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Establishment and Business development of a Geothermal Eco-Industrial Park in Iceland

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ABSTRACT

ON Power has in recent years encouraged diverse utilization of the variety of geothermal value streams available within the area of Hellisheidi Geothermal Power Plant, Iceland's largest of its kind and among the largest in the world. To this end, the company has established a 106 hectare eco-industrial zone developed to encompass various operations optimizing use of the sustainable geothermal resources harnessed at the plant.

In August 2018, ON Power and Algaennovation signed the first contract for operations in the eco-industrial park. The contract involves the delivery of resource streams for a commercial-scale algae cultivation facility. The experimental growth of algae at a practical innovation center established by ON Power was a key enabler for the consequent step of Algaennovation initiating commercial-scale cultivation in the geothermal eco-industrial park. The algae hatchery will be served renewable electricity directly from the power plant, cold water from nearby springs, in addition to by-products from the geothermal power plant's processes including heat in the form of hot water and carbon dioxide. By utilizing those in the algae cultivation process, by-product synergies ("waste-to-feed" exchanges) are exploited, enhancing the utilization of the resources and allowing for shared economic benefits.

By taking advantage of similar opportunities for diverse utilization of Iceland's natural geothermal resource, the eco-industrial park is considered to provide an essential opportunity for innovative business development while at the same time supporting the accomplishment of climate goals.

This paper will describe the business development of the eco-industrial geothermal park and take into perspective the characteristics that have been identified by existing research to influence successful development. The paper will share and discuss key challenges that have surfaced from the development of the park and are foreseen in its future evolvement. A critical success factor in this case is considered to be, the proactive establishment of the park, a sufficient opportunity for resource symbiosis and a mental cohesion on values of sustainability between the anchor company and the first tenant of the park. It is the objective that the paper will provide both inspiration as well as practical insight to other geothermal heat and power procedures that are thinking of establishing similar initiatives in their communities.

1. INTRODUCTION

Investment options realized by several companies in cooperation can enable new opportunities that expand the economic and environmental performance that a company can achieve on its own. Industrial symbiosis is a concept in industrial ecology aiming at local/regional firm networks in which the actors involved utilize each other's material and energy flows, including wastes and by-products (Gertler, 1995; Erkman, 1997; Cote and Cohen-Rosenthal, 1998). The concept of a Eco-Industrial Park (EIP) can be described as an industrial complex based on industrial symbiosis or by-product exchanges within a continuum of different levels of complexity. The approach seeks to develop systematic material and energy exchange to minimize their use and the generation of waste (Kim, 2007). The main characteristic of the EIP are community, cooperation, interaction, efficiency, and resources. "An EIP is a community of manufacturing an services businesses seeking enhanced environmental and economic performance by collaborating in the management of environmental and reuse issues, by working together the community of business seeks a collective benefit that is grater than the sum of the individual benefits each company would ralize if it optimized its individual performance only" (Martin, et al. 1996). To help mitigate environmental concerns the EIP strategy has been adopted by many countries in order to support business activities and local community life by optimizing the use of energy, materials, and community resources (Geng and Côté, 2004; Geng et al. 2010).

The practical implementation of local/regional industrial ecosystems or industrial symbiosis is a challenging task (Fichtner et al. 2005) and reports on practical examples demonstrate that far from all EIP initiatives are successful. Heeres et al. (2004) and Eilering and Vermeulen (2004) reviewed practical case studies that investigate which characteristics influence the success of EIPs and found that not nearly all of the investigated EIP initiatives are realized. Fichtner et al. (2005) investigated barriers for interorganizational environmental barriers and based on two case studies concluded that even if there are economic and ecological benefits resulting from cooperation of companies, a successful completion of such projects can be hindered by a variety of barriers.

As an owner of a geothermal power plant, having access to and utilizing a national resource of Iceland, ON Power acknowledges a responsibility to utilize the resource in the best way possible and to enable others, that want to experiment with or utilize by-products of the reserves, access to the resource streams.

