

# Realisation of Collaborative Hydrogen Projects in Dutch Regional Industries

A Multiple Case Study

by

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# Preface

In front of you lies my master thesis, *Realisation of Collaborative Hydrogen Projects in Dutch Regional Industries*. The thesis was written for the Master of Science in Complex Systems Engineering and Management (CoSEM) at TU Delft.

My interest in the hydrogen economy arose during my academic career. In various projects, including my bachelor's thesis, I delved into the Dutch hydrogen transition. I was delighted to conclude this academic career with this research on three realised Dutch collaborative hydrogen projects.

I would like to thank Ir. Renske van 't Veer, my second supervisor, for her excellent guidance throughout this thesis. Our discussions helped shape the research and raise it to a higher level. I would also like to thank Prof. Dr. Ir. Zofia Lukszo, chair of my graduation committee, and Dr. Amineh Ghorbani, my first supervisor, for their valuable support during this project.

To collect data for my research, I conducted interviews with stakeholders involved in collaborative hydrogen projects in the Netherlands. I am thankful to all participants for sharing their extensive knowledge and experiences. The passion with which the participants shared their experiences gave me energy and enjoyment during the research process. Conducting the interviews was the highlight of the project for me.

Finally, I would like to thank my family and friends for supporting me in my research process.

I hope you enjoy reading this thesis.

*S.R. Poli*  
*Delft, November 2025*

# Abstract

The Dutch industry must become more sustainable to achieve the national climate targets for 2030 and 2050. Hydrogen can contribute to these goals by decarbonising processes that are difficult to electrify. The national policy focusses on the five main industrial clusters and a national hydrogen network will be rolled out to connect these clusters. Regional industries outside these clusters also have demand for hydrogen, but the connection to a hydrogen network is uncertain. For the regional industries, there are concrete barriers: high initial investments, uncertainty about the infrastructure rollout timeline and grid congestion, which also affects the integration of electrolyzers. Both practice and literature indicate that collaboration between stakeholders helps overcome these implementation barriers. This makes collaborative hydrogen projects a plausible approach for regional industries. At the same time, only a limited number of such projects have actually been realised so far.

There is a knowledge gap regarding how collaborative hydrogen projects in regional industries can be realised. A collaborative hydrogen project is a project in which multiple stakeholders operate around a specific hydrogen application, make interdependent choices, contribute resources and knowledge and agree to jointly implement a hydrogen solution. To address this, the following main research question was formulated:

*"How can collaborative hydrogen projects in Dutch regional industries be realised?"*

To answer the main research question, a qualitative multiple case study was conducted. Three collaborative hydrogen projects that were in a realisation or operational phase were selected: WEVA (hydrogen-powered barge based on residual green hydrogen), H2essenpO2rt (1.2 MW electrolyser at a wastewater treatment plant in Hessenpoort) and the Hydrogen Cluster for Sustainable Mobility (joint hydrogen refuelling and demand alignment). These cases are all regional hydrogen initiatives with multiple actors in the Netherlands and therefore allow for comparison between different projects. Data were collected through semi-structured interviews with eight respondents directly involved in the three realised hydrogen projects. The interview transcripts were coded with a deductive structure based on the Institutional Analysis & Development (IAD) framework and the Social-Ecological Systems (SES) framework. Within these top-level themes, inductive subcodes were added to capture subthemes that emerged from the interview data. The SES part of the framework was used to organise the exogenous, pre-existing conditions (biophysical conditions, actors' attributes and governance system). The IAD part was used to identify and describe the project-internal action situations. An action situation is the context in which participants make choices and interact that lead to outcomes. By applying the same combined framework to all three cases, the influence of exogenous characteristics and project-internal characteristics on the realisation of the projects could be compared across cases. This comparison made it possible to identify the conditions under which collaborative hydrogen projects in Dutch regional industries can be realised.

The findings concern two dimensions: the exogenous characteristics that shape the project and the project-internal action situations through which actors actually realise it.

The exogenous characteristics influence the necessity, direction and pace of a project. In all three cases, a clear biophysical driver, either an opportunity or a problem, is always the catalyst that makes collective action meaningful. At the start of the projects, the hydrogen technology was relatively expensive and immature, which means that projects needed external financial support to become viable. The attributes of the actors that are involved in a collaborative hydrogen project mattered. Motivated individuals were able to create interest among actors. The regulations surrounding hydrogen applications were often lacking, which created uncertainty but also flexibility. Regulations are co-created by companies and governments during a project.

Within this enabling context, six recurring project-internal action situations were identified in all three cases: consortium formation, formalisation & contracting, financing, coordination, regulatory development and knowledge development & sharing. Each of these action situations was enabled by intrinsi-

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cally motivated individuals, some with idealistic drivers. Consortium formation occurs through existing relationships, subsidy linkage or problem-driven. Once a consortium is formed, it is formalised, leading to a 'point of no return'. Subsidies play a decisive role in financing a regional hydrogen project. Coordination during the formation of the consortium is handled by a single connecting actor; after formalisation, coordination is distributed among the actors within the consortium. At the start of the projects, there often is no complete regulatory framework for hydrogen applications; regulatory development should take place throughout the project. During the project, knowledge is developed through 'learning by doing', shared with the actors and translated into blueprints/business cases. Crucial in all these action situations is the participation of intrinsically motivated individuals, some with idealistic drivers. These individuals ensure that barriers can be broken down.

The cases show that these collaborative hydrogen projects could be realised primarily because favourable exogenous characteristics were present at the time: a clear driver, motivated actors and a governance setting that allowed for some flexibility. At the same time, across these different contexts of the three cases, the projects followed a comparable set of project-internal action situations. The projects must therefore work with the six recurring action situations, supported by intrinsically motivated individuals. For wider deployment, the hydrogen solutions must be more standardised and supported by a stable regulatory framework, so that projects do not depend on exemptions or a few highly motivated individuals. Involved stakeholders indicated that intermediate steps with near-zero or hybrid solutions may be necessary before fully hydrogen-based configurations become widely feasible.

This study contributes to the literature by identifying exogenous and project-internal characteristics that influence the realisation of a collaborative hydrogen project in Dutch regional industries. The results give a first structured overview of how such collaborative hydrogen projects can be realised in practice. This study describes project-internal action situations at meso-level. Future research can delve into these action situations in more depth, leading to a better understanding and how future projects can address them. In addition, a mirror study of unsuccessful regional projects can be conducted to clarify the causes of failure and contrast them with the characteristics identified in this study.

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# 1

## Introduction

### 1.1. Problem introduction

The European Parliament has set ambitious climate goals to adhere to global agreements, predominantly the Paris Climate Agreement [17]. The Dutch government is aiming for a reduction in CO<sub>2</sub> of 55% by 2030 [45]. The Netherlands aims to be climate neutral by 2050 [45]. Beyond these formal targets, the underlying societal motivation is the urgency of climate change [34]. Human activities are warming the world, which makes the world unliveable for future generations. [64]. To achieve these climate goals, sustainable energy sources can play an important role.

To achieve its climate goals, the Dutch government is committed to the use of hydrogen [44]. Hydrogen is an energy carrier that can function as a raw material, energy buffer, distribution medium and direct fuel. Hydrogen can be produced in various ways: from natural gas in which CO<sub>2</sub> is emitted (grey hydrogen), from natural gas in which CO<sub>2</sub> is captured and stored (blue hydrogen) and from renewable energy via electrolysis without CO<sub>2</sub> emissions (green hydrogen) [62].

Traditionally, hydrogen is used by the chemical industry as a raw material, the Dutch annual production amounts to 180 PJ [57]. In the future, hydrogen will also be seen as a replacement for fossil fuels in systems where electrification is not possible. In order to make hydrogen available to five industrial clusters in the Netherlands, Hynetwork (a subsidiary of Gasunie) is developing a national hydrogen network [20]. The five clusters are locations where heavy industry is located. Heavy industry is industry with energy-intensive processes and high emissions of pollutants [4]. The hydrogen network connects the clusters and also provides import and export options for hydrogen.

The new hydrogen network will provide connection at five geographical locations in the Netherlands [30]. Apart from these locations, heavy industry is also spread across the Netherlands, named regional industries. It remains uncertain when industrial companies in the regional areas will be able to connect to the national hydrogen network. These companies may be able to make their processes more sustainable with green hydrogen. For companies in regional industries, a hydrogen transition is less economically interesting due to the high initial investment for onsite generation [2]. In addition, connecting electrolyzers to a congested electricity grid is also difficult [2]. Hydrogen can be a zero-emission solution for medium and high-temperature processes in particular. For low and medium-temperature processes, heating by means of electricity can often also be carried out.

The Dutch hydrogen landscape is complex, because hydrogen projects in regional industries involve multiple stakeholders. The regional industrial companies produce food, bricks, paper and glass, among other things [58]. They use high-temperature processes that cannot be electrified and therefore can benefit from the use of hydrogen [2]. Environmental organisations like Greenpeace and Natuur & Milieu advocate for the use of green hydrogen and urge the government to support greater access [25] [43]. Knowledge institutions, including TU Delft and TNO, contribute technical and policy expertise to facilitate the adoption of sustainable hydrogen [63] [61]. Lastly, the Dutch government determines hydrogen policy, subsidises hydrogen initiatives and can influence future infrastructure for regional industries [12].

Collaborations between companies in the Dutch regional industry can play a key role in the development of hydrogen in regional areas [2]. Due to the high investment costs of a hydrogen installation, the limited space for electrolyzers in the electricity grid and the lack of a hydrogen infrastructure, it is difficult for individual companies to convert their business processes to hydrogen [2] [29]. By organising collective solutions, these barriers can be reduced [2]. According to the existing literature, these forms of industrial collaboration are an effective way to make the energy transition more efficient and economically feasible [15] [16]. In the Netherlands, collaborative initiatives have already been started in which companies work together to realise hydrogen projects [26].

Although the potential of regional collaborative hydrogen projects is clear, little research has been conducted on the factors that influence the realisation of such projects. Only a limited number of hydrogen initiatives in the Netherlands have actually reached the realisation or operational phase so far [26]. For the development of the Dutch hydrogen economy, it is important that regional hydrogen projects are actually implemented. The current literature mainly describes the technological and economic challenges of hydrogen initiatives. There is less attention to what factors enhance or hinder collaboration [2] [49]. It is particularly urgent for regional industries outside the five hydrogen clusters because they face uncertainty about hydrogen access while having few alternative decarbonisation options. This creates a knowledge gap on how collaborative hydrogen projects in regional industries can be realised.

## 1.2. Research objective and research questions

The objective of this research is to gain insight into how collaborative hydrogen projects within Dutch regional industries can be realised. This study uses a multiple-case study of collaborative hydrogen projects. This leads to the following main research question:

*"How can collaborative hydrogen projects in Dutch regional industries be realised?"*

To answer the main question, this study follows three consecutive sub-questions that work towards the answer.

*Sub-question 1: What are collaborative hydrogen projects in Dutch regional industries and which shared goals are pursued within them?*

This question clarifies what collaborative hydrogen projects in Dutch regional industries are and specifies the shared goals that give such a collaborative project direction. Describing the meaning clarifies the scope of the concept. This provides a basis for interpreting and comparing the results.

*Sub-question 2: What role do exogenous characteristics play in the realisation of collaborative hydrogen projects in Dutch regional industries?*

This question focusses on the influence of factors external to the collaborative project itself, which can nevertheless determine its success. These are variables over which stakeholders have no control during the collaborative project. This describes under which pre-existing conditions a collaborative project can be realised.

*Sub-question 3: Which project-internal characteristics support the realisation of collaborative hydrogen projects in Dutch regional industries?*

This question focusses on the internal mechanisms of a collaborative project. In addition to the second sub-question, these are factors that stakeholders can influence during a project and that require conscious decision-making. Together, these two questions provide a complete overview of the factors that influence how collaborative hydrogen projects in Dutch regional industries can be realised.

This study uses qualitative research based on semi-structured interviews and applies a structured and validated conceptual framework.

## 1.3. Relevance to study programme

The subject of this master thesis project is related to the Master of Complex Systems Engineering and Management (CoSEM). The development of hydrogen projects in Dutch regional industries has technological challenges as well as social, economic and institutional factors. Hydrogen projects in Dutch regional industries also involve different actors. The collaborative projects regarding hydrogen

can therefore be seen as a socio-technical system. These different factors ensure that the research is carried out in a complex system, which makes it fit in with the study programme. This research examines the technical, multi-actor and institutional components of a complex system to determine how these relate to the successful realisation of a collaborative project aiming to transition to hydrogen within Dutch regional industries.

## 1.4. Reading guide

This thesis is structured as follows: Chapter 2 outlines the theoretical background. Chapter 3 describes the research approach, cases and conceptual framework. Chapter 4 presents three case studies and their results. Chapter 5 discusses the theoretical and practical implications. Chapter 6 presents the conclusion, limitations and recommendations for future research and answers the main research question.

# 2

## Background

In this chapter, the background of the research is discussed. The hydrogen projects in the Dutch regional industry are decentralised energy networks because there is no connection possible to the national hydrogen network. Section 2.1 describes the current hydrogen landscape in the Netherlands. An overview of existing knowledge on collaborations between companies in decentralised energy networks is described in section 2.2. In section 2.3, the existing knowledge on stakeholder interactions, relationships and perspectives between companies in energy initiatives is described.

### 2.1. Hydrogen in the Netherlands

In the current energy landscape, hydrogen plays a primary role as a feedstock for the process industry [11]. The Netherlands consumes 180 PJ of hydrogen annually, most of which is 'grey' hydrogen [13]. The literature distinguishes between grey hydrogen (from natural gas, in which CO<sub>2</sub> is emitted), blue hydrogen (in which CO<sub>2</sub> is captured and stored) and green hydrogen (via electrolysis with renewable electricity, without CO<sub>2</sub> emissions) [62].

Although hydrogen is currently produced mainly in a grey way, a shift is visible. There are currently 11 electrolysis projects in the Netherlands with a capacity greater than 0.5 MW, which together account for a total capacity of 603 MW [56]. The Dutch government has made more than 700 million euros available in subsidies for the projects. The Netherlands aims to have 4 GW of electrolysis capacity by 2030 [48]. The government aims to have 8 GW of electrolysis capacity by 2032.

To connect supply and demand, growth is also visible in infrastructure. Hynetwork (a subsidiary of Gasunie) is developing a national hydrogen network that is expected to be completed by 2033 [20] [21]. The network will connect the five largest industrial clusters in the Netherlands, linking them to storage, imports and exports. The five clusters primarily targeted by this network are the Northern Netherlands, the North Sea Canal Area, Rotterdam-Moerdijk, Zeeland/West Brabant and Chemelot [1].

Outside of the five industrial clusters, the demand for hydrogen also exists [33]. The heavy industry in the so-called regional industries is spread throughout the Netherlands. The heavy industry consists of energy-intensive companies with medium-high heat processes and sustainability challenges. For medium- to high-temperature processes, sustainability through electrification is less attractive and a transition to hydrogen is obvious. For many of these companies, the transition is currently complex due to the high initial investments, uncertainty about the timing of the infrastructure and the congestion of the grid, which also affects electrolyser integration [2].

In addition to the large industrial clusters, the number of regional and decentralised hydrogen initiatives visible on the interactive Hydrogen Map of MissieH2 is growing in the Netherlands [26]. The projects can be categorised into the following value chains: fuel, import, production, storage, end-user, transport, research, R&D and others [26]. The projects are designed for the following applications: built environment, industry, mobility, energy supply, research, shared facilities, government and education [26]. As of October 2025, 403 initiatives were displayed on the hydrogen map, 224 of which are in the realisation or operational phase. This data includes the five large clusters that account for the majority

of the projects. Regional initiatives usually involve multiple project partners; this is supported by research that indicates that collaboration is important to overcome the barriers to the implementation of a hydrogen project [15] [16].

Both practice and literature confirm that collaborations between stakeholders are important for regional industrial projects. These regional initiatives are also (temporarily) organised outside the national grid, creating decentralised energy networks.

## 2.2. Decentralised energy networks

In recent years, there has been increasing attention to collaborative efforts between companies in decentralised energy networks. This review of the literature discusses what has been studied about such collaborations. Because the literature on regional hydrogen collaborations is still limited, the review also draws on broader studies of collaboration in decentralised energy systems.

Decentralised energy networks are regionally organised energy systems in which multiple actors jointly generate, store, convert and exchange energy, operating outside of a national grid [31]. Actors collaborate to establish and operate these initiatives. Due to the lack of academic research on regional hydrogen collaboration initiatives, the scope of collaborative research is being expanded to include decentralised energy networks. Regional hydrogen projects are also being developed without a connection to a national grid and actors collaborate to establish the project.

Successful collaborations in industrial clusters, such as the case study in Arak, Iran, emphasise the importance of community spirit and trust between industries [15]. Furthermore, it is important for companies that want to join an Industrial Community Energy Systems (InCES) that the benefits of renewable energy generation are clear [16]. Financial and environmental attitudes are especially crucial among cooperatives of citizens [15]. Industrial Community Energy Systems (InCES) require a transparent legal framework to manage conflicts due to varying energy demands and usage patterns.

In addition to collaborations between various large companies, collaborations between multinationals and local startups can also lead to great results [40]. In Algeria, a collaboration between a global energy technology company and a local startup has led to several successful sustainability projects [40]. In addition to achieving the sustainability goals of the multinational, it has also ensured business growth of the startup.

In Norway, the Centres for Environment-Friendly Energy Research (CEER) scheme was established to bring together research institutions, industry and government institutions [66]. CEER ensures knowledge sharing and promotes innovations. Companies gain valuable information from collaboration, which increases the absorptive capacity of a company. For a valuable contribution through participation, involvement from the company is required by the right representatives.

In the Netherlands, the collaboration between network operators and renewable energy initiatives for neighbourhood batteries has been studied and identified [54]. It emerges that the various stakeholders have conflicting expectations of collaboration. However, it also emerges that trust and transparency are important core values for good collaboration. Another study of Dutch hydrogen initiatives shows through social network analysis that decentralised collaboration promotes innovation, but that good coordination remains crucial to success [28].

Agent-based simulations show that collective investments are important for successful hydrogen adoption [2]. Collective action among industrial actors is an effective strategy to overcome institutional and financial barriers to hydrogen applications.

The literature shows that collaboration between companies can often lead to win-win situations and, therefore, results for both parties. For example, barriers that cannot be overcome individually can be overcome together, such as institutional and financial barriers. Although many studies have been conducted that emphasise the benefits of collaboration in decentralised energy systems, little is known about the realisation of collaborative projects.

## 2.3. Stakeholder interactions, relationships and perspectives

Regional hydrogen initiatives involve a wide range of stakeholders, as described in section 2.1. These stakeholders are interdependent because collaboration is essential for setting up a regional hydrogen project. These collaborations consist of interactions between stakeholders based on relationships and

perspectives, which this review of the literature examines in the context of stakeholders in energy initiatives [53] [22].

Research on renewable energy projects in Pakistan shows that effective communication is crucial for stakeholder engagement and project success [38]. Internal and external communication, leadership and relationships also significantly impact the success of renewable energy projects.

Another study on energy projects in Pakistan describes how satisfaction of both internal and external stakeholders mediates this relationship [59]. Internal stakeholder satisfaction has a greater influence on project success than external. The external stakeholder plays a more important role through communication and environmental factors. For successful projects, active involvement and alignment of stakeholder interests are important.

Companies participate in global multi-stakeholder initiatives for various reasons [36]. For example, they hope to contribute indirectly to the development of a market for energy-efficient technologies. They also hope to establish direct contact with potential customers and generate business from the collaboration. Stakeholders influence the development of collective renewable energy (CRE) projects at different levels (macro, intercommunity, intracommunity) [55]. They decide whether to participate in a project based on the expected benefits or disadvantages. The relationships between companies and other actors, such as governments and local communities, are dynamic and can be both supportive and obstructive. Intermediary organisations and key community figures play an important role in connecting interests and stimulating cooperation.

In the Dutch hydrogen transition, stakeholder analyses show that almost 88% of those involved see upgrading infrastructure as a significant obstacle, while more than 84% experience financial barriers despite existing subsidies [29].

Collaboration between actors in energy initiatives also presents barriers. Common barriers to effective collaboration include insufficient knowledge and experience, a lack of information integrity, unclear responsibilities and power imbalances among stakeholders [69] [37].

The literature shows that successful (decentralised) energy initiatives depend on various factors, such as effective communication, trust and alignment of interests. It also describes barriers such as knowledge gaps, unclear responsibilities and power asymmetries.

# 3

## Research Approach

This chapter describes the research approach to answer the main research question. Section 3.1 describes the research design. Section 3.2 describes the methods used to investigate the research questions. In Section 3.3, the conceptual framework used to analyse how collaborative projects can be realised is presented. Section 3.4 describes the cases examined in this study and how they were selected. Section 3.5 describes how the data for this study were collected and analysed.

### 3.1. Research design

This research focusses on understanding how collaborative hydrogen projects can be realised within Dutch regional industries. To address this, a qualitative research approach was chosen. Qualitative research not only allows factors to be identified, but also contextualised.

The research question for this study is:

*"How can collaborative hydrogen projects in Dutch regional industries be realised?"*

Figure 3.1 shows the steps taken in this research and indicates where each research question was addressed.

The qualitative research is conducted using a case study approach. A case study allows the collection of current and concrete information. [9] In this research, three collaborative hydrogen projects in the Netherlands are investigated. A multi-case approach allows for the comparison of cases and the identification of patterns within them.

A qualitative research approach can provide insight into social interactions [7]. In each case study, the interactions between actors during the collaborative project are examined, focussing on the relationships and perspectives of the stakeholders. This approach allowed for the identification of both enabling and hindering mechanisms. In addition to project-internal interactions, the context in which a collaborative project is located is also examined. This provides a comprehensive picture of the factors that influence the realisation of hydrogen projects in Dutch regional industries.

