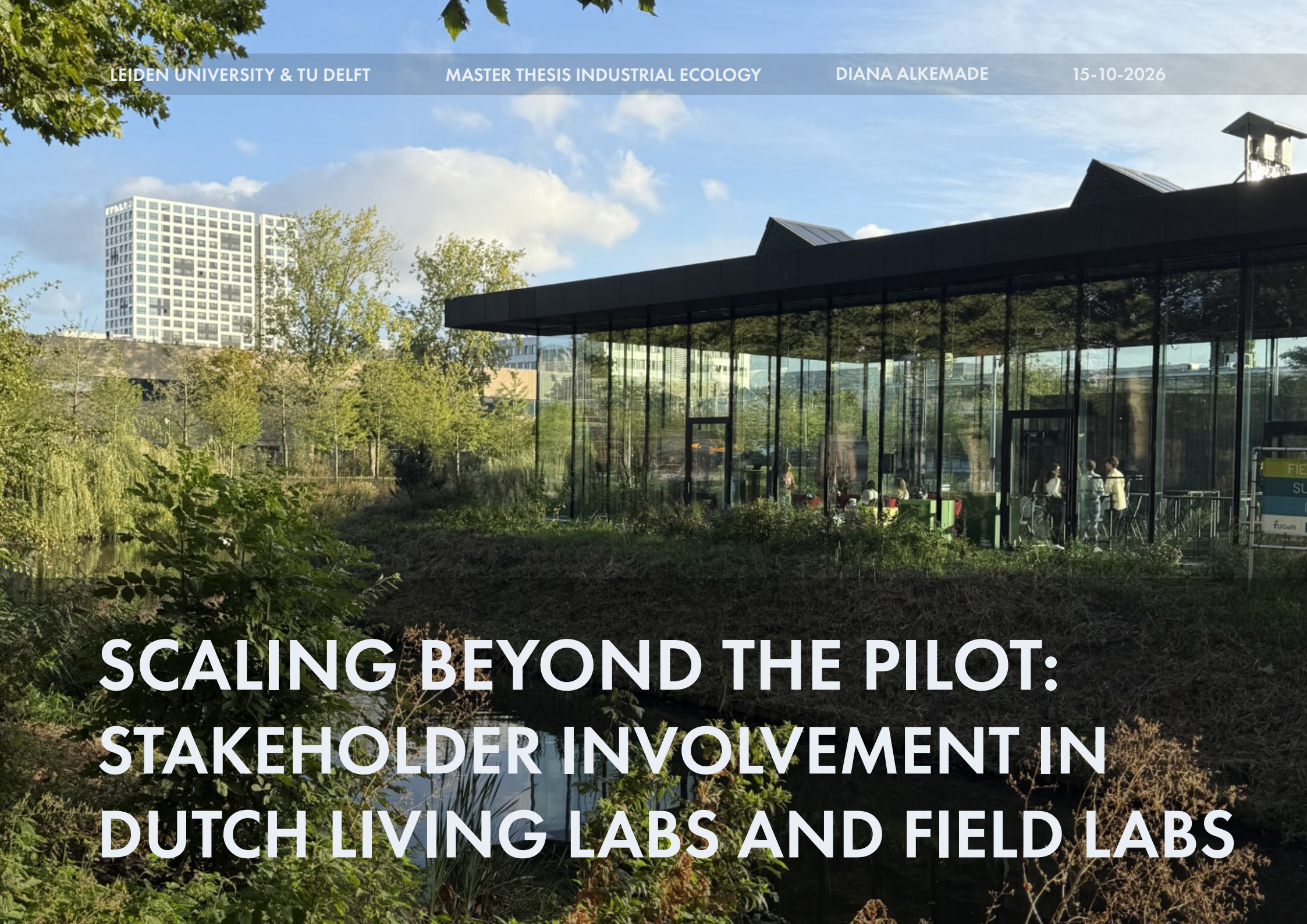


SCALING BEYOND THE PILOT: STAKEHOLDER INVOLVEMENT IN DUTCH LIVING LABS AND FIELD LABS

SCALING BEYOND THE PILOT:
STAKEHOLDER INVOLVEMENT IN DUTCH LIVING LABS AND FIELD LABS

MASTER THESIS

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When I started my Bachelor of Industrial Design Engineering about 7 years ago, I could not have predicted I would end up here, trying to complete not one, but two Master's degrees.

During my Bachelor's, I became interested in how design can be used for more than creating products. I learned that design can also help address complex social challenges and contribute to creating solutions for a better future. One area where solutions to complex social challenges are urgently needed is in addressing environmental challenges facing our society. To get a better understanding of the interactions between society and the environment and explore how we can contribute to more sustainable solutions, I started the Master's programme in Industrial Ecology. And now, two years later, I have finally completed my first thesis project.

Writing this thesis has been challenging, but also very valuable, as I learned more than I expected beforehand. And I could not have done it alone. Throughout the process, I received support, guidance, feedback, and encouragement from many people, whom I would like to thank.

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D.V. Alkemade

SUMMARY

Accelerating sustainability transitions requires moving innovations from experimental testbeds into mainstream practice. Across the Netherlands, Living Labs and Field Labs have emerged as environments in which technological, organisational and social innovations can be tested in real-world settings (European Network of Living Labs, 2024). However, successful experimentation within this testing environment does not necessarily result in development or adoption beyond the pilot. This is reflected in the 'pilot paradox', where projects can achieve their experimental objectives while remaining limited in their ability to develop beyond the pilot (Van Buuren et al., 2018).

Stakeholder involvement is important in this process because stakeholders can provide knowledge, resources and access to the contexts in which innovations need to be implemented. At the same time, previous research shows that identifying, attracting and maintaining stakeholder involvement can be difficult (Greve, 2019; Puerari et al., 2018). This thesis therefore investigates the challenges that projects themselves encounter when organising stakeholder involvement to support developments beyond the pilot.

The aim of this thesis is to understand how stakeholder involvement is organised in Dutch Living Labs and Field Labs and to identify the challenges that constrain stakeholder involvement in supporting scaling beyond the pilot. The central research question asks: What challenges do projects within Dutch Living Labs and Field Labs encounter when involving stakeholders to support scaling beyond the pilot?

To address this main question, three sub-research questions are formulated: (1) which stakeholders are involved in Living Lab and Field Lab projects, and why, when, and how are they engaged; (2) what types of success do stakeholders aim to achieve in Living Lab and Field Lab projects, and how do these relate to different scaling pathways; and (3) how are power imbalances between stakeholders addressed in Living Lab and Field Lab projects.