In 2018 ON Power established a Geothermal EIP located in proximity of Hellsiheiði Power Station. The objective of this paper is to present the approach of establishing the Geothermal Park and introduce insight into some of the practical learnings and challenges. The analysis will take into perspective some of the key factors and criteria identified by previous research on the successful establishment of EIP in practice. The paper presents a in depth case study analysis, based on a theoretical foundation and should be of value to geothermal power producers who are interested in establishing similar EIP intiatives and to researcher investigating EIP.

The paper is structured as follows. Section 2 introduces a theoretical background identifying key characteristics of EIP establishments. In Section 3 the case of ON Geothermal Park in Ölfus is presented, followed by a reflection of the park establishment compared to the identified key characteristics, in Section 4. Section 5 adds identified challenges and the paper is then concluded in Section 6.

2. THEORETICAL BACKGROUND

The literature review is meant to provide insight into factors that might influence the creation of an EIP. The focus is therefore on research contributions that include a range of EIP cases and identify characteristics that seem to have acted as barriers and success factors.

Fichtner et al.(2005) present barriers for achieving inter-organizational environmental management based on two case studies and interviews with 25 decision makers of industrial companies. In both case studies, the developed inter-company strategies would result in cost savings and environmental benefits compared to individually optimal strategies realized independently by each company on its own. Yet, it was identified that a successful completion of such projects might be hindered by various barriers, divided into three categories:

- An individual actor; related to individual resistance against an increased orientation towards cooperation such as lack of knowledge of the concept of inter-company cooperations and of potential inter-company strategies, lack of motivation or simply workload by other activities,
- An individual firm; the existence of company specific conditions that hinder the realization of inter-company cooperation such as low priority of sustainability and cooperations within the enterprise or insufficient communication and information sharing channels for such initiatives.
- An inter-firm or interorganizational level; conditions that aggravate an effective cooperation between firms and may be subdivided into barriers to cooperation (e.g. legal barriers, competitiveness, assignments of cost and befits to the partners, dependency of partners, insufficient trust between partners, need to disclose confidential information) and barriers to the interconnection of material and energy flows (e.g. legal barriers, different investment cycles and lacking physical symbiosis).

Fichtner et al. (2005) conclude to identify that important characteristics of successful inter-company cooperation include

- sufficient quality, continuity, and quantity of material or energy flows to be interconnected,
- companies within close proximity, trust and strong ties between plant managers, and
- one or more anchor tenants or drivers of the network system.

Beside these sector specific barriers can be observed such as

- unsettled legal framework,
- administrative barriers and
- public opposition, especially from local residents, which may impede the development of intercompany concepts.

Heeres et al. (2004) studied six case studies of EIPs in the Netherlands and in the US with the purpose of identifying which factors influenced failure or success. Research indicates that the Dutch EIP projects are more successful than their US counterparts. They investigate the following key characteristics of the establishment of the EIPs:

- *Objective:* An important difference between the Dutch and American cases were in the objectives of establishing the EIP. The key objective with the American projects seems to be the creation of jobs for the local populations and the economic factor was generally valued as more important than the environmental factor. However, the Dutch projects initiated in hopes of improving business economics and the environmental performance and the environmental and economic aspects seem to have been equally important.
- *Initiator:* In the Netherlands the local projects were initiated by the local entrepreneurs and employers, ensuring their active participation, while in the US the local and/or regional government initiated the EIPs in order to improve local economy while the local industry is more passive on the participation.
- *Public participation:* In the US the participation of the local community was high while in the Netherlands the community participation is unknown and the community is not encouraged to give their opinion or ideas on the EIP development.
- *Financing:* Both in the US and the Netherlands the financing for the realization of the EIP was provided by the companies who stand to gain from the implementation of the planned exchanges. In the US the government however paid for the planning of the EIP while in the Netherlands the cost for the planning seems to be split 50/50.
- *Local Champions:* An anchor tenant is a large industrial company that will attract other companies and can become the center node in the exchange network (Evans 1995, de Walle 1996). In both the US and Netherland projects there was an absence of a anchor tenant and a local champion. In the Dutch cases it was more the local business that took the role and there was no need for a company to fulfil such roles, while in the US the absence of anchor company to lead the development was felt missing.

