



ENTREPRENEURIAL ECOSYSTEM IN SOUTH KARELIA'S POWER-TO-X ECONOMY

Lappeenranta–Lahti University of Technology LUT

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ABSTRACT

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Entrepreneurial Ecosystem in South Karelia's Power-to-X Economy

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Keywords: PtX, Power-to-x, Power-to-x Economy, entrepreneurial ecosystem, competitive advantage, RBV, Resource-based view, VRIO

The global energy sector is undergoing a shift, caused by the need to urgently lower greenhouse gas emissions and transition away from fossil fuels. This study examines how entrepreneurial ecosystem can be developed to support the Power-to-X (PtX) economy in South Karelia. The study uses a qualitative case study approach with semi-structured interviews and a theoretical framework focused on competitive advantages in entrepreneurial ecosystems.

The findings highlight South Karelia's strong industrial base drives PtX development by providing key resources like biogenic CO₂ and creating demand for innovation. Material strengths, including infrastructure and institutional support, enable ecosystem growth, but gaps in the electric grid, renewable energy capacity, and cultural barriers, such as low public awareness and resistance to green initiatives, remain challenges. Social strengths, including a skilled workforce and collaborative platforms, are underutilised. Advancing PtX ecosystems requires improving infrastructure, fostering public-private partnerships, addressing cultural resistance, and aligning policies to reduce barriers and accelerate growth.

The study shows that entrepreneurial ecosystems are inherently unique, evolving within specific local contexts and shaped by dynamic, co-evolving relationships among stakeholders. Context-specific factors play a pivotal role in shaping ecosystem development. These findings highlight the importance of developing region-specific strategies to support entrepreneurial ecosystems.

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Globalilla energiasektorilla on käynnissä merkittävä muutos, jota ohjaa kiireellinen tarve vähentää kasvihuonekaasupäästöjä ja siirtyä pois fossiilisten polttoaineiden käytöstä. Tämä tutkimus tarkastelee, miten yrittäjyys ekosysteemiä voidaan kehittää tukemaan Power-to-X (PtX) -taloutta Etelä-Karjalassa. Tutkimuksessa käytetään laadullista tapaustutkimusmenetelmää, jossa aineistoa kerättiin puolistrukturoiduilla haastatteluilla ja analysoitiin teoreettisen viitekehyksen avulla, joka keskittyi yrittäjyys ekosysteemiin ja kilpailuetuihin.

Tulokset korostavat Etelä-Karjalan vahvaa teollista perustaa, joka edistää PtX-kehitystä tarjoamalla keskeisiä resursseja, kuten biogeenistä hiilidioksidia, ja luomalla tarvetta innovaatiolle. Materiaaliset vahvuudet, kuten infrastruktuuri ja instituutioiden tuki, mahdollistavat ekosysteemin kasvun, mutta haasteita aiheuttavat sähköverkon ja uusiutuvan energian kapasiteetin puutteet sekä kulttuuriset esteet, kuten vähäinen yleinen tietoisuus ja vastustus vihreää siirtymää kohtaan. Sosiaaliset vahvuudet, kuten osaava työvoima ja yhteistyöverkostot, ovat myös alihyödynnettyjä. PtX-ekosysteemin kehittäminen edellyttää infrastruktuurin parantamista, julkisen ja yksityisen sektorin kumppanuuksien vahvistamista, kulttuurisen vastustuksen käsittelemistä sekä politiikan linjaamista esteiden vähentämiseksi ja kasvun vauhdittamiseksi.

Tutkimus osoittaa, että yrittäjyys ekosysteemit ovat luonteeltaan ainutlaatuisia, kehittyen spesifien paikallisten olosuhteiden mukaisesti ja muovautuen dynaamisissa, yhdessä kehittyvissä sidosryhmäsuhteissa. Ekosysteemin kehitys riippuu vahvasti kontekstisidonnaisista tekijöistä, mikä korostaa aluekohtaisesti räätälöityjen strategioiden merkitystä yrittäjyys ekosysteemien tukemisessa.

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SYMBOLS AND ABBREVIATIONS

Abbreviations

CO ₂	Carbon Dioxide
H ₂	Hydrogen
PtX	Power-to-X
RBV	Resource-based view of the firm
KBV	Knowledge-based view of the firm
SME	Small and medium-sized enterprise

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1 INTRODUCTION

The global energy system is undergoing a major transformation. Energy production contributes approximately three-quarters of global greenhouse gas emissions. This will make energy production the primary driver of climate change and also create a risk to public health. To mitigate these impacts, the world must transition from fossil fuels to a low-carbon energy mix (Our World In data 2024). Renewable energy sources like wind and solar power are vital to replace fossil fuels in power and heat production (Our World In data 2024b).

Through Power-to-X (PtX) technology, renewable energy is converted into various synthetic fuels, chemicals, and materials, which can be used to substitute fossil fuel-based products across multiple industries. Industries like aviation, agriculture, manufacturing, heavy transport, and the chemical industry depend heavily on fuels and chemicals. (Karjunen 2022, 13) The renewable hydrogen-based economy can change energy production and consumption, creating new opportunities and challenges for local economies and global energy use. In 2022, the share of energy product imports accounted for 19.8 per cent of Finland's total imports, while energy product exports made up 10.4 per cent of total exports (Tulli 2022, 1). This indicates a significant trade deficit in energy products, which reached 9.7 billion euros for the year.

It is important to understand the regional capabilities and future potential of PtX technologies. This study aims to assess the current state of the PtX entrepreneurship ecosystem within the South Karelia area and the roles of its stakeholders, as well as to identify barriers and opportunities for development. Recognizing the distinct characteristics of the region is critical, as entrepreneurial ecosystems are inherently unique and evolve within specific local environments (Mason, Colin & Brown 2014).

To navigate the multifaceted dimensions of this transition, a clear vision and a robust, long-term investment strategy are indispensable, especially for critical energy infrastructure and industrial sites poised for transformation. This thesis explores the viability of the PtX economy in South Karelia.

1.1 Introduction to the Power-to-X Economy

Power-to-X as a term started to emerge in research in the year 2017 (Tuomisalo et al. 2024). Before the concept of the Power-to-X economy, the Hydrogen Economy concept was introduced. The Hydrogen Economy proposed hydrogen as the primary energy carrier. The idea of utilizing hydrogen for fuel and chemical synthesis, coupled with the complexities of hydrogen handling, prompted certain researchers to redefine the Hydrogen Economy as more of a Hydrogen-to-X Economy framework. However, it's now seen that while hydrogen-based solutions will have their place in specific sectors, they won't dominate future energy systems. Direct electric solutions are proving more efficient and versatile, leading experts to believe that hydrogen's role in final energy demand will be limited. Instead, it's suggested that hydrogen and electricity will complement each other, with electricity emerging as the primary energy vector. So, the idea of an exclusive Hydrogen Economy seems outdated, with hydrogen likely playing a supportive role alongside electricity. The Power-to-X economy emphasizes the importance of renewable electricity in the new energy system. This renewable electricity is used to produce hydrogen, which is a key component of the Power-to-X economy. Overall, the Power-to-X Economy represents a transition pathway toward a sustainable future energy system. (Breyer et al. 2024, 352-353)

The Power-to-X process involves transforming electric power, sourced from renewable sources, into various fuels, materials, or chemicals (referred to as "X"). It plays a key role in green electrification by helping to increase the use of renewable electricity in the energy mix and replacing fossil fuels with renewable and recycled resources. Often, Power-to-X involves the production of diverse hydrocarbons derived from green hydrogen (H₂) and carbon dioxide (CO₂), sourced either from the atmosphere or from sustainable point sources (or challenging-to-decarbonize industrial sectors) (Karjunen 2022,7).

Overall, the Power-to-X process requires more primary energy than the direct utilization of fossil fuels. Despite efficiency improvements across sectors, electricity consumption is expected to increase notably in the future. When selecting a plant location to maximize PtX plant productivity, several key aspects should be considered. Access to affordable, emission-free electricity for hydrogen production is crucial, whether through direct connections to nearby renewable energy parks or robust grid connections for renewable electricity transmission. The availability of a steady, concentrated biogenic CO₂ flow is a key consideration.

Efficient utilization of waste heat from hydrogen production is essential, which can be achieved by locating the plant near district heating networks or industrial heat consumers. Effective use of side-stream oxygen is also important, finding applications in various industries such as pulp mills, wastewater treatment plants, or hydrogen peroxide production. Optimizing transportation of PtX products to markets is crucial, requiring strategic locations with access to rail, road, and harbour infrastructure, as well as considering pipeline transport options for methane, hydrogen, or CO₂. (Karjunen et al. 2022, 8).

In this study, the Power-to-X-Economy is understood to include the Power-to-X processes, but also the transportation and possible by-products from the production of hydrogen and the Power-to-X economy overall represents the transition towards a sustainable energy system away from the fossil fuel-based economy. This transition also have enormous social, economic, and environmental impacts. (Figure 1) In this context, the Power-to-X investments can be a wide range of investments that will support the sustainable energy transition.

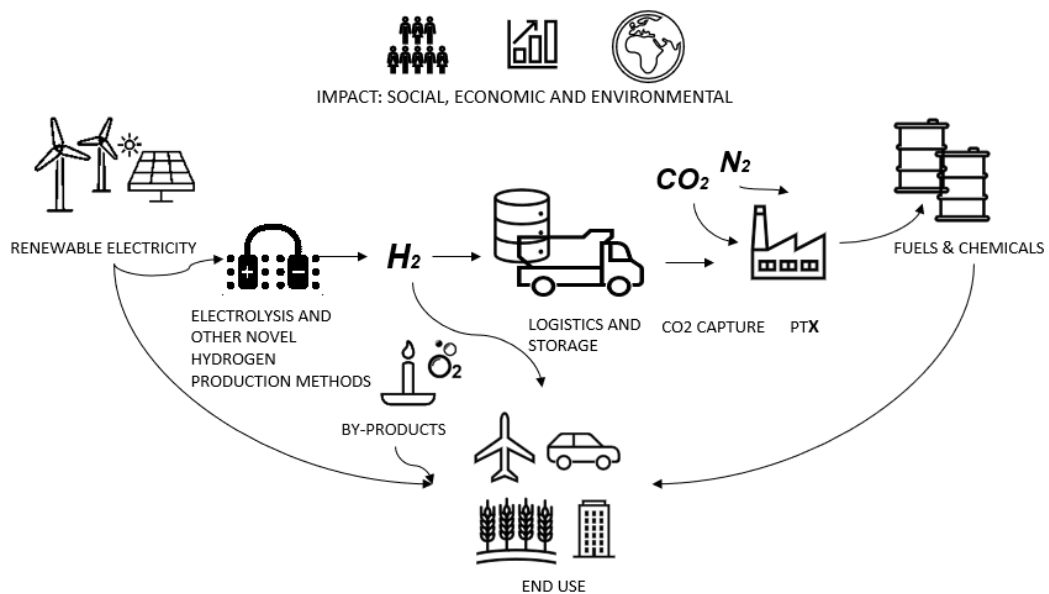


Figure 1: Power-to-X Economy

1.2 Objectives and Research Questions

The primary aim of this study is to answer the question: **How can South Karelia's PtX entrepreneurial ecosystem be advanced to better support investments, innovation, and regional development?**

To answer this main question, the study focuses on the following sub-research questions:

Q1: What are the strengths, weaknesses, and competitive advantages of South Karelia's PtX entrepreneurial ecosystem?

Q2: Who are the key stakeholders in South Karelia's PtX entrepreneurial ecosystem?

Q3: What is the current lifecycle stage of South Karelia's PtX entrepreneurial ecosystem?

To address Q1, the study analyses the entrepreneurial ecosystem in South Karelia through Spigel's (2017) classification of ecosystem attributes, focusing on cultural, social, and material elements that define the region. Spigel's framework highlights the importance of internal ecosystem attributes and how their configuration supports the ecosystem while enabling resource access for new ventures that might otherwise lack such access. The identified resources are analysed further using the Resource-Based View (RBV) approach (Barney, 1991). This helps evaluate how these resources contribute to South Karelia's competitive advantage in driving PtX initiatives.

To address Q2 on the role of stakeholders in regional competitiveness and ecosystem functioning, the study integrates Stam and Van de Ven's (2019) model with Spigel's (2017) entrepreneurial ecosystem framework. We can highlight how entrepreneurial ecosystems are dynamic by combining these models. In these ecosystems, stakeholders like policymakers, investors, entrepreneurs, and support organisations work together and affect each other. Their interactions play a role in shaping their responsibilities and the success of the ecosystem. The study examines stakeholder relationships and their development. It also explores how these relationships can strengthen or weaken the overall effectiveness of the ecosystem, influencing regional competitiveness.

To address Q3, the lifecycle stage of South Karelia's PtX entrepreneurial ecosystem is analysed. This involves determining whether the ecosystem is in the **emerging**, **growing**, or **mature** stage. Understanding the current lifecycle stage helps identify actionable strategies to strengthen the entrepreneurial ecosystem and support the PtX economy in South Karelia.

The research strategy chosen for this study is a qualitative case study approach. This approach involves examining the South Karelia region in the context of Power-to-X investments. The data was collected through interviews, seminar materials and notes, as well as existing documents on Power-to-X investments and activities in the South Karelia region. By employing data triangulation, the research aims to provide comprehensive insights into the phenomenon under investigation.

1.3 Structure of the Study

This study is divided into three main sections: (1) theory, (2) empirical analysis, and (3) conclusions, where the implications of the findings are discussed. The first chapter of the study is an introduction, which discusses the background, objectives, and structure of the work. The introduction chapter presents the justifications for this work and why the topic of research has been chosen from this subject area. The theoretical framework chapter addresses the theoretical part of this study, which is the previous theoretical knowledge related to the research problem. The theory is divided into two parts. The first part defines the strategic approach through a resource-based view (RBV) of the firm and presents the theoretical framework for identifying and evaluating regional competitive advantages. Once the strategic approach is addressed, the focus shifts to a regional-based approach where the concept of the entrepreneurial ecosystem is discussed alongside the regional competitive advantage theory.

Chapters 3 and 4 are devoted to outlining the process of data collection and construct development, along with detailing the research method and presenting the results. First in Chapter 3, the case itself, the region of South Karelia, is described. After that, the chapter introduces the data collection strategy, data acquisition methods, and data analysis methods, and it also discusses the validity and reliability of the research. The results of the empirical research are presented in Chapter 4. The aim is to describe the current state of the entrepreneurial ecosystem in South Karelia's Power-to-X (PtX) economy, with the findings discussed in relation to the theory presented earlier. The chapter will provide the key results of the study. Finally, in Chapter 5, the study will summarise and conclude my work, answer the research questions and present the limitations of the research and future research topics (Figure 2).

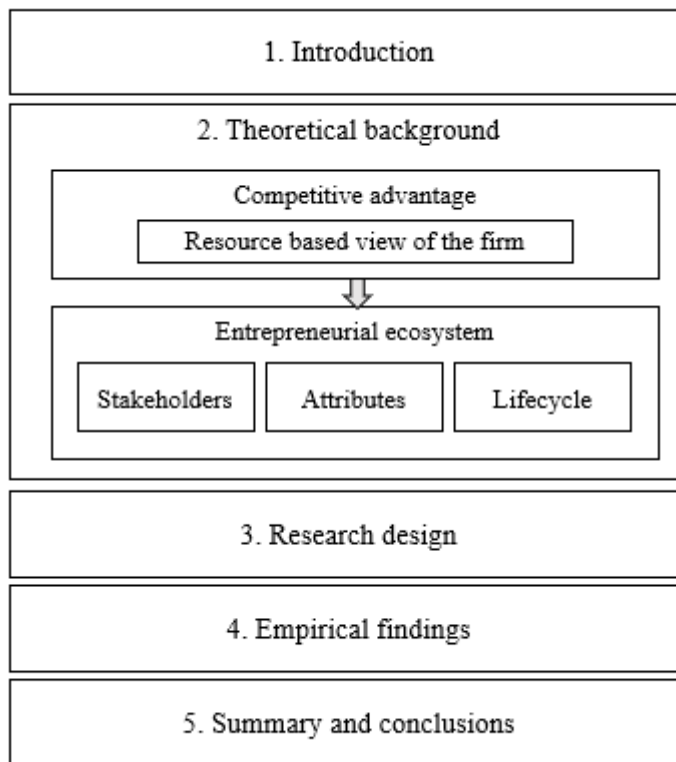


Figure 2: Structure of the Study

2 THEORETICAL BACKGROUND

In this chapter, the theoretical foundation and previous research relevant to the study are discussed. The theoretical framework consists of two main sections. The first section focuses on strategic approaches, particularly the concepts of competitive advantage and the resource-based view of the firm (RBV), which emphasize leveraging a company's internal resources to outperform competitors. This section also introduces the VRIO framework (Value, Rarity, Imitability, Organisation), which is used to evaluate the potential of a firm's resources in sustaining a competitive advantage.

The second section explores the entrepreneurial ecosystem as a regional approach to competitive advantage. The chapter will first explain the term entrepreneurship followed by an introduction to entrepreneurship ecosystem thinking. After that, the chapter will discuss the different entrepreneurial ecosystem models and examine the lifecycle of the entrepreneurial ecosystem.

The final part of this chapter integrates these two perspectives into a cohesive theoretical framework that connects the concepts of strategic management and regional development. The integrated framework aims to demonstrate how the interaction between the resource-based view of the firm and regional entrepreneurial ecosystems can create sustainable competitive advantages and drive regional economic growth.

2.1 Competitive Advantage

Competitive advantage is one of the most important concepts in strategic management, referring to the factors that help an organisation to outperform its competitors. All the theories represent explorations of the fundamental question: What strategies enable organisations to succeed? The aim of strategic management is not only to gain advantages over competitors but to sustain those advantages over time, adapting to changes in the environment to maintain market leadership.

Porter (1980) introduced the **concept of competitive strategies** which states that companies can achieve competitive advantages through cost leadership or differentiation.

Differentiation and low unit costs represent two key strategic approaches that Porter specifically identifies for strengthening a company's competitive position.

Differentiation is a strategy where a company seeks to distinguish itself from competitors by offering products or services that create value and are unique to the customer. The differentiation can be achieved through various means, such as better product quality, excellent customer service, innovative design, or other features that set the product apart. The goal of differentiation is to create added value for customers, which will allow the company to charge a premium price. To justify the higher costs, the company must ensure that the products it offers are meaningful to its targeted markets. Differentiation can also build brand loyalty, as customers perceive the product as being better for their needs or the products are something they cannot find elsewhere.

Low unit costs, or cost leadership, focus on achieving the lowest production costs in the industry. This strategy enables the company to offer products or services at a lower price than its rivals, appealing to cost-conscious consumers. Cost leadership can be achieved through economies of scale, optimizing production processes, or reducing procurement and operational expenses. By maintaining lower unit costs, companies can protect their market share by competing on price, which is especially advantageous in markets where price sensitivity is high. While the primary goal of cost leadership is to offer competitive pricing, it does not necessarily mean sacrificing quality; companies may also seek to maintain or improve quality to further enhance their position while keeping costs low.

