Master thesis

The development of ecosystem strategies

The case of the emerging green hydrogen ecosystem in the Netherlands

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MSc in Business administration
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Preface

This master thesis was written for the double degree offered by the University of Twente and Technische Universität Berlin. First off, I want to express my gratitude for the opportunity of this double degree. I experienced both universities and study programs as highly engaging, which allowed me to develop myself in the field entrepreneurship, innovation management, strategy, and sustainability. Moreover, the experience of a year abroad in Berlin, where I got to meet and work with a highly diverse group of individuals from around the world, has truly made my master's education an enriching period. For this, I want to thank everyone involved in making this experience so remarkable.

When I returned to the Netherlands and started with the thesis process, my initial quest was for an entrepreneurial research topic. However, my path took a different turn when I connected with Powerfield Netherlands B.V., who suggested a research project related to a green hydrogen endeavour. Given my prior management role in the student hydrogen racing team 'Green Team Twente' during a gap year in 2020, this proposal immediately sparked my interest. Although I wasn't initially seeking a hydrogen-related research, it resonated with my interest for novelty and innovations. Additionally, I was intrigued with understanding the current stated of the elaborate and complex hydrogen environments.

Having completed the research, I would like to express my gratitude. Firstly, I want to begin by expressing my sincere gratitude to my university supervisors, Prof. Dr. Ir. Klaasjan Visscher and Dr. Kornelia Konrad, for their guidance and feedback throughout the development of my master's thesis. Furthermore, I would like to thank everyone at Powerfield Netherlands B.V. Especially, The sessions where I could present my findings to the management team and others involved were very enjoyable and valuable for me. Therefore, special thanks to Ivo (my supervisor within the company), Jean-Louis, Kay and everyone who was closely involved and interested, and thereby made a valuable contribution to my research process. Finally, I express my gratitude to all individuals who took part in my research. I was pleasantly surprised by the openness and willingness to engage in conversations. This has led to many interesting and insightful discussions with, for me, impressive organizations.

To conclude, I hope this work contributes meaningfully to the existing body of knowledge on ecosystems and on the green hydrogen industry in the Netherlands, inspiring further advancements or exploration in this area.

Jelle Korbee

Abstract

Purpose – This thesis conducted an extensive exploration of the emerging green hydrogen ecosystem in the Netherlands. Its focus was twofold: (1) to comprehend the strategic dynamics of this emerging ecosystem, and (2) to explore and propose effective positioning strategies for medium-sized energy companies within this emerging ecosystem.

Design/methodology/approach – This research employed a qualitative embedded case study approach, employing five distinct data collection methods for gathering information. These methods included fieldnotes from hydrogen business events, analysis of documents and websites, open expert interviews, semi-structured stakeholder interviews, and a workshop with a representative case. The collected data underwent analysis, with a focus on thematic analysis for interview data, utilizing a coding approach that resulted in a comprehensive coding structure. The varied data sources enable a thorough analysis of the ecosystem, ensuring comprehensive triangulation of the findings.

Findings – The thesis presents a comprehensive overview of the ecosystem and its dynamics, offering extensive implications for potentially effective positioning strategies for a medium-sized energy companies. The most noteworthy findings from the ecosystem analysis include: (1) The government emerges as the keystone player within the government-driven ecosystem, (2) A two-layered development approach is observed, with the government focusing on a top-down approach, while many private organizations prefer a bottom-up approach. (3) The Hydrogen industry appears to be undergoing a hype-disappointment cycle. (4) A waiting game seems to have emerged.

The key findings regarding potentially effective positioning strategies are as follows: (1) Actively engage with governmental organizations and align your strategy with government goals. (2) Participate in communities, especially industry associations, appears to be effective. (3) Establish a position based on your own assets. (4) Actively seek opportunities within industry clusters and/or energy hubs.

Originality/value – This thesis offers an insight into the complex dynamics of an emerging ecosystem within an emerging industry. Moreover, The government-driven ecosystem is characterized by several issues. Such as, lacking economic incentives, a conflicting two-layers development approach, the presence of a hype-disappointment cycle, and the emergence of a waiting game. Therefore, this exploration of the ecosystem offers highly interesting and original insights that could prove highly valuable.

Keywords – Business ecosystem, Innovation ecosystem, Ecosystem strategy, Green hydrogen

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1 Introduction

In an attempt to fight the global climate crisis many countries have created strategic roadmaps for reducing the use of fossil-based energy sources (Sgarbossa et al., 2023). Hydrogen technologies present great opportunities to pursue the ambitious climate and environmental policies and has been considered a potential energy solution for at least four decades (Dehghanimadvar et al., 2020).

Hydrogen could serve as a clean fuel or, generally, low-carbon technology for society (Sgarbossa et al., 2023). With its main characteristics being: high energy density by weight, abundance in nature, large-scale storage and transmission capacity, and pollution-free combustion (Acar & Dincer, 2019; Kumar et al., 2023; Vidas & Castro, 2021), hydrogen can replace fossil fuels in processes where electrification is not possible or is economically inefficient (Vidas & Castro, 2021). However, currently approximately 99% of the available hydrogen is produced from fossil fuels. In total, this still amounts to 2,5% of global C02 emissions (Kumar et al., 2023). For hydrogen to truly be a sustainable energy solution and to reach the zero-carbon horizon, hydrogen must be produced in a cleaner way. Only 'Green hydrogen' generated from a renewable source can fulfil these sustainability requirements (Kumar et al., 2023; Vidas & Castro, 2021).

Recently, there was still a need for greater feasibility and economic competitiveness for green hydrogen production to be widely implemented and to be competitive with fossil fuel-based hydrogen production methods (Vidas & Castro, 2021). However, with European and Dutch policies pushing hydrogen supply chains and applications (National Hydrogen Programme, 2022; the European parliament and the council of the European union, 2018) investment in hydrogen are becoming more viable (Houghton & Cruden, 2011) and incentives to implement green hydrogen technologies are increasing. These developments are reflected globally as well, as the share of green hydrogen is expected to increase dramatically and could supply more than 24% of global energy needs by 2050 (Kumar et al., 2023).

As a result, the current Dutch hydrogen industry is expanding and transforming (Kumar et al., 2023). Firms are recognizing new business opportunities for the implementation of green hydrogen technologies, creating new business cooperations and pushing forward the green hydrogen industry. In other words, a new business ecosystem centred around the use and supply of green hydrogen is emerging in the Dutch economy. This emerging green hydrogen ecosystem provides great opportunities for firms looking to participate in, and eventually benefit from, this emerging ecosystem.

The emergence of the green hydrogen industry in the Netherlands, along with its emerging ecosystem and the opportunities it brings, has therefore sparked wide interest. However, such an emerging ecosystem comes with a highly challenging environment. Firms have to deal with technology and market uncertainty (Rong et al., 2013) and must decide how to position themselves effectively within the relevant business ecosystem (Gupta et al., 2020). This is especially relevant within the emerging green hydrogen ecosystem as the majority of hydrogen-related technologies are still emerging technologies themselves: they are in their early stages of development and lack maturity (Dehghanimadvar et al., 2020; Sgarbossa et al., 2023). As a result, substantial innovation is required for the business ecosystem to fully establish itself and reach its potential (Vidas & Castro, 2021). This simultaneous development of the green hydrogen technologies and the green hydrogen business and innovation ecosystem signifies the complex and dynamic nature of the industry.

One firm that has expressed the ambition of participating in the emerging green hydrogen ecosystem in the Netherlands, and has recognized the complex and dynamic environment, is PowerField Netherlands B.V. PowerField Netherlands B.V. is a Dutch-based scale-up company, established in 2019, that falls within the medium-sized enterprises category. They develop, realize, and manage energy systems. Currently, they are specialized in the development, construction, and management of solar parks, charging stations, and power storage systems. PowerField states that it is dedicated to continuous innovation within the renewable energy sector, ensuring efficient, sustainable, locally engaged, and socially responsible practices. The ambition of PowerField is to build the largest Virtual Power Plant in Europe in the coming years. Among their other notable ventures, PowerField has interest in establishing a green hydrogen production facility to expand their offer as part of their envisioned virtual power plant. To aid this ambition, this thesis has been executed in collaboration with Powerfield Netherlands B.V.

The situation at Powerfield Netherlands B.V. and the emergence of an ecosystem sparked interest in researching the complex dynamics of the green hydrogen ecosystem and its strategic implications. To achieve an effective focus, based on Powerfields Nederlands B.V.'s situation, the decision was made to explore effective ecosystem positioning strategies for medium-sized energy companies, leading to the following main research question:

RQ: How can medium-sized energy company effectively position itself within the emerging green hydrogen ecosystem in the Netherlands?

An energy company, in this thesis, refers to a business entity operating in the energy industry. These companies are involved in the production, distribution, or sale of energy, either in the form of molecules or electrons. The focus on such companies was selected to narrow down positioning opportunities and strategies for entities with pre-existing energy assets and experience in handling technologically complex projects. Secondly, the emphasis was placed on medium-sized companies, as they possess limited market power and capabilities, significantly influencing their opportunities and strategies.

To answer the research question a qualitative case study approach was adopted, analysing the emerging green hydrogen ecosystem and the stakeholder dynamics. The objective is to comprehend the ecosystem dynamics in order to come up with effective ecosystem positioning strategies and approaches that a firm, such as PowerField Netherlands B.V., can adopt to participate in and ultimately derive economic benefits from the emerging green hydrogen ecosystem in the Netherlands. Important to note, however, is that in this research approach, Powerfield Netherlands B.V. will primarily serve as a representative firm and won't be the main focus of the case study.

This thesis could provide valuable theoretical and practical contributions. Through this specific case-study there is attempted to derive strategic learnings by applying the theory of business ecosystems (Moore, 1993) in combination with the theory of innovation ecosystems (Adner, 2006) in an emerging ecosystem case. This analysis could provide new theoretical insights into the dynamics of emerging ecosystems and/or into ecosystem strategies and activities adopted by ecosystem stakeholders. Subsequently, these insights and strategic learning could prove highly valuable in a practical context for a multitude of organization active within the emerging green hydrogen ecosystem, especially medium-sized energy companies, providing a thorough insight into the ecosystem dynamics and strategic implications. Ultimately, these learnings can help organisations to participate in and add value to the emerging ecosystem, potentially aiding in advancing the overall ecosystem.

2 Theoretical framework

In this chapter the theoretical framework is presented, this includes the concepts and tools used in this thesis. The concepts this study is anchored on are: business ecosystems, innovation ecosystems and ecosystem strategies. This chapter concludes with the presentation of the developed theoretical framework for ecosystem positioning activities.

2.1 Business ecosystem

The concept ‘business ecosystem’ provides a bigger, cross-industry, view on business networks, rather than the limited traditional view that focusses on the directly linked partners in the supply chain (Moore, 1993; Rong et al., 2013). A business ecosystem involves, in addition to the traditional supply chain partners, other stakeholders like universities, government and industry associations in the network (Iansiti & Levien, 2004b; Moore, 1993). The different levels of organizations within an ecosystem, share a common goal, vision and fate. They form this community with the purpose of dealing with uncertain environments (Moore, 1993).

In practice, the stakeholders collectively contribute their complementary resources and capabilities within this business ecosystem to allow companies to capture value by coevolving new capabilities around innovations (Gomes et al., 2018). These new innovations support new products, new business project or an emerging industry, and eventually incorporate the next round of innovations (Iansiti & Levien, 2004b; Moore, 1993). Companies participating in a business ecosystem get the benefits by being able to find opportunities for alliances and thrive in a network, protected from potential intruders (Peltoniemi, 2006). As a result of these beneficial effects, the concept of business ecosystem has been well adopted by industrial practitioners, especially from emerging-industry perspectives (Rong et al., 2011). However, The process of co-evolution between the participating companies is a complex interplay between competitive and cooperative business Strategies. This complexity makes it difficult to manage. Yet, managers can’t afford to ignore the birth of new ecosystems or the competition among already existing ecosystems (Moore, 1993).

A business ecosystem is fundamentally a dynamic structure that evolves and develops over time (Peltoniemi, 2006). Moore (1993) identified four phases in the business ecosystem lifecycle: birth, expansion, leadership and self-renewal. Recently, the business ecosystem lifecycle concept has been updated by introducing the following five phases: Emerging, diversifying, converging, consolidating and renewing (Rong, 2011). Lu et al. (2014) added to this concept that emerging industry, which undergo deep intervention from governments, always experiences an ‘initiating’ stage before entering the emerging phase. This thesis focusses on the emerging green hydrogen ecosystem in the

Netherlands. This ecosystem does undergo deep intervention from the government, However, it currently passed the initiating stage and is in the emerging phase. This emerging phase ranges from a new solution being proposed, to a simple supply chain being produced (Rong, 2011).

In the emerging phase, the emerging industries often come with technology and market uncertainty as well as a weak industrial system (Rong et al., 2013), while simultaneously presenting future new value creation opportunity for firms that choose to collaborate effectively in a timely manner (Gupta et al., 2018). In order for a firm to cope with the uncertainties of an emerging industry the business ecosystem must be nurtured and a friendly and healthy stakeholders network should be set up (Lu et al., 2014). Some niche players, dominators and supporting infrastructure can already be observed in the early stages of an emerging ecosystem, when the stakeholder network is slowly being established. However, keystone players that legitimize the ecosystem are often not established yet (Gupta et al., 2020).

An emerging business ecosystem comes with a highly selective environment that consists of other organizations and the wider context where organization must survive in order to be present in future selection environments (Peltoniemi, 2006). In this selective environment the competition acts at two different levels: within the ecosystem, where firms compete to secure activities, positions, and roles. And across ecosystems, where the ecosystem actors collectively compete for advantages in creating and capturing value relative to rival ecosystems (Adner, 2017). Due to the selective and tumultuous emerging ecosystem environment, industry re-alignment takes place which promotes ecosystem evolution and growth. This process is, therefore, often accompanied with high intensity of firm level deals activities such as mergers, acquisitions, strategic alliances, joint ventures, capital injections and other financial transactions (Gupta et al., 2020).

To deal with this selective and tumultuous emerging ecosystem environment, Adner (2017) proposed a more actionable construct for ecosystems “Ecosystem-as-structure”, as distinction of “ecosystem-as-affiliation”. Where the more traditional view, Ecosystem-as-affiliation, sees ecosystems as communities of associated actors defined by their networks and platform affiliations (Adner, 2017), Ecosystem-as-structure, on the other hand, views ecosystems as configurations of activity defined by a value proposition (Adner, 2017). By having the value position as the core element of the ecosystem, the identification and alignment of the set of actors that need to interact in order for the proposition to come about becomes the actionable focus of the ecosystem. Therefore, the view ecosystems-as-structure is considered to be more effective in the context of ecosystem strategies, and is thus adopted for this study. The definition of an ecosystem used with this view is: “The alignment structure of the multilateral set of partners that need to interact in order for a focal value proposition to materialize" (Adner, 2017).

This structuralist approach to ecosystems comprises four basic elements that collectively characterize the configuration of activities and actors required for a value proposition to materialize (Adner, 2017):

1. Activities, which define the actions to be taken in order for the value proposition to materialize.
2. Actors, which are the entities carrying out the activities. A single actor can execute multiple activities; or, multiple actors can collaborate and undertake one activity collectively.
3. Positions, which specify where the actors are located within the ecosystem's flow of activities and thus characterizes who hands off to whom.
4. Links, which specify transfers between actors. The content of these transfers can vary; material, information, influence, resources. Critically, it is not necessary for these links to have any direct connection to the central actor.

2.2 Innovation ecosystem

Building on the idea of a business ecosystem, the concept of an innovation ecosystem has arisen as a promising approach to strategy, innovation and entrepreneurship (Gomes et al., 2018). Where the business ecosystem mainly relates to value capture, the innovation ecosystem concept addresses the process of joint value creation (Adner, 2006; Adner & Kapoor, 2016; Gomes et al., 2018). The definition proposed by Adner (2006) for an innovation ecosystem is "the collaborative arrangements through which firm combine their individual offerings into a coherent, customer-facing solution". Since the innovation ecosystem concept draws upon the former concept of business ecosystem, the two concepts have some common features (Gomes et al., 2018):

- Both business ecosystems and innovation ecosystems consist of a network of interconnected and interdependent actors (Iansiti & Levien, 2004b).
- Business ecosystems or innovation ecosystems may be led by a leader that is often a well-established and large firm (Iansiti & Levien, 2004b).
- Business ecosystems and Innovation ecosystem are built on a platform, such as a technological platform, supply-chain platform and industry platform (Gawer, 2014).
- Ecosystem actors have to deal with both collaboration and competition within both the business and innovation ecosystem (Adner & Kapoor, 2016; Iansiti & Levien, 2004b; Moore, 1993).
- Both the business ecosystem and innovation ecosystem follow a certain lifecycle (Moore, 1993; Rong, 2011).

While the two concepts share a lot of similarities, some scholars even regard the two concepts as synonymous (Gomes et al., 2018), it was considered to be valuable to highlight the difference in the context of this thesis. This is because, during the emergence of an ecosystem or industry, considering only the business ecosystem concept would confine the viewpoint to the competitive (economic) perspective of value capture, yet the innovation (technology) perspective of value creation is also significant in the emerging phase and should not be overlooked. This in in line with the argumentation of Adner and Kapoor (2010) that that value creation precedes value capture.

As previously noted, the key difference in practice primarily centres around the main focus of the ecosystem concepts. Where the focus of the business ecosystem is on value capture; location of actors and integration (Gomes et al., 2018). The focus of the innovation ecosystem lies on value co-creation; location of actors, integration, challenges distributed across partners and complementors (Gomes et al., 2018). In order for the ecosystem participants to manage these dynamic focus points various phenomena have arisen related to the concept of innovation ecosystem, such as 'Open innovation' (Chesbrough, 2003) and 'Innovation networks' (Lee et al., 2016). The exact strategic tools and activities that help establish the ecosystem, and which are relevant to this study, will be discussed in the next section, 2.3 ecosystem strategy.

To conclude this section, the four types of innovation ecosystems, proposed by Zahra and Nambisan (2012), will be related to the emerging green hydrogen ecosystem in the Netherlands. Initially, these authors presented these as business ecosystem types. However, currently, these ecosystem types align more closely with the innovation ecosystem concept, as they are predominantly focused on the creation of new innovations. The ecosystem types proposed by Zahra & Nambisan (2012) are:

1. The Orchestra model which refers to "a group of firms coming together to exploit a market opportunity based on an explicit innovation architecture/platform that is defined and shaped by a dominant firm" (Zahra & Nambisan, 2012).
2. In the Creative Bazaar model "a dominant firm shops for innovation in a global bazaar of new ideas, products, and technologies. It then uses its proprietary infrastructure to build on these ideas and commercialize them" (Zahra & Nambisan, 2012).
3. The Jam Central model "involves a collection of independent entities, such as research centres, collaborating to envision and develop an innovation in an emergent or radically new field. The term 'jam' signifies the improvisational nature of innovation (i.e., the objectives and direction of the innovation tend to emerge organically from the collaboration) and the lack of centralized leadership in the ecosystem (i.e., there are no dominant companies and the governance responsibility is diffused among partners)" (Zahra & Nambisan, 2012).

4. The MOD Station model adopts an approach in which a community of innovators, including customers, scientists, experts, and more, can leverage an existing, often proprietary innovation architecture or product/platform through modifications. Established companies primarily serve as catalysts by providing the foundational innovation architecture (Zahra & Nambisan, 2012).

When these innovation ecosystem model types are considered in relation to the emerging green hydrogen ecosystem in the Netherlands, it appears that the Jam Central model currently aligns most closely. This is because there appears to be a broad interest, with many entities attempting to kickstart collaborative initiatives in a clear emerging field, yet a centralized leadership structure seems to be lacking. How an organization can act in such an ecosystem type in order to derive benefit, will be discussed in the next section.

2.3 Ecosystem strategy

As highlighted before, an ecosystem is a complex system with many cooperative and competitive interaction (Moore, 1993). For a company looking to participate in- and benefit from- such an ecosystem it is therefore beneficial to develop an ecosystem strategy (Ma & Hou, 2021). Creating an ecosystem strategy differs from the development of a traditional strategy. The goal of a firm should not be to adapt to the competitive context in the search for a competitive advantage. An ecosystem strategy should recognize and manage indirect links (Adner, 2017), it seeks to shape the competitive context such that the firm can build, leverage, and extend, rather than locate and occupy, a strong competitive position (Adner, 2017; Autio, 2022).

Following the ecosystem-as-structure view, an ecosystem strategy can therefore be defined as the way in which firms approach the alignment of their activities within an ecosystem and the ways in which they secure their position in relation to other actors and to the competitive ecosystem as a whole, which is an adaption from the views of Adner (2017) and Visscher et al. (2021). Firms may develop such strategies more or less deliberate (Adner, 2017). Crucially, the development of an ecosystem strategy is an iterative process when it comes to emerging ecosystems. It involves a cycle of activities, including developing a vision, assigning responsibilities, forging opportunities, engaging with the government, acquiring partners or competitors, assessing risks, and re-evaluating the initial vision (Adner, 2006). Over time, this process allows firms to coevolve their capabilities and roles, and ultimately the firms tend to align themselves with the direction set by one or more central Companies (Adner, 2017).

Within the definition of ecosystem strategies two core concepts can be identified: Positioning and alignment. The first question to be answered when a firm decides to embrace a new emerging ecosystem, and is looking to form an ecosystem strategy, is what the firm's desired position, or role, within this ecosystem is (Ma & Hou, 2021). A role within a business ecosystem is characterized by a combination of specific behavioural patterns and activities that are influenced by economic interests and social responsibility (Wieninger et al., 2020). To achieve this desired position, Adner (2017) underscores partner alignment as a pivotal strategic challenge. He introduces it as a novel dimension in relation to traditional strategic thinking. Adner (2017) states "If the heart of traditional strategy is the search for competitive advantage, the heart of ecosystem strategy is the search for alignment" (Adner, 2017). In this context, alignment is described as the level of mutual agreement among members regarding positions and flows within an ecosystem (Adner, 2017).

The following two sections will build upon these two fundamental concepts. First, the various ecosystem roles, as proposed by various authors, will be discussed. This will be followed by an exploration of the corresponding positioning and alignment strategies and activities. The ecosystem roles, strategies, and activities discussed will encompass literature from both business ecosystems and innovation ecosystems, as both constructs have been previously explained as relevant.

2.3.1 Ecosystem roles

Various authors have proposed different approaches to the roles that organizations can assume within an ecosystem. A deep understanding of ecosystem roles is valuable for a firm that wishes to position itself within the ecosystem, as the health and stability of the ecosystem, the choice of ecosystem strategy, and ensuring the firm's well-being all depend on your role within the network, both in its current state and its potential (Iansiti & Levien, 2004a). One of the most frequently employed constructs for roles within an ecosystem is the one proposed by (Iansiti & Levien, 2004b). They describe three categories of players that participate within the ecosystem at a firm level: Keystone player, Dominator and Niche player. Iyer et al. (2006) on the other hand identified three central roles within business networks: Hub, Broker, and Bridge, which are related to the links between ecosystem actors. Rong (2011) did research on business ecosystem within the emerging EV industry, he defined three kinds of functional roles in the development of a business ecosystem: the Initiator, Specialist and Adopter. Furthermore, Pidun et al. (2022) made a distinction between the Orchestrator and Contributors within a business ecosystem, however the contributors are composed of out of both Complementors and Suppliers. The final mention of different types of players within an ecosystem is the one of Zahra & Nambisan (2012), who used a different approach and differentiated between three different kind of companies who are active in the business ecosystems: Established companies, corporate ventures and independent ventures.

A notable commonality in the discussion of these roles is the identification of a leader or central figure within the ecosystem, which may take the form of a Keystone, Hub, Initiator, Orchestrator, or an established central company. Around or following these leaders, several approaches are identified for actors who support, contribute to, or benefit from the ecosystem. For this thesis a broad perspective for these ecosystem roles is applied, combining the different approaches. However, in the context of ecosystem strategies for this thesis, the insight of Visscher et al. (2021) serve as a valuable tool. Following there statement, "when a position is identified, securing the chosen role boils down to creating and defending a profitable keystone position or finding a complementary position in relation to this keystone firm". The key insight from this statement is that a primary decision in ecosystem positioning is to either occupy a leader position or serve as a complement to a leading player. Below, the keystone player and complementor role are further elaborated on. It's important to note that within these two concepts, insights from multiple approaches are included.

The keystone players are central actors within a business ecosystem that have significant influence and control over the ecosystem's dynamics (Iansiti & Levien, 2004a). They can be seen as the rule maker, gatekeeper, allocator of profits, and judge and jury of the ecosystem (Pidun et al., 2022). They possess control over critical resources and linkages with many players, enabling effective coordination (Iyer et al., 2006; Pidun et al., 2022). However, it is crucial for the keystone player that it is perceived as a fair collaborator rather than a competitive threat, and is accepted by the other ecosystem participants (Pidun et al., 2022). Therefore, the keystone firm should provide a stable and predictable set of common assets, simplify complex tasks such as connecting network participants or developing third-party innovations, help participants respond to new and uncertain conditions by consistently incorporating technological innovations, and provide a reliable point of reference. Eventually, the keystone firm should also share much of the created value throughout the ecosystem (Iansiti & Levien, 2004a). In conclusion, it should be noted that the initiator role, as identified by (Rong, 2011), does not necessarily have to evolve into a keystone player. However, it does necessitate many of the same characteristics, including the facilitation of new connections, the establishment of a common framework, and the fair distribution of the value that is created.