- *Material Exchange:* Establishment of physical energy, water or material exchanges might not be an essential element in the initial EIP development. The initial development in the Dutch cases focused on the establishment of pollution prevention projects with utility sharing characteristics. This is a low risk collaborative effort with possibly substantial economic and environmental benefit. When the projects prove to be a success companies often become more enthusiastic about further EIP development with grater economic risk and benefit. In two of the US cases the project was immediately focused on the establishment of physical energy, water and waste exchanges, but in one project the companies did not want to participate in such exchanges because the financial risk and risk of continuity were to big, in the other the exchanges were limited to waste.

The results from the investigated case studies suggest that the main dominator of success for the establishment of a EIP is:

- To assure the active company or industry participation in the project. This is achieved by convincing the companies of the economic benefit of participating the project.
- The presence of a entrepreneurs'/employer\s association in the industrial park was identified as a needed platform for communication and education between the companies and the employees to learn of the potential benefits achievable.
- Already existing exchanges between the companies gaining economic and environmental benefits from the exchanges can be a strong incentive for other companies to search for exchange possibilities of their own.
- Also, as a first step it might be promising to start by identifying opportunities for shared utilities for a more direct and easily obtainable financial benefits.

An identified key characteristic of the projects that were unsuccessful is that they were:

- Initiated by local authorities for the key objective of job creation without involving the companies in the area.

Eilering and Vermeulen (2004) created a framework for analyzing factors influencing the process of arriving from ambition to performance focused on the practice of establishing of symbiosis and utility sharing. The factors were compared for eight case studies from the Netherlands investigating the correlation between the presence of certain characters and success. In this case what was identified as essential to all the successful cases was:

- Social cohesion features such as mutual trust between partner companies, the presence of an anchor company, the presens of a pioneer and a short mental distance between the companies. This might be more easily achievable if the companies know each other and have previously existing social networks, creating a source of mutual trust and social cohesion between companies.
- Physical business specific and location specific features are important as in practice there will be no symbiosis without the presence of resource exchanges or utility sharing. To achieve material exchanges it is important that the companies share complimentary needs for energy, water and/or residual substance flow.

Similarly, as Heers et al. (2004), Eilering and Vermeulen (2004) conclude that a serious pitfall in the establishment of EIPs is when the government establishes or stimulates the initiative without involving the relevant companies or other stakeholder.

These three papers will all be further referenced in the discussion of the case of ON's Geothermal Park.

3. INTRODUCTION TO ON POWER'S GEOTHERMAL PARK IN ÖLFUS

In Iceland geothermal energy meets heating and hot water requirements of 87% of all buildings. The largest geothermal power plant in Iceland, Hellisheiði Power Station, was fully established in 2007. Hellisheiði Power Station utilizes geothermal steam for electricity production with capacity of 303 MWe and produces 650 l/sec of 83°C district heating water (by heating cold ground water).

The geothermal plant runs on stable output and is set up to meet the demand of the coldest periods of the year (as a part of a larger district heating system) and must in addition have a capacity to meet demands some years ahead. In addition, there are two by-products of the production; geothermal gas which contains carbon dioxide and utilized geothermal water which is currently disposed of at average temperature of ~61°C. The area thus offers a close proximity to the output products of the power station; electricity hot district heating water (83°C) and cold water 4°C, in addition to the by-products; silica, carbon dioxide and geothermal water, see Figure 1.