The **resource-based view (RBV)** of the firm adds another dimension to the understanding of competitive advantage. The RBV shifts the focus from external market conditions to internal resources and capabilities. According to RBV, organisations are like bundles of resources, which can be tangible (physical assets) or intangible (intellectual property, brand reputation, or corporate culture). These resources create opportunities for competitive advantage when they are valuable, rare, inimitable, and well-organised (VRIO framework). Differences in resource endowments among organisations can explain why some firms consistently outperform others by exploiting their internal strengths and neutralizing or avoiding weaknesses. RBV emphasizes that sustainable competitive advantage arises when a company effectively combines its unique capabilities and resources to create products or services that are difficult for other companies to replicate. (Barney 1991, 100; Penrose (1959))

The dynamic capabilities framework extends RBV by focusing on a firm's ability to adapt to rapidly changing environments. Dynamic capabilities refer to a firm's processes for combining, building, and reconfiguring internal and external competencies to respond to changes in the market. Teece et al. (1997, 516) argue that in a dynamic industry, a company's ability to develop new capabilities and innovate is critical for sustaining competitive advantage. Dynamic capabilities framework recognizes that competitive advantage is not static; it must be maintained through ongoing organisational learning, strategic flexibility, and the ability to understand opportunities and threats.

The **knowledge-based view** of the firm (KBV) has gained prominence, suggesting that knowledge and intellectual capital are critical sources of competitive advantage. Grant (1996, 120-121) states that the ability to create, acquire, store and deploy knowledge are the most important activities in organisation and can led to sustained competitive advantages. In knowledge-intensive industries, where technology and innovation are pivotal, companies that can harness their intellectual capital are better positioned to compete and adapt to market changes.

According to Teece et al. (1997, 526), it is important to determine which of the several available frameworks for understanding a firm's competitive advantages is most suitable for a specific context. While the dynamic capabilities and knowledge-based views offer valuable perspectives for understanding the renewal and sustainability of competitive advantage, this study adopts the **resource-based view (RBV)** as the primary framework for analyzing the competitive advantages of firms. The RBV's emphasis on unique internal resources and capabilities aligns with the study's focus on leveraging a firm's assets to achieve superior performance in a competitive environment.

2.1.1 Resource-Based View of the Firm

The Resource-Based View (RBV) approach emphasizes the significance of unique, hard-to-copy resources in generating competitive advantage, focusing on internal capabilities rather than external market positioning. In today's volatile business environment, where external markets can be unstable and subject to constant change, strategies grounded in a firm's unique resources and capabilities are generally more sustainable (Grant, 1996, 116). The internal resources and capabilities of a firm form the foundation of its strategic decisions,

resulting in a competitive advantage that goes beyond market competition. Each organisation possesses strengths and weaknesses, both current and potential, which necessitates careful identification and differentiation. The extent of what a firm can achieve is contingent not only on external opportunities but also on the internal resources it controls (Teece et al., 1997, 513).

Resources can be categorized into tangible and intangible assets. Companies utilise these assets to develop and implement their strategies. Tangible resources include physical assets such as facilities, financial capital, and labour and intangible resources include non-physical assets such as knowledge, brand reputation, and proprietary technologies. Although capabilities alone do not enable a firm to execute strategies effectively, they play a crucial role in enhancing the utilization of other resources (Barney & Hesterly, 2008, 74).

There is a distinction between resources and capabilities. Resources include individual assets such as employees' skills, patents, and brand names. However, few resources are productive on their own. A capability, on the other hand, is the ability of a group of resources to perform a task or activity. While resources form the basis of a firm's capabilities, they are the capabilities that primarily drive the firm's competitive activities (Grant 1996, 118-119).

Capabilities are a combination of a firm's resources, including both tangible and intangible assets, that help the firm make the most of its other resources. Grant (1996, 119) categorized capabilities into six different categories: financial resources, physical resources, human resources, technological resources, reputation, and organisational resources. Barney et al. (2008,74) simplify this by grouping capabilities into four: financial resources, physical resources, human resources, and organisational resources. Johnson et al. (2007, 96) also introduced the term intellectual capital, referring to an organisation's resources and highlighting the value of knowledge and expertise within a firm.

Financial resources include all the money that firms can use to develop and implement strategies. These resources encompass funds from entrepreneurs, equity holders, bondholders, and banks, as well as retained earnings or profits reinvested in the firm. (Barney et al., 2008, 74)

Physical resources cover the physical technology used by a firm, such as its plant and equipment, telecommunications infrastructure, and access to raw materials. Examples include

computer hardware and software, manufacturing robots, and automated warehouses. (Barney et al. 2008, 74)

Human resources involves the experience, training, intelligence, relationships, and insights of individual managers and workers within a firm. Human resources are valuable not only for entrepreneurs and senior managers but for every employee within a company. Everyone plays a role in the organisation's overall success. (Barney et al. 2008, 74-75)

The intellectual capital of the company, or intangible resource, includes various patents, brands, business systems, and customer data. In a knowledge-based society, a company's intellectual capital is likely to be its most important competitive advantage. (Johnson et al. 2007, 96). Barney et al. (2008, 74-75) refer to intellectual capital as an organisational resource, which includes the formal reporting structure, planning, controlling, and coordinating systems, culture, and reputation. They also encompass informal relations within the firm and with external stakeholders. These resources alone are not enough, but it must be understood how these resources are combined in the company's operations and processes. In addition to these classifications, resources and capabilities and their combination can be classified as threshold resources, meaning that the resource itself or their combination is needed to compete in those markets. (Johnson, et al. 2007, 96-97.)

The RBV is based on two assumptions about the firm's resources and capabilities. These assumptions are that the resources are resource **heterogeneity** or resource **immobility**. Resource heterogeneity means that different firms may have different bundles of resources and capabilities, even within the same industry. This means that some firms may be more skilled in performing a given business activity than others. Resource immobility means that some resource and capability differences among firms may be long-lasting because it can be expensive for firms without certain resources and capabilities to develop or acquire them. Together, these assumptions explain why some firms outperform others within the same industry. If a firm possesses valuable resources and capabilities that few other firms have, and if other firms find it too costly to imitate these resources and capabilities, the firm with these assets can gain a sustained competitive advantage. (Barney, 1991b, 75). In addition to these classifications, resources and capabilities, as well as their combinations, can be classified as threshold resources, meaning that the resource itself or a combination of resources is necessary to compete in the given market. (Johnson et al., 2007, 96-97.)

2.1.2 VRIO: Value, Rarity, Imitability, Organisation

In the resource-based view (RBV) an organisation creates a competitive advantage and improves its performance through its own internal strategic capabilities and resources. (Johnson et al. 2007, 94). Understanding the specific characteristics of these resources is crucial for ensuring they contribute effectively to the firm's competitive advantage. According to Grant (1996, 124), four key characteristics of resources and capabilities that significantly influence the sustainability of competitive advantage are durability, transparency, transferability, and replicability. The VRIO framework serves as a valuable mechanism that can be applied to evaluate the sources of competitive advantage in firm's resources.

In the VRIO framework, the resources and capabilities must have four different characteristics: value, rare, imitability and organisation. The resources and capabilities should be valuable in the sense that they enable the company to either exploit opportunities or neutralize threats from the environment. Resources and capabilities should be rare in the company's operating environment. They should not be easy to imitate, and they should be possible to exploit in the organisation's processes. (Barney et al. 2008, 71)

The **value** of a resource is defined by whether the resource provides the company with the ability to exploit opportunities in the environment or help respond to potential threats. The value component utilises the idea in a SWOT model where the organisations can improve their performance by taking advantage of the opportunities or dealing with threats. Companies should have valuable resources to create economic value and increase customer willingness to pay more, lower costs, or do both. (Grant et al. 2014, 175.) The resources should bring value to its customers (Johnson et al. 2007,102).

Regarding the **rarity** of the resources, it is important to understand if the resource is available or controlled by only a few competitors. If many companies have the same valuable resources, it won't give anyone a competitive advantage. All those companies will use the resource in similar ways and follow similar strategies, so no one stands out. Companies often need to combine resources effectively to gain an advantage. Even if a company has valuable but common resources, it can still achieve a level of equality with competitors. (Grant et al. 2014, 175.) The rarity of resources can also be temporary or become a burden for the company (Johnson et al. 2007, 102).

The question of **imitability** is to understand how easily the resources and capabilities can be transferred. Companies with valuable and rare resources can lead the market because they use these resources to create strategies that others can't as they do not possess similar resources. However, to maintain their advantage, these resources must be hard for competitors to copy or replace. This difficulty in imitation can be due to three main factors: unique historical conditions, where past events create a path that others cannot easily replicate; causal ambiguity, where the link between resources and competitive advantage is unclear or not well understood, making it hard for others to mimic; and social complexity, where intricate social relationships, such as company culture and reputations, are difficult to manage or reproduce. These factors contribute to making valuable resources challenging to imitate. (Grant et al. 2014, 175-176.)

Valuable, rare, and non-imitable resources can serve as a source of competitive advantage if the company is well **organised** to use these resources effectively. Organisational processes are important for building and maintaining a company's competitive advantage. The company's reporting structure, management control systems, and reward policies help in maximizing the benefits of these resources. These complementary resources work best when combined with other resources and capabilities to achieve their full competitive potential.

The VRIO framework combines four key concepts: value, rarity, imitability, and organisation. It is a practical tool for evaluating how a company's resources impact its competitiveness and financial performance. (Grant et al., 2014, 176). This approach emphasizes that competitive advantage is not only about owning resources but also about how effectively a company can utilise these resources within its strategic operations.

2.2 An Entrepreneurial Ecosystem

The term entrepreneurial ecosystem is a combination of the two different terms, entrepreneurial and ecosystem. To understand the importance of these different terms in the context of the entrepreneurial ecosystem, this chapter will first explain the term entrepreneurship, followed by an introduction to ecosystem thinking. After that, the chapter will discuss the entrepreneurial ecosystem more and introduce different entrepreneurial ecosystem models. Lastly, the chapter will discuss the lifecycle of the entrepreneurial ecosystem.

2.2.1 Entrepreneurship

Defining entrepreneurship seems to be a complex task, and there are several definitions for it in the research community. Entrepreneurship can be understood primarily as activities like self-employment or the creation of new firms (Reynolds et al., 2005, 223), or it can be characterized by firm-level attributes such as an 'entrepreneurial orientation' (Lumpkin & Dess, 1996). Shane (2003, 4) defines entrepreneurship as an activity that involves the discovery, evaluation, and exploitation of opportunities. These opportunities are used to develop and introduce new products and services, ways of organizing, markets, processes, and raw materials, all achieved through efforts that previously did not exist. Furthermore, Shane and Venkataraman (2000, 219) expand this definition by stating that entrepreneurship does not necessarily require the creation of new organisations, although it can include this aspect.

Entrepreneurship impacts its environment in several ways. Economists have recognized the role of entrepreneurs in shaping economic structures since the early 20th century. Joseph Schumpeter's groundbreaking work laid the foundation for this understanding. Schumpeter (1934) described entrepreneurs as "agents of creative destruction," people who transform the economy by disrupting established industries and challenging market norms.

Entrepreneurs play an important role in the economy, particularly through small and medium-size enterprises (SMEs). The organic growth of these enterprises is associated with job creation, economic growth and fostering innovation. By being innovative, entrepreneurship contributes to the development of new ideas and solutions, generating new employment opportunities and enhancing economic vitality (Delmar, Davidsson, & Gartner, 2003, 5). In practice, entrepreneurship puts new business ideas into action, creating jobs that facilitate personal development (Dhaliwal 2016, 4269).

Extensive research supports the economic benefits of entrepreneurship. Blanchflower (2000, 502) and Parker (2009, 293-296) examine how entrepreneurs contribute to job creation, noting that entrepreneurial ventures are significant sources of new employment. By increasing job opportunities, entrepreneurship also generates tax revenues by adding taxpayers and corporations. Van Praag (2007, 377) highlights the impact of entrepreneurship on productivity, showing that although entrepreneurs' contribution to overall productivity levels may be relatively modest, they achieve high growth rates in both value added and productivity.

Additionally, entrepreneurship plays an important role in the dissemination of technology and knowledge. Small and medium-size enterprises create new technologies, develop new products, or process innovations, and open new markets (Audretsch 2002,13)

Moreover, entrepreneurship also impacts the social and cultural environment. It is likely that the entrepreneurial behaviour of members of the community will receive positive reinforcement. This behaviour enhances the national identity and pride, enhances competitive consciousness, and improves the quality of life. (Bridge et al. 2003, 115)

2.2.2 Introduction to the Entrepreneurial Ecosystem

An integral part of entrepreneurship is how entrepreneurs interact with their environment to leverage opportunities (Ratten, 2014, 298). Earlier research in entrepreneurship has often aimed to minimize the influence of context in order to create generalizable models of entrepreneurial activity when the context should be the specific focus of the study. A context such as location should not be treated as a simple control variable or proxy; instead, in-depth exploration is needed to understand how the cultural, social, political and economic structures and processes shape the entrepreneurial process (Stam et al. 2018, 407) In the context of entrepreneurship, Stam et al. (2018, 410) define the "entrepreneurial ecosystem" as a network of interrelated actors, institutions, and resources that collectively support and sustain entrepreneurial activities within a specific region. This definition shows that entrepreneurship is collaborative and depends on connections between different stakeholders.

Broadly speaking, an ecosystem refers to a community of living organisms interacting with each other and their environment, which includes both living and non-living elements (Stam & Spigel, 2018, 408). The concept has evolved over time, with Alfred Marshall (1920) introducing the term "industrial district" to describe the concentration of specialized industries in specific localities. According to Marshall, companies benefit from the advantages offered by their geographic area, such as access to specialized labour and knowledge spillovers.

The cluster approach builds on Marshall's ideas by focusing on regions where companies, suppliers, service providers, and other related institutions are interconnected and operate within specific fields. In these areas, there is both competition and collaboration (Porter, 1998, 197). In contrast, Regional Innovation Systems (RIS) are networks that link

knowledge sources like universities and research centres with innovative businesses in a region. These connections help share knowledge between organisations and improve the overall innovation of area. (Cooke et al., 1997)

Isenberg (2010) follows Porter's cluster approach and combines the concept of clusters with a firm-centric perspective and the concept of entrepreneurship with an entrepreneurship-focused perspective. The novelty of the entrepreneurial ecosystem approach lies in its focus on productive entrepreneurship as an outcome of the ecosystem. Traditional strategy literature prioritizes competition and value capture. In contrast, the entrepreneurial ecosystem model highlights the leadership role of entrepreneurs, especially those dedicated to their regions over the long term. These entrepreneurs are often inclined to collaborate with the public sector, sometimes even serving as integral members of it, such as mayors or leaders of regional economic boards. This notion of entrepreneurial leadership means that entrepreneurship is not merely a result of the ecosystem but is a vital component of its operational dynamics. (Acs et al. 2017, 3)

Within the research field of entrepreneurial ecosystems, there are two primary branches: the strategy literature and the regional development literature (Acs et al., 2017, 2). The strategy literature primarily discusses how companies engage in economic collaboration. A firm's ability to thrive and generate profit hinges on how effectively it collaborates with other companies offering complementary products or services. Adner (2016, 39-41) conceptualizes an ecosystem as a network in which different partners work together to deliver shared value to customers. He emphasizes that even if one company excels in its role, challenges can arise if other partners fail to perform, a phenomenon he describes as the "ecosystem as structure." The idea of business ecosystems, particularly innovation ecosystems, portrays a network of loosely connected companies that develop their capabilities around a shared innovation or platform, relying on one another for their overall effectiveness and survival. Organizing this collaboration is crucial for maximizing customer benefits (Zahra et al., 2011, 6).

The regional development literature explores regional ecosystems and seeks to explain the economic performance of different regions. It addresses several related concepts, including industrial districts, regional industrial clusters, and innovation systems (Stam & Spigel, 2018, 410). These two fields, strategy literature and regional development literature, differ in several key ways. While regional development literature focuses specifically on the territorial limitations of an ecosystem, strategy literature often assumes a global perspective.

Moreover, regional development literature aims to elucidate variations in overall value creation across regions, whereas strategy literature concentrates on creating value for individual companies based on a clear value proposition. The underlying idea is that managing the ecosystem effectively increases a company's value. Additionally, while strategy literature tends to position leadership within a single company at the centre of the ecosystem, regional development literature recognizes the role of facilitating entities, such as governments and business associations, in fostering collaboration (Zahra et al., 2011, 5-14).

The entrepreneurial ecosystem provides a framework for understanding regional development. Key features of this ecosystem include a systematic perspective, the centrality of the entrepreneurial discovery process, the significance of bottom-up-oriented political actions relying on local actors, and the crucial shaping and limiting roles of regional forces (Szerb et al., 2019, 1415).

In a strategic approach, value is created and captured by firms within a global context, with coordination managed by a focal orchestrator firm. Conversely, in regional development, value creation is driven by firms operating in specific industries, emphasizing productivity. This process is propelled by both competition and collaboration within a regional context, where coordination involves firms' rivalries, collaborative efforts, and government policy. In the entrepreneurial ecosystem approach, value is generated by individual entrepreneurs within a city, regional, or national context, and coordination necessitates public-private governance (Acs et al., 2017, 4). In this study, the ecosystem approach is **entrepreneurial ecosystem approach**.

2.2.3 Entrepreneurial Ecosystems Models

In this chapter, I will explore the models that have been developed to understand entrepreneurial ecosystem. Even though there are several different models that describes the entrepreneurial ecosystem, this study introduce Isenberg's model of the entrepreneurial ecosystem domains (2010, 2011a, 2011b), ecosystem attributes by Spiegel (2017) and Stam & Van de Ven (2021) Entrepreneurial ecosystem model.

Entrepreneurial Ecosystem Domains

Isenberg (2011a) introduced a theoretical model of the entrepreneurial ecosystem, which considers six different actors that support entrepreneurship. Isenberg defines the entrepreneurial ecosystem through the six distinct actors or factors. These groupings are made in a general sense, and according to Isenberg, there are hundreds of individual factors within them whose interaction affects the outcome. These areas are culture, policies, finance, skills, markets, and support functions (Figure 3) (Isenberg, 2010, 2011a, 2011b.)

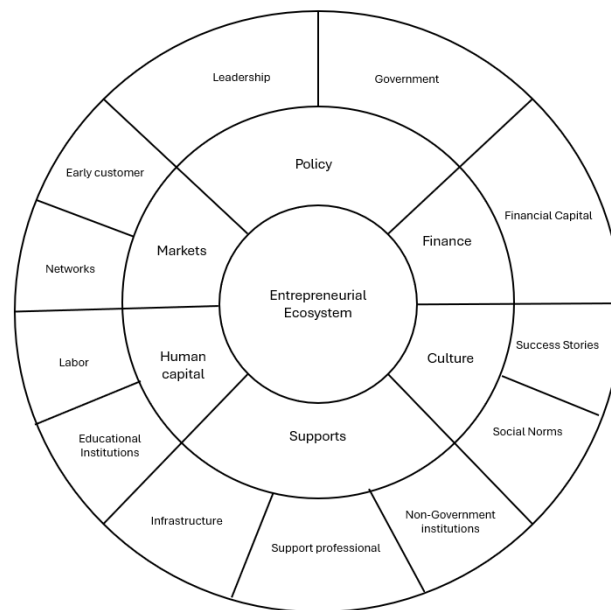


Figure 3: Entrepreneurial Ecosystem (Isenberg, 2010, 2011a, 2011b.)

The **policies** in the entrepreneurial ecosystem refer to government bodies, institutions, and research entities. These entities support entrepreneurship through management and the government's governance of the operating environment. The policies include laws, regulations, and support systems that are targeted to make entrepreneurship easier. For example, startups can benefit from tax breaks, simplified business regulations, or government-funded programs. They help foster innovation and entrepreneurship by ensuring that new businesses have the resources and support they need to grow and succeed. (Isenberg, 2011a, 2011b).