Besides the keystone player, the other actors within an ecosystem can be categorized as contributors. While the keystone role might initially appear to be the most beneficial, research indicates that the contributor role can be equally or even more financially rewarding. Because of the significantly higher demand for contributors, the contributor roles provide numerous opportunities (Pidun et al., 2022): Contributors can offer and/or facilitate valuable connections within the ecosystem (Iyer et al., 2006), operate in their own complementary niche (Iansiti & Levien, 2004b; Pidun et al., 2022), provide specialized resources or utilize the outputs from the ecosystem (Pidun et al., 2022; Rong, 2011), or possess and potentially dominate key resources essential within the ecosystem (Iansiti & Levien, 2004b; Pidun et al., 2022).

2.3.2 Positioning and alignment activities

In addition to the above mentioned roles, several activities and methods for choosing and securing a role within the ecosystem have been proposed. This section discusses these strategies and explores the different insights they offer.

Evaluating own capabilities, resources & assets

The initial step that has been identified from the literature is to look inward at the assets, resources, and capabilities of the organization (Pidun et al., 2022). Especially for contributors, Pidun et al. (2022) emphasize the importance of considering how they can contribute to the ecosystem and what essential assets and capabilities they possess that can be employed. When considering a medium-sized energy company's role within the emerging green hydrogen ecosystem, it seems far more likely that a contributor role is most suitable, as it is unlikely that a medium-sized company will be ready, willing, and able to be in a keystone position (Pidun et al., 2022). However, a company should not let its existing capabilities limit its strategic choices and should be aware of emerging opportunities (Pidun et al., 2022). Nevertheless, while many positioning and alignment activities are relevant for both keystone players and contributors, the subsequent sections will place greater emphasis on the contributor role. When the internal assets of the firm are assessed, ecosystems that align with the strategic priorities of the firm should subsequently be identified, and the appropriate level of engagement should be defined (Pidun et al., 2022).

Evaluating ecosystem environment

This leads to the second focus, which is to understand the ecosystem environment. Iyer et al. (2006) proposed general steps that can be used to asses a business network. These steps include the development of a dynamic and consistently updated overview of the business ecosystem, with a focus on highlighting key players. Subsequently, these players can be examined for to the similarities and differences in the competitive field, and assessed in order to understand the network of the specific roles. These steps are especially relevant for niche players as these firms are highly dependent on other ecosystem actors which results in the necessity to assess the ecosystem and identify the specific characteristics of the keystones and dominators (Iansiti & Levien, 2004a).

Based on the two previous steps, a firm should be able to decide on a role it wishes to secure. Following this decision, three distinct activities that help to secure a role and/or shape the ecosystem around it have been identified in the literature: (1) Creating a favourable position, (2) creating and/or joining networks and partnerships, and (3) aligning the strategies and goals.

Creating favourable position

The initial activity identified involves creating a favourable position. As an emerging business ecosystem comes with a highly selective environment (Peltoniemi, 2006), it is important to try to stand out from other contributors and improve your bargaining position (Pidun et al., 2022). A few different methods to accomplish this are proposed. Visscher et al. (2021) mentions the importance of reputation among ecosystem actors, as this plays a pivotal role in network formation and connection. Important factors for a reputation are the innovation reputation, reliability and trustworthiness of the organization. Therefore, actively promoting and enhancing your reputation can be regarded as a valuable positioning activity. Other factors that are important in order to secure a role in ecosystem include the size and market position of the organization (Visscher et al., 2021). Another method is to focus on develop specialized capabilities that sets the organization apart from other firms within the ecosystem (Iansiti & Levien, 2004a), or to focus on occupying control points within an ecosystem, such as essential components, customer access points, and bottlenecks (Pidun et al., 2022). Furthermore, Five specific successful contributor strategies to stand out from competitors are: "Become a category leader, Dominate a niche, Create a new category, Collaborate within a subset, Exploit the ecosystem mechanics"(Pidun et al., 2022).

creating and/or joining networks and partnerships

The second position securing activity identified is the creation and management of new relationships and linkages among organization, as this is an effective method to revise the dynamics of competition within the ecosystem (Zahra & Nambisan, 2012). Zahra & Nambisan (2012) stated that companies need to engage themselves in thinking strategically about the ecosystem in which they exist, their place within it, and how to develop and cultivate relationships with its other members. The latter involves creating, joining, and sustaining networks such innovation campuses, consortia, multilateral partnerships, strategic alliances, joint development programmes, etc. which are seen as core positioning and alignment activities (Visscher et al., 2021). In addition to these networks, collaborations with universities and government institutes are mentioned specifically as an important link for ecosystem strategies (Visscher et al., 2021).

These new relationships are develop because of specializations in different skill areas, historical ties among companies, and personal relationships among people working in different parts of the ecosystem (Zahra & Nambisan, 2012). In addition, Zahra & Nambisan (2012) proposed some specific focus point in terms of strategic thinking and entrepreneurship in relation to the creation and management of new relationships and linkages. Below, in table 1, the focus points of the Jam central ecosystem type are depicted.

Type of ecosystem	Strategic thinking and entrepreneurship by:		
	Established companies	**Corporate ventures**	**Independent ventures**
Jam Central	a) Think beyond existing ecosystems and consider new innovation opportunities that may create new ecosystems (and even render their existing ecosystem obsolete) b) Assume 'junior partner' role vis-á-vis relationships with new ventures with radically new ideas/technologies	a) Expedite the corporate parent's learning and catching up with industry changes, after independent ventures have proven the viability of the new technology or product ventures b) Assemble resources and skills that allow the corporate parent to focus on a unique market space	a) Boldly pursue opportunities for new knowledge creation in emergent areas that are congruent with unique internal assets, even in the absence of hard evidence on market potential b) Aggressively collaborate with partners who possess complementary assets/capabilities

Table 1 'Jam central' ecosystem focus points for three types of companies (Zahra & Nambisan, 2012)

To conclude this section, actively participating and taking a proactive or even orchestrating role in these networks can enhance your positioning, provide leverage to guide alignment, and ultimately could lead to a pivotal role for the company within the ecosystem (Visscher et al., 2021). Thus, Taking an active role in creating and managing new relationships and linkages connects back to creating a favourable position and vice versa.

<u>Aligning the strategies and goals</u>

The third and final activity identified to help secure a position within an ecosystem involves aligning the strategies and goals among the relevant ecosystem actors. This is necessary because an ecosystem where all participants focus on their own advantage will find it hard to establish the level of cooperation that is required to collectively create value (Pidun et al., 2022). While promoting a firms desired position and creating, joining, and managing links already involve alignment-promoting activities, this section shifts the focus to specific activities aimed at influencing the ecosystem according to a firm's preferences, thereby attempting to shape it to suit the firm's envisioned role. In accordance with this, Zahra & Nambisan (2012) emphasize the opportunities related to entrepreneurial behaviour and strategic thinking within business ecosystems. Because, while there are things about the ecosystem that should be taken as 'givens,' there are considerable opportunities for framing, revising, and transforming an ecosystem, or selected parts of it, for competitive advantage. Rong et al. (2017) identified three key management mechanisms for a firm looking to shape an emerging business ecosystem specifically in an emerging industry:

1. Vision developing; ensuring the future visions and intentions of the relevant stakeholders are aligned, as well as convincing relevant stakeholders to participate.
2. Platform organizing; focusing on the establishment of a suitable network and aligning activities within the ecosystem.

3. Institutional reconfiguring; focusing on ensuring policy flexibility of governments, as well as configuring local and societal contributions and impacts.

They added that for market-driven emerging ecosystems, sharing the vision to stimulate ecosystem innovation appears to be most relevant, while for government-driven emerging ecosystems setting up a functioning network and regulations is more relevant (Rong et al., 2017).

2.4 Conclusion

In this concluding section of Chapter 2, the relevant concepts discovered in the literature will be summarize and briefly discussed in relation to the research context, as these concepts form the basis for this thesis as the theoretical framework.

In the first two sections of this chapter the closely related concepts of business ecosystems and innovation ecosystems were discussed. Here a deep understanding of the scope and boundaries of these concepts, and a deep understanding of the cooperative and competitive nature of the interaction between the ecosystem participants was build. The primary tool identified for this thesis to identify and structure the ecosystem elements is the 'ecosystem-as-structure' approach proposed by Adner (2017), which relate both to the business and innovation ecosystem concept. There was, however, made a clear distinction between the two concepts. This is because, while there is a great deal of innovative activities necessary to develop the green hydrogen ecosystem in the Netherlands, medium-sized energy companies might not have sufficient innovative capabilities and find it challenging to fully engage within the innovation ecosystem. Consequently, they are forced to focus more on value capture than value creation during this emerging phase of the ecosystem. Nevertheless, ignoring the innovation ecosystem during this critical phase appears overly restrictive as well. Therefore, it was decided to incorporate insights from both business and innovation ecosystem literature when crafting the conceptual ecosystem strategy framework, yet deliberately emphasizing the distinctions. How the relations of the concepts is envisioned is depicted in figure 1.

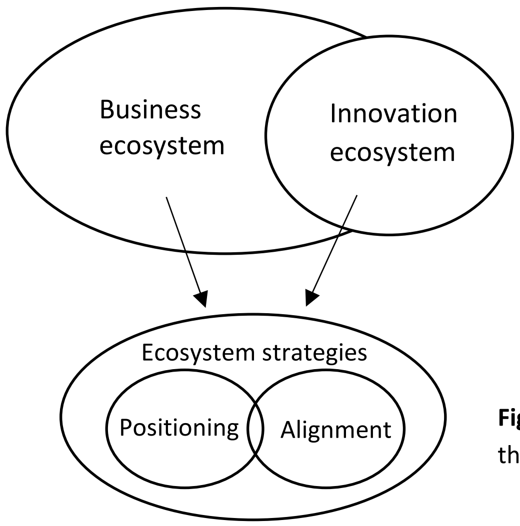

Figure 1 Relation between concepts in the theoretical framework. (own creation)

Subsequently, The concept of ecosystem strategies was explored and five methods/activities related to positioning and alignment were identified in the literature. These findings have been summarized in the following framework:

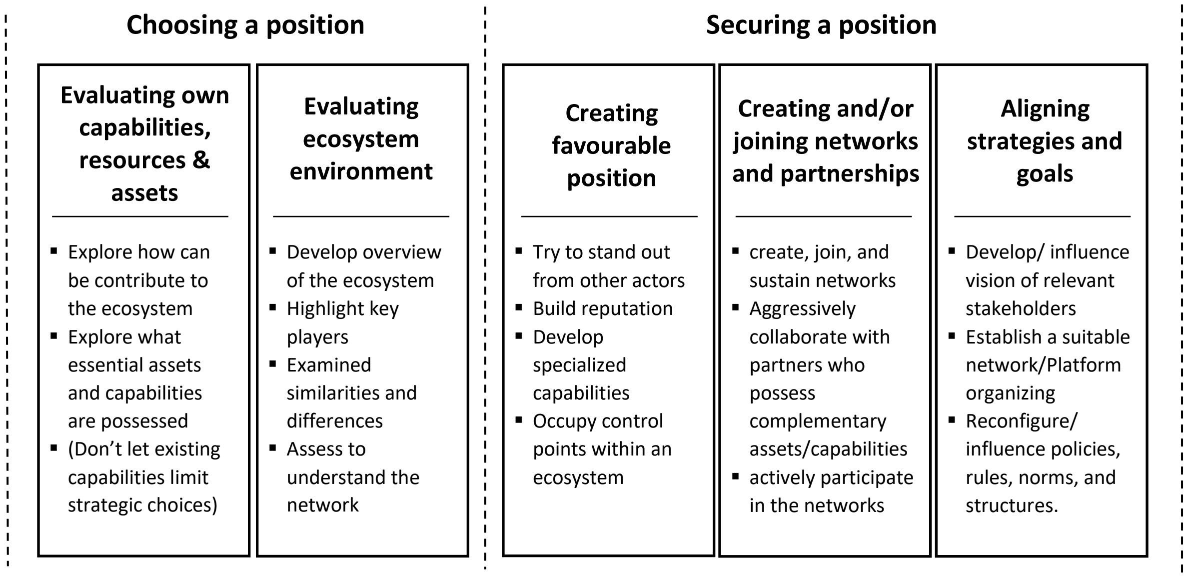

Figure 2 Theoretical framework for ecosystem positioning activities. (own creation)

While many of the activities of this framework are relevant to both the keystone and contributor positions, this framework primarily focuses on activities related to contributor positions. This is because the contributor role is the most likely one for a medium-sized energy company within the green hydrogen ecosystem in the Netherlands, as explained previously. Furthermore, although the five activities/methods are presented in a logical sequence, it does not mean that they should be performed only once in a linear order. As the development of an ecosystem strategy is an iterative process that should be constantly re-evaluated while the emerging ecosystems develops (Adner, 2006).

To conclude, this framework (figure 2) can aid in gaining a deeper understanding of the ecosystem environment and the strategies of the various stakeholders within it. Eventually, it can serve as a guide in formulating an effective ecosystem position strategy for a medium-sized energy company within the emerging green hydrogen ecosystem in the Netherlands.

3 Methodology

3.1 Research design

With the main research question "*How can a medium-sized energy company effectively position itself within the emerging green hydrogen* ecosystem in the Netherlands?", The focus of this thesis is twofold: firstly, to comprehend the strategic dynamics of this emerging ecosystem, and secondly, to explore and propose effective positioning strategies for medium-sized energy companies within this emerging ecosystem. These two foci are reflected in the four sub-questions for this research. The first two sub-questions are:

SQ1: What are the potential future scenarios for the emerging green hydrogen ecosystem in the Netherlands?

SQ2: How do the various (potential) stakeholders strategically position themselves, interact, and approach ecosystem development within the emerging green hydrogen ecosystem in the Netherlands?

In line with the first focal point of this thesis, the aim of these initial two sub-question was to analyse and understand the context, dynamics, opportunities, and competitive and cooperative landscape of the emerging ecosystem. While in some areas, the context and scope of a medium-sized energy company were considered, overall, a broad view of the ecosystem was purposely applied to form a complete understanding of the ecosystem environment.

After having acquired a thorough and comprehensive understanding of the ecosystem environment, the research progressed to the second focal point of this thesis, and specifically focussed on the context of a medium-sized energy company. The aim here was to infer, apply and verify the lessons learned from the initial two sub-questions. For the final sub-question, the lessons learned were applied within the context of the representative case of Powerfield Netherlands B.V. (see 3.3.1 Description of representative case). A workshop was conducted with the aim of validating previous findings and extracting new valuable practical insights in the process. These goals of the second focus resulted in the following sub-questions:

SQ3: What are potentially effective ecosystem positioning strategies for a medium-sized energy company based on the ecosystem analysis?

SQ4: How can PowerField Netherlands B.V. effectively position itself within the emerging green hydrogen ecosystem in the Netherlands?

Through these four sub-questions, the research follows a convergent path. Initially, a broad yet comprehensive understanding of the overall emerging green hydrogen ecosystem in the Netherlands is gained. This is followed by a detailed exploration of the implications of this ecosystem environment for a medium-sized energy company. Ultimately, these steps enable the formulation of conclusions for the main research question.

3.2 Methodology

The method chosen to answer the research questions is a qualitative embedded case study approach (Yin, 2014). For this embedded case study the unit of observation is the emerging green hydrogen ecosystem in the Netherlands, while the units of analysis are the (potential) stakeholders of this emerging ecosystem.

As the ultimate aim of this research is to explore the positioning strategies and approaches for an ecosystem that is still in the process of establishment, a qualitative research approach is considered appropriate due to the complex and dynamic nature of this developing industry. In addition, quantitative methods may lack sufficient data and might not be sufficient to capture the nuanced insights needed to understand the various positioning strategies and approaches (Yin, 2009). With this qualitative approach, empirical material (instead of numbers) is used (Flick, 2018a) such as interviews and documents. By means of the analysis of these qualitative sources there is aimed to gain a comprehensive understanding of the diverse perspectives and motivations of key stakeholders in this dynamic sector. Eventually, the intention of the qualitative approach is to produce knowledge that is practically relevant, which means relevant for producing or promoting solutions to practical problems (Flick, 2018a).

Furthermore, the nature of a case study is considered suitable for this research question, as it is a research strategy that focuses on understanding the dynamics present within a single setting. (Eisenhardt, 1989) and allows to explore the particularity, the uniqueness, of the single case (Simons, 2009), such as the emerging green hydrogen ecosystem. An embedded case study provides the right framework for understanding the dynamics of this case as it includes units of analysis at more than one level (Yin, 2014), which, in this specific case, relates to various types of stakeholders. Furthermore, case studies are considered to be effective in answering "how" and "why" questions (Yin, 2014) because they combine various data collection methods (e.g., interviews, documentation, etc.) and numerous levels of analysis (Eisenhardt, 1989). As a result, the selected qualitative embedded case study approach is anticipated to provide a rich picture and be able to capture and comprehend the complex environment in depth in order to produce relevant practical knowledge in positioning strategies.

Having outlined the research design and methodology for this thesis, the remainder of this chapter outlines the scope and boundaries of the case study in the case description. This including a detailed description of the representative case: PowerField Netherlands B.V. Following this, the data collection process, analytical approach, and the measures taken to ensure reliability and validity of this research are elaborated upon.

3.3 Case description

As mentioned above, the unit of observation for this case study is the emerging green hydrogen ecosystem in the Netherlands. More specific, the vast network of various actors that is forming, aligning and realigning alongside the emergence of the green hydrogen industry in the Netherlands. 'Realigning' because currently a hydrogen industry, and its corresponding ecosystem, does already exist. however, this current hydrogen industry is supplying 'grey' hydrogen, which is hydrogen produced using fossil fuels. The transition to supplying green hydrogen demands distinct technologies and innovations, thereby involving a different set of actors. This signifies the emergence of a new ecosystem, rather than merely the transformation of the old one. Besides, the anticipated increase in demand because of the greening of other sectors, such as heavy industry and mobility, underlines the transformation that is happening and the development of a new ecosystem.

In defining the scope of this study, a clear boundary was placed around the supply chain ecosystem of green hydrogen in the Netherlands, focusing specifically on the green hydrogen production steps, starting from the production of green energy, to the hydrogen production plant, until the hydrogen is ultimately delivered to the end user. During the initial analysis steps, the precise boundary and classification of ecosystem actors are established. Although the new technologies, innovations and involved actors reach far beyond the boundaries of the supply chain, such as in the technology development for large scale electrolysers or the innovations in hydrogen applications, the supply chain focus was chosen as an appropriate scope for medium-sized energy companies, as their primary focus is to benefit from providing green hydrogen through the use of renewable energy sources. The aim of establishing this scope is to arrive at a comprehensive answer to the research question by focusing on the boundaries relevant to the context of medium-sized energy companies.

As a final boundary for this study the timeline considerations are included. The focus is on the emerging phase, which ranges from a new solution being proposed, to a simple supply chain being produced (Rong, 2011). The goals stated by many reports (Missie H2 & TKI Nieuw gas, n.d.; National Hydrogen Programme, 2022) is to have a functioning green hydrogen industry in the Netherlands by 2030. This would mean the industry will have passed the emerging phase by then. Therefore, this study will focus on the position activities and strategies to secure an effective role at least before 2030.

As outlined in the research design, this study incorporates both an exploration and verification step in a practical context, conducted through a workshop involving a representative case study. In the following section, a detailed description of the representative company and its current situation is presented. While this representative case only becomes highly relevant when addressing the forth research question, the description below assists the reader in developing a better understanding of a medium-sized energy companies characteristics and its context. This might benefit the reader as the research begins with a broad ecosystem scope.

3.3.1 Description of representative case

PowerField Netherlands B.V., hereinafter referred to as PowerField, is a Dutch-based green energy company that strives for smart and innovative energy solutions. Currently, PowerField is specialized in the development and management of solar parks, charging stations, and power storage systems and is actively looking into other energy system solutions. PowerField’s team consists of 50+ employees. However, PowerField is currently undergoing rapid growth, transitioning from a startup to a scale-up following a €500 million capital injection.

Established in 2019 by two founders, PowerField is a young company. However, it stems from the company "Zonneperceel", established in 2016, which focused on acquiring land, developing solar parks, and subsequently selling these parks. In 2018, one of the two owners, now CEO, acquired the stake of the other. In the following phase, PowerField started to retain and manage the solar parks, and trading and selling green energy. In 2020, the business expanded with the subsidiary PowerGo, which develops and manages (fast) charging stations for battery electric vehicle, with 100% green energy linked to PowerField’s solar parks. The PowerGo subsidiary is currently experiencing rapid growth. Recently, PowerField has also started developing battery systems coupled to their solar parks to better respond to the fluctuating energy price and demand. These initiatives are driven by the company's commitment to ongoing innovation within the renewable energy sector, aiming for practices that are efficient, sustainable, locally engaged and social responsible. Ultimately, they aspire to achieve their future goal to "build the largest Virtual Power Plant in Europe in the coming years" (PowerField Netherlands B.V., n.d.).

As mentioned previously, PowerField’s operations are executed by a team of 50+ employees. The team is divided into five business units: (1) ‘PowerField Netherlands Group’ which manages all underlying business units, (2) ‘PowerField Solar’ which executes the solar park operations, (3) ‘Power Storage’ Which executes the battery system operations, (4) ‘PowerGo’ which execute all charging station operations, and (5) ‘PowerField Energy’ which is engaged in energy trading. In the recent past these departments showed a loose and overlapping internal structure. However, PowerField’s transition to the scale-up phase is leading to an increase in employees and the establishment of more formal structures and departments within the organization.

While internal structures and processes are still in the process of formalization, the organization has successfully established its core competency. These core competency lie in the specialized knowledge on the development of green energy systems, including various associated matters such as real estate acquisition, navigating the licensing process, and fostering connections with key, local, stakeholders. Collectively, these core competencies, the organizations track record, and the exclusive focus on renewable energy solutions has led to the trust of major investors to support the goal of PowerField Netherlands B.V. Therefore, at the end of 2022, PowerField Netherlands B.V. has succeeded in obtaining a substantial capital injection of €500 million. This capital was secured through a loan arrangement with EIG, a prominent institutional investor in the global energy and infrastructure sectors, and LBBW, one of Germany's largest banks. Because the capital was acquired through a loan arrangement, the founder and CEO remains the sole owner.

Following this investment, to support the ongoing efforts to build the largest virtual power plant in Europe, PowerField has expressed interest in (co-)developing and (co-)owning a hydrogen production facility. They perceive the greening of the industry through the use of hydrogen as a new business opportunity to expand their portfolio. PowerField has not yet established a separate business unit specifically for the development of a green hydrogen production facility; currently, this responsibility falls under the operations of the PowerField Solar business unit. Concurrently, PowerField has not developed or acquired internal capabilities related to hydrogen yet. However, they do have initial contact with other actors and provided a letter of intent to develop a green Power-to-Gas (P2G) hydrogen supply chain.

The case of PowerField is considered to be a suitable representative case for this research. PowerField has the capabilities, resources and experience to expand their operations with a new green energy solution. With little over 50 employees, the company falls well within the medium-sized classification. Being a medium-sized company comes with the lack of the market power or coverage to immediately be a dominant player in the ecosystem. Nevertheless, PowerField has clear intentions to become involved in the ecosystem. Therefore, PowerField embodies the specific type of company that is central to this research, for whom understanding the ecosystem's structures and development, and formulating effective ecosystem strategies, is highly relevant.

3.4 Data collection

This section outlines the different sources and methods of data collection used for this research. Multiple sources were used with different purposes in order to compile the data needed to answer the research question. The sources used include the field notes of an attended Dutch hydrogen network event, analysis of documents and websites, open expert interviews, semi-structured stakeholder interviews, and an interactive workshop.

To centralize all gathered data effectively, a case study database (Yin, 2014) was established. This database is a structured computer folder where fieldnotes, documents, and transcripts are systematically gathered. This enables easy access to all collected data and, when relevant, facilitates convenient sharing. An overview of the case study database is presented in Appendix II.

3.4.1 Hydrogen event

On June 22nd 2023 the researcher attended a Dutch hydrogen network event "Waterstof event Nederland" organized by Management Productions in partnership with Dutch energy company Essent. The event was attended by over 100 participants, a majority of whom held senior positions, representing the key organizations central to the advancement of the green hydrogen ecosystem in the Netherlands. Throughout the event, a series of presentations and discussions were conducted by prominent researchers and practitioners deeply involved in the Dutch hydrogen landscape. The five sessions attended by the researcher are presented in Appendix II.1.

The main purpose for attending the event was for the researcher to gain an understanding of the current status of the hydrogen ecosystem's development in the Netherlands and to experience the dynamics between the prominent stakeholders. Throughout the event, the researcher compiled field notes containing relevant quotes and statements from participants holding significant and relevant roles. These quotes and statements were handled with care by distinguishing between factual information and expert opinions. Ultimately, these field notes were included into the case study database facilitating their utilization in the analysis process in order to draw accurate conclusions.

