

HyDelta 2

WP10 – Social acceptance for hydrogen transport and storage

D10.3 – Case study report with best practices regarding risk governance and societal embeddedness of innovative energy technologies.

Status: final

Document summary

Corresponding author

Corresponding author	Sarah Elbert
Affiliation	Hanze University of Applied Sciences
Email address	s.p.elbert@pl.hanze.nl

Document history

Version	Date	Author	Affiliation	Summary of main changes
1	25-Jan-2023	Sarah Elbert, Marc Groote	Hanze University	First version
2	27-Jan-2023	Sarah Elbert, Marc Groote, Carina Wiekens	Hanze University	First revisions
3	31-Jan-2023	Sarah Elbert, Marc Groote, Carina Wiekens	Hanze University	Feedback from EAG.
4	10 Apr-2023	Sarah Elbert, Marc Groote, Carina Wiekens	Hanze University	Final version
5	27 Jun-2023	Sarah Elbert, Marc Groote, Laura Schouten, Carina Wiekens	Hanze University	Final version - translated

Dissemination level

PU	Public	X
RE	Restricted to <ul style="list-style-type: none"> Project partners including Expert Assessment Group External entity with whom a Non-Disclosure Agreement exists 	

Document review

Partner	Name
Stedin	Frank van Alphen
Alliander	Elbert Huijzer
NBNL, Gasunie, Kiwa, DNV, TNO, NEC, Hanze	HyDelta Supervisory Group

Executive summary

Societal aspects play an important role in successful implementation of renewable energy technologies such as hydrogen. In Work package 10 (WP10) within the Hydelta 2.0 research program, we investigated the societal challenges and lessons learned for deploying hydrogen transport/distribution and application within the built environment in the Netherlands. Furthermore, we studied how these societal challenges can be successfully embedded within an implementation strategy. In this deliverable (D10.3), the conducted field research of four cases, each in a different phase of implementation (Rozenburg, Lochem, Wagenborgen, Stad aan 't Haringvliet), is described. The central themes that we covered in this research are public support, (risk) communication, safety and the experience of safety, and perceived success of the project. For each case, we interviewed local stakeholders (24 interviews in total) and residents, including people living nearby the hydrogen pilot (17 interviews, 68 questionnaires and approximately 90 conversations). The results show mostly positive indications for public support (although this is not yet known for Stad aan 't Haringvliet). In all cases, the importance of communication between stakeholders and between stakeholders and potentially participating residents is acknowledged, even though there seems to be a lack of communication with residents living in the vicinity of hydrogen pilots. This is a missed opportunity and a potential risk, as these residents may have questions and doubts, for instance about the progress and decisions that have been made in the project. Positive attitudes concerning the safety are partly attributed to the trust people have in the involved stakeholders. It also seems important that there is a contact person whom people can reach in case of questions or concerns. Additionally, in some of the cases a demonstration house, where people can experience what it means when a house is heated with hydrogen, seems successful. Thus, the findings emphasize the importance of broad and frequent communication, not only with the directly involved residents, but also with people who live in the vicinity of a hydrogen pilot. Communication is not only important in the planning and implementation phase of the project, but also at the end of the implementation phase. Finally, shared ownership of the project and inclusion of all stakeholders in all phases of the project seems important to prevent delays in the project.

Samenvatting

Bij het succesvol implementeren van hernieuwbare energie technologieën zoals waterstof spelen sociaal-maatschappelijke aspecten een belangrijke rol. Binnen werkpakket 10 van het Hydelta 2.0 onderzoeksprogramma wordt onderzocht wat de uitdagingen en geleerde lessen zijn omtrent het bewerkstelligen van maatschappelijke acceptatie van waterstof en hoe deze kunnen worden vertaald naar een implementatiestrategie. In deze rapportage (D10.3) staat het veldonderzoek binnen vier verschillende cases centraal die zich in verschillende fases bevinden (Rozenburg, Lochem, Wagenborgen, Stad aan 't Haringvliet). Hierbij is er aandacht geweest voor de thema's maatschappelijk draagvlak, (risico)communicatie, veiligheid en veiligheidsbeleving en waargenomen succes van het project. Per casus zijn lokale stakeholders geïnterviewd (totaal 24 interviews) en is er specifieke aandacht geweest voor de bewoners als stakeholder, inclusief omwonenden van de waterstofpilot. In totaal zijn er 17 interviews met bewoners gehouden, 68 vragenlijsten door bewoners ingevuld en hebben er ongeveer 90 gesprekken plaatsgevonden met deelnemers dan wel omwonenden. De resultaten laten zien dat er veelal positieve indicaties voor draagvlak zijn (bij Stad aan 't Haringvliet is dit nog onbekend vanwege de reeds geplande draagvlakmeting vanuit die casus). In alle projecten wordt het belang van communicatie tussen stakeholders onderling en tussen stakeholders en potentieel deelnemende bewoners erkend, hoewel er minder aandacht wordt besteed aan het communiceren met omwonenden. Dit is een gemiste kans vanwege de vragen en twijfels die deze groep kan hebben, bijvoorbeeld over de gemaakte keuzes en de voortgang van het project. Er zijn positieve attitudes met betrekking tot de veiligheid, wat deels wordt toegeschreven aan het vertrouwen dat mensen hebben in de betrokken partijen. Het blijkt belangrijk te zijn dat er een aanspreekpunt is waar mensen terecht kunnen met hun vragen en zorgen. Ook zijn er in enkele pilots positieve ervaringen opgedaan met demo-woningen. De bevindingen bevestigen het belang van brede en veelvuldige communicatie, niet alleen met de direct betrokken bewoners, maar ook met mensen die indirect betrokken zijn. Deze communicatie is niet alleen belangrijk in de beginfase, maar ook in de afrondende fase van pilots wanneer er ogenschijnlijk weinig nieuws is te melden. Ten slotte wordt aanbevolen om alle stakeholders vanaf het begin mede-eigenaar te maken van het project en om tijdig alle betrokken partijen over de invulling van het project mee te laten denken. Dit laatste kan vertraging van het project voorkomen.

Table of contents

Document summary	2
Executive summary	3
Samenvatting.....	4
1. Introduction.....	6
2. Method.....	8
2.1 Case selection.....	8
2.2 Procedure	10
3. Results	14
3.1 Case 1: Rozenburg	14
3.2 Case 2: Lochem.....	21
3.3 Case 3: Wagenborgen	29
3.4 Case 4: Stad aan 't Haringvliet.....	34
4. Conclusion	39
Appendixes	43
Introduction.....	43
References.....	46

1. Introduction

Not only technical, legal and economic aspects play an important role in the successful implementation of renewable energy technologies such as hydrogen, the importance of societal aspects is also increasingly recognized [1,2]. Insufficient involvement of (local) stakeholders in the planning phase, including for example residents, can lead to resistance in the implementation phase. While it can often be challenging to develop a planning and implementation process in which stakeholders feel heard and seen and perceive distributive and procedural justice, it can prevent resistance and accelerate smooth implementation. The research program Hydelta 2.0 focuses on the implementation of hydrogen and identifies how hydrogen can be implemented in the Netherlands on a large scale and safely within the existing gas grid. In work package 10 we chart the state of affairs regarding the social acceptance of hydrogen. The main question here is:

What are the main societal challenges for deploying hydrogen transport / distribution, storage, and application within the built environment in the Netherlands and how could these challenges be overcome as part of the development and implementation strategy?

The literature (as also explored in work package 10, see D10.1) shows that there is medium to high willingness within the general population to accept hydrogen. However, this acceptance decreases when it concerns not just a theoretical idea, but a specific implementation process in the local environment [3, 7]. What factors play a role here? What factors can contribute to the acceptance of implementation of hydrogen in the local environment?

Academic literature provides some initial indications in answering these questions: for example, perceived risks and safety appear to be important factors in implementing hydrogen [4, 5]. Concerns about safety are especially expressed when it comes to the application of hydrogen within the built environment and specifically in households [4, 6]. Good communication appears to be important here. Communication is also important to achieve a transparent interaction between all stakeholders, including the local population. Here it seems important to give local stakeholders a voice in the planning and decision-making process. These aspects appear to play a crucial role in the acceptance of hydrogen project implementation and are thus important in larger scale adoption of hydrogen as a sustainable technology.

There are currently several hydrogen pilots realised in the built environment in the Netherlands. In these projects, a few houses in a street are heated by hydrogen, or an electrolyser is implemented in a neighbourhood that transports hydrogen from there to a nearby boiler house of an apartment complex. Some pilots have been going on for some time (e.g., in Rozenburg), others have recently started (e.g., in Lochem). Several projects have been set up with the intention of implementing hydrogen within a few months to a few years.

This exploratory study focuses on mapping the challenges and lessons learned for creating public support for hydrogen on the basis of several cases, each in a different phase of the planning or implementation process. The perspectives of different stakeholders are included, including those of residents. This report (deliverable 10.3) describes the collected results from stakeholder and resident research within four hydrogen pilots focusing on the themes of social acceptance and risk governance. Key questions are: How have risks been managed and how have the perspectives of different stakeholders been included in the process of implementing hydrogen as a renewable energy technology? What are success and failure factors regarding social acceptance and risk management?

The research consists of several components. Firstly, within the four cases, interviews were conducted with local stakeholders. Secondly, interviews were held with residents or (potential) users. Additionally, questionnaires were administered to both these potential users and local residents. After this field research, two co-creation sessions have taken place with relevant (future) stakeholders to discuss the collected results, to share the lessons learned and to translate the results into a (better) implementation strategy. The results of the co-creation sessions were integrated with the results of the other sub-work packages in the synthesis (literature review and national stakeholder interviews, D10.1 and D10.2, respectively) in D10.4. This document contains the results of D10.3, the field research in which several cases were studied and both local stakeholders and local residents shared their experiences.

2. Method

2.1 Case selection

The selection of the cases was started at the beginning of the project in order to include the most recent experiences with hydrogen pilots. The Supervisory Group was asked for case criteria and experts of the Hydelta 2.0 program were asked for input. A preliminary list with hydrogen cases was drawn up through desk research (Google and Lexus Nexus). In consultation with the Expert Assessment Group of work package 10, consisting of two experts from Stedin and Alliander, this list was finalised.

Some criteria were established to guide the selection of cases. The first criterion was the phase of the project management process, whereas it was deemed important to examine cases that were all in different phases (start – implementation / implementation - completion / completed). The second criterion was the presence of residents or potential users of hydrogen, in order to retrieve relevant responses. The third criterion was variety of cases (built environment, regional industry). Initially, and during the continuation of the project, we looked within cluster 6 of ‘other industry’ within the Netherlands as connected to the regional gas grid. (Cluster 6 means outside the five major regional clusters, such as the port of Rotterdam, the North Sea Canal area and Eemshaven, which are connected to the national gas grid). However, it turned out that within this cluster, many hydrogen pilots are still in the planning stage. Lessons regarding the implementation of the plans, therefore, could not be learned in these cases. It was therefore decided to include four cases in the built environment. Attention was also paid to the integration and synthesis of results both within this work package and in coordination with WP3 and WP6 (HyDelta 2) on risks, uncertainty and cooperation within the hydrogen value chain, or hydrogen safety, respectively.

The preliminary list of hydrogen pilots originally consisted of eleven hydrogen initiatives, all of which were explored individually through desk research to identify the dynamics and characteristics of each pilot. The first case was then chosen in coordination with the Expert Assessment Group, with the aim of gaining experience with the research materials and procedure within this case. A case was therefore chosen that had already been completed at the start of the study, namely Rozenburg. Three other cases within the built environment were then selected, all of which were in a different phase, provided that the initial exploration phase had been completed and there had been some communication with residents. Only then could the factors influencing acceptance and (expected) successful implementation be evaluated. Lochem and Wagenborgen were selected as cases that were in the implementation phase, where in Lochem, during the study, 10-12 houses were actually modified to enable hydrogen connection. Stad aan 't Haringvliet was selected as a case in the planning phase, as support was being researched at the time of this study. The final list of hydrogen pilots investigated in this study can be found below in Table 1, with some background information included for each pilot.