Building relationships with customers, suppliers, and partners is a key part of the entrepreneurial ecosystem and its **markets**. A thriving ecosystem offers the chance to engage with potential clients on both local and global scales. Additionally, the presence of established

companies also play an important role as they can become customers, suppliers, or partners, helping startups grow and scale. (Isenberg, 2011a, 2011b).

Having access to the right **financing** is essential for the emergence and growth of businesses. In the entrepreneurial ecosystem, this includes the availability of various financial products. These products are micro-loans, accessible financing, and equity funding for startups. To fund their businesses entrepreneurs, need to have the right investors and various financing options available. Without these financial resources, businesses struggle to grow or even survive. Having access to both traditional and innovative financial solutions fosters entrepreneurship by giving businesses the opportunity to scale at different stages of development (Isenberg, 2011a, 2011b).

A **culture** that promotes entrepreneurship is vital in shaping the mindset of individuals within the ecosystem. Visible success stories can inspire others to take risks and pursue entrepreneurial ventures, while cultural factors like social norms help create an environment where taking risks and learning from failures are accepted. The way entrepreneurship is valued within a community influence how positively or negatively entrepreneurship is perceived. This cultural perception also affects political decisions, such as whether to implement business-friendly policies or provide additional support systems to entrepreneurs. A supportive culture can thus drive innovation and growth (Isenberg, 2011a, 2011b).

Strong **support systems** and access to well-functioning infrastructure are important for entrepreneurship. These support systems include basic needs like telecommunications, transportation, and access to affordable, sustainable energy. The importance of affordable and sustainable energy sources has also increased, as it has a direct impact on business operations. Support also includes the availability of key professional services, such as legal assistance, banking, and consulting, which help entrepreneurs navigate business challenges. Networks are also important as they offer opportunities to connect with others, they can foster interests, and grow businesses (Isenberg, 2011a, 2011b).

Skilled labour is a fundamental aspect of the entrepreneurial ecosystem. Without a workforce with the necessary skills, entrepreneurs can face challenges in running and growing their businesses. The availability and quality of human capital are often influenced by educational institutions, such as vocational schools, universities, and colleges. These institutes serve as key players in producing skilled labour. Educational institutions are integral to the

ecosystem, as they provide the workforce for the businesses that are needed to succeed. Additionally, business-friendly markets, facilitated by functional distribution channels (both physical and digital), help companies reach customers interested in innovative and developing products and services, thereby driving market success (Isenberg, 2011a, 2011b).

The Attributes of Entrepreneurial Ecosystems

According to Spigel (2017, 50), the elements of an entrepreneurial ecosystem are a blend of cultural, social, and material characteristics within a particular region. These elements support the growth and development of innovative startups while encouraging new entrepreneurs and other stakeholders to take on the risks involved in launching, funding, and sustaining high-risk ventures. Ecosystem theory highlights the importance of internal structures and resources in supporting new businesses. It shows how different setups can result in high levels of entrepreneurial activity. A successful ecosystem is not defined by the sheer number of startups but by how the interaction between these elements creates a supportive regional environment that enhances the competitiveness of new ventures.

Cultural attributes refer to the foundational beliefs and perspectives regarding entrepreneurship within a specific region. Two key cultural components of entrepreneurial ecosystems are cultural attitudes and the historical context of entrepreneurship. Regional cultures influence entrepreneurial activities by setting the norms and practices considered acceptable in the field. Different attitudes toward entrepreneurship and risk-taking can lead to different economic outcomes and entrepreneurial environments. These cultural beliefs are important in shaping how entrepreneurship is viewed. The beliefs can make entrepreneurship look like a common career choice or, alternatively, a last option if nothing else is available. These beliefs create an atmosphere that either supports or discourages entrepreneurship. Also, local entrepreneur success has a key role in shaping these cultural attitudes. These success stories can help normalize entrepreneurship and encourage bold ventures. Stories of local entrepreneurs who launched startups that evolved into major global companies can inspire new entrepreneurs to pursue similar activities. Policymakers can also utilise these success stories in initiatives that will promote entrepreneurship. Highlighting successful individuals within the community can create discussions about the benefits and opportunities associated with entrepreneurship. It shows that entrepreneurship can be a legitimate career option. This approach helps maintain a steady stream of new entrepreneurs and also strengthens the cultural acceptance of risk-taking in the region (Spigel 2017, 52-53)

Social attributes refer to the resources that come from the local social networks. These networks are important for entrepreneurship. They help share knowledge about opportunities and technologies, make it easier to find funding, and shape entrepreneurial skills and mindsets. Successful new ventures rely on existing connections and trust between entrepreneurs, investors, and other key players. The main social attributes of entrepreneurial ecosystems include networks, investment capital, mentors and dealmakers, and skilled workers. Strong social networks help entrepreneurs to access market insights, resources, and customer connections. Local interactions within these networks increase the exchange of knowledge and ideas. Investment capital from institutional investors or personal contacts is crucial for startups to grow. Networks often have a role in funding. Mentors are also important. They improve entrepreneurs' skills and help businesses to succeed. Similarly, dealmakers are influential figures who connect various entrepreneurial actors, promoting firm formation and growth within the region. Finally, worker talent—skilled employees familiar with the dynamics of small firms—is vital for the competitiveness of new ventures. Skilled workers must not only possess technical abilities but also share a risk-tolerant mindset to thrive in the unpredictable startup environment. (Spigel 2017, 53-54)

Material attributes are tangible elements within an ecosystem. The key types of material attributes are physical locations such as universities, support services and facilities, policies and governance, and open markets. Physical locations such as Universities contribute by developing new technologies and fostering entrepreneurial mindsets. They will also create opportunities for both academic entrepreneurs and existing startups. Established firms also benefit from the universities. They have access to university knowledge by hiring graduates; they can fund research or through informal channels like faculty discussions and public talks. Universities also produce skilled graduates to the region's workforce. Support services like accountants and legal advisors are important for the entrepreneurial ecosystem. Support services provide important assistance to early-stage firms. They give startups access to needed expertise. Facilities like incubators and coworking spaces further support new ventures by offering subsidized office space and networking opportunities. Policies and governance influence the entrepreneurial ecosystem through regulations and public funding. The purpose of these measures is to lower barriers and foster startup growth. Strong local markets also contribute by providing a customer base that creates opportunities for new startups. Entrepreneurs can use these local connections to test products and develop skills. Not every

element is essential for a successful ecosystem; rather, they are key factors that help create a supportive environment and strengthen new ventures' competitiveness. (Spigel 2017, 54-55).

The attributes of an ecosystem are interconnected and evolve together, influencing and reinforcing each other. These relationships are not structured as a straightforward hierarchy, where "lower" elements like culture solely support "higher" elements such as policy. Instead, the development and success of material attributes can bolster social attributes, which in turn can enhance the foundational cultural elements. For example, entrepreneurial support organisations help build local networks and highlight successful startups, encouraging new participants and increasing financial, technical, and advisory resources. Strong networks, mentorship, and investment within a region reinforce the ecosystem's culture by normalizing these practices and adding to its history of success stories. (Spigel 2017, 55-56)

This model (Figure 4) proposes that entrepreneurial ecosystems can have various configurations consisting of overlapping attributes and institutions that support entrepreneurial activity. Ecosystem attributes are sustained through their interactions, with dense ecosystems featuring a supportive culture, strong networks, and effective public programs. In less connected ecosystems, a dominant factor, like a large local market, drives other attributes. The study of ecosystems should focus on the inputs—localized cultural, social, and material factors—rather than just the outcomes, examining how these elements interact to shape the ecosystem. (Spigel 2017, 56-57)

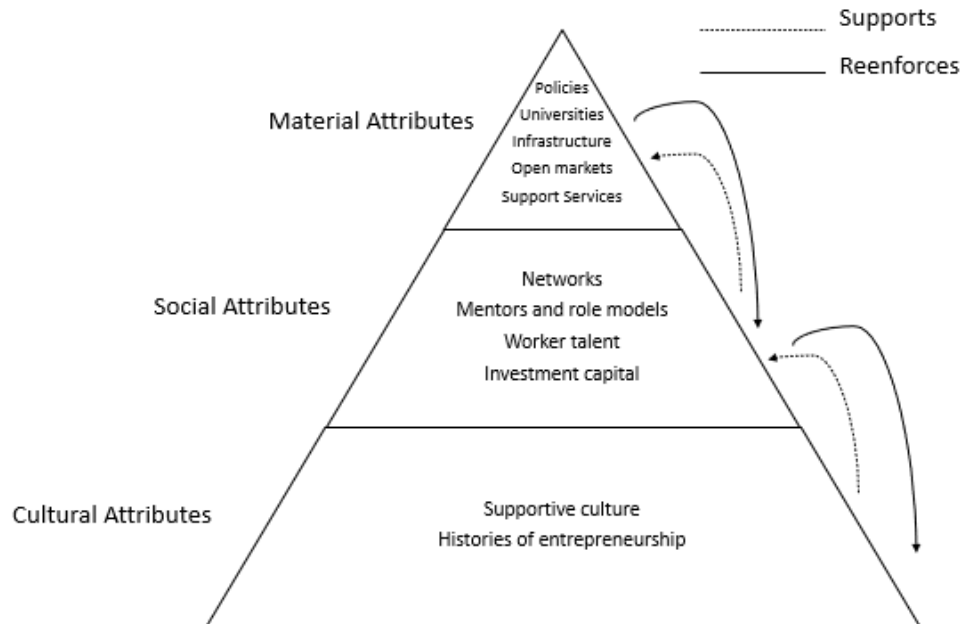


Figure 4: Ecosystem Attributes and their Relationship (Spigel 2017)

Entrepreneurial Ecosystem Model

Stam & Van de Ven (2019, 812-814) created the entrepreneurial ecosystem model (Figure 5), which consists of essential elements that support and sustain entrepreneurship within a region. These elements can be categorized into three main components: institutional arrangements, resource endowments, and proprietary functions. Institutional arrangements include formal rules, regulations, cultural norms, and networks that legitimize and incentivize entrepreneurship. Resource endowments encompass infrastructure, finance, leadership, talent, knowledge, services, and market demand that enable entrepreneurial activities. Proprietary functions involve entrepreneurial firms that commercialize innovations and create value, serving as the output of the ecosystem.

The success of the ecosystem depends on the interaction and mutual dependence of its elements. Institutions provide the legal and cultural foundation for economic activities. Networks play a key role in connecting entrepreneurs, allowing them to share information, resources, and opportunities. A strong infrastructure supports the needs of business operations. Additionally, access to finance ensures long-term investment in innovative and high-risk

ventures. Leadership provides vision and direction, often led by committed, entrepreneurial figures who help shape the ecosystem. Skilled talent is essential for driving new ideas and adapting to changing conditions, while knowledge derived from research institutions and companies fuels innovation. (Stam et al 2019, 812-814)

These elements do not function in isolation; they co-evolve and influence each other. As the ecosystem matures, the interaction between its elements grows stronger, creating a more supportive environment for entrepreneurship. The presence of diverse resources, collaborative networks, and adaptable institutions fosters a dynamic setting where entrepreneurship can thrive and contribute to regional economic growth. (Stam et al 2019, 812-814)

The first proposition of the entrepreneurial ecosystem model states that the elements within the ecosystem are interconnected and evolve together in a region. This means that changes or developments in one element, such as finance or talent, can influence and shape the other elements, leading to a co-evolutionary process where the ecosystem adapts and grows. (Stam et al 2019, 814-815)

The second proposition focuses on how the regional context, represented by the collection of ecosystem elements, influences the level of entrepreneurial activity. This is referred to as upward causation, where the structure of the ecosystem, such as available resources and networks, affects individual entrepreneurial actions and encourages productive entrepreneurship based on these elements. (Stam et al 2019, 814-815)

The third proposition addresses the feedback process where successful entrepreneurial activities impact the ecosystem itself, known as downward causation. In this process, entrepreneurs who achieve success can become venture capitalists, role models, leaders, or network developers within the region. These activities positively influence the ecosystem's components, such as finance, culture, leadership, and networks, reinforcing and enhancing the conditions for future entrepreneurship. (Stam et al 2019, 814-815)

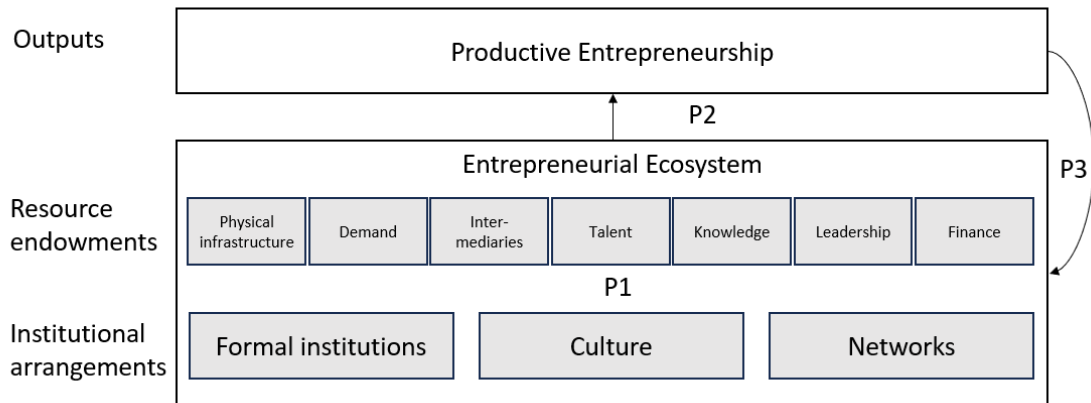


Figure 5: Elements and Outputs of the Entrepreneurial Ecosystem Model (Stam & Van de Ven 2019)

2.2.4 Lifecycle Stage of Entrepreneurial Ecosystem

Entrepreneurial ecosystems are all unique and emerge in specific environments. An often overlooked aspect is the dimension of time when discussing entrepreneurial ecosystems (Mason, Colin & Brown 2014). This chapter seeks to understand the different lifecycle phases and factors impacting various stages of entrepreneurial ecosystems. Previous research has primarily focused on what is needed to establish these ecosystems (Isenberg 2010; Mason, Colin & Brown 2014; Stam & Van de Ven 2021; Spiegel 2017) while giving less attention to their emergence, growth, and sustainability. Cantner et al. (2020) proposed a dynamic lifecycle model of an entrepreneurial ecosystem. They rely on the traditional concept of industry lifecycles, as introduced by Vernon (1966), to describe the evolution of an entrepreneurial ecosystem. They assume that entrepreneurial ecosystems evolve over time, passing through several distinct phases: the introduction or birth phase (I), the growth phase (II), the maturity or stabilization phase (III), the decline phase (IV), and a subsequent re-emergence phase (V)

Emerging entrepreneurial ecosystems focus on the importance of new opportunities. These opportunities often come from technological advancements and market changes. Disruptive technological changes often create significant opportunities for entrepreneurs, indicating that the success and growth of these ecosystems depend on innovation (Mason, Colin & Brown 2014). The ecosystem begins with the emergence of a novel idea, which may be

exploited either within an incumbent firm (intrapreneurship) or through the creation of new ventures (entrepreneurship). At this stage, knowledge sharing and spin-offs play a key role in shaping the ecosystem. (Cantner et al. 2020, 413-415).

As technologies and industries change, they create pivotal moments that can spark the development of entrepreneurial ecosystems. These moments often lead to the rise of new businesses and opportunities tied to specific breakthroughs. Examples include changes in consumer preferences, new regulations, or progress in scientific research (Mason, Colin & Brown 2014). This idea highlights how entrepreneurial ecosystems grow during periods of significant transformation driven by innovation. Entrepreneurs use these advancements to build new ventures, demonstrating how ecosystems evolve and respond to external shifts. The interplay between technological evolution and entrepreneurial activity emphasizes the essential role of timing and context in fostering successful ecosystems (Mason, Colin & Brown 2014).

Creating an entrepreneurial ecosystem involves developing an environment where entrepreneurship can flourish, allowing individuals and businesses to thrive. Successful entrepreneurial ecosystems typically result from strategic development that is based on a deep understanding of the ecosystem. This understanding allows stakeholders to recognize when assistance and guidance from public authorities can be reduced without hindering further development. Initially, guidance may be necessary to facilitate connections among the right actors and establish a foundation for collaboration. However, growth and development should occur with minimal intervention; otherwise, the ecosystem may struggle to succeed in the long term and could become overly dependent on public funding (Isenberg, 2011b).

Isenberg (2010) highlights nine key principles for building regional entrepreneurial ecosystems. Building regional entrepreneurial ecosystems should be based on local strengths and resources, with a focus on long-term goals like education and intellectual property. Engaging the private sector early is crucial for gaining insights and support. Leaders should prioritize high-potential ventures rather than spreading resources too thinly, as a major success can inspire others and attract investment. Clusters should be allowed to grow organically rather than through heavy planning and legal and regulatory frameworks should be reformed to create a business-friendly environment (Isenberg, 2010).

According to Stam et al. (2021, 812), cooperative relationships form when actors with diverse skills collaborate for mutual benefits, while competition arises as different entrepreneurs pursue various paths. In the early stages of an industry's development, research and development can be uncertain and often rely on basic science and technology. Firms may depend heavily on research institutions such as universities and labs for knowledge and techniques, depending on the chosen technology.

Growing entrepreneurial ecosystems emerge as the number of players increases, leading to a network of cooperation and competition that develops into a loosely structured system. Following the birth period, the growth stage is characterized by the emergence of an entrepreneurship culture, encouraging individuals to start their own businesses. (Cantner 2020 415-416). The hierarchy of this system can differ. It is often shaped by institutional rules or dominated by leading organisations that control key resources like funding or technology. The loose connections of the ecosystem provide flexibility and stability, allowing subsystems to adapt quickly to local changes while maintaining overall system stability. Entrepreneurial culture flourishes, supported by a robust ecosystem of financial, human, and institutional capital. Access to resources improves, and successful entrepreneurs act as role models, fostering further entrepreneurship and creating a dynamic and dense network of entrepreneurial activity (Cantner 2020 415-416).

Mature entrepreneurial ecosystems are characterized by their success not solely by high rates of entrepreneurship but by how the interactions among key attributes create a supportive regional environment that enhances the competitiveness of new ventures (Spigel, 2017, 49). The ecosystem includes key entrepreneurs and firms that perform essential functions for entrepreneurship to thrive in a region. When fully developed, the system enables productive entrepreneurship, which contributes to economic output and overall welfare. There is a mutual relationship between entrepreneurs and governments, as entrepreneurs depend on a supportive environment shaped by government policies (Stam & Van de Ven, 2021, 812). The rate of new venture creation declines as markets saturate. Established firms increasingly reintegrate entrepreneurial innovations, leading to a balance between the entrepreneurial and business ecosystems. The ecosystem becomes less dynamic but still supports regional economic activity. (Cantner 2020, 416-417)

Cantner et al. (2020, 417–418) also introduce the decline and re-emergence phases of entrepreneurial ecosystems. In the **decline phase**, innovation and the exploitation of ideas

predominantly shift to established firms. During this phase, new ventures become rare, and the entrepreneurial ecosystem transitions into a business ecosystem that is characterized more by incremental innovation rather than radical breakthroughs. The **re-emergence phase** builds on the existing entrepreneurial infrastructure and on past experience to create new opportunities for already existing firms. This can start a new cycle of entrepreneurship that will help the ecosystem reinvent itself and create space for new technologies and innovative business models.

Understanding entrepreneurial ecosystems requires a comprehensive approach that considers their unique characteristics, lifecycle stages, and the interplay between innovation and market dynamics. The emergence of these ecosystems is often contingent upon recognizing new opportunities and adapting to technological advancements. Stakeholders must take shared responsibility for fostering an environment conducive to entrepreneurship while being mindful of the local context and temporal factors.

