine closure and post closure aspects</td>
</tr>
</tbody>
</table>
2.3.6 SUSTAINABLE DEVELOPMENT IN MINING INITIATIVE: DEVELOPMENT OF INDICATORS FOR MONITORING THE CONTRIBUTION OF THE SOUTH AFRICAN MINING AND MINERALS SECTOR TO SUSTAINABLE DEVELOPMENT

In 2002, the Department of Minerals and Energy (DME) of Republic of South Africa developed a list of indicators in order to monitor the contributions of the South African mining and minerals sector to SD. The proposed monitoring system aimed to help decision makers to track the progress and contributions of the industry over time at the national scale (DME Republic of South Africa, 2002). Table 2-7 provides the outline of this framework in more details.

Table 2-7: Summary of guideline for the South African mining and sector (DME Republic of South Africa, 2002)

<table>
<thead>
<tr>
<th>Defined principles</th>
<th>Samples of proposed considerations</th>
</tr>
</thead>
</table>
| 7. Assurance and reporting | • Amount of land disturbed and rehabilitated  
• Number of operations with closure plans  
• Number of mines closed, rehabilitated and handed back  
**Assurance and reporting** |  
• Probation of mining lease  
• Improving SD performance as reported |

### Defined principles

| 1. “Maximize the contribution of the mining sector to national economic development | **Examples criteria related to Principle 1:**  
• Relevant technology is developed  
• Facilitate local (South African) beneficiation  
• Direct financial contribution |
| 2. Contribute to the socio-economic development of South Africa | **Examples criteria related to Principle 2:**  
• Skills development and transfer  
• Job creation and employment  
• Contribute towards community development |
| 3. Expand opportunities for historically disadvantaged persons | **Examples criteria related to Principle 3:**  
• Ensure the mining sector is aligned with applicable national guidelines that address historically disadvantaged persons |
| 4. Develop and strengthen health and safety programs and initiatives | **Examples criteria related to Principle 4:**  
• Reducing the spread of diseases (HIV)  
• Improving occupational health |
| 5. Promote responsible practice | **Examples criteria related to Principle 5:**  
• Contribute towards the development of responsible practices |
| 6. Contribute to achieving sustainable (efficient) patterns of production and consumption | **Examples criteria related to Principle 6:**  
• Efficient use of resources  
• Reduce environmental impact |
| 7. Reduce impact on life support systems and the ecological services they provide | **Examples criteria related to Principle 7:**  
• Minimize the impact on natural habitats  
• Promote biodiversity conservation |

Table 2-7: Summary of guideline for the South African mining and sector (DME Republic of South Africa, 2002)
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Defined principles | Samples of proposed criteria
---|---
8. Develop effective partnerships and communication networks to promote good governance | Examples criteria related to Principle 5:

- Law and regulation
- Promote human right and business ethics

9. Ensure the ability of government (i.e. the DME) to fulfill its mandate” (DME Republic of South Africa, 2002) | Examples criteria related to Principle 6:

- Water, air, land management

Examples criteria related to Principle 7:

- Mitigate affected natural capital

Examples criteria related to Principle 8:

- Ensure transparency
- Co-operative governance

Examples criteria related to Principle 9:

- Ensure common vision
- Promote accountability

2.3.7 ENDURING VALUE: THE AUSTRALIAN MINERALS INDUSTRY FRAMEWORK FOR SUSTAINABLE DEVELOPMENT

Following the release of a set of sustainable development principles by the International Council on Mining and Metals (ICMM), the Minerals Council of Australia (MCA) committed to put them into practice within the Australian mining sector at a project level in 2003. As a result, MCA developed a SD framework known as Enduring Value in 2005. The framework is based on the ICMM 10 principles for SD of mining industry, the concept of social license to operate, and GRI reporting structure. The aim was to develop a guideline for the industry best practice in implementing of SD and CSR concepts. MCA indicated that in order to gain social license, a company needs to manage its operation/project “in a manner that is attuned to community expectations and which acknowledges that businesses have a shared responsibility with government, and more broadly society, to help facilitate the development of strong and sustainable communities” (Mineral Council of Australia, 2005). Table 2-8 provides the outline of the framework.
## Table 2-8: Summary of Enduring Value framework for Australian minerals industry (Mineral Council of Australia, 2005; ICMM, 2006)

<table>
<thead>
<tr>
<th>Defined principles</th>
<th>Samples of proposed considerations</th>
</tr>
</thead>
</table>
| 1. “Implement and maintain ethical business practices and sound systems of corporate governance.”                                               | **Example of elements related to Principle 1:**  
- Develop and implement company ethical business principles and practices  
- Comply with the requirements of host country laws and regulations.  
- Work with governments, industry and other stakeholders                                                                           |
| 2. Integrate sustainable development considerations within the corporate decision-making process.                                         | **Example of elements related to Principle 2:**  
- Integrate sustainable development principles into company policies and practices. Plan, design, operate and close operations in a manner that enhances sustainable development.  
- Implement good practice and innovate to improve social, environmental and economic performance whilst enhancing shareholder value. |
| 3. Uphold fundamental human rights and respect cultures, customs and values in dealings with employees and others who are affected by our activities. | **Example of elements related to Principle 3:**  
- Ensure fair remuneration and work and conditions for all employees and do not use forced, compulsory or child labour.  
- Provide for the constructive engagement of employees on matters of mutual concern.  
- Ensure that all relevant staff, including security personnel are provided with appropriate cultural and human rights training and guidance.  
- Respect the culture and heritage of local communities                                                                                 |
| 4. Implement risk management strategies based on valid data and sound science.                                                         | **Example of elements related to Principle 4:**  
- Consult with interested and affected parties in the identification, assessment and management of all significant social, health, safety, environmental and economic impacts associated with our activities.  
- Ensure regular review and updating of risk management systems.                                                                         |
| 5. Seek continual improvement of our health and safety performance.                                                                      | **Example of elements related to Principle 5:**  
- Take all practical and reasonable measures to eliminate workplace fatalities, injuries and diseases among our employees and those of our contractors.  
- Provide all employees with health and safety training, and require employees of contractors to have undergone such training.  
- Implement health surveillance and risk-based monitoring of employees. Rehabilitate and reintegrate employees into operations following illness or injury, where feasible. |
| 6. Seek continual improvement of our environmental performance.                                                                          | **Example of elements related to Principle 6:**  
- Assess the positive, negative and indirect and the cumulative impacts of new projects – from exploration through closure.  
- Implement an environmental management system focused on continual improvement to review, prevent, mitigate or ameliorate adverse environmental impacts.  
- Rehabilitate land disturbed or occupied by operations in accordance with appropriate post-mining land uses.                         |
| 7. Contribute to conservation of biodiversity and integrated approaches to land use planning.                                               | **Example of elements related to Principle 7:**  
- Respect legally designated protected areas.  
- Disseminate scientific data on and promote practices and experiences in                                                                 |
<p>| 8. Facilitate and encourage responsible product design, use, re-use, recycling and                                                      |                                                                                                                                                                                                                                    |</p>
<table>
<thead>
<tr>
<th>Defined principles</th>
<th>Samples of proposed considerations</th>
</tr>
</thead>
<tbody>
<tr>
<td>disposal of our</td>
<td>biodiversity assessment and</td>
</tr>
<tr>
<td>products.</td>
<td>management.</td>
</tr>
<tr>
<td>9. Contribute to</td>
<td>Example of elements related to</td>
</tr>
<tr>
<td>the social,</td>
<td>Principle 8:</td>
</tr>
<tr>
<td>economic and</td>
<td>• Advance understanding of the</td>
</tr>
<tr>
<td>institutional</td>
<td>properties of metals and minerals</td>
</tr>
<tr>
<td>development of the</td>
<td>and their life-cycle effects on</td>
</tr>
<tr>
<td>communities in</td>
<td>human health and the environment.</td>
</tr>
<tr>
<td>which we operate.</td>
<td>• Conduct and support research and</td>
</tr>
<tr>
<td></td>
<td>innovation that promotes the use</td>
</tr>
<tr>
<td></td>
<td>of products and technologies that</td>
</tr>
<tr>
<td></td>
<td>are safe and efficient in their</td>
</tr>
<tr>
<td></td>
<td>use of energy, natural resources</td>
</tr>
<tr>
<td></td>
<td>and other materials.</td>
</tr>
<tr>
<td>10. Implement</td>
<td>Example of elements related to</td>
</tr>
<tr>
<td>effective and</td>
<td>Principle 9:</td>
</tr>
<tr>
<td>transparent</td>
<td>• Engage at the earliest practical</td>
</tr>
<tr>
<td>engagement,</td>
<td>stage with likely affected parties</td>
</tr>
<tr>
<td>communication and</td>
<td>to discuss and respond to issues</td>
</tr>
<tr>
<td>independently</td>
<td>and conflicts concerning the</td>
</tr>
<tr>
<td>verified reporting</td>
<td>management of social impacts.</td>
</tr>
<tr>
<td>arrangements with</td>
<td>• Ensure that appropriate systems</td>
</tr>
<tr>
<td>our stakeholders.</td>
<td>are in place for ongoing interact</td>
</tr>
<tr>
<td></td>
<td>with affected parties, making sure</td>
</tr>
<tr>
<td></td>
<td>that minorities and other</td>
</tr>
<tr>
<td></td>
<td>marginalized groups have</td>
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<tr>
<td></td>
<td>equitable and culturally</td>
</tr>
<tr>
<td></td>
<td>appropriate means of engagement.</td>
</tr>
<tr>
<td></td>
<td>• Contribute to community</td>
</tr>
<tr>
<td></td>
<td>development from project</td>
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<tr>
<td></td>
<td>development through closure in</td>
</tr>
<tr>
<td></td>
<td>collaboration with host</td>
</tr>
<tr>
<td></td>
<td>communities and their</td>
</tr>
<tr>
<td></td>
<td>representatives.</td>
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<td></td>
<td>Example of elements related to</td>
</tr>
<tr>
<td></td>
<td>Principle 10:</td>
</tr>
<tr>
<td></td>
<td>• Report on our economic, social</td>
</tr>
<tr>
<td></td>
<td>and environmental performance and</td>
</tr>
<tr>
<td></td>
<td>contribution to sustainable</td>
</tr>
<tr>
<td></td>
<td>development.</td>
</tr>
<tr>
<td></td>
<td>• Provide information that is</td>
</tr>
<tr>
<td></td>
<td>timely, accurate and relevant.</td>
</tr>
</tbody>
</table>

### 2.3.8 **Towards Sustainable Mining (TSM)**

During the 90s, a series of high-profile tailings dam failures tarnished the trust and reputation of Canadian mining sector internationally. As a result of these events, several proposed mining projects could not be pursued under the negative public pressure. Therefore, The Mining Association of Canada (MAC) voluntarily initiated the investigation and development of strategies to align the performance of the Canadian mining sector with the values and expectations of Canadian society and standards that became the foundations for Toward Sustainable Mining (MAC, 2015). The initiation started in 1998. For a period of four years, the focus was on gathering multi-stakeholders input and developing the main principle and criteria. From 2001-2004, the proposed framework was tasted; the first draft was published including principles, protocols, criteria, and implementation guidelines in 2004 (MAC, 2015).
Table 2-9: Summary of TSM (MAC, 2015)

<table>
<thead>
<tr>
<th>Defined main principles</th>
<th>Samples of performance protocol</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Involving communities of interest in the design and implementation of our</td>
<td>• Tailings management</td>
</tr>
<tr>
<td>Towards Sustainable Mining initiative;</td>
<td>• Energy use and greenhouse gas emissions management</td>
</tr>
<tr>
<td>• Proactively seeking, engaging and supporting dialogue regarding our operations;</td>
<td>• Aboriginal and community outreach</td>
</tr>
<tr>
<td>• Fostering leadership throughout our companies to achieve sustainable resource</td>
<td>• Crisis management planning</td>
</tr>
<tr>
<td>stewardship wherever we operate;</td>
<td>• Safety and health</td>
</tr>
<tr>
<td>• Conducting all facets of our business with excellence, transparency and</td>
<td>• Biodiversity conservation management</td>
</tr>
<tr>
<td>accountability;</td>
<td></td>
</tr>
<tr>
<td>• Protecting the health and safety of our employees, contractors and communities;</td>
<td></td>
</tr>
<tr>
<td>• Contributing to global initiatives to promote the production, use and recycling of</td>
<td></td>
</tr>
<tr>
<td>metals and minerals in a safe and environmentally responsible manner;</td>
<td></td>
</tr>
<tr>
<td>• Seeking to minimize the impact of our operations on the environment and</td>
<td></td>
</tr>
<tr>
<td>biodiversity, through all stages of development, from exploration to closure;</td>
<td></td>
</tr>
<tr>
<td>• Working with our communities of interest to address legacy issues, such as</td>
<td></td>
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<tr>
<td>orphaned and abandoned mines;</td>
<td></td>
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<tr>
<td>• Practicing continuous improvement through the application of new technology,</td>
<td></td>
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<tr>
<td>innovation and best practices in all facets of our operations.</td>
<td></td>
</tr>
<tr>
<td>• Tailings management</td>
<td></td>
</tr>
<tr>
<td>• Energy use and greenhouse gas emissions management</td>
<td></td>
</tr>
<tr>
<td>• Aboriginal and community outreach</td>
<td></td>
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<tr>
<td>• Crisis management planning</td>
<td></td>
</tr>
<tr>
<td>• Safety and health</td>
<td></td>
</tr>
<tr>
<td>• Biodiversity conservation management</td>
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</tbody>
</table>

2.3.9 **The Natural Step to Sustainability Framework for Businesses**

The Natural Step framework for businesses is shaped around the idea of helping companies to understand their role in society’s (host community’s) journey toward SD. The core process includes:

- “Recognize directions that drives society and business into unsustainable development paths
- Understand the Four System Conditions of the Natural Step explained in Section 2.3.3
- Defining the desired future vision (back-casting)
- Setting up strategies to guide the business toward that vision” (Nattrass & Altomare, 2013)

The key is in thinking within the system (as a part of society/community) instead within the corporate boundaries. The term *system-thinking* is defined as:

“An approach to problem-solving that assumes that the individual problem is part of a much larger system. The intent is to solve the problem in a way that does not create further problems
down the road. This approach is particularly important in complex systems where we do not always understand the inter-connection between parts.” (The Natural Step, 2016)

On one hand, communities can use the Natural Step framework to evaluate and monitor projects as well as dedicate their incentives and support. On the other hand, the companies can use the framework to design, transform, guide, and monitor their performance (Nattrass & Altomare, 2013). Note that the focus of the framework is generally on the environmental considerations of the businesses, as it assumes that the environmental actions lead to the social consequences.
2.4 SD Performance Evaluation

A remaining challenge confronting implementation of sustainable development goals is how to evaluate and track the overall outcome and progress of such efforts. “Besides many efforts and activities by NGOs, authorities and governments, corporations also seem to show an increasing commitment to a more sustainable behaviour. However, in many cases this is still done simply on the basis of a changed rhetoric, of green-washing (Laufer, 2003; Ramus, 2005). One reason for green-washing could be that corporations do not really know how they can integrate sustainability issues into their business routines and their strategies. It seems that sustainability issues are pursued more coincidentally than with a clear strategy” (Baumgartner & Ebner, 2010).

Sustainable development is a dynamic concept. As so, learning, updating/revising the objectives, and improving the performance of the defined system is inseparable part of any project that aims to contribute to the SD. Therefore, to ensure the desirable outcome, evaluating the performance of the system is crucial during the project lifetime. This section reviews some of the common approaches of sustainable development frameworks and guidelines to address the matter, including defining clear objective and sub-objectives, accompanying them with indicators, metrics and maturity models.

2.4.1 Indicators and Metrics

The first step toward sustainable development is to come up with agreement on a common understanding/interpretation about the meaning of sustainable development for that particular place and time. Therefore, specific SD goals and objectives should be defined (Redclift, 2005). Goals have to be clear and measurable (Ciegis, Ramanauskiene, & Startiene, 2009). Due to the dynamic nature of sustainable development, the goals should be continuously modified over time.

The next step is to measure the state of a system at which the defined goals are achieved. Indicators represent one of the tools that can be used for evaluation of the progress at any time. "In general terms, an indicator is a quantitative or a qualitative measure derived from a series of observed facts that can reveal relative positions in given area" (Ciegis, Ramanauskiene, & Startiene, 2009). Indicators are used to move from the theoretical stage to the practical and to better decision-making.
Measurements are needed for all dimensions of SD including environmental, economic, social, and governance dimensions. The indicators can be internal (indicating the functionality of the system itself) or external (indicating the state of the system in relation with external variables outside its boundaries) (Afgan & Carvalho, 2002).

Indicators are summarizing enormous amounts of information flowing into and within the system and providing a feedback mechanism for decision makers. This makes the role of indicators crucial in measuring the level of achieving SD goals. The following criteria have been defined for good indicators (based on the work of: Olsson, Hilding-Rydevik, Aalbu, & Bradley, 2004; Pastille Consortium, 2002 as referenced by Ciegis, Ramanauskiene, & Startiene, 2009):

1. Exact, transparent and explainable;
2. Relevant, cost-effective and sensitive;
3. Instructive and usable;
4. Scientifically reliable or analytically sound, including response to change;
5. Measurable according to standardized methods and based on accessible data;
6. Comparable, not ambiguous and robust or independent of assumptions;
7. Limited in number;
8. Related to a reasonable time horizon and to relevant spatial area; and,
9. Capable of relating to other indicators and aggregation.

"Indicators are strongly dependent on the type of the system they monitor" (Afgan & Carvalho, 2002), the meaning of SD for the decision makers for the given event, and the way they weight the importance of economic, environmental, and social dimensions. There are only few practical and effective examples of implementing integrated assessments in the world (Pope, Annandale, & Morrison-Saunders, 2004). Many of the current sustainability assessments are actually driven from impact assessment tools (Ness, Urbel-Piirsalu, Anderberg, & Olsson, 2007) like Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA). However, current sustainable development assessments have been extended in their consideration and coverage to meet growing demands on social and economic concerns (Pope, Annandale, & Morrison-Saunders, 2004).
For this application different weights are assigned to them (Gibson, 2001). This is the most common evaluation method used in SD frameworks.

2.4.2 Maturity Model

Corporate’s reactions toward facing new challenges, standards, or approaches vary based on their management style and culture. The maturity models show the cultural differences of companies in adopting, implementing and committing to the new standards or approaches. Most maturity models and corporate cultural profiles have been driven from Capability Maturity Model (CMM) developed by the Software Engineering Institute (SEI). This method is used “to deploy an evolutionary path to help organizations increase the capability of their processes through five consecutive stages or maturity levels” (Cagnin, Loveridge, & Butler, 2005). CMM identifies an increasing series of capability/maturity levels to help organizations that are heavily dependent on software-reliant systems to improve and maintain their systems over time (Paulk, 1994). These levels are a combination of capability level and organization cultural profile and can be categorized as:

- **Level 1 – Initial**: inconsistent management approach with no required processes, which are unpredictable and poorly controlled, as well as roughly predictable schedules and costs. Success depends on an exceptional manager and an experienced development team. However, processes cannot be repeatable without the same human resources involved. Hence, capability is a characteristic of individuals rather than of the firm;

- **Level 2 – Repeatable**: project management approach where previously mastered tasks can be repeated. Usual areas of improvement are: assistance and assurance of policy compliance; measurement projects; management of product configurations; management of suppliers; planning and tracking projects; and, managing requirements. Here the organization has achieved a stable process with repeatable management control level and project management of commitments, costs, schedules and changes. Thus, new projects are planned and managed based on experience with similar projects and, therefore, policies support managers to establish suitable management processes;

- **Level 3 – Defined**: process management approach where processes are characterized and fairly well understood. Usual areas of improvement are: coordination between organizational
groups; provision of organization-wide training; collection of process-level data; deployment and management processes; definition of common processes; identification of required processes; and establishment of improvement infrastructure. Here the organization defined the process as a basis for consistent implementation and better understanding and, therefore, the risk of introducing advanced technology is reduced. The process includes readiness criteria, inputs, standards and procedures, verification, outputs and completion criteria. Moreover, process capability is based on an organization-wide understanding of the activities, roles and responsibilities in a defined process.

- Level 4 – Managed: capability management approach where processes are measured and controlled. Usual areas of improvement are: establishment of capability baselines; and, quantitative management of processes. Here the organization initiated comprehensive process measurements and analysis. There might be an organization-wide database in use to collect and analyze data from projects’ defined process. Furthermore, the process is measured and operates within measurable limits, as well as it can predict trends in process and product quality.

- Level 5 – Optimized: change management approach with a focus on processes improvement. Usual areas of improvement are: elimination of causes of defects; evaluation and deployment of improvements; and development of change infrastructure. Here the organization has in place a foundation for continuously improving and optimizing processes. Best practices and innovations are identified and transferred throughout the organization. Project teams are capable to analyze defects and determine their causes, to evaluate the process to prevent known types of defects from recurring, and to disseminate lessons learned to other projects. In addition, efforts to remove waste along the process result in changing the common causes of inefficiency.\(^{13}\)\(^{14}\) (Cagnin, Loveridge, & Butler, 2005)

Many researchers have characterized the corporate management profile in general or for a specific topic (operational safety, sustainable development, et.) as a reflection of their management maturity. Regarding SD, the corporate profile illustrates how deeply the concept of SD is integrated within the structure of a company and its day-to-day decisions (maturity level). Although these levels/characteristics are named differently by various authors, they are often similar in descriptions. For instance the works of Baumgartner and Ebner (2010) on SD cultural profile or Pitzer and van Zyl
(2013) and Foster and Hoult, (2013) on corporate culture toward safety use slightly different terms with similar concepts:

- **Baumgartner and Ebner (2010):** defined maturity levels for corporate SD profile as:
  
  1. “Introverted - risk mitigation strategy: focus on legal and other external standards concerning environmental and social aspects in order to avoid risks for the company
  2. Extroverted - legitimating strategy: focus on external relationships, license to operate
  3. Conservative - efficiency strategy: focus on eco-efficiency and cleaner production
  4. Visionary (conventional & systematic visionary) - holistic sustainability strategy: focus on sustainability issues within all business activities; competitive advantages are derived from differentiation and innovation, offering customers and stakeholders’ unique advantages” (Baumgartner & Ebner, 2010).

- **Pitzer and van Zyl (2013):** categorized corporate profiles based on their maturity level in implementing the new risk management approach as in Figure 2-4.

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**Figure 2-4:** Corporate cultural differences based on their maturity to implement the new safety management approaches (Pitzer & van Zyl, 2013)
– Foster and Hoult, (2013): who defined corporate culture toward safety as:

1. “Pathological - Safety is a problem caused by workers. The main drivers are the business and a desire not to get caught by the regulator.”

2. Reactive - Organizations start to take safety seriously but there is only action after incidents.

3. Calculative - Safety is driven by management systems, with much collection of data. Safety is still primarily driven by management and imposed rather than looked for by the workforce.

4. Proactive - With improved performance, the unexpected is a challenge. Workforce involvement starts to move the initiative away from a purely top down approach.

5. Generative - There is active participation at all levels. Safety is perceived to be an inherent part of the business. Organizations are characterized by chronic unease as a counter to complacency” (Foster & Hoult, 2013).
Chapter 3

Reviewing Today’s Geothermal Power Development Practice

This chapter reviews today’s geothermal power development practices through case studies with the aim of recognizing its merits, recent initiatives and positive approaches as well as the gaps, limitations, and challenges that the industry faces to truly walk along a SD path. This is separated from the literature review to highlight the importance of these case studies, because the outcomes of these cases will be used in the further development of this thesis (Chapter 5 and 6). Note that the case studies in this chapter are only based on available public information and no field investigation was conducted.

The Chapter first reviews the common known impacts of a geothermal power project in literature review (in section 3.1) followed by three case studies in sections 3.2, 3.3, and 3.4 respectively to determine the other challenges that a geothermal power project may face in practice. The following case studies were selected based on country level economic development, project longevity, availability of data, or challenging development history:

- Olkaria III project in Kenya is an example of a world leading geothermal power producer with a unique and quite impressive governmental incentive program;
- Svartsengi project in Iceland as the world’s first geothermal power plant utilizing high-temperature reservoir with an initiative approach toward the concept of an industrial park;
- Puna project in U.S. as an example of a long and heated history associated with social controversies.

3.1 Overview of Geothermal Power Utilization Considerations

Geothermal energy is the heat inside the Earth’s crust stored dominantly within rocks and water. Conventional resources (those with the presence of steam or water as a heat carrier) can be extracted by drilling wells deep enough to hit high temperatures but shallow enough to be economically
feasible (Mariita, 2002). To generate electricity, the extracted steam or hot water is then fed through pipes to a thermal power plant facility.

As a base-load renewable power source, geothermal energy utilization is gaining more and more attention in both developed and developing countries around the world. Although, its environmental impacts are well understood, its socio-economic impacts have yet to become better known to the industry, public and governments (Odour, 2010). By 2010, 24 countries had installed total generation capacity of 13GW of geothermal power. About 90% of this amount is generated in USA, Philippines, Indonesia, Mexico, Italy, Iceland, New Zealand, and Japan (Bayer, Rybach, Blum, & Brauchler, 2013). These are the countries with more active tectonic and young volcanic areas resulting in higher temperature gradients, which makes geothermal power more economically attractive. To promote geothermal energy along with other renewable, environmentally friendly energy sources, it is essential to recognize all aspects of its development in both local and regional scales. In the following sections, the environmental and social impacts of a geothermal power project are discussed.

3.1.1 **Environmental Impacts**

As with all energy sources, geothermal power development has both positive and negative impacts on the environment. Many of its negative impacts can, however, be prevented through thoughtful designs, use of new technologies, and continuous monitoring. Some advantages of a geothermal power development are (Brophy, 1997; Gupta & Roy, 2007):

- It is renewable and can be extracted in a sustainable manner;
- As there is low to zero gas emissions, it can significantly reduce generation of greenhouse gases that are related to power generation from fuel combustion power plants as well as other renewable power sources;
- Its operation has little to no waste and often the extracted water/steam is injected back into the underground;
- Geothermal power plant facilities have a smaller footprint compared to conventional oil, gas, coal, nuclear, and other renewables like solar, hydro, and wind;
Using geothermal energy helps in preservation of non-renewable energy sources (fossil fuels) for future generations.