A qualitative multiple-case study was conducted on three innovation projects in a Dutch Living Lab and Field Lab. The cases were on the Control Flow and Mobile Flood Barriers at The Green Village, and on a District Heating Network within Energie-Lab Zuid Oost in Amsterdam. Data were collected through project documentation, participant observations and 15 semi-structured interviews with actors from governmental institutions, Living and Field Labs, the industry, and residents. The data were analysed using abductive thematic coding.

The findings show that stakeholder involvement was dynamic instead of continuous. Stakeholders became relevant at different stages of a project depending on the resources, responsibilities or connections needed by the project. The results show that projects within Dutch Living and Field Labs encounter several challenges in involving stakeholders to support scaling beyond the pilot. These challenges occur on both sides of the involvement process, as both project teams and stakeholders face challenges that can limit involvement. 6 categories were identified: (1) limited resources and capacity; (2) identifying and reaching relevant stakeholders; (3) perceived relevance and willingness to participate; (4) meaningful participation and influence; (5) institutional and commercial constraints; and (6) project purpose and development stage.

The results further show that success beyond a pilot can take different forms. The cases demonstrated spreading through physical expansion, broadening through connections to wider societal contexts, and deepening through learning in practices or institutional understanding. Physical spreading was therefore not the only indication of development beyond the pilot.

The main implication is that deliberate choices need to be made within projects about the relevance of stakeholders at different stages, how they can realistically participate, and what opportunities they have to contribute. The study recommends more flexible approaches to involvement, explicit attention to representation and power, and participation methods that are adapted to stakeholder capacities and project needs. The main limitations are the retrospective design, the focus on three cases within two experimental environments, and the emphasis on actors who were already connected to the projects. Future research should therefore also investigate the perspectives of stakeholders who were not involved but could have been relevant and examine how meaningful stakeholder involvement can be organised under the practical and institutional constraints of real-world experimentation.

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ABBREVIATIONS

ABBREVIATION	DEFINITION
AMS	Advanced Metropolitan Solutions
CEW	Centre of Expertise Water Technology
CF	Control Flow
DHN	District Heating Network
ELZO	Energie Lab Zuid Oost
FL	Field Lab
FPH	Flood Proof Holland
LL	Living Lab
LOI	Letter Of Intent
MFB	Mobile Flood Barriers
TGV	The Green Village
TRL	Technological Readiness Level
TU Delft	Technological University Delft
ULLWOW	Urban Living Lab Way of Working

AI STATEMENT

Generative AI, including ChatGPT, Gemini and Grammarly, were used during the development of this thesis as supporting tools. AI was used to help structure ideas, check whether the text is grammatically correct and discuss the structure of the thesis to improve the clarity and readability of the text. Furthermore, AI was used to assist with summarising academic literature and translating the questions within Appendix A.

All suggestions made by AI tools were critically evaluated before being implemented in the thesis.

1

INTRODUCTION

Accelerating urban sustainability transitions requires new technological, organisational and social innovations to become part of wider societal practice. Experimental environments such as Living Labs (LLs) and Field Labs (FLs) have become important settings for this purpose (European Commission, 2026; European Network of Living Labs, 2024). They provide opportunities to develop, test and evaluate innovations in real-world contexts, often by bringing together actors from government, industry, research and civil society (Vervoort et al., 2022). Through these collaborations, experiments can generate technical knowledge, practical experience and connections that may support further development of an innovation.

However, a successful completion of a project within an LL or FL does not necessarily mean that an innovation develops beyond the experimental setting. This is referred to as the 'pilot paradox': the conditions that make experimentation possible, such as a protected environment, temporary funding and a limited scale, can also make it difficult to connect experimental results to wider institutional and societal contexts (Van Buuren et al., 2018). So an innovation may reach its goals within a project of an LL or FL, but remain localised and fragile rather than becoming mainstreamed and institutionalised. Therefore, it is important to understand how an innovation project should be structured to move beyond these experimental settings and create a broader sustainable impact.

Stakeholder involvement is relevant to this challenge because developments beyond a pilot often depend on actors outside the immediate project team. Stakeholders can provide technical knowledge, financial resources, institutional authority, practical experience, access to users or implementation contexts, and connections to other organisations (Nguyen et al., 2022). Involving these actors can therefore help projects develop innovations and achieve transformative success (Berberi et al., 2026; Herth et al., 2025). LL literature therefore focuses on effective collaboration, user involvement and co-creation between different stakeholder groups (Huang et al., 2024; Menny et al., 2018; Vervoort et al., 2022).

However, involving stakeholders in practice is not straightforward. Previous research has shown that relevant stakeholders can be difficult to identify and reach, and that maintaining their involvement throughout an innovation process can be challenging (Greve, 2019; Paskaleva et al., 2015; Puerari et al., 2018). Stakeholders may participate at particular moments without remaining involved throughout a project because their interests, availability or resources change over time. Furthermore, being involved does not necessarily mean that stakeholders have meaningful influence over project decisions. Research on LLs has found that users can remain relatively passive, despite the emphasis placed on active participation and co-creation in LL literature (Greve, 2019; Puerari et al., 2018).

Recent research has provided further insight into the barriers experienced by stakeholders themselves to get involved in LL projects. Schubert et al. (2026), for example, identified limited time and resources, unclear communication and bureaucratic & legal constraints as barriers to stakeholder engagement in LL processes. Their findings also show that these barriers differ between stakeholder groups.

At the same time, stakeholder involvement also depends on the project side of the process. Project teams have to determine which stakeholders are relevant, identify ways to reach them, decide when their involvement is needed, and select appropriate ways of involving them while keeping practical constraints in mind. Project teams

therefore can influence which stakeholders become involved and have the power to control the opportunities stakeholders have to contribute. Although previous research has provided insight into stakeholder motivations, barriers and participation in LLs, less attention has been given to the challenges that projects themselves encounter when organising and facilitating stakeholder involvement in real-world experimentation.

This leads to the knowledge gap addressed in this thesis. Existing research shows that stakeholder involvement can be difficult to achieve and maintain (Greve, 2019; Paskaleva et al., 2015; Puerari et al., 2018) and provides insight into barriers experienced by stakeholders (Schubert et al., 2026). However, there is less empirical understanding of how projects identify and select relevant stakeholders, how they involve them at different stages, and which practical or institutional challenges arise when trying to organise this involvement. This is important to understand because stakeholder involvement is not organised independently of the project context. The way projects structure involvement can determine which perspectives, resources and relationships become available to the innovation and, therefore, which opportunities exist for development beyond the pilot.