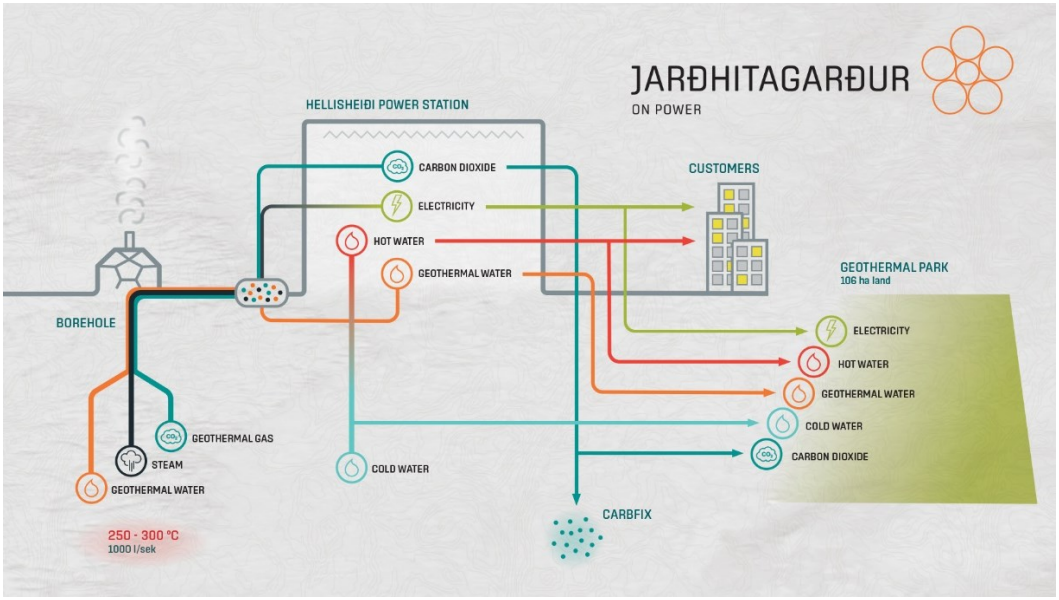

Figure 1: Resources and bi-products available at ON's Geothermal Park at Hellisheiði

ON Power has in recent years encouraged diverse utilization of the variety of geothermal value streams available within the area of Hellisheidi Power Plant. For this purpose, ON Power has established a EIP developed to encompass various operations optimizing use of the sustainable geothermal resource harnessed at the plant

To support entrepreneurship and research in the field of geothermal application, and to stimulate business development for the eco-industrial park, an innovation center allowing pilot studies with the use of value streams has been established. This area is referred to as Technical Park and is operated with the objective to activate innovation using geothermal resource streams and possibly energize the establishment of customers of the Geothermal Park. The innovation cluster provides slots where tenants are enabled to easily connect to geothermal resource streams and are offered access to utilities at Hellisheiði Power Station such as office areas, toilets and a canteen.

The innovation center has been the home of various R&D projects in recent years, e.g. microbiology research by the University of Iceland, extraction of silica from the geothermal water for food supplements, hydrogen production and ambient air carbon capture followed by subsurface mineralization.

The Geothermal Park is 106 ha. and includes 48 lots ranging from 0.1 ha to 8.5 ha. Hellisheiði Power Station is only about 500 m away from the closes sites and the hot and cold water pipelines that run through the park. The park is furthermore conveniently located 30 km from Reykjavík, 70 km form Keflavík International Airport, and 28 km from Þorlákshöfn industrial harbor.

4. THE CREATION OF A GEOTHERMAL EIP

In this section the establishment of the park will be introduced. The organization and process of the development of the park will be discussed and compared to some key characteristics identified from theory. In this case it is clear that ON Power has the role of an *anchor company* (as the establisher of the EIP, the owner of the land and of the producer of key resources at the park).

4.1 Resource symbiosis

The presence of physical business and location specific features that can enable symbiosis for resources and utility sharing have been identified as a key success factor and a prerequisite for the development of a EIP. In practice, there will be no symbiosis and/or utility sharing if the social features are present and the physical features are missing, but correspondingly there is no symbiosis and/or utility sharing if the physical features are present but he social features are missing (Eilering and Vermeulen, 2004). As can be recognized from the introduction of the case of ONs Geothermal Park the existence of physical business and location specific features are clearly available in the are of Hellisheiði Power Plant.