Development of a geothermal power plant may also raise some environmental concerns such as physical, biological, chemical (Note that many of these concerns can be minimized, controlled, or prevented):

The physical impacts of geothermal power development include land use and disturbance, localized climate change, possible land subsidence and ground deformation, visual impairment from steam condensation, soil erosion, noise pollution, disturbance to animal migration, aesthetic appearances (transmission lines, power tower, pipelines, power plant), micro earthquakes, and solid waste (Kubo, 2003). The last phase of the production is known as reclamation and abandonment. During this phase, a company is expected to remove the power plant, plug and cap the wells, and facilitate natural restoration in the site area. As an example of physical impacts, Table 3-1 illustrates typical land disturbance during the development of a 30-50 MW geothermal power plant based on the USA experience. The
value range depends on the location and size of a plant, and its distance to the demand/transmission lines (Bayer, Rybach, Blum, & Brauchler, 2013);

- Biological impacts include any form of chemical toxicity, heat waste, loss of micro-flora and fauna, habitat destruction, animal movement difficulties (Kubo, 2003). All geothermal power generation releases a large amount of waste heat into the atmosphere or surface water bodies depending on the power plant types that may impact the surrounding biodiversity. Figure 3-1 shows typical amounts of waste heat from different types of geothermal power plants;

- The chemical impacts of a geothermal power development include the emissions into the atmosphere, soil, and water. Although gaseous pollution from geothermal power plants has low measurable environmental effects, monitoring and measuring of the geothermal gases with specific environmental threats are necessary. These gases are mostly CO₂, H₂S, CH₄ and Rn. Other sources of chemical concerns are arsenic, boron, mercury that are leached by rain and threaten soil and surface water bodies, and drilling fluid effluents (Kubo, 2003; Bayer, Rybach, Blum, & Brauchler, 2013).

![Figure 3-1: Waste heat (MWt) per unit of electric capacity (MWe) based on different type of geothermal power plant (from Bayer, Rybach, Blum, & Brauchler (2013), prepared after Dippipo (1991))](image-url)
3.1.2 SOCIO-ECONOMIC IMPACTS

Though the first geothermal power plant came online in the early 1900s in Italy, the technology did not get much attention in the worldwide energy market until the 1960’s, and even more specifically after the 1970’s oil crisis. Since then, there have been few published studies on the social impacts of geothermal power projects. The social impacts of geothermal power developments are varied and typically site specific. It may seem that geothermal power developments have few direct social impacts on surrounding communities; however, they bring many indirect social impacts locally as well as regionally and nationally.

Some of the direct advantages of being near a geothermal power plant include providing professional job opportunities, connection to a reliable local power source, potential for attracting eco-friendly spin-off industry and tourism to the community, and also providing opportunity for other related industries to join in creation of an industrial park centered by geothermal power (Svartsengi project in Iceland, the case study in section 3.3, is an excellent example of such an approach). Furthermore, often there are voluntary contributions by geothermal power projects to the improvement of local community wellbeing via donation of additional funds to local schools or health centers, etc. (Kagel, 2006; Hence, 2005).

Construction and development of geothermal power plants involve many types of skilled workers, creating several job opportunities for locals and the rest of the nation. Studies by Hence (2005) show that the construction phase of each 2 MW power plant in USA involves 3.1 person-year jobs, during the project’s life, especially in the construction phase. Although the jobs related to the construction phase are mostly temporary, employment related to operation and maintenance (O & M) of a power plant are steady and secure. According to Hence (2005), geothermal power development is providing 0.74 steady, long-term jobs/MW in USA. Considering that development and construction of power plants needs various goods and services from other industries and businesses, geothermal development indirectly boosts the employment rates and economy on local, national, and global scales. Note that, the job opportunities for locals during the geothermal power developments are considered marginal, as typically specialized people and experts are mostly needed for design, drilling, plant operations, etc. (Bayer, Rybach, Blum, & Brauchler, 2013).
The main indirect socio-economic benefits of geothermal power developments are through royalties and taxes. In USA, since 2005, “25% of the federally imposed royalty is returned to the county/region of origin, 25% to the federal government, and 50% to the state (previously royalties were equally shared by the state and federal government)” (Kagel, 2006). Geothermal power development also has an indirect significant contribution on improvement of public health by reducing greenhouse gases emissions and provide clean source of energy and power. On the socio-political level, geothermal energy reduces a country’s dependency on international energy sources and increases the national energy security (Kagel, 2006).

Table 3-2 Economic benefits of a 50 MW geothermal power plant over 30 years of operation (Kagel, 2006)

| Employment (direct, indirect, and induced) | 212 fulltime jobs/800 person-years (p-y) |
| Economic Output (over 30 years, nominal)   | $749 million |
| Royalties                                 |
| Contribution to the Federal Government    | $5.46 million |
| Contribution to the State                 | $10.9 million |
| Contribution to the County                | $5.46 million |

Table 3-2 shows the average economic benefits that a 50 MW geothermal power plant can provide locally and nationwide over 30 years of operation on federal lands in USA (Kagel, 2006). The negative social impacts of a geothermal power project are listed below (note that severity of negative impacts can be minimized by collaboration with stakeholders, planning ahead, monitoring, and careful design):

- Cultural and lifestyle disturbance due to rush of outside labours to the area;
- Relocation of dwellings due to distance to power plant or construction site;
- Health issues mostly due to construction, noise levels, and other severe environmental impacts.
- Tourism and cultural activities for instance by impacting on nearby geothermal features like hot springs.
3.1.3 **Technical and Financial Challenges of Geothermal Power Developments**

Reviewing the recent growth rate and installed capacity of geothermal power developments show that the industry is behind the other renewable energies specifically hydro, wind and solar powers in terms of market share (Li, Bian, Liu, Zhang, & Yang, 2015). Table 3-3 compares the global power installation of these energy resources by 2013 as well as the increase installation amount between 2008-2013. The last column in table shows the market share percentage of each energy resource in the total global energy market (including renewable and non-renewable energy resources).

<table>
<thead>
<tr>
<th>Energy</th>
<th>Total installed by 2013 (GW)</th>
<th>Increase (2008-2013) (GW)</th>
<th>% of total power installed globally</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>139</td>
<td>116</td>
<td>2.42</td>
</tr>
<tr>
<td>Wind</td>
<td>318</td>
<td>159</td>
<td>5.55</td>
</tr>
<tr>
<td>Hydro</td>
<td>1000</td>
<td>125</td>
<td>17.44</td>
</tr>
<tr>
<td>Geothermal</td>
<td>12.0</td>
<td>1.10</td>
<td>0.21</td>
</tr>
</tbody>
</table>

The comparison between these power resources shows that social acceptance, high initial investment, long payback time, construction time, and difficulty to assess reservoir characteristic are the main reasons that slow down the geothermal power developments globally (Table 3-4) (Li, Bian, Liu, Zhang, & Yang, 2015). Note that these numbers may vary based on the reservoir characteristic, utilization method, demand size and proximity to the power plant, governmental incentive and subsidies, technological advances.

<table>
<thead>
<tr>
<th>Energy</th>
<th>Cost (USD/kWh)</th>
<th>Payback period (year)</th>
<th>Construction period (year)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar PV</td>
<td>0.24</td>
<td>1-2.7</td>
<td>0.3-0.5</td>
</tr>
<tr>
<td>Wind</td>
<td>0.07</td>
<td>0.4-1.4</td>
<td>&lt;1</td>
</tr>
<tr>
<td>Hydro</td>
<td>0.05</td>
<td>11.8 (small), 0.5 (large)</td>
<td>1 (small), 10-20 (large)</td>
</tr>
<tr>
<td>Geothermal</td>
<td>0.07</td>
<td>5.7</td>
<td>Varies depend on utilization mode</td>
</tr>
<tr>
<td>Coal</td>
<td>0.04</td>
<td>3.18</td>
<td>1-3</td>
</tr>
<tr>
<td>Gas</td>
<td>0.05</td>
<td>7</td>
<td>2-3</td>
</tr>
</tbody>
</table>

Temperature wise, geothermal resources can be divided into three categories of low-temperature (below 90 °C), moderate-temperature (between 90 and 150 °C), and high-temperature (above 150 °C). Temperature of lower than 100 °C are typically more suitable for heating and cooling application. But
the moderate-temperature resources can be technically used for both electrical and heating/cooling applications. However, a study by Kanoğlu and Çengel (1999) shows that in case of moderate-temperature resources, heating and cooling application produces a three times of revenue in comparison with electricity application. However, in the case of high-temperature reservoirs the combination of electricity and heating/cooling applications seems wiser.

While geothermal energy can be found everywhere, based on the current technology, only few resources are economically feasible for electricity generation. The challenges for a geothermal power project can be categorized in two groups: technical and financial. While power cost and payback time are among the main financial challenges of geothermal power projects, heat capacity, geothermal fluid type, well productivity and its rate of decline, construction time, project lifetime, efficiency, utilization mode, and resource characteristics are the technical challenges for the industry (Sanyal, 2005; Li, Bian, Liu, Zhang, & Yang, 2015; Kanoğlu and Çengel, 1999; Ungemach, Antics, & Papachristou, 2005).

Regarding the financial considerations, one of the important financial factors for power utilities and their investors is the power cost per kWh of production. Sanyal (2005) identifies the following six factors that affect geothermal power cost in developing a geothermal power project:

1. Capital cost;
2. Operations and maintenance (O&M);
3. Make-up well drilling cost;
4. Resource characteristics (well productivity and its rate of decline)
5. Development and operational options (installed plant capacity, number of years of make-up well drilling, and project life);
6. Macro-economic climate (interest and inflation rates)

Sanyal (2005) compared the effect of these six factors on power cost of geothermal projects with the installed capacity range of 5 to 150 MW. He found that the minimum achievable power cost is 3.4 ¢/kWh. Based on his study, the power cost is sharply reduced by maintaining the full capacity of the reservoir (e.g. by drilling make-up wells and reinjection) for the first 10 years of production.
However, after 20 years of production the cost of drilling new make-up wells may increase the power cost. Maintaining the reservoir status is a vital factor in feasibility of a project. As a result, the lifetime of reservoir and wells (production, injection, and make-up) are the key deciding features in management strategies for today’s geothermal power developments (Ungemach, Antics, & Papachristou, 2005).

Based on the reservoir characteristic, the drilling cost is typically in the range of 20-50% of the total geothermal electricity cost. In general, the relative magnitude cost of an average geothermal power project is 40% drilling, 40% surface plants (such as separators, piping, turbines, and generators), and the remaining 20% goes to operation cost and geological and geophysical exploration activities (Stefánsson, 2002; Murphy & Niitsuma, 1999). Due to the high upfront cost of the drilling, it is of economic importance to reduce the time laps between the drilling and start of production. However, in reality, this is quite impossible as generation capacity, production characteristic, and reservoir reaction to production, quality of geothermal fluid, geochemistry, and reservoir temperature is uncertain. To determine these factors running and monitoring a test production for couple of years is essentials. “This will result in a relatively high cost of investigation to be paid long before generation can start. If a stepwise development is adopted, on the other hand, production from the first unit can be used to monitor the reservoir response and to estimate the generating capacity of the geothermal system” (Stefánsson, 2002).

In 2014, the Geothermal Energy Association (GEA) published a summary report on risks associated with geothermal power developments. According to this report, drilling a single well may cost between $1 million and $7 million depending on the location, well depth and diameter, and geology of the area. A report by the International Finance Corporation (IFC) in 2013 indicated, “a success rate of between 60 and 70 percent was found to be the most common outcome for wells drilled during the Development Phase”. This upfront uncertainties and cost associated with the drilling and exploration phase bring a significant financial burden to the industry.

Note that, despite the enormous efforts by the industry to extent the lifespan of geothermal power projects to 100-300 years, the economic lifetime of geothermal power developments is often considered to be between 20-30 years (IEA, 2010). However, a report by the International Energy Agency (IEA) in 2010 indicated that about 50% of current installed geothermal power projects has
been in operation for more than 25 years including two developments with more than 50 years of operation (IEA, 2010).

Exploring these technical and financial considerations in greater details is beyond the scope of this research. However, for a detail reservoir engineering strategies, interested readers are encourage to review documents such as: IEA (2014); GEA (2014); Grant and Bixley (2011); Ghoreishi Madiseh, Ghomshei, Hassani, and Abbasy (2012); Ungemach, Antics, and Papachristou (2005, April); and, Coats (1977, January). Note that in some of these works, the term SD may be used in referring to a different concept. While, they are mainly focused on the longevity of the reservoir, this research is focused on the dynamics of the project in regard to its neighbouring community.
3.2 **Case Study One: Olkaria III Project, Kenya**

The Olkaria III project in Kenya is the first privately funded and developed geothermal power project located in Olkaria region in the Great Rift Valley. Kenya is the first African country that tapped geothermal energy as a source of power (Tole, 1996), and one of the world’s leading geothermal power producers (Micale, Trabacchi, & Boni, 2015). The significance of the Olkaria III project is related to a unique approach of the Kenyan government in attracting foreign investors to overcome the country’s struggle in boosting their energy sector.

![Figure 3-2: Location of KenGen power projects in Kenya (After KenGen, 2016)]
3.2.1 Kenya’s Energy Challenges

Kenya is considered a predominantly rural country in which about 80% of the population lives in the countryside. Electricity is considered to be an expensive luxury and power outages are common phenomena. With a population of about 44 million, 80% of Kenyans have no access to reliable electricity. Only 5% of the rural population has access to electricity. Governmental survey of 2014 predicted over 300% increase in electrical demand by 2016/17 (Micale, Trabacchi, & Boni, 2015). Despite the vast investments in the electrification program, the population growth and the consequent increasing demand exceeds the electricity production level. “Outages either due to drought or lack of system maintenance as well as voltage fluctuations have resulted in unreliable service causing economic losses” (Ogola, Davidsdottir, & Fridleifsson, 2011).

3.2.2 Vision and Policy

Until recently, the country mainly relied on hydro and diesel-fuelled plants for electricity. But several years of frequent droughts and reliance on expensive imported oil was hard on Kenyan industries and the economy. In 2008, 55% of the national foreign exchange earnings from exports were consumed by the cost of imported oil (Ogola, Davidsdottir, & Fridleifsson, 2011). The problem forced the Government of Kenya (GoK) to undertake extensive investments in renewable energies including geothermal power as a domestic, reliable, cost-competitive, and environmentally friendly source of power (Figure 3-2 shows the location of Kenya’s power stations). The country has a significantly high potential for various renewable energies such as geothermal, solar, hydro, and biomass. Of this potential, the country has only harnessed about 4% of its geothermal prospect, 30% of hydro and a slight portion of wind and solar potentials (Ogola, Davidsdottir, & Fridleifsson, 2011). Despite the high potential, the financial burden of this needed infrastructural energy development for the country, led the GoK to seek foreign investments. Even though the political will has been strong, the progress has been slow. The private sector is hesitant to step up to the plate “mainly due to the long timeframe required to confirm a geothermal resource, high upfront risks related to exploration, and significant capital investments for the development of power plants” (Micale, Trabacchi, & Boni, 2015). To encourage the private sector, GoK has conducted exploration and preliminary resource assessment beforehand in order to mitigated the upfront risks of investment in the Olkaria III project area.
Gok set the country’s 2030 energy vision’s core on increasing geothermal power production capacity to 5,000 MWe (Micale, Trabacchi, & Boni, 2015). Prior to the development of Olkaria III, all geothermal power activities were controlled and operated by the state corporation, Kenya Electricity Generating Company (KenGen). KenGen started the operation of geothermal power plants known as Olkaria I and II. To attract international investors, GoK has proactively worked on formulating supportive renewable policies and incentives. The Olkaria III project is the result of this approach and international cooperation. Various international financing players on board such as the World Bank, Japan International Cooperation Agency, the European Investment Bank, the French Agency for Development, USA government, and the German government-owned development bank KfW Entwicklungsbank has been attracted to the area (Out of Law, 2015).

### 3.2.3 Technical and Financial Overview of Olkaria III Project

After KenGen ran the preliminary exploratory test in the area, Ormat Technologies, an international private company, took over the Olkaria III project in the late 90s. As a welcome package, KenGen donated Ormat 8MWe of wells and all available data. Olkaria III’s first 13MWe power plant was successfully connected to the power transmission line in 2000. In 2009, Ormat signed a 20-year power purchase agreement (PPA) with Kenya Power and Lighting Company Limited (KPLC). By 2014, the company has managed to expand its production to 110 MWe. High governmental ambition and support has been a key factor in attracting both public and private investors to the project. Since 2000, Orpower 4 Inc, Ormat’s indirect wholly owned subsidiary, operates the power plant. Table 3-5 briefly shows the technical and financial features of the Olkaria III project.

<table>
<thead>
<tr>
<th>Power generation technology</th>
<th>Binary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of production wells</td>
<td>22 wells</td>
</tr>
<tr>
<td>Depth of production wells</td>
<td>2.3 km on average in 2000-2002; 1.7 km in 2011-2013</td>
</tr>
<tr>
<td>Reservoir temperature</td>
<td>High (above 200°C)</td>
</tr>
<tr>
<td>Installed capacity</td>
<td>110 MW</td>
</tr>
<tr>
<td>Total financial input by 2013</td>
<td>USD 445 million</td>
</tr>
</tbody>
</table>
Chapter 3 - Reviewing Today’s Geothermal Power Development Practice

On the technical side, Ormat applied a phase-by-phase approach in development of the project. Ormat started with a smaller facility including power plant, and the wells. Once their assessments were approved, the feasibility of further expansions, additional facilities was added. (Ormat Technologies, Inc., 2014). This development strategy enabled Ormat to minimize the upfront investment risks and to manage the cash flow while generating income from the first facility (Ormat Technologies, Inc., 2014).

3.2.4 Environmental Considerations

The Olkaria III project is located partly within the Hell’s Gate National Park and partly within two neighbouring farms. Several environmental audits, conducted by Tole, Shivoga and Konana during 2004-2010, indicated that the surrounding environment has not been significantly affected by the project development (Tole, Shivoga & Konana, 2011). It appears that Orpower 4 Inc. implemented its Environmental Management Plan well (Mariita, 2002; Odour, 2010; Kubo, 2003). The environmental audit mainly studied the project’s impacts on wildlife, the hydrology of lake Naivasha, health of the surrounding communities and workforce, air and noise pollutions, and impacts on the neighbouring flower farms (Tole, Shivoga & Konana, 2011). Ormat also presented these issues in its annual report (2014) called sustainability report on their website.

3.2.5 Socio-Economical Considerations

The socio-economic difficulties caused by the booming development of geothermal power plants in Kenya proves that how ignoring an integrated approach toward sustainable development (in this case lack of the social and governing aspects) can eventually trigger social conflict and local negative feelings toward further geothermal developments in the area despite of noticeable national positive impacts. The Olkaria geothermal field is located in a very sensitive area, both environmentally and culturally. The area is mainly used for wildlife conservation, tourism, geothermal activities, and flower-growing farming (Mariita, 2002). The land is a home to the country’s poorest nomadic communities of the Maasai. The nomadic lifestyle of Maasai communities has been slowly changing because of the geothermal project in the area and the farming activities in the area. There are about 2000 Maasai people near the Olkaria projects. These are mostly young people under 30 years old with low levels of formal education (Mariita, 2002).
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There are few available reports and studies on the direct and indirect socio-economic impacts of Olkaria III (such as Ormat Technologies, Inc., 2014; Mariita, 2002; Tole, Shivoga & Konana, 2011; Ogola, Davidsdottir, & Fridleifsson, 2011). The indirect contributions of the project are through different channels of various scales (local to national) such as tax, employment opportunities, providing electricity for other industries and lighting houses, reducing the adverse effects of power rationing on the national economic performance, and much more (Mariita, 2002; Tole, Shivoga & Konana, 2011). On the local scale, the project is providing free piped water and water tanks to over 90% of the surrounding residents. Because education is the focus of Ormat giving back plan to the surrounding communities, the company voluntarily helped the Maasai community to build a local primary school and teacher’s homes. Moreover, it sponsored 15 primary school teachers to supplement the government teachers, as well as providing secondary school bursaries. Also, during the peak construction period for the second expansion phase, Ormat created about 400 temporary positions for local people as general labourers (Ormat Technologies, Inc., 2014).

Construction of the access road to the project site has brought more tourists and public transportation to the park neighbourhood as the power plant itself has become a tourist attraction. The locals can use the power plant’s grocery store, public phone, and its dispensary in case of an emergency (Kubo, 2003). Also, since 2001, Ormat has annually donated a fixed amount to the Kenya Wildlife Services. The surrounding flower farms as well as 220,000 Kenyans homes are partially powered by Olkaria III’s geothermal power plant (Ormat Technologies, Inc., 2014). Olkaria III also supplies the non-condensable gases (e.g. SO3, CO2), as by-products of geothermal extraction, to the neighbouring flower farm as fertilizer.

One of the hidden social contributions of Olkaria III projects is to the health and wellbeing of women and children in the rural areas. Kenya meets 80% of its electricity need from renewable energy mainly from hydro and geothermal. However due to lack of proper energy infrastructure in rural areas, those communities are heavily dependent on non-commercial biofuels, collected by women and children, for cooking and lighting (Ogola, Davidsdottir, & Fridleifsson, 2011). Over reliance on this resource of energy in rural areas has put severe pressure on the health and wellbeing of people and the environment. Expanding the extraction of geothermal energy, as a base-load source of power that is independent of weather and locally available, can be the answer to the Kenya’s growing electricity demand.
Despite the socio-economic benefits of Olkaria III project, some social disturbances have also developed around the project. The main challenge of all geothermal power projects in the Olkaria field is the Maasai rights to the land. The next section reviews the matter in more details. The other one is that none of the rural dwellings around the project have access to geothermal electricity from the site (Mariita, 2002). Rush of an outside labour force during construction/ expansion periods causes social disturbance in the area. Though these situations are temporary, it does disturb the traditional Maasai lifestyle and cultural values (Kubo, 2003). The living standard of the Maasai community is really low as they are struggling to meet their basic daily needs (Mariita, 2002). Many members of the community believe that the geothermal companies have not done enough to improve their communities. “In terms of employment, the impact is negligible” (Mariita, 2002). Only a few low-key jobs are available to the community such as watchman, cleaner, etc. It is mostly due to lack of proper education and the nomadic life-style among the Maasai members.

**Indigenous Rights to The Land**

Over the past few years, the conflict between the Maasai communities, governments, and the geothermal developers over the indigenous rights to the land within the Rift Valley has become heated. On the one hand, the land has been the home of Maasai people and their ancestors for centuries; on the other hand, they do not own any official title to the land. The land policy in Kenya is visibly politicized and redistributed by the shift in the political power. The situation is more noticeable within the Rift Valley, which is the traditional indigenous land (Boone, 2012). “Approximately fifteen hundred people were killed and three hundred thousand were displaced in the 1991–93 and 1997 election periods. Deaths and displacements of approximately the same magnitude occurred in postelection violence in 2008” (Boone, 2012).

To expand the geothermal development in the area, many Maasai communities have been repeatedly force to move around without any compensation or consultation. This eventually sparked several protests, petitions, violence, complaints, and negative attitude toward the expansion of more geothermal power plants among the locals. One of the challenges is a lack of legal obligation for the companies to consult with the communities or share the benefits or have the acceptance and approval of the surrounding communities. In 2014, the Maasai brought their case (Parkire Stephen Munkasio
& 14 others v Kedong Ranch Limited & 8 others, 2015) to the High Court of Kenya to stop eviction and violence against their rights. The case has not been solved yet.

➢ **News, Reputation, and Future Funding**

The Maasai has been trying to get the attention of international financial supporters of projects like Olkaria III to the violation of their rights. They argue that the international institutes like the Word Bank should not continue supporting the projects and the governments who violate international human rights law such as UN Declaration on the Rights of Indigenous People (Koissaba, 2014; Fetzek, 2015). If the GoK, Orpower/Ormat, and other geothermal developers fail to address the conflict properly in the area, it can jeopardize the further expansion, reputation, and financial security of the projects.

➢ **Community Attitudes and Expectations**

Studies in 2001 by Mariita showed that at the time, the Maasai communities’ attitude toward the project was generally positive with low expectations. However, there has been a shift since then and the Maasai wants more benefits and involvement in decision-making. The Environmental Audit conducted by Tole, Shivoga and Konana (2011) also expressed concern over the matter and suggested the enhancement of positive impacts on the surrounding communities as well as formalizing the community collaboration plan since there is not any. The lack of solid agreement or valid consultation channels between the communities, government, and the company, caused misunderstanding, confusion, and mistrust on the expectation and responsibilities of all actors involved.

### 3.2.6 Key Lessons Learnt

- **Highpoints:**

  ➢ GoK approach: The main reason slowing down the expansion of renewable energy in Kenya is the governmental economic limitation. To overcome this challenge in the Olkaria III project, the GoK successfully started to attract international private investors. Moreover, the GoK liberalized the policy in the energy sector to boost the industry. The Olkaria III case
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study shows how the government can ease the pain for the developers and private investors by sharing and reducing the upfront risks and costs in the early stages of the development (exploration) (Micale, Trabacchi, & Boni, 2015), providing clear policies in favour of renewable energy expansions, as well as offering financial incentives like PPA contracts and carbon credits to private sector. These initiations boosted the geothermal power activities in Kenya, as it lowered the risk and uncertainty for investors (as before the exploratory drilling, which cost millions of dollars, reservoir capacity and feasibility of a project remain uncertain) in the industry.

- Company’s approach: Ormat is among the few geothermal companies who publish annual corporate “sustainability” and environmental reports that are easily accessible. The company demonstrates strong environmental management in the area by considering high-end technological progress to reduce their environmental footprint despite its location in the National Park. One of these approaches has been the phase-by-phase methodology in expansion of the reservoir that also resulted in minimizing upfront investment risks of the project as well as earlier payback period.

- Challenges and Gaps:

- The conflicts between the Olkaria III project and its stakeholders (mainly the local Maasai communities) are as follows:
  
  - Resettlements of nearby communities without any compensation or consultation (conflict over indigenous right to the land);
  
  - Negative attitude toward the expansion of more geothermal power plants in the area;
  
  - Concerns over water consumption by the development;
  
  - Feeling the company can and should do more for locals, and;
  
  - No geothermal electricity goes to the neighbouring communities.