Table 1. The four hydrogen pilots included in the current study

Hydrogen pilot	Phase	Stakeholders
<p>1. Rozenburg (survey: July 2022).</p> <p><i>In Rozenburg, hydrogen is produced locally by converting electricity into green hydrogen (Power2Gas, 2018-2023). This is then transported to an existing apartment complex where three hydrogen boilers have been installed in the boiler house. Hydrogen is blended with natural gas here. The regular natural gas network could be used for this purpose. The start of the first phase of the project had taken place in 2013 and was about the conversion of hydrogen to synthetic gas. In the second phase (2018-2023), the switch was made to full hydrogen supply to the boiler.</i></p>	Completed	<p>Stedin Remeha (boiler manufacturer) Municipality of Rotterdam Housing corporation Ressor Wonen Safety region* DCMR* Bekaert Heating* DNV*</p> <p>*No response was received from these stakeholders.</p>
<p>2. Lochem (survey: Nov/Dec 2022)</p> <p><i>In this pilot, 12 homes are heated with hydrogen starting in December 2022. Hydrogen will be transported from a nearby industrial site via newly constructed hydrogen pipelines.</i></p>	Implementation	<p>Alliander Qirion (energy consultant / communication) LochemEnergie Remeha Municipality of Lochem Westfalen Gassen Monuments coach KiWa BBSB* Kimenai Installation Management*</p> <p>*These stakeholders either referred to other stakeholders or did not respond to our invitation.</p>
<p>3. Wagenborgen (survey: Nov/Dec 2022)</p> <p><i>Divided into four streets, there are 33 households that indicated interest to participate in the hydrogen project. Sustainability measures are currently in place, but no experience with hydrogen has been gained yet.</i></p>	Ongoing case, implementation delayed until fall 2023	<p>Enexis Energiewacht Essent Groninger Huis Eelshuis Intergas*</p> <p>*No response was received from this stakeholder.</p>
<p>4. Stad aan 't Haringvliet (survey: Dec 2022 / Jan 2023)</p>	Ongoing case, support study	<p>Stedin Gasunie NIPV</p>

<p><i>The goal is to make the switch to natural gas-free energy supply by 2025 for and with the entire village (+- 600 homes). There is a public support measurement coming up (June 2023), where a threshold of more than 70% in favor of natural gas-free must be reached. Meanwhile, an inspiration house had been realised, which was heated with hydrogen for two months as a trial.</i></p>		<p>City Natural Gas-Free Project Group Rotterdam-Rijnmond Safety Region Fire station Stad aan 't Haringvliet Municipality of Overflakkee* Housing corporation Oostwest Wonen* Greenpoint Group*</p> <p><small>* These stakeholders either referred to other stakeholders or did not respond to our invitation.</small></p>
<p><i>Total: 24 interviews with local stakeholders</i></p>		

2.2 Procedure

For all pilots, through stakeholder and resident surveys, we aimed to gain insight into experiences with the project, perspectives on hydrogen and ideas on specific topics such as communication within the project, risk communication, safety and safety perception.

Stakeholder survey

Through desk research and in consultation with the Expert Assessment Group, stakeholders were identified. The selected parties were then contacted and online semi-structured interviews were scheduled. In some cases, we were put in touch with other relevant contacts and/or stakeholders that, up to that point, had not yet been identified. Interview topics were: 'public support,' 'communication and risk communication', 'safety and perception of safety,' and 'degree of success of the project.' In some cases it was chosen to zoom in on a particular theme, for example based on the role of the stakeholder within the project or on the information that was provided during the interview. The overall interview schedule is included in Appendix 1. The interviews were then summarized based on the recording. The main results for each case study will be shared in Chapter 3. The interview reports are in the possession of the authors and retrievable.

Resident research

In this work package, residents are considered to be a separate group of stakeholders. Besides interviews, questionnaires with the same topics were used to collect data. For each case study, a researcher spent two days at the site in question. There, respondents were either approached to participate in an interview or asked to complete the questionnaire. The focus was on two groups: the end users of the hydrogen application and local residents.

In the case of questionnaire rejection, the reason was asked to gain insight into causes of possible resistance. A questionnaire was put in the mailbox of residents who were not at home. Besides, a random sample of residents who did not participate directly (and were considered 'neighbors') received a questionnaire by mail. A neighbourhood analysis was made in advance for each hydrogen pilot to identify addresses of users and decide in which clusters around the area questionnaires should be distributed. A summary of this neighbourhood analysis, as well as an impression of the response rate for each case, is given in Table 2.

Table 2. The neighbourhood analysis by hydrogen pilot, and the collected responses (interviews and questionnaires) from the resident survey.

Hydrogen pilot	Clusters + response
1. Rozenburg	<p>A. Direct users; Flat Bosseplaat (40 addresses). Of the 12 people who were at home, 5 wanted to participate (1 interview, 4 questionnaires handed out, remaining 28 addresses questionnaire distributed). Response: 1 interview, 2 questionnaires</p> <p>B. Next to Bosseplaat (33 homes; 7 people who were at home. Total 25 questionnaires handed out), at the edge of the hydrogen power plant. Response: 1 interview</p> <p>C. Neighbours Blencken and Laan van Nieuwe Blankenburg (inside, direct view of hydrogen power plant) (22 homes; 17 questionnaires distributed). Response: 3 interviews, 3 questionnaires</p> <p>D. Neighbours, ring around it, Bosseplaat and Laan van Nieuwe Blankenburg, total 178 homes, 15 questionnaires distributed. No response.</p> <p>A total of 89 questionnaires were distributed. <i>Total response: 5 interviews, 5 questionnaires (3 online and 2 on paper)</i></p>
2. Lochem	<p>A. Hydrogen pilot participants; Nieuweweg (12 addresses; contacted through BBSB). Response: 4 interviews, 4 questionnaires.</p> <p>B. Non-participants Nieuweweg (48 addresses; 25 questionnaires distributed). Response: several short interviews, 3 questionnaires.</p> <p>C. Street where excavations have occurred (Endepool west, 35 addresses; 15 questionnaires distributed). Response: 3 interviews, 9 questionnaires</p> <p>D. Section east of Nieuweweg, where the BBSB is active (173 addresses; 63 questionnaires distributed). Response: several short interviews, 17 questionnaires</p> <p>E. Section south and west of Nieuweweg, where the BBSB is not active (374 addresses; 80 questionnaires distributed). Response: several short interviews, 16 questionnaires</p> <p>A total of 183 questionnaires were distributed. <i>Total response: 7 interviews and approx. 90 short conversations with residents. We received 55 questionnaires (25 online, 30 on paper), of which six the cluster could not be determined.</i></p>
3. Wagenborgen	<p>Four streets with rental houses, of which part of the residents wanted to participate in the hydrogen pilot. Questionnaires were also distributed in some of the surrounding streets.</p> <p>Total: 79 questionnaires were distributed <i>Total response: 4 interviews, 8 questionnaires</i></p>
4. Stad aan 't Haringvliet	<p>No resident survey conducted on-site after consultation with local stakeholders. Data retrieved from interview with a resident/delegate of concerned resident</p>

	group and previous research conducted on behalf of the municipality on residents' ideas and opinions ($n = 89$).
<i>Total: 17 interviews with residents, 68 questionnaires and approx. 90 short conversations with residents about the hydrogen pilot.</i>	

The interview schedule for residents was largely similar to the interview schedule for local stakeholders (Table 2). For residents, emphasis was placed on their experiences as users/receivers of the information (i.e., on the use of hydrogen, how they were informed about the project, what was important in it, and how they look back on the project as users or local residents. It was chosen to focus on interviews with end users, with whom conversations could sometimes be scheduled in advance with the help of local stakeholders. After that, an attempt was made to conduct at least two interviews with local residents per street, and after saturation of responses to focus on shorter interviews and ask people to complete the questionnaire (either online via Limesurvey or on paper). A return envelope was also provided with the paper questionnaires so that people could easily return the questionnaire.

Key questions from the resident interview schedule were included in the questionnaire. The questionnaire consisted of 3 sections: questions about one's own experiences, questions about the respondent's attitude towards hydrogen and questions about the respondents (demographics). After a brief instruction and information about anonymity and data management, respondents had to give explicit consent to participate in the study (informed consent). After this, the first part of the survey began, consisting of 11 questions (eight multiple-choice and three open-ended). For example, the first question asked to what extent one was aware of the hydrogen application in the neighbourhood (1- not at all, 10- very much) and another question concerned one's attitude toward it (1 - very negative; 5 - very positive). There was space in such multiple-choice questions to provide an explanation. People could then indicate in question 6 how they were informed about the hydrogen application in their neighbourhood. They could also indicate how positively or negatively they perceived this communication to be and to what extent they find the information sufficient, clear, given exactly on time, easy to understand, professional, reliable and credible (1 - not at all, 5 very much). The last three questions in this section were open-ended questions that addressed the content of the information, the importance and saliency of different aspects that were communicated, and whether the right person or organization provided the information. People who indicated that they did not receive any information could proceed to the second section of the questionnaire.

The second part of the questionnaire addressed what respondents think about hydrogen and the energy transition in general (attitude), how they perceive the safety of hydrogen, a general evaluation of the project and to what extent they feel they know something about the subject of hydrogen. These include questions such as: *“On a scale of 1-10, to what extent do you feel comfortable with hydrogen in your neighbourhood?”* and *“On a scale of 1 - 10, to what extent would you perceive the use of hydrogen in your home as safe?”* (1- not at all to 10 – very much). Open-ended questions about project evaluation included: *“Looking back on the project, are there things in the project that you thought went just right?”*, *“What would you like to see happen again next time?”*, *“Looking back on the project, are there things in the project that you thought went less well?”* and *“What would you prefer not to see again next time or what exactly did you miss?”* Finally, knowledge of the topic was mapped with two questions, including: *“On a scale of 1 - 10, do you feel you know enough about hydrogen?”* (1- not at all to 10- very much).

Finally, the third section of the questionnaire concerned some general questions about the respondent. These included how long one has lived there, the situation applicable to the person (pilot participant or local resident), gender, age, family composition, cultural background, level of education, main activities (working/studying/retired, etc.) and income level, where it was also an option to indicate not knowing or not wanting to share this. Finally, at the end of the questionnaire, there was space for the respondent to leave comments or questions.

The questionnaire was translated into English to ensure that non-Dutch speaking residents could also share their experiences (cluster B in Rozenburg, for example, consisted of mostly international residents). Ultimately, in all cases there was little or no use of this version of the questionnaire. The full questionnaire (English or Dutch) is available from the authors.

After our first experiences with the materials and the research procedure in Rozenburg, we made some adjustments. For example, we made sure that the two parts of the research (stakeholder and resident research) are conducted as little as possible simultaneously: it appeared useful to speak to the local stakeholders first to explore how they might be able to support in conducting the resident research. We could have made more use of this in Rozenburg, to possibly have reached more users from the apartment building.

The contact with the local stakeholders also allowed us to make timely adjustments in our procedure in case 4 (Stad aan 't Haringvliet) when this proved necessary. In Stad aan 't Haringvliet, for example, the 'Stad Aardgasvrij' project group indicated that it was not desirable to distribute our questionnaire among the residents, as they already received a lot of requests in the context of possible participation in the pilot. It was therefore decided (in agreement with the Supervisory Group) not to visit Stad aan 't Haringvliet. Instead, an interview was held with a resident and a delegate of "the Tafelaars"; a group of residents from Stad aan 't Haringvliet who are closely involved in the project and were able to give us insights into how residents view the project. In October 2022, another organisation also conducted research into support within Stad aan 't Haringvliet [8]. We used these data in this study to make statements about the attitude of residents towards hydrogen and the pilot project (see chapter 3.4).