3.4.2 Document & website analysis

The second data collection method employed for this thesis involves the analysis of various official documents and organizational websites. Document analysis as a data collection method involves a structured process of examining and assessing documents, encompassing both physical and digital forms, including computer-based and online content (Bowen, 2009). This method of data collection is particularly applicable to qualitative case studies producing rich descriptions of a single phenomenon, event, organisation, or program (Bowen, 2009). For a case study the most important use of documents is to corroborate and augment evidence from other sources (Yin, 2014). The analysis of documentations is valuable herein as they offer a stable, unobtrusive, specific, and broad source of information (Yin, 2014). However, while documents can be a rich source of data, they were treated with caution and not taken as literal facts (Bowen, 2009). Each document was carefully examined to determine its specific purpose and intended target audience. By consistently striving to identify these objectives the likelihood of misinterpretation of the documentary evidence is reduced while enhancing the likelihood of accurately and critically interpreting the contents of such evidence (Yin, 2014). The documents that were analysed for this thesis are listed in table 2. All of which were accessed in the period between April and November 2023. Detailed descriptions of the identified purpose, target audience, and the manner in which the documents were utilized for this thesis are available in the case study database (Appendix II.2).

Document title	**Organization**
Hydrogen roadmap Netherlands	NWP
Renewable energy directive II	EU
EU delegated regulation: detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin	EU
Hydrogen Guide - A Guide to the Dutch Hydrogen Chain.	TKI nieuw gas
Innovation agenda hydrogen	TKI nieuw gas
Hydrogen map	Missie H2 & TKI nieuw gas
Electrolysers - Opportunities for the Dutch Manufacturing Industry.	TNO
Potential cases for electrolysis as solution for grid congestion	TNO
Hydrogen event presentation slide decks	Various
Organizational websites	Various

Table 2 List of analysed documents. (Own creation)

These documents were selected because they are considered to be an accurate and complete representation of the plans and goals of some key central stakeholders for the emerging green hydrogen ecosystem in the Netherlands, or provide accurate information from a regulatory organization (EU). Like other analytical methods in qualitative research, document analysis requires that data to be examined and interpreted in order to elicit meaning, gain understanding, and develop empirical knowledge (Bowen, 2009). These document were analysed through meticulous reading, involving the identification, examination, and interpretation of specific goals, targets, and regulations established for the advancement of the green hydrogen ecosystem in the Netherlands.

Deviating in method and purpose from the selected documents was the analysis of organizational websites. These websites were analysed with the purpose of developing an overview of the types of actors that are currently present in the business environment. A total of 97 organizations related to hydrogen developments were collected. These websites underwent analysis through skimming to ascertain the goals and practices of each specific organization, which were then compiled in an Excel file (see Appendix IV). This process continued until a distinct pattern of stakeholder categories emerged.

3.4.3 Open expert interviews

The third data collection method utilized for this thesis involved conducting open expert interviews. Interviews in general are an essential source of case study evidence as most case studies are about human affairs or actions (Yin, 2014), expert interviews specifically are also considered a standard qualitative research method (Flick, 2018b). In this thesis the expert interviews are used as an exploratory tool (Flick, 2018b) preceding the main method of data collection (3.4.4 Semi-structured stakeholder interviews). These exploratory interviews with experts were conducted as openly as possible, in order to make it possible to gather unexpected information and interpretations (Flick, 2018b). By adopting this open approach to the expert interviews, they could serve to establish the initial orientation within the complex field of green hydrogen in the Netherlands and could help to identify potential positioning opportunities at an early stage in the research process (Flick, 2018b).

In this case 'experts' are considered to be individuals possessing specialized knowledge and experience (Flick, 2018b) related to the development of the green hydrogen ecosystem in the Netherlands, encompassing both technological aspects and the intricate network development. In addition, the interviewed experts are able to exercise power within the social contexts of the green hydrogen ecosystem's development in the Netherlands by applying their special knowledge (Flick, 2018b). This combination of specialized knowledge and social relevance makes them suitable for the explorative purpose of the open expert interviews.

The individuals that were interviewed for this thesis were selected using a purposive sample. This means the interviewees were carefully selected based on their positions and expertise, aiming to gather insights from those who were most likely to provide comprehensive insights into the subject at hand (Simons, 2009). The process of selecting new experts for interviews continued until no further new information emerged, signifying that saturation had been attained. This occurred at the third expert interview. The three conducted expert interviews are presented in table 3.

	Position	**Organisation**
1	Hydrogen advisor	RVO (Netherlands Enterprise Agency)
2	Hydrogen expert & Business development manager green hydrogen	TNO (Netherlands Organization for Applied Scientific Research)
3	Director	TKI Nieuw Gas (Top consortia for Knowledge and Innovation, new gas)

Table 3 Conducted open expert interviews. (Own creation)

All three interviewees were selected due to their interpretive knowledge (Flick, 2018b) in the subject matter, as well as either their specific technical or process knowledge (Flick, 2018b) – or both.

- The first interviewee was selected for his knowledge about the entrepreneurial network, developments and opportunities (Process knowledge), specifically from a governmental perspective. The topics discussed during the interviews included: Current market and projects, Business cases and opportunities, Regulations and support (subsidies), Establishment of the National supply chain, and the associated knowledge networks.
- The second interviewee was selected for his technical knowledge related to the green hydrogen innovation ecosystem. The focus of this interview was to delve into the technical challenges and opportunities related to the specific activities necessary for establishing the green hydrogen supply network. Additionally, the interview discussed topics such as the creation of the Dutch (hydrogen technology related) manufacturing industry and the associated knowledge networks.
- The third interviewee was selected based on his extensive network and the timeliness of his knowledge regarding green hydrogen projects, advancements, and innovation agenda (technical & process knowledge). The interview began with a brief discussion that encompassed a broad scope of emerging ecosystem dynamics regarding the establishment of the national hydrogen value chain. It then advanced to a more specific set of topics, including specific business opportunities and challenges with associated current examples, decentralized production and local ecosystems, strategic partnerships, timeline considerations, and the motives behind hydrogen projects (profitability vs. knowledge development).

The interviews lasted for approximately 1 hour and were carried out via Microsoft Teams video calls. The entire conversation was recorded in audio format and subsequently transcribed. The transcripts serve as the resource for analysis. From these transcription valuable quotes and insights were identified and utilized during the further analytical steps, using the method outlined in section 3.5 Analytical approach. During the analysis of the last interview, although the more targeted topic questions led to certain new and specific insights, all the findings continued to either reinforce or verify previous discoveries. As a result, there was determined enough evidence was collected to proceed (Yin, 2014) with the more targeted stakeholder interviews.

3.4.4 Semi-structured stakeholder interviews

The fourth and main method for data collection of this thesis, especially to address the second sub-question, consisted of conducting semi-structured stakeholder interviews. These stakeholder interviews were considered to be a highly effective method of collecting data to answer the research question. By directly engaging with the stakeholders who shape and influence the ecosystem's development, this approach allows to collects targeted and insightful data (Yin, 2014). Because of this targeted and insightful nature of stakeholder interviews these kind of qualitative interviews are widely used across disciplines as a primary research method (Flick, 2018b).

It was chosen to use a semi-structured approach to the interviews. For these semi-structured interviews, the interview topics were identified by the researcher but organized in a less tightly format (Flick, 2018b). The same topics formed the basis for questioning between interviews, yet the sequencing of the questions was participant-led (Flick, 2018b). Subsequent to these initial questions, room was intentionally left for follow-up questions, these were formulated relative to what interviewees had already said with the aim to generate free-ranging conversations (Flick, 2018b). This approach enabled the researcher to maintain a consistent focus across all interviews, while also allowing for flexibility to uncover more specific insights based on the individual participants. The topics selected for the interviews started with forming a general understanding of the organization through questions regarding the 'Organization's characteristic and hydrogen strategy', followed by two main topics identified form the literature. These topics are: 'Ecosystem roles' and 'Positioning & Alignment strategies & activities'. A visual representation of the topic guide in presented below in figure 3.

As a preparation for the interviews an interview protocol was created. This protocol included an standardized participation request and an informed consent form for the interviewee and an interview guide for the researcher (see Appendix I). Formulating the interview guide involved generating the topic guide along with associated questions that are likely to yield insights that speak to the research questions posed (Flick, 2018b). During each interview this interview protocol was applied to ensure consistency throughout the data collection process.

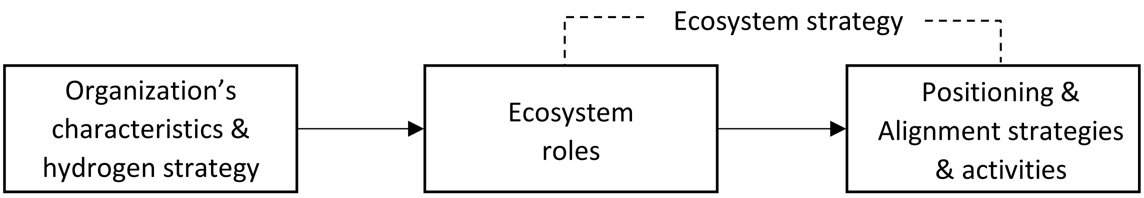

Figure 3 Topic guide for the semi-structured interviews. (Own creation)

As with the open expert interviews, the interview selection was done using a purposive sample (Simons, 2009). The primary consideration for selecting stakeholders for interviews was to ensure coverage of various stakeholder types. The classification of the various stakeholders types used for this research was developed for the first sub-question and is substantiated in 4.1.2 Actors. Following the initial rounds of interviews, key stakeholders were identified, and subsequent 'Expanding interviewees' were selected based on their potential to provide the most relevant information. This process continued until saturation was achieved. This resulted in a total of 16 interview, presented in table 4. A more detailed interviewee overview can be found in Appendix II.4.

	Stakeholder type	Company description
1	Energy Major	Oil major
2	OEM	Major energy technology manufacturer
3	OEM	Electrolyser manufacturer
4	Infrastructure	National grid operator gas
5	Infrastructure	National grid operator electricity
6	(Potential) Hydrogen producer	Renewable energy investor
7	(Potential) Hydrogen producer	Industrial gas supplier
8	(Potential) Hydrogen producer	Green hydrogen energy company
9	User: Industrial	Salt miner and processor
10	User: Industrial	Advanced biorefining
11	Governmental organization	Ministry of economic affairs & climate
12	Governmental organization	Netherlands Enterprise Agency
13	Knowledge institute	University
14	Industry association	National hydrogen Industry association
15	Area developer	Port authority
16	Consultancy firm	Subsidy and innovation consulting firm

Table 4 Conducted semi-structured stakeholder interviews. (Own creation)

The interviews were conducted in the period from 07-09-2023 until 17-11-2023. The interviews lasted for approximately 1 hour and were carried out either in person or via Microsoft Teams video calls. The entire conversation was recorded in audio format and subsequently transcribed. The transcripts were incorporated into the case study data base and analysed using the approach outlined in 3.5 analytical approach.

3.4.5 Workshop

The last method employed for data collection involved conducting a workshop with a small group of experienced individuals in key positions at the representative medium-sized energy company, PowerField Netherlands B.V. The workshop aimed to validate and refine the preliminary conclusions drawn from the results of sub-questions 1 and 2, presented in 4.3 Inferences for ecosystem positioning strategy, by linking and discussing the findings within a practical and representative context with experienced individuals. A Workshop can be an effective method for such a validation step, as it is recognised as a research method that can validate data already collected through interviews (Storvang et al., 2018). Workshops themselves are defined in different ways: A group discussion of an issue, a brainstorming and organizing session in a group, a meeting that is longer than usual, a public forum providing information or discussing an issue and a conference where many experts give presentations (Standfield, 2002). The conducted workshop for this data collection step was set up as a brainstorming session, facilitating an open and creative discussion that enabled the participants to share their tacit knowledge (Storvang et al., 2018).

The participant selected for the workshop session, as previously noted, consisted of experienced individuals in key position in the company. This included the CEO, CTO, COO, New Business development manager, ESG manager, and two experienced project managers. The workshop session took 1 hour, beginning with a concise 15-minute presentation by the researcher. This presentation provided an overview of the research goal, methodology, and presented the findings from research questions 1 and 2. The remaining 45 minutes were dedicated to an brainstorm discussion related to the preliminary conclusions, proposed by the researcher. The slides utilized to facilitate the workshop are included in Appendix VI.

The brainstorm discussion was structured following the theoretical framework for ecosystem positioning activities (Figure 2). For each block, a dedicated slide was created in which the researcher briefly explained the insights and conclusions obtained. Subsequently, participants were probed with questions such as, "Do you recognize these positioning activities in your network?" "Are you currently performing such activities?" "Do you recognize the potential effects of these proposed activities?" and "How would you respond to these insights?" After having asked some initial questions and follow-up questions the researcher allowed for a natural open discussion between the participant where specific strategies and/or opportunities could arise. These open brainstorm discussions were allowed to continue until no new insights were discussed or the topic strayed. At this point, the research suggested to move on to the next block.

The entire session was audio recorded and transcribed, allowing for an analysis of the generated insights. Eventually, these insights were applied in the research process to validate and finetune the conclusions.

3.5 Analytical approach

To arrive at a valid and reliable answer to the research question, the collected data was subjected to an analytical process. The chosen analytical approach for this research is a thematic analysis (Guest et al., 2012). This approach involves a systematic reduction and analysis of the collected data. It employed a formal inductive process, breaking down the textual data into segments. These segments were systematically categorized, labelled, and ordered as codes. This process, called 'coding,' is the act of associating specific labels or ‘codes,’ with particular data segments. ‘Codes’ can be defined as "a textual description of the semantic boundaries of a theme or a component of a theme" (Guest et al., 2012). These codes were then examined to uncover connections, patterns, and propositions that seek to explain the data though the emergence of themes (Simons, 2009). This inductive analysis approach was chosen for its primarily descriptive and exploratory orientation (Guest et al., 2012), which was considered suitable for addressing the research question. By rigorously applying this approach there was aimed to elicit meaning, gain understanding, and develop empirical knowledge from the bulk of textual data (Bowen, 2009) in a way that is transparent and credible (Guest et al., 2012).

The thematic analysis process was conducted iteratively throughout the data gathering period. In the initial stage, the transcribed texts were familiarized, and the noteworthy, revealing segments were coded. For this initial coding process an approach called structural coding (Guest et al., 2012) was used. This involved using the themes from the interview guide as the starting point to establish the initial set of codes. These initial themes encompassed ecosystem roles, specific networks and communities, positioning and alignment strategies and activities, innovation efforts, and other intriguing or unexpected mentions. Following the initial stage of interviews and their analysis, new expanding interviews were selected, conducted, and analysed in an iterative manner, expanding the collection of codes. Periodically, the collection of codes and associated themes were examined to identify the emergence of new themes or to restructure or refine the current ones. This iterative interview and analysis process is schematically depicted in figure 4.

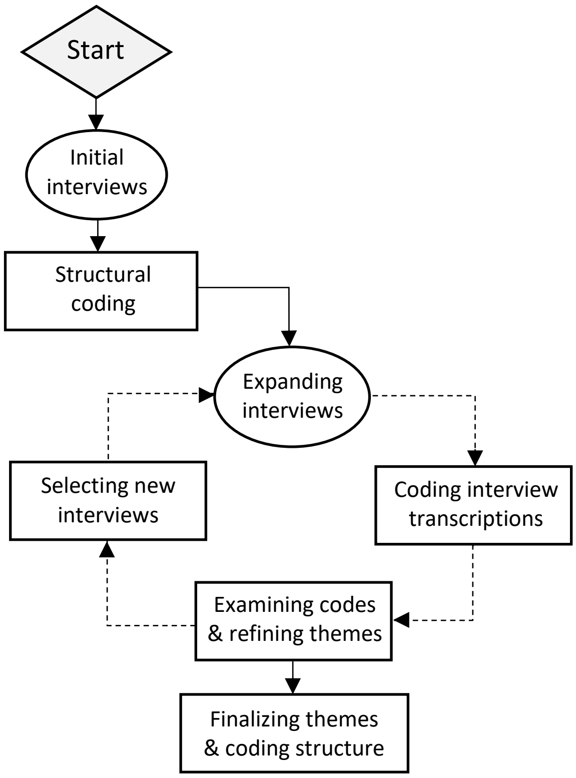

Figure 4 The iterative interview and analysis process. (own figure)

Following this approach, a total of 16 interviews were conducted and analysed, spanning across 4 iterative rounds. The process of examining codes and identifying and/or refining themes involved grouping, combining, restructuring, renaming, and splitting of codes, occasionally reviewing analysed transcriptions. After processing all the codes derived from the interview transcription, these individual codes constitute the first-order concepts of this analysis process. Following the final examination of these codes, they ended up into 25 second-order sub-themes. These sub-themes were further finalized into the nine aggregated themes, forming the basis for constructing the narrative that addresses the results of the second sub-question. The resulting narrative is presented in 4.2 Stakeholder dynamics within the emerging ecosystem, and the final coding structure is presented in Appendix V.

3.6 Validity & reliability

This subchapter elaborated on the efforts made to ensure validity and reliability of the case study results. This is discussed in four different categories: Construct validity, internal validity, external validity and Reliability (Yin, 2014).

3.6.1 Construct validity

Construct validity relates to setting the correct operational measures for the concepts being studied (Yin, 2014). In this study there is a focus on the ecosystem constructs and the stakeholder dynamics. In order to gain an accurate and valid understanding of these concepts, different data sources were used to triangulate the findings. This way, if the same trends and themes emerge within data from different data collection methods, the validity of the findings is substantially increased (Guest et al., 2012). The different data collection methods were considered to complement the others or to compensate for the weaknesses (Patton, 2002). The hydrogen event offered initial insights into the current state and business climate of the Dutch green hydrogen ecosystem. Document and website analysis provided accurate information on development plans, factual information from studies, or regulatory details. Expert interviews allowed to explain the overall context of the ecosystem through their expert views. Stakeholder interviews provided a more in-depth perspective on the dynamics within the ecosystem. The workshop allowed to validate the findings in the context of an specific representative case. Overall, these operational measures combined are considered to reflect the correct concepts by triangulating multiple points of reference of the same emerging ecosystem, allowing to minimize the influence of biases or outliers.

One aspect that needs consideration for construct validity is the competitive aspects surrounding ecosystem stakeholders. While the anticipation is that false information will not be provided, there is an anticipated risk of obtaining an incomplete view of the ecosystem's aspects and dynamics, particularly concerning confidential information. This risk is mitigated by conducting multiple interviews with diverse stakeholder groups to gather multiple perspectives. In addition, confidentiality is further ensured through the informed consent form. However, this risk needs to be considered throughout the study.

3.6.2 Internal validity

For internal validity, it is crucial that the study's conclusion, derived from the obtained data, is valid (Yin, 2014). To ensure the internal validity of this study, the data collection method and analytical approach were rigorously followed, using established coding process and a thematic analysis approach (Guest et al., 2012). The interviews were precisely transcribed and thoroughly reviewed by the researchers. The transcriptions were coded using the digital program Atlas.TI, providing an clear overview of the encoded data. Atlas.TI facilitated efficient and adaptable analysis of the codes, contributing to the formation of themes. Ultimately, this facilitated the development of the coding structure and the crafting of the narrative, supported by various quotes to reinforce the themes and interpretations (Guest et al., 2012). By rigorously following the analytical approach and presenting substantiated results, an attempt was made to ensure the internal validity of this study.

3.6.3 External validity

External validity concerns the generalizability of the findings within the defined domain (Yin, 2014), in this case within the domain of ecosystem strategies. By constructing the theoretical framework that incorporates theories from both business and innovation ecosystems, and by specifically formulating and applying the theoretical framework for ecosystem positioning activities (see Figure 2), an effort was made to contribute to and expand upon the existing literature. Utilizing these pre-existing constructs may enhance theoretical generalization within the defined domain, even though this study focuses on a specific case. This highlights the efforts made to ensure the external validity of this study.

3.6.4 Reliability

To enhance the reliability of this study, deliberate efforts were made in developing a transparent, consistent and rigorous research design and methodology. The data collection phases was thoroughly elaborated on in chapter 4.3 Data collection, for the semi-structured stakeholder interviews specifically an interview protocol was developed (see Appendix I) to ensure the consistency of the collected data. A transparent overview of case study evidence was established through the formation of the case study data base (see Appendix II). Utilizing these clear and standardized protocols for data gathering, presenting a comprehensive overview of the gathered data, and elaborating on the systematic approach to coding and thematic analysis, has provided a transparent and replicable research process. These efforts contribute to the overall reliability of the study.

4 Results

In this chapter the results from the research conducted as described in chapter 3 are presented. The four subchapters in this chapter stem from the four sub-questions presented previously. The first subchapter presents the insights into future ecosystem scenarios. These findings mainly come forth from the exploratory research steps: the Hydrogen Event, Document Analysis, and Expert Interviews, and were occasionally refined and substantiated by insights from stakeholder interviews. In the second subchapter the dynamics between the various (potential) stakeholders are discussed. These finding rely heavily on the semi-structured stakeholder interviews. In the third subchapter the preliminary conclusions on potentially effective ecosystem positioning strategies, inferred from the results of sub-question 1 and 2, are presented. Finally, the implications of these findings are discussed in the context of the representative medium-sized energy company; PowerField Netherlands B.V. These insights were obtained from the conducted workshop.

4.1 Future ecosystem scenarios

In this subchapter the findings on the future scenarios for the green hydrogen ecosystem in the Netherlands are discussed. What initially stood out during discussions on the future ecosystem scenarios with various stakeholders and hydrogen experts, as well as when analysing documents, is a general consensus on the potential and envisioned future of the green hydrogen industry which is being developed in the Netherlands. In addition to the general consensus, several sources highlighted the distinctive “positive vibe” surrounding the plans to build a green hydrogen industry in the Netherlands. These initial findings emphasizes the common cohesion in the Dutch economy and indicates a willingness to collectively cooperate to develop this shared future scenario. The general shared goals of this future scenario are well reflected in the document ‘Hydrogen Roadmap Netherlands’ by the National Hydrogen Programme (2022), which is a joint initiative between industry, government and industry associations. However, when delving deeper into the development of various aspects and the associated timelines, it reveals that there is a lesser degree of consensus about how the development of the specific aspects will unfold, or how they should be developed.

The general future scenario of the green hydrogen ecosystem in the Netherlands will be discussed in this chapter using the ecosystem-as-structure framework. In addition to the coherent aspects of the future scenario, several consideration will be addressed where there exist discussion. Following the ecosystem-as-structure approach, the initial step is to define the value proposition that is central to the green hydrogen ecosystem. This main value proposition of hydrogen is the ability to decarbonise processes (Vidas & Castro, 2021), however the resource is very versatile and can be produced, handled and applied in various ways as describes in this quote by Sgarbossa et al. (2023):

> *"Hydrogen can be produced in large volumes in a centralised production facility or in small volumes in local systems. Depending on the geographic location and types of applications, hydrogen can be stored in different forms, and thus transported via different logistics means, such as trucks, pipelines, compressed tanks, liquified tanks, etc. Storage is paramount in operating renewable hydrogen supply chains. In fact, hydrogen can be seen both as a final product and as an energy carrier, for example, to store electricity, both in terms of time and space. On the one hand, hydrogen storage can be used strategically to shift demand and supply across seasons, while on the other hand, storage is also used as a buffer for smoothing short-term supply and demand mismatches due to operational uncertainty."* (Sgarbossa et al., 2023)

While green hydrogen shows a promising value and versatility, an important barrier to mention in the establishment of the green hydrogen industry in the Netherlands is the high cost price to produce hydrogen. This results in the current situation where the industry cannot take off independently, as multiple sources have noted that a hydrogen production project currently requires governmental financial support for realization.

Having touched upon the general value proposition and the main barrier for the establishment of the green hydrogen ecosystem in the Netherlands, the following sections will discuss the basic elements of an ecosystem; activities, actors, position, and links, in relation to the future scenario of the green hydrogen ecosystem in the Netherlands.

4.1.1 Activities

One of the key factors that all sources seem to agree on are the activities that need to be performed to create a functioning green hydrogen industry and thus the realization of the value proposition. While there is not full agreement on how and by whom the activities should be performed, there seems to be a consensus that they need to be carried out in one way or another. These specific activities that need to be performed for the green hydrogen ecosystem to be fully established are depicted in a flow diagram in figure 5.

This range of activities also reflects the focus of the Netherlands, as mentioned by one of the hydrogen experts:

> *"Our focus as the Netherlands is on creating the entire hydrogen value chain. So, it's not just about investing in the electrolyser or fuel cell; we are simultaneously exploring whether we can connect hydrogen production with the generation of sustainable electricity, for example, offshore through wind. Can we deploy electrolysers for this purpose? Can we use that hydrogen in the industry to*

make it more sustainable? Can we convert our natural gas network to hydrogen to supply it to Germany? At the same time, can we develop our manufacturing industry? But can we also consider importing hydrogen? So, in a way, we are involved in various strategic moves. It's not a matter of choosing between producing it ourselves or importing it; we are pursuing both. We will convert our gas storages, lay down the infrastructure, foster industrial activity, ensure the development of policies, support, financing, and so on."