4.2 Involvement of authorities in the initiation of the Geothermal Park

Existing research (e.g. Eilering and Vermeulen, 2004, Heeres et al. 2004) suggests that a top-down approach organized by government or local authorities might be a less successful approach to establishing a EIP if the target companies do not buy in to or see a financial benefit of taking part in the initiative.

The government of Iceland did not initiate the Geothermal EIP project and the project has received limited official financial support. The government and the local authority are therefore not a part of the *organization of the decision-making process* of the Geothermal Park. Although the Geothermal Park is not initiated by the local authorities, they are seen as a key stakeholder both because of their power to influence the proceedings of the EIP implementation and as social cohesion with the local society is of outmost importance for the feasibility of the project. The local authority of Ölfus has been positive and supportive towards the project which has been uplifting for its development.

4.2 Objective

As the Geothermal Park was established a policy guideline, identifying its key objectives and criteria for the feasibility of collaborating tenants was defined. The resulting summit of the Geothermal Parks is that: "The Geothermal Park shall encompass a wide range of operations, with the objective of utilizing resources from Hellisheiði power plant in an optimal way and thereby decrease environmental impact, create value and promote innovation. The key objectives of the park are shown on Figure 3.

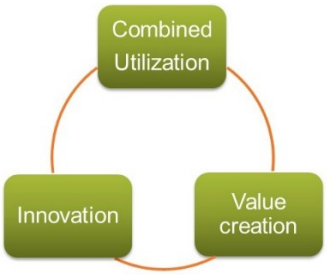

Figure 2: Key objectives of ON's Geothermal Park.

Thus, a clear objective of the Geothermal Park is to create value. This value has been identified as a key success factor by previous research. One can speculate if any business initiative is sustainable if it is not sustainable financially.

4.2 Proactive versus reactive establishment

The possibility of success is higher if the companies initiate the collaboration as a result of identification of collaboration opportunities. As a result, "What has evolved 'organically' or become self-organized elsewhere is very difficult to create in a planned fashion" (Eilering and Vermeulen 2004).

The Geothermal Park can be considered organized via *bottom-up* approach. Since the establishment of Hellisheiði Power Station there has been a vision among ON Power's employees to improve utilization and innovation with geothermal energy resources.

The first experiments with the geothermal resource at Hellisheiði was ON's own experiments with the Sulfix and Carbfix methods, with the objective of optimizing the operation of the plant and limiting its environmental footprint. In the following years this interest prospered and by 2012 the Technical Park was already being operated, providing infrastructure for researchers and entrepreneurs to set up experimental facilities in proximity of the plant. The interest in utilization and innovation with the geothermal resource, was vice versa as ON had also been approached by a number of interested parties with ideas for utilization of the geothermal water (e.g. for greenhouse cultivation, protein production and extraction of silica).

However, at the time there was no organized land for establishing commercial scale operations in close proximity of the plant and the structure for such business operations were not a part of the company's operations. Also, although there was interest among key personnel for such initiatives there had not been set an organizational policy for the direction ON Power should take for involving the company in initiatives of a larger scale.

As it became anticipated that feasible tenants and contracts could be established for an industry scale operation a more planned approach was initiated by ON Power, including the establishment of the policy guideline. There are evident benefits for taking a proactive approach to the EIP establishment.

Organization of the area: A local amendment established for the area incorporates advice from key stakeholders regarding protection of the Eco-biodiversity and limiting visual effects of the park's establishment. Lots were organized in various sizes and streets were organized to utilize the area in the best way possible. In the future, when new tenants approach, they can select between defined lots of various characteristics and are given a clear set of requirements applying to business establishment in the area.

Decision making support: A steering committee was established for the Geothermal Park involving key stakeholders from ON Power. The involvement of a steering committee is an important tool to increase the probability of successful development of the park as it outdraws different views from experienced employees before deciding on key decisions.