1.1 EMBEDDEDNESS IN THE NWO EXTRA PROJECT

This research is embedded within the NWO-funded EXTRA project, *From Experiment to Sustainable Change: TRAnsformative Methodologies for Innovation and Learning*. The EXTRA project investigates how physical experimentation and learning environments in the Netherlands can contribute to sustainability transitions in areas including climate, energy, circularity and biodiversity. Within this broader project, this thesis focuses specifically on the role of stakeholder involvement in projects operating within Dutch LLs and FLs. The focus on developments beyond the pilot connects the study to the wider EXTRA objective of understanding how experimentation can contribute to longer-term sustainability transitions.

1.2 RESEARCH OBJECTIVE AND RESEARCH QUESTIONS

Based on the knowledge gap described above, the objective of this thesis is to investigate how stakeholder involvement is organised in Dutch LL and FL projects and what challenges projects encounter when involving stakeholders in support of development beyond the pilot.

The central research question is:

Main Research Question

What challenges do projects within Dutch Living Labs and Field Labs encounter when involving stakeholders to support scaling beyond the pilot?

To answer this question, three sub-research questions are formulated:

Sub-RQ1: *Which stakeholders are involved in Living Lab and Field Lab projects, and why, when, and how are they engaged?*

This question examines how projects identify relevant stakeholders and how stakeholder involvement changes throughout the innovation process. It provides insight into when and why different stakeholders become involved in a project .

Sub-RQ2: *What types of success do stakeholders aim to achieve in Living Lab and Field Lab projects, and how do these relate to different scaling pathways?*

Development beyond a pilot does not necessarily mean an innovation is physically replicated. Other forms of success can be defined. This question examines different understandings of success and connects them to the scaling pathways of spreading, broadening and deepening.

Sub-RQ3: *How are power imbalances between stakeholders addressed in Living Lab and Field Lab projects?*

Stakeholders do not have equal access to financial, technical, institutional or social resources, which means that power between stakeholders is often imbalanced. Project teams can often determine how these power imbalances are addressed within LLs and FLs, which influences how stakeholders are involved in projects and whether they have influence over the decisions being made.

Together, these questions examine stakeholder involvement from three connected perspectives. Sub-RQ1 focuses on how involvement is organised, Sub-RQ2 on what types of success stakeholders seek to achieve, and Sub-RQ3 on how differences in power shape this process. This provides a basis for understanding the challenges projects encounter when trying to involve stakeholders in ways that can support further development of an innovation.

1.3 METHODOLOGICAL APPROACH

To answer the research questions, this thesis uses a qualitative, multiple-case study design. Three innovation cases were investigated across two Dutch experimental environments. The first innovation case, on the control flow, looks at a domestic water- and energy-saving technology tested at The Green Village. The second case, on mobile flood barriers, describes temporary flood protection systems developed and tested at The Green Village. The third case, on a district heating network, looks at the development of a low-temperature district heating project using waste heat within Energie-Lab Zuidoost in Amsterdam.

Data collection included project documentation, participant observations at EXTRA Community Days and project meetings, and 15 semi-structured reconstruction interviews with project actors from government, industry, research, housing organisations and testbed users. The data were analysed using abductive thematic coding, allowing findings from the cases to be interpreted in relation to the concepts and literature discussed in the theoretical background.

1.4 READING GUIDELINE

The remainder of this thesis is structured as follows. Chapter 2 (Theoretical Background) reviews literature on LLs and FLs, stakeholder involvement, power and scaling. It introduces the concepts of spreading, broadening and deepening and develops the conceptual framework used to analyse the cases. Most of the literature described focuses on LLs, as the literature on FLs is limited. Chapter 3 (Methods) describes the qualitative multiple-case study design, case selection, data collection, actor mapping and abductive thematic analysis. Chapter 4 (Results) introduces the two experimental environments and presents the findings for the three innovation cases. The chapter then compares the cases and describes the challenges encountered in stakeholder involvement. Chapter 5 (Discussion) interprets the findings in relation to existing literature. It discusses the organisation of stakeholder involvement, power and influence, different forms of development beyond the pilot, and the scientific and societal contribution of the study. Furthermore, recommendations for practitioners in LL and FL projects are presented. Chapter 6 (Conclusion) restates the conclusions of the sub-research questions and the main research question. The limitations of the study are discussed, and directions for future research are identified.

2

THEORETICAL BACKGROUND:

EXPERIMENTAITON, SCALING & STAKEHOLDER INVOLVEMENT

This chapter presents the theoretical background for investigating stakeholder involvement in LLs and FLs, and how it relates to development beyond the pilot. First, differences between experimental environments are discussed and the characteristics of two types of experimental environments will be explained. Next, different scaling pathways are introduced to show how innovations can develop beyond the pilot in different ways. The chapter then discusses the role of stakeholder involvement in these processes, including how stakeholders are identified and involved, how differences in power and influence can shape participation, and what challenges can arise when organising stakeholder involvement. Finally, the chapter brings these insights together in a conceptual framework.

2.1 OPEN AND CLOSED INNOVATION

Innovations focused on sustainability are often tested before they are introduced on a broader scale. This testing can take place within different types of experimental environments (see Figure 2.1). These environments can either be closed or open. This means that innovation can either stay within corporate boundaries (closed innovation), or it can integrate external parties into the development process (open innovation). These external parties can include users, but also parties like universities and competitors (Chesbrough, 2003; Surowiecki & Gardner, 2005).

Innovations that address complex socio-technical challenges can benefit from exchanging knowledge with external partners, since their performance cannot be understood through technical characteristics alone. Technical performance does not show the difficulties of implementing innovations in real-world socio-technical contexts (Engels et al., 2019). Real-world, open experimentation can therefore be used to identify and address practical, institutional, behavioural or social barriers and therefore potentially improve the prospects of an innovation for wider implementation (D'Hauwers et al., 2017).

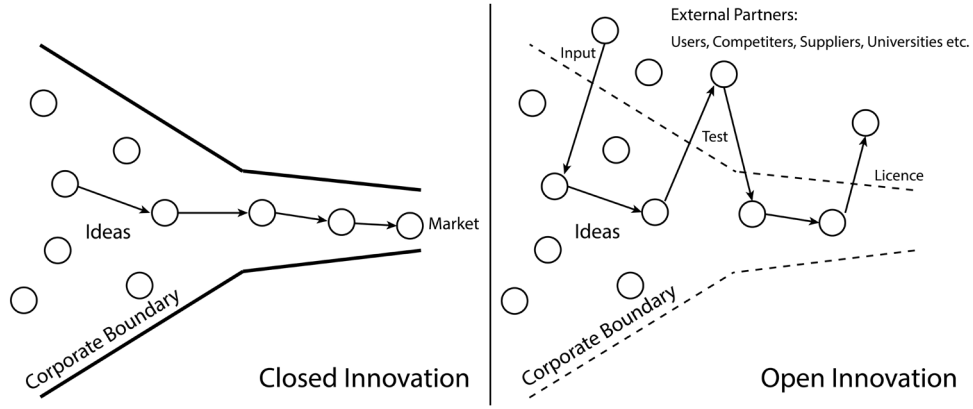


Figure 2.1: Closed innovation compared with open innovation. Following Egger et al. (2016).