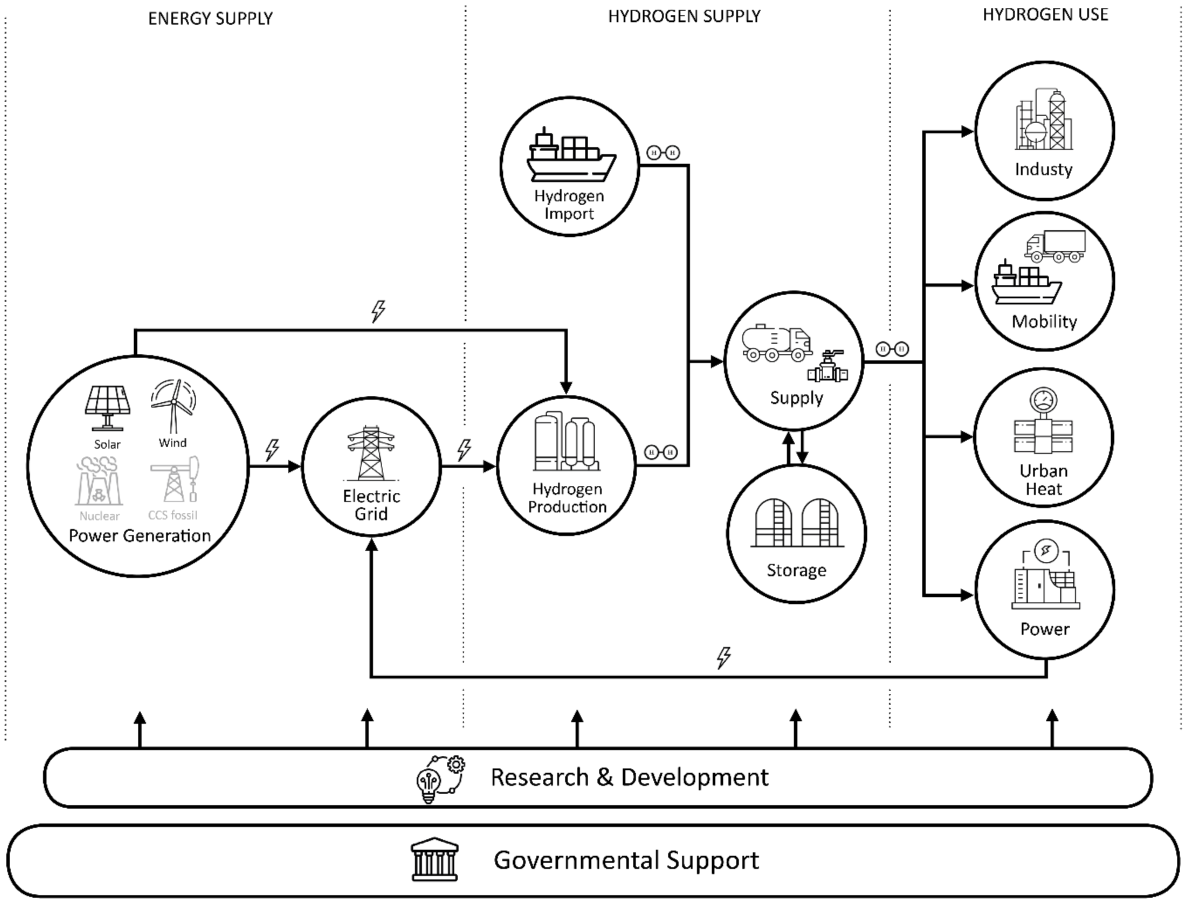

Figure 5 Flow of activities for the renewable hydrogen supply chain.
(Own creation, adapted from Vidas & Castro (2021))

As a result of this wide development focus in the Netherlands, an intricate and tumultuous environment has emerged. While highly relevant for strategy development, the current dynamics lie beyond the scope of the future ecosystem scenario. Some of the key takeaways, however, are highlighted in Appendix III. This section is concluded with three key takeaways from the necessary activities that are central to the future ecosystem scenario:

- The Dutch government aims to have 3 to 4 GW of electrolysis capacity, providing a production of 80 PJ of renewable hydrogen domestically by 2030. The remainder of the hydrogen demand is expected to be met through import (National Hydrogen Programme, 2022). Critical for the domestic production of green hydrogen is the condition that hydrogen is considered truly renewable or 'green' only when the electricity used to produce it comes from a renewable power source specifically constructed for this purpose. (The European Commission, 2023).

- The Dutch government has commissioned state-owned company ‘Gasunie’ to develop a national hydrogen gas network. In the future this will connect the 5 industrial clusters in the Netherlands, allowing the hydrogen within the network to become a tradable commodity (National Hydrogen Programme, 2022). While the initial plans for the development of the gas network are depicted in Figure 6, there is considerable uncertainty regarding the timeline for its realization according to one of the hydrogen experts.
- By 2030, 42% of all hydrogen consumption in the industry must be fully renewable (the European parliament and the council of the European union, 2018). Therefore, the industrial sector will be the main off-taker for renewable hydrogen. The expected sales price of hydrogen for mobility is anticipated to be higher, however, the demand is expected to be less certain, according to one of the Hydrogen experts. Other applications are of a lower priority (see Appendix III)

Phase 1 (2025-2026) **Phase 2 (2027-2028)** **Phase 3 (2030)**

Figure 6 Plans for development of national hydrogen gas network. (National Hydrogen Programme, 2022)

4.1.2 Actors

The second basic element of an ecosystem is the actors. Following the necessary activities for the value proposition to materialize, the question is what kind of actors will be performing these activities. A positive remark on the actors present in the Dutch economy was made by one of the experts:

> *"Everyone you need to build the entire chains, whether it's a grid operator, SMEs, large companies, the government, municipalities and provinces, the manufacturing industry, the resource community, everyone is on board. I find that really quite remarkable."*

While the statement that everyone is present and onboard is not treated as an indisputable fact, it does indicate, again, the positive vibe around the hydrogen ecosystem in the Netherlands.

In order to explore the ecosystem actors, there was decided to categorize the active actors in the emerging green hydrogen ecosystem in the Netherlands. This categorisation was devised through an extensive exploration of numerous organizational websites. This explorative overview is presented in Appendix IV. The classification derived from this exploration, refined based on insights from stakeholder interviews, is presented below:

- Energy majors: Major organizations in the energy sector with the resources and capability to develop and exploit the majority of activities in a hydrogen chain independently.
- Original equipment manufacturers (OEM's): Organizations that develop and manufacture technological equipment for the hydrogen chain. For this research this mainly relates to the OEM's of electrolyser installations.
- Energy companies: Organisations that produce, distribute, and sell energy carriers, this can be in the form of electrons or molecules. These are the organisations with the ambition to develop and exploit a hydrogen production plant. This category can be subdivided into three kind of energy companies:
  - Oil companies, who are looking to capture value earlier in the value chain by establish their own green hydrogen production.
  - Gas/liquid companies, who have an existing and strong position in the production of traditional grey hydrogen and other industrial gasses/liquids, and have ambitions in renewable alternatives.
  - Renewable electricity companies, who have the ambition to capture value a step further in the value chain by establish their own green hydrogen production.
- Infrastructure/transportation organisations: Organizations whose business is to facilitate the transportation of energy carriers.
- Industrial firms: organization that engages in various activities related to the production, manufacturing, processing, or distribution of goods. These organisation can apply hydrogen in high-temperature or chemical processes.
- Mobility provider: Organisations that sell goods or provide services related to transportation and mobility. These organisations can apply hydrogen as a clean fuel.
- Narrow use-case actors: (These actors hold a lower degree of relevance within the timeline scope of this thesis)
  - Residential energy providers: Organization that facilitate energy for residential areas. These organisations can apply hydrogen to heat urban area's.
  - Power plants: Organisation that balance the electricity grid. These organisation can apply hydrogen to generate electricity.

- Governmental organizations: These are public organisations that operate at the local, regional, or national level and are established by the government to perform specific functions. Providing financial support to the private sectors and establishing policies and regulations are the main relevant functions for this research. These organizations include: The parliament, Ministries, provincial government, executive government agencies, etc.
- knowledge institutions: organizations or institutions that are dedicated to the generation, dissemination, and application of knowledge. These include: Universities, Research centres and technology institutes.
- Industry association: These organisations bring together companies, organizations, and sometimes individuals with common interests, goals, or concerns related to the hydrogen industry. They facilitate, among other things, advocacy, knowledge exchange, and networking.
- Area developers: Organizations that are responsible for the development and management of a specific geographical area or region.
- Consultancy firms: Professional service organizations that provide expert advice and assistance to businesses, organizations, or individuals in various domains.
- Network facilitators: These organizations actively foster collaboration, communication, and synergy among different entities within a network or industry.

Besides these actors, or 'direct stakeholder', there may be interactions or influences from indirect stakeholders within the ecosystem. Therefore it is relevant to consider the type of secondary stakeholders that exist, meaning stakeholders that are not actively working to advance the hydrogen industry but who will contribute or come into contact with the industry. These indirect stakeholder include: Contractors, Material suppliers, Local businesses, Local residents, Environmental organizations, the general public, etc.

4.1.3 Positions

For the this third basic element of an ecosystem, a general classification of positions was created. This enables to group the actors into certain positions wherein competition and cooperation occurs. The resulting overview is presented in table 5.

In addition to this classification, a noteworthy insight emerged during the hydrogen event regarding future ecosystem positioning dynamics. An accomplished researcher and hydrogen expert highlighted expectations for the future competitive landscape in the Netherlands. It was suggested that by 2035, the competitive field within the Dutch hydrogen production ecosystem is probable to resemble an "Oligopoly with a competitive fringe." This expectation is telling with respect to competitiveness and positioning opportunities for the emerging green hydrogen ecosystem in the Netherlands. It indicates

Positions	Actors
regulatory body	▪ Governmental organisations
Green electricity provider	▪ Energy majors ▪ Renewable energy companies
Hydrogen producer	▪ Energy majors ▪ Energy companies ▪ Industrial firms ▪ Mobility provider ▪ Residential energy providers
Technology provider	▪ EOM's
Infrastructure provider	▪ Infrastructure/transportation organisations
User	▪ Energy majors ▪ Industrial firms ▪ Mobility provider ▪ Residential energy providers ▪ Power plants
Ecosystem facilitator	▪ Governmental organisations ▪ knowledge institutions ▪ Industry association ▪ Area developers ▪ Consultancy firm ▪ Network facilitators

Table 5 General classification of the ecosystem positions. (Own creation)

a high level of competitiveness within the dominant large-scale hydrogen production positions, with only a few major players controlling the hydrogen production industry. However, the expectation of a competitive fringe indicates the potential for smaller, local, alternative, or specialized hydrogen production positions within the Dutch hydrogen industry.

4.1.4 Links

The fourth and last basic element discussed in this subchapter is the links. This will give some insight in how the various actors are connected and how they interact with each other. While all ecosystem links within the scenario form a highly intricate network, this section focuses on outlining some key general findings related to how the network will be linked. In the following subchapter, 4.2 Stakeholder dynamics within the emerging ecosystem, findings regarding the specific connection and the corresponding interactions are discussed in a more detailed manner. This chapter, however, is concluded with a schematic representation of the ecosystem network resulting from the research steps that have been undertaken.

The initial key finding regarding the network links that form to build up the ecosystem is that the industry will be shaped through several projects. Initially, the hydrogen production ecosystem will function as a decentral project-based industry. This implies that when there are intentions to build a hydrogen production plant, every link in the chain of activities and between actors must be organized specifically for that particular hydrogen production project. Looking ahead, however, a more centralized production approach is envisioned for the future with the establishment of a national hydrogen gas network, as mentioned previously. The national hydrogen gas network provides greater flexibility in positioning the hydrogen production plant in relation to the off-takers, thereby facilitating a more centralized industry. Yet, the realization of this network and the technology readiness level of large-scale production facilities remain uncertain, causing the industry to probably remain project-based in the short to medium term.

This leads to the following insight concerning the development of links within the ecosystem. There appears to be a split in focus regarding the development path towards the eventual envisioned ecosystem scenario. On the one hand, there is a significant focus on a national, centralized, large-scale development path, while simultaneously there are focuses on building the ecosystem bottom-up or in a decentralized manner, focusing on smaller-scale projects for incremental developments. These considerations were also highlighted by the experts. One mentioned: "*Our strategy [as the Netherlands] is twofold. We are focusing on large-scale production, extensive import, and nationwide infrastructure coverage (...), if you don't tackle hydrogen on a large scale, it won't take off. (...) at the same time, it is also very important to consider decentralized hydrogen production for several reasons.*" Furthermore, another expert mentioned: "*I think those small projects, especially in the coming time, are becoming increasingly important. Also because those large projects are still challenging to get off the ground.*"

Taking into account the two insights outlined above, a schematic representation for the ecosystem links was developed, as presented in Figure 7. This schematic shows how the ecosystem links develop related to the two different development paths, which both occur simultaneously. On the left side the centralized/national ecosystem focus is depicted where multiple electrolyser projects connect via an national hydrogen gas infrastructure to the end-users, representing the eventual envisioned future scenario. On the right side, a more decentral approach is portrayed, with closely linked projects developed in connection with an individual user or a couple closely grouped users. This showcases how the links appear to be developed in the short to medium term.

This subchapter concludes with a noteworthy observation regarding the evolution of links within the emerging ecosystem. While there are a lot of activities and interactions in the hydrogen field through various events, networks and programs, where various stakeholders exchange ideas, share visions, and discuss challenges, there barely seem to be concrete steps resulting from these engagements. This was

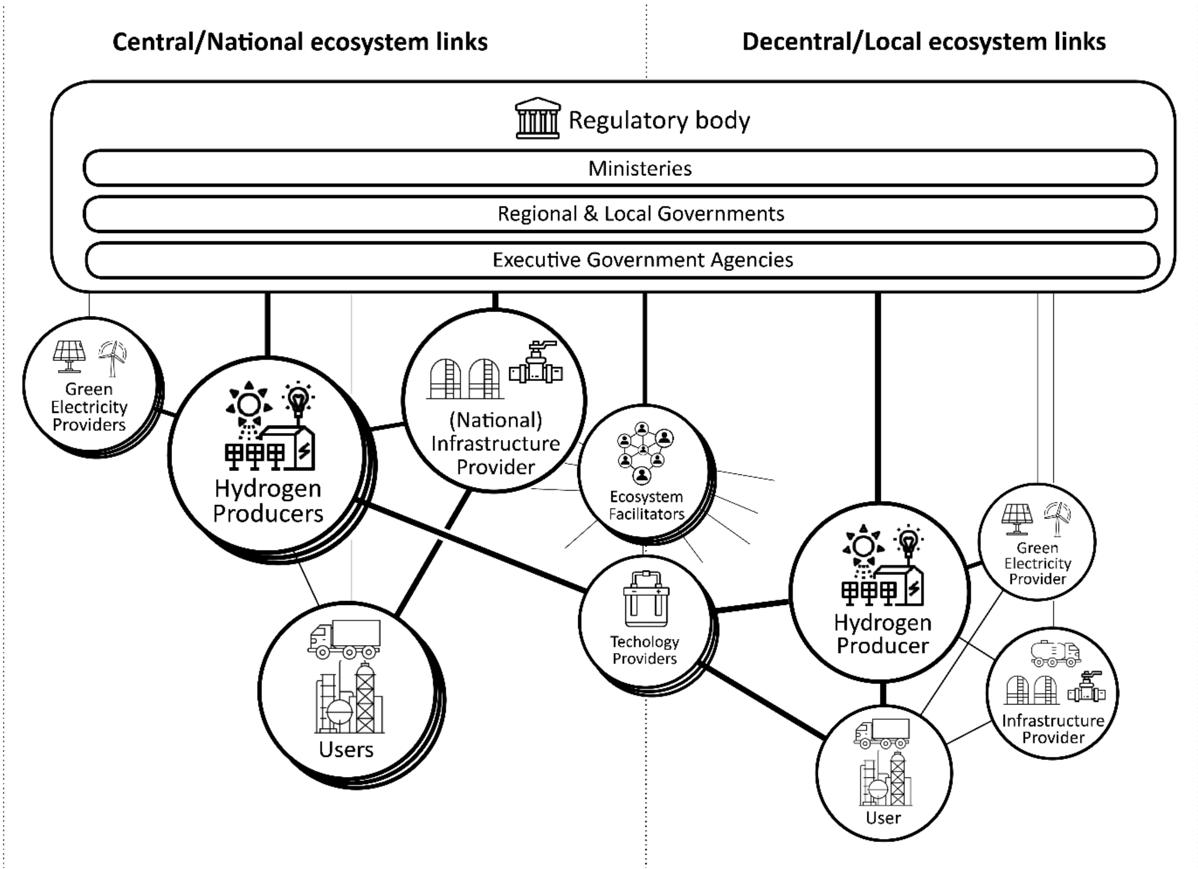

Figure 7 Schematic of ecosystem links. (Own figure)

highlighted by one of the hydrogen experts, who said: *"There are many talk clubs, but the real information shared there is very limited. So, there is a lot of talk about lobbying, but real knowledge-sharing and learning are genuinely limited. And we are occasionally surprised by the [low] level of knowledge among parties."* And during the hydrogen event multiple presenters mentioned: "*If we now realize a project for every hydrogen event, we'll finally make some progress."* This observation gives some insight into the stakeholders dynamics and the current developmental state of the green hydrogen ecosystem in the Netherlands. These topics are central to the second sub-question for this research which is discussed in the following subchapter.

4.2 Stakeholder dynamics within the emerging ecosystem

In this subchapter, the stakeholder dynamics within the emerging green hydrogen ecosystem in the Netherlands are discussed. The themes discussed here stem from the analysis of various (potential) stakeholders, examining the roles they assume, their strategic positioning, interactions between stakeholders, and their approach to and influence on ecosystem development. The coding structure from which these themes were developed are presented in appendix V. From this analysis an intricate and extensive insight into the complex dynamics of the emerging green hydrogen ecosystem emerged.

What stood out was that, as established previously, there seems to be a split focus in ecosystem development. Some stakeholders have a clear focus on advancing the nationwide industry while others are more focussed on the establishment of specific hydrogen chains. While interesting dynamics emerged surrounding the ecosystem developments on a nationwide level, where the quadruple helix model can describe the ecosystem dynamics with a larger focus on the explorative layer (Visscher et al., 2021) on topics like national infrastructure, import, the innovation agenda's and the human capital agenda, this subchapter focuses in on the exploitative layer of the ecosystem (Visscher et al., 2021). Here, there is a strong emphasis on realizing specific hydrogen production facilities. This focus was chosen to provide a more targeted perspective on the ecosystem dynamics, at a critical level for developing a positioning strategy for medium-sized energy companies. In the following sections the themes that emerged from the analysis, and reflect the relevant stakeholders and dynamics, are discussed.

4.2.1 Keystone role government

The primary and overarching theme that emerged from the analysis of the stakeholder interviews was the significant role of the Dutch government. Unanimously, the interviewees mentioned the government as a key stakeholder. The reason for this is that hydrogen is currently economically uncompetitive and primarily serves a societal goal, the industry therefore does not take off on its own. This results in the need for the government to implement various measures to stimulate the market, making it a government-driven ecosystem. One of the interviewees indicated the extensive influence of the Dutch government as follows:

> *"One way or another, the government is always involved, either as a regulator or standard setter, or as a supporter in the form of subsidies. Without subsidies, the development of a hydrogen project is not feasible. Therefore, government—whether local, regional, national, or European—is necessary, on the one hand, to understand within which framework, within which playing field we must operate. What are the rules regarding green hydrogen? When is green truly green? On the other hand, it is also required for questions like, can you build that factory here? What are the regulations and guidelines for emissions, heat, sound, etc.? On the other hand, the government also serves as a supporter in terms of capital expenditure or operational expenditure to make a hydrogen plant possible."*

What this quote highlights is the extensive and substantial influence of the government, thereby indicating the significant power it holds. Through funding, regulations and policies the government can orchestrate developmental aspects of the ecosystem. However, it cannot be classified in the orchestrator role, as the government only sets boundaries and develops the infrastructure platform for the ecosystem. It is not involved in establishing the industry itself, leaving that domain to the private sector. However, due to the government's influential, supportive, and platform-providing role, it is considered the keystone player within the Dutch hydrogen ecosystem in the context of this research.

It is important to note, however, that this is a highly simplified inference. while the government has been discussed here as a single entity, in reality, the government itself consists of various organizations on different levels, such as ministries, provinces, municipalities, and executive government agencies, each with different responsibilities and who are not always aligned. Additionally, the Dutch government must align and balance Dutch interests with various influences from the European Union. These two insights briefly highlight the complexity of the government's role in reality.

4.2.2 Industry-government interactions

As a result of the government's keystone position, the theme that emerged among industry actors was the importance of actively interacting with the government. All interviewees mentioned Industry-government interactions as a key method of influencing the ecosystem development, and thereby improving their position. One of the industry actors stated:

> *"On the government side, we try to provide our input, not necessarily through lobbying, but by offering our insights into where we believe the hydrogen market is heading, identifying its needs, pointing out any gaps, highlighting areas that require acceleration, or suggesting alternative approaches."*

Moreover, the government also values the industries input:

> *"We have a lot of consultations with industry associations. They try to unite their members in their position and not only present it to us but sometimes directly to the minister or members of parliament. So, they increasingly represent the business interests more clearly."*

While the main goal of active government interaction for a company is to inform and influence the government to align policies with the company's and the industry's interests, additional benefits emerged from the interviews. These include enhancing your understanding of the instruments and regulations employed by the government, fostering alignment within the industry itself, and actively promoting your position and ambitions within the industry. This indicates the importance of activity engaging in industry-government interaction, both in shaping the advancement of the ecosystem and as for personal benefit.

Diving deeper into the dynamics of industry-government interactions, four main practices emerged from the interviews:

- Industry association membership: These organisations unite the industry's position into one message, and regularly communicate with governmental organisations.
- Joint research: collectively develop knowledge, ensuring a common ground and alignment between participants.
- Formal communication: Communication through Laws & Policy, Subsidies, Official response letters, and Webinars.
- Informal communication: Communication through Lobbying, Networking, personal relations, and Events.

In conclusion, it is important to emphasize the significant role played by industry associations in the ecosystem. The industry association's valuable roles of "*knowledge sharing, networking, and advocacy*" were recurring sub-themes under the industry-government interactions. With their position connecting various ecosystem actors, these organisations can be considered as pivotal 'Brokers' (Iyer et al., 2006) within the ecosystem.

4.2.3 Key roles at local ecosystems level

Having discussed two overarching themes, the subsequent sections will focus in on the stakeholder dynamics concerning specific projects that contribute to building up the ecosystem. These project networks can even be considered as small, local ecosystems. In this section the key roles that emerged from the interviews will be discussed. These roles are in line with the positions and links from 4.1.3 Positions and 4.1.4 Links, However, here their influence on the ecosystem's development will be briefly discussed.

<u>Dominant user</u>

The first sub-theme discussed here is the dominant position of the hydrogen users. As long as the national hydrogen gas infrastructure is not realised, an off-taker for the produced hydrogen is essential, as a potential hydrogen producer indicated:

> *"The customer is, of course, super important; you can only make the first investment when you have a customer."*

With this dominant position, users have significant control over the development of production networks' structure. For other actors in the ecosystem, therefore, questions arise such as:

> *"How does the customer want that factory to be realized? Customers don't always want to do it themselves, sometimes they do, but also who wants to run it? (...) And then it depends on the customer's demand how broad our role is."*

So, because of the essential and thus dominant position, the user can exert significant influence, with the main control point being the price they are willing to pay for hydrogen. While users may occasionally even take on an initiating and leading role in establishing a new hydrogen production project, more often they simply position themselves as potential buyers. This initiator consideration is highlighted in the following quote:

> *"From a user perspective, [a project] is challenging to initiate because it requires knowledge and collaboration from various different angles. For an energy company, it makes more sense because you understand the logic of such a project. The different steps you need to take, the various types of knowledge that you either need to possess yourself or involve in some way."*

<u>Orchestrating hydrogen producers</u>

This leads to the central position of potential hydrogen producers, who, at this stage, act more as project developers. What was confirmed in the interviews is that this remains a complex and uncertain group of actors:

> *"the producers is still a relatively unknown group, because who will be building all those electrolysers?"* and *"What makes this complex is that green hydrogen development is currently being explored by many different companies. These are very diverse companies with ambitions to produce green hydrogen."*

These findings are in line with the selection of energy company actors in 4.1.2 Actors. Nevertheless, while the exact actor field is still uncertain and complex, the role these actors play in the hydrogen production networks are more evident. As stated by one of the energy companies:

> *"We are actually actively involved in every phase throughout the development process, broadly speaking, to take the lead. (…) Indeed, it is directing such a project. It starts with initiating the project, forming an idea, sort of conducting a rough feasibility study. (..) and then there will be a permit, a subsidy is needed and all the necessary parties are involved."*

While many interviewees emphasized the need for strong collaborations to collectively establish these aspects, the potential hydrogen producers involved in project development appear to take on the orchestrator role at the hydrogen production project level.

<u>Facilitating roles</u>

In addition to these two influential roles, several other essential roles in the establishment of a hydrogen chain were discussed in the interviews. While all these roles are crucial in realizing a hydrogen chain, their degree of influence in shaping the ecosystem varies. Here, the roles that emerged from the interviews are listed in descending order of influence:

- Infrastructure: Essential puzzle piece in the ecosystem development. However, usually, efforts are made to minimize infrastructure developments.

- Technology provider: Although crucial to find a reliable and competitive partner, they are generally open to following the project lead.
- Local government: Essential for obtaining the permits.
- Green energy provider & (Civil) engineering actors: Primarily occupies a supplier role without significant influence in shaping the ecosystem.

4.2.4 Strategic alliances

The next theme that emerged from the interviews was the formation of strategic alliances for the development of hydrogen production facilities. Notably, all actors involved in hydrogen production facility development mentioned forming some type of official strategic alliance. A potential users indicated:

> *“We notice that potential asset owners, because there are not yet many operational electrolysers in the market, basically all have more or less a deal with an energy supplier who has access to the wind farm, the solar park, or both.”*

The interviewee later highlighted that these deals and alliances are typically formed at an early stage, prior to engaging with the user. While this interviewee referred to the alliance as a deal, the main forms of alliances mentioned were consortia or joint ventures.