Clear support by management: The establishment of an EIP requires financial resources as well as human resource by the anchor company. The formal approval for the business development of an EIP ensures that personal can be assigned to the case and that services by the company can be utilized for the project. Also, this gives a clear message that the company is serious about the EIP establishment and authority to start negotiating with possible tenants.

Proactive business development: A planned approach to the EIP allows ON Power to actively seek tenants that can achieve resource symbiosis and complemented utility sharing. A proactive business development allows for a structured approach for setting up a business plan and evaluating the financial feasibility of the major investments needed for the establishment of the park and correspondingly a feasible pricing strategy. Most importantly transparency and knowledge of the feasibility of investment cases will provide rational decision making.

The Geothermal EIP of ON Power is seen as a long-term development that will happen gradually over the years to come. The target of an upfront establishment of the park is not only to encourage its development but to ensure the highest chance of success possible. Another key success factor to the establishment of the Geothermal Park is the establishment of the first tenant or a pioneer company.

4.6 The first tenant or pioneer company

Eilering and Vermeulen (2004) and Fichtner et al. (2005) suggest the importance of the first tenant of the EIP. In the case of ON's Geothermal Park, the first tenant is a microalgae producer, Algaennovation which can be seen as the *pioneer company*. Algaennovation will be served electricity, hot water and carbon dioxide from the Hellisheiði Power Station and cold water from a nearby ground waters reservoir. The operations of the two companies are complementary in needs for residual energy, water and substances. The opportunities for utility sharing are however limited, except for that the tenant enjoys the proximity and thus partly sharing of some of ON Powers hot and cold-water utilities.

4.7 Shared background and trust

Another important attribute of success is social cohesion and trust, therefore if the companies are familiar with each other (Eilering and Vermeulen, 2004; Fichtner et al. 2005). Prior to starting the contract negotiations, Algaennovation conducted experimental cultivation at ONs Technical Park. The companies collaborated on making the initial cultivation possible and have become familiar with each other. In addition, the companies share a vision on sustainability and on protecting the natural ecosystems. There is therefore a level of mutual *trust* between the companies. However as pointed out by van Leeuwen et al. (2002) and Korhonen (2001) there exist a strong codependency between companies that setup resource symbiosis and utility sharing and thus bind itself to a partner company and to a specific location.

Achieving symbiosis and/or utility sharing can provide benefits of agglomeration, however when a company achieves symbiosis or utility sharing by doing so it binds itself to the location where it is established and this may reduce the company's flexibility which can have negative effects on its competitiveness (van Leeuwen et al. 2002).

At the Geothermal Park the tenants will rely on contracts with ON Power regarding the rent of land and supply of critical resources. Once a company has located in the Geothermal Park it would be an obstacle for them to relocate. The tenants will therefore rely on good collaboration with ON Power and reverse. ON Power also relies on that the tenants do well so that they can withstand the agreement and secure the expected cash flow, as well as that they will comply with requirements e.g. regarding environmental management. If such a relationship would become problematic it would be a large burden for both companies. Even though there is a sufficient level of trust both parties must seek to avoid risk. This can be managed by comprehensive contracts and a shared understanding of flexibility as this is the first development of the park and learnings are still to be made.

5 CHALLENGES

In this section the challenges that have surfaced during the implementation of ON's Geothermal Park will be introduced. Some of the challenges are general for setting up an EIP operation while other are more specific for the geothermal resource and this specific case.

5.1 Estimating future availability of resources

The key purpose of the Hellisheiði Power Station is to provide district heating to the residents of Reykjavík and its surroundings. The hot water production has a critical contribution to a larger district heating system to ensure it can meet maximum demand at the coldest periods of the year. The resource usage at the Geothermal Park cannot compromise the secure delivery of district heating.