- The above challenges are mainly the combination of inappropriate engagement and failed communication strategies, the lack of consideration for the community’s traditions, culture, and capacity in the project planning and development by the company, in addition to, inadequate policy and regulations on indigenous right to the land, and stakeholders’ engagement strategies for companies.
Discussion and Recommendation:

- It will be beneficial for Ormat and other geothermal companies to lead their philanthropic activities and contributions toward empowering the affected communities to boost their capacity, so that in the long-term, communities can improve their resilience and independent of the project (SD objectives).
3.3 **CASE STUDY TWO: SVARTSENGI POWER PROJECT, ICELAND**

Iceland is a very small but well-developed country on the mid-Atlantic ridge with a population of about 300,000 people. Being close to the North Pole results in cold winters and cool summers. About 10% of the lands lie beneath glaciers. But luckily, volcanically active characteristic of the country resulted in enormous geothermal energy potential (Björnsson, 2006). Due to the cold weather, about 75% of the population lives near geothermal resources in the southwest of Iceland (The Guardian, 2008). This case study reviews the development of the Svartsengi geothermal project, the first co-generation geothermal power plant (used for both heating and electricity applications) in the world. The Svartsengi project has been chosen here for its unique approach with the creation of an industrial park and greater socio-economic impact on local and national scales.

![Electricity in Iceland](image)

**Figure 3-3: Electricity power plants in Iceland (Landsvirkjun, 2016)**
3.3.1 Iceland’s Energy Status

Energy/power is a fundamental need of a functioning society (Tester, 2005). The great example of the matter is the transformation of Iceland from one of Europe’s poorest countries to one of the countries with the highest GDP per capita in the world (The Guardian, 2008), only by investing in domestic renewable energy infrastructure. Switching to the reliable and affordable local sources of energy (such as geothermal and hydro) transformed the country’s welfare notably. Since 2014, Iceland relies 100% on renewable energy sources for electricity: 71% from hydro and 28.9% from geothermal energy (Björnsson, 2015). Figure 3-3 shows the location of the power plants. In total, geothermal energy provides about 68% of needed energy in the country, covering 90% of all energy usage for domestic space heating. Its other applications include heating swimming pools, industrial demands, fish farming, greenhouses, and snow melting (Ragnarsson, 2015).

3.3.2 Vision and Policy

Up until 70s, Icelandic citizens were economically struggling to meet their day-to-day needs. At the same time, the sudden 70% rose in the price of oil, forced the government to react (Ouko, & Omarsdottir, 2015). The government announced that transforming from imported fossil fuels to geothermal energy for space heating by itself saves the country $100 million dollars per year (The Guardian, 2008). A decision that saved Iceland about $8.2 billion over the last 30 years (The Guardian, 2008). Nowadays, fossil fuels are only used for transportation, fishing, and some industrial processes (Ragnarsson, 2008). By 2014, seven geothermal power plants were commercialized with a total installed capacity of 663 MWe (Ragnarsson, 2015).

Now, the political will in Iceland is clear: make the fullest use of locally renewable resources in a SD manner (United Nations Commission on Sustainable Development, 2006), the decision that boosted the country’s national saving. The Icelandic government has played an important role in the success of geothermal development. Various governmental funds are available to support initiating projects, mostly those projects that take place in the area with no visible sign of geothermal resources on the surface (Ouko, & Omarsdottir, 2015). In a case of an unsuccessful exploration result, the government often drops its claims on exploration loans to the developer. “Therefore it is safe to say that the
support of the Icelandic Government has been a vital part in the success of geothermal exploration in Iceland” (Ouko, & Omarsdottir, 2015).

### 3.3.3 Svartsengi Project Overview

It is almost 40 years that the Svartsengi power plant has been providing high-temperature brine for both heating and electricity (Thorolfsson, 2005). The success of the first experimental heat exchanger in 1974 resulted in the development of the first district heating system from the site for the Grindavík town two years later. By 1978, its first power plant came online; after that, the expansion has been step by step. The current installed capacity of the power plant is 150 MWt for hot water production and 74 MWe of electricity generation. A company called HS Orka hf has been in charge of the resource development since it came online.

The reservoir responses to production have been well studied and monitored since the beginning of the exploration. The data shows that production can be continued for 30 more years without significant pressure drop in wells with the proper re-injection method. Only 50 to 75% of the brine is re-injecting back to the reservoir (Ragnarsson, 2015). The field is liquid dominated with the average temperature of about 240 °C. Extracted brine is about 60% seawater and 33% fresh water (Alterra Power Corp, n.d.).

### 3.3.4 HS Orka hf Sustainable Development Plan and Resource Park

Publication of the Brundtland report, Our Common Future, in 1987 inspired HS Orka hf to transfer their Svartsengi geothermal project to the core of a complex industrial park (Resource Park). The main focus of the Resource Park has been set on harnessing all available resources and supporting sustainable development of nearby communities (Albertsson & Jonsson, 2010). Ever since, the idea has derived multiple revenue streams into the Resource Park, which resulted in reducing the financial risk for each individual business unit.

One of the main business units, besides the geothermal power plant, is Blue Lagoon. It was created accidentally from discharging of geothermal brine from the Svartsengi power plant into the close by lava field (Gudmundsóttir, Brynjólfsdóttir, & Albertsson, 2010). Blue Lagoon is now a leading tourist
attraction in Iceland because of its beauty and healing effects. Ever since, HS Orka hf has brought many more business units together such as; the Blue Lagoon spa; the Blue Lagoon Clinic for psoriasis patients and other skin disorders; the Blue Lagoon mineral and biotech unit; Eldborg conference, education and tourist center; the ongoing project of growing algae as bio fuel; Research and Development center; and carbon recycling project (emission from the power plant) (Albertsson & Jonsson, 2010).

### 3.3.5 Environmental Considerations

Some of the concerns around Svartsengi geothermal project include the amount of hydrogen sulphide gas emissions, discharge of geothermal brine on surface, thermal pollution, and subsidence (Kristmannsdóttir, Ármannsson, & Árnason, 2000; Ármannsson & Kristmannsdóttir, 1992; Kristmannsdóttir & Ármannsson, 2003). Blue Lagoon was created by the discharge of geothermal brine on the surface that has accidentally occupied much more land than was initially anticipated (Kristmannsdóttir, Ármannsson, & Árnason, 2000). This method of dealing with the waste brine won’t be allowed in today’s new project development paradigms. There is a concern that this method of dealing with the waste brine may pollute other water sources as well as leading to thermal pollution (i.e. effects on local weather, etc.). There is also the slight record of subsidence (7 mm/year) as a result of a low reinjection rate. Although most of these effects are local, temporary, and avoidable, society’s concerns should be properly addressed and careful monitoring and planning is vital.

### 3.3.6 Socio-Economic Considerations

In its 40 years of production, the Svartsengi geothermal project has impacted its surrounding and beyond significantly. The Svartsengi Resource Park has brought stable and growing revenue streams besides reliable energy and power source to locals and the nation at large. The power plant is located about 40 km from Reykjavik, the closest community to the Resource Park. The project provides heated freshwater for the 17,000 residents by feeding the town’s central heating facility (Gudmundsóttir, Brynjólfsdóttir, & Albertsson, 2010). When it comes to electricity, the Svartsengi geothermal power plant serves 45,000 people nationwide. There are more than 180 people working in the Resource Park (Albertsson & Jonsson, 2010) in addition to 30 permanent employees of
Svartsengi power plant (HS Orka hf, 2014). Many of these employees are local, well educated, and well trained.

Blue Lagoon and its association is the popular tourist destination of Iceland and a major revenue stream. However, tourism is a double-edged sword for the area. In 2014, Blue Lagoon spa and clinic brought 700,000 visitors to the country (Ragnarsson, 2015), almost twice the total size of the Iceland population. As the tourism boosts the local and national economy, it also disturbs day-to-day life of many Icelanders. Social factors are a vital part of corporate development according to Icelandic government; as such, energy companies are obligated to conduct their business in an environmentally and socially friendly manner. In general, Icelandic society’s attitude toward the geothermal transition has been positive and supportive. As Ouko, and Omarsdottir (2015) stated:

“For a successful geothermal development, a good and understanding cooperation between ministries, geothermal professionals, advising agents, energy companies, and last but not least the public is essential” (Ouko, & Omarsdottir, 2015, p. 6)

By all means, the geothermal industry has rebuilt the national economy in Iceland. However, there is a growing concern about the effect of such rapid developments on people’s health. Many are concerned about the effect of exposure to various toxic geothermal emissions (gas and heavy minerals) on society. There are several on-going studies in Iceland investigating the correlation between diseases like cancers, asthma, etc. and geothermal emissions such as hydrogen sulphide gas (H$_2$S), as well as radon (Rn), arsenic (As), lead (Pb) and mercury (Hg) in geothermal brine (Kristbjornsdottir & Rafnsson, 2012; Carlsen, Zoëga, Valdimarsdóttir, Gíslason, & Hrafnkelsson, 2012; Kristbjornsdottir & Rafnsson, 2015; Finnbjorndottir, Oudin, Elvarsson, Gislason, & Rafnsson, 2015). Although there have been no solid evidence and further investigations are needed, careful monitoring and planning are necessary.

- Public Concerns and Fights over the Rights for Renewable Energy

There is not a specific study on the public concerns around the Svartsengi project but screening between the news and online Icelandic blogs brought the following matters into the author’s attentions:
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- Change of ownership
- Drying of the reservoir due to the excessive production
- Concerns over the reason behind excessive production is to provide electricity to a smelter

Before the economic crisis of 2008, geothermal projects in Iceland were under the public control (pension funds), more recently, the Icelandic government allowed non-Icelandic companies to enter to the market. Now, the Canadian based company, Magma Energy that later changed its name to Alterra Power, has control of 66.6% of HS Orka hf’s shares with the rights of the land use and 65 years of exploitation. The unhappy Icelanders want the government to return the public rights for renewable energy mostly to stop the overexploitation of the reservoirs. The majority of the electricity from Svartsengi projects goes to the nearby aluminium smelter, a subsidiary of North-American aluminium producer Century Aluminum. Some are concerned that the government is exhausting the future generation’s energy resources for money (Saving Iceland, 2012).

3.3.7 **Key Lessons Learnt**

- **Highpoints:**
  - The Iceland case study highlighted the importance of collaboration between government, companies, and the public for a successful transition of the society toward SD goals. The stakeholders’ engagement and identification with the project is a key element of the Svartsengi project success.
  - One of the other elements that distinguish the Svartsengi case from the others is the presence of strong governance capacity among all involved parties. For instance, the government has provided clear and much needed policy and regulations (e.g. geothermal resource and underground water management); the company has established stakeholder engagement and collaboration opportunity from the early stages of the project; more importantly, the communities have built their community capacity and created a shared future vision.
  - The development of the industrial park to use the full potential of extracted geothermal energy was also another outstanding approach of Svartsengi power project. The company’s approach has brought multiple revenue streams, more job opportunities, boosting tourism, and larger economic benefits to the society and the company itself.
• **Challenges and Gaps:**
  - There have been some recent oppositions and concerns among the Icelanders toward the expansion of geothermal power projects including Svartsengi, these include:
    - Thermal pollution from discharging geothermal brine onto surface (low reinjection rate of 50-70%);
    - Concerns over drying the reservoir due to the excessive production, and;
    - Concern over disturbing of their day-to-day life due to boosting tourism as a result of the project.

• **Discussion and Recommendation:**
  - Reinjection of geothermal brine can prevent thermal pollution and unnecessary stress on the reservoir, as well as reducing the land subsidence and ground deformation as a result of reservoir’s pressure drop. Keep in mind that, today’s environmental regulations won’t allow the release of such high amount of high temperature geothermal brine on the surface.
  - The public sensitivity is increasing over the real purpose behind excessive extraction of Svartsengi geothermal reservoir. The opposition grows over exhausting the reservoir for activities like aluminum smelting for foreign companies instead of preserving the available resources for future generations. It is suggested that companies avoid involving into controversial activities that jeopardize their reputation and future relationship with their stakeholders.
3.4 Case Study Three: Puna Project, USA

When it comes to geothermal power installation and generation, the United States is one of the world leaders, although, geothermal energy accounts for only 0.48% of the total U.S. power market (Lund, Gawell, Boyd, & Jennejohn, 2010). The Hawaiian geothermal power project has been a controversial matter since the beginning. The outcomes highlight the importance of social acceptance and effect of a negative reputation of one project on the future of a whole industry in a certain region.

3.4.1 Hawaii’s Geothermal Power Story

The Hawaiian geothermal power story dates back to before Hawaii became part of United State in 1898. The idea of extracting geothermal energy for electricity generation emerged at the end of the 19th century. In 1881, when King David Kalakaua of Hawaii and his Attorney General (William Armstrong) met Thomas Edison and discussed the idea of producing geothermal electricity and transferring it between the islands by submarine cables. Edison answered, “it would cost so much, that’s all” (Szvetecz, 2001) and he was right. However, later the state and federal government wanted to give it a try. They spent over $64 million dollars on the idea of a huge 500-megawatt interisland cable project before giving up in 1992 under public pressure, lawsuits, and realizing that it is fiscally impractical. The public was concerned about the environmental and economic viability of such a project. It took a couple more unsuccessful attempts here and there in Hawaii to make geothermal power an option for the “Big Island only”. Bad management, public oppositions, and/or volcanic eruptions around the project sites contributed to these failed experiences (Szvetecz 2001). After all these years, geothermal energy is still a controversial topic for Hawaiians.

In 1973, the federal government provided funding to the state of Hawaii for a geothermal research and exploration grant for the Puna area of the Big Island. The effort resulted in the drilling of the first commercial geothermal well, called the Hawaii Geothermal Project (HGP). The project then expanded into Puna Geothermal Venture (PGV) in 1981. Ormat purchased 100% of PGV’s shares in 1988 and managed the first and only Hawaiian geothermal power plant (Richard, 1990).
3.4.2 **VISION AND POLICY**

U.S. geothermal power utilization has been through several ups and downs. The international oil crises, and lack of political will have turned the tables several times. However, since a decade ago, the U.S. government has been offering several incentives to encourage the private sector to delve into the new geothermal power projects including the Production Tax Credit, Renewable Portfolio Standards, $400 million geothermal energy funds, and 30% investment tax credit as a grant for the commercial operations of power plants (Lund, Gawell, Boyd, & Jennejohn, 2010). This has improved the interest in utilization of geothermal power projects in recent years.

Figure 3-4: Hawaii power plants (U.S. Energy Information Administration, 2016)
Having a reliable source of energy and power is more critical to remote or geographically isolated areas like Hawaii. Hawaii relies on imported oil for 90 percent of their energy needs. No other state in the U.S. has such high dependence on outside energy sources (U.S. Department of Energy, 2004). Consequently, the federal and state governments have supported geothermal development for both direct use and power generation in Hawaii. Increasing the portion of renewable energies will help Hawaii to reduce electricity costs, dependence on imported oil and the international energy market, and create job opportunities alongside the environmental benefits (Boyd, Thomas, & Gill, 2002). The plan is to enable Hawaii to use 100% renewable resources for generating electricity by 2045 with the help of mixed energy resources including geothermal. (Hawaiian Electric Company, Inc., 2016). Figure 3-4 shows the current power plants in Hawaii.

### 3.4.3 Technical and Financial Overview of Olkaria III Project

The project is located about 33 km southeast of the city of Hilo. Currently the Puna power plant reaches a generation capacity of 38 MWe, which delivers 20% of the electricity needs of Big Island (Ormat Technologies, Inc. 2015; Lund, Gawell, Boyd, & Jennejohn, 2010). Reservoir estimations showed a production capacity of up to 100-200 MWe but, currently, the company is only allowed to expand its production capacity up to 60 MWe based on their federal and state permits (PICHTR, 2013). So far, they have ten active wells (6 production and 4 injection) in the field. The average bottom hole temperatures of these production wells exceed 300 °C at a depth of 1.2 km. The brine is a mixture of steam and liquid (80 to 20 percent accordingly), all of which is re-injected back into the reservoir (Richard, 1990).

### 3.4.4 Environmental Considerations

When the Hawaiian geothermal power adventure started, the social and environmental aspects of such developments were not regulated. The previous endeavours of HGP and PGV have helped in the development of the state and federal regulations and energy policies for geothermal power utilization. The first decades of HGP’s journey were in some ways environmentally careless. Geothermal brine was discharged on the surface rather than re-injected back into the reservoir and proper H₂S abatement or noise control systems were not in place (Szvetecz, 2001). Since Ormat took over the project and state and federal regulations and policies were implemented, more cautious approaches
have been applied. However, despite all precautions, there have been several incidents (such as well blowouts, etc.) causing toxic air emissions (mostly H$_2$S), noise pollution, and minor health issues for workers and neighbouring communities (Boyd, Thomas, & Gill, 2002; Hansell & Oppenheimer, 2004). The major well blowout occurred in 1991 resulting in the emission of 2,247 pounds of hydrogen sulfide into the local climate (Szvetecz, 2001).

Conversely, the Puna power plant has brought great environmental benefits to the state of Hawaii. Since 1993, the plant has freed Hawaiians from consumption of 5.4 million barrels of oil for electricity, offsetting emission of about 2.5 million tons of carbon dioxide (Battocletti, 2006). In comparison, if instead of the Puna power plant there was a similar-sized fossil fuel plant, Hawaii could face yearly emission of 1,328 tons of nitrogen oxides and 983 tons of sulfur dioxides (Battocletti, 2006). In addition, the project reduces the risk of oil spills related to imported oil for electricity.

### 3.4.5 Socio-Economic Considerations

It is challenging to measure the socio-economic impacts of a geothermal power project as controversial as the Puna project since several outside factors, historical management strategies, and cultural aspects are involved. Stable energy supply is one of the key factors ensuring the continued prosperity of societies. Using locally available energy resources, such as geothermal reservoirs, may help Hawaii to establish lower electricity rates for long time. According to the U.S. Energy Information Administration reports (2015) the average price of electricity to customers is frequently the highest one for Hawaiians by 25-30 cents per kWh. In comparison, the average electricity price in the U.S. for residential, commercial, and industrial use is less than 13, 11, and 8 cents per kWh respectively. Besides, using more geothermal power leads to less money leaving the state in order to buy imported oil allowing for more funding available to spend on other endeavours within the islands (Battocletti, 2006).

In addition, the PGV project contributes to local, state, and federal economy through taxes and royalties, as well as job creation. As of 2006, PGV has created 30 full-time jobs in addition to 75 direct, indirect, and induced ones. It also annually pays an average of $2.5 million in taxes and
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royalties, which is distributed between the state, country, and office of Hawaiian Affairs (Battocletti, 2006).

Local Conflicts
While in general, Hawaiian people enjoy the positive socio-economic impacts of Puna project; its neighbouring communities may have a different experience. The project site is surrounded by several farmlands, a few small towns, rainforests, and, at times, an active lava flowing zone (Szvetecz, 2001). PGV is also located in a culturally sensitive area. Many native Hawaiians living in Puna are “Pele Practitioners”, relating to the goddess of volcanic activities and manifestations. They believe geothermal energy extraction harm and disturb their goddess, Pele (Szvetecz, 2001).

The history behind Hawaiian geothermal power is rich and heated. Over the decades of Puna power plant production, intense debates between opponents and supporters have grown stronger. Opponents argue that their concerns have not been adequately addressed while both the government and operators are pushing for expansion. The main concerns are as follows (Boyd, Thomas, & Gill, 2002):

- “Interference with worship of the Goddess Pele
- Interference with certain Native Hawaiian practices
- Rainforest destruction
- Possible health and safety impacts
- Disruption of the way of life for nearby residents
- Hydrogen sulfide and other air quality issues
- Noise
- Increased strain on an inadequate infrastructure
- Impact on native fauna and flora

Poor emergency management decisions, inadequate community engagements and data sharing, cultural differences, and several incidents on the site have led to an ambiance of mistrust between the community and PGV. There were several small and big well blowout and serious leak incidents
throughout the project history. As a result, H$_2$S gases and geothermal brine have been released for hours in the neighbouring areas, causing air and noise pollutions, health issues, and lifestyle disturbance to nearby residents. The previously mentioned well blowout on June 1991, resulted in the evacuation of nearby residents, emission of H$_2$S gas way above safe levels for hours, stronger mistrust between parties, and an end to other geothermal power developments in Hawaii. Alternatively, these incidents stemmed the establishment of better geothermal regulations and safety plans by state and federal agencies. (Szvetecz, 2001; Boyd, Thomas, & Gill, 2002).

Incidents like that in 1991 and PGV’s way of handling the situation resulted in the launch of opponent groups and several petitions against geothermal utilization in Hawaii. Opponents have challenged the ability of the PGV and the different government levels in developing a safe geothermal power project (Boyd, Thomas, & Gill, 2002). As a result, recent practices are more controlled and gas emissions are less of a problem for nearby residents (Szvetecz, 2001). Moreover, studies conducted by Hawaii Dept. of Business, Economic Development and Tourism (Gill, 2005) showed the possibility of using PGV wastewater for direct application. Right now, PGV is re-injecting back geothermal wastewater at 148°C to the reservoir. This temperature is high enough for many industrial and domestic applications such as fruit drying, fish farm, green houses, heating spas and pools, etc. (Gill, 2005). The Expansion and implementation of above ideas from theory to practice depends on the governments and PGV’s method of addressing the society’s concerns and building a proper trust. So that in the future, the geothermal energy can serve the public much better.

3.4.6 Key Lessons Learnt

- Highpoints:
  - One of the most important contributions of Puna geothermal power project was the influence of its development experience in establishment of better geothermal regulations and policies by USA state and federal agencies.

- Challenges and Gaps:
  - The Puna case displays the critical importance of gaining trust and acceptance of neighbouring communities especially in culturally sensitive areas such as Hawaii. As a result of the heated history, the Puna project remains as the first and only geothermal
power project in Hawaii. Despite the ongoing attempts by Ormat to improve their relationship with the neighbouring communities, the oppositions groups are still strong. The community concerns are mainly focused on the following:

- Health and environmental concerns:
  - Toxic air emissions
  - Noise pollution
- Pushing expansion without proper engagement with local communities
- Concerns over inadequate communication and information sharing
- Doubting in the ability of the company and the government to develop/expand a safe and sound geothermal power project.

**Discussion and Recommendation:**

- It seems that the lack of proper engagement and insensitivity toward native Hawaiian culture and tradition caused most of conflicts in the Puna projects. When the project started, the communities had a positive attitude toward the new development, however, over time, due to the lack of trust, and poor communication, community’s expectations and attitudes have been changed. Establishing a stakeholder map of neighbouring communities helps the company to better understand how to approach their stakeholders. It is vital to develop proper engagement strategies in a way that:
  - All involved parties have the opportunity to participate and agree upon the chosen engagement strategies;
  - Includes two-directed communication channels, and;
  - Has a clear dispute resolution mechanism.
Chapter 4
Diagnostic

Review of the case studies and the available literature (Chapter 2) stressed vulnerabilities and risks of geothermal power projects within the socio-economic and environmental areas. Note that while conducting the environmental impact assessment is often a legal requirement during the appraisal, development, and operating phases of a project, in most countries, social considerations are more of a good will from companies and no specific regulations are in place (Shortall, 2014). The resulting social conflicts increase a company and the industry’s vulnerabilities to the possible financial, environmental, and reputational consequences. Considering that most geothermal power companies voluntarily initiate philanthropic activities for their surrounding communities beyond their legal obligations, this research started with the aim of presenting a new way of thinking about the contributions of geothermal power projects towards sustainable development of their neighbouring communities.

The current development practices in the industry, as recognized in the cases reviewed in Chapter 3, do not typically use an integrated approach toward environment integrity, economic stability, social equity, and equitable governance (in other words, SD considerations) for geothermal power projects. As a result of raising concerns and opposition among the public and policymakers, and difficulty in accessing capital, it will be beneficial for the geothermal power arena to develop a more integrated and consistent approach towards sustainable development across the industry. Although the concept is still new to the industry and much work is needed, the following statement is promising:

“The sustainability perspective requires a much broader assessment of energy development. This implies that there is a need to monitor all of the environmental, social and economic impacts associated with geothermal energy developments.” (Shortall, Davidsdottir, & Axelsson, 2015)

While a geothermal power development can bring wide-ranging direct and indirect benefits to the society in national, regional, and local scales (as discussed in Section 3.1), typically the negative impacts of a project is on neighbouring communities (as discussed in Chapter 3). Neglecting the interest of these communities sooner or later may trigger the social conflict as it happened in the cases of Puna and Olkaria III projects. In one case, the project expansion and the future of the
industry in the area put on hold for almost a century; and, the other has been struggling with the growing conflict over expansion.

The industry should keep in mind that each community is different and their cultural resources are unique and irreplaceable. Stakeholders need to be confident that their safety, concerns, thoughts, and collaboration matter to the industry/company. One of the main challenges facing geothermal power projects is their attempt to be a good, quiet neighbour, moving under the radar. The aim of the industry is often to fulfill what is mandatory by law rather than reaching out to the stakeholders, building trust and a solid engagement platform especially with the affected local communities.

4.1 Geothermal Power Arena: A Responsible Neighbour

The Olkaria III and Svartsngi power projects are great examples of how geothermal energy can be a solution to energy problems of geographically isolated places, or those with high dependency on fossil fuels, or ones that are simply seeking environmentally friendly energy alternatives. The energy security that comes with this source of energy and power can transfer the wellbeing of society; more effectively, when a company properly integrates environment integrity, economic stability, social equity, and equitable governance (in other word, SD considerations) in its projects lifecycle. The cases also confirmed that despite the reservoir characterization (renewable or non-renewable, or clean or polluted source of energy), ignoring the above considerations may negatively impact the health and wellbeing of surrounding environment and communities.

Note that unlike other renewables, geothermal energy is not well known to the public and the governments in many countries including Canada. As a result, in a time of developing national and regional energy plans, the industry’s voice may easily be dismissed. The industry has a long way to fulfill its through potential and shares in the energy market. For sure, more successful implementation examples, compatible with today’s values and expectations of corporate responsibilities, will gain a louder voice for the industry and awareness among society and governments.