3. Results

The results of the various components of the research are highlighted below for each case study. A distinction is made between results from the stakeholder research (based on interviews) and results from the research among residents (based on interviews and questionnaires). Thus, residents are considered a specific stakeholder. The results are described thematically, covering the following four main themes: public support, (risk) communication, safety and perceived success of the project.

3.1 Case 1: Rozenburg

Stakeholder research (Interviews, n= 4)

Public support

Interviews with the local stakeholders (excluding the residents) revealed that there were somewhat different opinions in advance about social support for the pilot in Rozenburg. Whereas the municipality indicated that it did not think there would be support, two other stakeholders (grid operator Stedin and boiler manufacturer Remeha) had more positive expectations. After the municipality gained more information (especially about safety and risks), they also no longer saw any obstacles to continue the project.

It was emphasized by all stakeholders that there was no resistance among the residents. This was attributed to the observation that from the beginning of the project, people were included in the plans and had a say in the location of the hydrogen plant. Since it is an external installation, no modifications were required in the apartments, so residents have noticed little of the installation. According to stakeholders, an important reason that the implementation went smoothly is that the residents did not see or hear anything from the installation and therefore did not experience any inconvenience. Moreover, it was mentioned that most people in Rozenburg have an affinity with technology and are or have been employed in part in the nearby chemical industry. It was also indicated that in Rozenburg you are, as it were, 'sandwiched' between the industry: If you want to live safely, you shouldn't live in Rozenburg. Further on in the project, the municipality also noticed that Rozenburg residents were beginning to be enthusiastic about the application of hydrogen in a built environment. There were also mostly positive reports in the press, which was attributed to the notion that hydrogen could be a relatively simple way to achieve sustainability.

Thus, no resistance was observed from the residents of the apartment complex where hydrogen is blended with natural gas in the boiler house. According to the housing corporation of the complex, the residents are proud of the innovation. This stakeholder also mentioned that resistance could be expected from the Dutch government, mainly due to unfamiliarity with the technology or individuals who do not believe in it. This was not so much an issue within Rozenburg (according to the boiler manufacturer), but even within Rozenburg there were many conversations and discussions with civil servants (and, for example, the grid operator).

It was additionally mentioned by the grid operator that within such projects it is important to have someone who serves as 'the face of the project', as being the owner and initiator of the project. In

Rozenburg, this was the grid operator (innovation expert) itself. For the municipality, the role of the grid operator was decisive and it was felt to be important that the grid operator made a case for innovations and handled them thoroughly. It was also mentioned how important it is to involve residents (and other stakeholders) in the project as soon as possible and making them co-owners. Stakeholder management was therefore an important aspect within this project. This was done, for example, by responding adequately to objections and being present from the perspective of the grid operator. For example, when there are activities scheduled that affect the environment, the advice is to address this immediately. Co-stakeholders also indicated that they could always approach this contact person with their questions, and it was mentioned that it is important to stay in constant contact in order to radiate joint enthusiasm and tell the same story. Communication between the stakeholders, but also with the residents, is therefore considered essential.

(Risk)communication

Prior to the start of the project, there was communication through a letter and an information meeting ('bewonersavond' in Dutch) was organized by the municipality together with the other stakeholders, where topics such as safety and risks were also discussed. Together with the residents of the +- 40 apartments, a possible location for the power plant was discussed (where hydrogen would be produced and then used to make synthetic natural gas together with carbon dioxide). All participants of the information meeting were positive, except one. This person was contacted by the grid operator, and later partly reassured because it was indicated that multiple agencies were monitoring what was happening at the site.

The municipality was involved in the hydrogen project by providing a location for the hydrogen plant. Communication with residents has been mainly through the housing corporation, and the grid operator has done the communication regarding risks and safety. One of the main points from the housing corporation is that there was good communication with the residents beforehand about the costs: it is important to them that the living costs are lower after the sustainability measures. In the case of Rozenburg, according to the housing corporation, residents save on energy bills since they do not pay for the hydrogen that is blended in, which they may notice a little bit in consumption.

Other ways of mutual communication with residents included the use of articles in local newspapers and announcements for walk-in events. A number of residents made use of these opportunities. The project has received a lot of international attention; for example, people from all over the world have visited and meetings were organized for these visitors.

In summary, the stakeholders mentioned that important points to communicate about are safety and risks, the (possible) costs, convenience and what it delivers (e.g. in terms of innovation). The boiler producer mentioned that it is important to include people in the process: in what is going to happen and what the steps to be taken are.

Transparency is essential in this communication. It is also mentioned that it can help to display all the alternatives with the pros and cons, to use a frame of reference that people are familiar with (relative to natural gas, for example), and to keep it simple. When it comes to safety, do's and don'ts can be discussed. Risks can be communicated by informing people of the success experiences of other pilots (preferably within the built environment). Finally, the importance of connecting with the resident group is mentioned: that information is given in a language that suits the residents (i.e. not too technical, preferably with the help of a professional, for example a communications expert or a social professional).

Safety and security perception:

From the interviews with the grid operator and boiler manufacturer, the necessary information about the safety measures taken within Rozenburg emerges. They mention that several measures have been taken. Within the system, valves have been installed at a number of strategic places, which close in the event of an incident, so that the hydrogen then has nowhere to go (also known as flashback protection). In addition, there are sensors in places where hydrogen can leak. These are certified and maintained, tested every few months and replaced if necessary. Furthermore, care is taken to avoid storage, or a large amount of hydrogen in one place. Most risks arise -according to the boiler manufacturer- when pipelines have to be moved or replaced, because of the human intervention involved in this work. Safety is rated positively by the stakeholders (with a 9 or a 10 on a scale of 1-10), mainly because of the precautions taken, the limited size of the project (a small pipeline to two small boilers in a controlled environment) and the observation that a large number of scenarios have been taken into account to reduce the likelihood of risky events (the fourth respondent was not asked this as explicitly, but no concerns about safety were expressed here). There were also no negative reports or experiences from residents.

Evaluation of the project

The stakeholders all look back positively on the project in Rozenburg: it is seen as a good start in the market, clearing a path to continue with hydrogen in the Netherlands. The project has proven that hydrogen can be applied within the built environment. Especially the process with the stakeholders and the cooperation and communication between all parties is looked back on positively: 'Even though there was a lot of discussion with different officials such as civil servants, the result is that the project is running smoothly for 10 years and a lot of knowledge has been gained'.

The grid operator mentioned two aspects that could be done differently next time: the permit process (this took unnecessarily long, partly because, according to the grid operator, there were ideas among the permit issuers that hydrogen was dangerous, whereas there was no storage in this project). Eventually they jointly found out that a notification stating the amount of energy that would be used in Rozenburg was sufficient. Had the grid operator known this earlier, it might have saved two years in the project - according to the grid operator. Also, in retrospect, the grid operator says the project could have been larger, so that there was more space (in terms of ground area) to practice with the technology.

One other stakeholder mentions that the publication and accessibility of data on hydrogen pilots (in general, not just within this case study) should be improved, in order to better disseminate knowledge about hydrogen implementation. Related to this, the municipality mentions that an evaluation is missing ("*I don't actually know how things stand now either*"), for example, about how residents experienced the project and whether they are still enthusiastic about it. So there seems to be a need for regular updates on the current state of affairs and a look back at what has been accomplished.

Finally, the municipality mentions that a relevant question for them is whether hydrogen is appropriate for Rozenburg (after all, there is a large heat grid in Rotterdam and a lot of residual heat from industry). This is something also underlined by the housing corporation. So it is important to keep the local environment, and the residents themselves, clearly in mind during the planning phase of such sustainability projects.

Resident research: interviews (n = 5)

Of the five interviewees, four have lived in Rozenburg for 15 years or more. The fifth person has lived there for five years. The interviewees are all 50 years or older and live either in the apartment complex or in one of the surrounding clusters.

The interviewees indicate that hydrogen is not an unknown phenomenon in Rozenburg because it also has applications in nearby industry. For residents, hydrogen represents a good alternative to natural gas and making society more sustainable. No resistance to this hydrogen project was noted in the interviews. Residents find it a useful project and would like to see a follow-up, since sustainability is needed anyway. This confirms the positive impression of support among residents as mentioned by the other stakeholders. However, the interviewees did question the costs of the energy transition and who should pay for them. In future projects it could therefore be important to pay (more) attention to this issue.

The hydrogen installation causes little to no inconvenience to the residents of the apartment complex or neighbours. For example, they experience no noise pollution. At the beginning of the project, however, there was nuisance when the excavation work took place.

Communication and risk communication:

Interviewees indicated that they received a letter with information and an invitation to an information meeting ('bewonersavond' in Dutch). To what extent this was about risk cannot be properly recalled. Both actions could be appreciated by interviewees. However, interviewees (especially local residents) also indicated that they would have liked to have been invited themselves to meetings in the common room made available for visitors to the hydrogen project. It is also mentioned that they had to go after information themselves, whereas they would have liked to receive it from those involved.

People indicate that they would like to receive information about the risks and costs, and that frequent information is needed to become comfortable with new technology. People would also like to be informed in advance rather than after the excavation work has already started. Indeed, residents mostly indicate that they had to go looking for information themselves (for example, because as a local resident living nearby the site they did not receive it). People also mention that they would have liked to have had this information (especially about safety or about the course of events, for example upcoming work) from the project partners in advance. Finally, it is important to people that this information is then offered in a simple way (in "Jip and Janneke language").

The resident who has only lived in Rozenburg for a few years would have liked to be informed about the safety and potential risks of being able to feel comfortable and comfortable with new technology. The resident indicated that he knew little about the hydrogen application and had not studied it, but had been told that heating costs would be reduced. In use, the person does not notice anything about it, and therefore objects to the fact that it is offered as something very positive, about which nothing more is communicated. So it has not been tangible for this person what it means for the energy bill, because at the bottom line he or she didn't notice that much.

Safety and safety perception:

People generally feel pleasant and comfortable using hydrogen and the installation is perceived as safe ("I never think about it"). The relatively small size of the installation is cited as a reason for this, but also that residents are used to living around hazardous materials. It is said: '*If you really want to live*

safely, you shouldn't live in Rozenburg'. If a project has a larger scale, this may be experienced as different.

Residents would like to be informed about risks and operation in meetings and through clear leaflets. Here it can help if an expert provides additional information in personal contact, using simple language. What is striking is that the residents do not adequately know where they can go back to if something goes wrong. *'Sometimes a light flashes and then they call and respond'*. Some people indicate that they know how to find the contact person from the grid operator in case of concerns, others are less sure about what to do.

Evaluation:

There could be more explanation and education in simple language about the risks, safety and operation. Often this had to be proactively pursued. In addition, an update would also be appreciated; what is the current state of affairs? Even if nothing has changed, that is also news. People like to be kept informed, and for this older target group, paper flyers or letters are also preferred.

Resident research: Questionnaire data: n = 5

All respondents who completed the questionnaire were men of Dutch background, with ages between 57 and 89 years (mean =70 years, standard deviation 13.4). One of them had secondary education as the highest level of education completed, two completed Lower Vocational Education and two have completed Intermediate Vocational Education. Three of the respondents were retired and the other two persons were employed. Three persons indicated earning above modal, one person around modal (36,500 euros) and one person indicated earning below modal. People have lived there for an average of over 37 years, with one of the apartment complex residents (end user) having lived there for only 3 years and three residents having lived in Rozenburg for over 55 years.

All respondents said they are very positive about the energy transition, with the proposed requirements that it must be done by scaling up the infrastructure, by conducting thorough research and without much extra costs to citizens. On average, people indicated they know a little about hydrogen (5.4 on a scale of 10), with two outliers: someone who says to know nothing about it and someone who says knowing a lot about it (this person works in chemistry).