The future demand of district heating is depending upon many variables and is therefore difficult to predict. Furthermore, new technical advances (such as heat pumps) might improve the utilization of heating energy of the geothermal water, which could influence the availability of the geothermal water at the Geothermal Park. The challenge thus becomes that the quantity and quality (in terms of temperature) of the available geothermal water is challenging to predict long term. A similar scenario is evident for the carbon dioxide content in the geothermal gas which might decline as the geothermal reservoir is utilized. This limits the possibility to adequately map the resource streams and align them with suitable business operations.

Possible tenants that are thinking of establishing operations in the area, usually require long term contracts in order to justify building the necessary infrastructure and locating in the Geothermal Park. Due to the uncertainty in both the evolvement of the geothermal resource and the demand for hot water it is difficult o predict which resource streams it is safe to guarantee to tenants although they are currently available and might be in the future. In these cases a contract can be negotiated where the user accept that the delivery of resource streams is paused during peak periods, the tenants might be advised that the resource delivery might change over time and that they might need to take preliminary action for the resources to change. Finally, there might be cases where it would be more feasible to utilize the geothermal energy in the Geothermal Park rather than to produce electricity for the district market.

5.2 Merging the operation of the Geothermal Park with the operation of the power plant

The secure operation of Hellisheiði Power Station will always be the first priority for ON Power. The operation of the Geothermal Park will require interference and even modification to some of its equipment in order to direct resources to the EIP. This is an urgent task as no interruptions can risked to the operation of the plant. Also, there will be fluctuation of the resource usage of the Geothermal Park and this cannot influence the operation of the power plant. In general, this influences the complexity of operating the power plant and creates new assignments for its staff.

In addition, it is important to align the information flow between the operators of the power plant and the tenants of the Geothermal Park, e.g. related to expected stops of resource delivery, e.g. due to maintenance. Operating a Geothermal Park is a new task of the company and will surely require new processes, roles and responsibilities for its operators. These changes will require substantial stakeholder management at the company.

5.3 Building infrastructure for an unclear future demand

A key feature for a successful establishment of a EIP is the opportunity for shared energy or water utility sharing (Eilering and Vermeulen 2004). In fact, Heeres et al. (2004) identify that many of the successful cases investigated initiated because of opportunities

for shared environmental protection infrastructure. KPMG (1998) states: „The development of an eco-industrial park calls for substantial investment. It requires, for example, infrastructure for material and energy flows and the construction of shared facilities. Problems relating to the costs and the investment risks can endanger the continuity of the process. Besides the project costs, the division of the process costs must also be considered."

For the case of ON Power Geothermal Park, the tenants are not operating in the area prior to the park establishment and in addition it is unknown which operations will enter and when. The resource demand of the future tenants is thus impossible to predict. This makes it challenging to plan the a feasible built up of shared utilities and infrastructure. However, if the utilities are built on individual bases opportunities for cost reduction and shared benefits will be reduced.

5.4 Having a third party operating in the area of ON Power

ON Power has high ambition in regard to safety policies for all its operations which have been developed over years of experience. Specific safety measures have been defined and must be followed by ON's employees and all contractors who work for the company. Similar policies have been established for environmental protection measures (further discussed in Section 5.5).

As a consequence of tenants setting up operations in the Geothermal Park, third parties will be doing constructions and operating in the area. It is not the interest of ON Power to involve itself in the construction of other companies. However, the constructions are happening on ON Power's land and will be associated with the company, for example, if a serious accident were to occur in the area. ON Power intends to ensure the same standards regarding safety and environmental measures in the Geothermal Park as for other operations of the company and would hope that the tenants share a social cohesion in this regard. However, this shared mentality cannot be automatically assumed.

How to ensure that sufficient safety and environmental measures are followed in the Geothermal Park without involving itself too much in the operations of the tenants is an operational inquiry that will need to be further investigated. Currently, ON Power will set up a requirement specification that the tenants shall pose on their own operations and contractors. However, it remains how to ensure the requirements are being followed.

Both measures to ensure safety and to protect the environment are preliminary actions that cannot wait to be ensured afterwards.