A common shared SD vision and holistic framework definitely helps the industry to extent its potential as it brings consistency through the life span of a project and across the industry. As mentioned one of the objectives of this study is developing a guideline that helps geothermal power
projects to become a responsible neighbour of their host communities (see Chapter 1, Section 1.1 for detail explanation). The literature and the case studies (see Chapter 2 and 3) identified the following non-technical vulnerabilities (potential areas of financial, environmental, and reputational risks) in the current practice of the industry as:

1. Inadequate engagement and communication with stakeholders, mostly within the following areas:
   - Addressing cultural and environmental sensitivities
   - Information/ knowledge sharing
2. Lack of proper governance and institutional arrangement, mostly within the following areas:
   - Collaboration with stakeholders on development strategy
   - Regulations and policies
   - Consistency throughout a project lifecycle (change of management, owners, etc.)
3. Natural resource management (e.g. geothermal reservoir, water, etc.)
4. Inadequate approach toward benefit sharing with surrounding communities (long-lasting contributions, building community capacity)

Based on the lessons learnt from the literature review specifically on SD concept at project/community level and existing SD frameworks for other industries, the following essentials were recognized for the consideration of geothermal power projects aiming to improve the ethic of being responsible neighbour and reducing non-technical vulnerabilities of projects in their host society:

1. Considering societal and environmental sensitivities in development strategies
2. Addressing socio-environmental and socio-economic considerations in project economic decisions
3. Incorporating engagement and benefit sharing strategies to the wellbeing of the neighbouring communities (human and ecosystem) in the development paradigm
4. Establishing equitable governance and institutional arrangements
5. Considering conservation or improvement of natural resources

6. Considering cumulative impacts of several geothermal energy developments and/or other similar projects in local and regional scale

7. Establishing a long-term reliable energy system

8. Continuous improvement (research and innovation) and evaluation

9. Recovery and closure management

10. Establishing proper communication and reporting mechanism
Chapter 5

Research Approach and Methodology

This research uses a combination of quantitative and qualitative research approaches, known as the mixed method research approach (Klein & Richey, 2007; 2014). According to Ross and Morrison (2004) “quantitative and qualitative approaches are more useful when used together than when either is used alone ... [and] when combined, are likely to yield a richer and more valid understanding” (p. 1039). As mentioned in Chapter 1, Section 12, in order to address the objectives of this research, the thesis is divided into three main stages of diagnostic, design and development, and validation, analysis, and expert feedback.

As explained in Chapter 4 (diagnostic), the key lessons learnt from the literature review and the case studies helped to establish a required foundation for design and development stage of the research. The findings from the literature review and case studies used in recognition of the initiatives taken by geothermal energy companies and similar industries (especially the mining industry) provided a foundation for developing an appropriate framework and SD evaluation model for the geothermal power industry.

A framework, referred to as the Geothermal Sustainable Development (GSD) framework, is proposed aiming to guide and evaluate the contributions of a geothermal power project to SD in the local and regional communities. The proposed framework consists of seven key topics (overarched with that previously developed and applied in the mining industry) and is specifically developed to express the quality of the contribution that a geothermal power project can make on local and regional communities. After developing the framework, to help companies and other interested parties to track and evaluate the progress of the project with respect to its approach towards SD, an evaluation strategy in the form of a maturity model is proposed. The maturity model aims to highlight the depth

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1 Quantitative Research- A research approach that typically "employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data" (Creswell, 2003, p. 18).
2 Qualitative Research- “An approach to scientific inquiry which typically uses non-experimental methods, such as ethnography or case history, to study important variables that are not easily manipulated or controlled, and which emphasizes using multiple methods for collecting, recording, and analyzing data rather than using statistical analysis” (Klein & Richey, 2007;2014;).
and quality of SD-thinking and its influence within a company/project development paradigm. Both the GSD framework and the proposed SD maturity model are explained in details in Chapter 6 of this thesis.

To validate the proposed GSD framework, an online survey was set up to solicit expert feedback. The online survey was created as a means to: (1) assess whether the identified objectives presented for each topic in the GSD framework are indeed suitable and effective as tools for helping a geothermal project with defined SD goals; (2) solicit comments on the overall approach of the framework; (3) observe the general view of different parties involved on the extent of SD considerations in a geothermal power project. The survey was designed (format and questions) based on the University of British Columbia’s Research Ethics Board guideline and received the certification from the Board before distribution to the potential participants. The survey questions can be found in Appendix B.

Note that, for privacy purposes, data was collected anonymously and under a Canadian hosted survey tool (FluidSurvey). The survey was distributed online to the geothermal power arena starting mid-December 2016. Although the initial plan was to keep the survey open for a month, it eventually was open for almost four months to attract more respondents. Initially, the link to the survey was sent to the potential participants through online posts on geothermal social networking groups on Facebook (such as Women in Geothermal, and Geothermal Young Professionals), via Canadian Geothermal Association (CanGEA) distribution channel, and the Geothermal Resource Council (GRC) via their social media. When this strategy did not bring the predictable traffic to the survey website, the author reached out the potential participants via personal emails or LinkedIn messages to the related NGO’s (to the topic of SD or geothermal energy), faculties within universities, geothermal companies, geothermal division personnel within governments (when it was available), related law firms, and the financial institutes who has supported geothermal projects globally. The quantitative results of the survey outcomes are explained and discussed in detail in Chapter 7, Section 7.1.

The second part of the validation consists of interviews to evaluate and test the proposed SD maturity model (the maturity model is discussed in Chapter 6, Section 6.2). The outcome of interviews is presented in form of six case studies. The key objectives of the case studies are:
1. To investigate to what extent geothermal companies are integrating SD considerations into their project paradigm by evaluating the level of understanding and commitment in implementation of SD considerations (based on the proposed SD maturity model in Chapter 6);

2. To investigate the maturity of the geothermal power projects in adapting SD frameworks and considerations like the one developed in this research; and,

3. To investigate whether the proposed GSD framework can help addressing the current gaps and limitations of the geothermal power projects with respect to SD implementation and vision.

The broad outline of the interviews was based on the influence of SD implementation within the corporate culture and value, business model, and environmental, economic, and social aspects of project development. The potential participants were identified through the websites of geothermal power companies and governments, as well as personal profiles on LinkedIn. The invitations and follow-up emails and messages were sent in the duration of two months to at least 30 individuals and companies. The qualitative analysis of the interview results is discussed in greater details in Chapter 7 along with the limitations of the research. The example of self-evaluation questionnaire sent to participants before the interviews can be found in Appendix C of this thesis. Note that the material and format of the interviews were approved and certified by the University of British Columbia’s Research Ethics Board.
Chapter 6
Design and Development

The specific focus of this chapter is to develop a set of guidelines (goals, objectives, indicators, etc.) to lead and evaluate the compatibility of the industry’s approach with the SD objectives at project level and in each step of development. To this end, a GSD framework and SD maturity model have been developed. The framework and the proposed maturity model provide a systematic approach to integrate SD considerations (social, environmental, economic, and governance dimensions) into the both internal and external orientations of a project necessary of SD commitment.

6.1 Development of GSD Framework

The first step toward integrating SD considerations in the development of a project is to understand what should be maintained or improved and to engage with all stakeholders to develop a shared understanding/interpretation about the meaning of contribution to sustainable development for that particular place and time. The process is not easy; it requires much patience, expertise help, and building a mutual trust and respect among the parties involved. Using a framework that is specifically tailored to the need of the geothermal power arena can facilitate this process by providing a common ground for all involved parties as a starting-point, as well as guiding them toward a shared understanding and expectation.

The GSD framework can bring consistency in decision-making process across the project life span and most importantly, it can help to clarify what commitment to SD means in practice for the industry itself. The following steps were taken in the development of the proposed GSD framework described in this chapter:

1. Defining the scope and intentions of the framework including the scope; applications; target audience, etc.
2. Determining an appropriate structure to address these intentions
3. Developing applicable SD objectives and indicators tailored to the need of the geothermal power arena to monitor and measure the progress through the lifetime of a project.
6.1.1 Scope

Sustainable development concept started as a societal evolution aiming to improve and preserve the wellbeing of people and the environment for generations to come (Dyllick & Hockerts, 2002). SD is a dynamic concept that is dependent on time and place, “though values vary greatly in detail within and between cultures, at the heart of the concept of ... [SD] there is a fundamental, immutable value set that is best stated as “parallel care and respect for the ecosystem and for the people within” (MMSD North America, 2002).

Note that, while the proposed framework provides common goals and objectives to help aligning the visions and expectations, the detailed short-term and long-term goals of a project has yet to be set with collaboration of stakeholders based on the nature of the development and site-specific considerations as the project proceeds. Since each project has different characteristics in its size, social and political constructions, geographic condition, and legal limits and governmental incentives, the non-prescriptive method of problem solving was chosen in development of the proposed framework. The framework offers a common foundation, as a start-point only, for geothermal power projects and their stakeholders. Further adaptation may be needed to expand the framework into the appropriate context needed at that particular project and site.

As regulation and policies are often falling short on integrated SD considerations, the proposed framework incorporates further suggestions beyond regulatory requirements by recommending objectives that addresses the SD challenges more fully. The hope is to help geothermal power companies develop their projects socially and environmentally accountable, scientifically and technically sufficient, and financially viable during the life span of a project and well during the closure period.
6.1.2 **OVERARCHING CONSIDERATIONS**

To develop the proposed framework, the work done in other industries and similar sectors, and the recommendations of organizations such as the National Research Council Board on Sustainable Development (1999) and United Nations (1992; 2016;) on SD concept are taken into account (see Chapter 2 for more details). The attention was drawn specifically to the mining industry due to the similarities in exploration, development, and operation of mining and geothermal power projects. Both industries share similar social and environmental challenges during the life span of projects. While all reviewed frameworks and recommendations in Chapter 2 are kept in mind, based on the challenges and essentials identified in the Diagnostic Phase, the structural arrangement of the Seven Questions to Sustainability framework (7Qs) (MMSD North America, 2002) was chosen as an overarching scheme in development of the proposed framework here. One of the positive aspects of 7Qs work in the author’s opinion is the involvement of multi-interest stakeholders from mining companies to government, First Nations, academia, and NGO representatives in developing the framework. Besides, the scope of the framework is well designed for the implementation of SD concept at a project level. The proposed framework consists of seven key topics specifically developed to guide and express the quality of the contribution that a geothermal power project can make on local and regional communities. These key topics are as followed:

1. Engagement
2. Valuing people and their aspirations
3. Environmental considerations
4. Economic viability of the project and nearby communities as a result of the project
5. Including the importance of traditional and cultural activities and practices in project development and operation
6. Legal, regulatory, and company governance capacity
7. Ongoing review and improvement by company, community, and government
Each key topic is accompanied by objectives as a means to lead toward the achievement of the end SD goals. These objectives are the main considerations that are taken into the decision-making process. To monitor and measure the progress, a few key example indicators and metrics are suggested as a starting-point for further discussion and adaptation among the involved parties. Note that limiting the number of indicators is an essential requirement as a larger number of indicators pose a huge challenge in communication, aggregation, and interpretation of information to stakeholders and management level (Böhringer & Jochem, 2007). When developing indicators one should clearly define what knowledge/information each indicator has to reveal (objective).
Figure 6-1 shows the harmony between the components of the proposed framework and justification of the chosen topics. As illustrated, topic one indicates the state of collaboration between parties. This is a vital component as it is a foundation of equitable governance. Topics 2 and 3 are the ultimate desired goals of the corporate SD, the wellbeing of people and the environment. While topic 7 builds an evaluation mechanism, the rest of the topics seek all available resources to help achieving the desired goals (MMSD North America, 2002).

### 6.1.3 GSD Framework

The proposed topics in the GSD framework represent broad considerations for reaching corporate SD goals while, the objectives are targets set up to achieve those goals. The indicators are evaluation and monitoring tools to track progress. Each topic of the GSD framework is discussed in the following sub-sections. While the goals and objectives are discussed in this Chapter for each topic, further implementation details, are presented in Appendix A due to space limitation. Moreover, few clarifications by Prospects and Developers Association of Canada (PDAC, 2014) for some of the topics are also included into the same Appendix and readers are encourage reading it.

**Topic One: Engagement**

The focus of this topic is on the quality of the relationship between the involved parties. Stakeholder engagement is a vital component of SD implementation to achieve healthy, trusting, and lasting collaborations among the involved parties during the life span of a project. The first step toward establishing sufficient engagement is the identification of stakeholders. Figure 6-2 listed the range of stakeholder groups that may be involved in a geothermal power project. Each group is different in terms of their interests and power to influence the project decision-making process. Therefore, identifying these groups (e.g. creating a stakeholder map), their purpose of involvement, common interests and concerns as well as potential conflicts and level of influence are among the first steps that should be taken at the beginning of the project (Rhodes, Bergstrom, Lok, & Cheng, 2014). While a company may reach each of these groups separately at the beginning, the effort has to be put in place to create bridges between different groups of stakeholders in order to shape a shared common ground for decision-making within the SD framework.
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Note that engagement is a two-way channel involving all parties. Good stakeholder relationships benefits the company in many ways such that it leads to (Renaut, Robert, & Tollari, 2012):

- Better understanding of the community’s concerns and viewpoints leads to better decision-making
- Effective reduction of controversy and enhance the company’s legitimacy, reputation, and credibility among the community as well as government and shareholders
- Reduction of lawsuits, financial obstacles, and delays in permitting and implementation periods
**Figure 6-3: Proposed objectives for guiding and assessing the success of engagement process**

Figure 6.3 illustrates the specific objectives for guiding and assessing the success and progress of engagement approach between a geothermal power company and its stakeholders:

- Design and implement engagement strategies
- Develop and implement dispute resolution mechanisms

**Topic Two: Valuing people and their aspirations**

The second topic addresses the details of a geothermal power project’s contributions in maintaining and valuing the wellbeing and aspirations of its employees and local communities. It is important for a geothermal power project to recognize its direct and indirect impacts on the wellbeing of the affected communities and its employees. The government of Canada (2016) developed the schematic in see Figure 6-4, which identifies the various elements of individual wellbeing; it is clearly a complex subject.

**Figure 6-4: The figure shows the various elements of individual wellbeing in the Canadian context as defined by Government of Canada (2016)**
While all reviewed frameworks and recommendations (Section 2.3) are considered, Seven Questions to Sustainability (MMSD North America, 2002), e3 Plus - the Principles and Guidance Notes (PDAC, 2014), and e3 Plus - A Framework for Responsible Exploration by Prospectors and Developers Association of Canada (PDAC, 2009) provided the main overarching scheme for the GSD framework.

**Figure 6-5: Proposed objectives for guiding and assessing the consideration of valuing people and their aspirations**

Despite the voluntary nature of socio-economical contributions, companies are encouraged by governments to support and often if possible to contribute to the wellbeing of the affected communities (directly or indirectly) to strengthen the collaborative relationship with their stakeholders. The degree of contributions or support depends on the socio-political and cultural structures of the host society, the stage of the project, and existing regulation and policies (PDSC, 2014). The proposed objectives for guiding and assessing the impacts of a geothermal power project in local and regional communities are as follows (Figure 6-5):

- Identify, maintain, or facilitate the development of community’s future plan and strategies
- Maintain or improve the project area societal and cultural values
- Safeguard workers/community health and safety in the development and operations of a project

**Topic Three: Environmental considerations**

This topic addresses the environmental considerations in the area affected by a geothermal power project. Note that as geothermal power projects are different in terms of size, type of reservoir, method of extraction, project lifetime, and the original status of their host environment, the scale of their environmental impacts may vary. Companies should keep in mind that while causing stress or
trade-offs on the ecosystem in some period of a project development and operation might be unavoidable, the ultimate goal is to eventually maintain or, if possible, improve the ecosystem’s wellbeing along the way. The following objectives are proposed to guide and assess the success of addressing environmental considerations within the lifetime of the project (Figure 6-6):

- Maintain regulatory compliance and apply measures to improve conditions beyond regulatory requirements
- Evaluate the sensitivities of the environment to change

![Figure 6-6: Specific objectives for guiding and assessing the success of addressing environmental considerations](image)

**Topic Four: Economic viability of the project and benefit sharing considerations**

This topic addresses the economic viability of a geothermal power project and its direct and indirect economical contributions to the affected communities. Specific objectives for assessing the success of addressing the economic viability of a geothermal power project and its direct and indirect benefit sharing considerations are shown in Figure 6-7. These objectives are as follows:

- Maintain long-term economic viability of the project
- Develop vision and strategies for long-term economic benefit sharing
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Figure 6-7: Specific objectives for guiding and assessing the success of economic factors

Note that the success of the first objective of this topic sets the tone for the implementation of the rest of the topics in the framework. In other words, unless the economic viability of a project can be maintained over time, it cannot afford much contribution to SD to its neighbouring communities. One of the factors that affect the economic success of a geothermal project is the availability and power cost of other power sources in vicinity. For instance, in Middle Eastern countries, despite the tremendous geothermal potential, due to the availability of cheap oil and natural gas resources, the geothermal industry will not be able to compete.

**Topic Five: Including the importance of traditional and cultural activities and practices in project development and operation**

This topic addresses the consideration of cultural and traditional activities and practices in the affected area. Cultural, traditional, and non-market activities and practices are an important part of social identification in each community, but often absence in economic and social assessments of projects. The importance of these elements is more noticeable for projects affecting indigenous communities, as they are often more vulnerable against cultural stresses and more sensitive about cultural changes. These activities/practices includes but are not limited to hunting, gathering, believes and spiritual practices and activities, etc. The following objectives are proposed to address the cultural, traditional, and non-market activities and practices in the affected areas (Figure 6-8):

- Identify traditional and cultural activities and practices
- Contribute to and enhance these activities and practices during project development and operation
Topic Six: Legal, regulatory, and company governance capacity

The following objectives are proposed to assess the effectiveness of legal and regulatory structure and company governance capacity to address sustainable development challenges during the project lifetime as well as recovery and closure (Figure 6-9):

- Meet jurisdictional requirements
- Develop and improve corporate governance capacity and strategies

Equitable governance plays a vital role in successfully meeting the SD goals and objectives. In a project, governance dimension incorporates the capacity and resources (e.g. existing regulations and policies) of all parties (company, community, government, NGOs, and other interested parties). Country governance also includes political factors (e.g. political stability and governmental subsidies and incentives) that affect the feasibility of projects, as no investor is willing to provide funds in
politically unstable countries. In addition, direction of governmental subsidies and incentives (against or in favour of geothermal power projects) affects the feasibility of a project. For instance, in Canada, due to the vast availability of hydro resources, governmental subsidies are focused on hydro energy as the first alternative energy source; as a result, geothermal power industry is in disadvantage in comparison (Lopoukhine, 2014).

**Topic Seven: Ongoing review and improvement by company, community, and government**

Sustainable development is a dynamic process of ongoing learning, adopting, revising of decisions and approaches. Thus, constant reviewing and adjusting of the selected SD path and agreed goals is an essential part of adaptation. Aside from considering the changes in technology, changes in the needs, values, and political and cultural structures and capacities of the host society also affects the SD vision and strategies. To address the need for ongoing review of the SD approach adopted by the company, community, and government, the following objectives are proposed (Figure 6-10):

- Assess and improve on-going project contributions to SD
- Explore broader contributions and possibilities at larger geographic scales

![Figure 6-10: Specific objectives for guiding and assessing the success of ongoing reviews and improvement by company, community, and government](image-url)
6.2 Development of SD Maturity Model

There are two methods for project evaluation: formative and summative. “Formative evaluations are conducted during program development and implementation and are useful ... [when] direction on how to best achieve ... [defined] goals or improve ... [a] program. Summative evaluations should be completed once ... [a] programs are well established and will tell ... to what extent the program is achieving its goals ... which of these evaluations is most appropriate depends on the stage of your program” (Meera, 2016).

The SD maturity model is meant to demonstrate the extent to which a company understands, believes, implements, and commits to having positive contributions toward SD. The proposed maturity model in this Chapter aims to help companies and other interested parties evaluate the overall progress of a specific project or a company with respect to its approach towards SD. The model targets companies/projects, which are already committed or willing to commit to SD practices to verify the quality and level of consistency in the implementation and adaptation of SD concept. The proposed SD maturity model reflects the depth and quality of SD-thinking influences within a company/project development paradigm. These factors can be measured within three corporate structural layers: corporate culture and value toward the SD concept, influence of SD-thinking within the business model, and the company’s public relationships as a responsible neighbour of the host society. Figure 6-11 illustrates these structural layers and their related sub-layers.

![Figure 6-11: Corporate structural layers and sub-layers in adaptation of SD-thinking](image-url)
Note that as much as SD is about external relationship of a company with their stakeholders, it is also about internal corporate culture and relationships. The focus of the proposed GSD framework (Section 6.1) is more on the external considerations of the SD concept to assess geothermal power projects to be a responsible neighbour; however, the internal maturity is vital to make implementation of SD objectives happen. The proposed maturity model can be used at both organizational and project levels. A company and/or project management can use the proposed model, as a self-evaluation guideline to (a) evaluate and monitor their level of maturity and capacity to implement defined SD objectives (refer to GSD framework), and (b) deploy an evolutionary path to improve and maintain their SD maturity level over time. In applying this method, five increasing maturity levels are identified to help companies and project management track their progress.

![Figure 6-12: Charter of SD maturity](image)

A brief description of these levels is presented in Table 6-8 and is intended to form the basis of a more detailed maturity model based on the SD-thinking influence within each defined structural sublayer in Figure 6-11. In Figure 6-12, the proposed levels of maturity are weighted against a project/company’s extent of commitment and willingness to go beyond legal compliance to fulfill SD objectives. As shown, true implementation of the SD concept (outstanding level of SD maturity) requires commitments beyond compliance by projects/companies. The proposed maturity model helps projects/companies to evaluate their depth of SD-thinking, adaptation and commitments within each defined corporate structural layers in Figure 6-11. At this end, a maturity matrix is developed for each structural layer as a self-evaluation tool well suited to apply at project and corporate scales (Sub-
sections 6.2.1 to 6.2.6). Note that the method used in proposed maturity model in this Chapter can be used by any industry and projects in various fields regardless of adopting the proposed GSD framework here or other SD strategies to evaluate their maturity of SD-thinking adaptation and commitments.

Table 6-1: Description of SD maturity levels

<table>
<thead>
<tr>
<th>Maturity Levels</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>Project management is in denial about the importance of including SD–related matters and practices in their project designs and development. The management is not open or keen to discuss the topic or to know more about it. Management follows a closed-door policy in its interaction with stakeholders. Regarding the socio-environmental challenges, a reactive attitude toward events rather than a proactive attitude are followed.</td>
</tr>
<tr>
<td>Initial</td>
<td>A company manages its projects as a silent neighbour to the host communities. Projects comply with mandated laws and regulations, nothing more or less. However, the discussions about the importance of including SD-related matters in daily operations are already taking place at the management level of these projects. In some cases, special teams or individuals are designated to review the overall implementations of corporate and project specific SD initiatives. Some scattered individual SD actions are initiated in some projects without sharing this information across a company-wide basis.</td>
</tr>
<tr>
<td>Transitional</td>
<td>Projects are still silent neighbours in a transition phase where it is beginning to implement initiatives such as engagement processes to address community expectations. The overall SD objectives and organizational-wide policies are better defined and employees are undergoing training. SD practices are being refined and applied. The focus of the company is on building a solid basis for the full implementation of SD strategies at the project level.</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>A company encourages its projects to become active members of the host communities. SD practices is fully understood and implemented by the company’s management and employees at corporate and project levels. Monitoring and evaluation practices are in place to measure the progress. Cost/reward views are still prevalent and limits the extent of the contribution of the company and its projects to social matters.</td>
</tr>
<tr>
<td>Outstanding</td>
<td>A company leads its projects to take a proactive role within the host community and their overall implementation of broad SD practices. Two-way communication channels are established to exchange information and knowledge among the company and its stakeholders at corporate and project levels. SD is a main profit center for a company within the open market competition. Concerns over SD objectives are genuine and are perfectly aligned with business models and activities. Project management establishes long-term contributions that last after the project lifetime. They actively seek new ideas and continuously review and improve their SD actions within their host communities, which are beyond compliance with law and regulations.</td>
</tr>
</tbody>
</table>
6.2.1 Corporate Culture and Value

There are four sub-layers in evaluating the SD maturity level of “corporate culture and value” layer: overall SD approach; engagement and collaboration; knowledge management; and technology and innovation. The following is the list of few example questions and criteria to help projects/companies to self-evaluate their SD adaptation while using the proposed SD maturity matrix for this layer. The proposed maturity matrix is presented in Table 6-9. An extended list of questions and criteria is provided in Appendix C.