2.3 Integrated Theoretical Framework

The integrated theoretical framework merges the **Competitive Advantage Theory**, specifically the **Resource-Based View (RBV)** of the firm, with the **Entrepreneurial Ecosystem Theory** to provide a comprehensive analysis of the strengths and competitive advantages of regional entrepreneurial ecosystems. This subchapter synthesizes the theories discussed in chapter two, creating a cohesive understanding of how these frameworks interact. The integrated theoretical framework is presented in Figure 6.

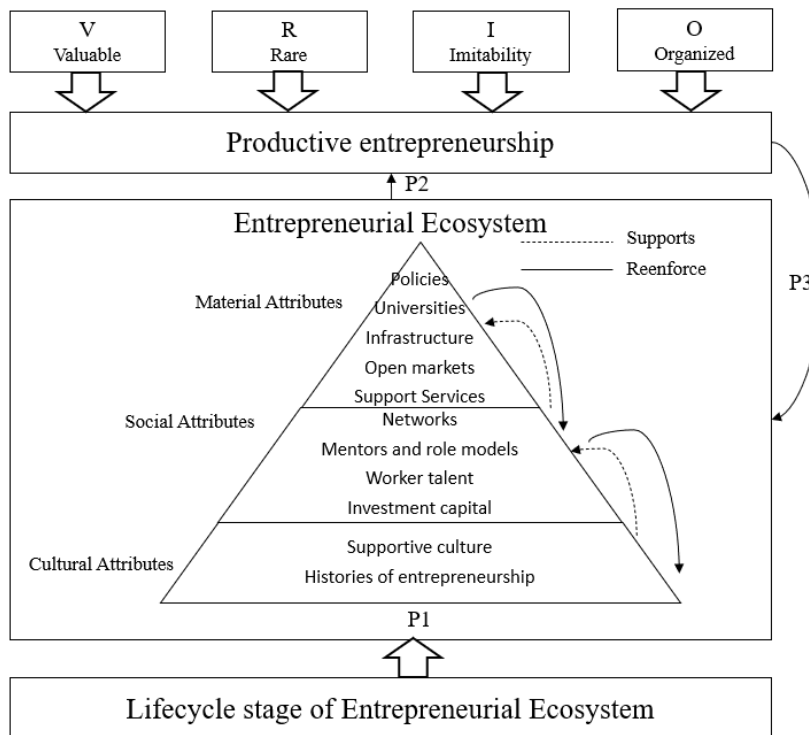


Figure 6: Integrated Theoretical Framework (adapted from Barney 1991, Spigel 2007, Stam et al. 2019)

The centre of this theoretical framework is an entrepreneurial ecosystem. In this case, it is primarily examined through Spigel's (2017) ecosystem attributes, which highlight the relationships among these entrepreneurial characteristics. Isenberg's (2010) entrepreneurial ecosystem domains offer a broad view of the ecosystem's components. However, they do not explain how these components are connected. Some detailed elements from Isenberg's model are included in the analysis, but the main categories come from Spigel's (2017) framework. Spigel's framework is used as the foundation to assess these ecosystem components, helping to better understand their connections.

Stam et al. (2019) highlight in their model that these entrepreneurial ecosystem elements are interconnected and evolve together, influencing each other. As ecosystems grow, these connections strengthen, creating a more supportive environment for entrepreneurship. Stam et al.'s (2019) three key propositions are relevant to understanding this interconnectedness and are included in the integrated theoretical framework.

The first proposition of the entrepreneurial ecosystem model asserts that the elements within the ecosystem are interconnected and evolve together within a region. This interconnection

implies that changes or developments in one element, such as financial resources or talent availability, can affect other elements. This creates a process where the ecosystem adapts and grows together as a whole. (Stam et al 2019, 814-815)

The second proposition focuses on how the regional context, represented by the collection of ecosystem elements, shapes entrepreneurial activity. Known as upward causation, it suggests that the structure of the ecosystem—such as available resources and networks—directly influences individual entrepreneurial actions and fosters productive entrepreneurship. (Stam et al 2019, 814-815)

The third proposition introduces downward causation, where successful entrepreneurial activities create feedback effects that impact the ecosystem. Successful entrepreneurs often take on roles as venture capitalists, leaders, or network developers, positively affecting ecosystem components like finance, culture, and networks, thus strengthening the environment for future entrepreneurship. These three propositions are integrated into the theoretical framework to enhance its explanatory power. (Stam et al 2019, 814-815)

Within this integrated theoretical framework, the resource-based view of the firm is modified to analyse the entrepreneurial ecosystem. The previously explained firm's capabilities, which The Resource-Based View (RBV) of the firm is adapted to analyse the entrepreneurial ecosystem, focusing on how ecosystem attributes provide competitive advantages. According to Grant (1996, 119), firm resources can be categorized into six types: financial, physical, human, technological, reputational, and organisational. These resource categories are aligned with Spigel's (2017) entrepreneurial attributes, which conceptualize ecosystems as combinations of cultural, social, and material attributes that are specific to a region. Treating these attributes as capabilities, the RBV provides insights into how they collectively drive competitive advantage.

To further assess the contribution of ecosystem attributes, the VRIO framework (Barney, 1991) is employed. This framework evaluates whether attributes are Valuable, Rare, Inimitable, and Organised—factors essential for establishing and sustaining competitive advantage. Spigel's (2017) attributes, examined through VRIO, help identify which aspects of the ecosystem are critical for long-term success.

Understanding the current stage of the entrepreneurial ecosystem is crucial for identifying targeted actions that promote its growth and sustainability (as discussed in Subchapter 2.2.4).

Ecosystems typically progress through various stages. First, there are emerging ecosystems and the creation of ecosystems, which represent early-stage systems characterized by fragmented networks and limited resources. Next, the ecosystem grows and develops as stakeholders become more connected, resources expand, and entrepreneurial activity increases. Finally, well-established ecosystems emerge as mature systems featuring strong networks, abundant resources, and sustained entrepreneurship. Additionally, Cantner (2020) introduces the decline and re-emergence phases of the ecosystem. These phases highlight how entrepreneurial ecosystems can change and renew themselves over time.

Understanding the stage of the ecosystem helps stakeholders create specific strategies. They can focus on addressing gaps, improving strengthen networks, and staying competitive in the long run. In emerging ecosystems, the priority might be building basic resources. In more established ecosystems, the focus often shifts to maintaining innovation and helping businesses grow.

3 RESEARCH DESIGN

In this chapter, first, the case of South Karelia is presented after that there will be a description of research methodology, the data collection process, and analysis method. Additionally, the reliability and validity of the study are considered.

3.1 Introduction to the Case: South Karelia

South Karelia (Figure 7) is in Southeast Finland, with a land area of 5,326.62 square kilometers. It has 1,545 square kilometers of freshwater surface area, which accounts for about 4.5% of Finland's freshwater area. Thus, the total area of South Karelia is 6,872.12 square kilometers. (Maanmittauslaitos 2024) The region consists of 9 municipalities and two cities: the regional center Lappeenranta and Imatra. (Etelä-Karjalan liitto 2024)



Figure 7: South Karelia on the Map (Etelä-Karjalan liitto 2024)

In South Karelia, there are 125,019 residents (Etelä-Karjalan liitto 2024a,1). During the first quarter of 2024, South Karelia lost 171 people from its population, the highest quantitative loss among all the regions in Finland. South Karelia also experienced the largest relative population loss, 1.4%, during that time (Tilastokeskus 2024). The weak population development is due to insufficient natural population growth, meaning that mortality exceeds birth rates. Currently, positive net migration is unable to compensate for the weak natural growth (Etelä-Karjalan liitto 2023).

The unemployment rate among job seekers in South Karelia was 12.8%, which is slightly higher than the national average of 10.9%. The proportion of those who have been unemployed continuously for 12 months or longer was 3%. The broad unemployment rate, which includes both the unemployed and those in services, was 17.7% at that time (Etelä-Karjalan liitto 2024a,5) (Table 1).

Table 1: Demographic and Economic Data for South Karelia

	South Karelia	Finland
Population	125 019	5 619 255
Unemployment rate	12,8 %	10,9 %
Self-employment rate (%)	10 %	13,9 %
Population with bachelor's degree or higher	19,4 %	24,6 %
GDP per capita at current prices in 2020	37 619	43 049
Share of companies, out of all companies in Finland	2,1 %	100 %

When examining the region's employment by occupational sectors, major sectors include specialists and professionals, such as various social and health care and technical professions, construction, repair, manufacturing workers, as well as process and transport workers. Due to the skills mismatch, there is simultaneously a shortage of skilled labour in the region. There is a particular shortage of social and healthcare professionals, including doctors, practical nurses, psychologists, and social workers. Filling specialized expert positions in the industry has also been challenging for a long time. To address this, various training programs have been initiated, such as the daytime education program for electrical and automation engineering at the LAB University of Applied Sciences in Lappeenranta starting in autumn 2024. Additionally, TE services have been reformed through close regional cooperation with the Kymenlaakso service area.

The higher education campus in Lappeenranta attracts talent and students, but the availability of suitable jobs influences whether students stay in the region. The potential for university-driven spin-offs is still underutilised, and efforts are being made to promote research-based entrepreneurship. The university and international technology and industrial companies attract international talent to the area. Going forward, more efforts must be made to attract a broader range of international workers (Etelä-Karjalan liitto 2023, 5-6).

In the fourth quarter of 2023, there were 64.8 businesses per 1,000 inhabitants in South Karelia, compared to the national figure of 82.2. The largest sector by number of establishments

was specialized construction activities. Of these establishments, 84% had fewer than five employees, 8% had 5-9 employees, and 8% had 10 or more employees. The industrial sector accounted for 8.3% of the establishments, compared to 6.9% nationwide (Etelä-Karjalan liitto 2024, 6-7).

The war in Ukraine and related sanctions significantly impacted South Karelia's business environment. The closure of the EU external border program, a crucial development tool, is a major consequence. The eastern border is completely closed as of January 2024, significantly affecting tourism and specialized retail sectors. (Etelä-Karjalan liitto 2023, 4-5).

In 2022, the region had the most establishments in primary production, typically involving agriculture and forestry, followed by construction, wholesale and retail trade, and professional, scientific, and technical activities. The industry was the largest sector by employee count and total turnover, with significant revenue per employee in the electricity, gas, steam, and air conditioning supply sectors. (Etelä-Karjalan liitto 2023, 4-5).

South Karelia is an industrial region, with forestry as a major sector, facing challenges in raw material procurement and global demand fluctuations. The construction sector also struggles, mirroring national trends. Green transition initiatives create new opportunities, particularly in industrial sectors related to climate action and energy crises. Technological industry expansions are planned, and efforts are being made to attract international talent through strategic initiatives and partnerships (Etelä-Karjalan liitto 2023, 4-5).

In Table 2, the distribution of Power-to-X (PtX) economy investments in Finland highlights significant regional differences between South Karelia and the broader Finnish landscape. Nationally, Finland has 287 PtX projects in the pipeline, with a combined investment of €217.46 billion, spanning sectors such as carbon capture, hydrogen production, and wind and solar power. In contrast, South Karelia, with 15 projects totalling €1.05 billion, exhibits a narrower focus. Specifically, the region has concentrated efforts on hydrogen (€100 million across three projects) and solar power (€951 million across twelve projects) while showing no activity in carbon capture or wind power sectors (EK 2024a).

Table 2: PtX Economy Investments in Finland and South Karelia (EK 2024a)

Theme	Finland Count of investments	Finland Sum of Investment (M€)	South Karelia Count of investments	South Karelia Sum of Investment (M€)
Carbon capture and processing	6	901,4		
Hydrogen	50	18227,8	3	100
Wind power	27	193217,7		
Solar Power	204	5109,15	12	951
Grand Total	287	217456,05	15	1051

Maintaining and boosting business dynamism, especially for small and medium-sized enterprises, is crucial. Despite challenges, the net number of new businesses remained positive until mid-2023. Active efforts to facilitate ownership transitions have reduced business closures. However, there is a lack of growth-oriented companies and a general reluctance among SMEs to pursue expansion. The service sector seeks new opportunities in nature and cultural tourism, exemplified by projects like the Imatra Wilderness and Nature Culture Museum. The region aims to leverage its industrial circular economy potential and green transition through initiatives like the Finnish Hydrogen Valley Association. The LUT University campus plays a pivotal role in innovation networks, particularly in green electrification projects (Etelä-Karjalan liitto 2023, 4-5).

3.2 Data Collection Strategy

The starting point for every scientific research is the question of what truth is. The aim of research is always to get as close to the truth as possible. Ontology, the study of being, defines how the nature of reality is perceived. Is there one correct, objective way to comprehend reality, or is reality subjective, thus allowing for multiple truths? Epistemology, the theory of knowledge, asks how we know what we know. On what basis is knowledge acquired? From where can a person obtain knowledge and from where not, and is this knowledge dependent on the knower? (Metsämuuronen 2006, 208-209)

In this study, truth is approached from a subjective perspective, viewing knowledge as a phenomenon dependent on both the researcher and the subject being studied. Therefore, the methodological approach of the research is qualitative. In qualitative research, the aim is to understand phenomena and explain them along with their interrelationships. Qualitative

research produces explanations from practice, i.e., empirics. (Kananen 2013, 26) In empirical research, findings are obtained by making concrete observations of the research subject and analysing and measuring it. In empirical research, concrete and collected research data are at the study's centre and serve as the basis for conducting it. (Lähdesmäki et al. 2015)

The research is an empirical qualitative study aimed to understand what Power-to-X investments in the context of South Karelia are the spearheads by making concrete observations and analysing it. Hirsjärvi et al. (2009, 136) suggest that if the purpose of the research is exploratory, the aim is to investigate lesser-known phenomena. Typically, in such cases, the research strategy is qualitative, such as a case study.

The research strategy chosen for this study is a case study. The study involves a case study approach to examine the South Karelia region in the context of Power-to-X Investments. One of the typical characteristics of case studies is the selection of a single case, situation, or set of cases. The typical goal is to describe phenomena (Hirsjärvi et al., 2009, 135). In this study, the phenomenon is to try to understand how to advance South Karelia's PtX entrepreneurial ecosystem. According to Metsämuuronen (2006, 212), qualitative research methods are also suitable for studying natural situations that cannot be arranged experimentally or where not all influencing factors can be controlled.

Case studies can be understood as a central strategy for qualitative methodology in information gathering, as almost all strategies use case studies as their approach (Kananen 2013, 31). In case studies, the key focus is on the case or cases under investigation, which are defined based on the research question, research design, and data analysis. A case study is a versatile research approach that can be characterized as a research strategy (Eriksson & Kovalainen 2008, 115-116).

The epistemological question related to case study research is: What can be learned from a single case? Metsämuuronen (2006, 215) writes that according to Robert E. Stake, the question is whether to optimize understanding of the case rather than generalizing it. Stake argues that in case study research, learning occurs from the specific case. Therefore, the choice of research methods is based on the researcher's philosophical views of science. Generalizations may not necessarily be drawn from the situation of the Power-to-X investments in South Karelia, nor is there necessarily a need for them. Metsämuuronen (2006, 216) writes that according to Stake, Cohen, & Manion, a case study can be seen as a small step towards

generalization. However, generalization should not be the target itself. More important than generalization is understanding the case.

3.3 Acquisition of Data

The starting point for acquiring research data is research problems or research questions. The aim of the data is to describe and understand the phenomenon under investigation. (Saaranen-Kauppinen et al. 2009, 47) The objective of this study is to answer the question: **How can South Karelia's PtX entrepreneurial ecosystem be advanced to better support investments, innovation, and regional development?** In this case, the aim is to gather data from individuals who have firsthand knowledge of the Power-to-X investments in South Karelia, as well as to examine the current situation of Power-to-X investments in South Karelia using existing documents. The collected data should provide perspectives and proposed solutions to the research problem and be relevant to the problem. (Saaranen-Kauppinen et al. 2009, 47-48) This section discusses the background, chosen methods, and justifications for these choices related to acquiring data for this study.

This study is a qualitative case study. In case studies, various types of data and sources are useful and used concurrently. This can be referred to as data triangulation (Figure 8), i.e., the use of different types of data in the same study. Typical sources of data in case studies include various interviews, media materials, statistics, observation, participant observation, and various documents such as brochures, meeting minutes, notes, diaries, and so forth (Eriksson & Kovalainen 2008, 126). In this study, data collection involves data triangulation. The data collection for the study utilised interviews, seminar materials and notes, and existing documentation on Power-to-X investments in the South Karelia region.

The seminar material and notes are from three different seminars held in the spring of 2024. These three seminars were Renewable Energy Current Affairs Day in January 2024, organised by the Energy Authority; the Green E2 Annual Seminar in March 2024, organised by Clic Innovation Ltd; and the Vetyä Virtaa Kaakkoon Seminar in March 2024.

Additionally, one of the datasets used was the "Green Investments in Finland" dataset collected by the Confederation of Finnish Industries. This dataset includes project outlines of

companies' green investments categorized by technology, location, and project phase. The monitoring began in 2021.

The study used semi-structured interviews. In semi-structured interviews where the main topics were defined, interviewers could also decide the order of the questions and the wording. This approach predetermined starting points for the interviews, allowing the researcher to guide the interview without fully controlling it. The challenge is to make sure that all topics are covered but also allow us to dive in more depth into the details. The goal of interviews, however, is to encourage the interviewee to speak openly about the topic area (Eriksson & Kovalainen 2008, 82)

Interviews were conducted during February - April 2024. The Interviews were pre-interviews for the other research to define the next phase of that research. In this study, these pre-interviews are used as the main material. The interviewees were provided with a research bullet, a privacy notice, and a short introduction to the topic in advance. In a thematic interview, it is assumed that the interviewer and the interviewee speak as if they were speaking the same language, and the terminology used carries roughly the same meaning for both parties (Puusa & Juuti 2011, 82). The introduction material was presented to the interviewee during the interview session to create a common understanding and language of the context. The introduction material also included questions discussed during the interview session (Attachment 1). In addition, the interviewees were encouraged to raise any other thoughts on the topic during the interview session.

The interviews were conducted as Teams interviews, and permission to record the interviews was requested from each interviewee, so the interviews were recorded, and transcriptions were made. Pseudonyms were also used for the interviews, so the names of the interviewees and organisations will not be revealed. Interviews were conducted by four different interviewers. The shortest interview was 8 minutes and longest was 73 minutes long. The average length of the interviews was 32 minutes.

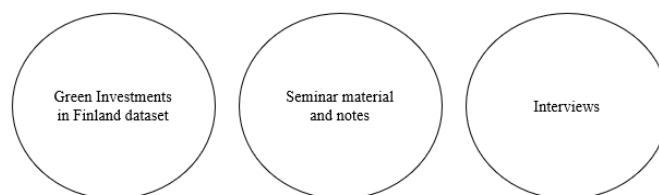


Figure 8: Data Collection Methods in Research.

3.4 Selection of Interviewees and Background Information

The adequacy of the data can be assessed from the perspectives of delimitation, saturation, and representativeness. There must be sufficient data in relation to the interpretations presented in the analysis (Saaranen-Kauppinen et al., 2009, 48). In qualitative research, the term purposive sampling is used. This means that typically, the material/participants are selected based on criteria set by the researcher. When collecting research data from individuals, participants can be sought, for example, through existing contacts, using a technique known as snowball sampling. In this approach, participants in the research are asked for referrals to other suitable participants. (Saaranen-Kauppinen et al. 2009, 49) Snowball sampling was used in this case, and each interviewee was asked who should be interviewed or participate in the research.