5.5 Protection of the local Ecosystem

Liu et al. (2015) point out that although methods have been established that can evaluate the environmental efficiency of industrial parks such as Life Cycle Assessment (LCA), Material Flow Analysis (MFA), exergy, emergy and System Environmental Economic Accounting (SEEA), the proposed methods have disadvantages in terms of considering the local ecological carrying capacity. Although the energy metabolism of the industrial system performs well and the environmental indicators are not bad, the carrying capacity of the local area might be ignored which can lead to ecological degradation.

The area of Hellisheiði is a popular outdoors area and has a rich biodiversity. ON Power has previously established environmental protocols to limit the environmental impacts of the operations of Hellisheiði Power Station and is ambitious to be sustainable in regards the quality of the local environment, the same must thus be expected of its tenants. The tools that have been used to protect the environment and limit visual effects as well as protect biodiversity in the area are the following:

Local amendment: ON Power has a firm ambition to be sustainable in regard to protecting local ecological environment. To limit the visible effect from the Geothermal Park creation the local amendment incorporates requirements regarding color codes that can be used for all constructions in the area. The amendment also states the maximum allowed heights of buildings and that in the future the visual effects of the constructions will be limited by the use of soil constructs. To reserve biodiversity ON Power has committed itself to saving all vegetable surface area removed due to operations and that all disrupted areas will be grown back with local vegetation. The vegetable surface must thus be safely removed and stored, to either be used to restore areas being disrupted or used for reclamation. The local amendment captures that this shall also be the protocol for the disruption of vegetable land and its restoration for the tenants of the Geothermal Park.

Requirement checklist: To ensure that the tenants keep the area tightly the rent contract for the lots include clauses about keeping the lots clean and time limits for restoring disrupted areas and removing equipment after construction. The rent contact includes a checklist for building requirements that must be submitted and approved by ON Power before filing for a building permit. The checklist is meant to ensure that the planned construction complies with the local amendment and the rent contract.

Environmental emission questioner: The Geothermal park area is sensitive to surface emission as remote ground water currents that lead to the main water reservoir of Reykjavík run thought the area. After meeting with an interested company, the initial measure taken prior to further investigating possible collaboration, is to send the company a questionnaire covering environmental emissions and risk. The questionnaire is meant to exclude operations that do not belong in the area and to highlight if specific solutions must be worked out to limit environmental effects. For some tenants closed loop sewage or adequate filtering systems might be adequate. However, not all companies are eligible for the Geothermal Park and no chances will be taken in this regard because of the threat to the ground water reservoir.

6. CONCLUSION

The objective of this paper has been to shed light on the practical "how to" and the considerations to address when establishing of EIP, in this case specifically a geothermal EIP. For this purpose, the case of ON's Geothermal Park has been compared to the key characteristics of EIPs identified by existing theory, in addition to presenting some additional challenges that need to be addressed. It was found that many of the characteristics of the process of building up the park have been discussed by previous research as well as many of the identified challenges. The Geothermal Park now has a single tenant and is in operation. What has been identified as a critical success factor in this initial success is considered to be, the proactive establishment of the park, a sufficient opportunity for

resource symbiosis and a mental cohesion on values of sustainability between the anchor company and the first tenant of the park. This further supports the integrity of the identified challenges, although here they have been are discussed in more depth since the focus is on a single case study. The hope is that this paper will enrich the discussion of industrial clusters and get around some of the practicalities that need to be addressed so that others can approach such an establishment in a structured manner and be prepared to meet some of the presented challenges.

Currently the Geothermal Park only has one tenant and the reflection of this paper are therefore limited to a single case. However, with one tenant operating in the park and active business development it can be stated that the Geothermal Park is in operation. Quantitative data about the economic benefits and environmental gains generated by industrial case studies could be an important stimulus for other companies in industrial parks to try and work toward symbiosis and/or utility sharing in practice (Eilering and Vermeulen, 2004). Further research at ON Power will focus on specifying measure indicators that can be applied to evaluate economic and environmental performance of ON's Geothermal Park and document the results from the further development of the initiative.

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