2.2 EXPERIMENTAL ENVIRONMENTS FOR INNOVATION

LLs and FLs are two types of experimental environments that facilitate this open, real-world innovation and experimentation projects. While both of these environments develop and test innovations in real-life environments together with external partners, they differ in the role that stakeholders play in the experimentation process (Duisterwinkel & Butter, n.d.; Innella et al., 2024). The following section will go further into the definitions of LLs and FLs and the differences and similarities of these two environments.

2.2.1 LIVING LABS

The definition of a Living Lab is not very straightforward. They have been interpreted and implemented differently across contexts, leading to several different definitions (see Table 2.1).

The definition of 'The European Network of Living Labs' for living labs is commonly used: '*user-centred open innovation ecosystems based on a systematic approach to user co-creation, integrating research and innovation processes in real-life communities and settings*' (Vervoort et al., 2022).

LIVING LAB DEFINITION	SOURCE
User-centered open innovation ecosystems based on a systematic approach to user co-creation, integrating research and innovation processes in real-life communities and settings.	European Network of Living Labs (ENoLL) (openlivinglabs.eu/aboutus)
Physical regions or virtual realities in which stakeholders form public-private-people partnerships of firms, public agencies, universities, institutes, and users all collaborating for creation, prototyping, validating, and testing of new technologies, services, products, and systems in real-life contexts.	Leminen et al. (2012)
A user-centric research methodology for sensing, prototyping, validating and refining complex solutions in multiple and evolving real life contexts.	Eriksson et al. (2005)
Experimentation environment in which technology is given shape in real-life contexts and in which (end) users are considered "coproducers."	Ballon et al. (2005)
A systemic approach to innovation in which all stakeholders in a product, service or its application directly participate in the development process.	Feurstein et al. (2008)
Public-Private-People-Partnerships (PPPPs) aimed at generating open and user-centered ecosystems, capable of accelerating the large-scale adoption of innovative technologies and services co-created with the users themselves.	European Commission (2009)
A Living Lab is a sociotechnical platform with shared resources, collaboration framework, and real-life context, which organizes its stakeholders into an innovation ecosystem that relies on representative governance, open standards, and diverse activities and methods to gather, create, communicate, and deliver new knowledge, validated solutions, professional development, and social impact.	Westerlund et al. (2018)

Table 2.1: Living lab definitions. Following Innella et al. (2024).

The idea of LLs is that research and innovation are achieved in real-life environments instead of laboratories. Through systematically applying co-creation methods, they place end-users at the centre and ensure that the innovations are grounded in real-world needs. LLs are therefore well suited to addressing "wicked problems"; complex societal challenges such as climate change, urbanisation, and social inequality that lack

straightforward solutions and are shaped by the competing interests of multiple stakeholders. Rather than seeking a single, definitive solution, LLs provide a collaborative and adaptive approach that brings together diverse perspectives, enables stakeholders to negotiate different interests, and allows solutions to evolve in response to changing circumstances (ENoLL, n.d.). There are many different sectors that LLs can focus on. These include topics like circular economy, agriculture, urban, and many more (ENoLL, n.d.).

While there are many definitions of LLs and sectors they can focus on, there are several characteristics that are shared between all of them. These include (Ballon & Schuurman, 2015; Galway et al., 2022; Vervoort et al., 2022): multi-stakeholder collaboration in LL activities, aimed at innovation, multi-method approach, co-creation as a central process, LL activities take place in real-life contexts and communities.

2.2.2 FIELD LABS

Field labs are slightly different from LLs. They are real-life testing sites where stakeholders can collaborate to develop, test, learn to implement and scale up new technologies for commercial applications (TU Delft, n.d.).

The definition of a field lab is '*a practical environment where solutions based on "enabling technology" are developed and tested, as well as an environment where people learn to apply these solutions*' (ZorgTech, n.d.).

The shared characteristics of FLs include (Duisterwinkel & Butter, n.d.): a physical location, focus on a new technology, multi-stakeholder collaboration and open access

2.2.3 DIFFERENCES AND SIMILARITIES

While FLs and LLs are both real-world testing environments where innovations are tested together with multiple stakeholders, their approaches differ. Figure 2.2 shows the similarities and differences between LLs and FLs.

LLs focus more on testing the use of innovations in everyday practice and ensuring that they meet the needs of the intended end-users. This is done through extensive collaboration with stakeholders and co-creation practices throughout all phases of an innovation project (Ballon & Schuurman, 2015; Galway et al., 2022). For FLs, stakeholder collaboration is less prominent and often only takes place in the testing phase. Innovation projects often focus on testing the technical ingenuity or the manufacturability of enabling technologies at a physical testing location (Duisterwinkel & Butter,

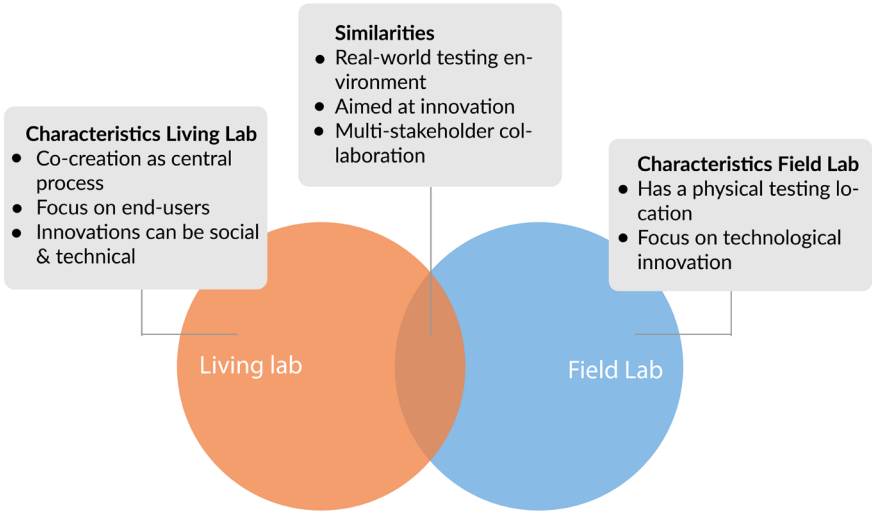


Figure 2.2: Differences and similarities between living labs and field labs

n.d.; ZorgTech, n.d.). While FLs always focus on technologies, LLs can also strive for social or organisational change without an enabling technology or product (ENoLL, n.d.; ZorgTech, n.d.).