When selecting the respondents it was considered that interviewees should have some knowledge of the phenomenon under study, i.e., Power-to-X investments. Respondents were not required to have knowledge of the South Karelia region, so the questions were slightly modified depending on the respondent's level of knowledge, whether they had local knowledge, knowledge of the Finnish situation, or, for example, a global perspective.

There are also several stakeholder groups connected to Power-to-X investments, and the plan was to interview people from all these defined stakeholder groups, meaning related industries and businesses, investors, academia, and administration, all both locally and beyond, to ensure an adequate understanding of the phenomenon. According to Puusa et al. (2011, 55), a sufficient amount of data is study-specific, meaning that the sample should include as many interviews as necessary to obtain the required information. The number of participants depends on the purpose and objectives of the study.

A total of 49 interviews were conducted during the research. The interviews were categorized based on the stakeholder group and its relation to the region to better understand the breakdown of the interviews (Table 3).

Table 3: Interview Breakdown

	Stakeholder group				
	Academia	Public Sector	Industry	Investors	Total
South Karelia	13	5	3		21
Other Regions in Finland	1	7			8
National		2	7	4	13
International		2	5		7
Total	14	16	15	4	49

Guest et al (2006,59) argue in their study that in qualitative research, after six interviews, the basic elements of meta themes are evident. Saturation is achieved during the first twelve interviews. While academia, administration, and industry were adequately represented, it is noteworthy that the investor group may have been relatively underrepresented.

Overall, the distribution of interviews appears skewed towards local and national interviewees, with comparatively fewer representatives from Europe and the global stage and other regional perspectives. This allocation aligns with the research's local focus rather than broader or international perspectives. Nonetheless, sufficient national and regional interviews contribute to a broader understanding of the research topic.

3.5 Data Analysis

After the interviews, the interview data was handled. The interviews were recorded in Microsoft Teams, and transcription was done simultaneously, resulting in the data being in a format ready for proper analysis. The interviews were also anonymized. In the analysis phase, the data is systematically reviewed, and there are numerous options to consider when selecting analysis methods. The analysis is more than just describing the data; its primary aim is to distil an understanding of the data relevant to the research task. In the context of empirical research, analysis refers to very everyday tasks such as carefully reading the material, organizing text material, dissecting content and/or structures, structuring, and reflecting (Saaranen-Kauppinen et al. 2009, 73)

In this study, the data was analysed using both the content analysis method and quantification. Content analysis begins with the researcher thoroughly familiarizing themselves with the data, internalizing it, and theorizing about it. Following this, the data is roughly

categorized or thematized. Thematic categorization helps to clarify the research task and concepts. The analysis identifies the frequency of phenomena, deviations, and potential new classifications. Subsequently, cross-validation is conducted, which involves validating and challenging the obtained categories using the data. Finally, conclusions and interpretations are drawn, which involves placing the analysis results into a broader framework for examination (Metsämuuronen, 2006, 248).

The analysis began with a careful review of the interview transcript interview to understand the data better. In the context of qualitative research, you often hear about something "emerging" from the data. It is logical that recurring themes begin to stand out and remain memorable as one reads through texts multiple times, reflecting. In addressing the research problem, perspectives need to be sought, meaning one must ask what aspects of the data are relevant to the research question (Saaranen-Kauppinen et al., 2009, 73). After familiarizing myself with the data, the material was systematically organised in Microsoft Excel to document emerging content from the interviews. This process aids in analysing the data to effectively respond to the research question. According to qualitative content analysis principles, the material is initially deconstructed into smaller units, conceptualized, and then reorganised into a new, integrated whole (Saaranen-Kauppinen et al., 2009, 97). After the data was roughly categorized, the frequency of different phenomena was identified, as well as deviations and potential new classifications. Moreover, in this study, the data was analysed using the theoretical framework that had been created.

In this study, both content analysis and quantification were used. Utilizing qualitative data does not exclude quantitative approaches. Quantity and quality can both be part of either qualitative or quantitative research. Sometimes, calculations make it easier to engage with qualitative data compared to repeatedly re-reading it. Quantification can also provide assurance that the conclusions presented as research findings are not based solely on subjective impressions. Too often, the analysis in qualitative research involves simply arranging data quotes sequentially, with some vague researcher commentary (e.g., "the respondents described the subject as follows") inserted between collections of quotes. However, research must involve analysis and interpretation, not merely the lazy extraction of quotes from the data with minimal description (Saaranen-Kauppinen et al., 2009, 98).

To support qualitative analysis, the number of elements belonging to different themes was calculated. Due to the amount of data, these counts helped highlight relevant topics and

compare their significance within the entrepreneurial ecosystem of the Power-to-X economy in South Karelia. Quantification helped to systematize the analysis, although the calculations themselves are, of course, constructs created by the researcher (Saaranen-Kauppinen et al., 2009, 98).

After the analysis, the data processing was done by documenting the results in a qualitative research report. According to Metsämuuronen (2006,256), the characteristics of a good qualitative report include relevant conceptualization of observations, formulation of the refined research question during the study, making recurring observations, and respecting the original context. A good research report contains implicit knowledge disclosed by the research subjects, which the researcher treats objectively. Other elements of a good research report include the evolution of interview guides developed for data collection as the process progresses, the presentation of various perspectives by the researcher, and clear reporting of any connections the researcher may have and their potential impact on the research.

3.6 Reliability and Validity of the Research

Reliability evaluation is a fundamental aspect of scientific research, as specific norms and values have been set for research to adhere to. Traditionally, key concepts have been reliability and validity when assessing the measurement reliability in quantitative research. (Saaranen-Kauppinen et al., 2009, 24-25).

In qualitative research, validity can be seen as a measure of credibility and persuasiveness: how well the researcher's constructs match the results produced by the participants and how well the researcher makes these constructs understandable to others. Research can only scratch or touch the surface of the phenomenon under study, and it can never be fully described in the report as it appears in the research situation or to the researcher. Research can never produce a complete understanding of the phenomenon. (Saaranen-Kauppinen et al., 2009, 25)

Several steps ensured the validity of this study. First, the interviews were recorded and transcribed to get the input from the participants. Then, the data was sorted and analysed by using MS Excel. The complete data set is stored and available for inspection to make the study transparent and reliable. This study also uses data triangulation, and it combines data

from interviews, seminar materials, and other secondary sources. This will provide a comprehensive understanding of the phenomenon. The data triangulation also reduces the likelihood of bias compared to using a single data source. Documenting how data was collected and analysed, including semi-structured interviews and quantification, allows readers to assess how well the data supports the conclusions.

Reliability in qualitative research can be approached in three ways. The first is through the assessment of the reliability of a particular method (quixotic reliability), which examines the conditions under which a method is reliable and consistent. For example, if a specific interview question consistently elicits predictable responses, it does not necessarily mean that the question holds true across different contexts. (Saaranen-Kauppinen et al., 2009, 25-26). The semi-structured interview approach provided flexibility while maintaining consistency across interviews. Since the interviews were conducted by different interviewers, variations in questioning styles may have affected how participants responded.

Temporal reliability, also known as diachronic reliability, refers to how stable measurements or observations remain over time. The challenge in this assessment is that qualitative research rarely deals with immutable objects – asserting otherwise denies history and natural changes (Saaranen-Kauppinen et al., 2009, 26). This study acknowledges the evolving nature of Power-to-X investments and the dynamic technological and policy landscapes. The findings reflect the situation during the data collection period (spring 2024) and may not fully apply to future developments. This limitation is inherent to research focusing on rapidly changing phenomena.

Thirdly, consistency in results (synchronic reliability) obtained simultaneously through different means. The challenge here is that results often diverge, prompting the researcher to consider how diverse results obtained through qualitative methods on the same phenomenon can hold true. When considering reliability, it is important to reflect on how the nature of the research and the research topic may have influenced how participants responded. (Saaranen-Kauppinen et al., 2009, 26) This study applied data triangulation to maintain consistency. Seminar notes and secondary materials were reviewed to confirm the themes that arose from the interviews. Using multiple sources of data helped minimize the risk of basing conclusions on single observations and strengthened the reliability of the findings.

In qualitative research, findings are often affected by how the researcher interprets the data. To bring more structure to the analysis and make it more reliable, MS Excel was used to organise and record data. Sorting themes is still a subjective task and can lead to bias. This is a recognised challenge in qualitative studies.

Overall, the study shows strong validity through its use of data triangulation, systematic analysis, and focus on the local context. Reliability is supported by consistent methods and limitations like changing contexts and subjective interpretation are acknowledged. By addressing these aspects transparently, the research provides a credible and thorough analysis of Power-to-X investments in South Karelia.

Artificial intelligence (ChatGPT) was utilised in the work for structuring information, brainstorming, and proofreading and grammar checking.

4 EMPIRICAL FINDINGS

This study aims to understand how the entrepreneurial ecosystem can support investments and projects in a specific industry in the region. Additionally, the study examines how to utilise and develop the entrepreneurial ecosystem to enhance innovation performance and drive organisational renewal within the South Karelia region.

The main research question is: **How can South Karelia's PtX entrepreneurial ecosystem be advanced to better support investments, innovation, and regional development?**

Sub-Research Questions:

Q1: What are the strengths, weaknesses, and competitive advantages of South Karelia's PtX entrepreneurial ecosystem?

Q2: Who are the key stakeholders in South Karelia's PtX entrepreneurial ecosystem?

Q3: What is the current lifecycle stage of South Karelia's PtX entrepreneurial ecosystem?

The objective of this chapter is to analyse the collected data to answer the questions, drawing on previous research and literature to inform the analysis. This approach will help examine how different elements of the ecosystem are connected and how they work together to support PtX initiatives in the region.

To understand the region's entrepreneurial ecosystem—its strengths, weaknesses, and competitive advantages—it was first important to identify the entrepreneurial attributes present in the region. For this purpose, the study utilised Spigel's (2017) classification of entrepreneurial ecosystem attributes to analyse the data. The study uses this framework to identify and categorise existing elements in the region into cultural, social, and material classifications. Once these resources are identified, they are examined using the Resource-Based View (RBV) approach (Barney, 1991), particularly the VRIO framework, to gain insights into the region's competitive advantages. In this context, the internal resources from the RBV framework refer to the entrepreneurial ecosystem attributes.

After mapping and categorizing the ecosystem attributes, including the strengths and challenges, and analysing competitive advantages, the empirical study then shifts to focus on stakeholders in the region. It explores their relationships and impact on regional

competitiveness and ecosystem functioning. The study combines Stam and Van de Ven's (2019) model together with Spigel's (2017) framework to highlight the interconnected and evolving nature of entrepreneurial ecosystems. This approach examines how stakeholders, such as policymakers, investors, entrepreneurs, and support organisations, influence and shape each other's roles. The analysis brings into focus that these relationships do not function in isolation but develop through ongoing interactions and mutual influence, which can either support or slow down the ecosystem's overall performance.

To answer question three, the stage of the South Karelia PtX entrepreneurial ecosystem is analysed by using the lifecycle status of the entrepreneurial ecosystem. This involves assessing which phase the ecosystem is in—whether it is at the emerging, growing, or mature stage—by applying the lifecycle stages of entrepreneurial ecosystems discussed in section 2.2.4. This analysis helps identify the necessary actions required to support the entrepreneurial ecosystem and the PtX economy in South Karelia.

This analysis brings together interview findings and established frameworks to give a clear picture of the current ecosystem. It sheds light on both the obstacles and advantages that can support the growth of the PtX economy in South Karelia. Gaining this perspective helps define the existing landscape while also presenting actionable ways to strengthen the region's entrepreneurial environment, encouraging innovation and investment in the Power-to-X sector.

4.1 South Karelia's PtX Ecosystem: Resources and Capabilities

The following table summarizes the findings from the interviews, categorizing the attributes identified within the entrepreneurial ecosystem related to the PtX Economy in the South Karelia region according to Spigel (2017) the Attributes of Entrepreneurial Ecosystems (Table 4):

Table 4. Entrepreneurial Ecosystems Attributes in the South Karelia Region

Attributes	Challenges	Strengths	Grand Total	% Challenges	% Strengths	% Total
Cultural Attributes	25	14	39	64 %	36 %	9,7 %
Social Attributes	26	32	58	45 %	55 %	14,4 %
Material Attributes	172	134	306	56 %	44 %	75,9 %
Grand Total	223	180	403	55%	45%	

A total of 403 citations were categorized under the attributes of the entrepreneurial ecosystem. In this categorization, the citations were assessed as either strengths or challenges for the area. It was found that 55% were identified as challenges, while 45% were recognized as strengths. The analysis reveals notable challenges across cultural, social, and material attributes, alongside significant strengths that can be leveraged to foster a robust entrepreneurial ecosystem in the South Karelia region. There are slightly more challenges than strengths in total. Given that cultural attributes comprise only 9,7% of total attributes (39 out of 403) and social aspects account for 14,4% (58 out of 403), these areas require further attention and investment compared to material aspects, which dominate at 75,9% (306 out of 403).

Cultural attributes make up only 9.7% of total citations, with challenges outweighing strengths at a ratio of 64% to 36%. The minimal focus on cultural attributes suggests that respondents do not see them as enabling or slowing down ecosystem development. Another explanation could be that cultural influences, like attitudes toward risk and failure, are considered more deeply rooted in the structure of the ecosystem. However, as Isenberg (2011a, 2011b) points out, a culture that supports entrepreneurship is crucial for fostering a community where people feel motivated to pursue business ventures. Cultural norms shape how entrepreneurship is perceived within a community, which, in turn, affects policy decisions such as the establishment of business-friendly policies and systems that support entrepreneurs.

Social attributes, comprising 14,4 % of the total ecosystem attributes, stand out as the only class where there were more strengths (55%) than challenges (45%). According to Spiegel (2017, 53), social attributes capture the resources generated through social networks within a region. In South Karelia, social attributes can be considered catalysts for entrepreneurial success. The strong representation of social attributes indicates that local networks in South Karelia are important for supporting the ecosystem. These networks support the flow of information, making it easier for entrepreneurs to recognise new market opportunities. They also help to recognise the latest developments in emerging technologies. The shared experiences within these networks foster a culture of continuous learning, where entrepreneurs benefit from both the successes and failures of others in the community (Spiegel 2017, 53-54).

The focus on material attributes (75,9%) implies that they are seen as important for the region's entrepreneurial ecosystem and can be seen as the foundation of the South Karelia entrepreneurial ecosystem. Material attributes consist of infrastructure, funding, and institutional support. These resources form the foundation that stakeholders view as essential for fostering entrepreneurship. These resources are instrumental in reducing entry barriers, enhancing operational stability, and ensuring that entrepreneurial ventures have access to necessary financial and physical resources. The prevalence of material challenges relative to strengths (56% challenges vs. 44% strengths) suggests a recognition of existing gaps in resource accessibility and reliability, potentially limiting entrepreneurial growth.

Spigel (2017) proposes that ecosystem attributes are interconnected and reinforce one another. Physical resources like infrastructure play a direct role in helping entrepreneurs. The infrastructure is more than just an essential building block for businesses. The availability and growth of the infrastructure help to build social connections, such as professional networks and mentorship. These social connections are just as important for long-term entrepreneurial success as the physical resources. For example, when infrastructure is reliable and funding is steady, people have more opportunities to work together, share resources, and make valuable connections. Over time, these interactions help shape the overall business landscape and influence how entrepreneurship is perceived within the culture (Spigel 2017, 55-56).

The findings reveal the complex interdependence between material, social, and cultural attributes in South Karelia's entrepreneurial ecosystem. Material resources form the foundation of the ecosystem. Social networks offer important informal support, and cultural factors shape attitudes toward risk and resilience. Strengthening each of these areas can help South Karelia expand its PtX economy and promote sustainable entrepreneurship. The focus on material challenges, together with strengths in social networks, creates a strategic path that concentrates on strengthening core resources and promoting a supportive entrepreneurial culture. Fixing cultural and social challenges is important for improving the entrepreneurial environment in South Karelia. At the same time, existing material strengths should be used to support growth. Fostering positive cultural narratives and building robust social networks can create a more conducive atmosphere for innovation and risk-taking. Spigel (2017, 55) emphasizes that the relationships between different attributes are not structured as a straightforward hierarchy; rather, the development and success of material attributes can bolster

social attributes, which in turn can enhance foundational cultural elements. This approach follows Spigel's (2017) framework. There is a need for different stakeholders to work together to improve the entrepreneurial ecosystem. By understanding and supporting these different stakeholder connections, South Karelia can build a strong entrepreneurial ecosystem. This will help entrepreneurs succeed and strengthen the links between cultural, social, and material attributes.

4.1.1 Cultural Attributes

Cultural attributes refer to the foundational beliefs and perspectives regarding entrepreneurship within a specific region. Two key cultural components of entrepreneurial ecosystems are cultural attitudes and the historical context of entrepreneurship (Spigel 2017,52). A total of 39 citations were categorized under cultural attributes, which encompass both strengths and challenges. Among these citations, the **supportive culture** emerged as a predominant theme, with 38 citations (97%). However, 66% of these supportive culture citations were identified as challenges. In contrast, the **histories of entrepreneurship** were represented by only 1 citation (3%), which was classified as a strength. This may mean that the history of entrepreneurship has little impact on the current entrepreneurial environment. Therefore, it may not play a significant role when discussing key factors of entrepreneurship in this context. (Table 5)

The challenges related to the supportive culture were mostly related to the reputation of the region and overall social acceptance of the new Power-to-X initiatives in the region and nationally.

"The general atmosphere in the region should support the green transition, particularly from the perspective of public discourse. Unfortunately, the "P2X world" is familiar only to a selected few, which contributes to a perception of the green transition as a 'the artist pays' metaphor. There is limited understanding of the green transition and the P2X world, which can foster negative attitudes and resistance to investments. It is important to enhance general awareness and support public discourse with positive information."

Table 5: Cultural attributes in Entrepreneurial Ecosystems in the South Karelia Region

Entrepreneurial attributes	Challenges	Strengths	Grand Total	% Challenges	% Strengths	% Total
Cultural Attributes	25	14	39	64 %	36 %	
Histories of entrepreneurship	0	1	1	0 %	100 %	3 %
	No challenges mentioned	University spin-offs	Parity with Competitors			
Supportive Culture	25	13	38	66 %	34 %	97 %
	Regional reputation due to proximity to Russia	Finland's reputation as a reliable partner	Temporary Competitive Advantage			
	Limited awareness of local capabilities	Strong image in green energy and technology	Temporary Competitive Advantage			
	Low social acceptance	The Finnish way of doing things	Sustainable Competitive Advantage			

According to Isenberg (2010, 2011), visible success stories are essential to inspire risk-taking and innovation. The absence of such stories in South Karelia could mean fewer role models and less community enthusiasm for entrepreneurial ventures. However, one interviewee pointed out that there is, in fact, a history of entrepreneurship emerging from the local university.

"From 2015 to this year, nine startups have spun off from our Electrical Engineering department, each employing at least one person. A large portion of these startups are focused on energy, specifically in the electricity sector... "

As noted, South Karelia's data contains only a single mention of "Histories of Entrepreneurship," indicating that respondents perceive a lack of local entrepreneurial legacy to draw upon for inspiration. One interviewee, however, highlighted the potential of university-based startups, particularly in the energy sector. For instance, examples from the Power-to-X sector local university-based startups, such as Neovolt, Soletair Power, and Solar Foods, further illustrate local achievements (LUT University, 2024a). According to Spigel (2017), such success stories have the potential to inspire emerging entrepreneurs and position entrepreneurship as a viable career path. Even though there are entrepreneurship stories in the South Karelia region, they are largely unrecognized by the interviewees. As a result, their impact on the community's overall perception of entrepreneurship is limited. Actively promoting

positive cultural narratives and addressing prevailing negative attitudes could strengthen the entrepreneurial culture in South Karelia. By showcasing even modest entrepreneurial accomplishments, particularly those achieved by young innovators, the region may foster a more supportive view of entrepreneurship.