This research used a combination of inductive and deductive approaches. A conceptual framework formed the top-level structure for the coding process. The findings from the case studies were then derived inductively [5]. Existing insights from the literature will be used to put the insights from the cases in perspective. These insights were derived from broader research directions, not just regional hydrogen collaborative projects. This choice was made because there is little comparable research on regional hydrogen collaborative projects. Regional collaborative hydrogen projects are part of decentralised energy network initiatives. In this way, the results were put into context using similar preceding studies on collaborative energy initiatives.

Based on the analysis of the cases, recommendations are made for future regional hydrogen collaborations. By identifying how such projects can be brought to realisation, the study aims to support the development of more effective collaborative hydrogen initiatives in the Netherlands.

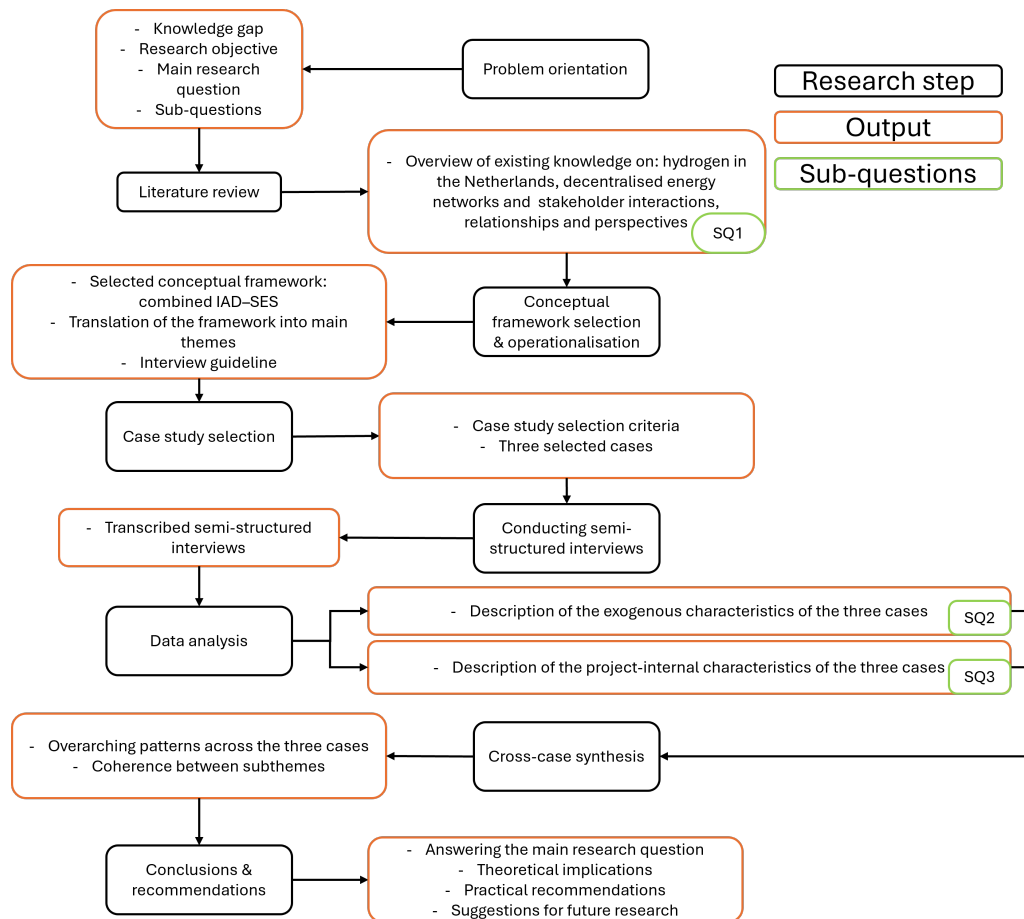


Figure 3.1: Research flow diagram

## 3.2. Research questions and methods

The research aims to gain insight into how collaborative regional hydrogen projects in the Netherlands can be realised. To answer the main research question, three underlying sub-questions have been formulated in Section 1.2. This section presents the data sources used, the data collection methods applied and the data analysis methods. This information is displayed in Table 3.1.

Table 3.1: Linking research questions to data sources, collection methods and analysis methods

RQ	Data source(s)	Data collection method(s)	Data analysis method(s)
<b>SQ1</b>	Scientific literature, stakeholders involved in the three selected regional hydrogen projects	Thematic literature review; semi-structured interviews	Thematic analysis of literature; qualitative coding of interview data
<b>SQ2</b>	Stakeholders involved in the three selected regional hydrogen projects; project/policy documents related to the cases	Semi-structured interviews; document analysis	Deductive coding on SES categories (biophysical conditions, actors' attributes, governance system); cross-case comparison
<b>SQ3</b>	Stakeholders involved in the three selected regional hydrogen projects; project/policy documents related to the cases	Semi-structured interviews; document analysis	Deductive coding of IAD action situations; cross-case comparison

Note: For the full wording of the research questions, see Section 1.2.

### 3.3. Conceptual framework

A conceptual framework provides an overview of existing information on a topic and the relationship between variables [60]. In the literature, collaborative projects in the energy sector are analysed using institutional frameworks that describe both the context and the internal characteristics of the project together. Exogenous and project-internal variables are considered. In particular, the Institutional Analysis and Development (IAD) and the Social–Ecological Systems (SES) frameworks are used to systematically interpret changes in institutions, actors' characteristics and biophysical conditions; in studies of institutional change, these two have also been applied in combination [8] [14] [51] [32]. Using a framework, the cases can be systematically analysed. The following sections describe the IAD and SES frameworks.

#### 3.3.1. Institutional Analysis and Development framework

The Institutional Analysis and Development (IAD) framework is a tool for analysing institutional processes [52]. These institutional processes lead to individual or collective choices of actors in an institutional setting. The framework is applied in research on collective action situations [47] [67] [18]. The IAD framework is well suited for studying cooperation in regional hydrogen projects. The IAD framework is depicted in 3.2. The main component of the IAD framework is the action arena. The action arena consists of participants and action situations. Participants are influenced by exogenous variables. The interactions between the participants lead to outcomes. These outcomes can then change the system for future situations.

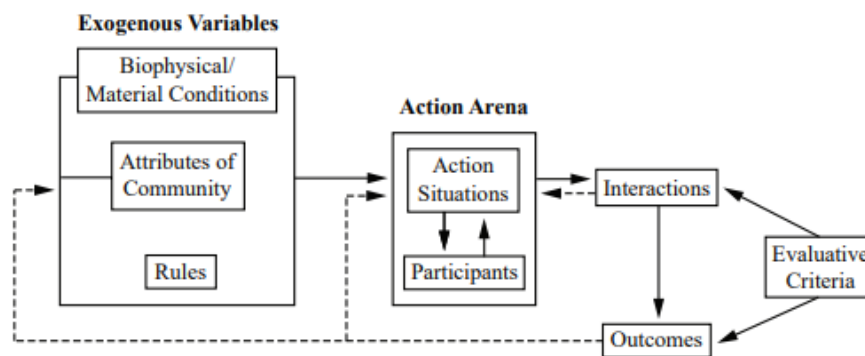


Figure 3.2: IAD framework [52]

The internal structure of the action situations from the IAD framework in figure 3.2 is depicted in figure 3.3. The action situation is the context in which participants make choices that lead to outcomes [52]. The action situation consists of seven components. The first component consists of the *participants*, which can be individuals or groups. The participants can assume specific *positions*. The position is not linked to a participant; therefore, a participant can take on different roles. The participants can perform *actions* in combination with their role. The next component is the *control*, which indicates the amount of control a participant can exercise over the situation. The *information* that participants have available about a situation often differs per participant and influences their actions. The above components together lead to *potential outcomes*, which can be physical or non-physical and have different consequences for each participant. The participant therefore has different *net costs and benefits* from an action.

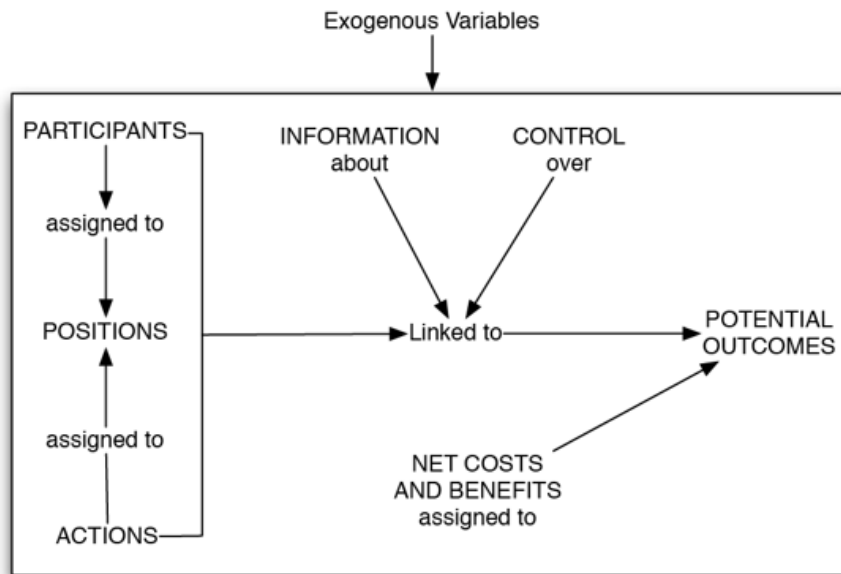


Figure 3.3: Action situation of IAD framework [52]

### 3.3.2. Social-Ecological Systems framework

The social-ecological systems framework (SES) expands on the IAD framework [52]. The framework is suitable for analysing interactions between people and natural resources. The framework has eight first-level subsystems: *Social, economic and political settings, resource systems, resource units, governance systems, users, interactions, outcomes and related ecosystems*. These components are then subdivided into multiple factors. The framework is originally static, but by adding action situations from the IAD framework, it can be investigated how social, ecological and institutional factors together lead to outcomes [8].

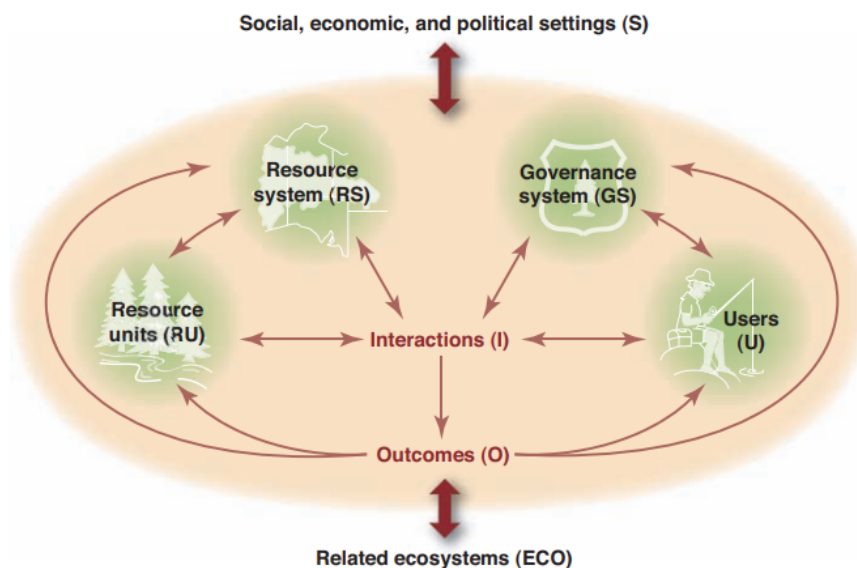


Figure 3.4: Social-Ecological Systems framework

### 3.3.3. Combined IAD and SES framework

The frameworks described above are used in collaborative project studies as a combination of the frameworks [8] [14] [32] [51]. Combined, this framework provides the tools to investigate the factors

that influence the realisation of a collaborative project. The SES framework describes the exogenous variables in which a collaborative project is set up, divided into the following components: biophysical conditions, actors' attributes and governance system. The IAD framework is used to describe the internal characteristics of the project in the form of action situations. The action situations lead to a change from pre-existing conditions to outcomes. The outcomes of a project are also described in biophysical conditions, actors' attributes and governance system.

Regional hydrogen projects in the Netherlands are multi-actor projects in which actors have to collaborate to achieve a desired outcome. These projects are embedded in a complex setting that involves technical, infrastructural, socio-economic, environmental and institutional dimensions and multiple stakeholders [29]. These aspects can be divided into the components of the SES framework: biophysical conditions, actors with different attributes and a governance system. This study combined the Institutional Analysis and Development (IAD) and Social–Ecological Systems (SES) frameworks to explain which factors influenced the realisation of collaborative regional hydrogen projects (see Section 3.3). The combined framework aligns with the objectives of this research: the SES framework organised the exogenous pre-existing conditions that constrained or enabled action, while the IAD framework structured the analysis of interactions within the collaborative project itself. The interactions in the action situations lead to changes in the pre-existing conditions, resulting in outcomes.

The combined IAD and SES framework is relevant to this study because it is suitable for analysing a collaborative project. In a collaborative project, actors take action together that leads to a change in the system. These actions are influenced by pre-existing conditions. The framework distinguishes between context and internal project characteristics and focuses on how stakeholder actions lead to an outcome. Using the combined IAD and SES framework ensured consistency across cases and enabled pattern identification.

Several lenses were considered to analyse how collaborative hydrogen projects can be realised. First, the IAD framework was considered for the analysis of collaborative projects without the addition of the SES framework. However, this lacks a clear division of the context. The SES framework can also be used on its own for the analysis, but this would not include the interactions between stakeholders. The Multi-Level Perspective (MLP) framework was also considered; this framework illustrates how socio-technical transitions occur at the landscape, regime and niche levels [23]. The MLP framework can be used to position Dutch hydrogen initiatives and describe the socio-technical transition. The framework is less suited for analysing specific collaborative hydrogen projects and comparing them.

In this study, the combined IAD and SES framework is used to analyse how collaborative hydrogen projects can be realised, it is shown in Figure 3.5.

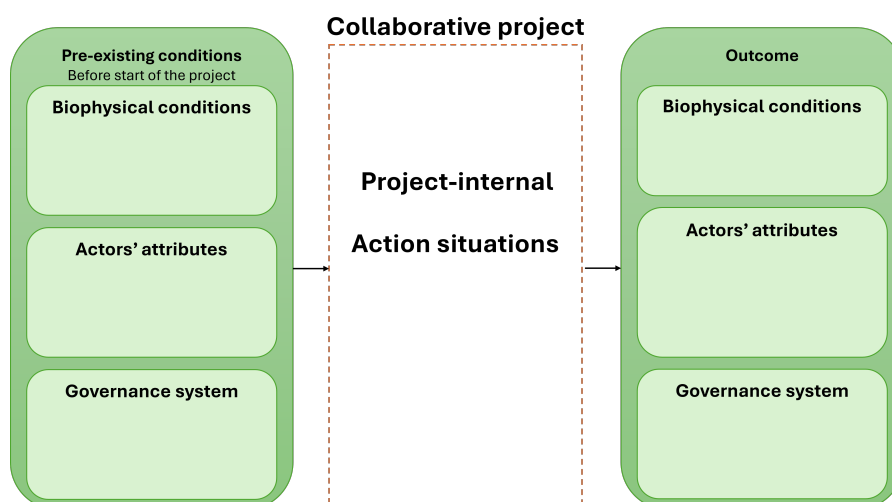


Figure 3.5: IAD and SES framework

## 3.4. Case Study

A multiple case study approach was chosen for this research. This approach allows for the comparison of various collaborative hydrogen projects. This leads to a broad understanding of how collaborative hydrogen projects can be realised. The cases were selected according to the selection criteria, which are discussed in 3.4.1. The selected cases are described in 3.4.2.

### 3.4.1. Selection criteria

To determine which factors influence how collaborative hydrogen projects in Dutch regional industries can be realised, three case studies were examined. Selection criteria were established to ensure that a case fits within the research framework. These criteria ensure that the cases are comparable. The cases had to meet the following criteria:

- **Project status: realisation or operational phase**  
A project progresses through the following four project phases: concept, investment decision, realisation and operational [26]. For this study, a case must be in the realisation or operational phase. A case in the realisation or operational phase provides more concrete and observable stakeholder interactions.
- **Multi-stakeholder structure**  
The project should involve multiple types of stakeholders (public sector, private sector, knowledge institutions, project organisations, etc.) to ensure visible interactions and collaboration. When different stakeholders are involved, this also leads to different interests, resources and perspectives, making it a complex system.
- **Stakeholder collaboration**  
The project must involve collaboration between companies, as the research is focused on collaborative projects. Collaboration must be active, with companies not simply coexisting but also interdependent on each other's input for the project's success.
- **Green hydrogen**  
As the study is focused on hydrogen, green hydrogen must be used within the scope of the case to align with sustainability goals. Although blue or grey hydrogen is acceptable as a bridging measure at some stage of the project, the goal should be to utilise green hydrogen.
- **Located in a regional industrial area in the Netherlands (outside the five main industrial clusters)**  
The research focusses on regional industry; therefore, the selected case should be located outside the five main hydrogen clusters in the Netherlands (Noord-Nederland, Noordzeekanaalgebied, Rotterdam-Moerdijk, Zeeland/West-Brabant en Chemelot) [1].
- **Stakeholder accessibility**  
The stakeholders in a case must be open to participating in interviews. Without the willingness of the stakeholders involved, qualitative information about the realisation of the collaborative project cannot be gathered.

### 3.4.2. Cases

This study examines three case studies. Each case study represents a collaborative hydrogen project in the Dutch regional industrial area. The cases were identified using the public Dutch hydrogen project map provided by MissieH2 [26]. This online overview lists ongoing and planned hydrogen initiatives in the Netherlands and was used as the initial population of projects. From this list, projects were screened against the selection criteria defined in Section 3.4.1. Projects that met these criteria were subsequently contacted for participation in the case study. The case studies analysed in this study are described in the following paragraphs.

#### WEVA-project

The WEVA project (short for Waterstof Elektrisch Vrachtschip Antonie, which translates as "Hydrogen Electric Cargo Vessel Antonie") is a demonstration project. The goal of the project is to develop an inland vessel powered by green hydrogen [68]. The vessel is 135 meters long and transports 240,000 tons of salt annually from Delfzijl to the port of Rotterdam. Lenten Scheepvaart, the vessel's owner,

transports the salt for the chemical company Nobian. Nobian supplies the hydrogen used by the vessel; this is a byproduct of Nobian's production process. NPRC (Nederlandse Particuliere Rijnvaart-Centrale) is also involved in the project; as an inland shipping cooperative, NPRC acts as an intermediary between Nobian and Lenten Scheepvaart. Koedood Marine, Concordia Damen, Hy-Energy TransStore and Nedstack are involved in the technical development of the vessel [50].

The project meets the selection criteria for a project and is therefore relevant to this research. The vessel is currently operating on hydrogen between Delfzijl and Rotterdam. Several stakeholders are involved in the project to achieve zero-emission inland shipping. The vessel runs on green hydrogen from Nobian's production process. While the vessel is sailing between two industrial clusters, the project is not based on the upcoming hydrogen network, but on the use of Nobian's hydrogen. Within this project, various stakeholders are willing to participate in this research and share knowledge about the project.

#### H2essenpO2rt

The H2essenpO2rt project is a consortium between H2-GO b.v. and the water board Drents Overijsselse Delta [27] [10]. Together, they have built a decentralised electrolyser. The 1.2 MW electrolyser produces 500 kilogrammes of hydrogen per day [46]. In addition to hydrogen, the electrolysis process also releases oxygen and heat. The (pure) oxygen is used to purify wastewater and reduce energy consumption in the wastewater treatment plant. The intended use of the heat is not yet known, but research is ongoing. In addition to H2-GO b.v. and the Drents Overijsselse Delta water board, the consortium also includes the municipality of Zwolle, the province of Overijssel, the WeSustain foundation and the Hessenpoort business association.

The project meets the selection criteria for a project and therefore aligns with this research. The project has been operational since January 2025. Various stakeholders are involved in the project and collaborate on the project's development. The electricity required for the electrolysis process is supplied by a solar farm, which enables the production of green hydrogen. Public sources do not indicate whether the electrolyser uses only green electricity. The electrolyser is located outside the five main industrial clusters and is a decentralised system. Within this project, various stakeholders are willing to participate in this research and share knowledge about the project.

#### Hydrogen Cluster for Sustainable Mobility

The Hydrogen Cluster for Sustainable Mobility (also mentioned as 'mobility cluster') is a collaborative project between hydrogen filling station owners, hydrogen vehicle suppliers and hydrogen vehicle buyers (personal communication with an involved stakeholder) [19]. The goal of the project is to accelerate hydrogen mobility in various regions by rolling out a hydrogen refuelling infrastructure and expanding the Dutch hydrogen vehicle fleet. Hydrogen mobility faces a "chicken-and-egg" problem: too few filling stations are being used because of a lack of vehicles and no new vehicles are being added due to a lack of extensive hydrogen infrastructure.

The project meets the project selection criteria and therefore aligns with this research. The project is currently in the implementation phase; filling stations are being built and vehicles are being ordered (personal communication with an involved stakeholder). Several stakeholders are involved, in addition to hydrogen filling station owners, hydrogen vehicle suppliers and hydrogen vehicle buyers; (local) governments also play a role. Collaboration between stakeholders is essential to address the "chicken-and-egg" problem, including infrastructure rollout and vehicle adoption. The project's goal is to use green hydrogen.

## 3.5. Data collection and analysis methods

This section describes how the data needed for the research are collected and analysed. Information is collected through a thematic literature review and semi-structured interviews.