2.3 SCALING WITHIN LIVING AND FIELD LABS

Testing an innovation can have several objectives. Therefore, success can also take multiple forms. One of these objectives can be whether the technology of an innovation is developed enough to be introduced to the market, often captured by the Technological Readiness Level (TRL). However, as stated before, the performance of innovations cannot be understood through technical characteristics alone (Engels et al., 2019).

While it is important for an innovation to function technically, it is likely to encounter institutional, behavioural or social barriers when it is introduced into everyday settings. The TRL does not indicate whether an innovation will be adopted, institutionalised or transformed beyond the experimental setting. However, this is often the goal behind the making of many innovations (Van Buuren et al., 2018).

Therefore, another type of success can be defined: whether an innovation can lead to transformative changes. These changes can be achieved through multiple transition pathways.

This section will describe these different forms of success and transition pathways.

2.3.1 TECHNICAL SUCCESS

The measure often used to define the maturity of technology is the TRL. It is an instrument that is used globally to assess the maturity of technologies. It consists of 9 levels, starting with basic principles and concepts and ending with successful demonstrations (Salvador-Carulla et al., 2024; Santonen et al., 2025). When the technology of an innovation is mature, it can be implemented, used and sold. By replicating the innovation, the innovation itself and the company producing it can grow (Olechowski et al., 2020).

This measure is usually more relevant for FLs as they are more focused on technology, while LLs emphasise participation and social impact and might test innovations that do not involve technology. However, the classic TRL framework has been adapted to fit LLs projects (Santonen et al., 2025).

2.3.2 FROM NICHE EXPERIMENTATION TO SOCIO-TECHNICAL TRANSFORMATION

The Multi-Level Perspective (MLP) provides a way to understand how innovations can contribute to wider socio-technical transitions (Geels et al., 2017). It distinguishes between three analytical levels: the socio-technical landscape, the socio-technical regime and niche innovations (see Figure 2.3).

The landscape represents wider political, economic, social and environmental developments. These developments usually change slowly, although external shocks can destabilise existing systems. The regime consists of the established structures and practices through which a socio-technical system operates, including technologies, policies, markets, infrastructures, user preferences, cultural expectations and institutions. These elements are mutually reinforcing and can create forms of lock-in. Finally, niches provide protected environments in which alternative technologies, practices or arrangements can develop (Geels et al., 2017).

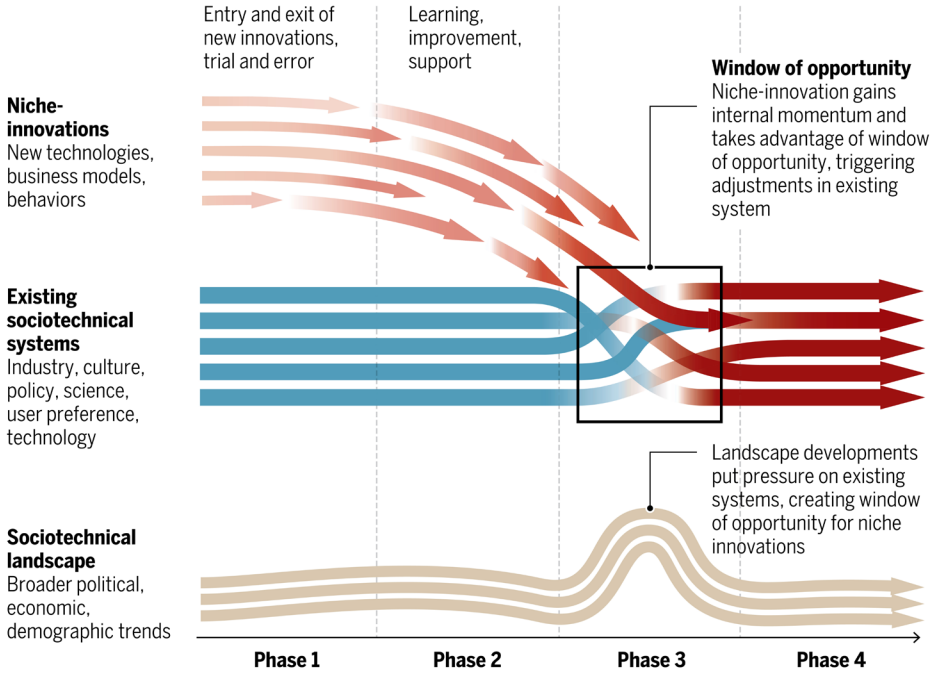


Figure 2.3: Multi-level perspective. Following Geels et al. (2017).

LLs and FLs can function as such protected environments. They allow innovations to be developed and tested at a relatively small scale, with sufficient resources available for exploration and often with actors who are willing to experiment (Van Buuren et al., 2018). However, an innovation remaining within the niche does not constitute a socio-technical transition. For transformative change to occur, the innovation or the practices surrounding it need to interact with and potentially alter the established regime (Geels et al., 2017).

In order for this to happen, the three levels described must be aligned. If existing systems are weakened and slow trends or shocks destabilise the landscape, a window of opportunity can be created, and niche innovations can become part of the regime. This can be strengthened when multiple niche innovations are linked together, since their functionality can improve and therefore gain momentum (Geels et al., 2017).

2.3.3 SMALL WINS AND SCALING

Both TRL and MLP mainly focus on the wider adoption of an innovation. However, transformative change does not necessarily occur through increasing the number of implementations or users alone. Innovations and innovation projects can contribute to transformation through different pathways.

Termeer & Metze (2019) describe how transformation does not necessarily occur through one large and disruptive change. The small-wins approach shows how relatively small changes can accumulate and contribute to broader transformation. Small wins are concrete, completed outcomes of moderate importance that contribute to a transformative ambition and involve changes in existing practices, routines, beliefs or ways of working (Schagen et al., 2023; Termeer & Metze, 2019).

This is particularly relevant for experimental environments. The impact of a project within an LL or FL may appear small when considered in isolation, but it can generate knowledge, relationships, institutional changes or evidence that enables further transformations. A project can therefore contribute to transformations even when the innovation itself is not immediately adopted at a larger scale.

To explain how small wins can contribute to transformative change, Schagen et al. (2023) distinguish between three development pathways: spreading, broadening and deepening (see Figure 2.4). These pathways describe different ways in which innovation can lead to transformative changes. They should not be understood as sequential stages. Initiatives can follow multiple pathways simultaneously, and the pathways can reinforce one another through positive feedback loops (Schagen et al., 2023).