Strengths that were recognized in cultural attributes of the supportive culture included Finland and South Karelia's reputation as reliable players, a strong image in green energy and technology, and an overall "Finnish way of doing things".

"Lappeenranta and also the city of Imatra have created a positive atmosphere."

Although cultural factors represent a smaller proportion of the ecosystem, they are foundational in fostering an environment conducive to entrepreneurship. The Resource-Based View (RBV) and VRIO analysis highlight both comparative and sustainable competitive advantages within these attributes. University spin-offs are one of the key strengths in the region. Spigel (2017) notes that entrepreneurial success stories will inspire individuals to take risks. Promoting these existing stories can advance South Karelia's reputation as a region for innovation and sustainability. The region's focus on green energy and the PtX sector gives it a competitive edge that aligns with global sustainability trends. Finally, Finnish cultural strengths—like trust, transparency, and collaboration—provide a strong base for business growth. These values build investor confidence and create an environment where new ideas can grow.

4.1.2 Social Attributes

Social attributes are the resources that come from or are gained through social networks in a region (Spigel 2017, 53). When analysing the data 58 citations were categorized under social attributes, and 45% of these were seen as challenges, while 55% were recognized as strengths. This shows a balanced view of social factors. It suggests that while there are challenges, the social environment also provides considerable support for entrepreneurship. (Table 6)

Fifteen citations were found related to investment capital. 80% of these findings were categorized as challenges. This is a major barrier for entrepreneurs in the region. In recent years, investments in Finland have lagged behind other areas of demand, making up just over one-

fifth of the GDP (EK, 2024). Plans for investment in Finland's green transition have reached over €200 billion, including onshore wind power and electricity transmission investments. All in all, nearly 300 investment projects are in the pipeline across Finland. In South Karelia, there are 15 investments related to the PtX economy currently in the pipeline (EK, 2024a). In the case of **networks**, the data shows a more positive situation. Out of 27 citations, 41% were seen as challenges, while 59% were viewed as strengths. This indicates that although there are some obstacles in networks, they are mostly seen as valuable assets. Networks are creating connections and opportunities for entrepreneurs in the region. The analysis of **worker talent** shows 16 citations. Of these citations, 19% were identified as challenges, and 81% were seen as strengths. The result of this analysis proposes that the availability of skilled labour is an important asset in the entrepreneurial ecosystem. It plays an important role in ecosystem development and its growth and supports innovation.

Some interviewees identified capital investment as a strength. They noted that Finland has valuable knowledge and potential opportunities. However, the challenge lies in attracting these investments.

"The current Invest In activities are not organised in a sufficiently professional and coordinated manner to attract large investments."

"Attracting investments could be further sharpened. Even though it seems that everyone in the region knows that hydrogen is the focus here, if we were to ask an English or French fund what Lappeenranta is and where it is located, they would have no idea. So, the sales efforts need to be strengthened."

Table 6: Social attributes in Entrepreneurial Ecosystems in the South Karelia Region

Entrepreneurial attributes	Challenges	Strengths	Grand Total	% Challenges	% Strengths	% Total
Social Attributes	26	32	58	45 %	55 %	
Investment Capital	12	3	15	80 %	20 %	26 %
	Current "Invest In" activities are not well enough organised.	Potential projects exist	Temporary Competitive Advantage			
Networks	11	16	27	41 %	59 %	47 %
	Large industrial players operate in isolation.	Existing networks: Hydrogen valley association and Greenreality	Temporary Competitive Advantage			
	Misalignment exists across the value chain.					
Worker talent	3	13	16	19 %	81 %	28 %
	Population development issues impact worker talent.	LUT University and LAB provides talents	Sustainable Competitive Advantage			

The challenges within the network are largely tied to the value chain, as the new energy system requires not only new skills but also integration with existing energy and forest companies that are part of this PtX economy value chain. Currently, the network for value chain creation is not yet established, and the involved parties are operating at different paces. One major challenge lies with the established forestry companies, which control access to the critical raw material, biogenic CO₂, needed for PtX products. Their pace of development is slower than what startups would ideally like, creating a bottleneck for faster innovation and growth in the sector.

"... misalignment across the value chain. It's a big, big challenge."

"Large players often operate in isolation, without extensive collaboration with the public sector or other companies. This hinders the emergence of a genuine ecosystem in which businesses and the public sector engage in continuous dialogue."

"When we talk about cooperation between the public and private sectors, it involves merging these two, even though it theoretically makes sense. However, the practical integration of these elements may not be as familiar..."

The challenges related to worker talent arise from regional population changes and the growing demand for new skills driven by Finland's changing plans.

"... we don't have that many engineers."

On the other hand, 32 citations were strengths (55% of total); when analysing networks, there are strong social connections, opportunities for collaboration, and a skilled workforce that supports entrepreneurship in the region. Spigel (2017) notes that robust social networks enable entrepreneurs to gain critical market insights and access necessary resources. There are established networks in the regions related to the PtX Economy, especially the Finnish Hydrogen Valley Association (Finnish Hydrogen Valley Association 2024), which was founded in 2023. The Finnish Hydrogen Valley Association promotes renewable energy and the hydrogen economy, particularly in eastern Finland. Their mission is to source, produce, and share information with public administrations, energy companies, technology firms, project developers, the media, and other stakeholders in the renewable energy sector. (Finnish Hydrogen Valley Association 2024) Another network in the region is a Greenreality Network, which is a business-oriented network in the energy and environmental sector in South Karelia, Finland. It fosters sustainable growth and new business opportunities for its 50 members, which include companies, municipalities, research and educational institutions, and a bank. (Green reality 2024)

"...there is an active network in the area consisting of various companies, research institutions, and universities. This willingness to collaborate gives strength to different investments. From my perspective, these are significant strengths."

Initiatives like the Hydrogen Valley Association can support flexible ways of working and attract new members. This helps build a stronger regional network and improves collaboration among different groups."

Having skilled workers is crucial for the local business environment, as they help drive new ideas and growth in the region. As Isenberg (2011a, 2011b) notes, without the right talent, entrepreneurs struggle to run and expand their businesses. The local university plays a key role in providing skilled workers for the region. It does this mainly through its research on energy transition and specialized training programs. Interviewees view the workforce as one of the region's strengths, primarily due to the presence of the university and its specialised training programs in the energy sector.

"LUT is well-known in this field in Finland, and I can imagine that among all the provinces in Finland, South Karelia has the least difficulty in finding a good team to undertake a large PtX project. In this case, local expertise is clearly a strength."

Spigel (2017) further emphasizes that skilled workers must not only possess technical abilities but also share a risk-tolerant mindset to thrive in the unpredictable startup environment (Spigel 2017, 53-54). Initiatives like the daytime education program for electrical and automation engineering at the LAB University of Applied Sciences in Lappeenranta, which started in the autumn of 2024, are important in preparing the future workforce.

Some interviewees also highlighted capital investment as a strength. They emphasized that while Finland has the necessary expertise and potential projects, the main challenge is securing funding.

Overall, social attributes—such as networks, relationships, and social capital—made up 14.4% of responses, receiving more mentions than cultural attributes. Interestingly, this was the only category where strengths (55%) outweighed challenges (45%). These factors are crucial for fostering collaboration, sharing knowledge, and improving access to resources for entrepreneurs (Spigel 2017).

The Resource-Based View (RBV) and VRIO analysis show that these attributes contribute to both comparative and sustainable competitive advantages, as well as temporary advantages linked to new initiatives. Networks like the Finnish Hydrogen Valley Association and the Greenreality Network play a key role in knowledge sharing and collaboration among stakeholders. These networks are still in their early stages, but they do provide a temporary competitive advantage for the region. It is important to commit to further developing these networks so that they can become long-term competitive advantages. LUT University and LAB University of Applied Sciences provide skilled labour for the South Karelia region. These institutions ensure a steady supply of experts in energy transition and sustainability, providing a long-term competitive advantage. These social attribute strengths provide important assets to South Karelia's PtX economy. They offer significant potential for growth through the possibility of improved collaboration and innovation.

4.1.3 Material Attributes

Material attributes consist of tangible elements, such as policies, physical locations, and resources that support entrepreneurial activities (Spigel, 2024). A total of 306 citations were categorised under material attributes. 56% of the citations were identified as challenges,

while 44% were classified as strengths, indicating that material attributes present a mix of both obstacles and supportive elements for entrepreneurs. The study found 69 citations related to **infrastructure-related topics**. 51% of these findings were categorised as challenges and 49% as strengths. The results for **open markets** were quite similar. Out of 133 citations, 56% were categorized as challenges, while 44% were strengths. When looking at regulations and **policies**, the analysis shows major obstacles in this area. There were 56 citations, and 80% of them were classified as challenges. **Support services** were seen more as a barrier than a driver in the region. 72% of the 18 citations were classified as challenges, and only 28% as strengths. The only material attribute which had more strengths than challenges was the local **university**. Of 30 citations, only 17% were classified as challenges. Academic institutions can play an important role in fostering entrepreneurship, offering valuable resources, knowledge, and talent in the region. (Table 7)

According to Spigel (2017), effective material attributes—like policies and strong market presence—can enhance both social and cultural aspects of the ecosystem. By addressing the identified challenges in material attributes, regions can create a more supportive environment for entrepreneurship.

Table 7: Material attributes in Entrepreneurial Ecosystems in the South Karelia Region

Entrepreneurial attributes	Challenges	Strengths	Grand Total	% Challenges	% Strengths	% Total
Material Attributes	172	134	306	56 %	44 %	
Infrastructure	35	34	69	51 %	49 %	23 %
	The local electric grid needs improvements.	Electrical grid	Temporary Competitive Advantage			
	Proximity to the Russian border adds complexity	Gas pipeline	Parity with Competitors			
	Overall logistics in the region require development	Water	Sustainable Competitive Advantage			
Open Markets	74	59	133	56 %	44 %	43 %
	Products not yet cost-competitive	Availability of Bio-genic CO ₂	Temporary Competitive Advantage			
	Lack of customers	Vast renewable energy potential	Sustainable Competitive Advantage			
	Traditional Industries' Slower Adaptation to Change	Globally evolving market	Parity with Competitors			
	Regional wind power restrictions	Regional, national, and European market potential	Parity with Competitors			
	Insufficient medium-sized or growth-focused companies					
Policies	45	11	56	80 %	20 %	18 %
	Policymakers often lack understanding, leading to poor decision-making.	The policymakers will to support Eastern Finland.	Temporary Competitive Advantage			
	Regulatory development is slow and unpredictable.	Local administration	Temporary Competitive Advantage			
	Finland's ability to compete for state-supported investments is limited.					
Support services	13	5	18	72 %	28 %	6 %
	Land use planning and permitting	Permitting processes in the region	Temporary Competitive Advantage			
Universities	5	25	30	17 %	83 %	10 %
	More research is needed.	LUT University	Sustainable Competitive Advantage			
	Multidisciplinary research is required.					
	Research results should be presented in an understandable format.					

The highest number of challenges were related to the markets. According to Isenberg (2011a, 2011b), a thriving ecosystem offers the possibility to engage with potential clients both

locally and globally. Additionally, the presence of already established companies is important. The existing companies in the ecosystem serve customers, suppliers, or partners and facilitate the growth and scaling of startups. The interviewees highlighted challenges related to established companies. They noted that there is an insufficient number of small and medium-sized enterprises (SMEs) or growth-oriented companies to fully form a supportive ecosystem. Additionally, some key corporations that control essential raw materials (Biogenic CO₂) have not advanced their position regarding the ecosystem, which further slows the development of the ecosystem. Local wind power restrictions have hindered necessary investments, compounding these issues and creating additional barriers to growth and collaboration within the ecosystem.

"There are not enough medium-sized or growth-oriented companies in the area to form a strong ecosystem. The business structure of the region largely consists of a few large players and micro-enterprises, which does not naturally attract new companies or promote innovation."

"The availability of bio-based carbon dioxide. Companies that are planning to establish themselves here in the region have not progressed far enough in contract negotiations to rely on having access to bio-based carbon dioxide."

"The wind power issue is extremely challenging for us, especially from the defence forces' perspective, and we have now proposed that we could start experimenting with it."

Another significant challenge under the open market is the profitability of PtX products. Their high production costs make them too expensive for potential customers, resulting in limited demand and a lack of buyers.

"It is a matter of it still not being economically viable."

"Who will the product be sold to?"

Policies and governance present significant challenges for the PtX Economy. Unlike tangible entities, policies and governance are manifested through government rules and regulations. They encompass laws and guidelines that establish publicly funded support programs aimed at fostering entrepreneurship. These programs often provide tax benefits and public investments or reduce bureaucratic hurdles (Spigel 2017, 54).

Interviewees indicate that policymakers often lack an understanding of the topic, possibly leading to poor decision-making. At the EU level, regulatory development is seen as slow, unpredictable, and complicated. Also, many bigger European countries provide significant support to attract PtX investments. Finland struggles to compete with these countries on the same level. This situation highlights the need for different kinds of solutions that can improve Finland's attractiveness among investors.

“The main bottleneck is politics; the governmental policy in Finland has not yet truly grasped that power to access is the way forward. If the policy framework is flawed, progress will be stifled. Decision-makers often lack the necessary insights or the right advisors.”

“The development of regulation is slow, and unpredictability hinders large investments. This is a significant barrier to industrial development in the area.”

“Finland’s ability to compete in state-supported investments is limited.”

Infrastructure presents a nearly balanced mix of strengths and challenges. It encompasses the availability of adequate office space, telecommunication facilities, and transportation networks necessary for companies to succeed (Spigel 2017, 56). In this context, infrastructure means electricity and gas systems, as well as overall logistics and the region's location near to the Russian border.

The challenges are primarily related to the local electric grid, which requires significant development, and the limited options for wind power due to the region's proximity to the Russian border. On the other hand, the overall electric grid in Finland is seen as a strength. Compared to other European Union countries (Nordic countries are similar to Finland), the grid is also clean. The share of emission-free electricity production is currently 94% of total production, including electricity produced by other industries (Energiategollisuus, 2023). In the first half of 2024, Finland had the lowest electricity prices for non-household consumers in the EU at €0.0928 per kWh, which was significantly below the EU average of €0.1867 per kWh (Eurostat, 2024). Finland's competitive electricity prices enable industries to reduce production costs and compete effectively in energy-intensive PtX Economy markets. This strength aligns with Porter's (1980) cost leadership strategy. Additionally, the existing gas pipeline in the region is another infrastructural advantage that could benefit hydrogen logistics in the future. One interviewee also emphasised the importance of water as an important resource in the PtX economy.

A couple of interviewees also mentioned challenges regarding universities. These challenges were more broader challenges related to the academic institutions, including the need for more research, particularly in multidisciplinary and interdisciplinary studies, as well as the importance of presenting research findings in a format that is accessible and easily understood by a wider audience.

Although there are numerous challenges related to the markets, several strengths were also highlighted. The strong local markets provide opportunities within entrepreneurial ecosystems. The presence of local customers with specialised needs creates opportunities for new companies and encourages entrepreneurial spin-offs. (Spigel 2017, 55) The strong regional industry, particularly the forest industry, was frequently mentioned in the interviews due to its sidestream product biogenic CO₂. Carbon dioxide is an important raw material for producing hydrogen derivatives and other value-added products. The availability of biogenic-CO₂ and the possibility of creating value-added products in the PtX economy aligns with Porter's (1980) differentiation strategy by creating high-value, sustainable goods that meet the growing market demand for green energy solutions. Other notable points included the vast renewable energy potential in the area and throughout Finland, which can generate up to 10% of Europe's energy needs (Karjunen et al., 2024).

“In that area, there is a forest industry. There is biogenic CO₂, which I hope will play a very important role in Power-to-X products in the future.”

The PtX economy market is evolving, and the region has strong potential with local and nearby customers. Existing industries like steel, chemicals and fuel production are already present in Finland, creating both regional and national markets. Additionally, there is recognition of the existing and upcoming market in Europe.

“... when we talk about fuels and e-chemicals, the global market will be enormous. However, in 15 years, solar-dominated regions around the world may offer lower costs. If we waste the next 15 years just talking, being inactive, and not taking action, the opportunity will be lost. We need to act quickly if we want to establish larger-scale industries and ensure we can remain competitive for valid reasons.”

“The most attractive aspect is the demand in Europe. We have an industry which many other countries, like Australia, South America, and Africa, lack. Here, there is a clear existing

demand that we know people can afford to pay for sustainability. Europe is truly the place where we should invest because all the major players are here.”

“There are significant industrial players in the area, like steel mills and the paper industry, that might be interested in utilising hydrogen in their production processes. This may not be the strongest competitive factor, but it provides a potential customer base for PtX solutions.”

LUT University is recognized as a key regional strength. The university is not only viewed as a significant asset but is recognized for its vital role in fostering entrepreneurship and innovation. As Spigel (2017, 54) points out, universities and other higher education institutions play a crucial part in training new entrepreneurs and generating knowledge spillovers that benefit the local economy.

"Finland is very advanced in Power-to-X research, energy storage, and similar solutions, which allows this expertise to transfer into companies—a relatively good number of which already exist in Finland, despite the newness of the field."

LUT University contributes to the entrepreneurial ecosystem, for example, by developing new technologies that create opportunities for innovation and new business ventures. Academic entrepreneurs can bring these technologies to market, or they may inspire and improve the capabilities of existing startups. Already existing companies can utilise the university's expertise by hiring graduates, commissioning research projects, or engaging in informal knowledge exchanges through discussions with faculty members and public lectures (Spigel, 2017).

” "A significant part of Finland’s energy research is done at LUT University. This is a strength that can help attract more companies and investment to the region."

LUT University also provides skills and knowledge to the regions which helps to grow the economy. The university encourages students to have entrepreneurial mindset and try new ideas with calculated risks.

“LUT University is an important local asset. It provides skilled people for the PtX economy.”

LUT University is a significant single regional strength. It does not only drive technological advancement but also plays an important role by developing the entrepreneurial spirit within the community. As noted by Spigel (2017, 54), the link between academic institutions and local industries creates a robust foundation for sustainable economic growth which will

benefit both new and established companies. This synergy is essential for ensuring that the region stays competitive and adaptable in an ever-evolving market landscape.

“There is a lot of collaboration between researchers and companies.”

“...that we have this expertise, and when we have it ourselves, we also have exceptionally strong networks that extend beyond borders and operate effectively...”

Local permitting, zoning, and regulatory processes were highlighted as strengths, while the local administration is recognized for its collaborative approach and low level of bureaucracy. Additionally, strong political will at the national level supports population retention and development in Eastern Finland.

Material attributes dominate South Karelia's entrepreneurial ecosystem. 75.9% of responses fell into this category, with 44% identified as strengths and 56% as challenges. These attributes play a key role in the region's entrepreneurial ecosystem, with the strengths offering varying levels of competitive advantage, including temporary, comparative, and sustainable types. LUT University plays a pivotal role in sustaining South Karelia's competitive edge through its focus on multidisciplinary research, innovation, and the development of highly skilled human capital. As a driver of technological advancement, particularly in the Power-to-X (PtX) sector, the university ensures the region remains at the forefront of energy transition technologies. This supports Spigel's (2017) point that building on inherent strengths is essential for the resilience of an ecosystem.