When asked to what extent people felt comfortable with hydrogen in the neighbourhood (mean = 7.4), four out of five respondents indicated they felt comfortable with it (score of an 8 or a 10 on a scale of 1-10), for example, because of the experience in their work. They refer for instance to hydrogen as the future, they have read that the existing gas pipelines did not have to be replaced and this is cost-saving, and respondents trust in safety. One respondent here indicated that they were not comfortable with it (score of 1, no further explanation was given for this). Equal answers, both quantitative and qualitative, are also given when asked to what extent people felt comfortable using hydrogen in the home. One respondent indicated, *"I don't think I would think about the dangers, I don't do that with gas either"*. With regard to perceived safety, the highest scores are found, with a range of 5-10 (mean = 8).

When asked to what extent people are aware of the hydrogen application in their neighbourhood, responses are mixed (mean = 5.2, standard deviation = 3.56, range 1-9). Three of the five respondents additionally indicated that they looked back very positively on the hydrogen project ('this alternative to gas appeals to me' or referring to experience within work), the other two answered neutrally. The majority indicated that they feel little has changed since the pilot, except the switch from natural gas to hydrogen. They all indicated that they noticed nothing at all to very little. Four of the five

respondents additionally indicated that they are very positive about the hydrogen project, one person is neutral in his/her response. Two of the five respondents then indicated that their perception of hydrogen had not changed because of the project (for example, because they had no direct experience with it), for the remaining three respondents this was the case (scores of 6, 8 and 10 on a scale of 1-10, with an average of 5.2)

The communication within the project is evaluated differently: one person indicated that there has been no communication about it, one person is a bit negative (*'The hydrogen site is pretty much at my doorstep, but I have to hear what they are doing from the media. I think this is a missed opportunity to involve the local residents'*). Furthermore, someone indicated to be neutral about this, another found it a bit positive and yet another was very positive (*'have been to the introduction'*).

Regarding the extent to which the information received was considered 'sufficient', 'clear', 'right on time', 'easy to understand', 'professional', 'reliable' and 'credible', it can be said that two respondents were negative about this (all scores of 1 or 2 on a scale of 1-5), and two persons were positive about this (only scores of 4, or only scores of 5). Average scores on these questions thus always come to 2.75 or 3. So this is not particularly high, but there is little variation in responses within respondents. One negative response explained that the information was only obtained from the media, and there was missing information from within the organization. According to respondents, the information was about that there was going to be a trial, the process of the trial and education about hydrogen as a sustainable alternative.

Of the four respondents who completed the two questions related to the evaluation of the project, mostly positive sounds were noticed. Two respondents mentioned as areas for improvement that more information would be appreciated, as would communication with the neighbourhood. This underlines the importance of broad and frequent communication, not only with the residents directly involved, but also with people indirectly affected.

The table below summarizes the results of Case 1, Rozenburg. It shows that similar conclusions can be drawn from the three different research sources regarding public support: consistently positive indications were found for this. There are also similar opinions about the safety of the project: all experience it as very safe. From residents and neighbours there is a desire for more and timely information, looking back on the project but also updates on the current state of affairs form an important evaluation point, also from the municipality as a local stakeholder.

Table 3. Summary of results (case 1).

Rozenburg	Interviews with stakeholders (n = 4)	Interviews with residents (n = 5)	Questionnaires residents (n = 5)
Social support	Except for initial doubts on the part of the municipality, there was support for the project. Also, according to stakeholders, there was no resistance among residents.	No resistance.	Four out of five respondents reported feeling comfortable with hydrogen in the neighbourhood.
Communication and risk communication	Important topics are safety and risks, the (possible) costs, convenience /adjustments in the home and what it will deliver (innovation). Include	There could be more explanation and education in simple language about the risks, safety and operation. Now, they	Mixed responses: from local residents, there could be more communication.

	residents in the process and be transparent.	often had to discover it for themselves.	
Safety and safety perception	It is considered very safe.	No security concerns (due to limited size and context of Rozenburg - people are used to something).	People experience it as relatively safe.
Evaluation of the project	Cooperation between parties = positive Provision of information: need for updates on current status; publication of data and results could be improved	Information provision: Update current state of affairs.	More information to and communication with the neighbourhood.
Other comments	Small sample within this study		

3.2 Case 2: Lochem

Stakeholder research (Interviews, $n = 8$)

Social support

Regarding support, all parties spoken to indicated that support was not an obstacle within the hydrogen project in Lochem (H2L). This is a project in which the local population actively looked for a party that could help them to become more sustainable, all participants participate on a voluntary basis, already showed interest prior to the Ukraine crisis (and the consequent rising gas prices), receive financial compensation for the modifications to their homes and are highly educated. However, participants did have to show patience in the initial phase of the project due to a delay in planning. According to the project management, it was also important to provide the other members of the residents' association (BBSB) with the necessary information to accept the pilot.

Some of the initially interested members eventually gave up participating. The reasons given by the project management include: the required modifications to the home, technical limitations of the home or other reasons such as, for example, the recent purchase of a new gas stove or a recent renovation or relocation.

Less is said about the opinion of local residents by the stakeholders spoken to. What is clear, however, is that at the information meetings (organised for residents), little opposition is heard.

Finally, the high prices and the increasing position of hydrogen in the (inter)national market appear to contribute to support for the project, according to the representative of the local energy cooperative. Almost all parties involved explicitly state that they benefit from a successful project in view of their own development and market position.

(Risk) communication

Local residents also received less attention within the topic of communication. Newsletters were distributed from the grid manager, reports were placed in local newspapers and online. Because the construction of a parallel pipeline was required, more communication with local residents proved necessary than initially thought. However, this communication only took place in a certain area and was largely limited to the relevant (excavation) work, according to the grid operator's communication consultant.

Communication with members of the BBSB and further interested parties went smoothly according to the project management. Largely, connections were made to already planned information meetings and, in some cases, a separate information meeting was organised. Interested parties were also welcomed to the demo house on the Kiwa site in Apeldoorn. All in all, there are positive sounds about these information meetings and the visit to Apeldoorn. As a success factor of this communication, it is mentioned that everyone was treated as a partner in the project. The various stakeholders also noted that the local energy cooperative was very important in bringing stakeholders and residents together.

Several stakeholders indicated that the extended initial phase of the project and the delay did prove challenging for communication. During this period, the impatience of the interested parties was evident. According to the grid manager, the local energy cooperative and the neighbourhood association, it helped that during this period, the houses also had to be made more sustainable, which

gave the participants the feeling that things were moving forward. To ease this process, a monument coach was also appointed.

As advice for communication within future projects, several stakeholders mentioned that information on safety should form the basis and that it is appropriate to communicate clear boundaries to local residents and interested parties, so that it becomes clear why certain choices are made.

Safety

The parties involved said they have a lot of confidence in the security of the installed system. After all, *'more safety is probably built in than is actually necessary in the end'*.

It is also indicated by the grid operator that there seemed to be early confidence in the integration of hydrogen in Lochem because of the parties involved. Questions were asked about the operation, the connection and the new central heating boiler, but they did not stem from mistrust. People quickly felt confident when they were given explanations - and when they knew which parties are involved in the project. The number of questions about safety and/or risks during the information meetings and in communication in general has been perceived as low.

Some stakeholders indicated that the demo house at Kiwa (Apeldoorn) contributed to confidence in the application of hydrogen. Here, interested parties were informed about the operation and safety of hydrogen within the context of a home. Mechanics (among others) are also trained at this house and undergo a three-day course before they are allowed to work with hydrogen.

To ensure safety, some conditions have been set within the project by the boiler manufacturer to prevent participants themselves from turning off the gas tap or otherwise affecting the operation of the boiler. It was also decided that there will be no hydrogen cooking; all participants are equipped with an induction stove.

Westfalen, as the gas supplier, has been responsible for establishing the location where the hydrogen is delivered. Within the project, they have based themselves as much as possible on the laws and standards surrounding natural gas. Where hydrogen behaves differently from natural gas, things have been reasoned and calculated differently, so that a safe situation is created. The local environmental services were included in this by inviting the fire brigade to visit them several times. During these visits, they explained what exactly happens, what the installation looks like and what possible dangers and risks are and how they can be dealt with. By doing so, they hoped to contribute to the fire brigade's action perspective. Within this framework, the situation in the participating homes was also discussed.

Evaluation of the project

All in all, the stakeholders spoken to looked back on the project so far with satisfaction. Mutual communication and cooperation was perceived as pleasant, and the success so far was attributed to the fact that all stakeholders have an interest in a successful outcome and are therefore relatively eager to learn: *"The mutual cooperation between project partners is going very pleasantly. And certainly the commitment and enthusiasm of the residents is admirable. Incidentally, this also applies to the suppliers,"* said the local energy cooperative. The importance of the involvement of the local neighbourhood association and energy cooperative is also underlined.

For the parties involved, the legal aspect of the project and the international scene has been especially challenging. Lack of laws and regulations, slow decision-making and rising prices have undeniably hampered and also delayed the project, according to the local energy cooperative: *"Also, the extremely slow decision-making by the province has been a factor that delayed us and increased costs as the*

market changed significantly". It is also stated by the project management that they would have liked to go 'live' earlier. Furthermore, according to the neighbourhood association, the communication to residents could have made it clearer which party they could turn to for various requests for help, the division of roles may now have been unclear to residents - no clear owner of the project can be discerned.

When asked how best to create support for a hydrogen application, interviewees mentioned that an acceptable business case, examples of best-practices and stories from residents play an important role. To what extent the pilot can be considered a success remains to be seen, according to some parties, according to the local energy cooperative; *"We can actually only say something meaningful about that at the end of the pilot. Then it will also strongly depend on how the natural gas/hydrogen market has developed."*

Resident research (Interviews with hydrogen pilot participants, n = 4).

(Risk) communication

The participants spoken to indicated satisfaction with the communication within the pilot. It quickly became apparent that there was a lot of relevant knowledge within the project group. The information they received during information meetings, in conversation with various stakeholders and during a visit to the demo house in Apeldoorn gave them a lot of confidence in a successful course of the pilot. The communication around the cost price of hydrogen was mentioned as a point for improvement; *'there could have been a bit more communication about that'*, one of the participants indicated.

Safety and safety perception

None of the participants spoken to expressed concerns about safety in the home. The fact that all pipes were properly pressurised and measured gives confidence. One of the participants even stressed that he feels even safer compared to being connected to natural gas: *"There are so many safety measures in place... there will be all kinds of sounds when gas is released, I do trust that."* In addition, cooking on induction is also perceived as relatively safe and practical compared to cooking on gas: *"It's easy to keep clean and you can boil an egg at the touch of a button"*.

Evaluation of the project

In general, participants are very satisfied with the information received, the working methods of the parties involved and the fact that they were able to implement a sustainability measure in their homes through this trial. They experienced little inconvenience from the work, nor did they hear any complaints from neighbours. The work around the connection was also seen as positive: *"They worked all day to get it done. When they failed, a new boiler was installed immediately the next day, in short, it was all very well organised"*. Participants do say that they would have liked to have been connected at an earlier time, although there is understanding for the delay. The power of the boiler did not go unnoticed either; the house gets sufficiently warm but participants notice that the tap water takes longer to heat flows less powerful. There is some understanding for this too: *'You do lose a little in comfort, but that's not a problem. After all, you are taking part in a pilot project'*.

Making the monumental house more sustainable is an important issue for all interviewed participants, they mainly speak out against the state: *"The state should set other priorities in the interests of sustainability; more adaptations should be accepted"*. A few hold an interesting opinion; *"Since the municipality does not help pay my energy bill I don't think they have the right to interfere with insulation measures, the fact that we have double-glazing everywhere is a fine example of civil disobedience"*.