> *"We would optimally like to be part of a consortium, where there is an asset owner, an energy supplier, and a customer.”*
>
> *“We have established a joint venture where we own 75%, and [company B] owns the remaining 25% for the production of hydrogen technology, for the production of electrolysers."*

Three main reasons for forming these strategic alliances were identified from the interviews. The primary reason is to combine the knowledge and expertise of different organizations, as hydrogen production plant involve different aspects from the energy industry, gas industry, and high tech industry.

> *“That is also one of the principles why we want to enter into a joint venture with a gas company. Because they typically have an in-house engineering branch that can integrate such a project and present it as a complete package.”*

The second reason that emerged was to spread the high investments needed for the projects, and thereby mitigating the risks.

> *“At the moment that the feasibility study and the business cases are more or less complete and you come to a decision that we can now proceed, it means that serious money is being spent. At this point, you start thinking about how you want the alliances to be structured.”*

And thirdly, it allows for more efficient progress and enables the timely capture of opportunities.

"We can build the collaboration in such a way that you establish a good relationship, and at the moment when we find out, yes, there is a certain subsidy available that will make it cost-effective for us to produce, then we know that the key partners in such a project are on board."

4.2.5 networking

To find the right partners and ultimately establishing strategic alliances, The interviews revealed recurring networking activities, forming the theme discussed here. These activities can be grouped into the following two sub-themes: Active participation in networks, Proactive approach to partners and clients.

Active participation in networks

As already remarked in the results of 4.1.4 links, there are numerous networks, communities, events, etc. with the goal to advance the green hydrogen ecosystem in the Netherlands. It is therefore no surprise that being an active participant in these networks is one of the prominent activities named by all stakeholders. As illustrated by the following remark:

"Our company is a member of various well-intentioned networks. (…) They are interest groups, they are industry associations that organize all kinds of events, there are industry fairs, there are presentations we sometimes attend, sometimes we also give the presentation ourselves. These are all occasions, events where you can meet people."

The abundance of hydrogen networks, communities, and events proves advantageous, simplifying the process of locating and connecting with the right actors. Establishing a new community or event can elevate your position as a leader or initiator. Additionally, it emerged that active participation in industry associations is extra valuable, as it promotes your commitment and seriousness regarding hydrogen developments.

Proactive approach to partners and clients

In addition to active participation in various networks, stakeholders indicated that they put extra effort into proactively approaching partners or clients of interest. This proactive connection is initiated from the off-taker side:

"What we do is actively announce to stakeholders, in the hydrogen market, that we are facing a challenging time when it comes to the transition in those molecules."

As well as from the supplying side:

"We continuously approach the market to explore who wants to buy renewable hydrogen, who needs it, for what reasons."

Maintaining an active dialogue with various actors in the ecosystem allows these stakeholders to stay up-to-date with all recent developments, build close relationships, and foster alignment in the process.

What these two sub-themes highlight is that, despite the sluggish progress in industry development, stakeholders are putting significant effort into connecting with others, discussing key topics, forming relations, and ultimately advancing the ecosystem. This implies that to participate in these activities, or even stand out from the competition, significant networking effort is required.

4.2.6 selection

With numerous actors, communities, and networks active in the field of hydrogen, there is a need to carefully choose the right partners. Therefore, a recurring theme in the interviews were some selection criteria. The main aspects stakeholders take into account when developing their partner network, in order of magnitude, are the viability of the business case, the stakeholders' capabilities, and general reliability.

<u>Business case</u>

The primary aspect for selection of the final project actors is their collective ability to establish a viable business case. In the current business landscape, this is a challenging aspect which has a large influence on which actors will ultimately commit to a project. While stakeholders may not actively seek this, it is the primary criterion that naturally emerges, as emphasized by one of the stakeholders:

> *"Parties usually select themselves 9 out of 10 times (...) When you look at the price we want to pay for hydrogen (...) everyone knows that it becomes very difficult to supply green hydrogen at that price, and then parties quickly drop out."*

This quote highlights that, despite many companies being interested in participation, the majority recognize the challenging and uncertain business environment, leading them to refrain from commitment.

<u>Capabilities</u>

The second factor, often mentioned by many stakeholders, revolves around the capabilities of the potential partners. While a company may have a desire to participate, it is crucial that the company has the capacity, expertise and track record to effectively meet the challenge:

> *"You want to look at someone's track record in green hydrogen. Green hydrogen is, of course, a new product. So, there aren't many people with a very long track record. But you can see who has access to interesting technology, who has delivered other projects in this space or has them in the pipeline, and how big the ambition of these companies is to play a major role in it."*

In addition, the general performance of potential partners are an important criteria as well another interviewee indicated:

"In the end, you look at the solvency of the clubs that might invest. So, when you decide to invest and prepare for the intake, you don't want one of the parties involved to pull the plug halfway through the process, because that's something we see far too often."

Reliability

The final criterion that emerged was the importance of finding trustworthy and reliable partners. While these qualities are essential in any partnership, they were emphasized by multiple partners. Given that green hydrogen production projects are investment-intensive and long-term projects requiring significant commitment and lasting relationships.

"It is very important to have reliable partners, and by reliable, I mean companies, especially for long-term ambitions and long-term stability."

4.2.7 Promotion

Following the networking activities and selection phenomena, the promotion of one own's positions and capabilities was a theme that emerged from the interviews. Notably, these promotional activities were not evident across all stakeholder categories. The actors for who promotion activities did emerge as an important aspect were the technology providers and users.

Technology providers engage in these promotional activities due to the competitive electrolyser business environment. Having invested significant resources in developing their technology, they actively work to promote and position it as the best available. One of the interviewees elaborated on these promotional activities, stating:

"What we try to do with customers we consider serious is to take them to our production facility and show them how we approach this industry, and 9 out of 10 times, that leads to an understanding. (...) So, we try to involve these key customers early on and demonstrate how we develop this product, the steps we take, how we shape our production process, the quality control involved, and how it eventually comes to fruition in their plant. And we hope that builds a certain level of trust from these customers."

User, on the other hand, engage in promotional activities because they have a mutual opportunity to offer by positioning themselves as a potential off-taker. However, as indicated in 4.2.6 selection, many potential hydrogen producers withdraw due to their inability to formulate a viable business case. Therefore, it is key for the potential user to reach many potential hydrogen producers in order to find the appropriate one. These user promotion activities was elaborated on by one interviewee:

"[We promote] that we have land at our disposal, which is our property, where we can easily establish ownership. Where there is, therefore, availability to undertake various activities. Combined with access to railways, connection to water, and relatively close proximity to major

roads, especially concerning heavy transport. That is essentially our outward promotion, in which we have been able to attract about two parties or consortia willing to conduct a study on this."

What stands out is that, in the stakeholder group marked by a lot of complexities and dynamics; the potential hydrogen producers, there were no specific remarks made about self-promotion. The explanation for this seems to be that, while these actors effectively identify opportunities due to the abundance of network activities, and the opportunities are actively promoted by both technology providers and users, in the end, there is no need for selection, and thus, promotion, because all potential actors are already self-selected by the challenging business case.

4.2.8 Industry clusters

Having discussed the network activities and behaviours, the subsequent theme that surfaced extensively in the interviews highlighted the significance of local clustering and the coordination of the energy system. In order to develop a viable business case for the hydrogen production network, it is important that it fits within and/or connects the local energy system, or groups several actors to increase efficiency. An alternative term for this is the development of efficient energy hubs, which is an important focus for local governments:

"There is more consideration for energy hubs where demand, supply, and conversion are brought together. So, mainly, provinces and regions are working on reserving spaces where you can undertake these types of developments."

As this quote illustrates, the reason why industry cluster are an essential focus within the green hydrogen ecosystem is because the coordinated energy hubs balance and localise the demand, supply and conversion and minimise transport, making the entire process more efficient, cheaper, and thus making the transition more viable. Especially the minimisation of infrastructure development is an essential advantage, as the infrastructure is one of the key development issues in the ecosystem at the moment:

"[The viability of hydrogen production] often revolves around infrastructure, electricity connections, connections to pipelines, which may be too expensive for an individual company, but for a collective, a clustering, it can work very well. So, you really have to think in terms of clusters."

Furthermore, these industrial clusters come with the additional advantage to make effective use of residual stream, which is one of the key advantages of well-coordinated and circular energy hubs:

"What we're also working on in this energy transition is bringing together separate chains, often in the form of residual streams. (...) An electrolyser, for instance, also produces oxygen and heat, and we can do something with that. Currently, it's just being cooled off and released into the air. Meanwhile, his neighbour needs the heat and has a boiler on his premises to generate heat."

What this section illustrates are the advantages of collaboration within an industrial cluster where multiple actors struggle with similar challenges. Given the complexity of the business case for hydrogen production, these industrial cluster, and a focus on creating energy hubs, are an essential theme in context of local hydrogen development.

It is essential to note, however, that despite the advantages of industrial clusters, local energy hubs will not address all challenges. For example, there are uncertainties regarding the feasibility of balancing local green energy generation with the consistent power demand for an electrolyser and the hydrogen demand of the market. Therefore, a thorough examination of all requirements and possibilities is necessary in every specific case.

4.2.9 chicken and egg problem

The concluding theme discussed in this subchapter regards the general development dynamic in the green hydrogen ecosystem. As there are still many uncertainties in the current development stage of the industry, and there are still certain challenges to overcome, many stakeholders are dependent on each other's developments to mitigate the uncertainty and make final decision, resulting in a "chicken and egg" situation. This is well illustrated in the following quote:

> *"We do have a very long list of parties all saying, Yes, we want to participate, we want to join in. But no concrete commitments or contracts yet. Because, well, they find it quite challenging. They say, Yes, we really want hydrogen, but I don't have certainty from the other parties that will produce that hydrogen. So, we go to those parties that need to produce the hydrogen. They say, Yes, we'd like to get started too, but we don't have certainty from the industry. Because they… and so on. So it's a bit of a chicken-and-egg story. So that's what we're currently fully engaged in. And those parties basically have to sign up for demand, supply, storage, import, all at the same time."*

Fortunately, the industry is currently overcoming this challenge, with the first actors making final investment decisions. However, while this marks positive progress, many initiatives still need to be collectively initiated, as explained by one of the interviewees:

> *"We are currently in discussions with a considerable number of parties, somewhat with the frontrunners. We have secured the first party now. But you can imagine, it needs to be dozens, hundreds of parties eventually to set the entire chain in motion."*

This final theme underscores, again, the challenging business environment. The uncertainty and risks associated with the substantial required investments are so significant that no single company is willing to bear the risk alone. Moreover, it is impossible to invest and bear all the risk alone due to the fact that multiple links in the hydrogen chain are yet to be developed. As a result, this theme indicates the profound need for close collaboration among a wide range of stakeholders and simultaneous collective commitment to a hydrogen production project in order to realize it.

Having discussed the theme's that emerged from the semi-structured stakeholder interviews. An elaborate and intricate overview of the emerging ecosystem dynamics was developed. The main findings from these initial two analysis steps highlight a significant influence of the government on the ecosystem, a two-layered development focus within the national ecosystem, a high level of networking and cooperative activities, yet a low level of ecosystem advancement. The latter is attributed to the challenging business case combined with the chicken-and-egg situation, resulting in a waiting game. These findings on the emerging ecosystem dynamics will be further discussed in chapter 5 Discussion. The following two subchapters will delve deeper into the second focal point of this thesis, exploring and proposing potentially effective positioning strategies for medium-sized energy companies within this emerging ecosystem.

4.3 Inferences for ecosystem positioning strategy

Following the exploration of future ecosystem scenarios and the analysis of the dynamic field, an understanding of the ecosystem was developed which allowed the researcher to infer potentially effective ecosystem positioning activities. This subchapter will discuss the inferred findings on how a medium-sized energy company can effectively position itself within the emerging green hydrogen ecosystem in the Netherlands. In this discussion, the theoretical framework (figure 7) will be applied. Each block will be elaborated upon to provide an overview of the strategic considerations regarding an ecosystem positioning strategy.

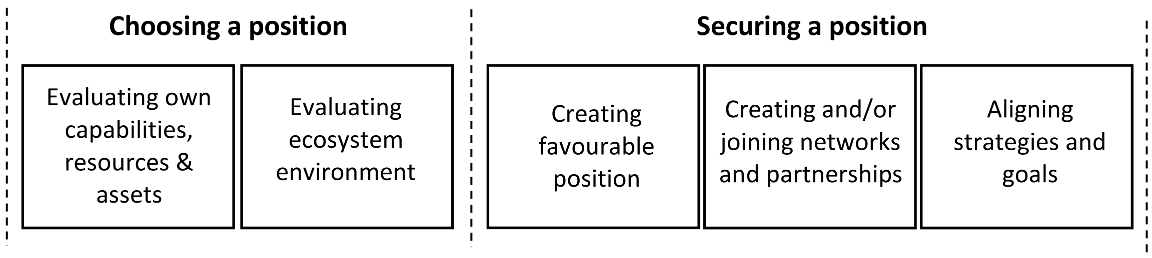

Figure 7 Simplified theoretical framework for ecosystem positioning activities. (own figure)

4.3.1 Evaluating own capabilities, resources & assets

When evaluating the initial position of medium-sized energy companies, it becomes a logical progression to build their future position from the energy supply side. This approach is in line with the primary capabilities, recourses and assets they already have at their disposal. Here the choice can be made to focus on just the energy supply side, or expand the position with a project developer/owner-operator role for hydrogen production. The previous experience gained from realizing technological energy systems can be a valuable resource when attempting to position oneself for a role as a hydrogen producer.

However, being medium-sized limits the ability to emerge as a primary frontrunner in ecosystem development, given that the major investments and associated risks might be too substantial. Therefore, evaluating asset locations and surrounding activities becomes a valuable approach, as it can provide leads to local opportunities. This leads to the second evaluation approach.

4.3.2 Evaluating ecosystem environment

An extensive overview of the ecosystem environment has been developed for this research and is presented in the previous two subchapters of this report. Here, the key findings that impact the choice of position for a medium-sized energy company are discussed.

The initial finding was that the ecosystem seems to be split into two layers: one focusing on a national system, developed top-down to realize a national hydrogen gas infrastructure and major centralized production facilities, and the other layer focused on establishing smaller, more local hydrogen production plants, with a bottom-up approach, to promote gradual technical developments. In the 'top-down' layer, ministries, National infrastructure developers, universities, and energy majors play the most active roles. As indicated in the previous section, medium-sized energy companies likely lack the size and market power to establish a strong position within this layer. Therefore, a focus on a position in the ‘bottom-up’ layer is perceived as a more effective approach.

In this more local layer, there may be potential to identify a niche position in relation to the national green hydrogen ecosystem. It is important to note, however, that this presents a challenging business case that heavily depends on the specifics of the local context. Therefore, as part of the proposed ecosystem positioning strategy, it is proposed to thoroughly evaluate local industry cluster, networks and communities to further understand those local ecosystem dynamics and identify potential positions.

Having identified a desired position, the following three sections discuss the findings on mechanisms to secure this chosen position.

4.3.3 Creating favourable position

For the creation of a favourable position for a medium-sized energy company three main findings, based on the framework, will be discussed: occupying control points, Building reputation and developing specialized capabilities.

Building on to the company's assets, valuable control points that can be occupied are green energy facilities in key positions, such as solar or wind farms. Given the scarcity of space in the Netherlands and the crucial clustering of industries and energy, having green energy facilities in key location provides a highly favourable position within the green hydrogen ecosystem. This can be utilized to kickstart a new hydrogen initiative or leverage your position to participate in another hydrogen initiative. These control points can be created by either identifying existing projects and using them as new control points, or actively scouting and acquiring new key positions for new green energy facilities.

Secondly, it emerged that the reputation or "seriousness" of stakeholder to develop green hydrogen facilities is an important factor. On the one hand, a good reputation is built by having a successful track record in technological energy system developments. On the other hand, social and policy engagement is viewed as an important indicator of seriousness. By actively engaging in (local) social and policy discussions regarding hydrogen developments, you gain the advantages of standing out from other actors, meeting more parties with similar issues, and promoting yourself as a committed actor in the industry. Overall, building a reputation as a favourable potential business partner.

Finally, if a company develops specialized capabilities, it can establish a unique and favourable position for itself. For a medium-sized energy company, this might involve developing expertise in green hydrogen production, ideally in combination with the company's energy assets. While acquiring experience can be challenging with limited project opportunities, it might be worth considering an investment in a small-scale test setup. Having gained this expertise could quickly leverage the company's position, given the limited experience and expertise in hydrogen production projects currently in the market.

4.3.4 Creating and/or joining networks and partnerships

Continuing on the topic of visibility and recognition of new opportunities, this involves creating and/or joining networks and partnerships within the green hydrogen ecosystem. As mentioned previously, numerous networking and communication activities are taking place within the emerging green hydrogen ecosystem in the Netherlands. Joining and participating in these activities is a relatively straightforward strategy to enhance visibility as an engaged participant and facilitates connections with other engaged actors. Industry associations and industry clusters stands out as particularly effective networks to be involved in. In addition, to establishing one's presence in the hydrogen environment, these networks facilitate active involvement with actors sharing similar goals and challenges. These are the key actors with whom it's advantageous to stand out as a potential collaboration partner or become involved in the establishment of new strategic alliances. Therefore, involvement in these two specific networks are highlighted here as a potential effective ecosystem positioning strategy.

When having identified suitable partners, a recurring theme is that many ecosystem actors collaborate early on and approach potential hydrogen production through a strategic alliance, often in the form of a consortium or joint venture. Therefore, to create a competitive position, it is recommended to aggressively collaborating with partners who possess complementary assets/capabilities early on, such as technology providers or alternative energy companies.

4.3.5 Aligning strategies and goals

The final block relates to influencing the strategies and goals of surrounding actors or adapting a company's own strategies and goals to form a more suitable position within the ecosystem. This is achieved by fostering alignment among the relevant stakeholders. The first focal point is alignment with the government's vision. As established, the green hydrogen ecosystem in the Netherlands is a government-driven ecosystem. It is, therefore, advisable to prioritize assessing how your goals and strategies align with government policies and to adapt them if needed. Alternatively, there can be focussed on actively influencing policy development to achieve better alignment with your initial vision. The latter underscores the benefits of being closely involved in industry associations and local cluster discussions with local governments.

Besides alignment with the government policies, involvement in the vision development of energy hubs and the organization of the local actors around this vision is potentially an effective alignment strategy that could lead to the creation of a (central) position in this energy hub. As there is a focus on localised energy solutions with efficient energy hubs in the Netherlands, assuming a leading role in these hubs by proposing solutions with your assets and organizing the system and actors within this vision could potentially be a strong and effective ecosystem positioning strategy.

4.4 Implications from PowerField's positionings strategy

Having discussed the potentially effective positioning strategies inferred by the researcher, these preliminary conclusion underwent a final triangulation step to validate and refine the proposed strategies. This was accomplished through a workshop involving the representative medium-sized energy company, PowerField Netherlands B.V., as described in 3.4.5 Workshop. The workshop session resulted in a brainstorm discussion on the developments of the green hydrogen ecosystem in the Netherlands and its implications for the company's strategy. This allowed for the validation and refinement of the preliminary results proposed by the researcher by applying them in a practical context. The slides used to present the findings and guide the workshop are presented in Appendix VI.

In this concluding subchapter of the results, the insights gained from the workshop and their implications on the conclusion are discussed. The findings were distilled into three sections, which are elaborated upon here.

The first two section discussed below corroborate and validate the conclusions drawn by the researcher from the previous findings. The third section, however, discusses an aspect that was underexposed in the previous results and thus provides some refinement to the proposed strategic ecosystem positioning considerations.

4.4.1 Choosing a position

The initial discussion focused on the potential positions proposed by the researcher, following from the company's existing assets. The propositions resonated with the participants, leading to a brainstorm discussion on the practical implication for these positions. This resulted in the following two potential positions: (1) Leveraging existing solar projects to launch or collaborate on a hydrogen production initiative, and (2) Leveraging the synergy of a solar field combined with hydrogen production to secure new projects. Below these opportunities are further elaborated on.

The first opportunity recognises the need for newly generated green electricity for green hydrogen production plants. With already having solar park projects in the pipeline, located near significant industrial users, a potentially strong position for collaboration is established. This could, for example, lead to forming a consortium with a local wind energy company to supply green hydrogen to potential local users. For this case, the importance of placing the electrolyser next to the customer, preferably on their premises, with the green electricity generation in close proximity, enabling connection through their own electricity cables to reduce infrastructure cost, was recognised.

The second opportunity recognised the limitation and opportunities that follow from governmental policies. Due to the declining receptiveness for large solar parks in the Netherlands, coupled with a rising interest in hydrogen, exploring new hydrogen production opportunities can assist in obtaining permits for solar parks, creating a synergy effect for PowerField. As a result, it could be advantageous for PowerField to shift its focus toward providing aggregated energy solutions, potentially initiating energy hub developments.

Through the discussion on the potential positions, the participants substantiated that their medium-sized energy company would deliberately avoid competing with large national players due to capacity constraints. Instead, they would focus on exploring local opportunities that align with their existing position and assets. Furthermore, the two positioning opportunities described above demonstrate that the participants recognised the relevance of considering the future ecosystem scenario and the themes ‘Keystone government role’, ‘strategic alliances’ and ‘industry clusters’ and this clearly shaped the perceived positioning opportunities for PowerField Netherlands B.V., as proposed by the researcher. In summary, during this initial discussion point no contradictions emerged. The discussion has shown that several of the study's findings and propositions resonate with PowerField's representative case, thereby affirming the validity of these conclusions.

4.4.2 Securing a position

After having discussed the potential positions and the ecosystem environment, the strategies or activities to secure a position were discussed and proposed by the researcher. Again, no contradictions by the participants emerged. The propositions were recognized and substantiated by the participants. However, actively engaging in the right communities and adopting a networking strategy, which was central theme in the preliminary conclusions, resonated especially with the participants during the brainstorming session and is therefore highlighted here as an important positioning strategy.

This emphasis on networking strategies resulted from the recognition that the specific opportunities with favourable conditions for a potential business case are not very common. Therefore, the participants recognised it can be valuable to actively engage in communities where these favourable conditions, and thus opportunities, arise. These insights followed from the questions *"Do you observe networks [regarding hydrogen production] emerging that you could leverage?"* and *"Are you actively engaged in the right communities to encounter these networks?"* The first question was answered with a definite *"yes"*; they see several new networks emerging regarding green hydrogen production through their personal and business networks. However, the response to the second question was a *"no"*, indicating that the new networks are less likely to be perceived at the emergence stage where an initiating role could be assumed. Instead, they become apparent at a slightly later stage when some actors are already involved.

These answers from the workshop participants corroborate the relevance of active engagement in the right communities in order to capture opportunities. following the insight from the participants, practical implications for such networking strategies in the representative case were brainstormed. In the following sections, the specific networking activities that emerged are further elaborated, thereby offering more practical insights and context to demonstrate the validity of these propositions.

The initial approach, suggested by the researcher, was to be closely engaged in communities related to government policies, such as industry associations. This approach, and the importance of understanding policy developments, was acknowledged by one of the participants:

> *"[finding the right opportunity] depends on several things, I think. We are trying to make our business case work with solar. If you then set up an electrolyser, who pays for what, and what does the customer pay? And if the customer is not willing to pay at least x, then your solar business case*

doesn't work. And that's ongoing now, so it only works if a good subsidy measure comes along. Then you could progress very quickly. So the question is also mainly about whether we are actively engaging in those communities now. But then we must have visibility on when that subsidy scheme will come and what it will look like."

Another approach that emerged during the brainstorming discussion involves close engagement with major hydrogen production developers. This approach is aimed at capturing opportunities that are considered too small and too local for the larger company's strategic goals, and these projects are therefore not taken on by these large organizations.

The final potential for a networking strategy that emerged involves engaging with major industrial gas consumers and their industrial clusters. Despite the emergence of various hydrogen initiatives in the Netherlands, many significant industrial gas consumers have not yet begun a transition to hydrogen use. The primary reason for these organizations not yet transitioning to hydrogen use is because they are awaiting the development of the national network and a decrease in hydrogen prices. However, as long as these companies haven't made a final decision on how to handle the transition, there remains the possibility of a business case for local production. Therefore, staying engaged and visible with these large companies could prove to be a beneficial networking strategy.

These outcomes of the workshop reflect and incorporate the influences that also surfaced in the research results. It clearly integrates the themes of 'industry-government interactions,' other 'key roles in the ecosystem,' 'industry cluster' and 'networking,' 'selection,' and 'promotion' considerations. Furthermore, it not only validates the strategic propositions made by the researcher but deepens them by providing several practical implications of the suggested strategies. Overall, the preliminary conclusion showed high relevance and acceptance in the context of PowerField's representative case, and no contradictions emerged, thereby affirming the validity of these conclusions.

4.4.3 differentiate through innovation

This third and final section discusses a new insight gained from the workshop, providing some refinement to the conclusion. This insight emerged when discussing the development of specialized capabilities, where one of the participants mentioned he was approached by a company to collaborate on an innovative hydrogen application. Such innovative or explorative activities did not emerge as a prominent theme within the local or project-related ecosystem layer based on the stakeholder interviews. These progressive innovation activities were only prominent at the national level as a key theme for ecosystem development. However, as noted, in the more detailed brainstorming session, the idea of investing in new technology did emerge, though it was met with significant skepticism.