1. **Overall SD Approach**: How does a company deliberate SD considerations into decision-making process? And, to what extent does the mindset of those acting on behalf of a company (management, employee, etc.) reflect SD values? Example criteria:
   - Defined integrated SD strategy with:
     - Clearly stated objective and goals
     - Shared organizational-wide SD values and objectives
     - Measurable targets with timeline
     - Clearly stated delivery method
     - Clearly state who is responsible for implementation and/or monitoring the progress
     - Community-wide integrated planning
     - Periodic evaluation and improvement of SD objectives, targets, and strategies
     - Compliance with law
     - Sufficient sureties

2. **Engagement and collaboration**: To what extent does a company engage and collaborate with its employees, partners and stakeholders on SD related issues? Example criteria:
   - Collaboration of employees in development of SD-related objectives and strategies
   - Stakeholders identification and interaction including:
     - Interaction start date (development stage)
– Participation opportunities and frequency
– Depth of involvements

3. **Knowledge management**: To what extent does a company share SD related information openly inside the organization and with the stakeholders? Example criteria:
   - Two-directional communication channels
   - Open and timely information sharing
   - Published SD report
   - Third-party compliance or monitoring report of SD progress

4. **Technology and Innovation**: To what extent does a company conduct R&D or adopt new technology to continuously improve the efficiency and SD-related issues? Example criteria:
   - R&D activities and resources

Suggested geothermal specific criteria:

   a. Considering broader possibilities, e.g.:
      - Cascading system
      - By-products (mineral extraction of brine, etc.)
      - Participating in creation of industrial park
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<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Overall SD Approach</th>
<th>Engagement and collaboration</th>
<th>Knowledge management</th>
<th>Innovation and technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>There is no specific SD strategies or objectives about this aspect. SD issues are not part of company decisions. In overall, SD considers as an overhead. There are some scattered acts of involved individuals on SD. These cannot be repeated without the same team as they depend on the experience and exceptional management skills of those individuals.</td>
<td>No engagement or collaboration on SD-related decision-making between the upper management level and their employees nor stakeholders</td>
<td>Minimum communication channels are in place to share and exchange information between the company and its stakeholders.</td>
<td>The only factor considered in adopting new technology is the economic benefit of that technology</td>
</tr>
<tr>
<td>Initial</td>
<td>Only mandatory SD policies and regulations are followed. Decisions on SD-related matters are limited to management level and mostly are duplicates of existing and tested practices within the system. SD goals have been defined but are not priority and planned actions are based on necessity and cost/risk/reward approach. As a company just starts looking into SD matters, this stage is more about enhancing SD knowledge and awareness among the management and employees and defining general SD objectives to share within the organizational structure. Responsibilities are unclear.</td>
<td>Engagement and collaboration are mostly in place between a company and its business partners only. However, the internal collaboration starts and engagement on SD matters are slowly implemented.</td>
<td>SD-related information and knowledge share only between business partners. No dedicated SD reports. Data sharing is only limited to positive environmental consideration on specific projects</td>
<td>Conformity with laws and regulations regarding adopting new technology and innovation</td>
</tr>
<tr>
<td>Transitional</td>
<td>A company partially adopts some SD aspects through voluntarily activities and guidelines in some projects. The focus is on enhancing a company's image and reputation. SD starts to be partially integrated into business aspects but it is mostly implemented parallel to overall management actions. The actions are more imposed by management into the system rather than being genuine acts of employees. Measurements strategies (indicators) are in place to collect data. Although a company motivates individual and team actions toward SD, the focus is more on attitude and culture rather than a physical action and implementation. There are defined organizational SD objectives, policies, and budget, but there is no integrated approach to guide the implementation and often depends on individual actions and understanding.</td>
<td>Selective engagement and collaborations are in place between a company and its stakeholders. The level of engagement varies between projects, as there is no organizational-wide policy. Internal engagement and collaboration is in place on SD matters with the focus mostly on interdependent teams.</td>
<td>Initiation is taken to establish a one-direction communication channel between the company and its stakeholders. SD report is available with the focus on environmental aspects of projects and some short-term positive social contributions. The effort is to build positive reputation that may encourage green-washing attitude</td>
<td>Beside conformity with laws and regulations on the matter, a company starts its first efforts in SD-related R&amp;D. The focus is often on adaptation of more environmentally friendly technologies for operation</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Overall SD Approach</th>
<th>Engagement and collaboration</th>
<th>Knowledge management</th>
<th>Innovation and technology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Satisfactory</td>
<td>Organizational–wide SD framework/strategy is adopted and integrated within the decision-making processes. However still cost/reward approach is dominating that limits the extent of corporate contributions. Organizational SD goals and objectives are clearly defined and understood within all levels. There is a shared SD vision agreed upon by employees and management. SD objectives are broadly absorbed within a corporate culture and values.</td>
<td>Engagement and collaboration with all stakeholders and among employees are in place regarding SD issues of projects.</td>
<td>Full SD report is shared through one-direction communication channel. Initiation is taken to build a trust and establish transparency and information sharing inside the organization and in relation with their stakeholders.</td>
<td>“Higher effort in sustainability related R&amp;D than industry average. The company invests proactively in technology (BAT) and uses integrated environmental technologies and/or cleaner production” (Baumgartner &amp; Ebner, 2010).</td>
</tr>
<tr>
<td>Outstanding</td>
<td>SD is a main profit center for a company within the market competition. Concerns over SD objectives are genuine and in perfect alignment with business models and activities. A company views its employee as an asset and values and motivates their visions, creativity to improve their actions. Evaluation tools are in place to confirm the positive contributions toward SD in local and regional communities. Targets are measurable with dedicated budgets and timelines. “Culture based on common principles and values, information sharing, participation in the decision-making processes, a learning environment and creative, flexible thinking” (Cagnin, Loveridge, &amp; Butler, 2005). Continuous improvement and new ideas are welcome.</td>
<td>All stakeholders are identified and sufficient engagement and collaboration platforms are in place. The company has a proactive role to establish such relationship as a foundation of its SD strategy.</td>
<td>Two-way communication channels are established to exchange information and knowledge among the company and its stakeholders. SD annual reports, measurements, timelines, budget and evaluation results are published. All stakeholders have the opportunity to participate in development of such reports.</td>
<td>“Significantly higher effort in sustainability related R&amp;D than industry average. BAT is proactively used, also integrated environmental technologies, cleaner production and zero emission” (Baumgartner &amp; Ebner, 2010). A company considers broader possibilities to enhance its contribution in SD of its host communities (e.g. industrial park, cascading system).</td>
</tr>
</tbody>
</table>
6.2.2 **BUSINESS MODEL**

There are three sub-layers in evaluating the SD maturity level of “business model” layer: transport; design and development; and, purchase and supplies. The following is the list of few example questions and criteria to help projects/companies in self-evaluating their SD adaptation while using the proposed SD maturity matrix for this layer. The proposed maturity matrix is presented in Table 6-10. An extended list of questions and criteria are listed in Appendix C.

1. **Transport**: To what extent does a company reduce the transport footprints of its activities?
   Example criteria:
   - Using local procurement
   - Switching to digital communication to reduce material and fuel consumption
   - Switching to eco-friendly transportation options
   - Cutting travel to only a necessity

2. **Design and Development**: To what extent does a company reflect SD objectives into design and development of its projects?

3. **Purchase and Supplies**: To what extent does a company reflect SD consideration in purchases and supplies that it uses? Example criteria:
   - Choosing local suppliers if possible to cut emissions and material consumption due to transportation
   - Using supplier with the same SD value and objectives as the company
   - Using eco-friendly materials during construction and operation
   - And other applicable company’s specific activities
### Table 6-3: Matrices of SD maturity levels for the layer of business model

<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Transport (local procurement, digital communication, traveling, transportation)</th>
<th>Design and development</th>
<th>Purchase and supplies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>No specific policies on this topic</td>
<td>No specific policies developed on this topic</td>
<td>No specific policies on this topic</td>
</tr>
<tr>
<td>Initial</td>
<td>Initial discussion started and a specific team/individual is assigned to review what this topic means for a company</td>
<td>Sustainable development issues are not respected in design and development stage</td>
<td>Initial discussion is started over consideration of SD concerns for the purchases and in choosing suppliers, but no action is taken yet.</td>
</tr>
<tr>
<td>Transitional</td>
<td>An initial report from the task force is received with series of alternative policies. The approach at this point is cost/reward focused on a company’s external image and reputation</td>
<td>The focus is on cleaner and more eco-friendly operations rather than design and development stage.</td>
<td>A company defined the areas of consideration on the matter and preparing cost/rewarding strategy over consideration of SD matters in its purchases and choosing suppliers.</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>Organizational wide policy is in place to partially use local products and services to reduce transport footprint of projects.</td>
<td>SD objectives are partially considered within the design and development stages. However, the economic benefit is the main derived.</td>
<td>Organizational-wide policy is in place on the matter and is partially implemented as much as the financial considerations allow.</td>
</tr>
<tr>
<td>Outstanding</td>
<td>To fulfill its contribution towards SD in local and regional communities, a company goes way beyond its societal and environmental requirements to minimize its transport footprints for instance by using local services and supplies, switching to digital communication, and limiting traveling and transportation to necessary level.</td>
<td>Sustainability issues are respected in design and development processes. Roles and responsibilities are defined. The aim is to design projects from the beginning in a way to reflect SD objectives.</td>
<td>A company proactively includes SD objectives in its purchases and choosing suppliers. Policies and responsibilities are clear and a company works closely with their suppliers to ensure its values and objectives are well understood and received.</td>
</tr>
</tbody>
</table>
6.2.3 **Environmental Aspects**

There are four sub-layers in evaluating the SD maturity level of “Environmental Aspect” layer: natural resources; emissions to air, water, and soil; waste (recycling, disposal hazardous, and non-hazardous); and, biodiversity. The following is the list of few example questions and criteria to help projects/companies in self-evaluating their SD adaptation while using the proposed SD maturity matrix for this layer. The proposed maturity matrix is presented in Table 6-11. An extended list of questions and criteria are listed in Appendix C.

1. **Natural Resources**: To what extent does a company reduce its use of natural resources? Example of geothermal specific criteria:
   - Efficiency (increasing power production efficiency, turbine efficiency, heat exchange, heat, water, and power transmission, cooling tower, lasting production rate, etc.)
   - Reducing water usage in cooling towers, drilling, construction, reinjection, etc.
   - Reducing material usage during design and construction as well as business model policies such as double-sided printing, reusable/recyclable supplies.

2. **Emissions into air, water, and soil**: To what extent does a company reduce its emissions into air, water, and soil? Example criteria:
   - Compliance with law vs. going beyond regulation
   - Zero/minimizing emissions policy from design, construction to operation
   - Close loop operation
   - Setting up sufficient monitoring and measuring mechanisms
   - Continuous adoption and upgrading of new technologies and innovations for cleaner outcome
   - Activities toward the end of a power plant operational lifetime to re-establish the natural conditions

3. **Waste (recycling, disposal (hazardous, and non-hazardous))**: To what extent does a company manage its waste disposal and reduction?
   - Reduction, recycling, and reusing
4. **Biodiversity**: To what extent does a company take care of biodiversity of the environment for its projects? Example criteria:

- Populations of plants, animals and micro-organisms
- Maintaining and improving biodiversity of effected surrounding
- Climate change in the micro scale as a result of heat pollution
- Animal mitigation
- Reclamation
- And other applicable company’s specific activities
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Table 6-4: Matrices of SD maturity levels for the layer of environmental aspects

<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Natural resources (geothermal, water, forestry, materials)</th>
<th>Emissions into air, water, soil</th>
<th>Waste (recycling, disposal (hazardous and non-hazardous), etc.)</th>
<th>Biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Poor</strong></td>
<td>Only economic and technical factors are considered for the use of natural resources. The outcome is completely depended on the management approach and individual actions. No geothermal reservoir utilization policy is in place.</td>
<td>No specific SD policies on this point. Mostly Ad-hoc reaction after incidents. SD issues handled based on individual actions.</td>
<td>No specific SD policies on this point. SD issues handled based on individual actions.</td>
<td>No specific SD policies on this point. SD issues handled based on individual actions.</td>
</tr>
<tr>
<td><strong>Initial</strong></td>
<td>Besides technical and economic aspect, environmental/social factors are partially considered. Some monitoring procedures are in place to measure and collect data of activities on geothermal reservoirs. Considerations are project-based and no clear organizational policy are in place for geothermal production rate or recovery time</td>
<td>Compliance with existing laws and regulations regarding the matter</td>
<td>Basic waste management policies regarding a company’s external relations has been developed at project levels (e.g. separation of recycling waste, etc.)</td>
<td>“Conformity with laws and regulations regarding biodiversity” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td><strong>Transitional</strong></td>
<td>Organization wide policies to minimize natural resource use during operations have been developed considering potential impact on natural resources. Clear measurements and objectives are in place for geothermal reservoir management.</td>
<td>Besides compliance with laws and regulations, organizational wide policies to reduce emissions during production are in place.</td>
<td>Organization wide waste management policies have been developed to minimize and separate waste (e.g. recycling) regarding the available local waste management requirements.</td>
<td>“Conformity with laws and regulations regarding bio-diversity. Most relevant impacts on biodiversity are identified and considered” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
</tbody>
</table>
## Chapter 6 - Design and Development

<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Natural resources (geothermal, water, forestry, materials)</th>
<th>Emissions into air, water, soil</th>
<th>Waste (recycling, disposal (hazardous and non-hazardous), etc.)</th>
<th>Biodiversity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Satisfactory</strong></td>
<td>A company considers minimization of natural resource use in all business aspects from projects designs to operations. Geothermal power projects are designed and operated based on reservoir capacity quick recovery and longer production</td>
<td>A company is widely adopting cleaner production technologies to minimize emissions</td>
<td>Organizational wide waste management policies have been developed to minimize and separate waste (e.g. recycling) in both office space and project sites. A company considers waste minimization while designing its projects</td>
<td>“Bio-diversity and the organizational impact on it in strategy, policy and processes are considered” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td><strong>Outstanding</strong></td>
<td>The company is looking very hard to protect natural resources used in its projects design and operations. Geothermal power projects are designed and operated based on the renewable capacity of the reservoir</td>
<td>In all aspects of business, a company goes beyond the mandatory regulations and laws. The policies and goals are clearly set: toward zero emissions</td>
<td>A company eliminates waste in project designs and operations to only maintain the level of unavoidable wastes. There are clear policies and designs to maximize internal reuse and recycling of waste</td>
<td>A company actively attempts to eliminate its biodiversity impacts during its project lifetime and proactively seeks new ideas and approaches to improve biodiversity of its projects surrounding environment after closure.</td>
</tr>
</tbody>
</table>
6.2.4 **ECONOMIC ASPECTS**

There are three sub-layers in evaluating the SD maturity level of “economic aspects” layer: economic viability of a company; economic benefit sharing; and, SD budget and human resources. The following is the list of few example questions and criteria to help projects/companies in self-evaluating their SD adaptation while using the proposed SD maturity matrix for this layer. The proposed maturity matrix is presented in Table 6-12. An extended list of questions and criteria are listed in Appendix C.

1. **Economic viability of a company**: Is the long-term economic viability of a company secure?
   
   Example criteria:
   
   - Average feasible project lifetime

2. **Economic benefit sharing**: To what extent does a company share its economic benefits with the affected communities? Example criteria:
   
   - Compliance with law (e.g. tax, royalty, etc.)
   - Long-term community capacity development
   - Direct vs. indirect financial contributions

3. **SD budget and staff**: To what extent does a company dedicate budget and human resource to implement SD concepts?
### Table 6-5: Matrices of SD maturity levels for the layer of economic aspects

<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Economic viability of a company</th>
<th>Economic benefit sharing</th>
<th>SD budget and staff</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Poor</strong></td>
<td>The project is designed to maximize the economic gain (high production rate) regardless of environmental and social impacts.</td>
<td>No specific policies on this point and the matter depends on individual actions and project specific needs.</td>
<td>No specific SD budget or human resources dedicated to the matter to this point.</td>
</tr>
<tr>
<td><strong>Initial</strong></td>
<td>SD considerations are partially considered in the budget of some specific projects, mostly in conformity with law. Considerations are project-based and no clear organizational policy are in place to consider SD consideration into budget and financial aspect of business.</td>
<td>Economic benefit sharing limited to regulatory requirements through tax, etc.</td>
<td>There is no specific team assigned to look after SD planning and implementation but budget is dedicated to each division of a company to include some SD aspects into their projects. However, SD budget and resources are the first to get cut due to financial considerations, as they are not priority.</td>
</tr>
<tr>
<td><strong>Transitional</strong></td>
<td>There are organization wide policies and objectives to consider SD aspects within the budget of development and operation. The focus is mostly on SD aspects that directly impact the competition on market or incentives and shareholders. Environmental aspects have the biggest share of SD budget.</td>
<td>Some economic benefit sharing is considered mostly to gain better reputation. The focus is on short-term, more monetary contributions. The effect of the contributions often won’t stay after a project/company’s lifetime.</td>
<td>“Sustainability responsibility is assigned to a unit or team. Internal relationships among teams exist and staff in general is well qualified to internalize sustainability and have the adequate resources available” (Cagnin, Loveridge, &amp; Butler, 2005). The focus of this team is more on external relationship and creating a positive image for a company.</td>
</tr>
<tr>
<td><strong>Satisfactory</strong></td>
<td>All SD considerations are included in the design and evaluation and well incorporated in a company’s budget from project design to operations. The goals are clear and well understood at various levels of the organization and included in the projects budget.</td>
<td>The focus is more on combination of short and long-term contributions within the society such as use of local services and supplies and helps in improving the society foundations.</td>
<td>Budget and human resources are dedicated to the matter. Responsibilities, tasks, and budgets are clear and defined.</td>
</tr>
<tr>
<td><strong>Outstanding</strong></td>
<td>Within all aspects of the business, SD considerations and beyond are well respected into a company’s budget and profit. Due to this, a company increases its economic profits and stability by gaining a better position in the competitive market, governmental incentives, outstanding reputation among the shareholders and investors, harvesting full capacity of its resources (cascading systems, by-products, etc.)</td>
<td>The focus is on building capacities of affected communities and long-term contributions way beyond project lifecycle. The contributions are in the direction of SD plans in local and regional communities and empowering local resilience (e.g. contribution in development of industrial park or cascading systems, etc.)</td>
<td>Budget and human resource is dedicated to the matter. Although the responsibilities, tasks, and budgets are clear and defined, a company proactively invests in R&amp;D and encourages new and creative ideas to improve its approaches.</td>
</tr>
</tbody>
</table>
6.2.5 **INTERNAL SOCIAL ASPECTS**

There are two sub-layers in evaluating the SD maturity level of the “internal social aspects” layer: labor practice; and, human rights. The following is the list of few example questions and criteria to help projects/companies in self-evaluating their SD adaptation while using the proposed SD maturity matrix for this layer. The proposed maturity matrix is presented in Table 6-13. An extended list of questions and criteria are listed in Appendix C.

1. **Labour practices**: To what extent does a company take care of its employee’s rights, safety, and health? Example criteria:
   - “Labour/management relations
   - Health and safety
   - Human capital development (training and education, organizational learning)
   - Diversity and equal opportunity” (Silvius, 2010)
   - Compliance with local and international workforce policies
   - Encouraging individual’s creativity

2. **Human rights**: To what extent does a company respect the human rights of its employees and those affected by its activities? Example criteria:
   - “Non-discrimination
   - Freedom of association
   - No child labour
   - No Forced and compulsory labour” (Silvius, 2010)
Table 6-6: Matrices of SD maturity levels for the layer of internal social aspects

<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Labour practices</th>
<th>Human rights</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>No specific policy on this point about diversity and equal opportunity</td>
<td>No specific policies on this topic</td>
</tr>
<tr>
<td>Initial</td>
<td>Conformity with laws and regulations</td>
<td>“Human rights are generally respected, but no codes and guidelines exist as well as no corporate common behaviour/within the organization” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td>Transitional</td>
<td>In order to improve internal labour practices and corporate culture and ethics, the company has a 3-5 years active plan to develop relevant policies.</td>
<td>“Human rights are respected. Principal rules how to behave within the organization are defined” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>The initiation is taken to improve labour practices through providing organizational guideline and policies.</td>
<td>“Definition of corporate codes and guidelines regarding (internal) behaviour throughout the whole organization exist” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td>Outstanding</td>
<td>The company has a proactive, continuous, and leading role in improving human capital and diversity and providing equal opportunity inside its business structure. Ongoing strategies of reviewing and improvement of the policies and guidelines are in place.</td>
<td>“Corporate codes and guidelines regarding (internal) behaviour throughout the whole organization are defined. Controlling and proactive improvement of these codes” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
</tbody>
</table>
6.2.6 **EXTERNAL SOCIAL ASPECTS**

There are four sub-layers in evaluating the SD maturity level of “external social aspects” layer: health and safety; cultural and traditional activities and practices; no controversial activities; and, no corruption and cartel. The following is the list of few example questions and criteria to help projects/companies in self-evaluating their SD adaptation while using the proposed SD maturity matrix for this layer. The proposed maturity matrix is presented in Table 6-14. An extended list of questions and criteria are listed in Appendix C.

1. **Health and safety**: To what extent does a company secure the health and safety of affected communities? Example criteria:
   - Health and safety monitoring and measuring mechanisms
   - Local and third-party monitoring mechanisms and collaboration
   - Developing emergency protocols agreed and understood by community
   - Health and safety information shared openly and in a timely manner.

2. **Cultural and traditional activities and practices**: To what extent does a company include the importance of cultural and traditional activities and practices in its projects development and operations?

3. **No controversial activities**: To what extent does a company avoid controversial activities and investments (those that negatively affects society’s journey toward SD)? Example criteria:
   - Clearly stated and shared value agreed and understood by employees, contractors, and all those who represent or work with a company

4. **No corruption and cartel**: To what extent does a company respect fair market and avoid corruptive and manipulative business activities? Example criteria:
   - Clearly stated and shared value agreed and understood by employees, contractors, and all those who represent or work with a company
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<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Health and safety</th>
<th>Cultural and traditional activities and practices</th>
<th>No controversial activities</th>
<th>No corruption and cartel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poor</td>
<td>No specific policies on this topic</td>
<td>No specific policies on this topic</td>
<td>No specific policies on this topic</td>
<td>No specific policies on this topic</td>
</tr>
<tr>
<td>Initial</td>
<td>“Health and safety is respected to the extent of legal obligation; it is not actively focused on” (Baumgartner &amp; Ebner, 2010)</td>
<td>Conformity with laws and regulations</td>
<td>“No declaration against controversial activities exists” (Baumgartner &amp; Ebner, 2010)</td>
<td>“Conformity with laws and regulations regarding corruption and cartel exists” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td>Transitional</td>
<td>“Health and safety is respected to the extent of legal obligation. Measures towards health and safety are set, when specific dangerous situations or accidents occur. Deployment is more of reactive character rather than systematically planned” (Baumgartner &amp; Ebner, 2010)</td>
<td>Besides conformity with laws and regulations, a company avoids offensive activities regarding local/regional cultural and traditional activities and practices.</td>
<td>“Firm declares itself to be aware of to whom it sells its goods” (Baumgartner &amp; Ebner, 2010)</td>
<td>“Compliance with laws and regulations; most important impacts regarding corrupt practices are identified” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td>Satisfactory</td>
<td>“Health and safety is systematically planned and deployed in most areas of the company. Activities are set to avoid health and safety risks in long term” (Baumgartner &amp; Ebner, 2010)</td>
<td>A company actively works with the local communities to better identify the traditional and cultural activities and practices as well as find out the areas of possible collaborations and involvement for the company. A team is assigned to provide guidelines and strategies for a smooth transition of a company towards this matter.</td>
<td>“Organization is aware to whom it sells its goods and sets measures to reduce controversial activities” (Baumgartner &amp; Ebner, 2010)</td>
<td>“Impacts regarding corrupt practices are fully identified and measures set to avoid them” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
<tr>
<td>Outstanding</td>
<td>“Health and safety approach supports organizational goals towards sustainability. It is systematically planned and deployed throughout the company. Activities are set to avoid health and safety risks in long-term and are consequently improved” (Baumgartner &amp; Ebner, 2010)</td>
<td>Company proactively collaborates with affected communities to provide respectful ambiance towards local/regional cultural and traditional activities and practices. Company encourages its employees to participate in local activities and be part of communities where their projects are located.</td>
<td>“Organization is known as non-controversial acting firm. It shows credibility in that it offers and follows possibilities to avoid negative use of its products, based on stakeholder requirements” (Baumgartner &amp; Ebner, 2010)</td>
<td>“Impacts regarding corrupt practices are fully identified. Distinct rules exist to demonstrate all kinds and (internal) consequences of corrupt practices and measures set to avoid them at all” (Baumgartner &amp; Ebner, 2010)</td>
</tr>
</tbody>
</table>
Chapter 7

Results and Discussion

The focus of this chapter is to report and analyze the outcomes of the survey and interviews that were conducted during the course of this research. This chapter covers the following topics:

- Report on the findings of the survey: this section aims to communicate the survey results. The survey is used as a quantitative research method to establish an external validation tool for the proposed framework (Section 7.1). The survey findings can help to generalize and refine the GSD framework to better suit the needs of the geothermal power arena.

- Report on the findings of the interviews: this section presents the results of testing the proposed SD maturity model on the six geothermal power projects that were discussed during the in-depth interviews (Section 7.2). The interviews were conducted as a qualitative research method to test the proposed SD maturity model in real world setting.

7.1 Survey

The survey participants were from different sectors of the geothermal power arena including the industry, consultants, government and municipal, NGO’s and civil society, academia, financial institutes, and law and policy sectors. Remarkably, while approaching the potential participants, the NGO’s were the least and the governments were the most supportive ones. The geographic distribution of the survey participants is presented in Figure 7-1. In total, 40 completed responses were collected from Canada, USA, Argentina, Germany, Iceland, United Kingdom, Uganda, Indonesia, Mongolia, Italy, and Romania. Table 7-1 presents the distribution of the survey participants in different sectors of the geothermal arena.
Figure 7-1: Survey participants’ location map

Table 7-1: Geothermal power related groups who participated in the survey

<table>
<thead>
<tr>
<th>Response</th>
<th>Chart</th>
<th>Percentage</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government &amp; Municipal</td>
<td></td>
<td>15.0%</td>
<td>6</td>
</tr>
<tr>
<td>Industry</td>
<td></td>
<td>17.5%</td>
<td>7</td>
</tr>
<tr>
<td>NGO's &amp; Civil Society</td>
<td></td>
<td>2.5%</td>
<td>1</td>
</tr>
<tr>
<td>Academia</td>
<td></td>
<td>25.0%</td>
<td>10</td>
</tr>
<tr>
<td>Financial Institutions</td>
<td></td>
<td>5.0%</td>
<td>2</td>
</tr>
<tr>
<td>Consultant</td>
<td></td>
<td>25.0%</td>
<td>10</td>
</tr>
<tr>
<td>Law &amp; Policy</td>
<td></td>
<td>7.5%</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td>2.5%</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total Responses</strong></td>
<td></td>
<td><strong>40</strong></td>
<td></td>
</tr>
</tbody>
</table>

Participants were specifically asked to rank:

- The potential suitability of objectives as an evaluation tool to determine whether topics are addressed during project life cycle on a scale of 1-5 (low to high)
Chapter 7 - Results and Discussion

- The GSD framework as a whole in terms of whether it reflects the main issues related to the contribution of a geothermal power project to SD in local and regional communities on a scale of 1-5 (low to high)
- The relative importance of each of the proposed seven topics on a scale of 1-5 (low to high)
- The importance of including community SD considerations in the frameworks on a scale of 1-5 (low to high)

A complete list of the survey questions can be found in Appendix C. The results of the survey are presented in the following sub-sections.