The future of the pilot involves some uncertainty. In the short term, people are not worried: *"actually we expect to be able to get the water hot for the next three years without any problems"* but the long term appears somewhat uncertain. After all, it is unknown what the market will be like in three years and whether hydrogen in the built environment will continue to prove feasible.

Research among residents in Lochem

In addition to the interviews with end-users and the data from the questionnaires (see later), a lot of information was also gathered as we conducted some interviews and many shorter conversations, with local residents as part of the residents' survey. This is summarised below:

An interview with a family on the Endepol (where the excavation work to lay the new pipes took place) revealed that they did experience inconvenience, both in communication and in the execution of the work. First of all, they received a letter informing them about the works, which described that they would 'not be able to use the pavement for a few days'. In reality, almost their entire driveway was deconstructed, several containers, large machines, generators were parked right next to their homes for a long time, resulting in traffic-, noise- and odour pollution. When these residents contacted the person mentioned on the letter, they were referred to the municipality. However, they said the municipality did not take their complaints seriously and did little to reassure them. They were also somewhat disappointed with the response they received from the local energy cooperative to their query.

Fortunately - indicate the residents - the duration of the works was not too long in the end, yet they would have liked to have been adequately informed about the scope and duration of the works. They would have liked more information in the form of newsletters or an information meeting organised for residents living nearby, as they also still wonder what exactly is happening on the other side of the Berkel [supply from the Stijgoord], why they cannot participate and what results are being achieved within the pilot. The fact that they have experienced inconvenience, the lawn has not been re-seeded, and only a small group of people are now receiving subsidies to become sustainable provides a somewhat 'sour' feeling within this household. They are not worried about the safety of hydrogen, although they do have some questions about the usefulness of the project; *'how can it make sense to do so much work to be able to heat a dozen homes with grey hydrogen'*, indicating a lack of information received about the purpose of the pilot.

Another resident says he is a chemist and therefore particularly sceptical about the integration of hydrogen in the built environment. He mentioned the volatility, explosiveness, the unsuitability of Dutch natural gas pipelines and, in particular, the bizarre amount of electricity it costs to produce hydrogen makes him think it is nonsense to invest in such a project. The person also indicates he is not particularly comfortable with hydrogen running underground at his place.

Interviews were also held with some residents at the door in nearby streets (cluster D). The majority indicated that they did not get much of a sense of the project, except that some items were left at the beginning of the street at the time of the works. After asking about safety, mixed reactions follow; people like the fact that sustainability is being implemented and also find hydrogen interesting, and it is not necessarily perceived as unsafe. A few did say they would like to participate, would like to receive more information about the project or harbour some resentment towards those who were chosen to participate and also receive subsidies. A local resident also works as a communications advisor at Lochem municipality and he or she indicated that in principle, the project was communicated in a door-to-door newspaper and information can be found on the municipality's website. He/she believes that residents and participants at the Nieuweweg in particular should be kept well informed of progress.

In some other streets in this cluster, the project is being discussed with some elderly residents of listed villas. They did get some information here and there about the project through the residents' association, expressed interest in progress and participation, and did not feel unsafe. One person did wonder whether it will work - after all, he read in the newspaper that hydrogen production only makes sense in industry - but he did not experience any inconvenience from the pilot so far.

Finally, some residents in the cluster of houses that do not belong to the residents' association area were also interviewed. They indicated they have had little exposure to the hydrogen pilot and there were no negative voices regarding safety, communication or nuisance.

Of the residents from the Nieuweweg who are not participating in H2L, those who have not expressed interest in participating in the project cite advanced age, recent purchase of a new boiler or gas appliance as reasons. People say they have not received particularly much information about the works (but do not resent this) and have experienced only minor inconvenience from the works.

Resident survey: questionnaire data (n = 55)

Of the respondents, 43 were male, 8 were female and 4 were of unknown gender. The average age was 65 years old. Regarding level of education, half of the respondents did finish college/university education with a combined percentage of 54.6%, while the rest of the respondents (45.4%) had primary, secondary or intermediate (vocational) education. Education level ostensibly translated into gross annual income: over 60% of respondents earn around or above modal (€36,500). People have lived there for an average of 23 years.

On average, the data showed a positive value judgment towards the energy transition: over 70% say they were very positive about it; over 20% were positive and a small minority (>10%) expressed a negative opinion. Some arguments for a positive opinion were that *'it is all taking far too long'*, *'we need to get rid of fossil fuels'* and *'we need to move towards circular energy'*. Those with negative views indicate that *'it's all a lot of work to provide the Netherlands with enough electricity'*.

The average opinion of 5.7 (on a scale of 10) when asked whether they feel they know enough about hydrogen is substantiated by those at the lower end by arguing that it hasn't been relevant to them yet, they would like to know more about hydrogen in the neighbourhood or that they don't believe in it. A few say they are very well informed because of their work.

When asked to what extent people feel comfortable with hydrogen in the neighbourhood, an average rating of 8.4 follows. Those responding positively, mentioned the argument that it should be little different from natural gas if everything is done right. One of the respondents with a negative opinion (lowest score: 5), who also explained this, indicated that he or she felt safe with any piping but not with the storage of hydrogen in a tank nearby shielded by concrete walls.

Similarly, when asked to what extent one (would) feel comfortable using hydrogen in the home, an average verdict of 8.4 is given with arguments for a positive verdict including *"there is more measuring and safety equipment in the house now than with natural gas"* and *"rather today than tomorrow"*. Those with a negative opinion mainly indicate that they still have too little knowledge. The question to what extent the use of hydrogen in the home would be perceived as safe falls a fraction lower with an average rating of 8.3. Most of the comments when answering this question are in the context of a lack of knowledge, illustrated by answers such as: *"should look into it more first"* and *"too little knowledge to answer this properly."*

Regarding the evaluation of the project:

A total of 51 respondents indicated the extent to which they are aware of the hydrogen application in the area. Of them, nine gave a value rating of '5' or lower; these responses were not provided with an explanation. 42 respondents indicated that they knew enough about the hydrogen application, stating that they had read about it in the newspaper or on social media or had been informed about the project through hearsay.

So far, the majority of respondents (over 70%) looked back on the project in the neighbourhood somewhat positively or even very positively. 11% is neither negative nor positive about it.

Only 1 respondent gives 'very negative' as an assessment, reasoning *"Completely unnecessary demonstration project that has only cost money that could have been better used for the transition to hydrogen. The main argument was said to be and to show the minister that houses from +- 1900 (poorly insulated) can also be heated with hydrogen. Of course, the minister is not waiting for such a demo project. These kinds of monumental houses have the lowest priority in the policy, has been communicated to ministry all along. Those pushing this project also say: this will put Lochem on the map. That, of course, is entirely a bad argument...."*. The positive responses were underpinned by the notion that it is a good initiative that people hope to benefit from in the future.

This predominantly positive opinion is reflected in the response to the question on how people now feel about hydrogen application in the area: over 85% of respondents expressed themselves as being 'somewhat' or 'very much' positive.

A total of 45 (of 51 responses) respondents indicated that they noticed 'nothing at all to very little' or 'fairly little' of the hydrogen application in their daily lives, which seems to be limited to the work performed. Those who noticed 'a little' or 'quite a lot' (6 in total) of the hydrogen application indicated that they participate themselves, live at the Nieuweweg or keep an eye on developments because of work.

Respondents indicated that their perception of hydrogen has changed slightly as a result of the project: an average rating of 4.6 follows (also on a scale of 1-10), the value judgement given varies widely (from 1 to 10) which is reflected in the explanations given: from *"no knowledge of the project, don't have an image of it"* to *"I didn't know much about hydrogen beforehand"*.

When people were asked what they thought went well within the project, they indicate: *"The work went smoothly and, as far as I can judge, fine."* and *"The information i.a.; the attention of the parties involved and the 'celebration' of the stages in the implementation of the project."* Yet, mostly negative answers were given, and when asked what they thought went less well, people also leave mostly negative answers such as: *"Didn't know about any project; info beforehand will be better."*, *"There is a lack of information and communication."* and *"Would have liked to have heard, read more about it, more communication would have been welcome."* There is also a lack of understanding about the lack of an invitation to participate: *"Maybe an invitation to participate? I live in a connecting street, plus the pipeline goes around the corner to the Berkel 20 meters from me."*

Communication within the project:

The non-participants who would have been communicated with, indicated that this was done in the following way: *"Not"*, *"only a few articles in local newspaper"*, *"note that something was going to happen, nothing more"*, *"via the press, but hardly enthusiastic"*, *"I went looking for info myself"*. Out of 46 responses to the question *"how do you look back on communication about hydrogen and the project in your neighbourhood/home?"* A total of 6 answered 'a little or very negative', 6 as 'not

negative/not positive', '19 a little or very positive', 14 respondents indicated that they were not communicated with. The positive responses consist mainly of participating respondents. The thrust of the comments reads that people would have liked to have been more informed.

In terms of the extent to which the information received was deemed "sufficient", "clear", "exactly on time", "easy to understand", "professional", "reliable" and "credible", it can be said that these questions were not rated as particularly high, with a spread of an average of 3.08 to 3.61 (on a scale of 1-5). Around 30% of these responses to these questions are negative. Comments on these questions include the following: *"In terms of technical content, hardly any information was given, only about the implementation of laying the pipes", "Could have been more comprehensive and why some were invited to participate and others not", "For us, communication was fine, clear, understandable and timely."*

When asked for further ideas, thoughts or comments on this survey or neighbourhood sustainability in general, the need for a neighbourhood-oriented approach was indicated: *"I miss a neighbourhood-oriented approach in terms of sustainability. No direction by municipality or other government agency", "More structured approach per district."* People also reiterated their wish for more information, both before the project starts and during the project regarding progress. Concrete advice for this from one respondent reads: *"Distribute a good clear flyer on this topic, in this neighbourhood, with pros and cons, and remove fears about danger of explosions, we are interested about sustainability in this neighbourhood."* It is also suggested to contact political party Lochem Groen! on this topic.

The table below (Table 4) summarises the results of case study 2, Lochem. It shows agreement between the different research sources on all themes. There are mainly positive indications of support, which can partly be attributed to the bottom-up movement from the start of this project and the cooperation between all parties. Safety is not seen as an issue here. Regarding communication, it can be mentioned that local residents would have liked to be more involved in the project, for instance regarding the progress and activities, but also regarding choices made (why they cannot participate themselves, for instance). This is confirmed by the stakeholders: it is important to communicate about boundaries in such a project.

Table 4. Summary of the results (case 2).

Lochem	Interviews with stakeholders (n = 8)	Interviews with residents (n = 7)	Questionnaires residents (n = 55)
Social support	It is a bottom-up project, initiated from residents. Positive indications of support.	No resistance, positive. A few in the neighbourhood feel uncomfortable with hydrogen in the neighbourhood.	On average, people feel comfortable with hydrogen in the neighbourhood, lack of knowledge is often mentioned but does not always result in lower scores on how it is perceived.
Communication and risk communication	Positive impression, partly because everyone is involved in the project as a partner.	There is confidence in the project group, through talks with parties and visit to demo house.	Local residents would sometimes have liked to be more informed (about progress, choices and why they cannot participate)
Safety and safety perception	It is perceived as safe, trust in all parties.	No worries about security (among	It is considered relatively safe.

		others because of measures done in the house).	
Evaluation of the project	<p>Cooperation between parties = positive</p> <p>Importance of local initiators</p> <p>Information provision around safety as a basis, make boundaries clear (e.g. to local residents)</p>	Residents are satisfied so far, both with communication and the method, no to little nuisance (a few in the neighbourhood do).	More information and communication with the neighbourhood/residents.