The reason for this topic to be underexposed in previous findings, is considered to be the same reason why the topic was met with scepticism during the workshop. All effort are focused on establishing a green hydrogen industry with the current established technologies, which is already a considerable challenge. There appears to be little confidence that new initiatives with a weaker use case and unproven technologies are worth pursuing. One of the participants stated regarding an alternative use case:

> *"My concern here is that this technology is quite new and not yet proven, posing a risk for PowerGo, PowerField, to invest in it. (…) In the coming 5 to 10 years, you won't get there either. That's simply too far in terms of technology, too many losses. Your advantage is simply not significant enough."*

Although pursuing and investing in new technologies did not emerge as a prominent theme within the emerging dynamics of the green hydrogen ecosystem, the discussions during the workshop sparked the insight that awareness regarding innovations is still relevant for potential ecosystem strategies. Especially for medium-sized energy companies that cannot easily compete with major firms by using mainstream technology. Two important strategic implication that follow from this are: (1) Actively maintaining visibility as a potential innovative customer for technology developers, increasing the likelihood of being approached to commercialize new technologies as an early mover, as this event is what introduced the topic during the workshop. And (2) Staying informed about potential innovative or even disruptive opportunities, enabling quick responses or even the initiation of early collaborations.

In conclusion, this final section contributed an insightful perspective that not only expanded upon but also refined the conclusions drawn by the researcher. It emphasized the importance of maintaining visibility as an innovative energy company and the potential benefits of collaborating with technically innovative companies as a potentially effective components of an ecosystem positioning strategy.

In summary, the insights derived from the workshop with PowerField Netherlands B.V., serving as a representative case, not only validated but also refined the preliminary conclusions drawn from the overall ecosystem exploration. This resulted in a conclusive overview on how a medium-sized energy company can strategically position itself within the emerging green hydrogen ecosystem in the Netherlands, as outlined in subchapter 4.3 Inferences for Ecosystem Positioning Strategy, in combination with 4.4 Implications from PowerField's Positioning Strategy.

5 Discussion

After completing all the research steps, providing answers to the research questions in the results section, and thereby working out the strategic implications of the findings, this chapter will further discuss the findings from the ecosystem analysis in relation to existing literature.

By applying the ecosystem-as-structure construct by Adner (2017) as a framework for the ecosystem analysis, this allowed to corroborate the presence of the basic element in the ecosystem and the complex nature of the green hydrogen ecosystem with many cooperative and competitive interaction (Moore, 1993). This research specifically corroborates previous studies on the emerging phase of an ecosystem. It was observed that the emerging green hydrogen industry in the Netherlands is characterized by technology and market uncertainty, as well as an immature industrial system (Rong et al., 2013), while simultaneously presenting future new value creation opportunity for firms (Gupta et al., 2018). As a result, a selective environment was recognized where competition acts at two different levels (Adner, 2017): Firms compete to secure activities, positions, and roles within a single hydrogen production project, and compete collectively against other hydrogen producers or even other energy solutions. Regarding the roles within an emerging ecosystem, Gupta et al. (2020) stated *some niche players, dominators and supporting infrastructure can already be observed in the early stages of an emerging ecosystem, when the stakeholder network is slowly being established. However, keystone players that legitimize the ecosystem are often not established yet*. This statement may not initially appear accurate. Due to significant government intervention, the government was labelled as the established keystone player in the ecosystem. However, given the different role concepts applied in this study, when we examine this statement in the context of the orchestrator within the individual hydrogen production ecosystem, it can convincingly be corroborated. And finally regarding the overall ecosystem dynamics, indeed a high intensity of firm level deals activities such as mergers, acquisitions, strategic alliances, joint ventures and capital injections (Gupta et al., 2020) were recognized in the emerging green hydrogen ecosystem in the Netherlands.

In addition to these more general emerging ecosystem concepts observed and recognized from the analysis of future ecosystem scenarios and stakeholder dynamics, some more specific findings on the ecosystem dynamics emerged. As mentioned previously, the main findings highlight a significant influence of the government on the ecosystem, a two-layered development focus within the national ecosystem, a high level of networking and cooperative activities, yet a low level of ecosystem advancement. The latter of which is attributed to the challenging business case combined with the chicken-and-egg situation, resulting in a waiting game. The following discussions will explore how these findings relate to existing literature and what insights can be drawn from the literature that are applicable to this situation.

5.1 Government-driven & multi-layered ecosystem

One of the initial findings from the research was that the green hydrogen ecosystem in the Netherlands is a government-driven ecosystem, opposed to a market-driven ecosystem. When reviewing existing literature on government-driven or policy-driven ecosystems, it becomes evident that for sustainable developments, where social and environmental issues arise, there may be a need to align with policy priorities. In addition, often, government or trust funding is needed to accelerate the adoption required for the initial viability of ecosystem creation (Li & Garnsey, 2014). This directly relates to the findings on the green hydrogen ecosystem as it has primarily a sustainable development objective and similar funding needs emerged from the analysis. In such a case it can be valuable to understand how governments can use policies to achieve their goals. Li & Garnsey (2014) found that "governments can guide innovation through policy directives. But they are more likely to achieve their goals if they can embed strategic objectives in innovation ecosystems by supporting and helping to pull innovations into use." The impact of such government strategies became evident in the ecosystem analysis, revealing that the Dutch government is actively pushing the strategic objective of large-scale decentralized hydrogen production by developing and supporting the decentral supply and value chains. Having analysed the ecosystem environment, it can be corroborated that when public policy is embedded in an ecosystem it can encourage firms to devise business models that meet strategic goals aligned with those of policy where market incentives are weak but needs are pressing (Li & Garnsey, 2014). Moreover, government policy can mitigate risk and provide infrastructure, funding stability and a safety net for continued efforts in difficult technical areas (Li & Garnsey, 2014). However, it has also been recognized that the government's strategic objective still conflicts with a portion of the private sector, resulting in the two layers of the ecosystem regarding the development path that have been identified in this research.

What this research appears to contribute to the emerging ecosystem literature is that, during the emerging phase of an ecosystem, various developmental foci could arise, resulting in a multi-layered ecosystem. Whether this is specific to a government-driven ecosystem or could also occur in a market-driven ecosystem cannot be determined from this study. Muli-layered ecosystem construct are, however, described previously in ecosystem literature. These multi-layered constructs are primarily used to describe the complexity of ecosystems (Visscher et al., 2021; Xu et al., 2020). Visscher et al. (2021) and Xu et al. (2020) describe two similar layer constructs: One layer described as the knowledge ecosystem or explorative layer of the ecosystem, and the other described as the business ecosystem or exploitative layer. These layers are interesting in relation to the green hydrogen ecosystem, as a predominant focus on the exploitative layer in the private sector with limited activity in the explorative layer can be observed, even though there is still a significant need for knowledge creation. Active efforts in the knowledge ecosystem or explorative layer are only really apparent in some large-scale organizations or within the government's focus. However, while these observations are interesting, these layers do not seem to align perfectly with the layers observed in this research. Autio (2022), on the other hand, did discuss a layered ecosystem construct that aligns more closely to what has been observed. While he proposed the four layers of technological, economic, institutional, and behavioral, he also extensively discussed top-down and bottom-up ecosystem development approaches. These conflicting approaches align perfectly with what has been observed in the emerging green hydrogen ecosystem in the Netherlands.

The key difference between the top-down and bottom-up approaches concerns the ontological assumptions these make regarding the ecosystem architecture (Autio, 2022). In the green hydrogen ecosystem in the Netherlands the top-down approach is pushed by the Dutch government. As the Dutch government has designed and is attempting to implement their ecosystem architecture. However, the viability of a top-down approach becomes increasingly constrained in high-uncertainty situations (Dattée et al., 2018), where the market context is less structured. (Autio, 2022) states that "the messy reality of ecosystem creation appears to call for a more bottom-up approach, one where the ecosystem orchestrator engages in multi-sided conversations with prospective ecosystem participants to co-discover an ecosystem architecture that is palatable to all those concerned." This, more messy reality, was also observed in the hydrogen ecosystem. The private sector is more risk-averse and is inclined to focus on smaller incremental projects, in a bottom-up manner. Going forward, it is difficult to determine how the ecosystem will develop. However, due to the need for government funding, the government has significant power to push their ecosystem architecture. Nevertheless, since private sector participation is necessary, the eventual ecosystem structure will therefore need to be negotiated and co-discovered endogenously, in a multi-sided negotiation with prospective ecosystem participants (Garud et al., 2002).

5.2 Hype phase & waiting game

The following section discusses the apparent contradiction of observing a substantial amount of networking and collaboration activities alongside a relatively low level of progress in the ecosystem. In this section of the discussion is argued that this indicates a hype phase surrounding the development of green hydrogen chains in combination with waiting game dynamics. In order to discuss these findings, 'Gartner hype cycle' is used as a tool. This tool was introduced by the Gartner consultancy firm to position emerging technologies on a timescale and to make recommendations about the timing of strategic investments in the technology. This model characterize the typical progression of innovation using five stages (see figure 8).

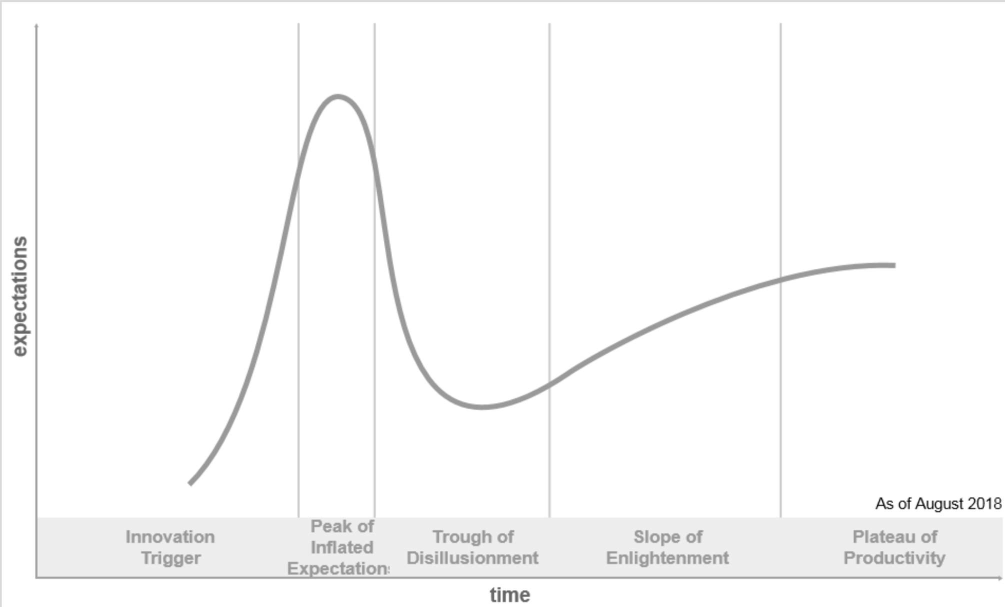

Figure 8 The Gartner hype cycle model (Blosch & Fenn, 2018)

When considering the high amount of attention, enthusiasm and networking activities in the industry surrounding the development of green hydrogen chains, there can be argue that this indicates the green hydrogen industry is going through a hype phase, or in the 'peak of inflated expectation' stage. However, what is interesting is that there was no apparent innovation trigger for this hype, as hydrogen technologies, and particularly electrolysis, are not novel innovations. When examining previous literature, it can be discovered that this is not the first hype phase related to hydrogen technology. In the first decade of the twenty-first century a technology hype, innovation race and subsequent disappointing dynamics were identified surrounding hydrogen fuel cell technologies (Bakker & Budde, 2012). Here, the risk of a potential waiting game was also perceived. Innovative developments that do not match the criteria that are shaped by current practices, and that require system innovations in which multiple actors need to cooperate and coordinate their efforts pose high risk to result in a waiting game (Bakker & Budde, 2012). Waiting games become even more likely in the case of eco-innovations, as regular market incentives, towards higher performance levels and lower costs, are lacking (Bakker & Budde, 2012). These barriers were present during both the hydrogen fuel cell hype and the current green hydrogen hype. Bakker & Budde (2012) discussed in their paper how the hype surrounding hydrogen fuel cells played a crucial role in overcoming these barriers. The paper elaborates on how hype can be effective in avoiding or overcoming waiting games and it how may even trigger actors to engage in an innovation race to be the first to develop and commercialize an emerging technology (Bakker & Budde, 2012). There is a risk, however, that high expectations eventually lead to disappointment (Bakker & Budde, 2012). This is exactly what happened following the hydrogen fuel cell hype, leading the fuel cell innovation into the 'trough of disillusionment' (Blosch & Fenn, 2018). "Hydrogen became known as the technology that always needs another ten years and sentiments turned negative in the second half of the first decade of the twenty-first century" (Bakker & Budde, 2012).

After these events, and applying Gartner's hype cycle model, one might anticipate the recent surge in optimism surrounding hydrogen technologies to be 'climbing the slope of enlightenment' (Blosch & Fenn, 2018). However, here I argue that a new hype phase was triggered by the introduction of government policies and released government funding, following the learnings from the past innovation race. Such a new hype phase has been described as a 'double peak' effect (Bakker & Budde, 2012) (see figure 9). However, over the past few years, it appears that hydrogen technologies have gone through several hype cycles (Konrad et al., 2012), suggesting that multiple hype cycles can occur during the development of an industry. This expands on the 'double peak' effect proposed by Gartner (Blosch & Fenn, 2018). Despite these multiple hype cycles, a strong hydrogen market has not yet emerged. Furthermore, it appears the new hype phase is not leading into a new innovation race. The initial effects of the hype phase were observed with the high level of networking and collaboration activities. Nevertheless, a waiting game seems to have resulted, caused by the high investment requirements and immature policies. Moreover, negative press has surfaced recently, revealing investment costs significantly exceeding expectations and the postponement of the first major hydrogen project. This indicates disappointment dynamics, with the hype potentially 'sliding into the trough of disillusionment' again (Blosch & Fenn, 2018).

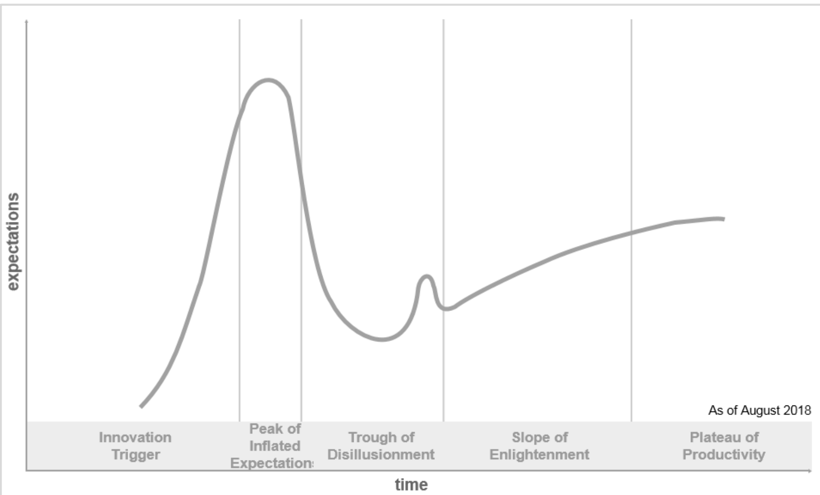

Figure 9 'Double peak' effect hype cycle model (Blosch & Fenn, 2018)

While morale might be decreasing once again, these disappointment dynamics do not necessarily have a detrimental effect on the development of a field (Konrad et al., 2012; Ruef & Markard, 2010). For instance, when key actors are less sensitive, they may constitute an important backbone for an emerging technology. This can result in a reduced impact of hype-disappointment cycles on the innovation system (Konrad et al., 2012). The keystone actor in the green hydrogen ecosystem in the Netherlands was determined to be the Dutch government. As the government generally shows limited sensitivity to market dynamics they possess the potential to sustain the advancements in the hydrogen field (Robinson et al., 2012). In the context of hydrogen, I see consistent government policies and sustained funding as promising mechanisms to promote the market to break out of the waiting game. However, the question remains if the government can keep this up.

Although the government can provide an important backbone for the emerging industry throughout these hype-disappointment cycles, this study showed that for the market to overcome the waiting game, the private sector must ultimately commit to making investment decisions. The Gartner hype cycle could prove an effective tool for the decision to invest. An important Hype Cycle lesson is that organizations should not invest in technologies just because the technology is being hyped. Organizations also should not ignore technologies just because the technologies currently are not living up to early over expectations (Linden & Fenn, 2003). Having discussed the current state of the hydrogen hype, it seems that the 'slope of enlightenment' is in prospect, especially with government policies continuing to push the hydrogen industry. Therefore, close attention to hydrogen developments and opportunities is advised. However, for the private sector to make final investment decisions and break out of the waiting game, uncertainties still pose a large barrier. Uncertainties, combined with disruptive innovation, are seen as a main cause of waiting games (Robinson et al., 2012). These uncertainties also surfaced in this research, as indicated by one of the experts: There is a low level of knowledge among parties and a limited sharing of knowledge. Therefore, a focus on inter-organizational digital knowledge networks could prove a value tool for ecosystem advancement, as proposed by (Csedő et al., 2021).

6 Conclusion

This thesis has shed light on the complex dynamics of the emerging green hydrogen ecosystem in the Netherlands. The aim has been to answer the research question of how a medium-sized energy company can effectively position itself within the emerging green hydrogen ecosystem in the Netherlands. The focus herein was twofold: firstly, to comprehend the strategic dynamics of this emerging ecosystem, and secondly, to explore and propose effective positioning strategies for medium-sized energy companies within this emerging ecosystem. To address the exploratory research question, an embedded case study approach was employed, building on the existing literature on business and innovation ecosystems, along with ecosystem strategies. Multiple data collection methods were employed for triangulation of the findings. The collected data was carefully analysed and the qualitative interviews underwent a thematic analysis using a coding approach. This case study approach allowed to address the research question and resulted in an extensive overview of perceived effective positioning strategies and considerations, presented in the results section. In the process, however, an insightful overview of the emerging ecosystem dynamics was created, thanks to the initial focus, allowing for an extensive discussion on the emerging ecosystem dynamics.

6.1 Theoretical contribution

The findings of this thesis contribute to the theoretical understanding of the development of business and innovation ecosystems in an emerging context. Having performed an extensive analysis of the emerging ecosystem environment, various theoretical concepts can be corroborated with the findings. Additionally, some new insights have emerged, enriching the theoretical understanding in the field. Furthermore, no notable contradictions to existing literature have been found. In the discussion section, the main findings were already extensively discussed in relation to existing literature. Bellow the key theoretical contributions are summarized, with a specific focus on a broader theoretical generalization.

Overall, the finding corroborate the characteristics of emerging ecosystem environments. Environments of this nature are characterized by technology and market uncertainty, operating within a highly selective framework both within and between ecosystem networks. There is a high intensity of firm-level deal activities, including mergers, acquisitions, strategic alliances, joint ventures, and capital injections, all while maintaining an immature ecosystem structure. What the findings add to the theoretical field is an extensive exploration of a government-driven emerging ecosystem, surrounding an eco-innovation that lacks natural economic incentives. Some insights resulting from this exploration include: it highlighted the significance of government support and the power and control it affords. Additionally, it provided insights into how the private sector acts in such an uncertain and government-driven emerging ecosystem. And thirdly, it demonstrated how conflicting government and private sector development goals can result in a divergence of development focus, leading to a layered ecosystem.

Furthermore, the analysis of the current stakeholder dynamics show indications of a hype-disappointment cycle. The finding show a high level of enthusiasm at a wide range of stakeholder, accompanied with a high level of networking and collaboration activities, indicating a hype phase. However, the hype phase lead to only a few concrete advancements, with many projects getting stalled in the planning phase due to increasing required investments, slow-moving policies, and market uncertainties. As a result, indications of disappointing dynamics are emerging, leading to a situation resembling a waiting game. This situation corroborate the characteristics of a hype-disappointment cycle as well as the potential cause of a waiting game. What it potentially contributes to the theoretical field is the recognition that multiple hype phases can occur within a single technological sector, illustrated by the occurrence of multiple hype phases in hydrogen-related technologies. Moreover, it is suggested that a hype phase may not necessarily require a technology trigger, as the current hype phase appears to be triggered by ongoing governmental policies. However, this proposition requires further research.

6.2 practical contribution

In a practical context, this thesis could prove valuable to a wide audience. The overview presented in 4.1 Future ecosystem scenario can aid ecosystem actors and the wider audience in gaining a better understanding and visualization of the green hydrogen business environment, and its developmental considerations. In addition, the elaboration on the identified themes in 4.2 Stakeholder dynamics within the emerging ecosystem offers insights into the crucial dynamics of the emerging ecosystem according to a diverse range of ecosystem actors.

The remaining result of 4.3 inferences for positioning strategy and 4.4 implications from PowerField's positioning strategy, while still interesting for a wide audience, is especially relevant to medium-sized energy companies. The inferred potentially effective positing strategies from the ecosystem analysis and PowerField's specific case provides an insightful overview of potential strategies and considerations, relevant when looking to participate in the emerging green hydrogen ecosystem. Important to note, however, these strategic results should not be regarded as a strategic roadmap. It is recommended that these strategic insights be viewed as an informative and inspirational tool.

Moreover, chapter 5 Discussion, offers a more profound elaboration on some of the highly topical identified ecosystem dynamics. By exploring these dynamics in relation to existing literature, these discussions can contribute to a better understanding of these phenomena. This, in turn, may facilitate a more informed assessment of these situations, potentially guiding investment decisions or other strategic approaches.

6.3 Limitations & further research

To conclude this thesis, the limitations of this research and potential further research directions are briefly discussed. This thesis employed a relatively broad scope of the hydrogen production ecosystem. With the various stakeholder types selected this allowed a collection of diverse perspective onto the same case. However, this came at the expense of limited data collected from each stakeholder group, as can be seen in Appendix II.4. With only 1,2 or 3 different interviews per stakeholder group it could have potentially provided a skewed or incomplete insights. Additionally, considering the timeliness and strategic nature of the developing hydrogen ecosystem, there was a risk of strategic answering from interview participant, which could potentially have lead to skewed or incomplete insights. It is suspected that this may have occurred, particularly concerning electrolyser technologies, as there has emerged minimal insight on this topic from the stakeholder interviews. However, it is not anticipated that any misinformation has been shared.

On the other hand, this thesis presented many insights into the hydrogen production ecosystem in the Netherlands. However, there must be recognized that there are more aspects at play, such as hydrogen import and national and international development goals. Therefore, there must be acknowledged that this research has gathered limited information on these aspects which might have an impact on the results.

A final note on the limitations reiterates that this research was exploratory. While multiple insightful aspects have emerged, such as the dynamics of a government-driven emerging ecosystem, the identification or a two-layered development path, and indications of a hype-disappointment cycle and waiting game, these aspects require further research to formulate conclusive theories or propositions. Which leads to potential future research direction following this thesis.

As mentioned above, the overview of the ecosystem dynamics has resulted in several insightful aspects. Future research could focus on each of these aspects individually to gain a comprehensive understanding of each. Future research topic suggestions include:

- The government role in the ecosystem.
- The effect of government policies and funding on the ecosystem.

- The evolution of the development paths and ecosystem structure.
- Specifics of the hype-disappointment cycle.
- The specific causes or dynamics of the waiting game.
- Analysis of current strategic choices at a later date.
- Comparative analysis of ecosystem aspects.

As demonstrated by the last two suggestions, there are opportunities for future timeline analysis. Naturally, this follows as this research analysed the dynamics of the emerging ecosystem at a specific point in time. Additionally, this research could also be the basis for a comparative analysis. This can be done, for example, by comparing to the hydrogen ecosystem in other countries or comparing to emerging ecosystems built around different technologies.

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Appendix

I Semi-structured stakeholder interview protocol

I.1 Invitation to participation

Beste [naam],

Mijn naam is Jelle Korbee, ik voer momenteel mijn afstudeeronderzoek uit naar ecosysteem strategieën binnen het opkomende groene waterstof ecosysteem als onderdeel van mijn studie Bedrijfskunde aan zowel de Universiteit Twente als de Technische Universiteit Berlijn. Binnen het groene waterstof ecosysteem… [Relevantie van organisatie]. Ik ben daarom zeer geïnteresseerd in de activiteiten van uw organisatie en uw expertise op dit gebied en zou graag de mogelijkheid willen verkennen om een kort interview met u te hebben.

Tijdens ons gesprek zou ik graag bespreken hoe [uw organisatie] de ontwikkelingen met betrekking tot het waterstofecosysteem in Nederland benadert, welke rol [uw organisatie] momenteel vervult in dit ecosysteem/welke rol het zou willen innemen, en hoe [uw organisatie] nieuwe netwerken en partnerschappen vormt binnen dit opkomende ecosysteem. Door middel van ons gesprek en mijn verdere onderzoek hoop ik tot nieuwe inzichten te komen die niet alleen voor mij, maar ook voor de waterstofindustrie interessant kunnen zijn.

Ik begrijp dat u het druk hebt, en ik waardeer uw tijd en overweging enorm. Als u bereid bent om deel te nemen of als u verdere vragen hebt, bespreek ik dit graag.

