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Powering Innovation: Geothermal Synergy at Hellisheiði in Iceland

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ABSTRACT

Eco-industrial parks (EIPs) are emerging as powerful platforms for advancing sustainable development, enabling industries to collaborate through shared resource use, waste-to-value systems, and circular economy principles. When anchored to renewable energy sources like geothermal, EIPs can accelerate innovation, improve efficiency, and reduce emissions.

ON Power's Geothermal Park by Hellisheiði Geothermal Power Plant in Iceland exemplifies this integration. The park provides access to geothermal resource streams, e.g., renewable electricity, heat, and water, supporting a growing ecosystem of companies shaping the future of sustainable industry. Its goal is to maximize resource value through cascaded utilization, enhancing both environmental and economic performance.

Integrating an EIP with a fully operational geothermal power plant requires navigating technical, operational, and strategic complexities. ON Power is actively assessing the associated opportunities and challenges, including optimizing resource flow without disrupting core operations and providing scalable infrastructure for multiple users. This involves determining which types of companies are most compatible with the park's resource streams and sustainability goals. Supporting their integration calls for innovative business models, technological fit assessments, and a deep understanding of potential synergies that can reduce waste and enhance overall system efficiency. To support this model, ON Power is establishing an innovation hub for pilot testing, research collaboration, and scalable development.

This abstract highlights the core opportunities and challenges of operating an EIP centered on a geothermal combined-heat-and-power plant. Drawing from ON Power's experience, it distills lessons that can inform the development of other renewable-anchored EIPs and support broader efforts to build circular, low-carbon industrial ecosystems.

1 INTRODUCTION

Iceland's energy system is unique, with the highest share of renewables in primary energy use worldwide (Energy Institute, 2025). Geothermal resources play a central role, supporting both electricity generation and renewable district heating. ON Power, a subsidiary of Reykjavík Energy, is Iceland's largest producer of geothermal energy (National Energy Authority, 2024). The company operates two combined heat and plants (CHP), where both electricity and hot water are produced (ON Power, 2025a). Since the beginning, ON Power has explored ways to ensure efficiency and create value from the high-temperature geothermal resources. About a decade ago, ideas emerged to establish an eco-industrial park next to the Hellisheiði Geothermal Power Plant. Today, this concept has materialized as the Geothermal Park, designed to improve resource use and support new forms of sustainable value creation (Geothermal Park, 2025). This development reflects a broader vision to transform conventional energy production into a multi-value system where every by-product becomes a potential resource (Geothermal Park, 2025).

Eco-industrial parks (EIPs) provide a useful framework for enhancing such resource systems. Built on principles of industrial symbiosis, EIPs enable companies to exchange energy, materials, and services to reduce waste and improve system-wide efficiency (Perucci et al., 2022). These functional synergies can generate environmental, economic, and societal benefits when supported by effective collaboration and

shared infrastructure. When anchored to a geothermal field, the potential is even greater as it offers opportunities for resource cascading and novel value creation.

Within this context, ON Power's Geothermal Park represents a strategic effort to pair geothermal CHP operations with industrial symbiosis and circular value creation. By coupling stable energy production with opportunities for resource cascading, the park seeks to generate economic, environmental, and societal benefits while maintaining reliable power-plant operations.

The objectives of this study are twofold:

1) to analyze the key opportunities and challenges involved in operating an eco-industrial park alongside a geothermal combined heat and power plant; and
2) to identify lessons learned that can inform future decision-making regarding the evolution of the Geothermal Park and similar eco-industrial parks.

These objectives are addressed through qualitative data collection and grounded-theory analysis. The paper is structured as follows: Section 2 provides background on ON Power's operations and the Geothermal Park; Section 3 outlines the methodology; Section 4 presents the findings; and Section 5 discusses implications and conclusions.

2 BACKGROUND

ON Power is Iceland's largest producer of geothermal energy, supplying 431 MWe of electricity and 580 MWth of hot water to homes, municipalities, and industries (ON Power, 2025a). Its flagship facility, Hellisheiði Geothermal Power Plant, is a double-flash CHP plant with 303 MWe and 200 MWth of installed capacity, serving both power generation and Reykjavík's district-heating system (Jakobsson, 2024). Recent upgrades include the Steingerður air-purification plant, which integrates Carbfix technology to capture CO_2 and H_2S for permanent mineral storage (ON Power, 2025b; Carbfix, 2025).