### 3.5.1. Literature review

To collect existing knowledge about collaborative projects in energy initiatives, a thematic literature study is conducted [24]. The literature is collected via Scopus and the repository of the TU Delft. Literature on collaborative projects in decentralised energy networks and stakeholder interactions, rela-

tionships and perspectives between companies in energy initiatives has been analysed. Furthermore, the literature is used as comparative material for the empirical data from the semi-structured interviews. Based on the literature on collaborative projects, frameworks were explored that can be used to analyse regional hydrogen initiatives. Triangulation is achieved by drawing on multiple sources of information: interviews and literature. In addition to the fact that these are different sources, the method for collecting the data is also different.

### 3.5.2. Semi-structured interviews

Semi-structured interviews were conducted to collect primary data in this study. The semi-structured interviews ensured flexibility for the researcher and the participant to explore the topics further, but also ensured that the interviews were comparable [35]. The participants with whom interviews were conducted were stakeholders in the three collaborative hydrogen projects. For the study, participants from the various stakeholders in the collaborative projects were interviewed. This ensured that the perspectives of various stakeholders were highlighted. A total of eight participants were interviewed, two to three per project. The participants were anonymised using codenames that are used throughout the thesis; Table 3.2 lists all participants and the case to which each was assigned. The interviews were conducted through a video call via Microsoft Teams. The interviews lasted 55 to 100 minutes with an average of approximately 70 minutes per interview. The research was conducted in accordance with TU Delft Human Research Ethics Committee (HREC). Participants who participated in the interviews received information about the purpose, objectives and interview procedure prior to the interview. The participants were asked to give permission for the recording and processing of the interview. All participants signed the informed consent form; the informed consent form is shown in the Appendix A. The interviews were transcribed so that the data could be analysed. The transcriptions and recordings were stored securely and confidentially on TU Delft OneDrive. ATLAS.ti was used to analyse the raw transcripts [3].

**Table 3.2:** Participants and cases

<b>Participants</b>	<b>Case</b>
Alpha	WEVA project
Bravo	WEVA project
Charlie	WEVA project
Delta	Hydrogen Cluster for Sustainable Mobility
Echo	Hydrogen Cluster for Sustainable Mobility
Foxtrot	H2essenpO2rt
Golf	H2essenpO2rt
Hotel	H2essenpO2rt

#### Interview analysis

The interviews were recorded and transcribed using Microsoft Teams. The automatically generated transcripts from Microsoft Teams were checked against the original recording and corrected where necessary. The interviews were conducted in Dutch which resulted in Dutch transcripts. This ensured the validity of the results.

The interview transcripts were qualitatively analysed using coding. The coding was conducted in English so that it could be used in this thesis. The quotes used to describe the results in Chapter 4 were translated into English.

Coding of transcripts started with data reduction [42]. Then, codes were added to the quotes from the transcripts. The coding process consisted of several rounds. In the first round, deductive coding was performed based on the fixed top structure based on the framework, which is shown in Table 3.3. During this round, subthemes were also created inductively that fit under the main themes of the pre-existing conditions and outcomes. Subthemes were also added under action situations to describe the identified action situations. After coding all interviews of a case, the code tree was updated with the new subthemes. The quotes within the main themes are then classified under subthemes. Subsequently, the code tree is retained for the next case and, if necessary, supplemented with new subthemes.

**Table 3.3:** Top-level coding framework based on the IAD and SES frameworks with definitions

<b>Main theme</b>	<b>Definition</b>
Pre-existing biophysical conditions	<i>“biophysical conditions”</i> of situation before the start of a project [51]
Pre-existing actors’ attributes	<i>“the social, economic and cultural attributes of the relevant actors”</i> of situation before the start of a project [51]
Pre-existing governance system	<i>“the features of the institutional arrangements and processes”</i> of situation before the start of a project [51]
Action situations	<i>“An action (or decision) situation (AS), the focal unit of analysis of the IAD framework, is the situation (i.e. the space, the setting) wherein action takes place and wherein actors make choices, interact and generate intended and unintended outcomes”</i> [51]
Outcome biophysical conditions	<i>“biophysical conditions”</i> of situation after a project [51]
Outcome actors’ attributes	<i>“the social, economic and cultural attributes of the relevant actors”</i> of situation after a project [51]
Outcome governance system	<i>“the features of the institutional arrangements and processes”</i> of situation after a project [51]

### 3.5.3. Development of the interview design

This section discusses the development of the interview design. The structure of the semi-structured interviews is based on the research paper by Cole et al. [8]. The study uses a combination of the IAD and SES frameworks to analyse institutional change processes over time. This combined framework is similar to the one used in this study. In line with this approach, the interview design is structured around three main components of the framework: pre-existing conditions, outcomes and action situations. Changes in the system result from action situations and thus interactions between actors. The pre-existing conditions change through actions and are expressed in biophysical conditions, actors’ attributes and the governance system. To make the results of the semi-structured interviews usable for analysis with the combined IAD and SES framework, the interview design aligns with the framework’s structure. First, the situation before the intervention is discussed, then the current situation (outcome) and finally the action situations that led to the change are discussed. The most important action situations are explored in more detail, using the seven basic components of an action situation. The questions are designed to be understandable to the participants and are further clarified by the researcher as needed. This approach is consistent with that described in the study by Cole et al. [8]. Cole indicates that it is first necessary to determine what has changed over time and then to address which action situations led to this change. The interview guide is provided in Appendix B.

# 4

## Results

This chapter describes the results of the analysis of the three case studies (WEVA, Hydrogen Cluster for Sustainable Mobility and H2essenpO2rt). Table 4.1 presents the main themes derived from the conceptual framework, with the inductively derived subthemes listed below each theme. The table shows where the subthemes recur for each case. The analysis is based on semi-structured interviews with eight stakeholders from the three projects. The transcripts of the interviews are provided in the Appendix C.

The analysis is structured using the combined IAD and SES framework: SES organises the exogenous context (biophysical conditions, actors' attributes and governance system), while IAD organises the project-internal action situations.

For each case, the description begins with an overview of the project, which summarises the key findings from the subthemes specific to the case. This is followed by a systematic elaboration of the subthemes. For each case, the pre-existing conditions, outcomes and action situations are elaborated. Section 4.1 describes the WEVA project, Section 4.2 describes the Hydrogen Cluster for Sustainable Mobility and Section 4.3 describes the H2essenpO2rt project.

Section 4.4 brings the findings of the cases together in a cross-case synthesis based on these themes. The synthesis describes the patterns within the same subthemes across cases and the relationships between the subthemes. The synthesis describes the pre-existing conditions and action situations. The outcomes are not reanalysed in the synthesis, but it does describe how the action situations lead to the outcomes.

**Table 4.1:** Subthemes: Checkmark indicates presence in projects

<b>Pre-existing conditions – Biophysical conditions</b>			
	WEVA	Mobility cluster	H2essenpO2rt
Availability of hydrogen as a byproduct	✓		
Existing infrastructure and logistic chain	✓		✓
Limited and underused refuelling infrastructure		✓	
Technological baseline and logistical constraints	✓	✓	✓
Technological immaturity and high costs		✓	✓
<b>Pre-existing conditions – Actors' attributes</b>			
Collaboration: NPRC, Nobian and Lenten Scheepvaart	✓		
Cost and efficiency motive			✓
Environmental motivation	✓	✓	✓
Knowledge base	✓	✓	✓
Lack of clear governmental direction		✓	
Lack of or no collaboration		✓	✓
Passion, vision and belief		✓	✓
<b>Pre-existing conditions – Governance system</b>			
Absence or incompleteness of regulations	✓	✓	
Environmental regulatory pressure			✓
Market and economic conditions	✓	✓	✓
Regulatory mismatch	✓		
Weak enforcement of emission regulations		✓	
<b>Outcomes – Biophysical conditions</b>			
Economic and technological barriers to scaling			✓
Electrolyser at wastewater treatment plant			✓
Hydrogen infrastructure	✓		
Hydrogen refuelling stations expansion		✓	
Hydrogen vehicles expansion		✓	
Hydrogen-powered ship	✓		
Lack of standardisation and compatibility	✓		
<b>Outcomes – Actors' attributes</b>			
Compressed hydrogen suppliers	✓		
Consortium Hydrogen mobility cluster		✓	
Cooperation and interest of water boards			✓
Initiator (H2-GO b.v.)			✓
New actors entering the consortium		✓	
Nobian, NPRC and Lenten Scheepvaart	✓		
Regulatory and certification bodies	✓		
Subsidy providers		✓	
Technical construction partners	✓		
<b>Outcomes – Governance system</b>			
Blueprint / business plan		✓	✓
Contract consortium		✓	
Contract construction ship	✓		
Institutional learning and collaboration with government			✓
Long term contract (Nobian, NPRC and Lenten Scheepvaart)	✓		
Regulation and standards	✓	✓	✓
Subsidy support	✓	✓	✓
<b>Action situations</b>			
Consortium formation	✓	✓	✓
Coordination	✓	✓	✓
External legitimation and reputation	✓		
Financing	✓	✓	✓
Formal collaboration and contract formation	✓	✓	✓
Individual motivation and idealistic drivers	✓	✓	✓
Knowledge development and sharing	✓	✓	✓
Overcoming technical challenges	✓	✓	
Regulatory development and standard-setting	✓	✓	✓
<b>Extra</b>			
Future feasibility	✓	✓	✓

## 4.1. WEVA project

This Section describes the results of the analysis of the WEVA-project. The analysis was based on three interviews with participants who are involved in the project; Alpha, Bravo and Charlie. The subthemes that emerged in the pre-existing conditions, outcomes and action situations are described.

Figure 4.1 summarises the key findings of the WEVA project.

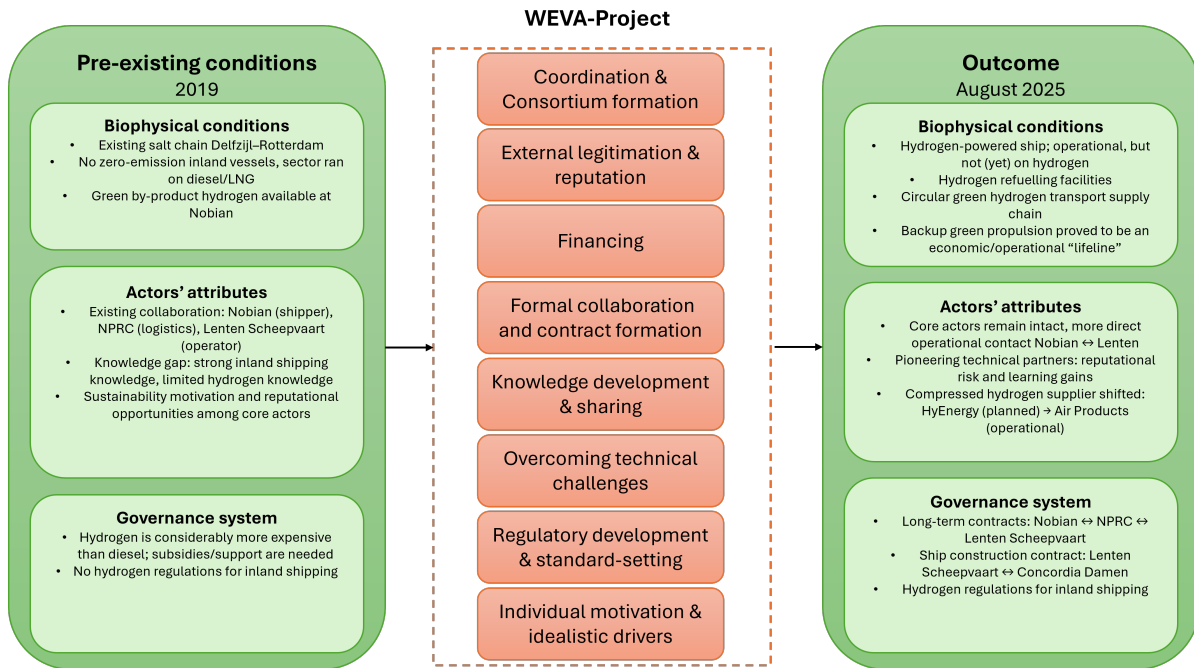


Figure 4.1: Overview of the WEVA-project

### 4.1.1. Pre-existing conditions - Biophysical conditions

#### Availability of hydrogen as a byproduct

In each of the three interviews with participants in the WEVA project, the availability of hydrogen as a byproduct of Nobian's production process is mentioned. The initial impetus for the project came during a working visit by the then CEO of NPRC (Nederlandse Particuliere Rijnvaart-Centrale) to the Nobian factory in Delfzijl, Alpha explains: *"What is that eternal flame over there? It turned out to be uncompressed hydrogen, a byproduct of their production process and that is how the idea arose: 'hey, can't we run a ship on hydrogen?'"* (transcript Alpha, line 8). A significant amount of hydrogen is released at the Nobian factory: *"they produce 1000 kg per day. That is quite a lot."* (transcript Bravo, line 97). The hydrogen is produced green, which contributes to the project's sustainability goal: *"Well, the most important incentive, actually, is the availability of cheap green hydrogen. It is also green-certified."* (transcript Charlie, line 106). This provided a technical and economic advantage for the project. Charlie explains: *"So you won't find cheaper hydrogen anywhere else [...] So that is crucial for the business case?"* (transcript Charlie, line 36). The presence of affordable available hydrogen was a decisive biophysical condition.

#### Existing infrastructure and logistic chain

Since the early 2000s, a transport chain has been operating that carries salt from Nobian's factory in Delfzijl to its factory in Rotterdam (transcript Bravo, line 28; Alpha, line 9). The transport was organised by NPRC and since 2005, Lenten Scheepvaart has also been operating under the NPRC flag between Rotterdam and Delfzijl (transcript Bravo, line 34). At that time, five ships were operating on the route. Therefore, the project will take place within a longer-established transport chain (transcript Bravo, line 42).

### Technological baseline and logistical constraints

Charlie describes the technological status of inland shipping in 2018: *"Building a zero-emission hydrogen ship had not happened before. [...] about 10,000 inland vessels in Europe. There were no electric ships. There were no ships other than those that ran on diesel and LNG."* (transcript Charlie, line 28). Therefore, there were no technological blueprints within the inland shipping sector on which the project could build. However, work had already been done in previous years to reduce ship emissions, Bravo describes: *"in 2009, a transporter for Nobian started installing aftertreatment, so [the transport] was greener."* (transcript Bravo, line 429). A key technical economic aspect in inland shipping is a ship's downtime: *"A ship is simply an expensive thing and it simply has to sail to recoup its costs. [...] if a ship is idle too much because of technical problems with its installation, then yes, you will go under"* (transcript Alpha, line 43).

### 4.1.2. Pre-existing conditions - Actors' attributes

#### Collaboration: NPRC, Nobian and Lenten Scheepvaart

A key element of the pre-existing conditions was the existing collaboration between Nobian, NPRC and Lenten Scheepvaart. NPRC handled Nobian's salt transport at the time (transcript Alpha, line 8). Four vessels under the NPRC flag carried out the salt transport. NPRC thus offers certainty to skippers and shippers: *"NPRC ensures that payments are always made. The freight is paid to the skippers."* (transcript Bravo, line 28). The relationship between the three companies was linear, Bravo describes: *"NPRC with Nobian and NPRC with skippers, but not the direct contact between Nobian and skipper"* (transcript Bravo, line 95). This collaboration forms the basis within the WEVA project, *"the core circle"* (transcript Alpha, line 20).

#### Environmental motivation

Among key stakeholders, there is awareness of the energy transition, which serves as an incentive to carry out a project. Alpha describes this individual involvement: *"As a private individual, I also see that climate change is happening [...] I believe I have to contribute my own version, regardless of what everyone else is doing"* (transcript Alpha, line 47). Nobian is also working on sustainability, as explained by Bravo: *"[Nobian] really wanted that [sailing on hydrogen] to make their supply chains greener."* (transcript Bravo, line 57). NPRC and Nobian were also able to profile themselves positively through a sustainability project: *"Nobian was able to profile itself as being greener. And NPRC was able to present itself to customers other than Nobian, saying, 'Look, this is what we do.'" (transcript Bravo, line 124). In addition to the three main actors, other actors are already working on sustainability: "Koedood Marine, an importer of Mitsubishi diesel engines for shipping, They had also started thinking about sustainability. So, they had already been working on developing a fuel cell system."* (transcript Bravo, line 83). At the same time, Charlie emphasises that the environmental motivation itself was not decisive: *"Marketing. Yes, that too. But that is not why you do it. You just have to make money with it."* (transcript Charlie, lines 45-47).

#### Knowledge base

The knowledge for building a hydrogen ship was not yet fully available to the three key actors. Bravo indicates that knowledge about inland shipping is available, but knowledge about hydrogen was lacking (transcript Bravo, line 130). Charlie describes his knowledge of hydrogen ships: *"Eight years ago I knew nothing about it. And yes, now we have built a real hydrogen ship."* (transcript Charlie, line 16). However, Charlie also indicates that a lot of knowledge about fuel cells already existed: *"There was a fuel cell production location in the Netherlands [...] So, that knowledge was there. We could simply build fuel cells in the Netherlands. And those installations had been running on land for 20 years."* (transcript Charlie, line 130). The knowledge about hydrogen containers was not yet available and using the systems on a ship was also new: *"We had to investigate all that, but beyond that, it was not rocket science."* (transcript Charlie, line 130).

### 4.1.3. Pre-existing conditions - Governance system

#### Absence or incompleteness of regulations

Within the context of the governance system, there was no complete regulatory framework before the project began: *"When we started this, there was very little legislation or regulation. There were not even any exemptions."* (transcript Alpha, line 72). With the existing regulations, a hydrogen ship was

not even a possibility: *"The original rules about building the ship [...] stated that you were not allowed to have hydrogen on board."* (transcript Bravo, line 280). The lack of regulation created uncertainty, but the stakeholders also saw it as an opportunity: *"The fact that there was absolutely nothing, because there was not even a little bit. [...] That was actually quite nice."* (transcript Charlie, line 55). At the start of the project, participants noticed a shift as hydrogen played an increasing role in the energy transition. *"In 2020, [...] The government was like: 'Well, lets help the hydrogen economy by setting up regulations now.'" (transcript Bravo, line 289). In practice, this meant that the project proceeded under temporary arrangements while the formal regulatory framework was being developed. So, at the start of the project, there were few regulations, but the government was aware of the missing regulations and intended to set something up.*

#### Market and economic conditions

In 2019, hydrogen was an expensive fuel compared to diesel, the common fuel for inland shipping. Charlie describes the difference between hydrogen and diesel: *"The gap that exists now between sailing on diesel, which is €1.10 per unit. And sailing on hydrogen, when it started, cost €6 per kilo per unit. So you simply have to go from €1.10 to €6 back then."* (transcript Charlie, line 106). Bravo highlights a key challenge for a hydrogen project with a comment: *"What matters is that going green is all well and good, but the stove still needs to keep burning."* (transcript Bravo, line 55). With relatively expensive hydrogen, it is difficult to set up an economically viable project.

#### Regulatory mismatch

The Dutch government began developing regulations for the use of hydrogen. However, the first draughts of the regulations resulted in an unclear policy that was not applicable to hydrogen use: *"That [draughting regulations] is a good idea in theory. The downside is that they have copied regulations from the LNG regulations to hydrogen."* (transcript Bravo, line 291). The regulations do not match hydrogen, Bravo explains why hydrogen differs from LNG: *"LNG is super cooled and hydrogen as we use it is just atmospheric temperature, [...] hydrogen is 16 times lighter than air, [...] so you cannot compare that one to one"* (transcript Bravo, line 293).

### 4.1.4. Outcomes - Biophysical conditions

#### Hydrogen infrastructure

The hydrogen infrastructure is a key technical component in the implementation of hydrogen in inland shipping. The WEVA project planned to build a compressor station at the Nobian factory in Delfzijl. Bravo describes the compressor station's status and indicates its current source of hydrogen: *"It is still not operational because the filling station in Delfzijl wasn't ready on time. [...] Of course, we also have hydrogen from the factory in Rotterdam."* (transcript Bravo, line 148). To fill this gap, Air Products in Rotterdam will fill the hydrogen containers: *"[Air Products] will now also fill my hydrogen containers. Well, that just added another party to the chain."* (transcript Bravo, line 150). Air Products is imposing new requirements for the hydrogen containers, making it more complex (transcript Bravo, line 152).

#### Hydrogen-powered ship

The physical result of the collaborative project is the hydrogen-powered ship. The ship is equipped with, among other things, a fuel cell and containers to store hydrogen. Interchangeable containers are used to allow for the continuous transport of salt between Delfzijl and Rotterdam: *"For example, we opted for interchangeable containers [...] three are permanently on shore and three are on board the ship"* (transcript Alpha, line 20). The ship is technically capable of running on hydrogen, but the construction of the hydrogen containers was two years later (transcript Bravo, line 126). As of August 2025, the ship had not yet begun running on hydrogen: *"The ship has now been in service for 1.5 years and is not yet running on hydrogen... but is running on the diesel generator"* (transcript Alpha, line 39). The additional option of using a propulsion system other than hydrogen is crucial for the project's economic viability: *"the fact that we have that backup has saved the project"* (transcript Alpha, line 39).

#### Lack of standardisation and compatibility

A physical bottleneck that the participants encountered during the project is the lack of standardisation in the Dutch hydrogen context. As described, Air Products became involved in the project to fill the containers: *"Filling the containers at Air Products meant that a different filling connection was needed,*

as well as other safety features in the containers” (transcript Bravo, line 165). This is an example of a larger problem in the hydrogen sector, as Charlie describes: *“There are 100 parties in the hydrogen world, all of whom are also considering this. The first thing they say is ‘yes we need to standardise’. [...] so no standard has been developed for those containers”* (transcript Charlie, line 118). The lack of a standard makes the containers incompatible with other filling systems (transcript Alpha, line 29).