Dank u wel voor uw aandacht, en ik kijk ernaar uit van u te horen.

Met vriendelijke groet,

Jelle Korbee

+31 6 XXX XXX XX

I.2 Informed consent form

Information sheet for participation in research interview

You will be given a copy of this informed consent form

Project: Master thesis at University of Twente & Technical university of Berlin
Project topic: Ecosystem strategies for the emerging green hydrogen ecosystem in the Netherlands
Researcher: Jelle Korbee
Supervisor: Dr.Ir. K. Visscher

Thank you for participating in this research project. This consent form is necessary for us to ensure that you understand the purpose of your involvement and that you agree to the conditions of your participation. Please read the information below carefully before signing the consent form.

- This master thesis research is conducted with the University of Twente, Technical university of Berlin and Powerfield Netherlands B.V.
- The purpose of this research is to explore how a company can effectively position itself within the emerging green hydrogen ecosystem in the Netherlands.
- Your participation is voluntarily, you are free to not answer any questions and you can withdraw from the study at any time, without having to give a reason.
- During the interview, the researcher will collect relevant data about the represented organization.
- The interview will be audio recorded and transcribed.
- The recording and transcription will be deleted when it is no longer needed.
- The transcript of the interview will be analysed by the researcher and will not be shared with third parties.
- Any content from the interview used in academic publications will be anonymized so that you cannot be identified.
- Your personal information (information that can identify you or your organization) will be deleted when it is no longer needed.
- This research project has been reviewed and approved by the BMS Ethics Committee/domain Humanities & Social Sciences.

By participating in this interview, you are eligible to receive the research results. We value your contribution and believe that sharing the findings with you is an important way to acknowledge your involvement and ensure transparency in the research process.

Contact Information for Questions about Your Rights as a Research Participant
If you have questions about your rights as a research participant, or wish to obtain information, ask questions, or discuss any concerns about this study with someone other than the researcher(s), please contact the Secretary of the Ethics Committee/domain Humanities & Social Sciences of the Faculty of Behavioural, Management and Social Sciences at the University of Twente by ethicscommittee-hss@utwente.nl

Study contact details for further information:

Researcher: Jelle Korbee
Email: j.a.korbee@student.utwente.nl
Phone: +31 6 37275395

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Consent Form for participation in research interview

You will be given a copy of this informed consent form

Project: Master thesis at University of Twente & Technical university of Berlin
Project topic: Ecosystem strategies for the emerging green hydrogen ecosystem in the Netherlands
Researcher: Jelle Korbee
Supervisor: Dr.Ir. K. Visscher

Please tick the appropriate boxes	**Yes**	**No**
Taking part in the study		
I have read and understood the study information, or it has been read to me. I have been able to ask questions about the study and my questions have been answered to my satisfaction.	○	○
I consent voluntarily to be a participant in this study and understand that I can refuse to answer questions and I can withdraw from the study at any time, without having to give a reason.	○	○
I understand that taking part in the study involves audio recording that will be transcribed, and deleted when no longer needed.	○	○
Use of the information in the study		
I understand that information I provide will be used for research purposes only and will be analysed by the researcher.	○	○
I understand that personal information collected about me that can identify me, such as my name and organization of employment will not be shared beyond the researcher and research supervisors.	○	○
I agree that my information can be quoted in research outputs.	○	○

Signatures

______________________ ______________________ __________
Name of participant Signature Date

I have accurately communicated the information sheet to the potential participant and, to the best of my ability, ensured that the participant understands to what they are freely consenting.

__________________________ ______________________ ___________
Researcher name Signature Date

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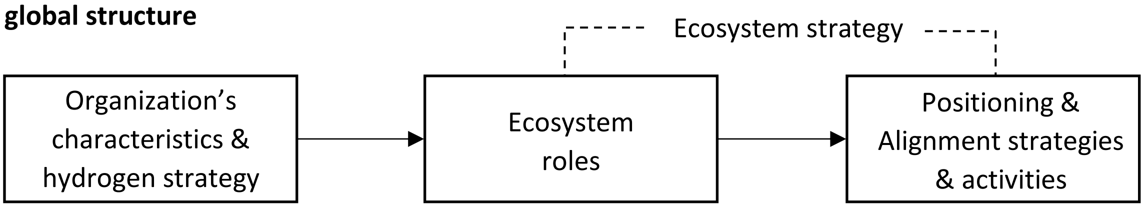
I.3 Interview guide

global structure



Question format:

- Main question [note to interviewer]
  - Follow up question guides

1. Organization's information & Hydrogen strategy

- Can you tell me a bit about the organization and your function?
- What drives your organization's interest in developing a hydrogen-based business?
- What is, in your view, the future direction of the hydrogen market?
  - Use cases
  - Commodity vs. Project based
- Can you describe the envisioned hydrogen initiatives and activities within your organization?
  - Use case
  - distribution channel
  - product quality
  - location
  - Timeline considerations

Ecosystem strategy

2. Ecosystem roles

- What role do you see you organization playing in the national hydrogen value chain? And why?
- What role do you see you organization playing in the development of a hydrogen project? And why?
- Who is/are the key player(s) in the Dutch hydrogen ecosystem?
  - What are the most essential activities/positions within the ecosystem?
  - How do you respond to/interact with these key players?
- What types of actors are essential for a hydrogen project? And why? Elaborate please?
  - Suppliers, Customers, Complementors, Connectors, Knowledge?

3. Positioning & Alignment strategies & activities

- Do you have a deliberate ecosystem strategy? [Explain]
- How are you trying to attain your envisioned position? And why?
  - Which activities do you undertake?
  - How do you stand out?
  - Related to which (key) players?

- How are you finding, connecting with and/or selecting the desired partners? and why?
  - Which activities/networks do you organize or join?
  - Which are most effective?
- What kind of networks/partnerships have been entered into/are desired? And why?
  - What are most effective methods: innovation campuses, consortia, multilateral partnerships, strategic alliances, joint development programmes, etc.
- How are you building strong relationships?
  - What do you consider important in this regard?

- Are you trying to influence the ecosystem development according to your view? How?
- How are you trying to advance the ecosystem as a whole?

- How do you collectively develop to this novel technology?
  - ➢ open question probing for new insights

II Overview case study database

II.1 Hydrogen event sessions

22-06-2023

1	**What will hydrogen mean for the Netherlands?**	
	Presenter:	**Coby van der Linde** Director CIEP (Clingendael International Energy Programme)
2	**Strategy & Policy: How do we implement hydrogen throughout the supply chain**	
	Panel:	**Gijs Postma** Member of the MT within Ministry of Economic Affairs and Climate Policy **Richard Middel** Manager Strategic Business Development, Port of Groningen **Alice Krekt** Director, NLHydrogen (Hydrogen Association Netherlands) **Diederick Luijten** VP Hydrogen Energy, Air Liquide **Coby van der Linde** Director CIEP (Clingendael International Energy Programme)
3	**The Dutch hydrogen backbone**	
	Presenter:	**Marcel Michon** Managing Partner, Buck Consultants International
4	**How do we successfully implement hydrogen in the industry supply chain?**	
	Panel:	**Jeroen Klumper** Director Sustainable Transition, Tata Steel **Maarten Moolhuysen** Director Hydrogen, Essent **Robert van Tuinen** Director Industry Clusters, Gasunie
5	**Rolling out hydrogen in our systems**	
	Panel:	**Andre Jurres** Managing Director, VoltH2 **Marcel van de Kar** Director New Energies, Vopak **Hans Peter Oskam** Director of Policy & Energy Transition, Netbeheer Nederland

II.2 Document & Website analysis

all accessed between April – November 2023

Document title	Organization	Purpose	Target audience	Utilized
Hydrogen roadmap Netherlands	NWP	Proposing a roadmap to reach hydrogen goals in the Netherlands for 2022-2025 and 2025-2030.	Government agencies, industry stakeholders, investors, researchers, policymakers, and the broader public.	Read the report to understanding the shared vision for the development of the ecosystem form public and private organisations.
Renewable energy directive II	EU	Set binding targets and provide a framework for the development of renewable energy sources within the European Union.	European Union member states, national governments, energy authorities, regulatory bodies, industry stakeholders, renewable energy project developers, and the broader public.	Skimmed the document to understand Europe's approach to the energy transition.
EU delegated regulation: detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin	EU	Establishing a Union methodology setting out detailed rules for the production of renewable liquid and gaseous transport fuels of non-biological origin.	Regulatory bodies, energy authorities, transport fuel producers, industry stakeholders, environmental agencies, and researchers.	Extracted factual information about policies and regulations regarding hydrogen production.
Innovation agenda hydrogen 2023	TKI nieuw gas	A proposal for the implementation of the hydrogen innovation agenda for the upcoming years.	Government agencies, industry stakeholders, investors, researchers, policymakers, and the broader public.	Read to better understand the challenges for the development of the industry/ecosystem.
Hydrogen Guide - A Guide to the Dutch Hydrogen Chain.	TKI nieuw gas	Presenting the active innovative hydrogen projects in the Netherlands.	Government agencies, industry stakeholders, investors, researchers, policymakers, and the broader public.	Skimmed to familiarise with the current projects in the Netherlands.
Hydrogen map	Missie H2 & TKI nieuw gas	Presenting an overview of all innovative hydrogen projects in the Netherlands.	Government agencies, industry stakeholders, investors, researchers, policymakers, and the broader public.	Used the explore the hydrogen developments in the Netherlands.

Electrolysers - Opportunities for the Dutch Manufacturing Industry.	TNO	Presentation of regional opportunities and possibilities for establishing an electrolyzer industry in the Netherlands, accompanied by recommendations.	Government agencies, industry stakeholders (Specifically, the manufacturing industry), investors, researchers, policymakers, and the broader public.	Read to better understand the electrolyser environment.
Potential cases for electrolysis as solution for grid congestion	TNO	Presenting potential cases for electrolysis as solution for grid congestion	Energy planners, grid operators, policymakers, renewable energy project developers, researchers.	Read to discover more about this specific use case.
Hydrogen event presentation slide decks	- Groningen sea port - NLHydrogen - Air Liquide - Buck consultants - TATA Steel - Essent - Gasunie - Total energies - VoltH2 - Vopak - Netbeheer Nederland	Introduce their organisations position and concerns to an audience of highly relevant and influential individuals, such as policy maker and top managers.	An audience of highly relevant and influential individuals, such as policy maker and top managers.	consulted to understand the current areas of concern for various key actors.
Organizational websites	Various	Provide information, engage with the user, and promote the organization’s offer.	Customers, stakeholders and the general public seeking information of the organization.	Explored numerous websites to understand the different actors and position within the ecosystem.

II.3 Open expert interviews

Expert	Hydrogen advisor
Organisation	RVO (Netherlands Enterprise Agency)
The first interviewee was selected for his knowledge about the entrepreneurial network, developments and opportunities (Process knowledge), specifically from a governmental perspective. The topics discussed during the interviews included: Current market and projects, Business cases and opportunities, Regulations and support (subsidies), Establishment of the National supply chain, and the associated knowledge networks.	

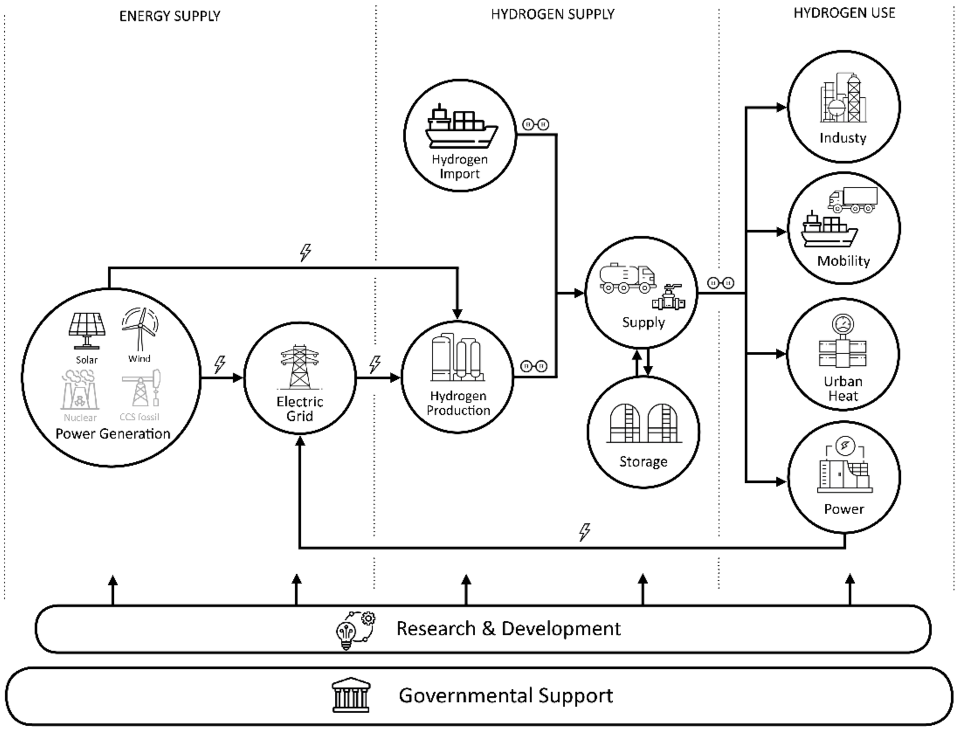
Expert	Hydrogen expert & Business development manager green hydrogen
Organisation	TNO (Netherlands Organization for Applied Scientific Research)
The second interviewee was selected for his technical knowledge related to the green hydrogen innovation ecosystem. The focus of this interview was to delve into the technical challenges and opportunities related to the specific activities necessary for establishing the green hydrogen supply network. Additionally, the interview discussed topics such as the creation of the Dutch (hydrogen technology related) manufacturing industry and the associated knowledge networks.	

Expert	Director
Organisation	TKI Nieuw Gas (Top consortia for Knowledge and Innovation, new gas)
The third interviewee was selected based on his extensive network and the timeliness of his knowledge regarding green hydrogen projects, advancements, and innovation agenda (technical & process knowledge). The interview began with a brief discussion that encompassed a broad scope of emerging ecosystem dynamics regarding the establishment of the national hydrogen value chain. It then advanced to a more specific set of topics, including specific business opportunities and challenges with associated current examples, decentralized production and local ecosystems, strategic partnerships, timeline considerations, and the motives behind hydrogen projects (profitability vs. knowledge development).	

II.4 Semi-structured stakeholder interviews

	Stakeholder type	Company description	Interviewee position
1	Energy Major	Oil major	Portfolio Lead Hydrogen
2	OEM	Major energy technology manufacturer	Head of business development
3	OEM	Electrolyser manufacturer	CEO
4	Infrastructure	National grid operator gas	manager energy system
5	Infrastructure	National grid operator electricity	Relation manager & Policy officer Electricity Market
6	(Potential) Hydrogen producer	Renewable energy investor	Head of hydrogen energy development
7	(Potential) Hydrogen producer	Industrial gas supplier	Manager public affairs
8	(Potential) Hydrogen producer	Green hydrogen energy company	Business developer
9	User: Industrial	Salt miner and processor	Director operations
10	User: Industrial	Advanced biorefining	Head of strategy & business development
11	Governmental organization	Ministry of economic affairs & climate	senior policy officer
12	Governmental organization	Netherlands Enterprise Agency	Hydrogen advisor
13	Knowledge institute	University	Business Development Manager Hydrogen Storage and Transport
14	Industry association	National hydrogen Industry association	Hydrogen Availability Committee
15	Area developer	Port authority	Business manager energy transition
16	Consultancy firm	Subsidy and innovation consulting firm	Senior Consultant Renewable Energy & Energy Efficiency

III Key takeaways from the ecosystem activities



Power generation

- Hydrogen is only considered renewable or 'green' when the electricity used is generated from a renewable power source which was newly built for this purpose (:built within 36 months of the built of the hydrogen production plant) (The European Commission, 2023).

Electric grid

- Electrolysis can be used locally to combat net congestion (Dowling & Jansen, 2023).
- The cost of a new connection to the electric grid for electrolysis is high.

Hydrogen production

- The Netherlands aims for a total of 3-4 GW of domestic electrolyser capacity in 2030 (National Hydrogen Programme, 2022).
- The research institute TNO considers three different electrolysis technologies (TNO, 2021).
    - Alkaline electrolyser (AE): Commercially available, most mature, largest scale.
    - Proton exchange membrane (PEM): Commercially available, most flexible in use.
    - Solid oxide electrolyser (SOE): R&D phase, most efficient.

Import

- Imported hydrogen is expected to account for the majority of the hydrogen used in the Netherlands in the future, later than 2030 (Fieldnote from Hydrogen event, 2023).
- There is much uncertainty about the roadmap for hydrogen imports.

Supply & storage

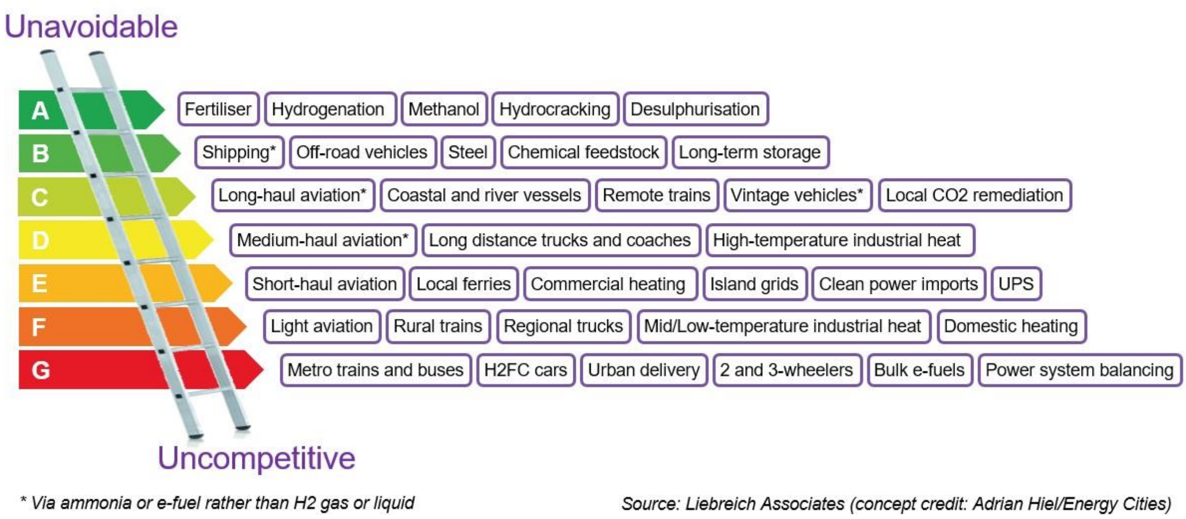
- The Dutch government aims to develop a national hydrogen gas network which connects the 5 industrial clusters (National Hydrogen Programme, 2022).
- There is much uncertainty about the realization of this national hydrogen gas network.
    - “I do not expect that within the next 10 to 15 years, the entire Netherlands will be connected to the national hydrogen gas network” (Hydrogen expert, 2023)

Phase 1 (2025-2026) **Phase 2 (2027-2028)** **Phase 3 (2030)**

Figure 2. Plans for development of national hydrogen gas network. (National Hydrogen Programme, 2022)

Hydrogen demand

- By 2030, 42% of all hydrogen consumption in the industry must be fully renewable (the European parliament and the council of the European union, 2018). Therefore, the industrial sector will have an increase in demand.
- The business case for mobility will be more attractive.
    - "The price you can get for your hydrogen in mobility is simply significantly higher [than in the industrial sector]" (Hydrogen expert, 2023)
- Applying hydrogen for urban heat and power generation have low use case priority



Research & development

- Many developments are still needed to increase the viability of the business cases.
  - "The large hydrogen production installations need to become cheaper, more efficient, more compact, use fewer scarce materials, lower production costs, and the production lines need to be set up more effectively" (hydrogen expert, 2023).
- The technology readiness level of most components is high. However, there is a need to further develop system integration.

Governmental support

- The government can provide substantial financial support.
  - As an example:
    - The climate fund, has already allocated €8 billion to spend on hydrogen project by 2030 (Hydrogen expert, 2023).
    - There is an upscaling plan in progress; a 250 million tender for electrolysers ranging from 0.5 to 50 megawatts (Hydrogen expert, 2023).

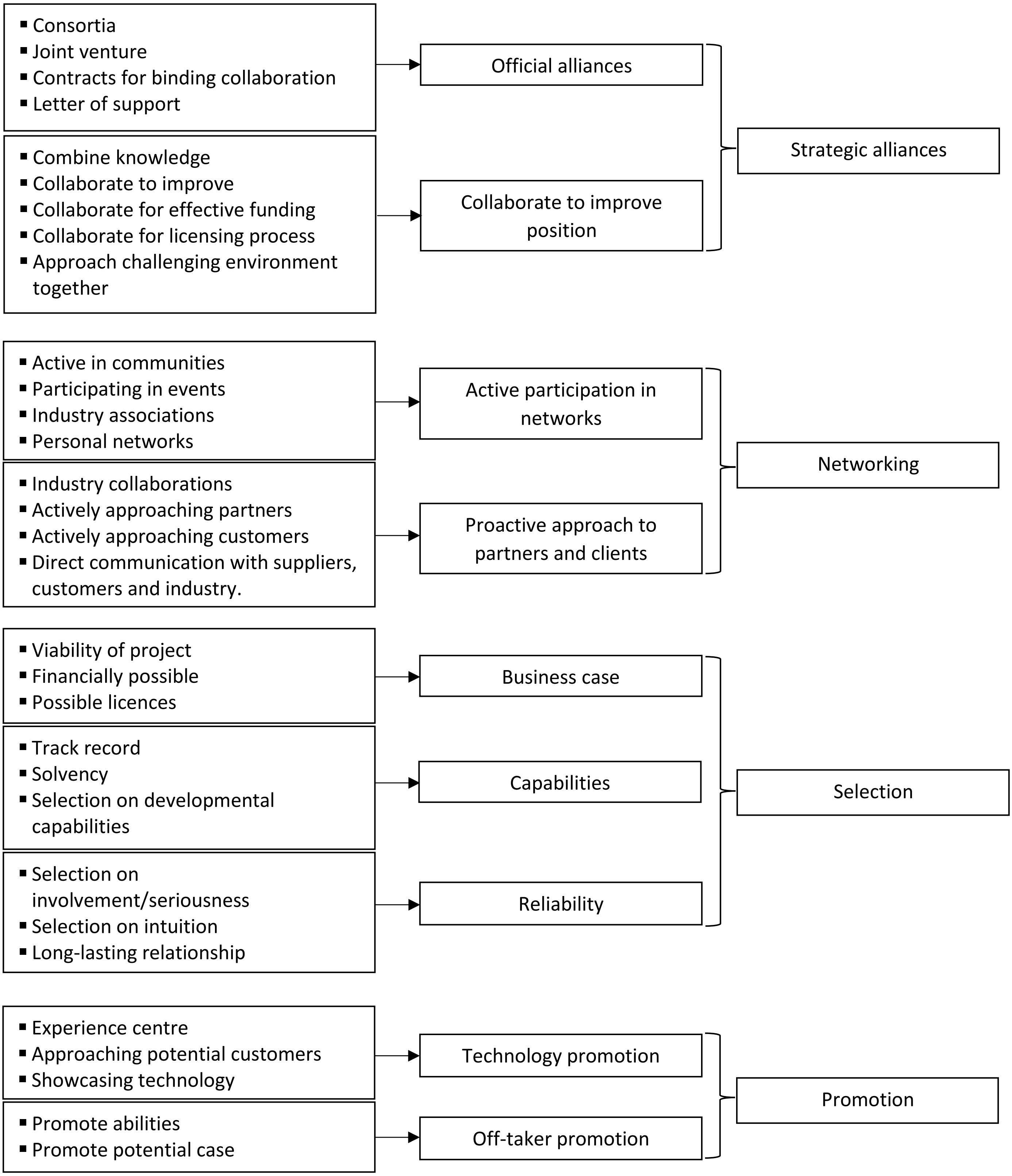
IV Ecosystem actors categories

Actors	Category
North Sea Port	area developer
Port of Groningen/Groningen Seaports	area developer
SADC	area developer
Aveco de Bondt	Consultancy
BDO Tax & Legal	Consultancy
Been Management Consulting	Consultancy
Buck Consultants International	Consultancy
Croonwolter&Dros	consultancy
Loyens & Loeff	Consultancy
Technip Energies	Consultancy
VCCR Advies	Consultancy
Volt Energy	Consultancy
Egen green	Consultancy
Ysubsidie	Consultancy
Shell	Energy Major
Vattenval	Energy Major
EON	Energy Major
RVO	Governmental organizaton
BOM Capital II	Governmental organizaton
Ministerie van Economische Zaken en Klimaat	Governmental organizaton
Ministerie van Infrastructuur en Waterstaat	Governmental organizaton
Oost NL	Governmental organizaton
Provincie Groningen	Governmental organizaton
Staatstoezicht op de Mijnen	Governmental organizaton
ConPackSys	Infractructure developer/manufacturer
AirProducts	Infractructure developer/manufacturer
Enexis	Infractructure developer/manufacturer
Gasunie	Infractructure developer/manufacturer
Koninklijke Vopak	Infractructure developer/manufacturer
Air liquide	Infractructure developer/manufacturer
Netbeheer Nederland	Infractructure developer/manufacturer
BOL van Staveren	Infractructure developer/manufacturer
Hydrasun	Infractructure developer/manufacturer
Kersten Techniek	infractructure developer/manufacturer
Koole Terminals Botlek	Infractructure developer/manufacturer
Van Gelder Kabel-, Leiding- en Montagewerken	Infractructure developer/manufacturer
Westfalen Gassen	infractructure developer/manufacturer
Qirion	infractructure developer/manufacturer
NLHydrogen	Network facilitator
TKI nieuw gas	Network facilitator
WaterstofNet	Network facilitator
Rotterdam Shortsea Terminals	Network facilitator