Adjacent to the plant lies the Geothermal Park, a pioneering EIP based on circular resource use, symbiosis, and innovation. Operated by ON Power, it provides companies access to a unique suite of geothermal resources and infrastructure, including electricity, geothermal brine, hot and cold water, gases, and minerals, enabling the development of sustainable, resource-efficient industries (Geothermal Park, 2025; Tzachor et al., 2022). Current tenants include Climeworks, Carbfix, and VAXA Technologies (Geothermal Park, 2025). Future development centers on Glóð, an innovation hub that will offer research facilities, collaboration space, and support for pilot projects and early-stage companies (Geothermal Park, 2025).

3 METHODOLOGY

To address the research objectives, informal interviews were conducted with key stakeholders at ON Power (Gunnarsdóttir et al., 2021). Stakeholders were selected based on their direct involvement in the development and operation of the Geothermal Park. In addition, conversations and interviews with representatives of companies located within the park were analyzed to capture external perspectives.

The data were analyzed using open coding following grounded-theory principles (Merriam & Tisdell, 2016). Through iterative coding and comparison, recurring issues were identified and organized into themes representing the main opportunities and challenges of developing and operating the EIP.

4 RESULTS AND DISCUSSION

The grounded-theory analysis revealed four overarching themes that describe the main opportunities and challenges of operating an EIP alongside a geothermal CHP plant: Shared Infrastructure, Resource Interdependence, Circular Value Creation, and Long-Term Governance. Although distinct, these themes are interconnected and have jointly shaped the development and management of the Geothermal Park. Some of the quotations in the following sections are translated from Icelandic by the authors.

4.1. Shared Infrastructure

Stakeholders emphasized that shared infrastructure is both a core asset and a source of complexity. Companies in the Geothermal Park gain access to geothermal value streams through existing pipelines in some cases, improving utilization of infrastructure that might otherwise remain underused. At the same time, this shared setup requires careful coordination of expansions, modular and redundant design to ensure continuity, and pricing models that reflect the rising marginal costs of incremental build-out. Interviewees stressed the need to balance early-mover advantages with fair pricing for new entrants, ensuring long-term cost recovery without creating inequities. Several also noted a tension between building infrastructure ahead of demand and waiting for confirmed need, a classic "chicken-or-egg" challenge. ON Power's ownership and operation of all park infrastructure help maintain continuity and safety. Despite these challenges, shared systems remain a central source of value for the park.

4.2. Resource Interdependence

One of the main reasons for the existence of the Geothermal Park is to create value from underutilized resources. Hellisheiði CHP plant is at the center of the EIP and provides the geothermal resources that companies depend on. Interviewees described this as both a strength and a weakness. The power plant and its operations are always the main priority. As a result, there is a close link between plant operations and resource availability in the park. Maintenance activities, load changes, and seasonal variations can affect the supply of geothermal resources. This creates uncertainty for companies that require stable year-round inputs. As one interviewee put it:

> *„This is an incredibly complex optimisation problem. We're always trying to improve the efficiency of the power plant. Adding the Geothermal Park into the mix, adds another layer of complexity."*

Because of this interdependence, new projects must be assessed with respect to the operational needs of the CHP plant. Stakeholders noted that this coupling shapes which types of companies can be supported and how contracts and expectations must be managed.

4.3. Circular Value Creation

Circularity was seen as one of the strongest opportunities in the park. Stakeholders identified several synergies, such as the use of CO_2, heat, and water in biological or industrial processes. These exchanges can reduce waste and improve environmental and economic performance. The low carbon footprint of geothermal resources was considered important for companies aiming to develop sustainable products, as one interviewee noted:

> *"Locating in ON Power's Geothermal Park… we are sustainably using the energy streams from the power plant but also, when we have used those streams, our waste can become someone else's raw material, either for other tenants in the park or the powerplant itself."*

Circular exchanges depend on reliable operations and clear expectations. Interviewees highlighted that shifting needs and operations, especially among start-ups, can create risks for dependent partners. Geothermal brine offers a concrete example of circular use: it is used in the power plant, then by companies in the park, and subsequently returned for reinjection. ON Power is exploring additional cascading steps, such as a geothermal lagoon (Geothermal Park, 2024). Beyond resource flows, several interviewees emphasized the value of the park as a community of practice, where proximity to ON Power provides access to R&D facilities, technical support, and informal knowledge sharing. These relational benefits were seen as important enablers of circular value, provided operational stability can be maintained.