7.1.1 ENGAGEMENT

As mentioned in Section 6.1.3.1, there are two objectives under the topic of “engagement”: (1) design and implement engagement strategies; and (2) develop and implement dispute resolution. Figure 7-2 shows the scores for the suitability of the developed objectives for guiding and assessing the implementation of “engagement” topic. It can be seen that, while the majority of participants agreed upon the suitability of developing and implementing engagement strategies for the task, the participants showed a less unified response on developing and implementing dispute resolution mechanisms in projects. On average, objective one received the overall score of 3.8 with the standard deviation (Std.Dev) of 0.9 while objective two scored 3.6 on average with Std.Dev of 1.3.

To further investigate, the results are broken down based on the employment sector of the top four larger participant groups: government and municipal, the industry, academia, and consultant. The results revealed an interesting trend. For instance, while the majority of the participants from industry gave a median score (3 out of 5) to both engagement objectives, the survey participants from academia and government/municipal sectors are more interested in applying both objectives. The score for the consultant sector is scattered from low to high while they slightly lean toward the higher end.
7.1.2 **Valuing People and Their Aspirations**

“Valuing people and their aspirations” topic was presented in 6.1.3.2 with the following objectives: (1) identify, maintain, or facilitate the development of community’s future plans and strategies; (2) maintain or improve the project area societal and cultural values; and (3) safeguard worker/community health and safety in the development and operations of a project. Figure 7-3 shows the scores for the suitability of the developed objectives for guiding and assessing the implementation of “valuing people and their aspirations” topic. As shown, the tendency of majority is on the higher end for all three objectives. The average scores and their standard deviations for each objective are:

- Objective one received the average score of 4.0 with a standard deviation of 0.6;
- The second objective scored the average of 3.8 with a standard deviation of 1.0, and;
Objective three scored 4.3 on the average with a standard deviation of 1.0

Figure 7-3: Suitability of objectives defined for addressing “valuing people and their aspirations” topic on a scale of 1-5 (low to high)

Further analysis based on the employment sector of the top larger participant groups shows a united agreement on the suitability of the first objective to guide and evaluate the implementation of the topic. The average scores from government/municipal, industry, academia, and consultant sectors are 3.8, 4.0, 4.2, and 3.9 respectively. Table 7-2 shows the average suitability scores of each objective based on the employment sector of the participant groups. It can be seen that the majority of the participants agreed upon the suitability of the objective three as one of the indicators that confirms the topic is addressed properly.

Table 7-2: The average (Ave.) scores of objectives for Topic 2 based on the employment sector of the top larger participant groups on a scale of 1-5 (low to high)

<table>
<thead>
<tr>
<th>Response</th>
<th>Government &amp; Municipal</th>
<th>Industry</th>
<th>Academia</th>
<th>Consultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective one</td>
<td>3.8</td>
<td>0.8</td>
<td>4.0</td>
<td>1.5</td>
</tr>
<tr>
<td>Objective two</td>
<td>4.3</td>
<td>0.7</td>
<td>3.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Objective three</td>
<td>4.5</td>
<td>0.4</td>
<td>4.6</td>
<td>0.8</td>
</tr>
</tbody>
</table>
7.1.3 Environmental Considerations

Figure 7-4 shows the scores for the suitability of the developed objectives for guiding and assessing the implementation of “environmental considerations” topic. As shown the majority of the participants agree upon the suitability of both objectives. The participants scored the first and second adjectives (“maintain regulatory compliance and apply measures to improve conditions beyond regulatory requirements” and “evaluate the sensitivities of the environment to changes”) as an average of 4.3 with the standard deviation of 0.8 and 0.9 respectively.

Further analysis of the results based on the employment sector of top larger participants is shown in Table 7-3. While the majority of scores from government/municipal, industry, and academia sectors lean toward the higher scales for the first objective (scores of 4-5), the consultant sectors showed less unity with scattered scores between 2-5. Moreover, in evaluating the suitability of “sensitivities of the
environment to changes” objective as an indicator of implementing the topic, unlike the other sectors, the industry sector leaned toward the middle.

Table 7-3: The average (Ave.) scores of objectives for Topic 3 based on the employment sector of the top larger participant groups on a scale of 1-5 (low to high)

<table>
<thead>
<tr>
<th>Response</th>
<th>Government &amp; Municipal</th>
<th>Industry</th>
<th>Academia</th>
<th>Consultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>Av.</td>
<td>Std.Dev</td>
<td>Av.</td>
<td>Std.Dev</td>
</tr>
<tr>
<td>Objective one</td>
<td>4.5</td>
<td>1.6</td>
<td>4.6</td>
<td>0.8</td>
</tr>
<tr>
<td>Objective two</td>
<td>4.5</td>
<td>1.6</td>
<td>4.0</td>
<td>0.8</td>
</tr>
</tbody>
</table>

7.1.4 Economic Viability of the Project and Nearby Communities as a Result of the Project

Table 7-5 shows the scores for the suitability of objectives defined for addressing “economic considerations” topic on a scale of 1-5 (low to high). As shown, the tendency of the majority is towards the higher end of the scale for both objectives, as:

- Objective one (maintain long-term economic viability of the project) received the average score of 4.5 with a standard deviation of 0.7

Figure 7-5: Suitability of objectives defined for addressing “economic viability of the project and nearby communities as a result of the project” topic on a scale of 1-5 (low to high)
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- Objective two (develop a vision and strategies for long-term economic benefit sharing) scored the average of 4.2 with a standard deviation of 0.9

Table 7-4: The average (Ave.) scores of objectives for Topic 4 based on the employment sector of the top larger participant groups on a scale of 1-5 (low to high)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective one</td>
<td>4.7</td>
<td>1.4</td>
<td>4.7</td>
<td>1.7</td>
<td>4.4</td>
<td>1.3</td>
<td>4.2</td>
</tr>
<tr>
<td>Objective two</td>
<td>4.0</td>
<td>0.3</td>
<td>4.3</td>
<td>0.9</td>
<td>4.6</td>
<td>1.0</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Further analysis of the results based on the employment sector of the top larger participants shows the majority of participants in all sectors agreed upon the suitability of the first objective. But as shown in Figure 7-6, when it comes to benefit sharing with the community (objective two), government/municipal and industry sectors took more conservative scores than academia and consulting sectors.

Figure 7-6: Suitability of objective two (develop a vision and strategies for long-term economic benefit sharing) of Topic 4 based on the employment sector of the top larger participant groups
7.1.5 Including the Importance of Cultural and Traditional Activities and Practices in Project Development and Operation

Figure 7-7 shows the scores for the suitability of objectives defined for addressing the topic of “including the importance of cultural and traditional activities and practices in project development and operation” on a scale of 1-5 (low to high). It can be seen that while “identifying traditional and cultural activities and practices” (objective one) received higher recognition among the participants by the average of 3.9 (Std.Dev of 1.1), the companies’ contribution to these activities received a lower score (average of 3.7 and Std.Dev 1.1).

Figure 7-7: Suitability of objectives defined for addressing “including the importance of cultural and traditional activities and practices in project development and operation” topic on a scale of 1-5 (low to high)
Figure 7-8: Suitability of objective two (contribute to and enhance these activities and practices during project development and operation) of Topic 5 based on the employment sector of the top larger participant groups

Further analysis of the results for objective two, based on the employment sector of the top larger participants, shows that while the majority of the participants in the academic sector recognized the importance of the companies’ contribution to cultural preservation of the host community, the tendency of the government/municipal and the industry sectors is on the lower end, Figure 7-8.

7.1.6 LEGAL, REGULATORY, AND COMPANY GOVERNANCE CAPACITY

Figure 7-9 shows the scores for the suitability of objectives defined for addressing the topic of “legal, regulatory, and company governance capacity” on a scale of 1-5 (low to high). As shown, both objectives received almost the same scores with an average of 3.9 and a Std.Dev of 1.0 and 1.1 respectively. Further analysis of the result based on the employment sectors revealed the following interesting insights:

- Regarding objective one (meeting jurisdictional requirements), while the industry, consultant, and academia sectors recognized the importance of this objective; the
government/municipal score of this objective was the lowest with the average of 3.5 (Std.Dev 0.4).

- Regarding the second objective (develop and improve corporate governance capacity and strategies), while a majority of the participants shared a relatively similar view about the proposed objective (with the average scores of 4.3, 4.6, and 4.1 respectively), the participants from the consulting sector have a less collective bargaining with the average score of 3.1 out of 5.

![Figure 7-9: Suitability of objectives defined for addressing “legal, regulatory, and company governance capacity” topic on a scale of 1-5 (low to high)](image)

### 7.1.7 *ONGOING REVIEWS AND IMPROVEMENT BY COMPANY, COMMUNITY, AND GOVERNMENT*

Figure 7-10 shows the scores for the suitability of objectives defined for addressing the topic of “ongoing reviews and improvement by company, community, and government” on a scale of 1 to 5 (low to high). Objective one (assess and improve ongoing project contributions to SD) received the score of 4.1 with a Std.Dev of 0.9. The overall score decreased to 3.9 with a standard deviation of 1.0
for the second objective (explore broader contributions and possibilities at larger geographic scales). Further analysis of the results based on the employment sectors of the participants showed that:

- Regarding objective one, while the majority of participants within the industry, academia, and government sectors recognized the importance of continuous improvement and assessment, the consultant sectors does not share the same view (see Table 7-5).

- Regarding the second objective, as Figure 7-11 illustrated, while the majority of the participants in academia and the government/municipal sectors are keen on including the possibility of exploring broader contribution and possibilities, the industry and consultant sectors indicated a lower interest on the matter. The average score of second objective from government was 4.0 (Std.Dev 1.2), academia 4.2 (Std.Dev 1.0), industry 3.7 (Std.Dev 0.5), and the consultant 3.4 (Std.Dev 0.6).

![Figure 7-10: Suitability of objectives defined for addressing “ongoing reviews and improvement by company, community, and government” topic on a scale of 1-5 (low to high)](image)

<table>
<thead>
<tr>
<th>Response</th>
<th>Government &amp; Municipal</th>
<th>Industry</th>
<th>Academia</th>
<th>Consultant</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective one</td>
<td>4.2</td>
<td>1.0</td>
<td>4.3</td>
<td>1.0</td>
</tr>
<tr>
<td>Objective two</td>
<td>4.0</td>
<td>1.2</td>
<td>3.7</td>
<td>0.5</td>
</tr>
</tbody>
</table>
When participants were asked whether they agreed that these seven topics (the GSD Framework as whole) reflect the main issues related to the contribution of a geothermal power project to SD in local and regional communities, the majority were in agreement, with an average score of 4.0 (Std.Dev 1.0). Figure 7-12 shows the distribution of the responses based on the employment sectors of the participants. Further analysis of the result indicated that the majority (above 50%) of the participants in the academia (60%), industry (57.1%), and financial institutes (50%) scored the suitability of the framework for the task 5 out of 5. The percentage of the participants with the positive opinion (higher scores of 4 and 5) of the framework in each sector is as follows: industry 100%, academia 80%, consultant 70%, government/municipal 66.7%, financial institutions 100%, and law and policy 66.7%.
Figure 7-12: The overall score of the GSD Framework on the scale of 1-5 (low to high) based on the employment sectors of participants

Figure 7-13: Overall relative importance of the topics
The assumption behind the development of the seven topics was that each topic should carry the equal relative importance in evaluating the overall contribution of a project to SD in local and regional communities. To investigate the view of the geothermal power arena on the matter, the participants were asked to indicate the relative importance of the topics in regard to contribution of a project to SD in their opinion. As shows in Figure 7-13, the majority of the participants assigned an equal weight to the topics of “engagement”, “valuing people and their aspiration”, “including the importance of cultural and traditional activities and practices”, and “ongoing reviews and improvement by company, community, and government”. It can be seen that these topics are mainly related to the social dimensions of the SD concept. On the other hand, the topics of “environmental considerations”, “economic viability of the project and nearby communities as a result of the project”, and “legal, regulatory, and company governance capacity” are considered more important by the majority. Further analysis of the results based on the employment sectors of the top larger groups of participants is shown in Figure 7-14. It can be seen that:

- Within the industry sector, economic and environmental considerations (topic 3 and 4) are considered more important, while the societal topic (including the importance of cultural and traditional activities and practices) is granted a “less important” score.
- Within the government and municipal sector, “environmental considerations” (topic 3) was the most important topic, following with the “economic viability of the project and
nearby communities as a result of the project” (topic 4), “legal, regulatory, and company
governance capacity” (topic 6) and “valuing people and their aspiration” (topic 2)
respectively.

- Within academia, the most important topic is the “legal, regulatory, and company
governance capacity” (topic 6) followed by “including the importance of cultural and
traditional activities and practices” (topic 5), “environmental considerations” (topic 3),
and “economic viability of the project and nearby communities as a result of the project”
(topic 4) respectively.

- Among the consultants, the majority of participant unanimously scored all topics equally
important except for the “environmental considerations” (topic 3) and “valuing people
and their aspiration” (topic 2), which were marked as “more important”.

7.1.9 Further Analysis

Note that while the results presented here (sub-sections 7.1.1 to 7.1.8) determined the overall
agreement upon the suitability of the GSD framework for its defined tasks, it also revealed a lack of
consensus among the participants from various employment sectors within the geothermal power
arena. The lack of a shared SD vision, common understanding, and guidelines play an important role
in the perceived deviation, the exact challenge that motivated this research at the beginning.

To further examine the depth of SD-thinking within the geothermal power arena, the participants
were asked to rank the importance of including the sub-objectives shown in Figure 7-15 in the
framework. These sub-objectives mainly deal with community SD considerations. According to
Figure 7-15, the majority agreed that those sub-objectives are related to the environmental
considerations and to some extent required by law, for instance, “greenhouse gases”, “natural
resource managements”, and “polluting emissions related to air, soil, and water”. However, the sub-
objectives which are related to the social dimensions or are beyond the legal requirements, are less
popular, such as, “use of local services and products”, “energy and material consumptions”, and
“green building designs”. Further investigation based on the employment sector of the top larger
participant groups shows that:
Chapter 7 - Results and Discussion

- Regarding the use of local services and products, while the majority of the participants in academia sector (Ave. 4.0, Std.Dev 0.4) support this sub-objective, the government/municipal, industry, and the consultants have a more conservative approach with the average score of 3.5, 3.6, and 3.4 respectively.

- Regarding the energy and material consumptions, the results show that while the government/municipal and academia sectors support including this sub-objective in the framework by an average score of 4.0 (Std.Dev. 1.2) and 4.5 (Std.Dev. 1.7), the industry and consultants are less eager with average scores of 3.6 and 3.8 respectively.

- Regarding green building designs, similar to the above analysis, the majority of participants within the government/municipal and academia sectors are agreed upon inclusion of this sub-objective with average scores of 4.0 (Std.Dev. 0.3) and 4.1(Std.Dev. 0.9), but the average scores of the industry and consultants leaned toward the middle with 3.3 (Std.Dev. 0.6) and 3.1 (Std.Dev. 0.3).
Figure 7-15: The importance of including community SD consideration into the framework
7.1.10 Recommendations

A total of 16 recommendations and suggestions were received online with the survey. Those that were directly related to the proposed framework are shown in Table 7-6 and are reflected within the final draft of the framework. There were some general suggestions on how to further improve and grow the geothermal power arena from the survey participants. Although these suggestions were beyond the scope of this research, the author decided to present them here in Table 7-7. These recommendations can provide further insight into other existing needs and gaps within the geothermal power arena. Note that due to the dual nature of some feedback, they are included in both tables.

Table 7-6: Feedback received by the survey participants that directly related to the GSD framework

<table>
<thead>
<tr>
<th>Feedback</th>
<th>Is the feedback included within the final draft of the GSD framework?</th>
</tr>
</thead>
<tbody>
<tr>
<td>The companies can contribute via: employment of local people on the project, support technical education locally to provide support and career opportunities for the next generation</td>
<td>Yes Within the Topic 4</td>
</tr>
<tr>
<td>All the 7 topics are quite significant in contributing geothermal energy to SD; depending on the scale of the project (local or regional) and the heat/power production targets, the weights of some factors are higher. Regarding current regulatory hurdles in developing geothermal energy in provinces, building legal and regulatory capacity has the most top importance.</td>
<td>Yes Within the Topic 6</td>
</tr>
<tr>
<td>The survey does not address trade-offs and incentives</td>
<td>No Within Topic 3 and 6</td>
</tr>
<tr>
<td>Suggested SD topics to be added: Corporate transparency; standards for disclosures and reporting</td>
<td>Yes Within Topic 1</td>
</tr>
<tr>
<td>Suggested SD topics to be added: Ability of the project proponent to pay for harm that may occur; general financial viability of the proponent</td>
<td>Yes Within Topic 4</td>
</tr>
<tr>
<td>Suggested SD topics to be added: resource management, utilization efficiency, research and innovation, energy security, and knowledge sharing</td>
<td>Yes Within Topic 1, 2, 3, 7</td>
</tr>
<tr>
<td>Suggested SD topics to be added: on going public communication, transparency in all communication including benefits paid, localization and training, local business development, closure plans</td>
<td>Yes Within Topics 1, 4, 6</td>
</tr>
<tr>
<td>Suggested SD topics to be added: geothermal safety. In looking at scientific, (both spectacular and mundane) conditions at Yellowstone, there are some concern about geothermal catastrophic events. Would it be possible over the next two hundred years to drain off energy from the Caldera to eliminate risk of a super eruption?</td>
<td>Yes Within Topic 2 and 7</td>
</tr>
<tr>
<td>Suggested SD topics to be added: Education of communities and professionals through the projects, also in regards to sustainability</td>
<td>Yes Within Topic 2</td>
</tr>
</tbody>
</table>
**Chapter 7 - Results and Discussion**

Table 7-7: General feedback received from the survey participants

<table>
<thead>
<tr>
<th>Suggestions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Countries with a very well-developed framework and technologically advanced should assist second and third world countries in this kind of projects, with transfer of technology and funding, because CO2 and other GHG effects on the entire planet.</td>
</tr>
<tr>
<td>Devising a plan of action for immediate development of geothermal resources globally on a scale adequate for replacement of all fossil fuel powered electrical power generation stations and implementation of the plan during the coming decade.</td>
</tr>
<tr>
<td>Will sustainable development be same level in every country e.g. Africa, Asia, Europe etc.?</td>
</tr>
<tr>
<td>All the 7 topics are quite significant in contributing geothermal energy to SD; depending on the scale of the project (local or regional) and the heat/power production targets, the weights of some factors are higher. Regarding current regulatory hurdles in developing geothermal energy in provinces, building legal and regulatory capacity has the most top importance.</td>
</tr>
<tr>
<td>The high initial cost of geothermal exploration which is always prohibitive should be considered</td>
</tr>
<tr>
<td>Bringing in foreign specialists who can share their developments and new ideas would be a great asset in SD approach.</td>
</tr>
<tr>
<td>In looking at scientific, (both spectacular and mundane) conditions at Yellowstone, there are some concern about geothermal catastrophic events. Would it be possible over the next two hundred years to drain off energy from the Caldera to eliminate risk of a super eruption? Geothermal safety consideration would be great addition to the project planning?</td>
</tr>
</tbody>
</table>
7.2 **INTERVIEWS**

This section reports the outcome of interviews conducted to investigate the current SD maturity status of geothermal power projects using the proposed SD maturity model (see Chapter 6, Section 6.2 for detail explanation of proposed maturity model). As discussed in the methodology chapter (Chapter 5), the six interviews were conducted by focusing on six case studies on specific geothermal power projects. The main challenge was to find individuals with holistic knowledge of considerations in the proposed SD maturity model for a specific geothermal power project. The outcome of this high expectation was that a few interviews were cancelled midway through, as the respondents did not have the holistic view of the project. The groups targeted for the potential interviewees were CEO’s, project managers, and other high-level authorities in the projects. These individuals unfortunately have extremely busy schedules. At the end, a group of six project individuals kindly accepted to participate. Remarkably, the author found that those who were related to or those whose projects were funded by governments were keener to collaborate in the research. Eventually, the SD considerations, understanding, and commitments are evaluated on six projects through interviews. Except for one of the projects, which is located in the Middle East, the rest are in North America and Europe.

For privacy purposes, the name of the interviewees, their companies/projects, and other indicative information are kept confidential. The interviewees are employed within the various sectors of geothermal power arena such as the industry, government, and consulting practices. Participants were presented with a “booklet of maturity model for corporate contribution to SD” which was developed based on the proposed maturity model to help them to self-evaluate their performance and future progress. This booklet can be found in the Appendix D on this thesis. While all interviewees are based in developed countries, some are/were involved in projects in developing countries and shared interesting insight on the differences of SD-thinking and implementation in different regions. To evaluate the influence of SD-thinking in projects, questions were categorized based on the corporate structural layers in the proposed maturity model (refer to Chapter 6, Section 6.2 for details explanation). The questions are asked on the following topics:
1. Corporate culture and values layer: the questions are categorized as overall SD approach, engagement and collaboration, knowledge management, and innovation and technology.

2. Business model layer: the questions are categorized as transport, design and development, and purchase and supplies.

3. General SD dimensions layer: the questions are categorized as environmental aspects (natural resources, emissions, waste, and biodiversity), economic aspects (economic viability of a company, economic benefit sharing, and SD budget and staff), internal social aspects (labour practice and human rights), and external social aspects (health and safety, cultural and traditional activities and practices, controversial activities, and corruption and cartel).

Examples of questions used in the interviews can be found in Appendix C of this thesis. To better understand the variables influencing the performance of geothermal power projects in respect to SD considerations, the projects were selected from the different stages of development (exploration to operation), geographical location, and ownership (private vs. governmental), as follows:

1. Project A is located in a North American country and it is currently in the exploration phase. The company plans to apply a phase-by-phase utilization strategy starting with small production rate (under 10 MWe) before expanding it into a medium size project over time (10-50 MWe). This project is the first geothermal project for this small energy company. The company also initiated the proposal for a greenhouse growing facility near the project to share the economic benefits with the indigenous community.

2. Project B is located in Europe. It is a medium size project in the operation stage.

3. Project C is located in Middle East and it belongs to the public sector. It is a small size project (less than 10 MWe) in the late developing stage (installing the power plant and refurbishing the wells). The exploration started decades ago but was put on hold till recently. The production will start in the next 2-3 years. It has been developed by European contractors. The project also proposed to provide heating for nearby community if it is financially feasible.

4. Project D is a medium size project developed by a big company located in North America. Currently the project is in the exploration stage.
5. Project E is a medium size project (Under 50 MWe) located in Europe. The first phase of the project came online and the second phase is under development (phase-by-phase utilization approach). This project is a hybrid project, a mix of geothermal and hydropower.

6. Project F is an EGS (Enhanced Geothermal System) project located in North America. It is a research project in nature, funded by government to bridge the technical gaps in large commercial development of EGS projects. It will come online in a couple of years.

The results of the case studies are displayed in the forms of a spider diagrams (an alternative name for spider diagram is radar diagram) in Figure 7-16. The diagram is arranged according to the headings in Table 6-9 to 6-14 of the maturity model developed in Chapter 6, Section 6.2, as shown in see Figure 7-16. Note that the spider diagrams present the author’s understanding and evaluation of the projects’ maturity levels on each topic based on the interviews. The interviewees scored the overall maturity level of their projects based on the description of maturity levels in Table 6-8 at the end of the interview. Due to time limitation, they have not had the opportunity to review or provide input on the outcomes of the evaluations.
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Figure 7-17: SD maturity model for project A

Figure 7-18: SD maturity model for project B
Chapter 7 - Results and Discussion

Case study C

Figure 7-19: SD maturity model for project C

Case study D

Figure 7-20: SD maturity model for project D
Chapter 7 - Results and Discussion

Figure 7-21: SD maturity model for project E

Figure 7-22: SD maturity model for project E
The evaluation determined that most projects in general belong to transitional level of maturity and in several categories, lean towards the satisfactory level. It can be seen in the diagrams that in the environmental-related topics, the projects are often going beyond regulations when it was economically feasible and there was an economical payback. Comparing the results of all the evaluation models, a similar pattern in respect to the influence of SD-thinking can be deducted in different corporate structural layers of geothermal power projects. As illustrated in Figure 7-23, all projects show similar maturity patterns in most areas. The considerations and sub-layers that have been less implemented by geothermal power projects are as follows:

![Figure 7-23: Displaying the results of evaluating SD maturity levels in all case studies](image-url)
Chapter 7 - Results and Discussion

- **Transport and purchase and supplies:** the SD strategies within the areas such as transport footprint, design and development, purchases and supplies during the lifetime of the projects is investigated as one of the indicators. Although these considerations are beyond regulations, they have an important impact on the journey of society toward SD in the local and regional communities, as they may directly or indirectly effect local and national challenges such as air pollution and climate change. While projects indicated that they often voluntarily go beyond regulatory mandates to minimize their environmental impacts within the design and development stages, they don’t see the need to go further in reducing their transport footprint implement other considerations related to purchase and supplies.

- **SD budget and staff:** The interviewees indicated that since there is not any integrated SD strategy within their projects or companies, there is not any dedicated budget or team in charge of the SD budget and staff. However, the discussion on integrated SD considerations already has been initiated in the European projects that were interviews (both from the same country) and one of them recently dedicated a team and budget to develop SD protocol for their projects. Most projects specified that their environmental team lead SD related issues.

- **Controversial activities and corruption and cartel:** although all reviewed projects showed a lower level of considerations in these two topics, it was not necessarily an indication of low activity in these areas. All projects indicated that they comply with law and regulations on the matters but they have not necessarily thought about it beforehand and they do not have a specific policy about it.

As illustrated in Figure 7-23, the maturity level of most of the projects showed a lower score in the following areas (between initial and transitional maturity levels), for instance:

- **Overall SD approach:** Except for one of the European projects (case study E), the others don’t have any SD strategies, policies, or common SD vision in their projects and companies.

- **Knowledge management:** One of the interesting topics that came up during the interviews was the common close culture of knowledge management in geothermal power arena.
Chapter 7 - Results and Discussion

Publishing a SD report is not a common practice and there are few companies who publish such reports. In the host countries of the projects, there is no obligation for private companies to publish annual reports on their activities or other related reports such as environmental, reservoir condition, or economic status of the project. Although many companies publish their environmental reports, it is not easily accessible by the public. The difficulty in accessing capital in geothermal industry is partly responsible for the closed-door culture. The industry is small and financial support is limited. The high competitive ambiance over capital makes the projects extremely sensitive about the information that they share, especially economic and reservoir related data.