Finland and the South Karelia Region have a great water resource, and they are considered as a **sustainable competitive advantage**. Water is one of the important raw materials in PtX economy. Overall, Finland and the region have also vast renewable energy potential. When this is combined with the country's commitment to sustainability, it strengthens its position as a sustainable player in the global green energy market.

The local electric grid offers a **temporary competitive advantage** by reliably supporting industrial and residential needs in South Karelia, even though there is a need for improvements. Overall, the grid in Finland can be considered as a significant strength. Compared to other European Union countries, Finland's grid stands out for its cleanliness, with 94% of total electricity production being emission-free, including electricity produced by other industries (Energiateollisuus, 2023). Finland's low electricity prices further improve its comparative advantages; in the first half of 2024, Finland had the lowest electricity prices for

non-household consumers in the EU at €0.0928 per kWh, which was significantly below the EU average of €0.1867 per kWh (Eurostat, 2024). These national competitive advantages support the region's competitive position by ensuring cost-effective and sustainable energy availability. This reinforces the region's potential for attracting energy-intensive PtX investments while addressing local infrastructure improvements to fully capitalise on these national strengths.

The region's existing gas pipeline help it stay comparative parity with competitors, by providing stable and reliable logistics for industry and PtX initiatives. South Karelia also benefits from its integration into regional, national, and European markets, offering opportunities for growth in alignment with other ecosystems. While these advantages may not be unique, they provide a solid baseline for the region's entrepreneurial ecosystem.

4.2 South Karelia's PtX Ecosystem: Stakeholders and Relationships

Isenberg (2010, 42) points out that public authorities alone cannot make entrepreneurial ecosystems successful; instead, all actors must actively take responsibility for their roles and help the ecosystem grow and function. In the interviews, participants were asked which stakeholders should be invited to future working groups focused on advancing Power-to-X (PtX) investments in the South Karelia region. The responses were categorised according to Spigel's (2017) framework, which divides ecosystem attributes into cultural, social, and material dimensions (Figure 9). Each dimension includes specific stakeholders who play roles in shaping the entrepreneurial ecosystem.

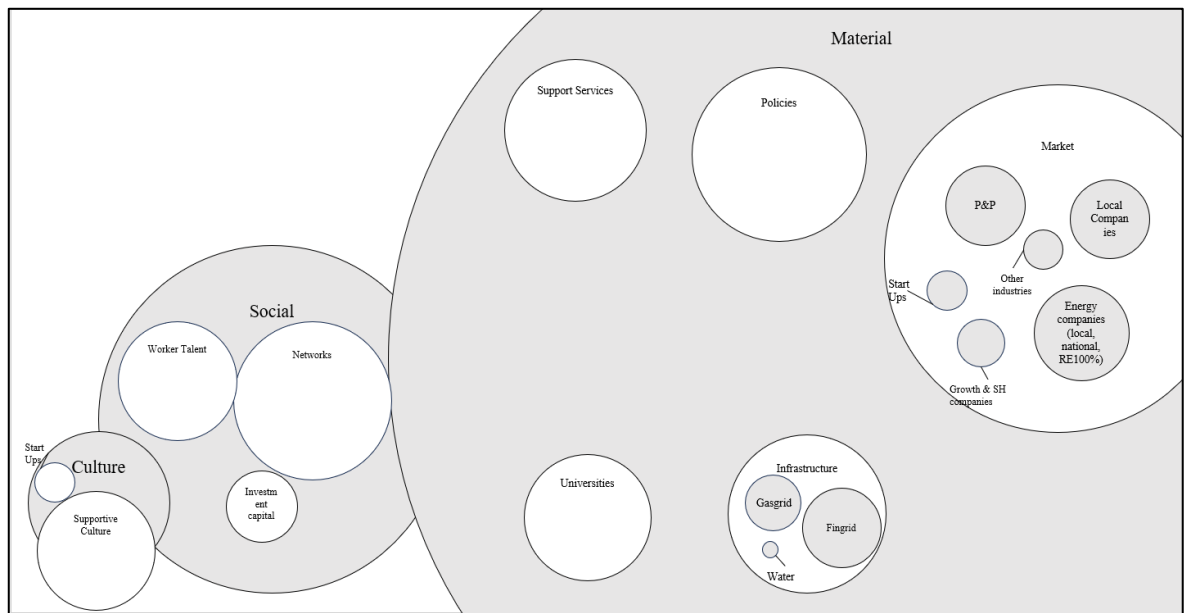


Figure 10: Illustration of key Stakeholders in South Karelia PtX Entrepreneurial Ecosystem

In the dimension of the culture, the stakeholders influence the norms, narratives, and values that define entrepreneurial attitudes and inspire innovation. Key stakeholders in the cultural dimension are associations, chambers of commerce, trade unions, and governmental agencies, which foster trust and collaboration. Also, stories of past startups offer a sense of continuity and serve as modern examples of entrepreneurial success. These actors create an environment where entrepreneurs feel supported and confident to take risks (Spigel 2017)

In South Karelia, supportive culture is shaped by stakeholders such as associations (6 mentions), chamber of commerce (3), and trade unions (3), which help build trust and collaboration. A Governmental agency was mentioned only once, so public-sector involvement can be seen having a smaller role in promoting entrepreneurial culture in the region.

The histories of entrepreneurship and startups (5) highlight legacy and current entrepreneurial identity of the region. Previous startups have a low impact on the ecosystem due to a limited knowledge about them.

Increasing the visibility and involvement of the public sector could strengthen the cultural aspect of the ecosystem. Spreading knowledge about existing and past startups, based on Spigel's (2017) framework, helps create a more cohesive and supportive ecosystem.

Social attributes emphasize the networks, relationships, and social capital that connect ecosystem participants, facilitating resource sharing, mentorship, and collaborative ventures. Key stakeholders include networks, universities, and investors, alongside the skilled workforce that drives entrepreneurial success (Spigel, 2017).

Networks (14 mentions) are important for linking entrepreneurs to opportunities and resources. Public Sector (6 mentions) provides structure and coordination in the ecosystem and provide support to the network activities. The limited public-sector involvement in the regions might indicate that there is opportunity for strengthen the collaboration and improve these connections.

Investors (9 mentions) are important for funding new initiatives, but the region lacks them, making it hard to get enough financing.

Universities (15 mentions) play a big role by producing skilled workers and encouraging innovation. However, keeping this talent in the region is a challenge. Stronger partnerships between universities and local businesses could help match workforce development with the needs of local entrepreneurs.

Social attributes, including networks, investors, and universities, are indispensable to South Karelia's entrepreneurial ecosystem. While these mentions reflect the perceived importance of stakeholders for future collaboration, they do not fully represent the ecosystem's current dynamics. By enhancing public-private partnerships, broadening investor engagement, and improving talent retention, South Karelia can strengthen its social capital and align more closely with Spigel's (2017) framework to foster sustainable growth and innovation.

Material attributes represent the physical and institutional infrastructure supporting entrepreneurship. This group includes industry players who provide market opportunities and collaboration, support services such as incubators and advisory organisations, and public-sector actors who shape policies and regulations. Universities also contribute to material attributes through research, innovation, and talent development. These stakeholders ensure the availability of tangible resources essential for entrepreneurial growth. (Spigel 2017)

Industry stakeholders (44 mentions) are a cornerstone of South Karelia's entrepreneurial ecosystem, providing markets, collaboration opportunities, and resources. The Pulp and Paper Industry (10 mentions) is particularly prominent, reflecting the region's industrial legacy and its capacity to integrate into modern green initiatives like Power-to-X (PtX) projects.

The Chemical Industry (3 mentions) and Marine Industry (2 mentions), while smaller, highlight the diversity of industrial stakeholders contributing to the ecosystem.

Local companies (6 mentions) are well represented in the ecosystem. These companies provide important support for small-scale collaboration and supply chains within the ecosystem. At the national level, leading Finnish companies (4 mentions) stand out for their innovation, which can create a strategic advantage for all of Finland. Growth companies (2 mentions) create the potential for expanding the ecosystem.

Energy companies are also important in the PtX economy ecosystem. Local energy companies (5 mentions) and renewable energy companies (5 mentions) provide critical resources and infrastructure for the PtX economy. Leading energy companies in Finland (2 mentions) bring advanced capabilities and national leadership to regional efforts.

Infrastructure (20 mentions) plays a key role in supporting entrepreneurial activity through physical and technological systems. The most important infrastructure-related stakeholders in the region are Fingrid (10 mentions), the national electricity transmission operator, and Gasgrid (7 mentions), which are responsible for natural gas transmission. These two organisations are crucial for supporting energy distribution and storage.

Reliable water management (2 mentions) ensures access to water, a key resource for the PtX economy. Logistics expertise (1 mention) is important in building new and efficient supply chains, which are essential for connecting South Karelia to larger markets.

The public sector (18 mentions) plays a key role by offering advisory and funding support, as well as shaping the regulatory environment (12 mentions). Strengthening collaboration between universities and industries could better align talent and research with entrepreneurial needs.

Universities, with 15 mentions, remain essential for producing skilled workers and driving innovation, while Scientific Advisory Panels (1 mention) emphasize specialized expertise to advance technical solutions. Material attributes in South Karelia are shaped by public-sector support, industry engagement, and university contributions. While these stakeholders are well-represented, improving private-sector involvement, regulatory frameworks, and university-industry collaboration is necessary to align with Spigel's (2017) framework for a robust entrepreneurial ecosystem.

The analysis of stakeholders in South Karelia's entrepreneurial ecosystem, based on Spiegel's (2017) model, highlights key areas of focus for advancing Power-to-X (PtX) investments. Interviewees emphasized the market-driven stakeholder dynamics of the region, with particular importance placed on the pulp and paper industry as well as energy companies—including local energy companies, renewable energy providers, and national energy firms. These stakeholders can be seen as critical drivers of PtX initiatives.

Local companies were also highlighted as vital contributors to the ecosystem, particularly for fostering collaboration and ensuring supply chain success, as well as for driving the creation of new technologies and fostering growth as a result. Infrastructure-related stakeholders and policymakers were identified as essential for providing the regulatory frameworks and systems needed to support ecosystem growth.

The local university was seen as very important for both the material and social sides of the ecosystem. The university trains skilled workforce, supports innovation, and connects research with business needs. This is the key for the success of the ecosystem. The university also adds value by connecting different stakeholders and matching workforce skills with industry needs.

Networks were also seen as important for supporting cooperation, sharing resources, and creating partnership opportunities. The development of diverse and multi-level collaboration between stakeholders was emphasized as necessary for advancing the PtX economy. Effective partnerships between industries, energy companies, universities, policymakers, and other ecosystem participants are seen as the foundation for achieving a sustainable and successful entrepreneurial ecosystem.

4.2.1 Stakeholder Relationships and Dynamics

The analysis of South Karelia's entrepreneurial ecosystem, based on Spiegel's (2017) model, points out key areas to improve for supporting Power-to-X (PtX) investments. The conclusion from the interviews was that the ecosystem is mostly driven by the market. Interviewees brought up several relationships between different stakeholders and how these connections affect the ecosystem. The market was seen as having a strong impact on most stakeholders, except for support services, which seemed less connected to the market. This suggests that

while markets and stakeholders related to the market act as a central force in the ecosystem, the role of support services may need further development to strengthen their contribution to entrepreneurial activities. (Figure 11)

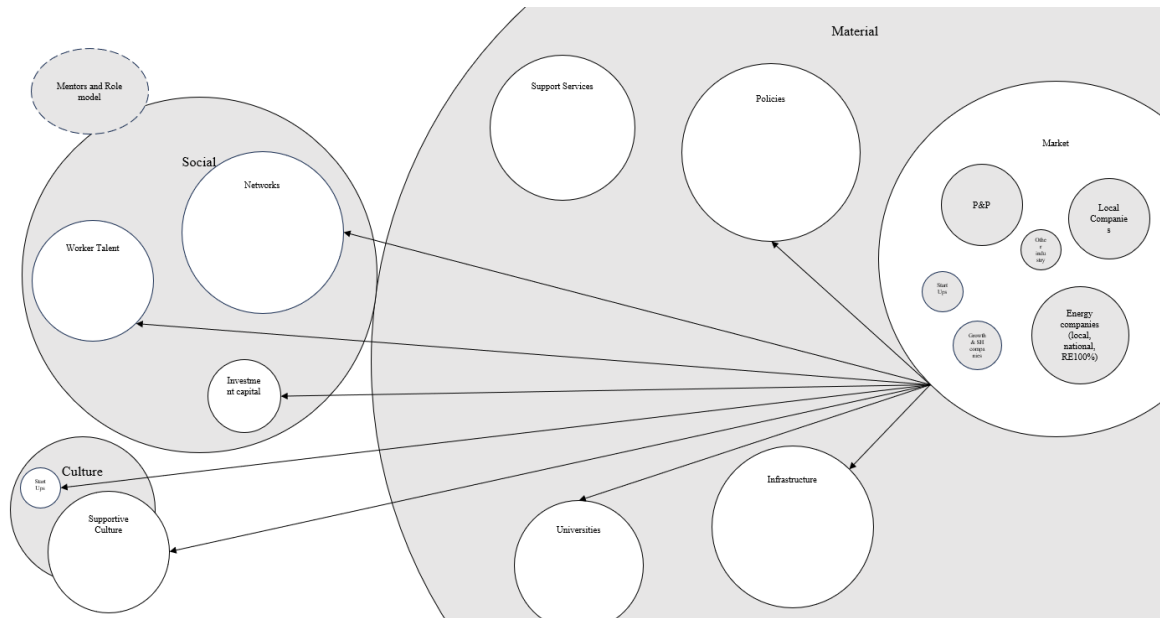


Figure 12: Illustration of Stakeholder Dynamics South Karelia PtX Entrepreneurial Ecosystem

Material attributes, which include industry players, support services, public-sector actors, and universities, represent the physical and institutional infrastructure supporting entrepreneurship. Universities stood out as especially important stakeholders. They influence all material parts of the ecosystem, such as markets, infrastructure, funding, and networks. Infrastructure strongly supports market-driven activity. Policies impact all the material components. It has a key role in shaping the ecosystem. The markets, policies, and infrastructure are impacted by the support services. The role of support services seems more isolated compared to other stakeholders in the South Karelia region. Additionally, the influence of universities extended beyond material attributes, impacting networks, worker talent, and startups, reinforcing their centrality in the ecosystem.

Social attributes include networks, relationships, and social capital. These social attributes promote resource sharing, mentorship, and collaboration (Spigel 2017, 53–54). The stakeholders operating in the ecosystem

are networks, investors, and skilled workers. These stakeholders have an important role in advancing the entrepreneurial ecosystem. Networks are a key part because they link people to opportunities and resources. Universities help by building skills and encouraging people to work together. Investors were found to be critical for funding ventures, and the skilled workforce was identified as essential for supporting startups and maintaining ecosystem dynamism. Worker talent influenced startups, networks, and investment capital, while networks and investment capital were seen to have reciprocal relationships with a supportive culture. These interactions highlight the interdependence of social attributes and their connections to other ecosystem dimensions.

Cultural attributes affect the norms, stories, and values that define entrepreneurial attitudes and inspire innovation (Spigel 2017, 52-53). The key stakeholders are associations, local chambers of commerce, trade unions, and government agencies. These stakeholders promote trust and cooperation within the ecosystem. Historical stories and knowledge about the startups provide a sense of continuity and set an example. The stakeholders related to the cultural attributes create an environment where entrepreneurs feel supported and are willing to take risks. Startups affect workers' skills, networks, investment capital, and support services. Historical stories about local entrepreneurs were recognized for inspiring innovation and providing a cultural foundation for entrepreneurship. There was no mention of mentorship and individual role models in the interviews, pointing to a gap in the stakeholders related to the cultural attributes.

The analysis showed how social, cultural, and material factors are connected. For example, workers' skills had an impact on universities, markets, investments, and infrastructure. Markets, universities, infrastructure, and culture were shaped by the local networks. Investment capital also showed its impact across different areas, especially in its relationship with startups, worker talent, and supportive culture, underscoring its critical role in driving entrepreneurial activity.

Using Stam and Van de Ven's (2019) framework, the findings align with the entrepreneurial ecosystem model, which emphasizes the interdependence of institutional arrangements, resource endowments, and proprietary functions. Policies, as institutional arrangements, were shown to have a broad impact on all stakeholder groups, legitimizing and incentivizing entrepreneurial activities. Resource endowments, such as worker talent and universities, emerged as critical enablers of entrepreneurship, while startups exemplified proprietary

functions by driving innovation and creating value. The results also support Stam and Van de Ven's propositions regarding ecosystem dynamics. The interdependence and co-evolution of ecosystem components were evident, particularly in the market's influence on other stakeholders and the central role of universities. The feedback effects of entrepreneurial success, as described in the downward causation proposition, were also visible in the influence of startups on supportive culture, networks, and investment capital.

The analysis shows that market-driven dynamics are important in South Karelia's entrepreneurial ecosystem. It also shows that there are strong connections between different stakeholder groups. Based on the analysis, the stakeholders important for the collaboration and innovation are local university, skilled workers, networks, associations, chamber of commerce, and existing startups. The analysis also showed that there are areas that need improvement especially support services and missing mentorship. Strengthening these elements and fostering multi-level collaboration between stakeholders will be essential for advancing the region's Power-to-X economy and creating a dynamic and interconnected ecosystem capable of supporting sustainable growth and innovation.

4.3 South Karelia's PtX Ecosystem: Lifecycle Stage

This chapter analyses the lifecycle stage of South Karelia's Power-to-X (PtX) entrepreneurial ecosystem. The analysis examines the region's unique features, collaboration between stakeholders, and the development of the ecosystem. These aspects help describe the current situation and development potential of South Karelia's PtX ecosystem.

The region shows strong signs of an emerging entrepreneurial ecosystem, particularly in its ability to leverage technological opportunities in renewable energy and PtX innovations. Disruptive technological changes often open significant pathways for entrepreneurs, underscoring that the success and growth of ecosystems heavily rely on innovation (Mason, Colin & Brown, 2014).

South Karelia benefits immensely from institutional support, with LUT University and LAB University of Applied Sciences serving as pivotal drivers of knowledge creation, talent development, and spin-offs in energy technologies. This stage of ecosystem evolution is characterized by knowledge spillovers and the emergence of spin-offs as critical contributors to

its formation (Cantner et al., 2020, 413–415). Stam et al. (2021, 812) explain that cooperation happens when people with different skills work together for common benefits, while competition arises when entrepreneurs choose their own paths. In the early stages of an industry, research and development can be uncertain and rely a lot on basic science and technology. To get the knowledge and techniques they need for technological progress, companies often depend on research institutions like universities and laboratories.

The ecosystem is still in an early development stage when universities and public authorities play a central role, and the ecosystem depends on this institutional support. Awareness of the green transition and PtX technologies is still limited, which restricts broader societal acceptance and participation in the ecosystem's development. Additionally, the infrastructure needed to scale PtX projects, such as electricity grids and access to wind power, is insufficient, and these challenges must be addressed to support the growth of the ecosystem.

There are several signs that South Karelia could be in the early stages of developing a growing entrepreneurial ecosystem. Collaborative networks, like the Finnish Hydrogen Valley Association and the Greenreality Network, have begun to take shape, providing early-stage platforms for knowledge-sharing, resource mobilisation, and partnership-building among stakeholders. As ecosystems grow, more players join in, creating a network that combines both cooperation and competition, eventually becoming a more flexible system (Cantner et al., 2020, 415–416).