4.4. Long-term Governance

Long-term governance was described as essential for the park's development. Many challenges stem from the fact that the Geothermal Park was not part of the original design of the Hellisheiði plant and its surrounding area, as one interviewee noted, it was "an after-thought." This has created issues related to layout, pipeline routing, and land drainage, including occasional flooding in some areas. In the current setup, power plant operations take priority, which can lead to temporary disruptions in resource supply for tenants and added complexity when integrating new projects. These factors significantly complicate design, construction, and planning in an area already dense with pipelines and high-voltage cables.

Stakeholders emphasized the need for pricing models that reflect long-term costs and infrastructure requirements to ensure fair pricing for future customers. Contracts must incorporate maintenance schedules and operational variability. Interviewees highlighted the challenge of setting prices that balance current resource use with future infrastructure needs. Despite these challenges, interviewees viewed scalability as a strength of the park. Companies within the park began with small pilot projects and have been able to expand their operations over time.

4.5 Synthesis and Lessons Learned

These themes show that the Geothermal Park's strengths lie in shared geothermal infrastructure and opportunities for circular value creation. Its main challenges arise from operational interdependence and the need for clearer long-term planning. Overall, operating an EIP alongside a geothermal CHP plant requires balancing new industrial activity with the operational realities of power-plant management.

Several lessons emerged. Long-term, modular infrastructure planning is essential to support new tenants and avoid inefficient layouts. Resource variability and operational coupling must be managed through transparent communication, contingency planning, and contracts that reflect geothermal conditions. Circular synergies depend on stable operations and technical compatibility, making coordination and mutual reliability critical. Stakeholders also emphasized the need for dedicated governance capacity to connect park development with plant operations and provide a clear point of responsibility. As the park grows, pricing and contractual structures must adapt to rising marginal infrastructure costs and ensure fair risk-sharing among tenants.

Interviewees also noted the value of scalability, where companies can start small and expand as capacity allows. Glóð, the park's emerging innovation hub, will support this by providing a test-bed for pilots, early-stage technologies, and incremental growth. This staged approach reduces risk, strengthens compatibility assessments, and allows companies to grow in alignment with geothermal operations. Some emphasized that beginning in a small container-based pilot before scaling up has been essential in reducing technical and financial uncertainty.

These lessons align with broader EIP literature, which highlights governance, reliable resource flows, and well-managed interfirm cooperation as key factors for success. Many historical EIP initiatives have struggled due to weak coordination, uncertain supplies, or insufficient planning (Perucci et al, 2022). The experience at Hellisheiði reinforces the importance of governance structures that match the physical and operational constraints of the energy system. Overall, the success of the Geothermal Park depends as much on governance and system design as on access to geothermal resources. These insights can guide further development of the Geothermal Park and other renewable-anchored industrial ecosystems.

5 CONCLUSIONS

The Geothermal Park at Hellisheiði demonstrates how geothermal resources can support both industrial activity and innovation when combined with shared infrastructure and circular value pathways. The

findings show that its potential is strong, but dependent on coordinated governance, clear long-term planning, and the ability to manage operational interdependence with the CHP plant.

Key lessons include the need for modular infrastructure planning, clear communication about resource variability, and contractual arrangements that reflect geothermal operating conditions. Circular synergies create value but rely on reliable operations and technical compatibility. A dedicated coordinating role is essential to align park development with the power plant and manage added complexity.

Glóð will play an important role in supporting these efforts by offering a test-bed for pilot projects and enabling companies to scale gradually within operational limits (Geothermal Park, 2025). This staged growth model helps ensure technical fit, reduces risk, and strengthens collaboration between industry and energy providers.

Overall, the experience from Hellisheiði shows that geothermal-based EIPs require strong governance and system design as much as resource availability. These insights can support the development of other renewable-anchored industrial ecosystems seeking to leverage shared infrastructure, improve resource utilization, and foster low-carbon innovation.

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