- **Waste management:** There are two forms of waste management in the projects, one from operations (waste brine) and the other from day-to-day business activities. Most interviewed projects only focused on waste brine.

- **Economic benefit sharing:** Geographical factors play an important role in economic benefit sharing of a project. Society’s standard in evaluating things like benefit sharing varies in developed and developing countries. In developed countries, the community often expects the indirect economic contributions through tax, royalty, and the possibility of job opportunities for locals. But in developing countries, local communities may expect more direct economic contributions from the projects. However, in comparison with the industries like mining, the expectations from geothermal power projects for direct contributions are relatively low. According to interviews, one of the reasons is that in geothermal projects the product (energy and power) gets back to the community but in mining project, it goes out of the community and somebody else gets the benefits of mining products.

Most projects indicated that due to their budget limitations, they often comply with law and cannot go beyond many categories. However, when it comes to health and safety, design and development, innovation and technology, emission, and natural resources, most projects are above transitional level and lean toward the satisfactory maturity level. About half of the reviewed projects initiated the side projects (e.g. cascading system and by-production) besides the power generation to use more capacity of the extracted energy (when there is a demand for it and it is economically viable) such as
greenhouse growing facilities, and heating nearby houses and pools. Further investigations identified some variables that affect the maturity levels of the projects in various layers as follows:

- **Development phase:** Projects in early phases such as exploration and development are more focused on technical and environmental aspects of the projects than the social and governance dimensions due to budget limitation (e.g. SD budget and strategy).

- **Company size and experience:** Reviewing projects A and D, both North American companies in the exploration phase, showed how previous experiences make a difference in overall corporate culture and policy such as wide-organizational policies on labour practice and health and safety. When a company is young and a project is its first, they have not yet had a chance to develop and think about internal culture and policies.

- **Ownership in terms of public and private sector:** Public projects or those that are funded by government are more likely to go beyond the law on environmental and engagement and collaboration aspects to meet the governmental expectations. Also, the reports of their projects activities are more easily accessible to the public.

- **Geographical factors:** Cultural and traditional considerations are more important in developing countries and North American countries due to rich indigenous culture in both areas. However, the European projects mentioned that this factor is not considered important in their project paradigm. As a result, the evaluation shows a lower level of consideration in European projects, which is not an indication of poor action.

Figure 7-24 illustrates the spider diagrams for all the governmentally funded or owned projects. As shown, the projects in North American and European (case studies B, E, and F) demonstrate very similar patterns, except that European projects have higher maturity levels when it comes to overall SD approach and SD budget and staff. Cultural and traditional activities and practices play more important roles in the projects located in developing and North America countries. There is still place for improvement within knowledge sharing and social considerations within the projects that are located and owned by developing counties.
Figure 7-24: Comparison of the maturity levels in the governmentally funded or owned projects

7.3 GENERAL DISCUSSION

The results of the survey and interviews indicate that the topics and objectives selected for the framework received broad acceptance by participants. Also, the outcome of the interviews and survey indicates that the concept of SD, as defined in this research (which is based on internationally accepted definition of the concept at project level), is still new to those associated with the industry. Ever since the publication of the Brundtland report, the SD concept has expanded remarkably at local, national and regional level. Renewable energies including geothermal power were initially promoted as one of the solutions to achieve the SD goals at global and national scales. In this approach, geothermal power projects are part of a global SD plan; i.e. a green and
environmentally friendly substitute of fossil fuels generators. However, there is no clear outline of the SD goals and objectives at the project level, which causes a lot of misaligned understanding within the industry. During the interviews, some interviewees mentioned that, as their project provides clean energy for the society, further economic benefit sharing or social contribution to neighbouring communities is unnecessary as they consider the clean energy as their contribution to sustainable development. The industry should keep in mind that at the project level, like any business development, geothermal power projects should consider an integrated approach towards SD dimensions instead of solely focusing on environmental and economic aspects of the development. As geothermal power projects, in many aspects, already reach the transitional level of SD maturity or even higher, the combination of the GSD framework and the proposed SD maturity model developed in this research can help them to fill the current gaps and be prepared for the future requirements and societal values.

The proposed framework along with the maturity model can help the full implementation of SD concept in order to transfer geothermal power projects to responsible neighbours of their host communities. The proposed framework can be used by both the industry and its stakeholders to: a) guide the contribution of geothermal power projects to SD in local and regional communities through the life cycle of the projects; b) evaluate the quality of a project’s contribution and the progress made on implementing the set objectives and commitments, during the project phases.

Note that sustainable development is about understanding the complexity of interconnection between environment and society in gaining the economic benefits and aiming to integrate socio-economic and environmental considerations into the development paradigm. Leading a community toward the ultimate SD goals requires collective teamwork by all involved parties (including citizens, the government, NGO’s, academia, and companies, etc.) rather than an integration of uncoordinated and inharmonious individual action toward individually defined-SD paths. Each community has a different understanding, long and short-term goals, and strategies toward SD based on its unique needs, culture, development level, and political structure. All involved parties are held responsible for the successful implantation of these goals. Accordingly, companies or development projects (temporary or permanent) as members of their host community need to align their SD strategies with those of the communities. This research is developed in a way that helps geothermal power projects to be a proactive part of their host community, i.e. to become a responsible neighbour.
The author wants to highlight that this research presented a holistic approach from a project management point of view without going to economic and reservoir technicality detail of such development. Note that financial, political, and technical considerations affect the feasibility of a project, consequently its longevity. Due to the economic life expectancy of the wells and power plants (about 10 years and 25-30 years respectively), the aim of this study is to broaden the industry, stakeholders, and investors’ horizons more toward the importance of contribution of a project to SD of its neighbouring community (regardless of a project lifetime), rather than keeping a project for 100-300 years. In this way even if the project won’t last for generations, its contributions to the wellbeing of the community and surrounding environment will last.

### 7.4 Limitations of the Study

- One of the key challenges in this research was the difficulty in reaching the larger participants population for both the survey and the case studies. Despite significant effort and extended campaigns, a smaller population of the geothermal power industry could be persuaded to participate. Although a larger number of participants would have helped in enriching the result, the collected data is a fair representative of key parties involved in the industry statistically.

- As the maturity model and the GSD framework were developed solely by the author, the multi-stakeholder input through workshops may add interesting dimension to the present research outcome.

- Due to time limitation during the interviews, the interviewees have not had the opportunity to provide input on the outcome of the author evaluation on maturity level of their projects. Consequently, as with any qualitative and quantitative research, the outcome of the evaluation may carry potential biases from personal views and perspective of the author due to the data limitation from the projects or personal experiences.
Chapter 8

Conclusion, Contributions, and Future Work

This chapter concludes and summarizes the key findings with regard to the research questions as well as the key contributions of the thesis to the industry, research literature, academia, and policy makers. Moreover, the chapter provides some recommendations and suggestions for future direction of the present work.

8.1 Conclusion

As noted in Chapter 1, the main question of the research is: can the contributions that a geothermal power project makes to sustainable development of its neighbouring communities be evaluated? Subsequently, to address the main question, four sub-questions and four objectives were defined as shown in Table 8-1. The following sub-sections provide a description of how these objectives and sub-questions were addressed through the course of this research.

<table>
<thead>
<tr>
<th>Sub-questions</th>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1: How is sustainable development defined in broad terms, for the community and at project level? And what is the preferred terminology to express sustainable development in relation to the geothermal industry?</td>
<td><strong>Objective 1</strong>: Demonstrate the need for more integrated approaches toward socio-economic and environmental considerations within the geothermal power arena</td>
</tr>
<tr>
<td>Q2: How can a project contribute to SD plans of their neighbouring communities?</td>
<td><strong>Objective 2</strong>: Provide clarification of what the term “contributions to SD” means for the geothermal power industry and then recognize the broad key essentials of successful contribution to sustainable development (SD) in local and regional communities where geothermal project development takes place</td>
</tr>
<tr>
<td>Q3: What approach can be specifically developed for geothermal power projects to guide and evaluate their contributions to SD in local and regional communities?</td>
<td><strong>Objective 3</strong>: Develop a pilot framework to guide and/or test the contributions of a geothermal power project to sustainable development in local and regional communities</td>
</tr>
<tr>
<td>Q4: How can the quality of a project’s performance and progress toward SD be evaluated and tracked?</td>
<td><strong>Objective 4</strong>: Develop an approach to evaluate the performance of geothermal power projects, in terms of compatibility with the concept of sustainable development</td>
</tr>
</tbody>
</table>
8.1.1 **Objective One**

To address the first objective, a comprehensive literature review was conducted about the SD-thinking and approaches within the industry as presented in Chapter 2 of the thesis. The outcome demonstrated that:

1. There is no holistic sustainable development guideline or framework available for the geothermal power arena; and,

2. The lack of shared SD vision within the industry starts from a lack of consistent SD terminology. The research demonstrated the lack of shared vision and terminology (as defined and accepted internationally) within the geothermal power arena.

The issue is not only affecting the industry’s ability to grow, but it also impedes the communication of its impacts and contributions to stakeholders and investors.

8.1.2 **Objective Two**

1. To address the second objective, an extensive literature review was conducted on what the term “contributions to SD” means in broad term as well as, at community, and project levels (as reported in Chapter 2, Section 2.2 – 2.3). The outcome also addressed the first and second sub-questions. In addition, to providing a better clarification on the vulnerabilities of current geothermal power development practices, three in depth case studies were conducted as reported in Chapter 3 of this thesis. As a result: Appropriate SD terminology for geothermal power industry was defined (see Chapter 2, Section 2.1.4).

2. The broad key essentials of successful contribution to sustainable development (SD) in host communities where geothermal project development takes place were recognized as reported in Chapter 4 of this thesis. The essentials aim to recognize the areas to improve the ethic of being responsible neighbour and reduce the non-technical vulnerability of projects in their host community. Engagement and communication with stakeholders, governance and institutional arrangement, resource management, and benefit sharing strategies are among the suggested areas of improvements.

8.1.3 **Objective Three**
Addressing the second objective helped in the development of the GSD framework as described in Chapter 6, Section 6.1 of this thesis. The main objective of GSD framework is to identify SD considerations to facilitate the decision-making process within both internal and external orientations of a geothermal power project. The framework consists of seven key topics specifically developed to guide and express the quality of the contribution that a geothermal power project can make on local and regional communities. Each key topic is accompanied by objectives as a means to lead toward the achievement of the defined topics. To monitor and measure the progress, a few key example indicators and metrics are suggested as a starting point for further discussion and adaptation among the involved parties. The result addresses the third objective and sub-question of the research as listed in Table 8-1. A survey was next conducted to solicit expert’s feedback on suitability of the components of the proposed framework (see Chapter 7, Section 7.1). Due to time limitation, only the suitability of the topics and their objectives were assessed by the survey. The result of the survey demonstrated a large positive acceptance toward the key components of the GSD framework among the various sectors of the geothermal power arena. However, the depth analysis of the answers highlighted the lack of common ground across the involved parties on SD-thinking and vision.

8.1.4 OBJECTIVE FOUR

An SD maturity model was developed to address the last sub-question and objective of the research (see Chapter 6, Section 6.2). Note that the evaluation strategy is a feedback mechanism to critically examine, judge, and inform decision-makers about the effectiveness of their actions or future plans (Patton, 1997; Turvey, 2007). The evaluation strategy could help both the industry/a project and its stakeholders to track the project progress and the areas of improvements. The SD maturity model is meant to demonstrate the extent to which a company understands, believes, implements, and commits to having positive contributions toward SD. The proposed SD maturity model reflects the depth and quality of SD-thinking influences within a company/project development paradigm. The model measures these factors within three corporate structural layers: corporate culture and value toward the SD concept, influence of SD-thinking within the business model, and the company’s public relationships as a responsible neighbour of the host society.
A number of interviews were conducted to test the proposed model in practice. The results of both interviews and surveys highlighted that the economic viability of a project and the environmental considerations (often controlled by regulatory obligations) are the priorities of the projects. However, as geothermal power projects, in many aspects, already reach the transitional level of SD maturity, the combination of the GSD framework and the proposed SD maturity model in this research can help them to fill the current gaps and be prepared for the future requirements and societal values.

8.2 CONTRIBUTIONS

The proposed framework in this thesis is the first holistic guideline developed to guide and evaluate the contribution of geothermal power projects to SD in the local and regional communities. Since there is limited scholarly work on the topic of SD in the geothermal power industry, the outcome of this research contributes in providing a foundation for the further discussions and improvements in both academia and industry. The key contributions of this work are as follows:

1) Terminology

- In Chapter 2, Section 2.1, the proper SD terminology for geothermal power arena is defined. This was a necessary step for the preparation of this thesis as well as further discussion within the industry. Through this research, the author came to the realization that the concept of SD in the context of the geothermal power arena is limited and often referred to the reservoir utilization. This limited interpolation was even highlighted during the interviews as a number of participants responded that the concept of SD is about sustainable production. Consistent terminology opens the doors to better communication and understanding between academia, politicians, communities, and the industry. The author wants to emphasize the importance of broadening the industry perspective on the concept.

2) GSD Framework:

- The proposed framework in Chapter 6, Section 6.1 of this thesis, can be used by the industry, community, NGOs, and government as a starting-point to establish a common ground while bringing all the involved parties toward a shared understanding and expectations.
Chapter 8 - Conclusion, Contributions, and Future Work

- The GSD framework is a guiding tool that helps stakeholders and the company reach a shared vision on substantial SD considerations, the implementation strategies, assignment of each party’s responsibilities, and coordinating efforts toward expected outcomes. The framework helps decreasing the risk of potential environmental and social conflicts throughout the project lifetime.

- The GSD framework is a clarification of what SD means in practice for geothermal power projects based on the projection expectations on corporate responsibilities. Therefore, it benefits the company to envision whether or not they can afford (financially and technically) to fulfill SD commitments and expectations (current and future ones) ahead of the project’s commencement. Note that SD is a long-term process that requires commitments from all involved parties. Following the current path of regulatory compliance especially within the social and governance aspects of SD may have little use in future. As such considering the future expectations of the involved parties is an important part of the framework.

- As an evaluation tool, the GSD framework provides the industry with an opportunity to assess their performance and communicate their performance, contributions, and progress to the stakeholders and (possible) investors consistently and clearly.

- The framework can be used by stakeholders (specially, the community and the local/regional government) to better understand the holistic scale and duration of the project impacts (positive and negative) in local and regional scale. The outcome provides the stakeholders (government and community) with a much clearer vision in dedicating their support and incentives.

- The framework helps development of consistent actions across the industry; therefore, it has the potential to become a benchmark for comparing the performance of geothermal power projects with respect to SD considerations.

- Adapting a GSD framework helps keep consistency throughout a project lifecycle regardless of changes in the ownership (from exploration teams to developers, consultants, and operator companies).

- The ultimate goal is that the framework helps geothermal power companies to develop their existing or new projects in socially and environmentally accountable, scientifically
and technically sufficient, and financially viable during the life span of a project and well after at the closure period.

3) **Maturity Model**

- The combination of GSD framework and the proposed SD maturity model help with tracking the overall performance and progress of a project in corporate structural layers and development phases with respect to SD-thinking and implementation (see Chapter 6, Section 6.2 for detail explanation). An evaluation tool enables geothermal power projects to demonstrate their progress and commitments. The present thesis developed, a “booklet of maturity model for corporate contribution to SD” to help companies to self-evaluate their performance. This booklet was provided to the interviewees who participated in the case studies explained in Chapter 7, Section 7.2.

- The approach used in the proposed SD maturity model can be extended to other industries at project and company levels that have already committed or are willing to commit to SD to evaluate their performance.

### 8.3 **Recommendations for Future Work**

The author recognizes the following possibilities to extend this work:

- The proposed framework here can be extended into governmental policy, protocol, guideline, or benchmark for geothermal power companies. It can bring valuable insights in updating existing policies such as the Canadian BC Geothermal Act of 1982. Despite being located on the ring of fire, Canada has yet to develop its first geothermal power project. Having a holistic SD framework along with adequate and supportive regulations and policies will help to set the ball rolling in the right direction.

- As the proposed GSD framework and SD maturity model are the first holistic guidelines for the geothermal power industry, the framework and the maturity model have to be deployed in practice to fully assess the practicality and suitability of their design. As a result, it would be good to perform field reviews of the framework and model on existing power plants to further refine them. The successful showcase of the framework
implementation will help in generalizing and adapting the framework by the industry and its stakeholders.

- The framework and SD maturity model can also be further tested in smaller groups by holding workshops.
REFERENCES


Government of Canada. (2016). Indicators of well-being in Canada, Government of Canada, Retrieved June 24, 2016, from: http://well-being.esdc.gc.ca/misme-iowb/h.4m.2@eng.jsp;jsessionid=RaWKfQ_183HETC9bfhEkTIs2OySSeNbXC7CRrWW6OVihjrf4m7V7!-361209515


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REFERENCES


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REFERENCES


REFERENCES


Appendix A: Implementation of GSD Framework

**Topic One: Engagement**

Table A-1 provides more details on the goals and proposed objectives and an example of related indicators and metrics to implement the topic.

**Table A-1: Topic one - Engagement**

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1.1 Design and implement engagement strategies:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>a) Participatory Approach</strong></td>
<td>• Comprehensive stakeholders map is created and periodically updated to identify all interested parties</td>
<td>• True/False</td>
</tr>
<tr>
<td>Design and implement a participatory approach, that is compatible with the norm, legal, and cultural structures of the host community to serve as a mechanism for:</td>
<td>• Participatory approach is designed and effectively working in ways that is compatible with the norm and legal structures of the host community, and is agreed upon by all interested parties (e.g. gatherings, workshops, meetings)</td>
<td>• Degree of satisfaction via periodic surveys</td>
</tr>
<tr>
<td>• Providing stakeholders with the opportunity to participate in decision-making activities</td>
<td></td>
<td>• Number of participants from various groups of stakeholders in project-related events such as meetings, workshops, etc.</td>
</tr>
<tr>
<td>• Providing stakeholders with the opportunity to hear and be heard about the decisions that may affect their future</td>
<td></td>
<td>• Number of grievances received from stakeholders</td>
</tr>
<tr>
<td>• Providing the stakeholders with the opportunity to collaborate in setting up the goals and objectives</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Objectives</td>
<td>Example Indicators</td>
<td>Example Metrics</td>
</tr>
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<td>---------------------------------------------------------------------------</td>
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<td>----------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>b) Capacity and resources of the company and civil society</strong></td>
<td>• Adequate capacity related to funding and human resources (knowledge and expertise) are provided and projected in a project development paradigm to improve or maintain a company’s and community’s capacity to implement engagement strategies</td>
<td>• True/False</td>
</tr>
<tr>
<td>Provide adequate resources in terms of funding and human resources to build acceptable engagement capacities within a company and the host community, so that:</td>
<td>• All stakeholders can effectively collaborate and get involved as needed</td>
<td>• Amount of available funding</td>
</tr>
<tr>
<td>• All stakeholders can effectively collaborate and get involved as needed</td>
<td>• Continuous improvement of community capacity be safeguarded during a project’s life cycle that last even after a project</td>
<td>• Degree of satisfaction via periodic surveys with a level of commitment and participation from the company, government, and the involved communities</td>
</tr>
<tr>
<td><strong>Note:</strong> Building capacities are the shared responsibility between the government, company, and the involved communities. The outcome and distribution of the responsibilities calls for close collaboration of all parties</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>c) Communication and reporting</strong></td>
<td>• Appropriate mechanism of communication and reporting are in place and agreed upon by interested parties, as indicated by:</td>
<td>• True/False</td>
</tr>
<tr>
<td>Design and implement appropriate mechanisms of communication and reporting in order to build a healthy, trusting and lasting relationship with stakeholders. A mechanism that:</td>
<td>- Published SD report and other related information</td>
<td>• Frequency of publishing SD, environmental and other related reports</td>
</tr>
<tr>
<td>• Provides clear and accurate information in a timely manner, accessible by all stakeholders, and includes information on uncertainties, limits, risks, and benefits of current and future decisions</td>
<td>- Availability of information sharing channels such as online websites, news release, gatherings and meetings, etc.</td>
<td>• Degree of satisfaction via periodic surveys on accessibility and timely disclosure of information</td>
</tr>
<tr>
<td>• Makes sure that the information reaches the majority of stakeholders through various communication techniques</td>
<td>• Accessibility of two-way communication channels, e.g. telephone, personal meetings, emails, etc.</td>
<td></td>
</tr>
<tr>
<td>• Provides information in an understandable, suitable, and acceptable format for public</td>
<td></td>
<td></td>
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<tr>
<td>Objectives</td>
<td>Example Indicators</td>
<td>Example Metrics</td>
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<td>---------------------------------------------------------------------------</td>
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<tr>
<td>reading (e.g. indigenous languages)</td>
<td>• Provides the two-directional communications channels between and among the stakeholders and the company</td>
<td></td>
</tr>
</tbody>
</table>

**1.2 Develop and implement dispute resolution mechanisms**

| Develop and implement dispute resolution mechanisms that are compatible with the norm and legal structures of the host community, agreed upon, and understood by all stakeholders. | • Dispute resolution mechanism is developed and works effectively | • True/False  

- Degree of satisfaction via periodic surveys  
- Percentages of received grievances that has been addressed |

Geothermal power companies are encouraged to document their commitments towards their stakeholders (especially the neighbouring communities) in written format. Interested readers are encouraged to review the mining industry’s practice in the preparation and implementation of the concept of the so-called “Good Neighbour Agreement” with the local communities (e.g. Masaitis & Miller, 2013). This approach may have significant benefits in developing more meaningful engagement programs between companies and neighbouring communities.
**Topic Two: Valuing people and their aspiration**

Table A-2 provides more details on the goals and proposed objectives and an example of related indicators and metrics to implement the topic.

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
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</thead>
<tbody>
<tr>
<td><strong>2.1 Identify, maintain, or facilitate the development of community’s future plans and strategies</strong></td>
<td>• Baseline study on existing community plan and strategies is completed in order to align the company SD considerations with those of the community&lt;br&gt;• Appropriate mechanism is in place to support community in maintaining or facilitating the development of their future plan, as indicated by:&lt;br&gt;  o Dedicating monetary funds (direct or indirect)&lt;br&gt;  o Devoting Company’s staff and facilities&lt;br&gt;  o Providing human resources (expertise) or training</td>
<td>• True/False&lt;br&gt;• Degree of satisfaction via periodic survey&lt;br&gt;• Availability and adequacy of funds, company facilities, training hours or human resources (e.g. expertise) that are dedicated to assist the community in the matter</td>
</tr>
<tr>
<td><strong>a) On the company side:</strong></td>
<td>• Establish adequate mechanisms capable of identifying the existing local and regional development goals, plans, and strategies&lt;br&gt;• In the absence of such plan and strategies in the community, make sure that the adequate mechanism is in place to encourage or if necessary facilitate the development of such plan by the community itself in coordination with residents, government and/or NGOs (PDAC, 2009)</td>
<td>• True/False&lt;br&gt;• Degree of satisfaction via periodic survey&lt;br&gt;• Number of formal consultation sessions with community on temporary consultation&lt;br&gt;• Availability and adequacy of funds, company facilities, training hours or human resources (e.g. expertise) that are dedicated to assist the community in the matter</td>
</tr>
<tr>
<td><strong>b) All involved parties:</strong></td>
<td>• Appropriate plan and strategies are designed and implemented to establish a long-term reliable energy system, as indicated by:&lt;br&gt;  o Identifying, planning, and projecting the alternative source of power/energy in the project development paradigm for the recovery</td>
<td>• True/False&lt;br&gt;• Degree of satisfaction (via periodic survey) with the level of commitment during the project lifetime, recovery and post-closure period&lt;br&gt;• Number of formal consultation sessions with community on temporary consultation&lt;br&gt;• Availability and adequacy of funds, company facilities, training hours or human resources (e.g. expertise) that are dedicated to assist the community in the matter</td>
</tr>
</tbody>
</table>

Goal two: The community/workers wellbeing and aspirations are valued, maintained or improved as a result of a geothermal power development

- During the lifetime of the project, and;
- In recovery and closure period.
## Appendices

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
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<tbody>
<tr>
<td>transition of the society toward recovery and closure periods.</td>
<td>and post-closure period o Publishing reports on projected geothermal power/energy affordability and production rate from the project in the future Note: the company’s responsibility is more on aligning its production rate and lifetime with the community’s future energy plan and strategies</td>
<td>and permanent closure plans o Degree of satisfaction via periodic surveys on availability of report on projected geothermal power/energy affordability and production rate.</td>
</tr>
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</table>

### 2.2 Maintain or improve the project area societal and cultural values

Design and develop sufficient mechanism, so that:

- The communities and the government have reasonable degree of confidence that the integrity of their social and cultural structures will be maintained and respected.
- Any involvement in improving the societal and cultural aspects of the community will be aligned with the community’s vision and agreed upon.

**Note:** the responsibility of gathering data and statics on the wellbeing’s status of the society is on all stakeholders mainly the government. That is why the close collaboration and input of all stakeholders is necessary in the journey toward SD goals.