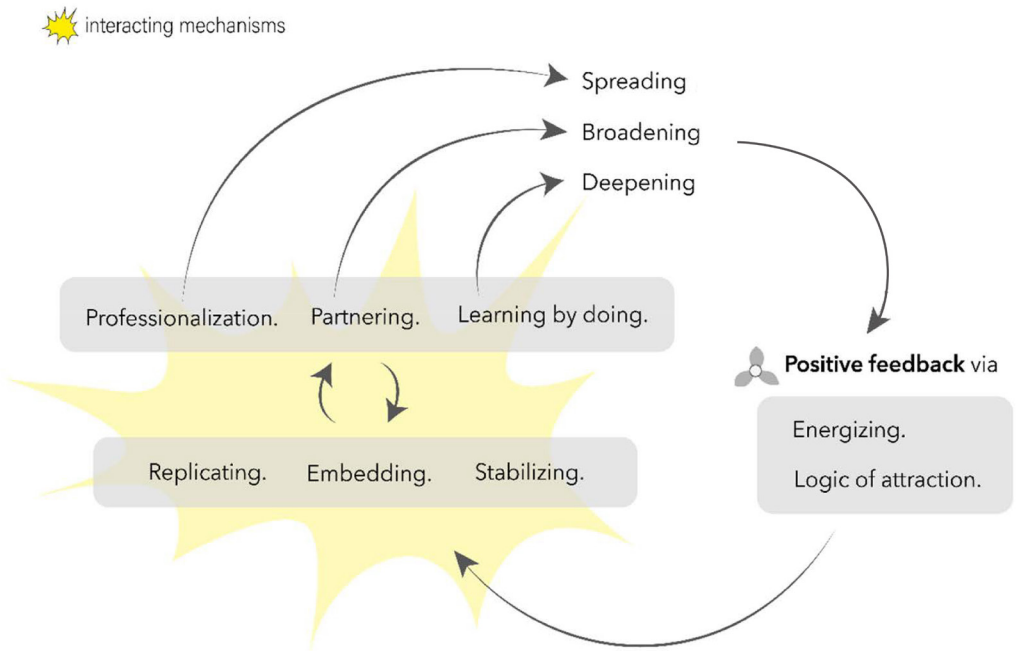


Figure 2.4: Dynamics of mechanisms and spreading, broadening and deepening. Adapted from Schagen et al. (2023).

Spreading is achieved through the replication or adaptation of an initiative across a larger number of locations or users. The innovation itself does not change while its reach increases (Termeer & Metze, 2019). Spreading can be facilitated by mechanisms such as professionalisation, stabilisation and replication. Professionalisation enables an initiative to acquire the resources, capacities and legitimacy required for further development, while stabilisation creates the resources and organisational conditions needed for continuity. Replication occurs when other actors adopt and reproduce an initiative or its practices in another context. Positive results can stimulate a 'logic of attraction', where new resources, partners and opportunities are drawn towards an initiative (Schagen et al., 2023).

Broadening is achieved when the consequences of an innovation are extended to other fields, sectors, agendas or contexts. Rather than simply increasing the number of users, broadening changes the range of actors or domains connected to the initiative. As the innovation becomes a part of other fields and agendas, the innovation may change (Termeer & Metze, 2019). A central mechanism is partnering, through which actors combine resources, knowledge and

competences and connect different ambitions or policy domains. Embedding can further support broadening by integrating an initiative's approaches or outcomes into existing institutions, regulations, policies, agendas or communities of practice (Schagen et al., 2023).

Deepening is achieved through intensifying and radicalising initiatives and making them more transformative. It does not focus on expanding, but on offering better solutions. The innovation may change practices, relationships, learning, values, routines or ways of understanding a problem (Termeer & Metze, 2019). A key mechanism is learning by doing: experimentation generates feedback about opportunities, barriers and the effectiveness of existing approaches, which can stimulate reflection, adaptation and further experimentation. Through these iterative learning processes, an initiative can become more transformative over time (Schagen et al., 2023).

The three pathways are not mutually exclusive. Instead, the mechanisms underlying them can interact and reinforce one another. For example, learning by doing may improve an innovation and produce visible results, which can increase trust and motivation among actors. These results can attract new partners and resources, enabling the initiative to broaden or spread. Furthermore, spreading can increase an initiative's visibility and legitimacy, which can facilitate further partnering, embedding and access to resources. Schagen et al. (2023) therefore show that transformative change is a continuous and non-linear process in which mechanisms generate positive feedback and enable initiatives to develop repeatedly.

These pathways demonstrate why physical implementation is not the only possible indicator of success. An experiment at an LL or FL may generate institutional learning or changes in practices without immediately resulting in widespread adoption. On the other hand, an innovation may be replicated without substantially changing the structures or practices surrounding it.

For this thesis, transformative success therefore refers to changes generated through experimentation that contribute to the wider development, adoption, institutionalisation or transformation of an innovation or its surrounding socio-technical system. Spreading, broadening and deepening provide analytical categories for examining these different pathways. To address these 3 pathways, the overarching term 'scaling' will be used within this report.

2.4 THE IMPORTANCE OF STAKEHOLDERS FOR SCALING

If experimentation within LLs or FLs is meant to achieve transformative changes within the socio-technical system, it is important to understand how stakeholders are involved within these experiments. This is important because established practices within socio-technical systems can often hinder systemic shifts (Huntjens et al., 2025). Therefore, the ability of an innovation to move beyond an experimental setting depends partly on the stakeholders connected to these established practices.

This section will explain how stakeholders can help achieve transformative success through resources they carry and power they have. Furthermore, this section will describe the power imbalances that are often present within LL and FL projects and how these imbalances can lead to less successful outcomes.

2.4.1 STAKEHOLDERS AS CARRIERS OF POWER AND RESOURCES

A stakeholder can be understood as an actor who can affect, is affected by, or has an interest in the innovation process. In the context of LLs and FLs, stakeholders can therefore include users, citizens, companies, public authorities, researchers, intermediaries, infrastructure providers and other organisations.

Stakeholders are not only relevant because they are affected by an innovation or project within an LL or FL, but also because they possess different forms of power that can help an innovation scale. For example, stakeholders may have the power to write a policy that supports an innovation or obstructs it.

To fully understand how stakeholders can help or hinder an innovation from scaling, it is important to define what power means.

It is debated whether power is something that is possessed (power to accomplish something) or exercised (power over others) (Nguyen et al., 2022). Generally, power is defined as: 'the capacity of actors to mobilise means or to influence others' behaviours to achieve a specific purpose' (Avelino & Wittmayer, 2016).