Although still in the early stages, these networks are building a foundation for collaboration between various actors, including industry leaders, academic institutions, and public sector organisations. South Karelia's skilled workforce, developed through targeted academic programs, bolsters the region's capacity for innovation and strengthens its position within the PtX economy. As access to resources improves, successful entrepreneurs act as role models, inspiring further entrepreneurial activity and contributing to the creation of a dynamic and interconnected network of innovation (Cantner et al., 2020, 415–416).

South Karelia has key industries like pulp and paper, local energy companies, and renewable energy businesses, which could help grow entrepreneurial efforts. But the lack of coordination between these groups makes it harder to develop a more connected and effective ecosystem.

Even with these advantages, there are still challenges holding South Karelia back from fully developing as an entrepreneurial ecosystem. Policies and regulations are slow and unpredictable, which creates uncertainty for investors and businesses. Local support for PtX projects exists, but there isn't a clear connection with national and EU policies, making it difficult to attract big investments. The region's investment strategy is lacking, and the most promising projects may not be recognized. Cultural factors, such as social resistance to change and the lack of startup examples, also hinder the growth of the ecosystem. Risk-taking and innovation are seen as difficult. These challenges should be addressed for the ecosystem to grow.

South Karelia's entrepreneurial ecosystem benefits from strong material attributes, as evidenced by the infrastructure and renewable resources available for PtX initiatives. However, material attributes hold also challenges, especially relate to the open markets and policies. Table 8 summarizes the distribution of strengths and challenges across the ecosystem's key dimensions, illustrating the region's reliance on material resources and the relative underdevelopment of cultural and social attributes.

Table 8: Entrepreneurial Ecosystems Attributes in the South Karelia Region

Attribute Category	Challenges	Strengths	Total	% Challenges	% Strengths
Cultural Attributes	25	14	39	64%	36%
Social Attributes	26	32	58	45%	55%
Material Attributes	172	134	306	56%	44%
Total	223	180	403	55%	45%

As presented, material factors dominate the ecosystem, accounting for 75.9% of all citations. More than half of these were identified as challenges. For the ecosystem to grow, it's important to address issues in infrastructure, policy, and market conditions. Social factors came up less in the interviews, but most of them were seen as strengths. In particular, the region's networks and skilled workers help strengthen the ecosystem. Cultural factors were mentioned the least, and most were seen as challenges. There is a need to improve entrepreneurial stories, share success examples, and build a culture that supports entrepreneurship.

The way these different sectors interact shows how they depend on each other, as Stam et al. (2021, 814-815) explain. Material resources like infrastructure and funding are essential, but improving them can also strengthen social networks and cultural attributes, which will help the ecosystem to grow. Solving problems in one part of the ecosystem can help the

whole ecosystem grow. For example, strengthening networks and supporting cooperation between public and private stakeholders can improve resource use, increase knowledge sharing, and support innovation.

In conclusion, South Karelia's PtX entrepreneurial ecosystem is moving from the emerging to the growing stage. While it has strengths in material resources, skilled workers, and early networks, it also faces challenges in regulation, coordination, and cultural support. To reach a fully developed ecosystem, South Karelia should focus on promoting success stories, improving regulatory flexibility, and encouraging collaboration between different sectors.

5 SUMMARY AND CONCLUSIONS

This chapter provides the results of the study by highlighting the main findings and conclusions. It combines chapter four, the empirical analysis, and chapter three, the theoretical framework and previous research. The aim is to deliver thorough answers to the research questions and ensure alignment with the thesis objectives established in chapter one. The chapter is structured into three sections: Section 5.1 offers a summary of the study, and section 5.2 discusses the conclusions of the study by answering the research questions and considering the wider implications. Finally, section 5.3 proposes ideas for future research.

5.1 Research Summary

The global energy sector is under transition because of the need to reduce greenhouse gas emissions and move away from fossil fuels. Renewable energy, like wind and solar, along with new solutions like Power-to-X (PtX), are leading this change. PtX technologies make it possible to turn renewable energy into synthetic fuels and materials, which are important for cutting emissions in sectors like aviation, farming, and heavy transport. This change isn't just about technology—it also affects the economy and society. This study looks at South Karelia's PtX entrepreneurial ecosystem to find its strengths, challenges, and ways it can grow to support the region's energy and industrial transformation.

The main objective of this study is to explore how the entrepreneurial ecosystem in South Karelia can be advanced in the context of the PtX economy. The theoretical framework employed combines the **Competitive Advantage Theory**, specifically the Resource-Based View (RBV) of the firm, with **Entrepreneurial Ecosystem Theory** to provide a comprehensive understanding of the strengths and competitive advantages of regional entrepreneurial ecosystems. This framework looks at the idea of an entrepreneurial ecosystem by breaking it down into its key parts: its attributes, the stakeholders involved, and its stage of development. It mainly uses Spigel's (2017) model, which focuses on cultural, social, and material attributes that shape the ecosystem. Spigel (2017) points out that these internal attributes—and how they fit together—are important for helping the ecosystem work well and giving new businesses access to resources they might not get otherwise. The framework also combines ideas from Stam et al. (2019), showing how the ecosystem is always changing and how everything is connected. It highlights that people like policymakers, investors, entrepreneurs, and support groups all affect each other and play a role in how well the ecosystem works. These stakeholder relationships are seen as co-evolving rather than static, developing through continuous interaction and mutual influence. The lifecycle stage of the entrepreneurial ecosystem in South Karelia is conceptualized to understand whether it is in the emerging, growing, or mature phase. Identifying the lifecycle stage provides a basis for understanding the ecosystem's current state and offers a foundation for strategies to support the PtX economy. The framework also incorporates the Resource-Based View (RBV) (Barney, 1991) into entrepreneurial ecosystem theory. RBV helps show which attributes in the ecosystem give a competitive advantage. This view connects RBV's resource categories with Spigel's (2017) ecosystem attributes. It helps show the strengths in South Karelia's ecosystem that support innovation and development in the PtX economy.

This study focuses on a specific region and investigates the phenomenon in-depth, making the case study approach the most suitable empirical method (Hirsjärvi et al., 2009, 135). The research questions outlined in section 1.2 were carefully defined to guide the research process. The main research question is: “How can South Karelia's PtX entrepreneurial ecosystem be advanced to support investments, innovation, and regional development?” To answer the main question, three sub-questions were formulated, focusing on the strengths, weaknesses, and competitive advantages of South Karelia's PtX ecosystem, the key stakeholders involved, and the lifecycle status of the entrepreneurship ecosystem.

The primary data collection method was semi-structured interviews. Interviewees were chosen using the snowball sampling technique, ensuring the participation of individuals with relevant knowledge and insights. All interviews were recorded and transcribed for accuracy. The data was analysed step by step through coding. After that, the findings were interpreted in two ways: first, by allowing the data to partly guide the analysis, and second, by contextualising the data within the preliminary theoretical framework. This two-step approach helped identify key themes from the data and connect them to the framework.

An iterative process between the data and theory was conducted to make the study more reliable and improve the validity. This approach allowed for a deeper integration of empirical findings and theoretical insights. This helped to get a stronger analysis and understanding of the phenomenon (Hirsjärvi et al., 2009; Saaranen-Kauppinen et al., 2009; Puusa et al., 2011).

The study shows that South Karelia's entrepreneurial ecosystem is driven by the market, with the region's industrial base and new renewable energy opportunities playing a key role. The **pulp and paper industry**, along with **energy companies**, are the main drivers, creating demand for innovative Power-to-X (PtX) technologies and working together with startups and universities. These industries offer market opportunities and essential resources, like biogenic CO₂, for PtX projects. South Karelia's ecosystem follows Porter's (1980) strategies of cost leadership and differentiation. The region's low-cost energy keeps prices competitive, while its renewable energy and biogenic CO₂ help create value-added products that differentiate in the market.

Material attributes, like infrastructure and institutional support, are the main drivers of the ecosystem, showing the importance of tangible resources in the PtX ecosystem. **LUT University** plays a central role, acting as a catalyst for innovation, talent development, and knowledge dissemination. However, there is still a need to improve the dissemination of research results and present them in a manner that is easily understandable to the public. The gaps in infrastructure, such as limitations in the local electric grid and wind power availability, constrain the region's ability to scale PtX ventures. Furthermore, the lack of mid-sized, growth-oriented companies reduces opportunities for ecosystem integration and innovation.

The **social attributes** of the ecosystem, including networks and skilled worker availability, are a relative strength. **Networks** such as the Finnish Hydrogen Valley Association and the Greenreality Network provide platforms for collaboration, although these remain

underutilised due to limited public-private alignment. The **skilled workforce** emerging from LUT University and LAB University of Applied Sciences is a key asset, with specialized programs focused on energy transition technologies. However, challenges in persist retaining talent and fostering stronger ties between academic institutions and industry.

Cultural attributes present the greatest challenges, with **limited public awareness** of PtX technologies and insufficient narratives celebrating entrepreneurial success. Resistance to change and scepticism about the green transition hinder broader societal acceptance. While Finland's reputation for reliability and innovation supports the ecosystem's image, a lack of visible entrepreneurial role models constrains the development of a risk-tolerant, innovation-driven culture.

The ecosystem's **stakeholder dynamics** reflect significant interdependence, aligning with Spigel (2017) and Stam et al. (2019) models of entrepreneurial ecosystems. Universities bridge gaps between material and social dimensions, influencing networks, markets, and worker talent. Industry players drive demand for PtX innovations, while networks facilitate resource sharing and knowledge exchange. However, the underdeveloped role of **support services** and **fragmented policy frameworks** pose barriers to cohesive growth.

South Karelia's PtX ecosystem is at a transitional stage, demonstrating characteristics of both **emerging and growing ecosystems**. To advance the ecosystem, the region should focus on improving infrastructure, including upgrades to the electric grid and enhancements to wind power capabilities. Additionally, it is essential to drive cultural change by highlighting entrepreneurial success stories and fostering a greater tolerance for risk. Strengthening public-private partnerships will be critical for aligning policies and refining investment strategies. Furthermore, expanding collaborative networks to integrate diverse stakeholders will help accelerate innovation and support the ecosystem's growth.

5.2 Conclusions

This section addresses the research question: *How can South Karelia's PtX entrepreneurial ecosystem be advanced to support investments, innovation, and regional development?* To answer this question, it is essential to first understand the strengths, weaknesses, and competitive advantages of South Karelia's PtX entrepreneurial ecosystem. By identifying the

key attributes that define the ecosystem and their interplay, this study highlights how they collectively shape the region's capacity for innovation and growth.

Secondly, understanding the roles of key stakeholders within the ecosystem is crucial. Stakeholders, such as policymakers, businesses, academic institutions, and investors, form the backbone of the entrepreneurial ecosystem. Their interactions and collaborations influence the region's ability to attract investments, foster innovation, and navigate the challenges associated with transitioning to a green economy.

Finally, determining the lifecycle stage of South Karelia's PtX entrepreneurial ecosystem provides a temporal perspective on its development. The ecosystem, which is positioned between the emerging and growing stages, demonstrates both significant potential and key challenges. Understanding this stage is vital for tailoring strategies that address current gaps while leveraging existing strengths to facilitate the transition to a more mature and sustainable entrepreneurial environment.

Recognizing the distinct characteristics of the region is critical, as entrepreneurial ecosystems are inherently unique and evolve within specific local environments (Mason, Colin & Brown 2014). This study concludes that South Karelia's PtX entrepreneurial ecosystem is at a transitional stage between the emerging and growing phases. The region demonstrates significant potential to support investments, innovation, and regional development, particularly within the PtX economy. The analysis identifies several critical factors shaping this ecosystem, including its material strengths, such as robust industrial foundations and renewable energy potential, and its social and cultural dynamics.

According to Spigel (2017,50), the elements of an entrepreneurial ecosystem are a blend of cultural, social, and material characteristics within a particular region. Material attributes, such as infrastructure, institutional support, and contributions from LUT University, form the South Karelia entrepreneurship ecosystem's foundation. However, challenges persist, including gaps in the local electric grid, regulatory barriers, and the slow adaptation of traditional industries. Addressing these limitations requires improved policy alignment across local, national, and EU levels, which would reduce regulatory barriers, expedite permitting processes, and foster greater private-sector participation. Simultaneously, prioritizing infrastructure upgrades—such as enhancing the electric grid and expanding wind power capabilities—is crucial to scaling PtX projects and attracting larger industrial players to the region.

Social attributes (Spigel, 2017), including networks and a skilled workforce, emerge as relative strengths. Platforms such as the Finnish Hydrogen Valley Association and the Green-reality Network offer opportunities for resource sharing and partnership-building, though these remain underutilised due to fragmented public-private coordination. Strengthening these networks and integrating them into the broader ecosystem will be essential for future growth. Collaboration through public-private partnerships provides a robust mechanism to align resources, strategies, and investments. Enhanced partnerships among public authorities, private industries, and academic institutions can improve coordination and drive innovation. Moreover, workforce development must remain a priority, with universities and vocational institutions aligning educational programs with the PtX sector's needs while creating pathways to retain local talent.

Cultural attributes (Spigel, 2017), however, represent the most pressing area for improvement. Limited public awareness of PtX technologies and the absence of strong entrepreneurial narratives hinder the development of a supportive cultural environment. Promoting visible success stories and fostering a culture of risk tolerance is essential to overcoming resistance to change and encouraging innovation-driven activities. Communication campaigns and participatory planning initiatives can enhance public trust, reduce resistance to PtX projects, and build societal support for the green economy.

The ecosystem's stakeholder dynamics underscore its interconnected nature (Stam et al. 2019; Spigel 2017). Universities play a pivotal role in bridging material and social attributes by providing innovation, talent, and knowledge exchange. Industry players create demand for PtX innovations, while networks facilitate collaboration and resource sharing. However, fragmented policies and underdeveloped support services slow down growth, emphasizing the need for better collaboration and coordination among stakeholders.

To advance South Karelia's PtX entrepreneurial ecosystem, the region must prioritize infrastructure enhancement, foster cultural change to support entrepreneurship, strengthen public-private partnerships, and expand collaborative networks. These efforts will facilitate the ecosystem's transition to a more mature one. By utilizing its strengths and addressing its challenges, South Karelia can create a dynamic, resilient entrepreneurial ecosystem that drives sustainable development and innovation in the PtX sector.

This study provides actionable items for advancing South Karelia's PtX ecosystem while also contributing to the broader understanding of entrepreneurial ecosystems. Practically, the findings emphasize the need for policy alignment to streamline regulatory processes, infrastructure investments to enable scalability, and public-private collaboration to enhance resource coordination. Efforts to promote cultural change and expand networks are highlighted as critical for building societal acceptance and fostering innovation.

Theoretically, the study integrates Spigel's (2017) entrepreneurial ecosystem framework with lifecycle modelling and the Resource-Based View (RBV), offering a perspective on ecosystem dynamics. Focusing on South Karelia, it demonstrates how established frameworks can be adapted to emerging industries like PtX, which are characterized by rapid technological change and high uncertainty. The findings emphasize the importance of material and social attributes in PtX economy-related entrepreneurial ecosystems at early stages while highlighting the critical need for cultural transformation to ensure sustained growth.

Moreover, the study reinforces the dynamic and co-evolving nature of stakeholder relationships, aligning with Stam et al. (2019) propositions. It also highlights the role of context-specific factors—such as industrial legacies and renewable energy potential—in shaping ecosystem development. This regional perspective underscores the importance of tailored strategies to foster entrepreneurial ecosystems in diverse local contexts, as stated in previous studies (Mason, Colin & Brown 2014; Isenberg 2010).

In conclusion, South Karelia's PtX entrepreneurial ecosystem is positioned at a critical juncture. By addressing its weaknesses, enhancing its strengths, and fostering collaboration among stakeholders, the region can drive its PtX economy forward.

5.3 Limitations and Future Research

This study, conducted as a qualitative case study, limits the generalizability of its findings. By focusing on South Karelia's entrepreneurial ecosystem within the context of PtX investments, it provides valuable, in-depth insights into the region's specific challenges and opportunities. However, these insights may not fully reflect the dynamics of other regions or contexts. Nevertheless, the study gains credibility and relevance beyond South Karelia due to the robust scope of its data collection. With a relatively large sample of 49 interviewees,

57% of whom were based outside South Karelia, the study provides a broader perspective that supports the extension of its findings to the national level. This broader representation strengthens the potential applicability of the findings to Finland's national PtX economy.

Additionally, the study captures the state of the ecosystem at a particular point in time, meaning that the findings are influenced by the conditions and developments prevalent during the research period. As the PtX economy continues to evolve and is shaped by technological advancements, changing market dynamics, and policy shifts, these findings may become less representative of future contexts. This temporal limitation highlights the importance of periodic reassessments to account for ongoing developments.

The findings of this study highlight several promising areas for further investigation related to PtX Economy. One critical area is the policy and regulatory frameworks. To better support PtX investments, future studies could explore strategies for aligning local, national, and EU-level policies. Research could investigate mechanisms to reduce regulatory barriers and foster a consistent and supportive legislative environment.

Another key area for future research is value chain integration. Integrating traditional industries, particularly those tied to fossil fuels, with emerging PtX startups remains a significant challenge. Mechanisms to improve collaboration within the value chain, with an emphasis on biogenic CO₂ and other critical inputs in the PtX ecosystem, require further exploration. Understanding how traditional industries can pivot to support green transition efforts while maintaining economic viability is essential.

The study also underscores the importance of public perception and engagement in advancing PtX initiatives. Future research could analyse strategies for increasing public acceptance of green transition initiatives. This might include participatory planning methods or communication campaigns aimed at building trust and reducing resistance to PtX projects. Understanding public attitudes and crafting effective engagement strategies will be crucial for advancing green transition objectives.

The impact of infrastructure and logistics development on the scalability of PtX projects also requires further study. Future research could evaluate the economic and environmental benefits of upgrading energy and transportation infrastructure.

Comparative research offers another promising avenue related entrepreneurial ecosystem. Comparative studies of South Karelia's PtX entrepreneurial ecosystem with other regions

nationally and globally could provide valuable benchmarks and help identify best practices. These comparisons could uncover strategies for differentiation and highlight successful approaches to overcoming similar challenges in other ecosystems.

Finally, current entrepreneurial ecosystem models lack lifecycle-specific considerations. Future research could address this gap by integrating lifecycle modelling into ecosystem frameworks, offering a more dynamic and temporal understanding of how ecosystems evolve from emerging to mature stages. Additionally, while this study utilised the Resource-Based View (RBV) to analyse competitive advantages, alternative approaches such as the Knowledge-Based View (KBV) or dynamic capabilities frameworks could be explored to assess their relevance and effectiveness in entrepreneurial ecosystems.

By addressing these topics, future research can expand upon this study's findings, providing a more comprehensive understanding of how entrepreneurial ecosystems like South Karelia's can advance PtX investments, support regional development, and drive innovation in a rapidly evolving energy landscape.

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Appendix 1: Interview Questions

1. From your point of view, what are the 3 most critical bottlenecks/challenges 3 most critical bottlenecks/challenges that hinder P2X that hinder P2X investments in South Karelia (Finland)? Why?investments in South Karelia (Finland)? Why?
2. From your point of view, what are the 3 most critical strengths/advantages 3 most critical strengths/advantages that South Karelia that South Karelia has for attracting P2X investments? Why?has for attracting P2X investments? Why?
3. Who should we invite as an Expert to Fast Expert Teams digital co--creation process to discuss creation process to discuss how to get P2X investments to South Karelia? how to get P2X investments to South Karelia?