#### 4.1.5. Outcomes - Actors' attributes

##### Compressed hydrogen suppliers

A key actor in the project are the compressed hydrogen suppliers. Alpha describes why compressing hydrogen is important: *“To run an inland vessel on hydrogen, you at least have to compress it so you can get it on board the vessel”* (transcript Alpha, line 20). HyEnergy is building a compression station at the Nobian factory in Delfzijl; however, this project has been delayed and is not completed in August 2025 (transcript Bravo, line 148). To prevent the project from stalling due to this delay, Air Products has been asked to supply compressed hydrogen to the vessel: *“In that sense, HyEnergy has effectively been replaced by Air Products, although it is still expected that HyEnergy will also build the compression station in Delfzijl.”* (transcript Alpha, line 55). The change of actors demonstrates that a complete chain must be built for the project and that no link can be missing. As described in Section 4.1.4, the change of actors also introduces new complexity.

##### Nobian, NPRC and Lenten Scheepvaart

The three main core actors in the project remain NPRC, Nobian and Lenten Scheepvaart (transcript Bravo, line 142). However, their bonds have been strengthened through the collaborative project. Under pre-existing conditions, there was little contact between Nobian and Lenten Scheepvaart and all communication went through NPRC. The relationship is different in that Nobian and Lenten Scheepvaart have more contact, primarily at the operational level (transcript Bravo, line 144). Although the three actors together form the core of the consortium, they each have their own roles. A key role for Lenten Scheepvaart is its responsibility for the ship and its fixed costs (transcript Alpha, line 24).

##### Regulatory and certification bodies

The regulatory and certification bodies play a key role in the project (transcript Alpha, line 20). Alpha describes the attitude of government organisations as follows: *“In my experience, they are willing to do so but are risk-averse.”* (transcript Alpha, line 72). However, Charlie indicates that government policy was quickly available and that daring to take risks is then crucial: *“That’s incredibly fast, it depends on the civil servant and the minister who allows for it and also senior civil servants who are willing to take that risk with us.”* (transcript Charlie, line 96).

##### Technical construction partners

Various actors played a role in the construction of the ship. Bravo describes the relationship between the technical construction partners and the core actors as follows: *“That is a collaboration of companies under a main contractor”* (transcript Bravo, line 233). Concordia Damen is the main contractor. The technical construction partners are each working on a hydrogen ship for the first time: *“Everyone is doing it for the first time. Concordia is delivering a hydrogen-powered ship for the first time and Ned-stack is building fuel cells on a new ship for the first time.”* (transcript Alpha, line 24). The technical construction partners are not only involved in the project’s implementation, they also act as innovative partners. The reputation of the technical construction partners is at stake because of this project: *“If the thing does not work at all, the next person who might build a hydrogen ship will no longer go to [the stakeholders currently involved]”* (transcript Alpha, line 99). However, this can also have a positive outcome if the project is successful, as actors possess a great deal of knowledge.

#### 4.1.6. Outcomes - Governance system

##### Contract construction ship

Lenten Scheepvaart has a contract with Concordia Damen for the construction of the ship (transcript Alpha, line 24). Concordia Damen has several specialised subcontractors. This resembles a traditional contract between the client and the contractor, but there is collaboration between all the different parties. For example, Alpha explains: *“One thing I learnt throughout the process is that it is a whole chain and the chain is only complete when all the links are in place, so everyone is pioneering.”* (transcript Alpha,

line 24). Alpha emphasises that the legal relationship through a contract is an important foundation (transcript Alpha, line 29).

#### Long-term contract (Nobian, NPRC and Lenten Scheepvaart)

Contracts have also been drawn up between the three key actors. Nobian signed a long-term contract with NPRC and NPRC signed a long-term contract with Lenten Scheepvaart (transcript Alpha, line 51). The long-term nature of the contracts allowed Lenten Scheepvaart to invest in the hydrogen ship. The contract stipulates that the transport will be carried out with zero emissions (transcript Charlie, line 80). Contractual agreements form the legal foundation of the project, as they eliminated uncertainty.

#### Regulation and standards

During the project, new rules and standards were developed for hydrogen-powered shipping (transcript Alpha, line 39). Before the project began, there was no legislation or guidelines on hydrogen-powered shipping. Charlie describes how this has changed over time: *"There is a thick book explaining how to build a hydrogen ship and what safety requirements you need to consider."* (transcript Charlie, line 96). The Central Commission for the Navigation of the Rhine granted an exemption for this project to operate on hydrogen (transcript Charlie, line 58). The exemption was granted on the condition that the classification societies determine whether it is safe: *"This required conducting all kinds of safety studies, HAZIDs and HAZOPs. Extensive calculations were performed and all risks were weighed and it was determined whether it was possible or not."* (transcript Charlie, line 55).

### 4.1.7. Action situations

#### Coordination & Consortium formation

Coordination in the WEVA project has been crucial throughout. From the start, coordination was essential: *"About six years ago, there were already rumours that something was going on. We were asking around here and there"* (transcript Bravo, line 40). At that time, there were ideas about sailing on hydrogen and NPRC and Lenten Scheepvaart expressed their interest in taking on this project. This led to the concrete collaboration: *"Nobian, NPRC and Lenten Scheepvaart will have the ship powered by hydrogen and also make it a new construction project. That was the idea"* (transcript Bravo, line 73). The core actors then began searching for partners to build the ship. Nedstack became involved in the project through a previous relationship with Nobian (transcript Bravo, line 73). Koedood Marine became involved because it was already developing fuel cell systems and had previous collaborations with the core actors (transcript Bravo, lines 83-85).

During the project, there were two levels of coordination. The working group is responsible for the operational level. The steering committee includes executives from the involved actors and provides broad guidance (transcript Bravo, line 91).

There was also coordination between the core actors and the technical construction partners. Bravo describes some challenges here: *"They react differently to that, in Scotland. I would say 'Hey, have you heard anything about that?' and then it would say 'They still have five weeks to respond.'"* (transcript Bravo, line 63). Bravo describes a different way of collaborating: *"If you are waiting for this, [...] Then you pick up the phone and call that person."* (transcript Bravo, line 63).

#### External legitimisation and reputation

A key action during the project was external legitimisation. The interviews reveal that there were several moments in which information about the project was shared externally. A good example was the visit of Dutch king Willem-Alexander: *"the crowning glory of our work [...] That was also an important action. [...] we knew at that point that we weren't quite there yet, so it made everyone enthusiastic again and committed to tackling those final difficult steps together."* (transcript Alpha, line 87). The King's visit also created vulnerability due to the public exposure: *"The sector is watching you. [...] It can also work against you, especially when the King arrives. Yes, that means you are completely in the picture."* (transcript Alpha, line 91). This shows that external legitimisation creates support but also increases pressure. The extensive publicity about the project was not planned (transcript Bravo, line 359). Bravo does indicate that it helps prevent resistance from bystanders (transcript Bravo, line 334). However, Charlie indicates that it is not essentially about the reputation (transcript Charlie, line 45). The external legitimacy and reputation provide additional motivation for the project's stakeholders and greater acceptance within society at large.

### Financing & Formal collaboration and contract formation

Financing and contract formation play a key role in the project's realisation. Contract formation focusses primarily on the agreement between key actors, while financing focusses more on the other financial aspects of realising a collaborative project. Due to significant overlap, the action scenarios are described together.

The project starts with expressing commitment from core actors: *"These three parties have jointly signed a letter of intent."* (transcript Alpha, line 20). The key stakeholders then began to inventory the needs and possibilities of the project. Lenten Scheepvaart also mapped out the costs of a new ship during that time. To actually begin construction of the ship, a contract was necessary between key actors. As a hydrogen-powered ship is more expensive than a conventional inland vessel, a long-term contract was then signed between the actors: *"This was possible because NPRC had signed a long-term contract with Nobian, giving Lenten Scheepvaart sufficient certainty that it could recoup its investment before Lenten Scheepvaart commissioned the financing"* (transcript Alpha, line 51). As Alpha describes, after the contract with NPRC, Lenten Scheepvaart also entered into a contract with the shipbuilder Concordia Damen.

The signing of the contract is described by Alpha as a 'point of no return', the actors were legally bound to each other for a long time: *"That [signing the contract] was indeed a crucial moment."* (transcript Bravo, line 179) and *"that was the hard formal point of no return. We had long-term commitments to each other."* (transcript Alpha, line 87).

In addition to the increased financial security of a long-term contract, the project is also supported by subsidies: *"The subsidy provider provides two larger and two smaller subsidies."* (transcript Bravo, line 187).

### Knowledge development and sharing

As described in Section 4.1.2, the actors still have little knowledge about hydrogen in inland shipping. Therefore, the development of knowledge is a key action situation during the project. Alpha describes this: *"The parties themselves don't know those problems yet either. [...] You know that you will encounter ups and downs. You don't know yet which ups and downs. The know/unknown"* (transcript Alpha, line 33).

The stakeholders had existing knowledge of inland shipping but also had to expand into new domains: *"We had to immediately enter an environment that was unfamiliar to us"* (transcript Bravo, line 130). However, Bravo describes that the technological partners already had knowledge of hydrogen that the project could build on: *"They had already been working on developing a fuel cell system"* (transcript Bravo, line 83). During the project, a great deal of knowledge had to be gathered to overcome technical challenges; this action situation is described in the next paragraph.

In addition to gathering knowledge, it is also shared among stakeholders. The consortium is also obligated to share knowledge with the sector: *"Pilot project is for knowledge sharing"* (transcript Bravo, line 218).

### Overcoming technical challenges

The project faced several technical challenges. Charlie describes it as follows: *"Everything went smoothly, except for a few technical complications."* (transcript Charlie, line 116). The technical complications significantly impacted the project's planning: *"You run into so many things that complicate things that you can forget about planning."* (transcript Charlie, line 62).

A technical and economic issue was the method of hydrogen storage on the ship. The original plan was to use a fixed storage tank, but there were economic barriers: *"Then it turned out that it would take 6 to 8 hours to refill the storage tank with hydrogen"* (transcript Bravo, line 105). Ultimately, interchangeable containers were chosen, but this resulted in higher investment costs and a different filling connection at Air Products (transcript Bravo, lines 114, 165).

Besides the technical challenges of building the ship, the use of the hydrogen installation also presents an additional challenge: *"The maintenance of this installation is completely different. Safety is... you have to completely transform yourself into a safety expert. Otherwise, you should not even start and that applies to your entire staff."* (transcript Charlie, line 136).

### Regulatory development and standard-setting

As described in Section 4.1.6, the governance system expanded significantly during the project. Initially, there were no laws or regulations regarding hydrogen-powered inland shipping: *"There was no law*

*telling us what to do*" (transcript Charlie, line 36). Charlie then describes how the key actors, together with the minister, began exploring a solution: *"We asked the minister under what conditions we could do this. He said, 'Well, if there is an expert opinion and classification society that determines it is safe, then I am willing to grant an exemption.'"* (transcript Charlie, line 36). Lloyd's subsequently conducted several safety studies and subsequently approved the vessel (transcript Bravo, line 160).

Obtaining a permit for the vessel from Rijkswaterstaat (the Directorate-General for Public Works and Water Management) also proved challenging. Rijkswaterstaat granted a multi-year permit to operate a vessel longer than permitted at the time (transcript Bravo, lines 241-243). This was crucial for the project's feasibility; without this permit, it would have been less financially viable.

#### Individual motivation and idealistic drivers

Realising the collaborative project was carried out mainly in the eight aforementioned action situations. However, the interviews reveal that a key component within these action situations is the individual motivation and idealistic drivers of several individuals among the actors. One of the participants describes his own motivation: *"Also as a private individual I see that climate change is happening [...] I think I should contribute my version of that."* (transcript Alpha, line 47).

Alpha also describes that it has been important for the project that people in key positions within the companies involved support this project: *"What is simply important is that you have a few people who are also simply believers [...] that certainly has to be at C-level as well, so at the highest level of the organisations"* (transcript Alpha, line 95).

The support of individuals within the government was also crucial to the project's success. Charlie emphasises: *"The willingness of civil servants to fully participate in making this project possible. Without them, it would not have happened."* and *"The willingness of grant providers to place their trust in this project would not have happened otherwise either."* (transcript Charlie, line 116).

## 4.2. Hydrogen Cluster for Sustainable Mobility

This Section describes the results of the analysis of the Hydrogen Cluster for Sustainable Mobility project. The analysis was based on two interviews with participants who are involved in the project; Delta and Echo. The subthemes that emerged in the pre-existing conditions, outcomes and action situations are described.

Figure 4.2 summarises the key findings of the Hydrogen Cluster for Sustainable Mobility project.

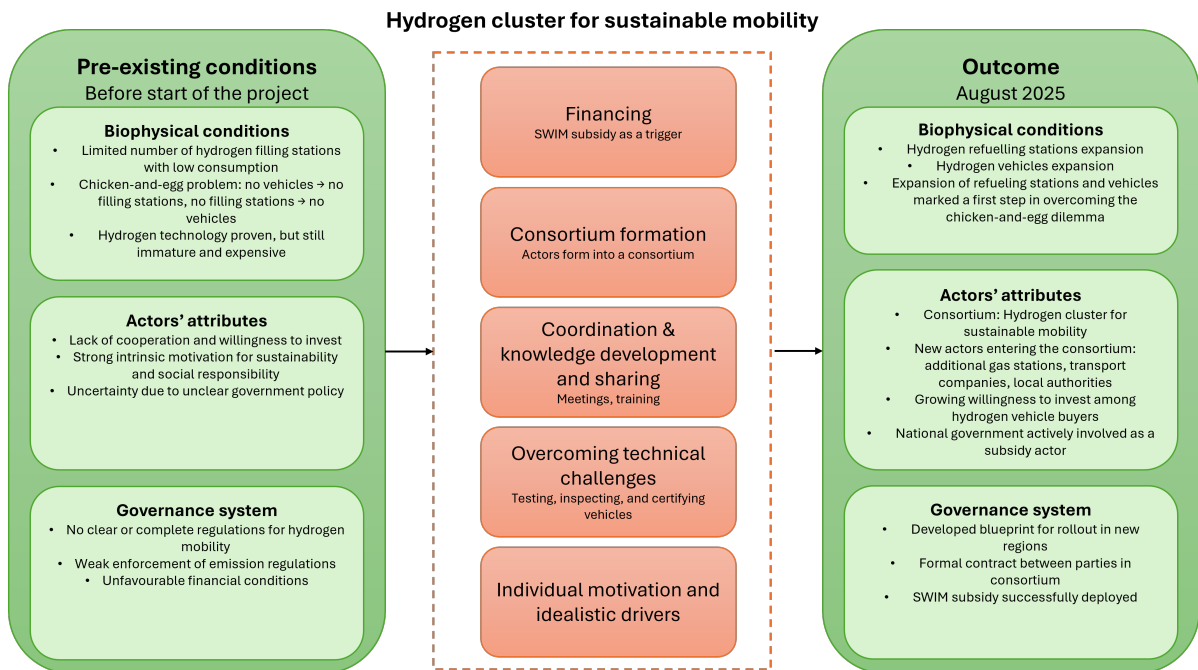


Figure 4.2: Overview of the Hydrogen Cluster for Sustainable Mobility

### 4.2.1. Pre-existing conditions – Biophysical conditions

#### Limited and underused refuelling infrastructure

The fuelling infrastructure for hydrogen mobility in the Netherlands is limited and underused. There are a few operational hydrogen filling stations in the Netherlands, but they are hardly used. Delta describes: *"No one comes to refuel at all. [...] because there are not enough hydrogen vehicles."* (transcript Delta, line 42). Echo describes this situation as a chicken-and-egg problem: *"Everyone is looking at each other and the chicken-and-egg dilemma is not being resolved. [...] Fountain Fuel is just going to build it. Fountain Fuel is just going to install that first chicken."* (transcript Echo, line 72). In addition to filling stations, vehicles are also needed for hydrogen mobility: *"You essentially need a vehicle, you need a filling station. And that is it. You actually have those two things, biophysically, you need those two."* (transcript Echo, line 48).

#### Technological baseline and logistical constraints

In addition to the limited hydrogen mobility infrastructure, there is an extensive fossil and electric mobility system (transcript Echo, line 48). Delta and Echo indicate that electric vehicles are less suitable for fulfilling certain logistical links: *"Well, it became increasingly clear that an electric vehicle, a 100% electric vehicle, is not capable of fulfilling that distribution or operational link."* (transcript Delta, line 56; Echo, line 48). Hydrogen-powered mobility can offer an emission-free alternative for fulfilling certain logistical links.

#### Technological immaturity and high costs

The participants describe hydrogen technology as immature and expensive. The high cost of a hydrogen vehicle makes it less attractive. Delta describes the high costs with the analogy of a sports car: *"a business model where you calculate a cost price for which you could easily buy a beautifully decorated Porsche."* (transcript Delta, line 36). Delta indicates that the high costs are due to the relatively

expensive nature of hydrogen technology and the inability to produce it on a large scale, as an OEM (Original Equipment Manufacturer) can (transcript Delta, line 36). In addition to the high cost of hydrogen technology, the technology is also not yet fully developed: *"fuel cell technology is still relatively in its infancy."* (transcript Delta, line 68). Interestingly, Echo considers hydrogen technology already proven: *"and that hydrogen technology in vehicles has actually been proven for quite some time."* (transcript Echo, line 48). However, Echo also indicates that despite its proven potential, it is still an immature technology: *"That is an important characteristic, so it is not like we had to develop a new product or a new technology. It was already there, it just wasn't necessarily implemented on a large scale yet."* (transcript Echo, line 48).

#### 4.2.2. Pre-existing conditions - Actors' attributes

##### Environmental motivation

An attribute that several actors shared before the collaborative project was launched was the environmental motivation. Delta describes finding a sporting event he was involved in as too polluting: *"One of the things I started to dislike at some point was the sheer amount of pollution from this truly wonderful event."* (transcript Delta, line 34). Delta also describes his broader responsibility for the climate: *"We owe it to our future generations to ensure that we conduct our work in a less polluting way."* (transcript Delta, line 36). In addition to individuals who have an intrinsic environmental motivation, companies also have the motivation to become more sustainable. For example, Delta indicates: *"another company said: [...] we also have a business argument. If we tender for a government tender and can demonstrate that we do our work 100% zero emission, then we win those contracts."* (transcript Delta, line 36).

##### Lack of clear governmental direction

The project starts in an unclear policy context. Delta points to the lack of decisive policy measures: *"The government in general was still reluctant to embrace the idea of zero-emission zones [...] Local governments aren't sure yet whether they will actually issue fines."* (transcript Delta, line 52). This results in lower willingness to invest in hydrogen mobility among companies: *"As an entrepreneur, you do not immediately rush to say: 'Well, we have to do this.'"* (transcript Delta, line 52). Moreover, Delta describes government policy as creating barriers: *"The government puts a lot of barriers in the way of businesses, but does not really come up with structural solutions."* (transcript Delta, line 195). The role of local government institutions is also important in setting up tenders; if the emphasis is on low costs, this discourages more sustainable choices: *"Then those companies cannot actually make their business more sustainable, because they are faced with enormous additional costs, while they know they will not get the work."* (transcript Echo, line 56).

##### Lack of or no collaboration

Before the collaborative project was established in 2024, the actors had no other collaborations with each other: *"those actors [...] actually they only existed."* (transcript Echo, line 86). The lack of collaboration can be explained, among other things, by the transport companies' lack of willingness to invest (transcript Echo, line 98).

#### 4.2.3. Pre-existing conditions - Governance system

##### Absence or incompleteness of regulations

The participants describe the policy context with respect to hydrogen mobility as incomplete. A subsidy scheme for establishing a hydrogen mobility market is also lacking from this policy. Echo describes how the government has handled this: *"The Dutch government actually came to Foutain Fuel some time ago [...] to gather input for a new subsidy scheme they wanted to set up."* (transcript Echo, line 96).

##### Market and economic conditions

The high cost of hydrogen technology plays a significant role. Hydrogen vehicles are expensive: *"The vehicle is quite expensive, so without government support, you cannot get there."* (transcript Delta, line 40). In Section 4.2.3, it is described that a subsidy scheme is still lacking in the policy context. Echo considers subsidies necessary: *"Those hydrogen vehicles are more expensive than fossil fuel variants [...] that subsidy covers that gap, allowing companies to avoid those additional costs and actually make*

*that investment.*" (transcript Echo, line 62). Echo also indicates that the subsidy and the development of the collaborative project are linked: *"The subsidy was necessary for the collaboration to be established because there was no subsidy before, but there was afterward"* (transcript Echo, line 62).

#### Weak enforcement of emission regulations

Finally, participants describe enforcement around zero-emission zones as weak. The zero emission rules are intended to ensure that green mobility is mandatory in selected areas (transcript Echo, line 54). However, participants indicate that enforcement is inadequate: *"If you don't get a fine, you might as well just drive your polluting diesel into the city, no problem at all."* (transcript Delta, line 56). It is further emphasised that the regime is non-binding: *"once is a warning, twice is an angry look and three times is a fine. So yeah, nobody is going to run for that"* (transcript Delta, line 58). Companies therefore see little reason to invest in green mobility technology. Later in the interview, Delta emphasises that enforcing strict regulations is important: *"Regulations are of course incredibly important, because when the national government [...] is an ambassador for hydrogen mobility and also communicates this, for example, in tenders, then there is an additional incentive for companies to switch to zero-emission mobility."* (transcript Delta, line 94).