Stakeholders can possess three types of power (Hardy & Phillips, 1998):

- **Formal authority**: legitimate right to make decisions. Often within institutions.
- **Critical resource control**: power to decide who gains access to necessary tangible and intangible resources.
- **Discursive legitimacy**: The ability to influence values and societal norms.

There are several types of critical resources that actors can control. These include financial, institutional, technological and social resources (See Table 2.2).

Within an LL or FL context this could mean that companies can provide technological expertise, financial resources and implementation capacity that can help an innovation move further. Public authorities can provide institutional authority and connect innovations to policies and regulations. Users and citizens can contribute experiential knowledge about how innovations function in everyday life. Through these resources, stakeholders can enable mechanisms through which initiatives scale. For example, when an innovation partners with new stakeholders, it can enable broadening. Furthermore, embedding can be achieved through cooperating with governmental actors and learning by doing needs feedback of users or installers.

CATEGORY	RESOURCES (EXAMPLES)
Financial	Money, capital, other financial assets. Access to credit/creditworthiness (e.g., through ownership of physical assets).
Institutional	Formal legal, regulatory, or contract authority to decide, permit, forbid, use, etc. Official organizational mandates. Organizational tissue, strength of internal organization. Rights and powers derived from informal rules or cultural norms.
Social	Position in network (and connections to mobilizable troops). Access to public via (social) media platforms. Public opinion, popular support.
Technical	Knowledge and expertise in a specific domain. Technical skills and capabilities to manufacture, produce, or repair artifacts. Manpower/human resources. Tools and materials (natural resources). Leadership, entrepreneurial, or mediation skills.

Table 2.2: Categories of resources actors can control. Following Cunningham and Hermans (2018).

2.4.2 POWER IMBALANCES WITHIN LIVING LABS

Not all types of stakeholders have the same type and amount of power. Nguyen et al. (2022) analysed the type of power different stakeholder groups have within LLs.

- **Governmental** actors possess the strongest formal authority. They have a legitimate right to make decisions and change regulations. They can also offer or withhold critical resources, such as funding.
- **Industry** actors often lack formal authority, but they can have critical resource control. They create economic value in society and determine citizens' economic welfare.
- **Academia**' possess critical resources, such as human capital and research expertise.
- **Communities** possess discursive legitimacy, especially when they are represented by civil society organisations.

If stakeholder relevance is connected to resources and capabilities required to move an innovation through different stages of development and implementation, stakeholders who have less power and resources are less likely to be included in LL and FL projects.

Often the actors that have less power within LL projects compared to other stakeholder groups are the communities or end-users. These actors often have fewer resources and time available, cannot initiate processes that serve their interests, cannot define a scope for participation, have less knowledge and skills, cannot define what is considered relevant and important, and are not paid for their contributions (Turnhout et al., 2020). Furthermore, the government, academia and industry benefit from the knowledge that users can provide. However, if users try to withhold this information to create leverage, they suffer because the solutions to their problems will become less useful (Nguyen et al., 2022).

These power imbalances are worrying because they can reproduce inequalities found outside of the project boundaries (Turnhout et al., 2020). Furthermore, there are other reasons to include less powerful actors within projects.

2.4.3. ACHIEVING TRANSFORMATIVE SUCCESS THROUGH BALANCING POWER

Only including powerful actors might seem enough to reach the objectives of a project, and this might even be the case if the experiment strives for TRL alone. However, excluding less powerful actors during innovation projects can harm transformative success in the long run.

In order to reach transformative success, it is important to understand whether powerful and less powerful stakeholders have needs or concerns about the innovation. For example, if an innovation impacts the goals of governmental actors negatively, they are less likely to support it. And, if an innovation does not take the needs of the end-users into account, they are less likely to use it. Therefore, active and early stakeholder involvement can contribute to scaling since it allows concerns, needs and conflicts to be identified before an innovation becomes difficult to change. Active stakeholder involvement can reveal hidden conflicts, value disagreements and practical problems and enable these issues to be incorporated into the innovation process (Innella et al., 2024; Starke et al., 2022).

When these problems are identified during the early stages of an innovation project, they can generally be addressed more easily than problems discovered after widespread implementation (Huang et al., 2024; Innella et al., 2024). All types of stakeholders can contribute important information. For example, within LL or FL

projects, users can reveal problems concerning usability or acceptance, installers can identify practical implementation constraints, public authorities can identify regulatory or policy requirements, and researchers can identify methodological weaknesses or uncertainties in the evidence base.

Since all types of stakeholders can contribute important information, even less powerful ones, it is important that the power they have within a project is balanced. All stakeholders must have influence over the project to address the concerns and needs of their stakeholder group. It can help an innovation align with the social, technical and institutional conditions required for its later adoption (Innella et al., 2024; Starke et al., 2022). Berberi et al. (2026) and Herth et al. (2025) also found that including stakeholders within LL projects is an enabler for success. However, it is important to note that it is not a precondition for successful innovations, and success can also be reached without a high level of stakeholder involvement (Menny et al., 2018).

In addition to stakeholder inclusion being important because stakeholders can provide important resources to a project, it can also contribute to a just transition. Menny et al. (2018) argue that a truly sustainable transformation needs to be built on ethically justified and socially inclusive processes, as perceptions of fairness within a project can have a big impact on the acceptance of the outcomes (Axon & Morrissey, 2020; Ricci et al., 2025).

Procedural justice is often used to describe whether a process within an LL or FL is fair. Procedural justice is achieved when the decision-making process is both fair (equal opportunity) & transparent. To make the decision-making process fair, all stakeholders must formally have an equal opportunity to contribute and therefore also be involved in innovation processes (Martinez & Keserü, 2026; Young et al., 2023). This means that when a stakeholder is invited to give their opinions but cannot change decisions being made, procedural justice is not achieved.

2.5 DESIGNING STAKEHOLDER INVOLVEMENT

Stakeholder involvement can contribute to different transition pathways. However, the way in which stakeholders are involved is important, since involvement can also initiate conflict if done incorrectly (Gebauer et al., 2013). To understand how stakeholders should be involved in order to reach the right results, this section will explore principles on how stakeholder involvement should be designed in to have the highest likelihood of success.

2.5.1 TYPES OF STAKEHOLDERS

LLs and FLs are defined by multi-stakeholder collaboration (Duisterwinkel & Butter, n.d.; Galway et al., 2022). To distinguish between the different groups of stakeholders that are involved in LL projects, the quadruple-helix model (see Figure 2.5) is often used (Carayannis & Campbell, 2009; Nguyen & Marques, 2022; Schubert et al., 2026).