3.3 Case 3: Wagenborgen

Stakeholder research (Interviews, $n = 4$)

Social support:

Residents of social housing were actively approached by the project management in this project, asking if they would like to participate in the pilot. Ultimately, of the 42 households approached, 33 households agreed to participate. According to the project management, the remaining residents had 'practical' reasons for not wanting to participate. These included residents who were too old and therefore had no energy or time, or there were financial concerns. Financial concerns could stem from the fact that the neighbourhood consists of social housing, so monthly costs such as energy bills could prove a difficult issue. It is also mentioned that hydrogen projects are new and therefore sceptical opinions can arise quite quickly. These opinions easily lead to difficulties with finances. Therefore, it is important to residents that the costs do not become higher than they already were. This is therefore being addressed with the so-called 'no more than usual' concept (as has also been done in Lochem), through which Essent aims to ensure that residents do not have to pay more for their heating compared to when their homes were connected to natural gas. The earthquake issue sometimes prompted residents to be more willing to participate in such a project, in order to become less dependent on natural gas.

(Risk)communication

From the housing association, a resident consultant was appointed to be the point of contact for the residents. In the first phase, one could initially not organise an information meeting due to corona measures. Therefore, Enexis decided to call the 42 residents individually, which was appreciated by many residents afterwards. Because they were talking to one resident at a time, it felt more personal, and they could talk one-on-one but also listen to what the resident had to say. This also ultimately made residents feel more heard. Although not originally planned, it proved to be a positive learning point and this personalised approach would also be recommended in new projects.

For the first meeting, the individual approach was the right one, according to Enexis. In the subsequent phases of the project, they used information meetings to inform the residents. The fact that all residents could be informed at the same time made it easier to update residents during the project. An information meeting also made it straightforward to use visual means to involve residents in the project activities, according to the project management. For instance, a number of information meetings were organised, where Intergas, among others, was able to use visual aids such as a model boiler to properly inform residents about the planned work. These information meetings were organised by Enexis together with the other stakeholders, with each party involved having a table where residents could engage in conversation with the party. For example, a hydrogen-powered induction plate was also demonstrated by Enexis to show that and how it worked. New information was as yet lacking at these meetings, for instance on long-term plans. A pitfall regarding the organisation of such meetings turned out to be that these moments were sometimes used as a moment to discuss outstanding complaints with the housing corporation, for instance, instead of project-related issues.

Safety and safety perception:

Enexis indicated that trust around the safety of the project is high because of the participating parties. Because this includes familiar names, residents feel more at ease. No major safety concerns were reported by residents either. Efforts are being made to reduce risks during the work, for example by visiting each resident and instructing them about the new boiler. Besides instructing, Energiewacht will be a point of contact for residents if there is anything, and service technicians will be available to residents if, for example, something is broken. Energiewacht also mentions how important it is to have a certain level of reliability as a stakeholder, so that residents feel at ease when jobs need to be done in and on the houses.

For example, the Energiewacht sees to it that residents are involved in new aspects, for example regarding how a heat pump works. Because of the new heating system that will be installed, heating will be done at 60 degrees instead of 80 degrees, as the insulation will also be renewed. This will heat the house, but will take longer.

Evaluation of the project so far:

A series of preservation works were carried out in all participating rental properties. To reduce draughts, window frames have been renewed and draught strips installed. When the window frames were renewed, the large single-glazed windows were replaced with double-glazed windows to reduce heat loss.

Due to supply and permit issues, hydrogen has not yet been delivered to the homes. Stakeholders and residents alike have not yet been able to experience anything from the hydrogen project apart from making the houses more sustainable. A unique aspect of Wagenborgen is that three municipalities converge here. However, this also means that bureaucratic processes sometimes come into play that can slow things down.

Although hydrogen technology is growing a lot, there are still many unknowns, leading to concerns and or doubts. From Enexis, it is thought that there is not always the same level of cooperation and commitment from municipalities because of this. It is also stressed that a lot of flexibility is needed in hydrogen projects. If you make extensive planning in preparation for the project, there is a good chance that it will not turn out as planned beforehand.

Security of supply does affect the parties involved. Especially in the first phase of the project where the hydrogen is not produced locally, security of supply needs to be ensured. This will therefore come down to how often and for how long the trucks carrying gas can deliver. What currently distinguishes hydrogen from natural gas is that natural gas will always flow through the pipes, while hydrogen only flows through the pipes when it is delivered. To reduce the impact of this problem, a buffer tank is being constructed to make delivery less dependent on truck supply.

Another troublesome element is the price cap, the system where an energy supplier is not allowed to charge more than a certain amount for a cubic metre of gas. According to Essent, this creates a gap between the purchase price and the sales price set according to the price cap. The grid operator indicated it only would want to participate in hydrogen-related projects if that gap between purchase price and selling price can be filled by, for example, subsidy, from an involved party or from the government.

Resident research (Interviews, $n = 4$)

The four interviews with the pilot participants showed that they are satisfied with the contact with the resident advisor, they can go there with questions or complaints. The residents who went to the information meeting found them informative. Besides being given information about the new boiler that will be installed, there was also an opportunity to be able to ask questions or put down complaints in a more direct way.

Most of the complaints or irritations came as a result of the delays. One resident indicated they had to stop work halfway through because of delivery problems of building materials. As a result, the house was left in a working state for a while, causing residents a lot of draughts. Then the construction workers returned unannounced on an unfavourable day and time.

No negative things were said about the hydrogen aspect of the project. There are question marks as to whether it will work, but people are keeping an open mind. Other residents are also curious or are not so concerned about the project and will let it happen. Positive opinions about hydrogen come mainly from the fact that Wagenborgen can become natural gas-free. Wagenborgen is in the earthquake area and several residents named this as a reason for wanting to participate in such a project.

In approaching residents for an interview, a number of owner-occupied houses were also approached. None of the residents of owner-occupied houses heard anything about the project, as no hydrogen-related activities had yet taken place. It is expected that these surrounding residents will become familiar with the project once more activities take place.

Resident survey (Survey data, n = 8)

A total of 8 respondents completed a questionnaire. Of the respondents, 4 were male, 2 were female and 2 were of unknown gender. The average age was 57 years old. Regarding level of education, 2 respondents indicated higher education, 3 respondents had mbo level, 2 respondents lbo level and of 2 respondents the level of education was unknown. Gross annual income was not mentioned by 5 of the 8 respondents, and of the remaining 3, two of them earn (well) above modal (>36,500) and 1 (well) below modal.

Of the 2 respondents indicating which situation applies to them, 1 lived in a street where the pilot is taking place, but the respondent him- or herself was not a participant. The other respondent lived in a surrounding neighbourhood. The average length of residence is 28 years.

The data showed a predominantly positive value judgment towards the energy transition: 6 of the 7 responses to this question are 'somewhat' or 'very' positive, a few give 'very negative' as their answer. One of the arguments for a positive opinion reads: *"Energy transition is necessary, but it all has to happen very fast now (read: too fast). Furthermore, there is no clarity on what is right and how it should be done. Politicians also shout a lot, but these statements do not seem to be founded on knowledge about the subject. Politicians easily impose obligations but hardly/not at all take into account what is feasible and affordable. Applications mainly consider what is available now, but future developments do not seem to be taken into account. As a homeowner, I therefore do nothing to prevent expenditure now from turning out not to be a waste of money because in the near future something else is and must be done anyway."* Those with a negative view indicate the following *"Too much cost, too little return"*.

The average verdict of 2.9 (on a scale of 1-10) on the question of whether people felt they know enough about hydrogen is substantiated by a single respondent with the following comment: *"Doesn't really play here in the district yet. Just the word hydrogen, we have to laugh at. It's promised a lot, but haven't seen or noticed anything about it yet."*

When asked to what extent people felt comfortable with hydrogen in the neighbourhood, an average rating of 5.2 follows. The respondents with positive responses do not explain this. One of the respondents with a negative opinion (lowest score: 1) places 'dangerous' as a comment. The question to what extent people felt comfortable using hydrogen in the home is answered by 4 respondents and receives an average rating of 6.3. The question to what extent the use of hydrogen in the home would be perceived as safe is also answered by 4 respondents (the highest with an average rating of 6.5). Those answering explained that they 'are only now hearing the word hydrogen pilot for the first time' and/or '*cannot answer this question right now*'.

Regarding the evaluation of the project:

Of the eight respondents, two indicated that they were not at all aware of the hydrogen application in the area, these answers were not provided with an explanation. The rest of the respondents gave a value rating of 5 or higher, bringing the average to 5.8.

So far, respondents looked back on the neighbourhood project both very negative and very positive. The main reason given is unfamiliarity; a few expect that no central heating boiler is suitable for hydrogen. This assessment is reflected in the response to the question of how people now feel about hydrogen application in the neighbourhood. Only one respondent said they notice anything about the hydrogen application in their daily lives.

Respondents indicated that their perception of hydrogen has changed very little as a result of the project: an average rating of 3 (on a scale of 10) follows, the value judgement given is explained by comments such as '*Not applicable, had no information and not involved in the project.*' When asked what people felt went well within the project, similar responses follow.

Regarding communication within the project:

All eight respondents said they did not know enough about the hydrogen application and responded predominantly negatively when asked how they looked back on the communication. One comment reads: "*We are waiting to see what is to come. Everything in the district is currently at a standstill.*" One of the respondents did attend an information meeting, the latter indicating that it was mainly about the project and that questions were answered reasonably well. Other respondents 'did read something about it' but for most, 'not applicable.'

When asked for further ideas, thoughts or comments about this study or the sustainability of the neighbourhood in general, the need for more information is indicated: "*Is the project already underway here, are households already connected to it?*" An occasional comment indicating resistance is also heard: "*Don't rush people too much with unfeasible projects!*".

The table below (Table 5), summarises the results as retrieved from Wagenborgen. Within this case study, there is little evidence of the project yet because actual hydrogen is not yet being delivered. Social support is less present among local residents here, partly because people have less knowledge of the project. Information about the project is lacking within this group, and indeed communication with residents participating in the project has so far been mainly focused on. Personal contact (for example, when approaching households asking them to participate in the project and contacting the housing corporation's resident advisor as a point of contact) has proven especially important here.

Table 5. Summary of the results (case 3).

Wagenborgen	Interviews with stakeholders (n = 4)	Interviews with residents (n = 4)	Questionnaires residents (n = 8)
Social support	+ 80% of households have indicated their willingness to participate in the project, initiated by the housing association.	There is support among households who want to participate.	Compared to the other two cases, people feel less comfortable with hydrogen in the neighbourhood.
Communication and risk communication	Importance of personal approach is revealed.	Contact with resident consultant perceived as positive.	People do not know enough about it yet and are awaiting what is to come.
Safety and safety perception	There is confidence regarding safety by stakeholders. Affordability also seems there important to residents.	No negative indications regarding safety heard.	There is still too little information about this.
Evaluation of the project	Importance of personal contact Hydrogen has not yet been delivered due to problems with deliveries and permits.	Residents wonder about the delays.	Little has been noticed of the project in the area. Need for information.
Other comments	Small sample within this study		

3.4 Case 4: Stad aan 't Haringvliet

Stakeholder research (Interviews, $n = 10$)

Social support

For this project to succeed, support is one of the most important issues, as every household is entitled to natural gas by law and will therefore have to be provided with an alternative. A support measurement will take place later this year (summer 2023), which requires a significant majority vote in favour, according to the project management. This means that the project is receiving a lot of attention and raising questions from various parties. A lot is being invested in this by the project team, working from the 'eight promises': 'safe or not at all', 'always warm', 'affordable', 'sufficient support', 'green', 'it is allowed', 'it is possible' and 'translatable'.

Because of its social cohesion and the suitability of its housing stock, Stad aan 't Haringvliet was in 2010 selected by the Goeree Overflakkee municipality out of 14 villages in the municipality, as the most suitable village centre for sustainable development. According to the project management, the village council has been key in the realisation of the project, making the whole project truly a residents' initiative. The group of initiators and representatives of residents (or 'De Tafelaars') is considered a partner within this project. The added value to a group like the 'Tafelaars' concerns the fact that they are very involved, know what is being communicated in the village, who is all working on it and what is going on in the village.