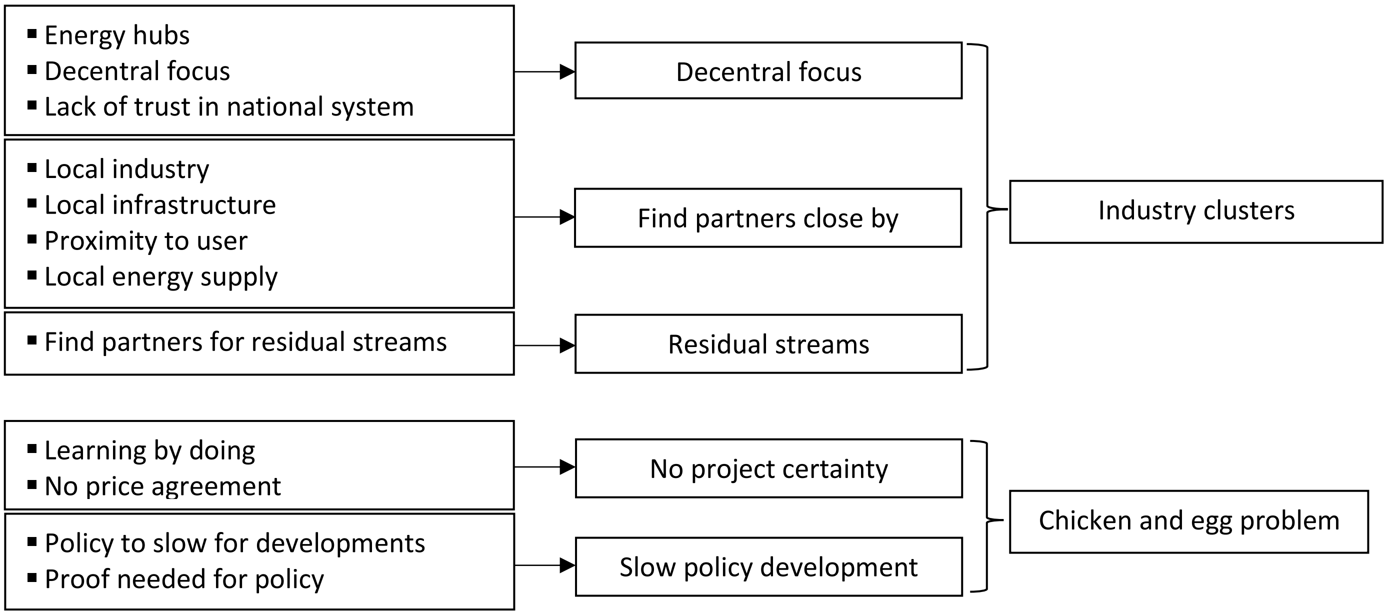
Elektrolyser maker platform	Network facilitator
VoltaChem	Network facilitator
NWP	Network facilitator
GroeivermogenNL	Network facilitator
Alliander	project developer/production
BP	project developer/production
Emmett green	project developer/production
Eneco	project developer/production
Engie	project developer/production
Eurus Energy	project developer/production
HyCC	project developer/production
Neptune energy	project developer/production
Orsted	project developer/production
PowerField	project developer/production
RWE	project developer/production
Uniper	project developer/production
VoltH2	project developer/production
Nobian	project developer/production
Groenleven	Project developer/production
TNO	Research group
CIEP	Research group
Rabo reseach	Research group
EDSN	Research group
Universities	Research group
Airliquide	Technology developer/manufacturer
Battolyser Systems	Technology developer/manufacturer
NEL	Technology developer/manufacturer
Nedstack	Technology developer/manufacturer
Hydron Energy	Technology developer/manufacturer
Fountain Fuel	User
OG clean fuels	User
Louwman & Parqui	User
TATA Steel	User
Yara	User
Remea	User
Resato Hydrogen	User
Total energy	User
Daimler truck nederland	User
VOS transport	User
Alco Energy Rotterdam B.V.	User
Amvest	User
Antea Group	User
Bam Infra NL	User
Future Proof Shipping	User
Heijmans Infra Techniek	User
Vos Logstics	User

V Code structure

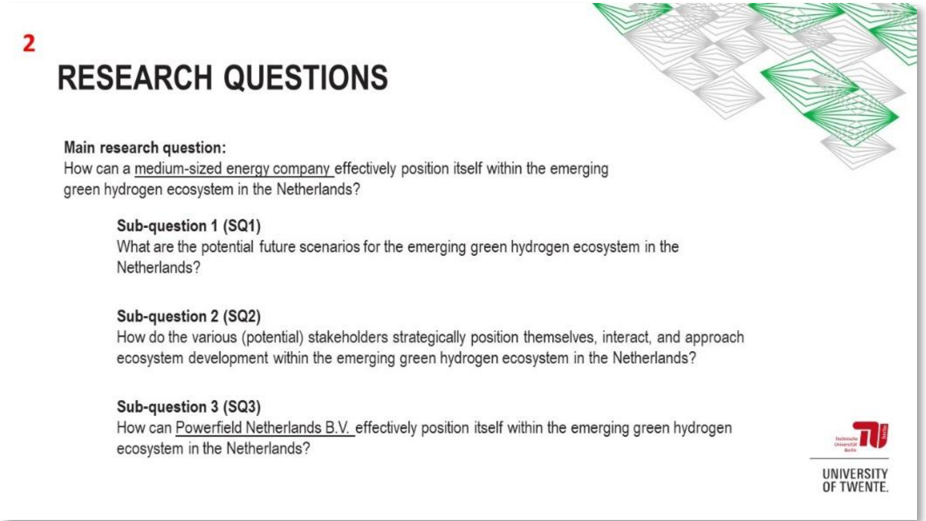
First-order concepts	Second-order sub-themes	Aggregated themes
▪ Government makes laws ▪ Government sets standards	Government controls policy	Keystone role government
▪ Subsidies	Government provides essential funding	
▪ Government Dictates infrastructure roles ▪ Government manages spatial planning ▪ Government regulates the market	Government Orchestrates	
▪ Government Manages international alignment ▪ European influences	Government Manages international alignment	
▪ Industry association interactions ▪ Public-private programs ▪ government discussion groups	Communities for government communication	Industry-government interactions
▪ Joint research ▪ Open communication government ▪ Industry-government collaborations	Industry-government alignment	
▪ Laws & Policy ▪ Subsidies ▪ Official response letters ▪ Knowledge sessions	Formal government interaction	
▪ Lobbying ▪ Networking ▪ Personal relations ▪ Events	Informal government interaction	
▪ User is essential to initiate hydrogen project. ▪ Users can dictate other roles	Dominant user	Key roles at local ecosystem level
▪ Project developer initiates ▪ Orchestrating project network ▪ Owner-operator role	Orchestrating project developers	
▪ Infrastructure role ▪ Technology provider role ▪ Local government role ▪ Green energy provider role ▪ (Civil) Engineering role	Facilitating roles	

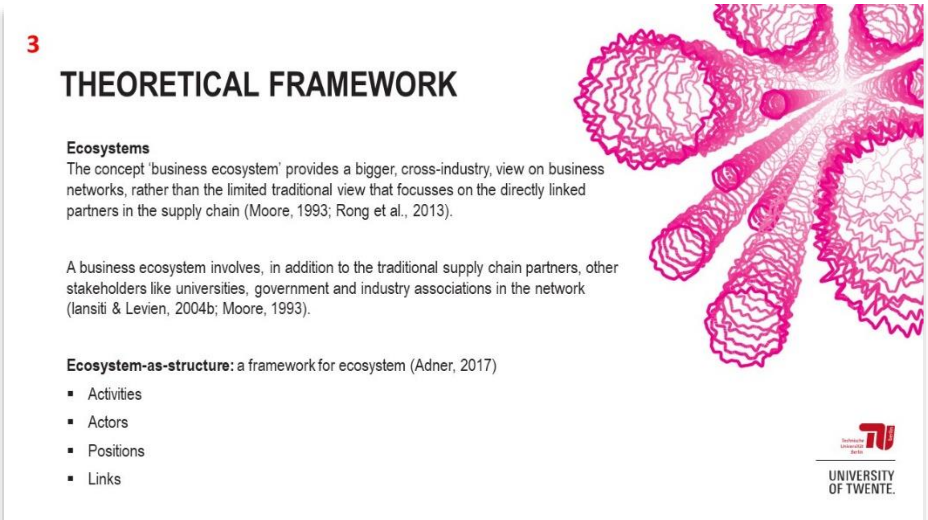


Consortia
Joint venture
Contracts for binding collaboration
Letter of support
Official alliances
Combine knowledge
Collaborate to improve
Collaborate for effective funding
Collaborate for licensing process
Approach challenging environment together
Collaborate to improve position
Strategic alliances
Active in communities
Participating in events
Industry associations
Personal networks
Active participation in networks
Industry collaborations
Actively approaching partners
Actively approaching customers
Direct communication with suppliers, customers and industry.
Proactive approach to partners and clients
Networking
Viability of project
Financially possible
Possible licences
Business case
Track record
Solvency
Selection on developmental capabilities
Capabilities
Selection on involvement/seriousness
Selection on intuition
Long-lasting relationship
Reliability
Selection
Experience centre
Approaching potential customers
Showcasing technology
Technology promotion
Promote abilities
Promote potential case
Off-taker promotion
Promotion


Energy hubs
Decentral focus
Lack of trust in national system
Decentral focus
Local industry
Local infrastructure
Proximity to user
Local energy supply
Find partners close by
Industry clusters
Find partners for residual streams
Residual streams
Learning by doing
No price agreement
No project certainty
Chicken and egg problem
Policy to slow for developments
Proof needed for policy
Slow policy development

VI Workshop slides





4

THEORETICAL FRAMEWORK

Ecosystem Strategy
Definition: *The way in which firms approach the alignment of their activities within an ecosystem and the ways in which they secure their position in relation to other actors and to the competitive ecosystem as a whole.*

Competitive positioning strategy vs. ecosystem position strategy

- Competitive positioning strategy relates to pricing, target market, product differentiation, etc.
- Ecosystem positioning strategy relates to network development, partnerships and alliances, value chain integration, communication, etc.

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5

THEORETICAL FRAMEWORK

Central framework for this study:

Choosing a position		Securing a position		
Evaluating own capabilities, resources & assets	**Evaluating ecosystem environment**	**Creating favourable position**	**Creating and/or joining networks and partnerships**	**Aligning strategies and goals**
- How can you contribute to the ecosystem? - What essential assets and capabilities do you possess? - Don't let existing capabilities limit strategic choices	- Develop overview of the ecosystem. - Highlight key players. - Examine similarities and differences - Assess to understand the network	- Try to stand out from other actors - Build reputation - Develop specialized capabilities - Occupy control points within an ecosystem	- Create, join, and sustain networks - Aggressively collaborate with partners who possess complementary assets/capabilities - actively participate in the networks	- Vision developing - Platform organizing - Institutional reconfiguring

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6

RESULTS

SUB-QUESTION 1 & 2

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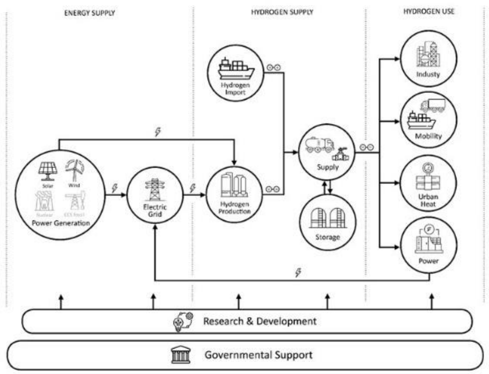
7

SQ1: FUTURE ECOSYSTEM SCENARIO
ACTIVITIES



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SQ1: FUTURE ECOSYSTEM SCENARIO
ACTORS

- Energy majors
- Original equipment manufacturers (OEM's)
- Energy companies
  - Oil companies
  - Industrial liquid & gas companies
  - Renewable electricity companies
- Infrastructure/transportation organisations
- Users:
  - Industrial firms
  - Mobility provider
  - Narrow use-case actors: (These actors hold a lower degree of relevance within the timeline scope of this thesis)
    - Residential energy providers
    - Power plants
- Governmental organizations
- knowledge institutions
- Industry association
- Area developers
- Consultancy firms
- Network facilitators

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9

SQ1: FUTURE ECOSYSTEM SCENARIO
POSITIONS

Positions	Actors
regulatory body	- Governmental organisations
Green electricity provider	- Energy majors - Renewable energy companies
Project lead/developer	- Energy majors - Energy companies - Industrial firms - Mobility provider - Residential energy providers
Technology provider	- EOM's
Infrastructure provider	- Infrastructure/transportation organisations
User	- Energy majors - Industrial firms - Mobility provider - Residential energy providers - Power plants
Ecosystem facilitator	- Governmental organisations - knowledge institutions - Industry association - Area developers - Consultancy firm - Network facilitators

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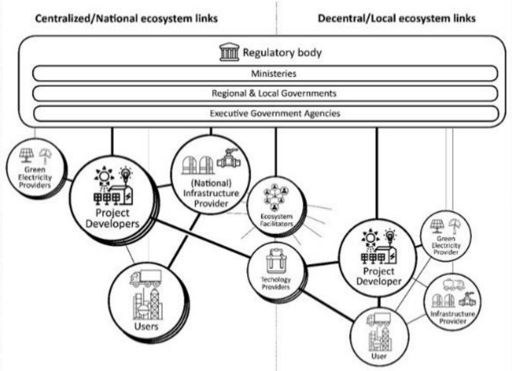
10

SQ1: FUTURE ECOSYSTEM SCENARIO
LINKS



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11

SQ2: STAKEHOLDER DYNAMICS
INTERVIEWS

	Interviewed organisations	Position
1	[redacted]	Energy major
2		OEM
3		OEM
4		Infrastructure
5		Infrastructure
6		Project developer
7		Project developer
8		Project developer
9		User
10		User
11		Governmental organisation
12		Governmental organisation
13		Knowledge institute
14		Industry association
15		Area developer
16		Consultancy

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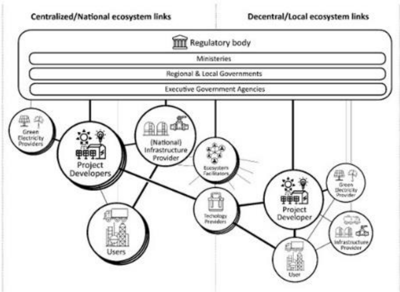
12

SQ2: STAKEHOLDER DYNAMICS

THEMA'S

1. Government keystone player
2. Industry-government interactions
3. Key roles local ecosystems
   a. Dominant users
   b. Orchestrating project developers
   c. Key enabling roles:
      i. Infrastructure
      ii. Technology providers
      iii. Local government
      iv. Green energy providers & civil engineering
4. Strategic alliances
5. Networking
6. Selection
7. Promotion
8. Industrial clusters/energy hubs
9. Chicken and egg problem



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WORKSHOP

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SQ3: WORKSHOP

Choosing a position		Securing a position		
Evaluating own capabilities, resources & assets	Evaluating ecosystem environment	Creating favourable position	Creating and/or joining networks and partnerships	Aligning strategies and goals

In the upcoming slides, I will mention some aspects, conclusions, or questions for each section.

- I would like to discuss these with you.
- Additionally,I would appreciate it if you could share any additional insights that I may have overlooked.

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SQ3: WORKSHOP

Choosing a position		Securing a position		
Evaluating own capabilities, resources & assets	Evaluating ecosystem environment	Creating favourable position	Creating and/or joining networks and partnerships	Aligning strategies and goals

- How can you contribute to the ecosystem?
- What essential assets and capabilities do you possess?
- Don't let existing capabilities limit strategic choices

Opportunity 1:
Connect or take the lead in the development of an energy hub with electrolysis.

Opportunity 2:
Collaborate with major electrolysis developers to supply green electricity.

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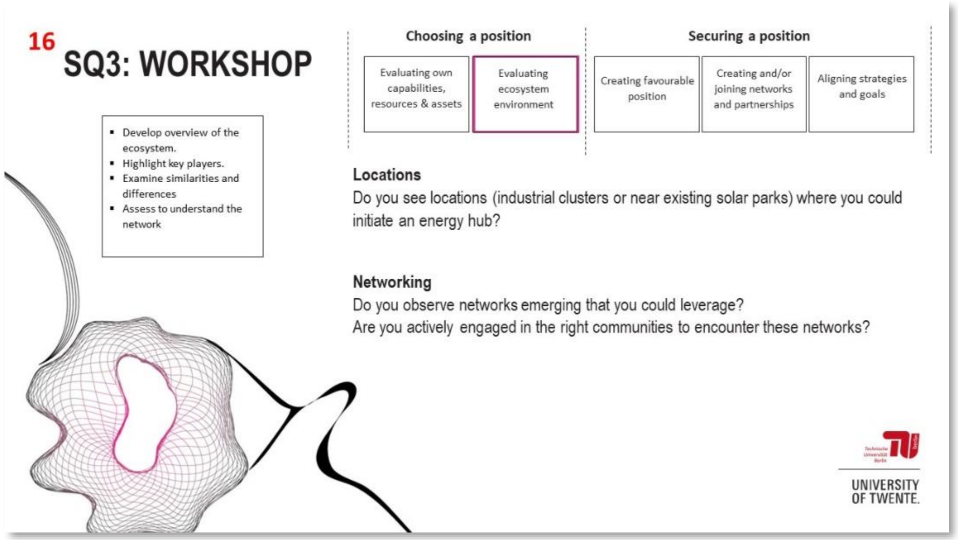
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SQ3: WORKSHOP
Choosing a position
Securing a position
Evaluating own capabilities, resources & assets
Evaluating ecosystem environment
Creating favourable position
Creating and/or joining networks and partnerships
Aligning strategies and goals
Develop overview of the ecosystem.
Highlight key players.
Examine similarities and differences
Assess to understand the network
Locations
Do you see locations (industrial clusters or near existing solar parks) where you could initiate an energy hub?
Networking
Do you observe networks emerging that you could leverage?
Are you actively engaged in the right communities to encounter these networks?
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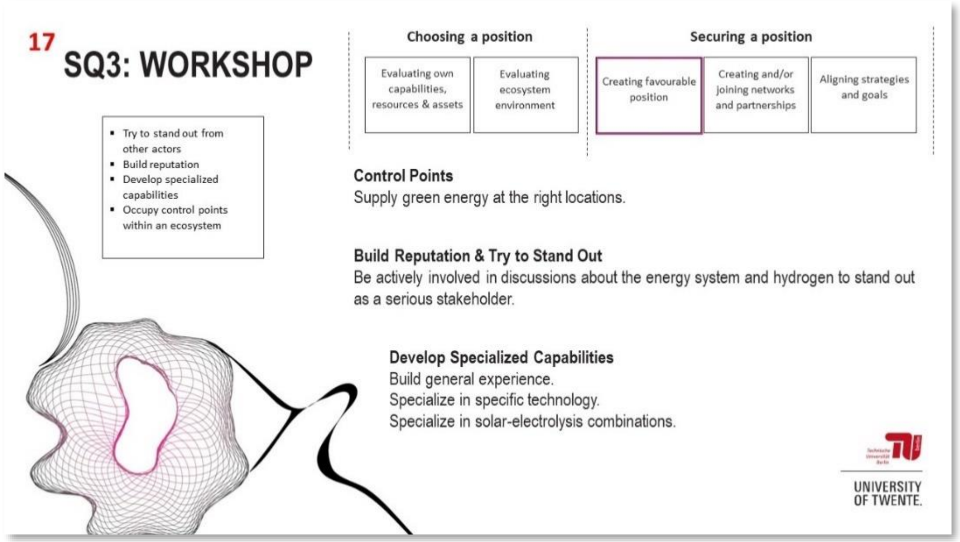
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SQ3: WORKSHOP
Choosing a position
Securing a position
Evaluating own capabilities, resources & assets
Evaluating ecosystem environment
Creating favourable position
Creating and/or joining networks and partnerships
Aligning strategies and goals
Try to stand out from other actors
Build reputation
Develop specialized capabilities
Occupy control points within an ecosystem
Control Points
Supply green energy at the right locations.
Build Reputation & Try to Stand Out
Be actively involved in discussions about the energy system and hydrogen to stand out as a serious stakeholder.
Develop Specialized Capabilities
Build general experience.
Specialize in specific technology.
Specialize in solar-electrolysis combinations.
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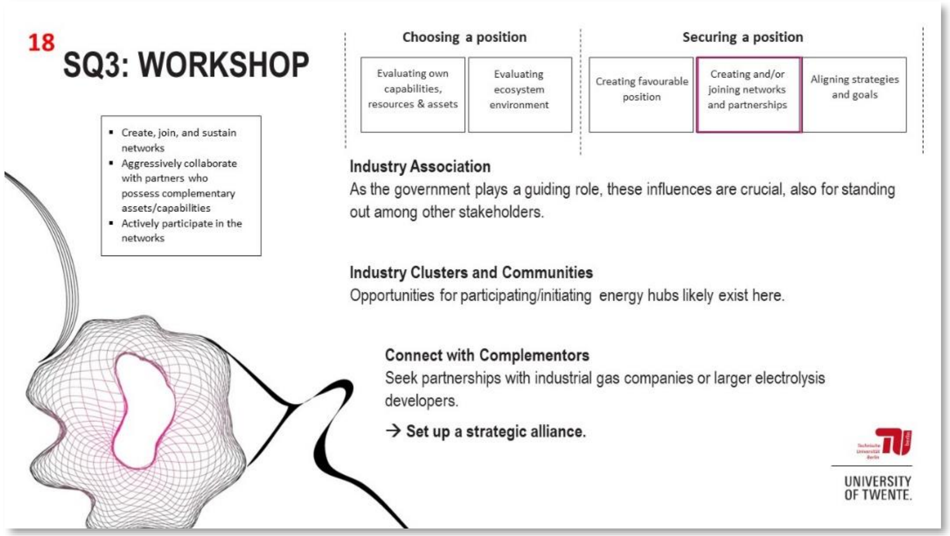
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SQ3: WORKSHOP
Choosing a position
Securing a position
Evaluating own capabilities, resources & assets
Evaluating ecosystem environment
Creating favourable position
Creating and/or joining networks and partnerships
Aligning strategies and goals
Create, join, and sustain networks
Aggressively collaborate with partners who possess complementary assets/capabilities
Actively participate in the networks
Industry Association
As the government plays a guiding role, these influences are crucial, also for standing out among other stakeholders.
Industry Clusters and Communities
Opportunities for participating/initiating energy hubs likely exist here.
Connect with Complementors
Seek partnerships with industrial gas companies or larger electrolysis developers.
→ Set up a strategic alliance.
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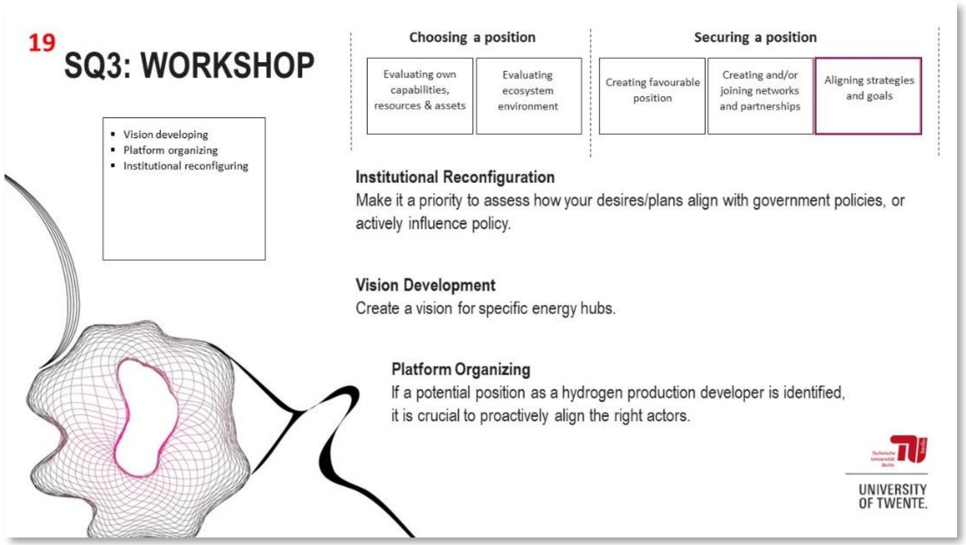
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SQ3: WORKSHOP
Choosing a position
Securing a position
Evaluating own capabilities, resources & assets
Evaluating ecosystem environment
Creating favourable position
Creating and/or joining networks and partnerships
Aligning strategies and goals
Vision developing
Platform organizing
Institutional reconfiguring
Institutional Reconfiguration
Make it a priority to assess how your desires/plans align with government policies, or actively influence policy.
Vision Development
Create a vision for specific energy hubs.
Platform Organizing
If a potential position as a hydrogen production developer is identified, it is crucial to proactively align the right actors.
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