### 4.2.4. Outcomes - Biophysical conditions

#### Hydrogen refuelling stations expansion

A key tangible result of the project is the (planned) expansion of the hydrogen fuelling infrastructure in the Netherlands. The project has already resulted in several new fuelling stations (transcript Echo, line 135). Echo describes that the existing infrastructure is being expanded: *"Fountain Fuel already had a number of stations and as a result of that partnership, an investment decision has been made for two additional stations"* (transcript Echo, line 68). The new fuelling stations will expand national coverage: *"Each fuelling station focusses on a different city and in this case, a different province"* (transcript Echo, line 135).

#### Hydrogen vehicles expansion

In addition to the expansion of the hydrogen filling stations, the hydrogen mobility fleet is also expanding. Under pre-existing conditions, vehicles were still in the development phase at vehicle manufacturer E-Lions; the collaboration made it possible to sell the vehicles commercially: *"While that [E-Lions vehicle] has now gone into production and has been proven. So there is now a roadworthy version of that vehicle available, which was not the case all along."* (transcript Echo, line 62). As a result of the collaborative project, vehicles are also being ordered: *"I think another very important step is that the vehicles have been ordered. In other words, there was no subsidy before and now there is, so the vehicles are now receiving a subsidy."* (transcript Echo, line 62). Echo further emphasises that the results of the latest collaboration will be visible in the short term: *"The first cars are scheduled for delivery in 3 weeks"* (transcript Echo, line 131).

### 4.2.5. Outcomes - Actors' attributes

#### Consortium: Hydrogen mobility cluster

The stakeholders who collaborate on the implementation of hydrogen mobility in the Netherlands are doing so under the umbrella of the *Hydrogen Cluster for Sustainable Mobility* consortium. Echo describes it as an independent partnership where the operational plan is shared by all participants (transcript Echo, lines 98-100). There are three core actors within the consortium: hydrogen station operators, vehicle suppliers and customers who want to use a zero-emission hydrogen vehicle (transcript Delta, line 46; Echo, line 64). Several companies fulfil the role for each type of actors. Echo considers the consortium "the" output of the project: *"That partnership has actually been the enormous output, because it includes all the companies that have also invested in hydrogen vehicles and sustainable transport."* (transcript Echo, line 64).

#### New actors entering the consortium

The consortium described in the previous Section will be expanded over time to include new companies. Hydrogen station operators have expressed interest and joined the consortium (transcript Echo, line 78). Companies that were previously reluctant are now also participating in the consortium by purchasing hydrogen vehicles: *"because before this whole collaboration, [...] they [transport companies] were*

*not willing to invest in these types of vehicles. And now they are willing to invest.*" (transcript Echo, line 78). The expansion of the consortium is also occurring geographically; new stakeholders are joining the construction of new hydrogen stations: *"two new local governments have been activated and new transport companies from that region have joined"* (transcript Echo, line 135). Even stakeholders not currently involved in the collaborative project are showing interest, such as hydrogen producers (transcript Echo, line 78). The consortium is therefore expected to grow in the future.

#### Subsidy providers

The other key actor is the SWIM (Hydrogen in Mobility Subsidy Scheme) subsidy provider. The subsidy provider has actively participated in providing subsidies and plays a key role in this process. Echo emphasises: *"The national government made the subsidy available, so they have indeed become actively involved in the entire consortium, as they now also manage the financial aspects for many of the investing parties"* (transcript Echo, line 78).

### 4.2.6. Outcomes - Governance system

#### Blueprint / business plan

A key outcome of the collaborative project is a blueprint. Using a blueprint, a hydrogen mobility development project can be rolled out in a new region: *"We created a blueprint that we continually try to roll out in an area and we do that rollout together"* (transcript Echo, line 143). The blueprint provides information for efficiently developing new projects and demonstrates the partnership's ambition to expand.

#### Contract consortium

The signing of a contract with all involved parties made the collaborative project official. Echo describes it: *"As soon as all those signatures were in place, I think there were about 27, the outcome was achieved."* (transcript Echo, line 100). The contract forms the basis for the collaborative project between hydrogen station operators, vehicle suppliers and customers who want to use zero-emission hydrogen vehicles.

#### Subsidy support

The subsidy and its structure played a significant role in the collaborative project. The SWIM subsidy was announced in January 2023 (transcript Echo, line 188). *"That new subsidy scheme called SWIM [...] aims to encourage businesses, not private vehicles, but businesses, to transition to zero-emission transport, regardless of electrification"* (transcript Echo, line 50). The subsidy is considered a significant step and remains the driving force behind the project.

### 4.2.7. Action situations

#### Financing

The financing using a subsidy was a key component of the project (transcript Delta, line 217; Echo, line 178). The stakeholders involved in this action situation were the Dutch Enterprise Agency (RVO) (the subsidy provider), hydrogen station operators, vehicle suppliers and hydrogen vehicle buyers (transcript Delta, line 180). The government established the criteria for the subsidy. Hydrogen station operators, vehicle suppliers and hydrogen vehicle buyers collaborated to qualify for the subsidy. The so-called SWIM subsidy had several conditions that had to be met to qualify for the subsidy (transcript Delta, line 217). One of the conditions was that at least one participant from each group of stakeholders was required: *"You can only apply for the subsidy with those three signatures and that is a fundamental difference"* (transcript Echo, line 123). These conditions necessitated collaboration between stakeholders, breaking the chicken-and-egg dilemma. In addition to these conditions, there are substantive requirements such as: *"required to keep the vehicle registered for at least four years."* (transcript Delta, line 184), *"the hydrogen station must demonstrate that they could supply at least 300 kg of hydrogen per day."* (transcript Delta, line 180) and *"after registration, three years to actually complete your project."* (transcript Delta, line 125). These conditions ensure significant investment from the consortium.

Echo considers the publication of the subsidy scheme as the start of the collaborative project: *"the beginning of the collaboration between all parties and stakeholders was January 2023. That is actually the moment the subsidy scheme was announced."* (transcript Echo, line 188). From then on, hydrogen

station operators and vehicle suppliers began working together to find buyers for hydrogen vehicles. This collaboration was a logical consequence of the subsidy structure: *"We have this subsidy and we need each other for this, because the hydrogen station has to participate based on the subsidy, but the vehicle supplier also has to participate."* (transcript Echo, line 98).

As soon as the subsidy was awarded to a consortium, it immediately provided a financial reward to offset the additional costs of hydrogen vehicles and hydrogen stations: *"Those hydrogen vehicles are more expensive than fossil-based variants, [...] the subsidy covers that gap, so companies don't have those additional costs"* (transcript Echo, line 62).

#### Consortium formation

After the subsidy programme was released, stakeholders reached out to collaborate within the Hydrogen Cluster for Sustainable Mobility consortium. Fountain Fuel initially played a leading role, but over time, the project evolved into an independent partnership (transcript Echo, line 98).

The hydrogen station operators and vehicle suppliers initially sought each other out and then jointly sought buyers for the vehicles and hydrogen. They used the following rhetoric: *"There is now a hydrogen vehicle available and the initial reaction was always 'But that is incredibly expensive,' and we could then say, [...] there is a subsidy available for those vehicles, which covers the additional cost."* (transcript Echo, line 98).

In addition to the mutual commitment within the consortium with respect to the purchase of hydrogen stations and vehicles, other agreements were also made to enthruse current and new members of the consortium: *"we want to meet every six months for dinner to share experiences. [...] Additional subsidies and tax benefits were also explored. [...] driver training has become part of the partnership."* (transcript Echo, line 100).

The goal of the consortium was to qualify for subsidies to get the hydrogen mobility sector off the ground; without collaboration, there was no entitlement to the subsidy (transcript Echo, line 68). The formation of the consortium was an iterative process in which new actors continually joined.

#### Coordination & Knowledge development and sharing

Fountain Fuel had a key role in the project coordination, acting as the driving force at the beginning (transcript Echo, line 98). Vehicle suppliers are primarily involved in the nomination of new partners who wish to purchase vehicles. Vehicle buyers have provided input on their wishes and conditions to make the consortium more attractive to new buyers (transcript Echo, line 98).

A key component of project coordination in this project is knowledge development and knowledge sharing. Four of the seven quotes on knowledge development and sharing are also related to coordination, which shows the agreement. A time for sharing this knowledge is during a biannual dinner: *"We all meet every six months for a dinner to exchange experiences."* (transcript Echo, line 100). The collaboration also provided insights into new financial aspects: *"It emerged that it was important to also consider additional subsidies and tax benefits."* (transcript Echo, line 100).

Regular information meetings were organised to reach new stakeholders: *"Telling them, look, you will soon be able to refuel at Rotterdam Airport with hydrogen."* (transcript Delta, line 190). As previously described, training sessions were also provided: *"So, all companies that participate [...] the drivers will receive training."* (transcript Echo, line 100).

Within the project, actors also take on each other's roles and support each other (transcript Echo, line 151). Echo explains the reason: *"We are a first mover and the first mover strategy simply means that you cannot piggyback on things that have already been done."* (transcript Echo, line 151).

#### Overcoming technical challenges

To make the project successful, several technical challenges were also overcome. As described in Section 4.2.1, hydrogen vehicle technology was immature and expensive. The high costs are covered by the subsidy, but for immaturity, knowledge must be gathered and several technical challenges must be overcome.

Vehicle suppliers are responsible for hydrogen vehicles and therefore, play a key role. An external vehicle manufacturer assessed the quality of the vehicles: *"they were commissioned to conduct a complete designer review of the vehicle."* (transcript Delta, line 78). The Dutch and German vehicle inspection authorities also played a role in determining the technical challenges, as they technically determined whether a vehicle is permitted on public roads (transcript Delta, line 78).

The approval of the inspection authorities was an important step for the vehicle suppliers because this is necessary for commercial rollout.

#### Individual motivation and idealistic drivers

Realising the collaborative project was carried out mainly in the five aforementioned action situations. However, the interviews reveal that a key component within these action situations is the individual motivation and idealistic drivers of several individuals among the actors (transcript Delta, line 227).

Several individuals identified sustainability and social responsibility as key drivers: *"They really wanted to make that sustainable impact and profit margins were not the only important factor for these individuals. That personal drive has created a larger ambition to make this a success."* (transcript Echo, line 170). Echo describes how individuals became unsolicited ambassadors for the project: *"Certain individuals [...] were inspired by the idea of this collaboration and actually [...] became driving forces and inspirators within their own massive organisations."* (transcript Echo, line 166). However, Echo also notes that not everyone in the collaborative project has this drive (transcript Echo, line 168).

In addition to high intrinsic motivation, the personal connection between the project participants is also important: *"Business is, of course, also just a human thing [...] It all depends on the personal connection and I think that is a very important element of the success of this collaboration."* (transcript Echo, line 165).

### 4.3. H2essenpO2rt

This Section describes the results of the analysis of the H2essenpO2rt project. The analysis was based on two interviews with three participants who are involved in the project; Foxtrot, Golf and Hotel. In one interview, participants Golf and Hotel are interviewed simultaneously. The subthemes that emerged in the pre-existing conditions, outcomes and action situations are described.

Figure 4.3 summarises the key findings of the H2essenpO2rt project.

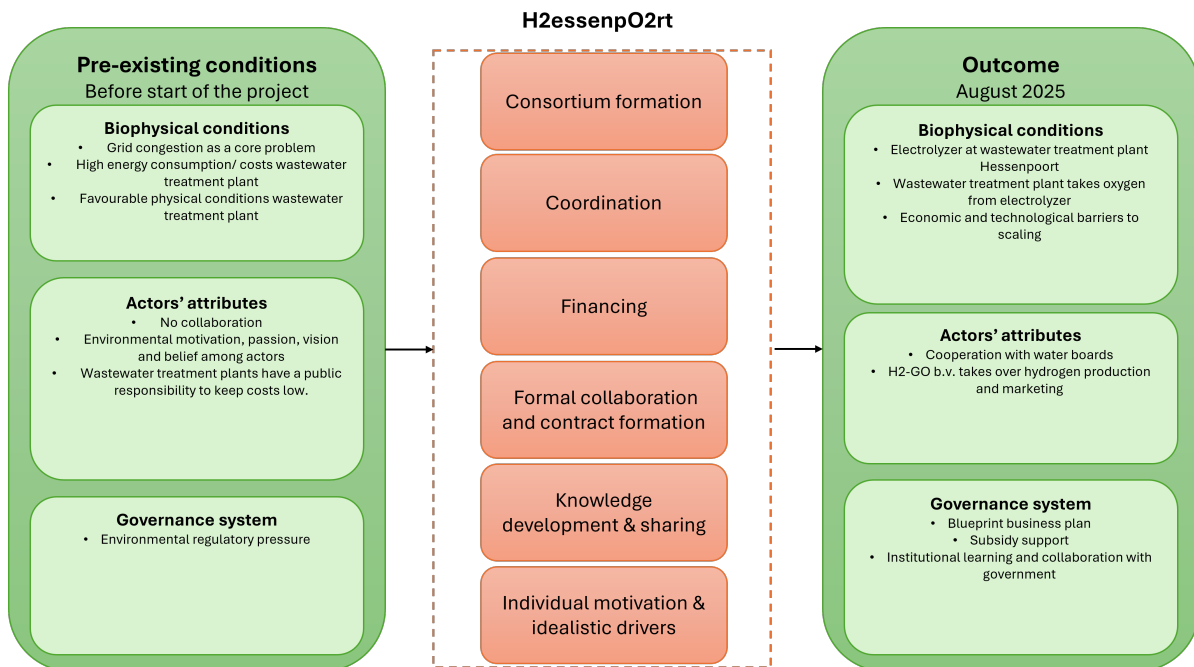


Figure 4.3: Overview of the H2essenpO2rt

#### 4.3.1. Pre-existing conditions - Biophysical conditions

##### Technological baseline and logistical constraints

At the Hessenpoort industrial estate in Zwolle, grid congestion is occurring, resulting in an imbalance between the electricity used and the electricity generated (transcript Golf, line 12; Foxtrot, line 22). The wastewater treatment plant at the site also consumes a lot of energy and is expected to do so in the future: *"Wastewater treatment plants will use a lot of energy because water quality needs to be improved. [...] This means they will need to use a great deal of energy to implement all the new technologies."* (transcript Foxtrot, line 27). Electricity is therefore an *"essential asset"* for the Hessenpoort wastewater treatment plant (transcript Foxtrot, line 27). In addition to the uncertainty surrounding electricity supply, the rising price also worries Foxtrot: *"The price was rising [...] and the water board aims to provide their services at the lowest possible price."* (transcript Foxtrot, line 27). These technological and economic factors make Hessenpoort a suitable location for the construction of an electrolyser: *"An electrolyser would be more difficult to install in another location with very high energy demand."* (transcript Golf, line 25).

##### Existing infrastructure and logistic chain

The wastewater treatment plant site was biophysically suitable for the construction of an electrolyser. Foxtrot describes the advantages of the location: *"It is a protected area. People walk on the floor, well protected. So, that makes it an interesting place."* (transcript Foxtrot, line 40). This makes the location more suitable than *"close to those wind turbines, in the middle of nowhere."* (transcript Foxtrot, line 40). Golf also sees the location as interesting: *"A fairly small wastewater treatment plant. That still has sufficient capacity to do all sorts of things, to grow."* (transcript Golf, line 12). The interesting location coincides with the uncertainty about the supply of affordable electricity.

### 4.3.2. Pre-existing conditions - Actors' attributes

#### Cost and efficiency motive

A key driver for the actors involved was the cost and efficiency of the processes. As described in Section 4.3.1, the wastewater treatment plant is facing higher costs. The water board is a public organisation and must fulfil its task at a low cost (transcript Foxtrot, line 27). This was a reason for the water board to express interest in this project: *"The water board joined because they believed that they could increase the efficiency of an electrolyser by utilising the residual products of electrolysis"* (transcript Golf, line 17).

#### Environmental motivation & Passion, vision and belief

In addition to the argument about energy security, the participants also have an environmental motivation. The water board is a public organisation and supports government policy: *"The water board, as a government, supports all government policy, so it wants to contribute to that"* (transcript Foxtrot, line 22). The participants also share a personal motivation to contribute positively to the environment. Hotel describes how he has repeatedly encountered the *"problems surrounding nitrogen"* throughout his career and sees this as a reason to address it structurally and technologically (transcript Hotel, lines 47, 54). The participants also decisively agreed that hydrogen could be an interesting component of the future energy system (transcript Foxtrot, line 24). The participants discuss visionary leaders and influencers who put hydrogen on the agenda: *"There were some visionary leaders and influencers [...] The outcome was 'Hey, we have an opportunity here to shape the energy landscape of the future.'" (transcript Golf, line 17). The initiator, H2-GO b.v., believes in the future of hydrogen, according to Hotel: "H2-GO believes that hydrogen is like the best battery in the world."* (transcript Hotel, line 29). Among some of the actors, it is clear that there is individual passion and belief in a greener future with hydrogen.

#### Lack of or no collaboration

The actors did not collaborate prior to the project. There was no collaboration between stakeholders in the region with respect to hydrogen or grid management. However, the wastewater treatment plant and the initiator themselves were addressing the challenges described above. When their interests converged, there was room for collaboration (transcript Foxtrot, line 30).

### 4.3.3. Pre-existing conditions - Governance system

#### Environmental regulatory pressure

Within the governance system, stakeholders see the growing pressure surrounding the nitrogen crisis as a trigger for the project: *"If I could give a trigger, it would be the nitrogen problem."* (transcript Hotel, line 52). For the participants, it was the main reason that the existing system was no longer sustainable: *"That [nitrogen crisis] is what it is, was something I said, 'It has to change.'" (transcript Hotel, line 54). Although the participants see this as a trigger, they also believe that the national government is reacting too slowly (Golf & transcript Hotel, line 76).*

### 4.3.4. Outcomes - Biophysical conditions

#### Electrolyser at wastewater treatment plant

The concrete physical result of the collaborative project is the electrolyser on the site of the wastewater treatment plant in Hessenpoort. The hydrogen from the electrolyser is not used by the water board, but is marketed by the initiator (H2-GO b.v.) (transcript Foxtrot, line 30). The other product of the electrolysis process, oxygen, is used for the purpose of energy conservation: *"What was new was that we connected it to a wastewater treatment plant to introduce pure oxygen."* (transcript Hotel, line 36).

#### Economic and technological barriers to scaling

Despite the results of the electrolyser in Hessenpoort, the participants described that scaling up this electrolyser project is proving difficult. Foxtrot indicates that the ambition is to set up more projects: *"And then actually use three projects as demos [...] And that is the only one that was accomplished at that time, that is Hessenpoort."* (transcript Foxtrot, line 59). This shows that Hessenpoort is currently an exception to the rule. Hotel also sees that electrolysis projects are not yet getting off the ground (transcript Hotel, line 47). Hotel indicates that this is due to production costs that cannot be recouped (transcript Hotel, line 47).

### 4.3.5. Outcomes - Actors' attributes

#### Cooperation and interest of water boards

A key result of the project is that the water boards have increased their cooperation on hydrogen thanks to the pilot project in Hessenpoort. Foxtrot describes the interest shown by other water boards: *"At all 21 water boards, something is happening, but it is still in the early stages. But in those six, serious steps have been taken to explore the how and what."* (transcript Foxtrot, line 59). Foxtrot indicates that a business plan is being developed at one water board, indicating that the plans are becoming concrete and that Hessenpoort is seen as a model. The water boards also exchange knowledge about developments surrounding hydrogen: *"The water boards meet once a month and a close-knit group has developed there, a kind of cross-link, a thematic cross-link among the water boards."* (transcript Foxtrot, line 61).

#### Initiator (H2-GO b.v.)

The initiator played a key role in the collaborative project. The water board saw opportunities for an electrolyser at the wastewater treatment plant site but did not have the resources to realise it. H2-GO b.v. took on this role and built an electrolyser on the wastewater treatment plant site in Hessenpoort and markets the hydrogen produced (transcript Foxtrot, line 30; Golf, line 19).

### 4.3.6. Outcomes - Governance system

#### Blueprint / business plan

A result of the collaborative project is the business plan developed by the water boards. Foxtrot describes the document's contents: *"A guideline written for the water boards on how to start such a project? Why start such a project? What it means to you? What are the technical aspects involved? What are the legal aspects involved?"* (transcript Foxtrot, line 59). A section has also been added to the document that allows a water board to determine whether a similar project is worthwhile: *"A business case model has also been developed that every water board can use to assess whether something similar is feasible."* (transcript Foxtrot, line 59).

#### Regulation and standards

The Hessenpoort project influenced the development of regulations. In the initial phase of the project, the regulations were barely adapted to the practicalities of hydrogen production, resulting in many uncertainties for the projects: *"In terms of regulations, we actually had the wind at our backs. We did encounter all sorts of obstacles, because the regulations weren't yet sufficiently developed to allow for everything, but we navigated through them fairly well."* (transcript Golf, line 64).

#### Subsidy support

The government provided a subsidy for the pilot project. Hotel indicates that the new application of an electrolyser resulted in a subsidy for the project: *"a subsidy application was requested and actually received, simply because we demonstrated that the residual products in hydrogen production are perfectly suitable."* (transcript Hotel, line 36).

#### Institutional learning and collaboration with government

The lessons learnt in the Hessenpoort project on collaboration with the network operator were shared with the national government. The project served as a good example of what could be presented to the ministry and of which lessons could be learnt (transcript Foxtrot, line 49). Following the report, the government took action: *"Now someone will be specifically appointed to map out and implement this grid congestion story."* (transcript Foxtrot, line 49). This shows that the pilot project not only gained knowledge about electrolysis in wastewater treatment plant environments but also achieved governance outcomes outside of the project.