A support measurement will take place in 2023; a vote must be taken on whether people want to get off natural gas. If insufficient support is found, a continuation of the project is unfeasible, according to the stakeholders involved. To prevent this, the project team is putting a lot of effort into transparency and certainty; openness to residents is very important to them, so residents have access to all relevant documentation. Support measurement will take place in a bus driving through the village; residents in need of help will be supported to take the measurement.

At the moment, it is unclear among stakeholders to what extent the support measurement will result in a positive outcome. The dissemination of information is done by spokespersons of different stakeholders, the participation supervisor and an environment manager, amongst others. Various media (internet, newspaper, inspiration house) and social institutions are also used, and each house is inspected by 'viewers'. Inspecting the various homes and informing individual residents/entrepreneurs about the possibilities and the cost of the project is obviously time-consuming but is considered necessary for creating support.

(Risk)communication

Both a participation supervisor and an environment manager were hired to handle communication within the project. The participation supervisor's efforts, according to her, relieve the 'Tafelaars' of a considerable administrative burden, thus forming the connecting link between the steering committee and the local population.

The environment manager forms the link between the environment and the steering group, with this he is the face to the outside world. He indicates that his working method is adapted to the local context, which means connecting to the information needs and he does not hesitate to actively go door-to-door, visit the church or otherwise get in touch with the residents. For example, information meetings are organised and even local youth are informed at schools.

The project leader is largely involved in the content of the project and reports to the steering committee. He says the challenge for him is to get the whole thing funded and to realise the part from production to transport, storage and distribution in cooperation with various partners. There is also, of course, the social aspect of the project. Because of the innovative and large-scale nature of this project (never before has setting up an entire hydrogen chain on this scale taken place in the built environment), communication is taking place at all sorts of levels from national level to individual households. Other stakeholders are also putting considerable effort into communication (for example, grid operator Stedin is also filling two jobs with 'internal' and 'external communication' within the project).

The project management indicates that during the project, efforts were made to categorise all the questions that residents could possibly ask into eight promises. This has been done by contacting their fellow villagers in many ways. To this end, a role was played by the 'Tafelaars'; they thus had a great deal of influence on the creation of these pledges. The communication around the hydrogen pilot is hung up on these themes. There has been a lot of knowledge sharing with the residents of Stad aan 't Haringvliet (in the form of newsletters, digital surveys, information meeting and through the inspiration house).

Within communication, according to the project management and the 'Tafelaars', the different phases of the project are taken into account and communication is adjusted accordingly. The grid manager noticed that some 'information fatigue' is now occurring. Because the realisation of the switch to hydrogen is still a long way off, the working group has decided to focus on the questions that residents have and to try to get them on board as much as possible. Efforts are therefore currently being made to make the necessary information easily accessible so that people can look it up whenever there is a need. Most of the questions currently being asked relate to costs and expected home modifications. The City Natural Gas-Free website has a lot of information about the project. A booklet for residents is also being prepared explaining exactly how the promises will be fulfilled.

In addition, the factors characterising the residents are taken into account; think of social cohesion, age, level of education, etc. Extra consideration is given to the group of people who have less scope to engage in this project due to their socio-economic status.

In the context of effective communication, the various stakeholders give a few more tips; it is emphasised that especially the videos on the website are remembered by inhabitants, for instance when compared to a flyer on the doormat. It also emerged that a personal offer is necessary; before making a choice, people need to know exactly what modifications are necessary in the house and what the project is going to cost (from this 'guideline' also came the 'viewing' of the houses and the development of a calculation tool). Reference is made to the 'six components of sustainable leadership', advising to check that these are represented in the steering committee. The importance of an open attitude is stressed; it seems essential not to try to convince residents but only to answer questions and get to the heart of the matter through good listening and questioning. The use of a paid participation supervisor and/or environment manager are very important here. One applied strategy that is further emphasised is 'making it big'; 'you have to name the end result as many times until it is seen as normal.' Furthermore, it pays above all to be transparent.

Safety and safety perception

One of the eight pledges reads '*safe or else not*'. This theme has a lot going for it. This promise was worked out over a time span of two years with many different supervisors (Netherlands Institute for Public Safety (NIPV), ministries, residents and project partners).

For the realisation of this project, according to the project management, what happens behind the meter is also very relevant, so residents must also be made clear that they play an important role in the transition to hydrogen. For example, participation in inspections is expected and more safety checks than necessary will be carried out in the first hydrogen applications as a precaution and for research purposes. A key lesson already emerged from surveying the various homes, namely that the *"relatively easy conversion from natural gas to hydrogen can be quite disappointing in practice"*. In many homes, necessary measures still need to be taken before they can safely convert.

Apart from including residents in such a project, it is recommended from the safety region that they should be involved in decision-making at an early stage of the project. The local fire brigade should be well informed about the installations used and be able to help think about their placement in order to act responsibly in case of calamities. It also inspires confidence: in the case of Stad aan 't Haringvliet, the local fire chief himself is very enthusiastic about hydrogen and therefore acts as an ambassador.

The safety region also plays an important role in issuing permits: at the moment, the municipality is obliged to seek advice from the safety region before granting permits and, for example, guaranteeing the so-called 'site-specific risk' and 'group risk'. With the arrival of the new Environment Act, the intention will be for municipalities to organise public participation rounds for bystanders and interested parties and to make their own agreements on the relevant risks. Then it will become even more important that municipalities and safety regions know how to find each other.

Evaluation of the project

For the steering group, the combination of pioneering, making promises and maintaining trust proved to be quite a challenge. They soon faced understaffing because of the size, diversity of tasks and lack of relevant knowledge among all parties involved. A reorganisation also proved necessary; when the project leader reports directly to the steering committee (instead of to the municipality, as was the case during the project's inception), they proved better able to represent all interests and work transparently. The importance of a project organisation that can function independently proved to be an important lesson within this project.

Stakeholders also mentioned points for improvement with regard to planning: the project would like to be connected to the national network in the future, but in terms of planning this is not going well yet. The intended start is planned for 2025, while the GasUnie wants to have its 'national hydrogen network' ready around 2030.

The importance of good communication between and involvement of all stakeholders is also mentioned. The 'voice of the resident' also proved to be very important in this project. The extent to which the 'Tafelaars' were able to act as advocates with the help of the participation facilitator is looked back on with satisfaction.

The importance of the role of the safety region was also pointed out in this project, especially as in some cases it only got involved in decision-making at a later stage, resulting in necessary delays. In such projects, the steep learning curve sometimes proves challenging, for example, if it is decided that solar panels producing hydrogen will be used, the local fire brigade may not be prepared for this.

Finally, the importance of the concrete offer for each individual household is underlined, the need for this was never initially recognised.

Resident research

Because of the extent to which the 'Stadtenaren' are already burdened to realise the project, the project group 'Stad Aardgasvrij' asked not to expect them to participate in the form of interviews and/or questionnaires. Within this part of the study, we therefore look at the results of the 'Sprockler survey' or the 'Energy story Stad aan 't Haringvliet', which was carried out in 2022 by Perspectivity in cooperation with the Stad Aardgasvrij project team [8]. The survey described experiences, opinions, expectations and concerns of 89 people from the village. The findings are largely consistent with the results of the stakeholder survey, probably partly because of Perspectivity's implementation of the survey results and the contact there is from the project group with residents.

The majority of respondents indicated that they would rather be sustainable now than in 30 years' time, with the majority of respondents expressing positive views on the future heating of their homes on hydrogen, yet there is also an ear for alternative means and there is no lack of negative reactions towards the transition to hydrogen. In particular, as a motive for a negative opinion, issues around financing, home modifications and the lack of usefulness of hydrogen-powered sustainability seem to emerge. As conditions for the switch, respondents mainly mention 'Reliability' (that my house will be heated properly at all times and that agreements made will be kept), 'Money' (that it will not be more expensive than now)', 'Nuisance' (that it requires virtually no renovation or takes up a lot of extra space)', 'Climate' (that it is good for the environment; that it reduces CO2 emissions) and 'Relief' (that everything will be arranged and done for me).

Furthermore, respondents indicated they value having a say in new forms of renewable energy. They feel 'reasonably involved to involved', and 'reasonably to well informed' at the time of taking the questionnaire. Respondents suggested that there should be personal discussions with residents and that what is needed should be looked at per household. Financial compensation also seems important. They also recommended involving children and parents by working with schools. Furthermore, people said they want clarity, affordability and certainty, and value concrete agreements in the short term.

The table below (Table 6) summarises the results for the Stad aan 't Haringvliet case study. Support is a current and important issue here, given the support measurement that will take place soon. Communication with residents is an especially important aspect in Stad aan 't Haringvliet, as this is a larger-scale project involving 600 households. This has been addressed by appointing several people within the project group to focus specifically on this, and attention is also being paid to this from other stakeholders. There is frequent communication with residents, and people are currently looking for ways to shape this without asking too much of the residents. A representation of residents is also involved in the project, and the importance of this cannot be overemphasised. An individual approach has also proved important within this case study, for example to assess the readiness of individual houses to switch to natural gas-free living.

Tabel 6. Samenvatting van de resultaten (casus 4).

Stad aan 't Haringvliet	Interviews with stakeholders (n = 10)	Sprockler resident survey (n = 89)
Social support	So far it is unclear to what extent the support measurement will yield a positive result.	People want to have a say and participate in decision-making.
Communication and risk communication	Much effort is being put into this in this project (e.g. by appointing an environmental manager and	There is a need for clarity and concrete agreements.

	<p>participation supervisor). There is therefore frequent communication with residents through various media and through information meetings.</p>	
<p>Safety and safety perception</p>	<p>Safety is an important promise within the project and has been elaborated with various stakeholders.</p>	<p>Safety was not explicitly questioned in this study. Affordability and certainty are important to residents.</p>
<p>Evaluation of the project so far</p>	<p>Importance of communication between all parties</p> <p>Importance of the voice of the resident through the involvement of 'de Tafelaars'.</p>	<p>Personalised approach is recommended, looking at solutions on an individual level.</p>

4. Conclusion

In this research, local support of stakeholders, including residents, for the implementation of hydrogen was studied. Important themes were: public support, (risk) communication, safety and perception of safety, and the evaluation of the project so far. Below, the main results are summarised per case study, followed by generic conclusions and recommendations.

No support issues emerged in **Rozenburg**, which was partly attributed to the location and small size of the hydrogen project. Residents also indicated that they did not notice or have noticed much of the hydrogen pilot, which may be due to the limited size and the absence of home modifications.

From both stakeholders' and residents' perspectives (interviews and questionnaires), the need was voiced to be and remain informed about the current state of affairs, even though the project was already in its completion phase and there was relatively little to report. Local residents indicated that they would have liked to receive more information during the project about the course of events and possibilities to be kept informed.

In the **Lochem** case study, it can also be concluded that the necessary social support for implementation was present. This may have to do with the fact that the local population had actively searched for sustainability options, received financial compensation for the modifications to their homes and that they were relatively well-educated, which enabled them to understand the information given about hydrogen and the project.

However, critical notes were made by the residents on the information provision. It was indicated that more knowledge is needed for experiencing a pleasant/safe feeling with hydrogen in the neighbourhood. Whereas the majority of participants responded positively to the method of communication and the information received, local residents expressed a different opinion. It could be seen from the data that they would have liked to have received more information about the project, resulting in a need for information about the progress of the project and in the case of interested parties; lack of understanding about the absence of an invitation to participate.

In the **Wagenborgen** case study, residents have not yet had an actual experience of the hydrogen project due to delays. Here there were also some more critical voices from local residents, the participants in the pilot are generally satisfied with the provision of information and no negative issues regarding support have been mentioned here. Residents here are more concerned about the costs of hydrogen, and as in the other cases, concerns about safety are minimal: people also trust the parties involved in the projects.