- Effective mechanism is in place to understand existing social, cultural, and political structures, norms, and believes within the community and the local/regional government
- Effective mechanism is in place to identify and address all social and cultural benefits, cost, and risks found across the full life-cycle of a project, as indicated by:
  - Resident resettlement strategies
  - Power outage from the project
  - Cultural and religious conflicts
  - Companies involvement in controversial activities
  - Local accessibility to the electricity/energy produced by the project
  - Worker and other inhabitants moving to the area
  - Effect on geothermal related tourism

- True/False
- Level of satisfactory supply of electricity/heat to customers based on periodic surveys
- Percentage of annual power outages
- Number of grievances received and addressed due to; cultural and religious conflicts with the project; dissatisfaction over involvements of company in controversial activities in the context of host society; worker and tourism related-disturbances
- Frequency of publishing

- Total number of nearby residents that relocated due to the project
- Number of grievances received and addressed due to; cultural and religious conflicts with the project; dissatisfaction over involvements of company in controversial activities in the context of host society; worker and tourism related-disturbances
- Frequency of publishing
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<th>Objectives</th>
<th>Example Indicators</th>
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<tr>
<td></td>
<td>o Project-related direct and indirect contributions to local activities (cultural, traditional, and non-traditional)</td>
<td>reports or releasing information through other channels on project-related direct and indirect societal and cultural risk, cost, and benefits</td>
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<tr>
<td></td>
<td>o Project-related direct and indirect impact on rate of negative social behaviours such as drug abuse, crime rate, prostitution, etc.</td>
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<td></td>
<td>o Project-related direct and indirect stress on cultural integrity of the community resulting from attracting/hiring outsiders</td>
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<td></td>
<td>o Project-related direct and indirect contribution in providing training and education opportunities for the community in order to qualify them to join the company, boosting local businesses, or personal qualification</td>
<td></td>
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</table>

2.3 Safeguard workers/community health and safety in the development and operations of a project

|                                                                 | • Effective mechanism is in place to monitor, identify, and improve the safety and health of the workers and nearby communities | • True/False                                                                                                                                                                                                                                                                                                                                 |
|                                                                 | • Frequency of ongoing appropriate safety and job preparation training                                                                                     | • Frequency of operational-related injuries or diseases, as a result of:                                                                                                                                                                                                                                                                                                                     |
|                                                                 | • Degree of satisfaction via periodic surveys on effectiveness of emergency strategies (preparation, communication system/alarm, training)                                                                                                                           | o Construction incidents                                                                                                                                                                                                                                                                                                                                                                      |
|                                                                 | • Frequency/number of operational-related injuries or diseases, as a result of:                                                                         | o Geothermal well explosion                                                                                                                                                                                                                                                                                                                                                                |
|                                                                 | o Construction incidents                                                                                                                                                                                             | o Land subsidence                                                                                                                                                                                                                                                                                                                                                                              |
|                                                                 | o Geothermal well explosion                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                                                 | o Land subsidence                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                             |
### Appendices

<table>
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<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
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<tbody>
<tr>
<td></td>
<td>o Noise pollution</td>
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<tr>
<td></td>
<td>o Toxic geothermal gases emissions (H₂S, CO₂, CH₄, Rn, etc.)</td>
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<tr>
<td></td>
<td>o Seismic activities as a result of geothermal development, etc.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Thermal pollution</td>
<td></td>
</tr>
<tr>
<td></td>
<td>o Other incidents related to project development and operations</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Number of grievances received and addressed due to working conditions, labour and human rights</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Number of fatalities due to project development</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Number of accident-free days (MMSD North America, 2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Percentage of workers with access to acceptable medical facilities and plans</td>
<td></td>
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<tr>
<td></td>
<td>• Proportion of population with access to basic infrastructure like clean water, sewage, electricity, education, etc.</td>
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</tr>
<tr>
<td></td>
<td>• Project-related direct and indirect impacts on the health of nearby residents as a result of noise pollution, gas emission, seismic activities, etc.</td>
<td></td>
</tr>
</tbody>
</table>

The Prospectors and Developers Association of Canada (PDAC, 2014) published the following recommendations on the responsibilities, involvements, and commitments of companies in their contribution to the wellbeing of nearby communities:

- **Note on Expectation and Independency for companies:**
Avoid creating unrealistic expectations and unnecessary dependency about the company’s role in the development of a community’s wellbeing

Highlight necessity of focusing on creating long-lasting capacity and opportunities that contribute in society’s wellbeing after the project lifetime rather than short-term benefits

- **Note on Responsibilities:**

  - “Respect existing social structures and local authorities when defining the roles and responsibilities of the various actors in community development initiatives. Where appropriate, support local governance capacity building to manage community development initiatives into the future” (PDAC, 2014).
Topic Three: Environmental considerations

Table A-3 provides more details on the goals and proposed objectives and an example of related indicators and metrics to implement the topic.

**Table A-3: Topic three - Environmental considerations**

<table>
<thead>
<tr>
<th>Goal three: A project, directly or indirectly, leads to the maintenance or strengthening of the ecosystem so it can continue to support the wellbeing of people and other life forms during and after the project lifetime (MMSD North America, 2002)</th>
</tr>
</thead>
</table>

<table>
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<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3.1 Maintain regulatory compliance and apply measures to improve conditions beyond regulatory requirements</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
| Design and implement appropriate mechanisms in order to:  
  - Maintain regulatory compliance during a project lifecycle  
  - Provide a reasonable degree of confidence to communities that the ecosystem life support system and resilience (natural resources and services; e.g. geothermal resources, water resources, air and soil) will be maintained or improved to support the needs of present and future generations over the long-term (even if it is needed to go beyond the regulatory requirements). Note that North American Indigenous populations express long-term as seven generations (Jeannotte, 2017) |  |  |
|  | - Appropriate mechanism is in place to meet regulatory requirements |  |
|  |  | - True/False  
  - Monetary value of significant fines for noncompliance with regulations  
  - Total number of non-monetary sanctions for non-compliance with laws and regulations  
  - Efficiency of power production, turbine, heat exchange, heat/water/power transmission, and cooling tower  
  - Annual amount of water usage and saving on cooling tower, during drilling and construction  
  - Annual amount of material usage and savings during design and construction as well as business model and office  
  - Annual amount of air |
<table>
<thead>
<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Natural resource management including geothermal and water resources</td>
<td>• Polluting emissions and reduction (e.g. SO₂, H₂S)</td>
<td></td>
</tr>
<tr>
<td>• Collaborating with interested parties to strengthen the ecosystem resilience on non-project related matters</td>
<td>• Annual amount of water usage reduction, recycling and reusing</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Annual percentage of greenhouse gas emissions due to transportation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Land use area</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Annual amount of reservoir temperature and pressure drop and recovery</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• “Population effects of project on indicator species. (e.g., Bathurst Caribou herd, northern Canada)”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Fish, ungulate, small mammal and bird population health</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Health and abundance of medicinal plants used for traditional purposes” (MMSD North America, 2002)</td>
<td></td>
</tr>
</tbody>
</table>

### 3.2 Evaluate sensitivity of the environment to change

Establish appropriate mechanisms in order to:

- Identify, monitor, and measure environmental sensitivity and its level of stress as a result of a project
- Identify and address community dependency on the environment and their threshold on the potential environmental impacts in the development paradigm
- Deal with and mitigate uncertainties

- Effective mechanisms are in place to evaluate sensitivity of a geothermal system in the area, as indicated by:
  - Consideration of cumulative impact of several geothermal activities in the area by different companies, (e.g. sharing related-information on reservoir status, and collaboration

- Frequency of publishing report or through other collaborative corporate channels to evaluate sensitivity of a geothermal system in the area
- Likelihood of annual impact on the surface manifestations of a geothermal system in the area
<table>
<thead>
<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
</table>
| and risks | between companies on production and reinjection rates)  
  o Monitoring and measuring impacts on the surface manifestations of a geothermal system in the area  
  o Identifying and addressing local dependency on the environment and a geothermal system in the area (e.g. tourism and medical usage of hot springs) | • Annual likelihood of impact on biodiversity |

• Mitigation Mechanism works effectively as indicated by designing and implementing:  
  o Reclamation strategies  
  o Geothermal reservoir utilization strategy  
  o Waste disposal and reduction management  
  o Water resource management  
  o Surface and ground water management  
  o Monitoring and improving air quality |

• Annual ratio of land under reclamation and/or condition improvement  
• Annual ratio of temperature and pressure modification in the reservoir (e.g. reinjection ratio)  
• Projected recovery period  
• Annual amount of waste reduction within the field and the office  
• Annual amount of water usage reduction and quality improvement  
• Annual ratio of air emission reduction |

• Monitoring environmental stress mechanism works effectively as indicated by measuring the level of stress imposed on the ecosystem:  
  **Physical Impacts**
<table>
<thead>
<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>o Localized climate change&lt;br&gt;o Land subsidence&lt;br&gt;o Soil erosion&lt;br&gt;o Noise pollution&lt;br&gt;o Disturbance to animal migration&lt;br&gt;o Micro earthquakes&lt;br&gt;o Solid waste&lt;br&gt;o Heat pollution on surface&lt;br&gt;o Nearby geothermal features (hot springs, glazers, etc.)</td>
<td>• Annual level&lt;br&gt;• Noise level off site&lt;br&gt;• Degree of disturbance&lt;br&gt;• Degree and level of sensitivity to nearby communities&lt;br&gt;• Annual amount of waste generation&lt;br&gt;• Contamination level&lt;br&gt;• Temperature of water release on surface&lt;br&gt;• Degree of pressure and temperature changes&lt;br&gt;• Annual contamination level&lt;br&gt;• Percentages of deforestation&lt;br&gt;• Population of indicator species (including animals, flora and fauna)&lt;br&gt;• Contamination level&lt;br&gt;• Annual emissions level</td>
</tr>
<tr>
<td><strong>Biological Impacts</strong></td>
<td>o Chemical toxicity on surface and ground water&lt;br&gt;o Impact on flora and fauna&lt;br&gt;o Animal population&lt;br&gt;o Biodiversity</td>
<td></td>
</tr>
<tr>
<td><strong>Chemical Impacts</strong></td>
<td>o Gas emission mostly CO₂, H₂S, CH₄ and Rn&lt;br&gt;o Chemical wastes from drilling fluid effluents</td>
<td></td>
</tr>
</tbody>
</table>
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**Topic Four: Economic viability of the project and benefit sharing considerations**

Table A-4 provides more details on the goals and proposed objectives and an example of related indicators and metrics to implement the topic.

Table A-4: Topic four - Economic viability of the project and nearby communities as a result of the project

<table>
<thead>
<tr>
<th>Objective</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4.1 Maintain long-term economic viability of the project</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Establish appropriate strategies to achieve the project’s financial goals</td>
<td>• Sufficient arrangements and strategies are in place to reach intended financial goals</td>
<td>• Satisfactory degree of investors and other shareholders on economic status of a project</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Ratio of economic factors such as: cash flow, investment Rate of Return, NPV, payback period, development Margin</td>
</tr>
<tr>
<td><strong>4.2 Develop vision and strategies for long-term economic benefit sharing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In cooperation with community, government, and other interested parties, develop a vision and strategies that:</td>
<td>• See Table A-2, part 2.1</td>
<td>• True/False</td>
</tr>
<tr>
<td>• Lead the socio-economical contributions of a project toward existing visions of the community (e.g. poverty reduction programs, education, etc.)</td>
<td>• Proper mechanisms and resources are in place to identify and lead the possible direct and indirect socio-economical contributions of a project</td>
<td>• Degree of satisfaction via survey on the effectiveness of designed mechanism</td>
</tr>
<tr>
<td>• Creates long lasting capacity and opportunities toward strengthening community resilience and independence</td>
<td></td>
<td>• Number of contracts and their total value awarded to the local supplier and businesses</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Amount of direct financial contribution to local communities such as donations, or community investments</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of project-related direct and indirect overall job creation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Number of project-related</td>
</tr>
</tbody>
</table>
Economic benefit sharing of projects in their nearby communities is often a very difficult and profound matter. Geothermal power companies should avoid creating unrealistic expectations about their financial role and involvement (direct and indirect) in the development of a community’s wellbeing. Prospectors and Developers Association of Canada published (PDAC, 2009) a list of considerations on the matter for the attention of the mining industry that can be perfectly applies to the geothermal power projects. Considerations such as:

- "Define the nature, schedule and scope of any contributions to community development in written agreements with the community…"

- "... Where possible, partner with government or appropriately qualified non-governmental organizations to facilitate delivery of programs that benefit the community"

- "With the exception of employment and payment for goods and services, limit or avoid the use of money as a vehicle for providing benefit. Rather, through engagement with the community or affected parties and, where appropriate, consider providing benefits in the form of goods and services or initiatives identified by the community or affected parties"
Appendices

- Through engagement with the community, identify where infrastructure required for exploration and development can also benefit the community and, if economically feasible, focus on creating such common improvements.

- Respect existing social structures and local authorities when defining the roles and responsibilities of the various actors in community development initiatives. Where appropriate, support local governance capacity building to manage community development initiatives into the future.

- In collaboration with the community, identify indicators of social and/or economic wellbeing that can be used to monitor and measure the outcomes of any community development programs or investments.

- Where possible, establish cooperative processes with other ... [geothermal] companies to avoid duplication of efforts and to enhance the results of any community development initiatives.

- Where possible, liaise with regional and national authorities to coordinate development initiatives with the implementation of existing government development programs, including (but not limited to) health and education.

- Where possible, support education and training initiatives that enable local people to qualify for employment [in a project].” (PDAC, 2009)
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**Topic Five: Including the importance of traditional and cultural activities and practices in project development and operation**

Table A-5 provides more details on the goals and proposed objectives and an example of related indicators and metrics to implement the topic.

<table>
<thead>
<tr>
<th>Goal five:</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ The project or operation contributes to the long-term viability of cultural, traditional, and non-market activities in the surrounding community and region (MMSD North America, 2002)</td>
<td>• Baseline studies on cultural, traditional, and non-traditional activities and practices is completed</td>
<td>• True/False</td>
</tr>
<tr>
<td>▪ The proper capacity is in place to ensure establishment of a respectful, understandable ground toward beliefs and cultural orientations of a host society</td>
<td>• Investigate dependency levels of the community on these activities and practices</td>
<td>• Statistical evaluation of the results</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Objectives</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.1 Identify traditional and cultural activities and practices</td>
<td>• Effective mechanism is in place</td>
<td>• True/False</td>
</tr>
<tr>
<td>Develop adequate mechanisms and resources to identify the nature, use levels, dependency, and threshold of the community in terms of their traditional and cultural activities and practices</td>
<td>• See Table A-2, part 2.2</td>
<td>• Degree of satisfaction via periodic surveys</td>
</tr>
<tr>
<td>Develop adequate mechanisms and resources in collaboration with the community to maintain and enhance cultural, traditional, and non-traditional activities and practices during and after the project lifetime</td>
<td>• Use of indigenous languages in community’s related publications and agreements</td>
<td>• Use of indigenous languages in community’s related publications and agreements</td>
</tr>
</tbody>
</table>
### Topic Six: Legal, regulatory, and company governance capacity

Table A-6 provides more details on the goals and proposed objectives and an example of related indicators and metrics to implement the topic.

Table A-6: Topic six – Legal, regulatory, and company governance capacity

<table>
<thead>
<tr>
<th>Objective</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
</table>
| **6.1 Meet jurisdictional requirements** | Develop proper mechanisms to safeguard that jurisdictional requirements will be fulfilled | • Baseline studies on existing legislations and regulations in local and regional scope are completed and periodically updated  
• Effective mechanism is in place to safeguard that a project meets jurisdictional requirements | • True/False  
• Number of sanctions and fines for non-compliance with jurisdictional requirements  
• Number of sanctions that has been addressed |
| **6.2 Develop and improve corporate governance capacity and strategies** | Develop a collaborative governance mechanism among government (incentives, regulations and rules, experts, etc.), community, and company to:  
• Lead implementation of the agreed upon SD objectives and strategies  
• Plan a smooth transition of the community throughout the project and into the recovery and closure | • Satisfaction that the governance capacity is in place within all involved parties to lead implementation of agreed strategies and visions during the lifetime of a project and after, as indicated by:  
  o Existence of needed regulations and policies  
  o Existence of alternative energy/power plan for recovery and closure periods  
  o Availability of monetary and non-monetary resources  
  o High level of SD | • Satisfaction with level of commitment indicated via periodic surveys  
• Satisfaction with the level of funding and other resources (experts, etc.) to lead the recovery and closure plans  
• Level and quality of services (regulations, experts, etc.), incentives, and support provided by local and regional government indicated via periodic surveys  
• Level and quality of the company’s arrangement |

Notes:
- Building governance capacities are the shared responsibility between government, the company, and the affected communities. The outcome and distribution of the responsibilities calls for close
<table>
<thead>
<tr>
<th>Objective</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>collaboration of all parties</td>
<td>corporate maturity (see section 6.2)</td>
<td>and capacity via periodic surveys</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Level and quality of the community’s arrangement and capacity via periodic survey</td>
</tr>
</tbody>
</table>
Appendices

Topic Seven: Ongoing review and improvement by company, community, and government

Table A-7 provides more details on the goals and proposed objectives and an example of related indicators and metrics to implement the topic.

Table A-7: Topic seven - Ongoing reviews and improvement by company, community, and government

Goal seven: … “An overall evaluation [has] been made and ... a system [is] in place for periodic re-evaluation based on:

- Consideration of all reasonable alternative configurations at the project level (including the no-go option in the initial evaluation);
- Consideration of all reasonable alternatives at the overarching strategic level for supplying the commodity and the services it provides for meeting society’s needs;
- A synthesis of all the factors raised in this list of questions, leading to an overall judgment that the contribution to people and ecosystems will be net positive over the long term” (MMSD North America, 2002)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.1 Assess and improve ongoing project contributions to SD</td>
<td>- Proper mechanisms are in place to assess and improve ongoing contributions to SD, as indicated by: o Review of the project design and alternatives o Review of agreed SD strategies and goals o Review of the overall effectiveness of this framework components</td>
<td>- True/False - Degree of satisfaction via periodic surveys - Frequency of informative or overall assessments</td>
</tr>
</tbody>
</table>

<p>| 7.2 Explore broader contributions and possibilities at larger geographic scales | - Establish adequate mechanisms to explore broader contributions and possibilities that a project is able to deliver, such as o Using fullest capacity and contribution of the extracted geothermal energy (e.g. creation of industrial parks, cascading system, | - Appropriate strategies, collaboration, resources are in place in cooperation with the community to expand the possibilities and contributions of a project to a wider scope than power production | - Annual amount of fund and human resources dedicated to R&amp;D - Annual amount of fund and human resources dedicated to adaptation of new technologies - Number and |</p>
<table>
<thead>
<tr>
<th>Objective</th>
<th>Example Indicators</th>
<th>Example Metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>and mineral extraction of brine) • Continuous learning and improvement</td>
<td></td>
<td>development stage of non-electricity related projects</td>
</tr>
</tbody>
</table>
Appendix B: Survey Questions

1. How would you rate the potential suitability of the above two objectives as guiding and evaluation tools for confirming topic one ("engagement") is addressed during project life cycle, on a scale from 1 to 5 (low to high)?

   - Design and implement engagement strategies
   - Develop and implement dispute resolution mechanisms

2. How would you rate the potential suitability of the above three objectives as guiding and evaluation tools for confirming Topic Two ("Valuing people and their aspirations") is addressed during project life cycle, on a scale from 1 to 5 (low to high)?

   - Identify, maintain, or facilitate the development of community’s future plans and strategies
   - Maintain or improve the project area societal and cultural values
   - Safeguard worker/community health and safety in the development and operations of a project

3. How would you rate the potential suitability of the above two objectives as guiding and evaluation tools for confirming Topic Three ("Environmental considerations") is addressed during project life cycle, on a scale from 1 to 5 (low to high)?

   - Maintain regulatory compliance and apply measures to improve conditions beyond regulatory requirements
   - Evaluate the sensitivities of the environment to changes

4. How would you rate the potential suitability of the above two objectives as guiding and evaluation tools for confirming Topic Four ("Economic viability of the project and nearby communities as a result of the project") is addressed during project life cycle, on a scale from 1 to 5 (low to high)?
5. How would you rate the potential suitability of the above two objectives as guiding and evaluation tools for confirming Topic Five (: "Including the importance of traditional and cultural activities and practices in project development and operation") is addressed during project life cycle, on a scale from 1 to 5 (low to high)?

6. How would you rate the potential suitability of the above two objectives as guiding and evaluation tools for confirming Topic Six (: "Legal, regulatory, and company governance capacity") is addressed during project life cycle, on a scale from 1 to 5 (low to high)?

7. How would you rate the potential suitability of the above two objectives as guiding and evaluation tools for confirming Topic Seven (: "Ongoing reviews and improvement by company, community, and governance") is addressed during project life cycle, on a scale from 1 to 5 (low to high)?

8. Would you agree that these 7 topics (framework as whole) reflect the main issues related to the contribution of a geothermal power project to sustainable development in local and regional communities, on a scale of 1-5 (low to high)?

9. In evaluating the overall contribution of a project to SD in local and regional communities, please provide your rankings of the relative importance you would select for each topic?
### Appendices

<table>
<thead>
<tr>
<th>Engagements</th>
<th>Less Important</th>
<th>Equally Important</th>
<th>More Important</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engagement</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Valuing people and their aspirations</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Environmental considerations</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Economic viability of the project and nearby communities as a result of the project</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Including the importance of cultural and traditional activities and practices in project development and operation</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Legal, regulatory, and company governance capacity</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Ongoing reviews and improvement by company, communities, and government</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

10. When considering a sustainable development framework such as the one proposed, what level of importance do you associate with each of the following sub-objectives in dealing with sustainable community development?

<table>
<thead>
<tr>
<th>Objectives</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Greenhouse gases</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Fossil fuel consumption (transportation, energy, etc.)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Natural resource managements (geothermal reservoirs, water resources, forestry, etc.)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Use of local services and products</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Energy and material consumptions (elimination of persistent chemical substance, minimizing usage, etc.)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Waste management (reducing, recycling, reusing, remanufacturing, etc.)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Green-building designs (power plant, personnel accommodations, offices, etc.)</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
<tr>
<td>Polluting emissions related to air, soil, and water</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

11. Do you have suggestions about any other topics that should be considered? (If yes, please elaborate)
Appendix C: Example of Self-Evaluation Questionnaire

Corporate Culture and Values

1. Of the company who you have worked with or are doing business in your jurisdiction, do you consider it small, medium or large?

2. In which phase of development is your project?

3. Does your company/project have a defined integrated SD strategy?
   - Where the main focus of your strategy is regarding to environmental, social, and economic SD-related matters?
     - Does it clearly state SD objectives and goals?
     - Does it include measurable targets with timeline? Or based on specific defined objectives that is used as a basis for defining the next targets?
     - Does it clearly state how targets would be met?
     - Does it clearly state who is responsible for implementation and/or monitoring of progress?
   - Are there any mandate or sureties to fulfill the commitments?

4. How often do you review and revise your SD objectives, targets, or strategy? What process do you follow? What is the management process to make decisions on new approaches?

5. Regarding the overall SD approach in your company: do Is it defined by the management and then impose on the rest of the organization or everybody are proactively collaborating on and participating to do so, or you think, it is somewhere in between?

6. Regarding the relationship with stakeholders:
   - Do you interact with stakeholder? How do you identify them? And how soon in a project’s life do you start engaging them?
 Appeals

- Which of the following is more actively involved in SD-related decision making: shareholders and partners, governments and policy sectors, affected communities?
- At what stage of development do you identify your stakeholders?
- When has the company started approaching the affected communities about the project?
- Do you think all affected communities and groups of interest have the opportunity to participate in the decisions that influence the future of them and their communities?
- Is there a multi-stakeholder committee that collaborates to develop SD objectives and goals?

7. Regarding knowledge management:
- What is your company’s progress with respect to (rating of 1) sharing SD-related matters at the management level to (rating of 5) sharing all information (financial, environmental, social, etc.) openly inside the organization and with all stakeholders?
- Do you publish SD reports? How often is the report published? Do you use the GRI guidance in preparing this report?
- Which of the following data is contained in your SD reports: objectives, time series trends of progress and achievements, challenges and incidents, complains and mitigation mechanisms?
- Is there a regular public or third-party monitoring report evaluating the company’s SD performance and/or public evaluation and compliance report?
- How are the communication channels with stakeholders? One-direction vs. two direction?

8. What is the operating strategy for your project, e.g. are considering the possibility to extract the full capacity of the geothermal resource or are you planning to operate it as a cascading system?

9. Do you do any R&D? Mostly in what topic area:
- Improving project economic?
- Improving energy or reservoir usage or production efficiency?
- Reducing waste or emissions?
Corporate business model

10. In which stage of development is your business model compared to the maturity model?

11. Do you have limitations or gaps?

12. Would you consider using local supplies and services or eco-friendly suppliers and companies? What about using eco-friendly materials during construction and project development?

13. Regarding the transport footprint of your activities, where do you think your company stands if a ranking of (1) indicates there is no policy yet on the matter, and (5) indicates high considerations like using eco-friendly cars, cutting unnecessary travel, switching to online technologies for meetings, etc., and using local products to cut carbon dioxide emission due to transportation?

Economic Aspect

14. What is the expected project lifetime for your geothermal power project? Would it be based on economic considerations, or reservoir capacity, or society energy stability plan, or something in between?

15. Regarding economic benefit sharing with the stakeholders, would you consider your approach to conform with law (for instance by paying tax, etc.) or do you move beyond the regulatory requirements? How do you share the benefits of your projects with local communities?

16. Do you have sufficient budget and staff to monitor, review, and continuously improve the SD consideration in your company or do you find that financial constraints at times and influence this?

Environmental Aspect

17. When it comes to environmental considerations, would your company go as far as complying with law or go beyond that? For instance:

➢ Regarding emissions to air, water, and soil, what of the following options best describe your approaches:
  o Complying with law
  o Minimizing emissions as much as a project finance allows
  o Have zero emission policy in designing, construction, and operation stages
18. Regarding waste management, which of the following statements describe conditions in your company:

- Waste in the project is separated in recyclable and non-recyclable and collected by the local waste handling companies;
- The project has policies (e.g. about drilling fluid, paper use) to minimize waste and waste in the project is separated;
- The project is designed to minimize waste and necessary waste is as much as possible recycled in the project itself, or;
- The project and the result it delivers are designed to minimize waste and necessary waste is as much as possible recycled in the project or result itself.

19. Regarding the use of natural resources (mostly geothermal, water, materials)

- What is the most important factor of geothermal reservoir utilization? For instance economic, recovery time, or somewhere in between?

20. Regarding biodiversity, how does your company handle the matter? (Reduce impact, monitor, reclamation)

**Internal Social Aspect**

21. Considering the internal social aspect of your company, for instance employees’ health and safety, human rights, diversity, unions, etc., does your company comply with the law or go beyond that?

**External Social Aspect**

22. Would you consider the importance of cultural and traditional activities and practices of neighbouring communities in your decisions?

23. Does your company have any policy on the nature of activities or projects it gets involve or corruption and fair market?

This is where your company is, would you consider being on the lower end or the higher end of maturity levels?
Appendix D: Booklet of Maturity Model

Participants in the interview were presented with a “booklet of maturity model for corporate contribution to SD” developed based on the proposed maturity model (Chapter 6, Section 6.2) to help them to self-evaluate their performance and future progress.