### 4.3.7. Action situations

#### Consortium formation

The formation of the H2essenpO2rt consortium was a process in which the actors gradually found common ground. The water board was aware of its dependence on energy, as described in Section 4.3.1 and saw hydrogen as a possible solution (transcript Foxtrot, line 24). So there was interest and the H2-GO b.v. showed willingness to invest in the project (transcript Foxtrot, line 30). Ultimately, the

province of Overijssel, the municipality of Zwolle and the Hessenpoort business association established an energy cooperative (transcript Golf, line 17). This was a broad plan to address the energy system in Hessenpoort. One component of this project is the electrolyser at the wastewater treatment plant (transcript Golf, line 17). Hotel notes that forming the consortium was also a search for individuals with the same vision: *"People who see that things need to be done differently and who, at some point, found each other there and had the courage."* (transcript Hotel, line 130).

#### Coordination

A key element of coordination emerges when collaboration with the grid operator is difficult. The grid operator's attitude was defensive: *"This results in a rather rigid attitude from the grid operators, which essentially makes it impossible to arrange that agreement."* (transcript Foxtrot, line 47). To overcome this, the matter was escalated to a ministry. The water board was able to present the exact case to the ministry, which could use it as a practical example (transcript Foxtrot, line 49). In addition to coordination with the grid operator and the ministry, there was also coordination among the water boards. Following the project, a thematic collaboration was established with all the water boards on the topic of hydrogen (transcript Foxtrot, line 61).

#### Financing & Formal collaboration and contract formation

External support is needed to finance the project; currently, there is no sound market model for hydrogen production (transcript Hotel, line 121). Foxtrot describes how the possibility of financial support became known early on in the project: *"So then there was room to present the project to the ministry. And that led to a financial contribution from the ministry to the project. Well, that certainly helps boost the launch of a pilot project."* (transcript Foxtrot, line 22). The project has been awarded a subsidy from the Netherlands Enterprise Agency (RVO) (transcript Hotel, line 36). To obtain the subsidy, the project was set up as a pilot project. However, the pilot project has also presented new challenges: *"But a pilot project is by definition not necessarily based on profitability. It is now preventing us from growing and developing it further."* (transcript Golf, line 57).

#### Knowledge development and sharing

A key component of the project was to develop knowledge about the application of the electrolyser in a wastewater treatment plant. STOWA (Foundation for Applied Water Research) conducted initial exploratory studies to determine the potential role of hydrogen or an electrolyser in a wastewater treatment plant (transcript Foxtrot, line 24). This research highlighted the potential role of oxygen in the electrolysis process (transcript Foxtrot, line 27). This exploratory study described the system and determined how a wastewater treatment plant could benefit from an electrolyser. This was then investigated in practice: *"We initially investigated, through trial and error, what the benefits would be if we were to introduce pure oxygen [...] And the results were so positive that we decided we are going for this together."* (transcript Hotel, line 36). This marked the beginning of the construction of the electrolyser on the site of the wastewater treatment plant. The knowledge gained from the project was subsequently shared with all water boards to provide momentum for new initiatives (transcript Foxtrot, line 61).

#### Individual motivation and idealistic drivers

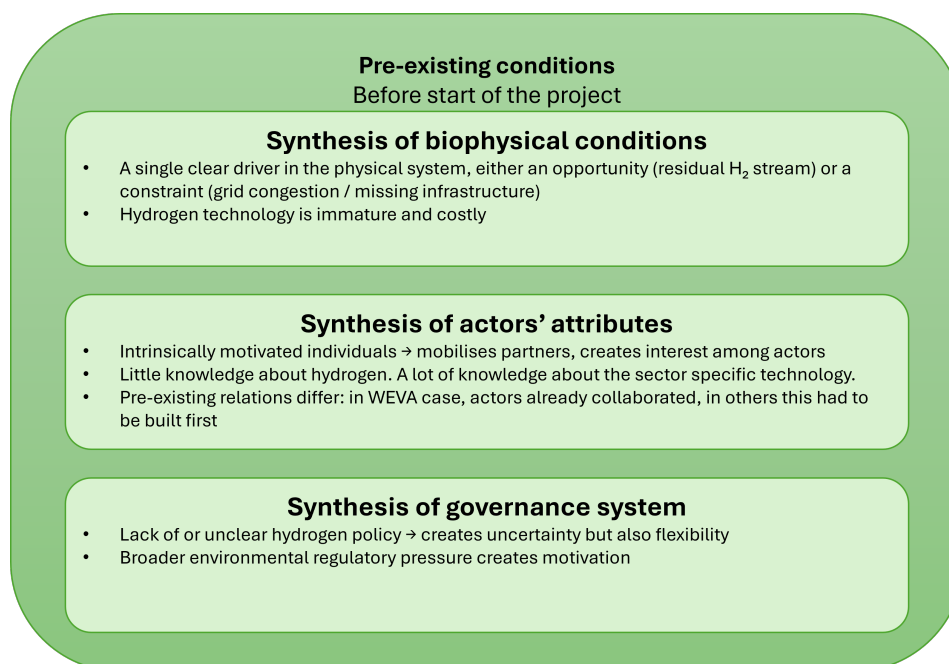
Realising the collaborative project was carried out mainly in the five aforementioned action situations. However, the interviews reveal that a key component within these action situations is the individual motivation and idealistic drivers of several individuals among the actors (transcript Golf, line 130). Several visionary individuals were involved in the project's development. Golf emphasises its importance: *"I think that is a prerequisite for these kinds of initiatives to ultimately get off the ground."* (transcript Golf, line 45). The participants share the personal conviction that existing energy systems are unsustainable. Hotel describes the initiative: *"to connect ideas, perhaps even delusions, as some call them, to at least lay a foundation."* (transcript Hotel, line 47). Although some call the participants' vision *"idiocy"*, the respondents consider their vision and courage essential for the project's success (transcript Hotel, line 47).

## 4.4. Synthesis

This Section brings together the results of the three cases. It discusses how the cases differ and resemble each other and how this can be explained. Sections 4.4.1, 4.4.2 and 4.4.3 describe the synthesis of the pre-existing conditions. This answers the following sub-question: *What role do exogenous characteristics play in the realisation of collaborative hydrogen projects in Dutch regional industries?*

Figure 4.4 provides an overview of these pre-existing conditions (biophysical conditions, actors' attributes and the governance system) as they emerged across the three cases. The figure does not reproduce all coded subthemes, but groups them under the three analytical themes to show the overall narrative. It serves as a visual guide for Sections 4.4.1–4.4.3.

Section 4.4.4 describes the synthesis of the action situations. The action situations describe the project-internal characteristics of the three projects. This answers the third sub-question: *Which project-internal characteristics support the realisation of collaborative hydrogen projects in Dutch regional industries?*



**Figure 4.4:** Cross-case synthesis of pre-existing conditions

### 4.4.1. Biophysical conditions

The analysis of the three cases shows that the biophysical conditions were decisive in the development and direction of the projects. The specific circumstances varied from project to project, but provided a trigger for the collaborative project.

#### Resource and infrastructure conditions

This section describes the synthesis of the following subthemes: availability of hydrogen as a byproduct, existing infrastructure and logistical chain, and limited and underused refuelling infrastructure. The biophysical conditions differ; in the WEVA project, a residual hydrogen stream is available (resource) (transcript Charlie, line 106). In the Hydrogen Cluster for Sustainable Mobility project, the pressure is due to the lack of infrastructure (constraint), as Delta indicates: *"There are already a number of hydrogen filling stations, no one comes to refuel [...] because there are not enough hydrogen vehicles."* (transcript Delta, line 42). In the H2essenpO2rt project, the pressure stems from grid congestion in the industrial estate (constraint), as Foxtrot describes: *"In the meantime, it was clear that Hessenpoort is an interesting location because of grid congestion and because of the amount of sustainable electricity generated there."* (transcript Foxtrot, line 22).

In all three cases, the hydrogen project depends on the physical infrastructure and the limitations or opportunities it offers. Biophysical pressure can arise from an opportunity (WEVA project) or a problem

(H2essenpO2rt and mobility cluster) within the current system.

In the H2essenpO2rt project and the mobility cluster, participants face limitations in the existing infrastructure and technology, such as grid congestion and empty fuel stations due to lack of vehicles. However, in WEVA, the participants describe an already well-functioning transport chain: "*Lenten Scheepvaart has been transporting salt for Nobian*" (transcript Bravo, line 28).

#### Technological baseline, maturity and costs

Furthermore, all three projects demonstrate that hydrogen technology is immature and economically unattractive (transcript Charlie, lines 28, 106; Delta, lines 36, 68; Hotel, line 121). The high costs of hydrogen technology hinder the potential for profitability, but this does create a situation in which political support, such as subsidies, can become available. Although the technology already exists in all three projects, it has not yet been fully developed and has not yet been used for the chosen application (transcript Alpha, line 24; Echo, line 48; Hotel, line 36).

### 4.4.2. Actors' attributes

#### Environmental motivation & Passion, vision and belief

In all three projects, the environmental motivation of the stakeholders plays a crucial role (transcript Alpha, line 47; Delta, line 34; Golf, line 17). Before projects begin, key stakeholders have an interest in or motivation for greening a process. Regarding environmental motivation, a distinction can be made between individuals or companies with environmental motivation. Respondents from the WEVA project mention that profiling and reputation are important for companies to differentiate themselves from other organisations. Bravo describes this: "*Nobian could profile itself as being green. And NPRC could profile itself to customers, saying, 'Look, this is what we do.'*" (transcript Bravo, line 124). However, Charlie emphasises that this is not the be-all and end-all (transcript Charlie, line 45). For companies in the mobility cluster, the advantage in tenders plays a role. For example, Delta indicates that companies are sometimes eligible for tenders if they carry out zero-emission work (transcript Delta, line 36). In all three projects, stakeholders participate to gain knowledge about hydrogen in their sector, also to ensure future proofing (transcript Alpha, line 47; Bravo, line 83; Delta, line 64; Foxtrot, line 45). In addition to the companies' interests in actively participating in greening, the participants also express their personal environmental motivation. In all three projects, participants indicate that before the project begins, there are people who "must contribute their version" to the better climate (transcript Alpha, line 47; Delta, line 36; Golf, line 45). Golf refers to the idealism of the involved individuals as "*a prerequisite for these kinds of initiatives to ultimately get off the ground*" (transcript Golf, line 45). Highly motivated individuals are important for the project to come to fruition; without the courage and conviction of the actors involved, it would probably not be possible.

#### Previous collaborations between actors

In the H2essenpO2rt project and the mobility project, the core actors had not previously collaborated with each other. Echo describes the lack of collaboration in the mobility cluster: "*before that, those actors existed beforehand [...], in fact, they only existed*" (transcript Echo, line 86). The core actors (Nobian, NPRC and Lenten Scheepvaart) within the WEVA project had a long-standing collaboration before the project began, regarding the salt transport between Delfzijl and Rotterdam (transcript Bravo, line 28). The available residual hydrogen stream, as described in Section 4.4.1, came from the core actor Nobian. Because the actors had an existing collaboration, this opportunity arose during a working visit (transcript Alpha, line 8).

#### Knowledge base

The knowledge already present among the stakeholders influenced the implementation of the hydrogen projects. In all three cases, there is a mix of existing technical knowledge and a lack of knowledge about hydrogen integration (transcript Charlie, line 130; Delta, line 68; Echo, line 48; Hotel, line 36). Learning by doing is therefore a recurring theme in the projects. In the WEVA project, the stakeholders had a broad knowledge about inland shipping (transcript Bravo, line 85). However, Charlie describes that much knowledge about hydrogen was still lacking among the core stakeholders: "*But the knowledge of building such a hydrogen container was not there; that was completely built up. We had to research all the knowledge to do that on board [...] but beyond that, it was not rocket science.*" (transcript Charlie, line 130). The mobility cluster builds on existing automotive and testing capabilities (including VDL,

TÜV, RDW), while practical knowledge of hydrogen vehicles was still limited (transcript Delta, line 68). In the case of H2essenpO2rt, the core knowledge in wastewater treatment process technology was already present on the water board. External resources were needed for electrolysis, which came from H2-GO b.v. The existing knowledge of the stakeholders served as a basis for the projects. It provided a springboard for the hydrogen projects. In all cases, external parties with hydrogen expertise participated in the project to share their knowledge about hydrogen. However, in the WEVA and H2essenpO2rt projects, the application of hydrogen knowledge or solution is new to external parties.

### 4.4.3. Governance system

#### Absence or incompleteness of regulations

In two of the three cases, participants indicated that regulations regarding hydrogen for the planned application are not yet in place. The WEVA project lacked a complete legislative framework (transcript Alpha, line 72). In the mobility project, regulations regarding zero-emission zones were rarely present and strict enforcement was lacking, resulting in low investment willingness (transcript Delta, line 56). There was also no suitable subsidy programme to support the project. In January 2022, stakeholders involved provided input to the government to establish the subsidy (transcript Echo, line 186). Echo considers this as the "trigger" for the collaborative project on the mobility project (transcript Echo, line 96).

The participants describe the lack of regulations as both a barrier and an opportunity (transcript Charlie, line 55). Charlie points out that traditional propulsion systems are heavily regulated, providing frameworks but also obstacles for a project (transcript Charlie, line 96). During the WEVA project, it was possible to develop guidelines and regulations together with the government. This aligns with the approach the government took in the mobility project by collaborating with stakeholders to develop the subsidy scheme, which later formed the basis for the collaborative project.

#### Environmental regulatory pressure

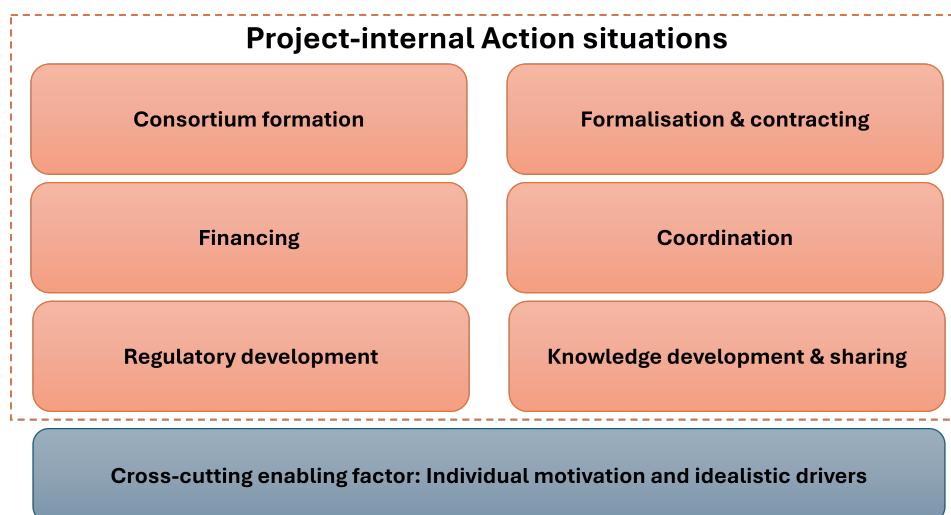
In the H2essenpO2rt project, participants are less vocal about the lack of legislation or regulations that specifically impact the project, but they do indicate that the national "nitrogen problem" is a trigger for the project (transcript Golf, line 52). Although this isn't specifically mentioned by participants in the other two projects, the transcripts do indicate that the energy transition is the driving force behind the projects. Alpha states: *"We see that an energy transition is necessary."* (transcript Alpha, line 47) and Delta states: *"We all have to do our best to leave this planet cleaner. But a key part of that is the transition to sustainable mobility."* (transcript Delta, line 38). This shows that the climate crisis is a factor for actors and that it is part of the motivation for regional hydrogen projects.

#### Market and economic conditions

The participants outline that hydrogen applications are relatively expensive compared to existing applications. Operational costs are high due to the high price of hydrogen (transcript Charlie, line 106). But capital costs are also high, making government support necessary for a viable business case (transcript Delta, lines 40-44; Echo, line 62; Hotel, line 121).

### 4.4.4. Action situations

The three projects revealed six recurring project-internal action situations that had to be organised in order to realise a regional hydrogen project. Figure 4.5 summarises the recurring action situations identified in the cases and highlights the cross-cutting role of individual motivation and idealistic drivers. Together, these action situations explain which project-internal characteristics support the realisation of collaborative hydrogen projects in Dutch regional industries.



**Figure 4.5:** Cross-case synthesis of action situations

### Consortium formation

The formation of the consortia for the hydrogen projects takes place according to three logics: (i) a formation based on existing relationships (WEVA), (ii) a formation driven by a subsidy that forces actors to work together (mobility project) and (iii) a formation by actors who experience the same problem due to grid congestion (H2essenpO2rt).

The participants in the WEVA project do not specifically mention the formation of the consortium. The collaboration of the core players is a natural outcome of their previous collaborations and the low-cost green hydrogen from the Nobian plant. The expansion with the technical partners also stems from existing collaborations (transcript Bravo, line 85).

In the mobility cluster, the SWIM subsidy conditions connect the stakeholders (transcript Echo, line 98). After the subsidy was announced, the stakeholders began to reach out to each other, with Fountain Fuel taking the lead (transcript Delta, line 180).

In the H2essenpO2rt project, the province, municipality and business association are organising a larger plan with building blocks to address grid congestion around Hessenpoort (transcript Golf, line 17). One of the building blocks is the electrolyser at Hessenpoort.

In all three projects, an actor is actively involved in connecting the parties in the consortium: in the WEVA project, this is NPRC, which connects Nobian and Lenten Scheepvaart; in the mobility cluster, Fountain Fuel is actively involved in connecting actors; in H2essenpO2rt, visionary people connect actors.

### Formal collaboration & contract formation

The participants describe that after bringing the actors together, they sign one or more contracts with all the stakeholders involved. This is considered the formal "start", "point of no return", "outcome" or "crucial moment" of the collaborative project (transcript Alpha, line 87; Bravo, line 179; Echo, line 100). In the WEVA project, the core stakeholders initiated the project by signing a letter of intent (transcript Alpha, line 20). Participants in the other projects only mention contracts that establish a legal relationship. This could be explained by the fact that, unlike the WEVA project, the stakeholders in these projects have not previously collaborated. In the mobility cluster, formalisation was achieved through a consortium agreement involving 27 actors (transcript Echo, line 100). For the H2essenpO2rt project, the formal basis is a pilot project (transcript Golf, line 57).

Contracts were crucial for the WEVA project. Because the stakeholders had signed long-term contracts with each other, the risk was acceptable (transcript Alpha, line 51).

### Coordination

Coordination is a broad concept; it refers to the communication between stakeholders that aligns and organises how the overall goal will be achieved. In the WEVA project, coordination is handled by a steering committee (general planning) and a working group (operational planning) (transcript Bravo,

line 91). Various stakeholders are included in the steering committee and working group. In the mobility project, coordination is initially handled by Fountain Fuel, which will gradually shift to an independent partnership (transcript Echo, line 98). In the H2essenpO2rt project, no specific project coordinator is appointed by the participants.

#### Financing

Project financing was a key element in all three cases. Subsidies were used for all three projects (transcript Bravo, line 187; Delta, line 50; Hotel, line 36). The subsidy was a requirement for completing the projects' business cases: *"You need a subsidy like that to make it financially feasible at all."* (transcript Echo, line 178).

The WEVA project and the H2essenpO2rt project are pilot/demo projects (transcript Bravo, line 216; Golf, line 57). In exchange for receiving the grant, the projects share their knowledge with the sector, spreading innovation and enabling the hydrogen market to flourish (transcript Bravo, line 218).

The subsidy programme plays a special role in the mobility project. To be eligible for the subsidy, several conditions must be met. For example, there is a collaboration requirement between the hydrogen station, the vehicle supplier and the transport companies (transcript Echo, line 98). The structure of the subsidy has thus largely shaped the collaborative project. Echo describes this requirement as the *"most decisive connection between the chicken [hydrogen station] and the egg [vehicles]"* (transcript Echo, line 120).

The subsidies will be used for the development and purchase of hydrogen installations [6] (transcript Echo, line 62; Bravo, line 114).

#### External legitimation and reputation

Only in the WEVA project do external legitimacy and reputation emerge as a factor that contributed to the success of the collaborative project. The project received several publicity announcements, culminating in the visit of the King of the Netherlands (transcript Alpha, line 87). This positive publicity generated acceptance from the community and a good reputation for the stakeholders involved (transcript Bravo, lines 317, 334). However, the publicity also has a downside, as it places additional pressure on the stakeholders: *"It can also backfire, especially when the King comes. That is all in the picture."* (transcript Alpha, line 91). Charlie emphasises that marketing is not the decisive factor for the project: *"That is not what you do it for."* (transcript Charlie, line 45). Within the mobility cluster, Echo has deliberately chosen not to generate too much publicity and is currently focussing entirely on the project (personal communication with Echo). Participants in the H2essenpO2rt project do not mention external legitimacy and reputation.

#### Individual motivation and idealistic drivers

In all three projects, the individual motivation of the actors involved and their idealistic drivers are key to the projects' success. The participants themselves also indicate that they want to contribute to the future: *"The better world starts with you"* (transcript Alpha, line 47). All participants indicated that this theme is important to the success of collaborative projects. Echo emphasises the contribution of the individual actors: *"It [intrinsic motivation] is actually, I think, secretly more important than all those other things."* (transcript Echo, line 176). The intrinsic motivation of individuals ensures that the actors continue to move forward in "known unknown" situations; they ensure the project's perseverance (transcript Alpha, line 81; Echo, line 165; Golf, line 45). It is crucial that even at the senior management level, there are "believers" who make difficult decisions and maintain commitment (transcript Alpha, line 95). Intrinsically motivated individuals also shape the project's vision (transcript Golf, line 130; Hotel, line 126).

#### Knowledge development and sharing

For all three projects, "learning by doing" is the foundation for knowledge development. The WEVA project and the H2essenpO2rt project are pilot/demonstration projects, making knowledge development a key objective of the projects.