As for public support in **Stad aan 't Haringvliet**, it can be concluded that there seems to be the necessary support, but this will have to be proven by the support measurement planned for spring 2023. Strict conditions are also attached to this from the residents. These conditions are translated into the eight promises: *'safe or else not'*, *'always warm'*, *'affordable'*, *'sufficient support'*, *'green'*, *'it may'*, *'it can'* and *'translatable'*, which seem to cover the load. It is mentioned that affordability for residents is the most important promise.

In terms of communication, it can be concluded that the project management seems to be doing well to adapt communication to the needs of residents and also dwell on which phase of the project they are in. By making use of an environment manager, the participation supervisor and connecting with the social institutions present, the contact with residents seems to be largely organised.

The Sprockler survey results reflect to a lesser extent how safe residents would feel when using hydrogen in the neighbourhood and/or home. However, the stakeholders spoken to agree that the main concerns relate to finances and home modifications.

When evaluating the project so far, the contact with residents and between the different stakeholders in particular appears to be essential for a successful project, something also picked up in other cases. The extent to which the work already carried out in Stad aan 't Haringvliet will lead to an actual success should become clear from the support measurement later this year.

Generic findings and conclusions

Within all four pilots, it is evident that it is important to involve the pilot participants (the end users) in the planning phase of the project and the steps that follow. Information meetings ('bewonersavonden' in Dutch) are a tool that have been used in all pilots and are looked back on positively. However, it is also recognised that this is not the only thing that should be done because of the limited reach of such meetings. It also depends on the target group and the phase of the project to what extent these meetings are successful. In Wagenborgen, for example, there have been positive experiences with an individual approach in the initial phase of the project in which personal contact was made with those involved and individual questions could be answered. This way, people also get a 'face to the project'. Above all, it is important to include residents in the process, in what is happening, what the choices are, and to communicate this in an understandable way. Important topics people want to know about are costs, risks and safety, and what it will benefit them (what are they contributing to?). These topics are also mentioned by stakeholders as relevant.

All in all, communication is and remains important, at all stages of the project. When a project is completed, residents/end users would also like to be informed about things like follow-up steps and whether the pilot was successful and what that would exactly mean. Even if there is no progress or few results, it can make sense to communicate to residents what the status is. People like to be informed, and here it is important to offer the information through different channels (so not just with flyers or only with social media). It is also important in communication not only to focus on end users, but also to keep local residents frequently and carefully informed. The findings confirm the importance of broad and frequent communication, not only with directly involved pilot participants, but also with people indirectly involved.

The different cases all had different dynamics and residents' characteristics. Rozenburg is quite a heterogeneous neighbourhood in terms of education level and cultural background, whereas this was more homogeneous in Lochem (consisting of relatively well-educated residents), and in Wagenborgen it concerns social housing. These characteristics can possibly have an impact on knowledge and awareness levels which can in turn influence support levels.

Within such small-scale hydrogen pilots where more experience will be gained in the coming years, there are often short lines of communication between local stakeholders and residents. This may possibly have contributed to the positive impression of support within Rozenburg, Lochem and Wagenborgen. It is relevant to consider how such results can be generalised when hydrogen is to be implemented on a larger scale, for instance in whole neighbourhoods, villages or towns, as may be the case in Stad aan 't Haringvliet. There may then be much more diversity, both in homes, but also in demographics (age, cultural background, etc..) and attitudes towards new energy technologies. This presents new challenges for the adoption of such technologies. One suggestion for dealing with this is to embrace this diversity and engage with smaller subgroups of residents.

Recommendations

Some generic recommendations can be made from the projects. These recommendations apply to several phases of the project: if they are relevant in a specific phase, this will be mentioned below.

- In the planning phase: involve relevant parties in time

To avoid delays, it is important to involve relevant parties in the project on time. This applies, for instance, to involving the safety region or permit providers, so that they are well informed about the specific situation and can have an advisory role in it.

- Provide a clear point of contact throughout the project

With regard to stakeholder management, it is advisable to ensure a clear point of contact, a clear owner/face of the project, both for fellow stakeholders and for residents/end users. In Lochem, residents and interested parties can go to different parties for information, here there is no clear owner of the project - as was also noted by the grid operator. This has not led to problems in Lochem's small-scale pilot so far, but this may be an important point to consider in larger-scale pilots.

- Make all stakeholders co-owners of the project from the start

It is also recommended to make all stakeholders (including residents) co-owners of the project. This was a recommendation that emerged from several case studies, and the added value of this comment can be seen clearly in the hydrogen project in Lochem where residents have been at the helm of the project. It is important to maintain this energy with this group during the project, which may be easier because they also experience ownership. In Stad aan 't Haringvliet too, this was clearly translated into a role for the group of initiators and representatives of the residents ('the Tafelaars').

- In communication, do not only focus on project participants

The findings show that local residents not directly involved in the project also prefer to be kept informed about the progress and plans. They may be indirectly affected by digging activities in the neighbourhood and also hear about it via-via. It can also help, for instance, to explicitly invite local residents to information moments where they can ask questions and thus also be included as stakeholders within the project.

- Communication with pilot participants and the local neighborhood during the implementation phase is important, even if there is little news to report

The survey shows that people like to be kept informed about the progress of the project, even when there is little news to report during the implementation phase or completion and everything is going well. A lot of work is often done behind the scenes, for example, and it seems appropriate to let residents know this, without going into details. This explicitly includes communication with local residents. It is also important to communicate about delays (as in Lochem and Wagenborgen, for example) and to look for ways in which people do feel progress is being made (e.g. sustainability measures).

Reflection on the research

The remarkably high response rate for the residents' survey in Lochem (especially compared to the other two cases where we were physically present to conduct interviews and distribute questionnaires) may have several reasons. The main reason is probably the phase of the project: at the time we went to Lochem and contacted residents, the roll-out of the project was in full swing. This

means that the topic and the project were on top of minds among residents. We were also less able to cooperate with local stakeholders in Wagenborgen, for example, compared to Lochem where we were announced by the local energy cooperative. It would therefore be interesting to monitor support and social acceptance in the other two ongoing cases (Wagenborgen and Stad aan 't Haringvliet).

The research in Rozenburg and Wagenborgen was done with small samples, for example, within Rozenburg only one resident of the apartment complex where the admixed hydrogen runs through the pipes was spoken to. For Rozenburg, this could possibly be due to the timing of the survey taking place (as this period fell in the summer holidays, but also because the project started quite some time ago). In Wagenborgen, it has been the case that people have had little experience with the project, and there has also been little communication with local residents yet, for example. This may also have contributed to the low response rate. Nonetheless, it is important to interpret the findings in a cautious way, and to see it as a first exploration of experiences of residents or local stakeholders within these innovative hydrogen projects.

Appendixes

Appendix 1. Interview schedule: stakeholders of hydrogen applications within cases

Objective	Mapping experiences within hydrogen pilots
Relevant variables/ constructs	<ul style="list-style-type: none"> - - Social support - - Communication - - Risk communication - - Safety and perception of safety
Introduction	<ul style="list-style-type: none"> ● Introduction of the interviewer and Hydelta as a project ● Objective, duration, form of conversation - Identify experiences of stakeholders of hydrogen project pilot - Duration: 30 / 40 min. ● ● (If online: recording, agreement?) Any questions beforehand?
Opening question	<p>“Can you tell something about your involvement in the project concerning the development of the hydrogen application in (Pilot: Location)?”</p>
Experience hydrogen in general	<p><i>There now follow some questions about your attitude towards hydrogen and experience with the hydrogen project in (Pilot: Location).</i></p> <ul style="list-style-type: none"> - What is the company's vision for hydrogen? Within that, how would you describe? Sceptic / catalyst? - What future do you think hydrogen has in our society? - To what extent do you have knowledge of renewable energy? On a scale of 1-10 - How familiar are you with hydrogen? - Regarding the project in (Pilot: Location), did you expect in advance that there would be social support? How did you deal with that? - Can you expect opposition in such a project? Did you have an idea of that? How did you deal with that?

<p>Communication en risk communication</p>	<ul style="list-style-type: none"> - In what way has the hydrogen application been communicated with the potential users? For example, have conversations about this been conducted? How was this done? - What was this communication mainly about? - To what extent was it about the associated risks and safety? - How do you look back on this? - What were the biggest bottlenecks here? How did you manage to overcome them? - What was important in the way of communication? - In what way did you communicate between the different stakeholders? communicated? How was this organised? What was this communication was mainly about? - What would you do differently next time / what would you advise others recommend to others at the start of such a project?
<p>Safety and safety perception</p>	<p><i>Another important aspect of social acceptance is the safety of the hydrogen application and its perception.</i></p> <ul style="list-style-type: none"> - What safety measures are in place at hydrogen applications in the environment (Pilot: location)? - Who were involved to ensure this? - To what extent do you experience the hydrogen applications in the environment (Pilot: Location) as safe on a scale of 1-10? - What is your perception of the users' perception of safety in the environment? - What do you think is the most appropriate way to communicate about hydrogen safety? Towards users? Towards local residents? <p><i>Besides safety, cost can also come into play when it comes to social acceptance of a new technology.</i></p> <ul style="list-style-type: none"> - What is known about this? - What has been communicated to residents about this, and how was this done? - What do you think is the most appropriate way to communicate about the cost of hydrogen?
<p>Evaluation</p>	<ul style="list-style-type: none"> - To your knowledge, have any things occurred or incidents occurred with the hydrogen application? - Are there things you missed in this project, what would you prefer to see added next time? - Suppose you were allowed to do the project again now, what would be done differently? - Are there things you thought went just right? - How do you think one gets as much support as possible for this hydrogen application? - Would you like to repeat this project again yourself, why / why not?

Other	<ul style="list-style-type: none">- Who did you work with in this project and should we still need to talk to?- Do you have any comments?- Personal details (age, income, position within the company, education, (identification with) gender)
Closing	<ul style="list-style-type: none">• Thank you for participating• Brief summary• Follow-up: Data processing: Respondent does not receive feedback of the interview.• Do you have any questions?

References

- [1] M. Duijn, H. Puts and T. Boxem, “Laying the groundwork for public acceptance of enhanced geothermal systems, GEISER project,” TNO, Delft, 2013.
- [2] C. Wiekens, *Duurzaam Gedrag*. Lectorale rede, Groningen: Hanzehogeschool, 2020.
- [3] A.-L. Schönauer and S. Glanz, “Hydrogen in future energy systems: Social acceptance of the technology and its large-scale infrastructure,” *International Journal of Hydrogen Energy*, vol. 47, pp. 12251-12263, 2021.
- [4] N. V. Emodi, H. Lovell, C. Levitt and E. Franklin, “A systematic literature reivew of societal acceptance and stakeholders' perception of hydrogen technologies,” *Journal of Hydrogen Energy*, vol. 46, pp. 30669-30697, 2021.
- [5] L. L. Lozano, B. Bharadwaj, A. de Sales, A. Kambo and P. Ashworth, “Societal acceptance of hydrogen for domestic and export applications in Australia,” *International Journal of Hydrogen Energy*, vol. 47, pp. 28806-28818, 2022.
- [6] B. Zaunbrecher, T. Bexten, M. Wirsum and M. Ziefle, “What is stored, why, and how? Mental models, knowledge, and public acceptance of hydrogen storage.,” *Energy Procedia*, vol. 99, pp. 108-119, 2016.
- [7] D. Baur, P. Emmerich, M. Bauman and M. Weil, “Assessing the social acceptance of key technologies for the German energy transition.,” *Energy, Sustainability and Society*, vol. 12, no. 4, pp. 1-16, 2022.
- [8] “Energieverhaal Stad aan 't Haringvliet: Uitkomsten Sprockler onderzoek,” Stad Aardgasvrij, Stad aan t Haringvliet, Oktober 2022.