The uncertainty in projects often means that problems are shared among the various stakeholders, leading to intensive knowledge flows between all involved. Alpha indicates that this goes beyond contractual relationships; even stakeholders without a legal relationship share knowledge to overcome barriers (transcript Alpha, line 29).

The emphasis varies by case. In the WEVA project, participants primarily indicate that knowledge development is strongly operational and maritime. Historical shipping data supports design choices, the fixed tank is eliminated due to unacceptable bunkering times and interchangeable containers are chosen (transcript Charlie, line 78; Bravo, line 160). Crew training professionalises use (transcript Charlie, line 136). In the mobility cluster, knowledge development is test- and certification-driven. There are design reviews by VDL ETS, TÜV approval and additional RDW requirements (transcript Delta, line 78). To share knowledge, there are driver trainings and periodic knowledge exchange within the cluster (transcript Echo, line 100). H2essenpO2rt focusses on process integration: it starts with practical tests with oxygen supply to the wastewater treatment plant and efficiency effects of electrolysis (transcript Hotel, line 36). To share knowledge, there is a monthly thematic knowledge network within the water boards to ensure collective learning (transcript Foxtrot, line 61).

In general, it is noticeable that the projects set up organisational mechanisms to share knowledge (transcript Delta, line 190; Foxtrot, line 61).

#### Overcoming technical challenges

Overcoming technical challenges is part of knowledge development. As described in Section 4.4.1, hydrogen technology is still immature and its application has not yet been implemented in any of the projects. In the WEVA project and the mobility project, participants mention various technical challenges that have been overcome. In the WEVA project, this stemmed, among other things, from the operational requirement that a ship cannot be idle for long periods while loading (transcript Charlie, line 78). In the mobility cluster, technical challenges arise from the certification requirements that must be met for hydrogen cars (transcript Delta, line 78). Experts are deployed in both projects to overcome these challenges (transcript Bravo, line 160). Participants in the H2essenpO2rt project do not identify specific technical barriers during the project.

#### Regulatory development and standard-setting

As described in Section 4.4.3, the WEVA and mobility project lack regulation. In these projects, stakeholders help to co-design the regulations. The timing of input varies: in the WEVA project, regulations are developed during the project based on research by certification companies (transcript Charlie, line 55). A requirement for this was that the government grant an exemption in advance based on the inspections (transcript Charlie, line 36). This exemption ensures that the project can start quickly. In the mobility cluster, stakeholders provided information in advance for setting up the subsidy scheme (transcript Echo, line 96). During the project, there is also collaboration with municipalities to develop policies that make investing in zero-emission mobility more attractive (transcript Echo, line 58). In the WEVA and H2essenpO2rt projects, it is indicated that the permitting process proceeds smoothly due to "*administrative support*" (transcript Charlie, line 116; Golf, line 50).

#### 4.4.5. Future feasibility

In addition to the themes based on the framework, several interviews revealed stakeholders' perspectives on the future feasibility of a similar project. The participants emphasised that scaling up the hydrogen application requires a more robust technical solution (transcript Alpha, line 39). Participants also noted that, before achieving a fully robust hydrogen solution, intermediate steps must first be taken with near-zero emission or hybrid solutions (transcript Alpha, line 43; Charlie, line 63).

The participants describe how the projects have developed under what they consider favourable circumstances. The hydrogen applications are successful, but only under specific conditions. The participants pointed out that a more robust design is needed for the broader deployment of the hydrogen application developed in the project. A more robust design can then be applied within a broader context.

First, on the biophysical/technological side, participants mentioned that the technical operationalisation of hydrogen is more complex than with fossil applications, which entails more technical challenges and higher costs (transcript Charlie, line 74; Delta, line 135). The hydrogen applications in the cases could be realised because there are favourable technical conditions, such as available cheap hydrogen (transcript Charlie, line 108). A more robust design here means that the technical solution is standardised enough that other projects do not have to re-develop technological hydrogen elements each time.

Second, in terms of governance, the WEVA and mobility project faced a lack of/mismatch in regulation and rules had to be co-designed (transcript Alpha, line 72; Echo, line 96). In the WEVA project an

exemption from the government was needed to start quickly (transcript Charlie, line 36). The cases studied demonstrate that there is no stable governance foundation upon which new projects can be built. In the cases examined, regulatory customisation was applied to realise the projects. Clearer policies are needed for scaling up regional hydrogen projects.

Third, regarding actors, the studied projects are built on intrinsically motivated individuals who have the mandate to keep the project moving (transcript Charlie, line 136). Charlie emphasises this: "*Not everyone can do this, not everyone has to do this.*" (transcript Charlie, line 136). This demonstrates that current projects depend on intrinsically motivated individuals, precisely because they are still relatively specific and experimental. As the technical solution and the regulatory framework become more standardised, this dependence on specific individuals will decrease.

Future feasibility thus adds an important, participant-driven insight. To scale up, the technical solution has to be less context-dependent and more standardised. A stable regulatory and policy framework is needed so that new projects do not depend on case-by-case arrangements. When these conditions are met, projects will rely less on highly motivated individuals.

# 5

## Discussion

In this chapter, the implications of the study are discussed. In Section 5.1, the results are interpreted and connected to the literature. Section 5.2 describes the practical implications and recommendations for consortia and policymakers.

### 5.1. Theoretical implications

This study enriches the literature by providing insights into three realised regional hydrogen projects in the Netherlands. The study demonstrates how pre-existing conditions and project-internal action situations jointly lead to outcomes. The results of this study demonstrate that collaborative projects can be realised when the following factors are present in the exogenous context: (i) a clear biophysical driver as the catalyst, (ii) the presence of intrinsically motivated individuals who can mobilise other parties and (iii) a governance setting that provides space or actively supports the application of hydrogen technology. The following project-internal action situations must be established within the project to realise a collaborative hydrogen project: (i) consortium formation, (ii) formalisation & contracting, (iii) financing, (iv) coordination, (v) regulatory development and (vi) knowledge development & sharing. Each of these action situations requires the presence of highly motivated individuals.

Existing literature already describes that pre-existing biophysical conditions can act as a driver for starting up a project. For example, Urs' research describes that grid congestion is fuelling a transition to hydrogen in a project in California [65].

The literature on energy initiatives emphasises that intermediary organisations and key community figures play an important role in promoting interest and stimulating cooperation [55]. This partially aligns with the findings of this study. Key community figures, comparable to highly motivated individuals, can help break down barriers. The influence of intermediary organisations is only considered in this study in the case of H2essenpO2rt.

Formalisation creates a 'point of no return' and forms the legal basis for the collaborative projects analysed. The existing literature supports this finding and indicates that formalisation has a positive impact on collaborative projects [70]. The existing literature also notes that contractual aspects can have a negative impact on collaboration [41]. In this study, only the positive side of formalisation was highlighted, which can be explained by the fact that only successful projects were analysed.

The literature describes how decentralised collaborations lead to innovation, but coordination within these projects remains crucial [28]. This finding is consistent with the results of this study, which identified coordination as an internal project factor. In the analysed cases, the collaborative hydrogen projects also generated new knowledge.

In this study, the financial viability of a hydrogen project is considered a barrier. This aligns with the literature, which states that 84% of a group of stakeholders surveyed indicate that financial barriers are an obstacle to the transition to hydrogen [29]. In the cases examined in this study, these financial barriers are overcome through subsidies.

The findings of this study align with existing literature, in which effective communication and leadership are crucial to project success [38]. This is evident in the following action situations: coordination and

individual motivation & idealistic drivers. Another study describes active involvement and alignment of stakeholder interests as important factors for a successful project [59]. This also emerges in the two action situations. The core of these factors is confirmed in this study and is truly specified: there must be actors who are not only involved, but also intrinsically motivated; this is the driving force behind sustainable coordination.

The results of this study are aligned with the existing literature on decentralised energy networks and energy initiatives. However, this study differs from the existing literature in three aspects. First, it examines three completed regional hydrogen projects using a qualitative research method. Second, the study demonstrates two forms of coordination during the formation of the consortium and the implementation of the project. Third, the study shows that in regional hydrogen projects, regulation is co-created with government authorities to accelerate project launches.

The overlap with the existing literature on decentralised energy initiatives makes the results of this study on regional hydrogen projects plausible. Furthermore, the study identified factors that influence how a collaborative project in Dutch regional industries can be realised.

## 5.2. Practical implications and recommendations

This section translates the results of the WEVA project, the Hydrogen Cluster for Sustainable Mobility and the H2essenpO2rt project into practical implications and recommendations. The recommendations are targeted at future or ongoing consortia that want to realise a regional hydrogen project and policymakers that shape the governance and financial conditions of such projects.

### 5.2.1. Consortia

The results of this study show that in all three cases a strong biophysical driver was the starting point for the project. The collaborative projects were designed to capitalise on this opportunity or solve the problem. This finding suggests that a hydrogen project can only exist if there is a biophysical rationale. For new consortia, this means that a concrete biophysical condition must be present when establishing a hydrogen project. Based on the finding, it is recommended that consortia first make this driver explicit for themselves before taking further steps in the project.

In the analysed cases, one actor is strongly involved in bringing together the actors and establishing a consortia. The connecting actor is primarily at the forefront during initiation. For new consortia, this means that a connecting actor must be present within the consortium to mobilise actors. Because this role often emerges informally, it is recommended to make this connecting role explicit at the start of the project and to assign time and mandate to the actor that is best positioned to perform it. However, the analysis reveals that these actors assume this role through a natural process, depending on their pre-existing actor attributes. The results show that once a consortium is formed, the leadership is distributed among the actors involved. For new consortia, this means that a coordination mechanism must be chosen in which the involved actors have a voice in decision making. Therefore, it is recommended to adopt a coordination structure that moves from a single initiating actor in the formation phase to distributed decision-making in the implementation phase.

This study shows that once a consortium is formed, the project becomes sustainable through formalisation. For new consortia, this implies that a project must be contractually established early on. It is therefore recommended to plan a clear formalisation step in the project trajectory. The project can begin with a letter of intent, but it must be legally formalised before the project begins.

The research results show that the consortia analysed are developing, collecting and sharing knowledge. The goal of this knowledge is to inform follow-up projects. Although no follow-up projects have yet been generated based on the knowledge gathered from the analysed projects, blueprints and business cases have been produced. For future regional hydrogen projects, this means that collecting and sharing knowledge is not a requirement for project realisation, but it could help in developing follow-up projects. Therefore, it is recommended to include knowledge development and sharing as an explicit work package in the project. It is recommended to share knowledge through concrete outputs, such as blueprints or business cases. However, acquiring knowledge is essential to overcome barriers.

The research results show that the projects are still context-dependent. Participants emphasise the need to continue with near-zero emission or hybrid intermediate steps and standardisation. A fully hydrogen-based solution, according to the participants, is still too dependent on a suitable context. Therefore, it is recommended that future regional hydrogen projects do not focus exclusively on fully

hydrogen-based configurations, but consider a broader set of low- and near-zero-emission options, so that projects can be realised under more diverse contextual conditions.

### 5.2.2. Policymakers

The findings also have implications for policy. Government influence largely shapes the pre-existing governance system. The study results reveal that in the pre-existing conditions of collaborative hydrogen projects, no complete regulatory framework is yet in place. Policymakers can address this in two ways. They can establish a regulatory framework prior to a project. However, in the cases studied, the government opted to grant an exemption and develop a regulatory framework based on the experiences from the project. Based on these findings, it is recommended that policymakers provide an exemption route for first-of-a-kind regional hydrogen projects and use the operational insights from these projects to formalise the regulatory framework. This ensures that a project can be implemented sooner and ensures appropriate regulations.

The cases show that fully hydrogen-based configurations are not yet feasible in all contexts. Policymakers can accelerate the diffusion of hydrogen by also making hybrid or near-zero configurations eligible for support, allowing more organisations to participate and build experience.

Finally, the study reveals that subsidy regulations are crucial for the viability of hydrogen projects. The policymakers can also use these subsidy regulations to shape hydrogen projects by imposing conditions. These conditions can require collaboration, knowledge sharing and project speed. If policymakers want to support regional hydrogen projects, it is advised to do so by offering subsidy schemes.

# 6

## Conclusion

The aim of this study was to gain insight into how collaborative hydrogen projects within Dutch regional industries can be realised. This research aims to contribute to the research question:

*"How can collaborative hydrogen projects in Dutch regional industries be realised?"*

To answer this question, a qualitative multiple-case study of collaborative hydrogen projects in Dutch regional industries was chosen. The analysis was structured by a combined Institutional Analysis and Development (IAD) and Social-Ecological Systems (SES) framework. This chapter addresses the main findings in Section 6.1. In Section 6.2 the main research question is answered. Section 6.3 describes the limitations of this study. Section 6.4 provides directions for future research.

### 6.1. Main findings

The appropriate framework for this research was identified by reviewing how collaborative projects are analysed in the literature. A combination of the Institutional Analysis and Development (IAD) and Social-Ecological Systems (SES) frameworks is used to analyse the exogenous characteristics and project-internal characteristics in the regional hydrogen projects. The IAD framework provides a framework for investigating how project-internal interactions (action situations) between actors lead to outcomes. The SES framework structures exogenous characteristics into biophysical conditions, actors' attributes and the governance system.

#### 6.1.1. Collaborative hydrogen projects and shared goals

The first sub-question is:

*"What are collaborative hydrogen projects in Dutch regional industries and which shared goals are pursued within them?"*

Collaborative hydrogen projects in Dutch regional industries involve multiple stakeholders, often a combination of public and private parties. A consortium is formed around a specific hydrogen application. The stakeholders make interdependent choices, contribute resources and knowledge and agree to jointly realise a hydrogen solution.

In this research, five shared goals were identified. A shared goal is a goal that is common to all involved actors and provides a reason for collaboration. The first shared goal is to reduce emissions in production processes or sectors, making the operation more future-proof. The second goal is to share the risks of the project. Innovation projects carry risks because they must be developed in a "known unknown" situation. There are foreseeable technical, organisational and regulatory issues, but these have not yet been resolved. The third goal is to jointly build and operate the infrastructure. The fourth goal is to develop knowledge. The actors want to explore the hydrogen market and the acquired knowledge can be applied in future projects. The fifth goal is joint-subsidy applications. To be eligible for some subsidies, cooperation between actors is required. Within a project, there are one or more shared goals.

### 6.1.2. Exogenous characteristics

The second sub-question is:

*"What role do exogenous characteristics play in the realisation of collaborative hydrogen projects in Dutch regional industries?"*

Exogenous characteristics set the initial context for the project within which actors have to operate. In this study, exogenous variables are defined as biophysical conditions, actors' attributes and the governance system that exist prior to the project start. The analysed consortia are formed around a single clear pre-existing biophysical driver. In the WEVA project, this is the opportunity presented by the residual green hydrogen stream, while in the H2essenpO2rt and mobility projects, the project is forced by grid congestion or the lack of supply/demand for hydrogen mobility. Hydrogen technology is immature and expensive, which impacts profitability and creates room for subsidies. Regarding the actors' attributes, intrinsically motivated individuals with vision and passion who are involved in the project, along with a large existing knowledge base, act as accelerators. However, the lack of knowledge on hydrogen applications leads to 'learning by doing'. The presence of connecting key actors helps to form consortia. In the governance system, two out of the three cases involve a lack of or unclear policy. This presents a barrier because it creates uncertainty in the project and an opportunity because it offers institutional flexibility for the project. Targeted government instruments, such as subsidy programmes, can stimulate collaborative projects. The exogenous variables shape the action situations that the actors in the collaborative project encounter. Because many of these drivers and constraints are context-specific, scaling similar projects requires more robust designs.

### 6.1.3. Project-internal characteristics

The third sub-question is:

*"Which project-internal characteristics support the realisation of collaborative hydrogen projects in Dutch regional industries?"*

Six recurring action situations were identified within the analysed projects: consortium formation, formalisation & contracting, financing, coordination, regulatory development and knowledge development & sharing. Each of these six situations depends on the presence of intrinsically motivated individuals with an idealistic drivers. Taken together, these action situations describe the project-internal characteristics that lead to outcomes. Consortium formation can be based on different logics. The identified logics are: through existing relationships (WEVA), subsidy-driven coupling (mobility cluster) and problem-driven around grid congestion (H2essenpO2rt). Formalising a project by signing a contract is the 'point of no return'. Formalisation distributes risks and provides greater investment security. Long-term contracts lead to reduced risk which enables investment decisions. The financial feasibility of a project is essential; these projects are capital intensive and have high uncertainty. Subsidies are currently required to finance regional hydrogen projects. The design of a subsidy can steer a project in terms of time and consortium formation. Subsidies were used in all three projects to cover additional costs of relatively expensive hydrogen applications. The role of the coordinator changes during a project. During consortium formation, one active actor takes the lead. As the project progresses, the role of coordinator is distributed among the actors involved. During the project, the consortia support the government agencies in establishing a regulatory framework. Regional hydrogen projects are built on 'learning by doing'. They involve first-of-a-kind challenges, such as integration with existing systems, safety and the overcoming of technical challenges. The consortia share the acquired knowledge through blueprints, training sessions and meetings. Public visibility acts as an accelerator, but also puts pressure on a project. It increases motivation within a project team, but also increases the risk of reputation loss. To successfully complete the action situations mentioned above, intrinsically motivated individuals, both in the public and private sectors of the project, are essential. They provide an initiating and unifying force within the project. Motivated individuals with a mandate are crucial in breaking through impasses.

## 6.2. Main research question

The main research question is:

*"How can collaborative hydrogen projects in Dutch regional industries be realised?"*

Collaborative hydrogen projects in Dutch regional industries can be realised when the exogenous and project-internal characteristics are enabling.

First, exogenous characteristics must provide a favourable starting context. Collaborative hydrogen projects in the Dutch regional industries must be enabled by a clear biophysical driver, which can be an opportunity or a problem in the pre-existing conditions. There must be intrinsically motivated individuals who can mobilise parties. Finally, there must be a governance system that provides the space for the deployment of the hydrogen application.

Second, the project-internal characteristics describe the set of action situations that must be organised within the project itself to translate this favourable context into actual realisation. First, a consortium must be formed around the project's objective. The formation of consortia can be formed through distinct logics (existing relations, subsidy-driven coupling, or problem-driven assembly). An active connector is needed to bring the actors together. Second, the consortium must be formalised. Establishing a legal basis creates a 'point of no return' and provides certainty for stakeholders. Long-term contracts reduce risk and enable investment decisions. Third, governmental financial support is required for the realisation of a collaborative regional hydrogen project. The design of subsidies can influence the timeline of a project and the formation of consortia. Fourth, project activities must be coordinated by an independent project team that includes representatives of the stakeholders involved. Fifth, the consortium must support the development of the regulatory framework. Because rules are often incomplete during these projects, actors have to co-create with government and inspection bodies, so that project experience can be translated into guidelines. Sixth, knowledge must be developed and shared. Hydrogen projects apply 'learning by doing' and share this knowledge with their stakeholders. The developed knowledge is converted into blueprints and business cases for future projects.

Intrinsically motivated individuals are an essential part of collaborative projects; they take initiative and ensure perseverance within a consortium. If these components are present simultaneously, feasible regional hydrogen projects can emerge. However, the cases show that the current hydrogen projects work because they were realised under specific and favourable conditions. To scale up, the technical setup must become more standardised and less context-dependent. It must be supported by a stable regulatory framework, so that the application can be deployed more broadly and does not depend on a few intrinsically motivated individuals.

## 6.3. Limitations

This study offers valuable insights into realised regional hydrogen projects, but it also has limitations. The study analyses three case studies to gain insight into how regional hydrogen projects can be realised. While the multi-case approach allows for comparisons, it poses several limitations. The cases were selected based on criteria. These criteria ensure that the cases are consistent and comparable. The selection of completed projects provides a wealth of information. However, the selection criteria only address successful cases. The findings show mainly conditions for the successful realisation of a project. As a result, the factors that lead to project failure fall outside of the scope and factors necessary for a collaborative hydrogen transition project to take place may be missing.

In addition to the three analysed cases, there are more cases that meet the selection criteria. Due to the limited resources available for a master's thesis, three cases were examined. Other cases may reveal new factors not addressed in this study.

Furthermore, the favourable, context-specific conditions under which the three projects were realised limit the generalisability of the findings. Participants emphasise that more robust solutions that are less context-specific must be developed to ensure the projects' future feasibility. Consequently, more robust implementations may encounter different barriers.

The data analysed in this study was collected through interviews and a literature review. Interviews are suitable for gathering the perspectives of stakeholders. However, there are limitations to conducting interviews. Participants are asked about their memories of the start of a project two to six years ago, which can lead to selective recollections. There is also a risk that participants give socially desirable answers; to mitigate this risk, respondents could participate anonymously. The interviews with the

participants were conducted in Dutch and subsequently translated, which may have led to subtle differences. In addition, the interviews were automatically transcribed and subsequently manually corrected, which could have led to misinterpretations.

To analyse the case studies, two or three participants per case were interviewed. The participants were individuals who were actively involved throughout the project. This limited sample size is due to the time constraints of a master's thesis. The limited sample size may have resulted in more factors influencing the case studies or a lack of nuance within the factors.

To compare and analyse the cases, the interviews were coded using a combination of deductive and inductive coding. The main themes were based on the Institutional Analysis and Development (IAD) and Social Ecological Systems (SES) framework and the subthemes were built iteratively. The researcher's interpretation may have had an influence here. A codebook was used during the coding process to limit the researcher's influence.

The interviews focused on identifying the action situations and providing a concise description of each. According to Ostrom's framework, an action situation consists of seven basic components [52], which were not fully elaborated in this study due to time constraints of a master's thesis. The researcher did clarify the action situations by asking questions based on the seven basic components. While these components are reflected in the descriptions of the action situations, the data is incomplete. The action situation may lack nuance and depth would provide a more detailed explanation of an action situation. Based on a fully developed action situation, the action situations could be linked according to the Network of (adjacent) Action Situations (NAS) framework [39]. The NAS framework can function as a third layer on the framework to capture how decisions in one arena influence decisions in adjacent arenas. The results of this study show that pre-existing conditions influence the outcomes of the projects. These pre-existing conditions in the Netherlands change over time. For example, the analysed projects lack legislation and regulations, which shapes their nature. However, policies on hydrogen were developed during these projects. The projects also are heavily dependent on subsidies. These specific circumstances change over time and can lead to new factors that influence the realisation of a collaborative regional hydrogen project.

## 6.4. Future research

Based on the discussion of this study, several directions for future research emerge.

Future research could explore action situations in more detail. In this study, the action situations were identified and described concisely at the meso-level. These can be fully broken down into seven basic components. Based on this data collection, the action situations can be better understood. This can provide insight into how actors can influence specific action situations. The data could also be used to apply the NAS framework to a collaborative project, as it shows how the action situations relate to each other. On the basis of these more detailed action situations, it becomes possible to determine how action situations in regional collaborative hydrogen projects should be organised and future research can further specify what each action situation requires in practice. This study forms the basis for the proposed further research; through interviews, the action situations can be worked out in detail.

Secondly, follow-up research could conduct a similar study with unsuccessful regional hydrogen projects. This can clarify whether and how pre-existing conditions and action situations differ from those of realised projects. Based on this study, combined with the proposed study, it can be better assessed whether projects can be realised and what stakeholders should (this study) and should not do (future research).

The results of this study show that 'learning by doing' is a frequently used concept in regional hydrogen projects. This knowledge is being translated into blueprints and business cases. However, this study does not reveal whether these results actually accelerate follow-up projects or whether they help with their setup. Therefore, future research could examine the influence of a blueprint or existing business case on subsequent regional hydrogen projects.

Further research can also address the scalability of hydrogen applications. The participants emphasise that expanding hydrogen applications requires a more robust design. They indicate that current hydrogen applications are context-specific and require changes for broad rollout. This study focusses on the influence of the context and project-internal characteristics on the realisation of the projects. Future research can analyse how the design of future hydrogen applications can be made more robust to enable a broader deployment.

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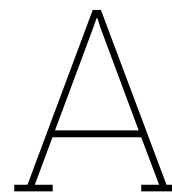
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# Informed consent

## A.1. Informed consent - Dutch

Datum: 05/06/2025

U wordt uitgenodigd om deel te nemen aan een onderzoek genaamd Realisation of Collaborative Hydrogen Projects in Dutch Regional Industries. Dit onderzoek wordt uitgevoerd door Stefan Poli van de TU Delft, onder begeleiding van prof. dr. ir. Z. Lukszo, dr. A. Ghorbani en ir. R.J. van 't Veer.

Het doel van dit onderzoek is om inzicht te krijgen in de samenwerking in regionale waterstofprojecten en zal ongeveer 60 minuten in beslag nemen. De data worden gebruikt voor het formuleren van resultaten en conclusies in de masterscriptie van Stefan Poli. U wordt gevraagd om verhalen, perspectieven en ervaringen te delen over de samenwerking in het waterstofontwikkelingsproject waaraan u deelneemt.

Zoals bij elke online activiteit is het risico van een databreuk aanwezig. Wij doen ons best om uw antwoorden vertrouwelijk te houden. We minimaliseren de risico's door de transcripties en opnames van de interviews tijdens het onderzoek op te slaan in een beveiligde omgeving aan de TU Delft. De verkregen informatie wordt na publicatie van het onderzoek verwijderd. Na het interview sturen we u de transcriptie van het gesprek toe en kunt u indien nodig wijzigingen voorstellen.

Uw deelname aan dit onderzoek is geheel vrijwillig en u kunt zich op elk moment terugtrekken. U kunt vragen overslaan.

Stefan Poli

*Telefoonnummer*

PLEASE TICK THE APPROPRIATE BOXES	Ja	Nee
<b>A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION</b>		
1. Ik heb de informatie over het onderzoek gedateerd 05/06/2025 gelezen en begrepen, of deze is aan mij voorgelezen. Ik heb de mogelijkheid gehad om vragen te stellen over het onderzoek en mijn vragen zijn naar tevredenheid beantwoord.	<input type="checkbox"/>	<input type="checkbox"/>
2. Ik doe vrijwillig mee aan dit onderzoek, en ik begrijp dat ik kan weigeren vragen te beantwoorden en mij op elk moment kan terugtrekken uit de studie, zonder een reden op te hoeven geven.	<input type="checkbox"/>	<input type="checkbox"/>
3. Ik begrijp dat mijn deelname aan het onderzoek de volgende punten betekent: – Het interview wordt opgenomen en tijdelijk opgeslagen. – De opname en het transcript worden uiterlijk 2 maanden na publicatie van het onderzoek verwijderd, naar verwachting eind 2025.	<input type="checkbox"/>	<input type="checkbox"/>
<b>B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)</b>		
4. Ik begrijp dat deelname aan het onderzoek de volgende risico's met zich meebrengt: mogelijke datalekken. Ik begrijp dat deze risico's worden beperkt door veilige opslag van gegevens en transcripties in een beveiligde omgeving van de TU Delft.	<input type="checkbox"/>	<input type="checkbox"/>
5. Ik begrijp dat mijn deelname betekent dat er persoonlijk identificeerbare informatie en onderzoeksdata worden verzameld, met het risico dat ik hieruit geïdentificeerd kan worden.	<input type="checkbox"/>	<input type="checkbox"/>
6. Ik begrijp dat de volgende stappen worden ondernomen om het risico van een databreuk te minimaliseren, en dat mijn identiteit op de volgende manieren wordt beschermd in het geval van een databreuk: – Alle opnames worden veilig opgeslagen op de systemen van de TU Delft. – Na transcriptie worden de opnames definitief verwijderd. – De transcripties van de interviews worden geanonimiseerd. – Alleen het onderzoeksteam van de TU Delft heeft toegang tot de originele gegevens. – Alle bevindingen die in publicaties worden gedeeld, worden volledig geanonimiseerd en op een manier gepresenteerd dat individuele deelnemers niet kunnen worden geïdentificeerd.	<input type="checkbox"/>	<input type="checkbox"/>
<b>C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION</b>		
7. Ik begrijp dat de geanonimiseerde informatie die ik verstrek na afloop van het onderzoek gebruikt zal worden voor publicatie van de masterscriptie in de TU Delft repository.	<input type="checkbox"/>	<input type="checkbox"/>
8. Ik geef toestemming om mijn antwoorden, ideeën of andere bijdrages anoniem te quoten in resulterende producten.	<input type="checkbox"/>	<input type="checkbox"/>
<b>D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE</b>		
9. Ik geef toestemming om de geanonimiseerde gegevens, de resultaten en conclusies van de interviews die ik verstrek, te archiveren in de repository van de TU Delft, zodat deze gebruikt kunnen worden voor toekomstig onderzoek en onderwijs.	<input type="checkbox"/>	<input type="checkbox"/>

## A.2. Informed consent - English

Date: 05/06/2025

You are being invited to participate in a research study titled Realisation of Collaborative Hydrogen Projects in Dutch Regional Industries. This study is being done by Stefan Poli from the TU Delft, supervised by prof. dr. ir. Z. Lukszo, dr. A. Ghorbani, ir. R.J. van 't Veer.

The purpose of this research study is to gain insight into the collaboration in regional hydrogen projects, and will take you approximately 60 minutes to complete. The data will be used for formulating results and conclusions in the master thesis of Stefan Poli. We will be asking you to share stories, perspectives and experiences about the collaboration in the hydrogen development project you are participating in.

As with any online activity the risk of a breach is always possible. To the best of our ability your answers in this study will remain confidential. We will minimize any risks by storing the transcripts and recordings of the interviews during the research in a secure environment at TU Delft. The information obtained will be deleted after publication of the research. After the interview, we will send you the transcript of the conversation, and you are welcome to suggest modifications if deemed necessary.

Your participation in this study is entirely voluntary and you can withdraw at any time. You are free to omit any questions.

Stefan Poli

*Phone number*

PLEASE TICK THE APPROPRIATE BOXES	Yes	No
<b>A: GENERAL AGREEMENT – RESEARCH GOALS, PARTICIPANT TASKS AND VOLUNTARY PARTICIPATION</b>		
1. I have read and understood the study information dated 05/06/2025, 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.	<input type="checkbox"/>	<input type="checkbox"/>
2. 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.	<input type="checkbox"/>	<input type="checkbox"/>
3. I understand that taking part in the study involves: <ul style="list-style-type: none"> <li>– The interview will be recorded and temporarily stored.</li> <li>– The recording and transcript will be deleted at the latest 2 months after publication of the study, expected the end of 2025.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>
<b>B: POTENTIAL RISKS OF PARTICIPATING (INCLUDING DATA PROTECTION)</b>		
4. I understand that taking part in the study involves the following risks: possible data breach. I understand that these will be mitigated by secure storage of data and transcripts in a secure environment of the TU Delft.	<input type="checkbox"/>	<input type="checkbox"/>
5. I understand that taking part in the study also involves collecting specific personally identifiable information (PII) and associated personally identifiable research data (PIRD) with the potential risk of my identity being revealed.	<input type="checkbox"/>	<input type="checkbox"/>
6. I understand that the following steps will be taken to minimise the threat of a data breach, and protect my identity in the event of such a breach: <ul style="list-style-type: none"> <li>– All recordings will be stored securely on TU Delft systems.</li> <li>– After transcription, the recordings will be permanently deleted.</li> <li>– Interview transcripts will be anonymized.</li> <li>– Only the TU Delft research team will have access to the original data.</li> <li>– Any findings shared in publications will be fully anonymised and presented in such a way that individual participants cannot be identified.</li> </ul>	<input type="checkbox"/>	<input type="checkbox"/>
<b>C: RESEARCH PUBLICATION, DISSEMINATION AND APPLICATION</b>		
7. I understand that after the research study the de-identified information I provide will be used for publication of the master thesis in the TU Delft repository.	<input type="checkbox"/>	<input type="checkbox"/>
8. I agree that my responses, views or other input can be quoted anonymously in research outputs.	<input type="checkbox"/>	<input type="checkbox"/>
<b>D: (LONGTERM) DATA STORAGE, ACCESS AND REUSE</b>		
9. I give permission for the de-identified data, the results and conclusion on the interviews, that I provide to be archived in TU Delft repository so it can be used for future research and learning.	<input type="checkbox"/>	<input type="checkbox"/>

# B

## Interview guideline

### B.1. Design of semi-structured interviews (Dutch)

#### **Introductie**

Het doel van dit onderzoek is te bepalen welke factoren invloed hebben gehad op het realiseren van van dit samenwerkingsproject. Om deze factoren te identificeren gebruik ik een combinatie van de IAD and SES frameworks. Aan de hand van deze frameworks kan ik de 'participatory intervention' analyseren. Het framework is opgedeeld in drie delen. Tijdens dit interview wil ik informatie gaan verzamelen bij u, om het framework in te kunnen vullen. We beginnen straks bij het linker groene blok, de 'pre-existing conditions'. Hierin ga ik u vragen te omschrijven wat de situatie was voordat dit project begon. We kijken dan naar de biofysische processen, de kenmerken van de betrokken actoren en de institutionele regelingen en processen. Vervolgens gaan we kijken naar het rechter groene blok, de outcome. Hier kijken we naar dezelfde onderwerpen, alleen kijken we naar de huidige situatie. Dus naar de huidige staat van het waterstofproject. Vervolgens, als we dat hebben gedaan, wil ik gaan kijken naar wat zat er dan tussen. Welke factoren, of zoals dat in dit framework wordt genoemd, action situations, hebben geleid tot de outcome situatie. Deze actie situaties zullen we vervolgens gaan uitwerken op basis van de 7 basiscomponenten.

#### **Pre-existing conditions**

1. Kan u de technische of fysieke omstandigheden beschrijven van de situatie voor het samenwerkingsproject?
  - Welke technische of fysieke omstandigheden zorgde ervoor dat het waterstofproject wordt opgezet?
2. Wat voor soort partijen waren er betrokken of actief in de regio voordat het samenwerkingsproject begon, en hoe stonden zij toen tegenover samenwerking?
  - Was er al eerder contact, vertrouwen of gezamenlijke ervaring tussen sommige van deze partijen?
3. Welke formele of informele regels, beleidskaders of instituties waren er vóór het samenwerkingsproject die invloed hadden op hoe partijen zich gedroegen?
  - Waren er toen al subsidies, beleidsplannen of andere prikkels die samenwerking stimuleerden of juist in de weg zaten?

#### **Outcome**

1. In hoeverre is de fysieke of technische situatie veranderd sinds het samenwerkingsproject tot stand kwam?

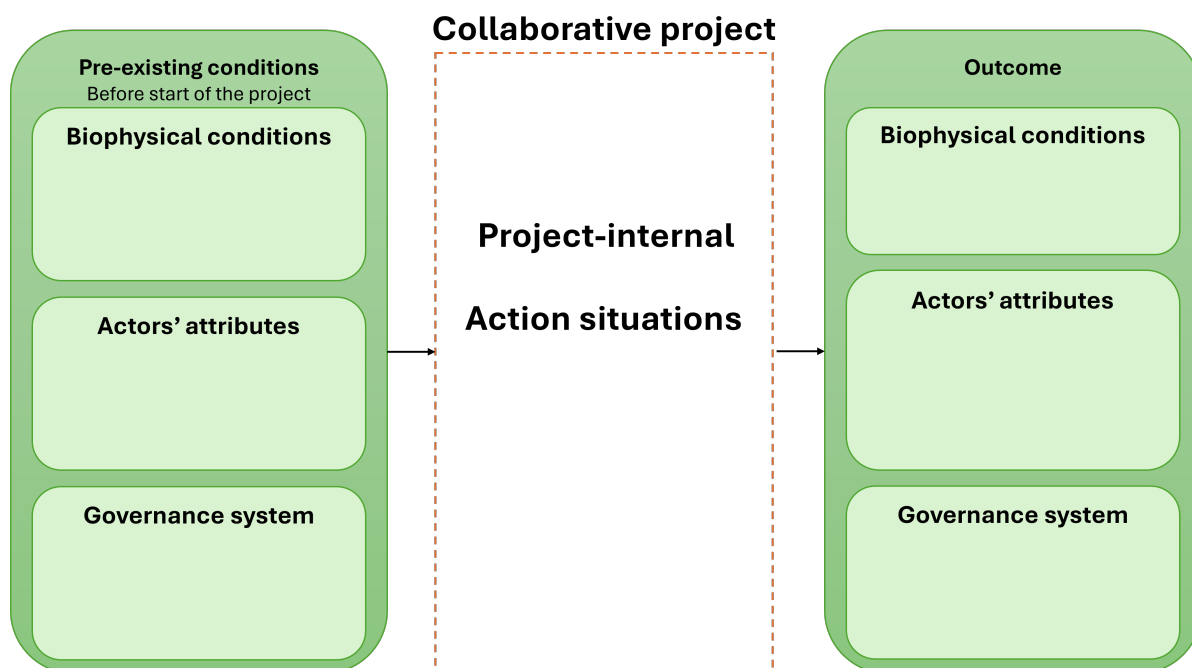


Figure B.1: Combined IAD and SES frameworks

2. Heeft het samenwerkingsproject iets veranderd in de houding, kennis of onderlinge relaties van de betrokken partijen?
3. Zijn er nieuwe afspraken, regels of vormen van organisatie ontstaan als gevolg van dit samenwerkingsproject?

#### Action situations

1. Wat zijn volgens u de belangrijkste stappen of acties geweest die geleid hebben tot de ontwikkeling van gezamenlijke infrastructuur of technische voorzieningen?
  - Welke achterliggende factoren worden beïnvloed door de actie situatie?
2. De actie situatie uitwerken
  - Wie waren er op dat moment actief betrokken bij deze beslissing of activiteit?
  - Welke rol of positie had elke partij in dit proces?
  - Welke concrete handelingen of beslissingen zijn toen genomen door de verschillende partijen?
  - Wat was het directe resultaat van deze actie of dit moment?
  - Wat leverde deze beslissing op voor de betrokken partijen, en waren er ook nadelen of risico's?
  - Welke informatie was beschikbaar op dat moment, en hoe werd die gedeeld tussen partijen?
  - Wie had er uiteindelijk zeggenschap of doorslaggevende invloed op wat er besloten werd?

#### Afronding

1. Zijn er nog onderwerpen die u verder wilt toelichten of toevoegen?
2. Op basis van dit interview zijn er nog personen betrokken bij dit project die geïnterviewd zouden moeten worden?

## B.2. Design of semi-structured interviews (English)

### Introduction

The goal of this research is to determine which factors influenced the realisation of this collaborative project. To identify these factors, I use a combination of the IAD and SES frameworks. These frameworks allow me to analyse the participatory intervention. The framework is divided into three parts. During this interview, I want to gather information from you to complete the framework. We will start with the left green block, the "pre-existing conditions." Here, I will ask you to describe the situation before this project began. We will look at the biophysical processes, the characteristics of the actors involved, and the institutional arrangements and processes. Next, we will move on to the right green block, the outcome. Here, we will look at the same topics, but we will focus on the current situation: the current state of the hydrogen project. Once we have done that, I want to examine what happened in between. Which factors, or as they're called in this framework, action situations, led to the outcome. We will then elaborate these action situations on the basis of the 7 basic components.

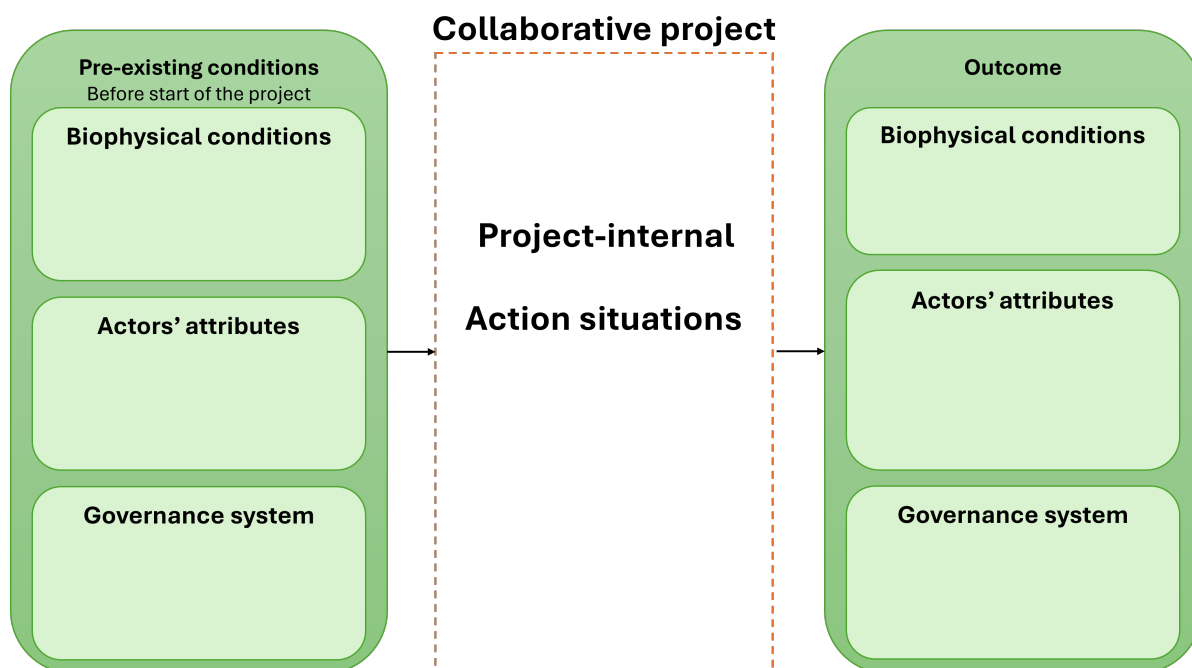


Figure B.2: Combined IAD and SES frameworks

### Pre-existing conditions

1. Can you describe the technical or physical conditions of the situation before the collaborative project?
  - Which technical or physical conditions led to the initiation of the hydrogen project?
2. What types of parties were involved or active in the region before the collaborative project began, and how did they view collaboration at that time?
  - Had there already been contact, trust, or shared experience between some of these parties?
3. What formal or informal rules, policy frameworks, or institutions existed before the start of the collaborative project that influenced how parties behaved?
  - Were there already subsidies, policy plans, or other incentives that encouraged or hindered the collaborative project?

### Outcome

1. To what extent has the physical or technical situation changed since the collaborative project was established?
2. Has the collaborative project changed anything in the attitude, knowledge, or mutual relationships of the involved parties?
3. Have new agreements, rules, or forms of organisation emerged as a result of this collaborative project?

**Action situations**

1. According to you, what have been the most important steps or actions that led to the development of shared infrastructure or technical facilities?
  - Which underlying factors are influenced by the action situation?
2. Elaborate on the action situation
  - Who were actively involved in this decision or activity at the time?
  - What role or position did each party have in this process?
  - What concrete actions or decisions were taken by the different parties?
  - What was the direct result of this action or moment?
  - What did this decision bring to the involved parties, and were there any disadvantages or risks?
  - What information was available at that moment, and how was it shared among the parties?
  - Who ultimately had authority or decisive influence over what was decided?

**Wind-up**

1. Are there any topics you would like to elaborate on or add?
2. Based on this interview, are there any other people involved in this project who should also be interviewed?

# C

## Transcriptions

This appendix is confidential and not for publication.