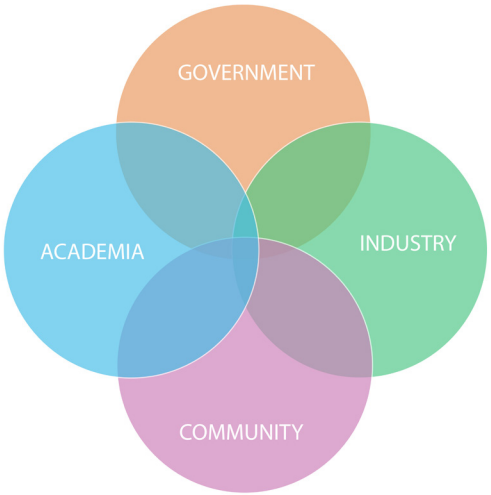


Figure 2.5: Quadruple helix model

The model consists of the government, academia, industry and civil society. While the inclusion of these 4 stakeholder groups defines an LL (Vervoort et al., 2022), it can also be seen as an ideal practice to involve all four of them.

Each group can contribute different resources to an innovation process. Civil society and citizens can provide lived experience and knowledge of everyday practices. Academia can provide scientific knowledge and evaluation. Industry can provide technological expertise, market knowledge and implementation capacity. Government can provide institutional authority and connect innovations to policy and regulation. By involving all four groups, a neutral environment should be created where testing innovations can take place collectively (ENoLL, n.d.). Excluding one group may therefore mean that a relevant perspective or resource is absent from the innovation process.

2.5.2 TIMING OF STAKEHOLDER INVOLVEMENT

Stakeholders can be involved in all phases of innovation projects. Generally, it is said that stakeholders should be involved in the process as early as possible (Huang et al., 2024; Innella et al., 2024; Krabbenborg & Mulder, 2015; Mahmoud et al., 2021; Paskaleva et al., 2015). By involving stakeholders early in the process, before the project is clearly formulated, aspirations and concerns can be articulated, leading to a shared goal between stakeholders. Furthermore, involving participants from the very beginning until the end also creates a sense of belonging, which makes it more likely that they have a long-term commitment to the project (Mahmoud et al., 2021).

Within LLs and FLs, stakeholders can be involved during different phases of an innovation project. Menny et al. (2018), building on Friedrich et al. (2013), distinguish between design, implementation and evaluation.

The design phase focuses on understanding the context and developing the project. The implementation phase concerns executing the experiment and the evaluation phase focuses on learning from the experiment and adapting its outcomes (Menny et al., 2018). It is likely that not all stakeholders will be engaged throughout the entire process as the relevance of stakeholders can change as the project moves through different stages (Huang et al., 2024).

2.5.3 LEVELS OF INVOLVEMENT

Stakeholder participation can occur at different levels of intensity (Arnstein, 1969; Innella et al., 2024; Menny et al., 2018). Menny et al. (2018) distinguish between non-participation, information, consultation and co-creation (see Figure 2.6), adapted from Arnstein (1969). The figure shows that stakeholders can be involved at different levels. They can only receive information (Information); they can be asked to provide feedback (consultation) or to collaborate with other partners (co-creation). Stakeholders only have the power to influence decisions at the level of co-creation.

The level at which stakeholders should be involved depends on what level they are connected to the project. Often, stakeholders who have initiated the project or belong to the core of the project are involved at a high intensity, while others might only wish to participate at lower intensities (Puerari et al., 2018).

For less powerful actors to be able to be involved at a higher intensity and influence decisions, power needs to be balanced. This can be done through ‘power banking’ (Nguyen et al., 2022). It focuses on how power can be lent to powerless actors (often users) and includes two self-reinforcing

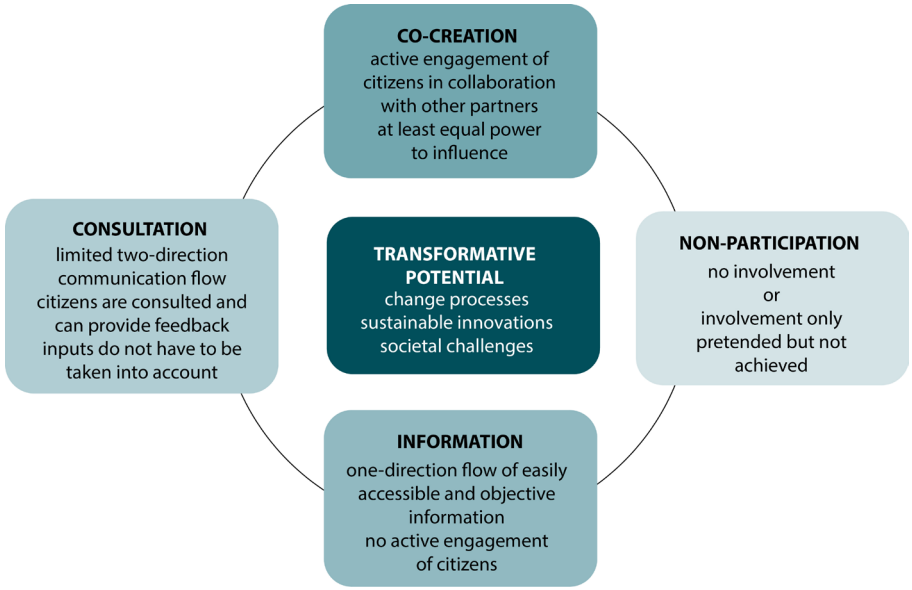


Figure 2.6: Four levels of user involvement (represented on the ring). Following Menny et al. (2018).

elements. The first element is 'the willingness of users to borrow power and use it to influence the decision-making process'. The second element is 'the commitment of the power bankers to use their own legitimacy, critical resources and formal authority to better include citizens in activities with other actors' (Nguyen et al., 2022).

While LLs try to address power imbalances through the involvement of stakeholders, this does not necessarily lead to empowerment (Turnhout et al., 2020). Projects can appear to be inclusive when they are used, but often unequal influence and formal authority stay intact (Metze et al., 2026).

Furthermore, overly consensus-oriented processes may hide tensions, marginalise dissent or depoliticise sustainability debates. Not addressing political and power dimensions within co-production can reinforce unequal power relations (Turnhout et al., 2020). Therefore, the goal is not to eliminate power imbalances and conflict, but to reflect on how it operates. Stakeholders should look at their own institutional role, their authority and influence within governance processes (Metze et al., 2026).

2.5.4 METHODS USED TO INVOLVE STAKEHOLDERS

A broad range of methods can be used to involve stakeholders. These include observations, surveys, user testing, interviews, focus groups, co-creation workshops, storytelling, serious games, key enabling methods and other forms of engagement (Huang et al., 2024; KEM, n.d.).

The choice of method influences what type of knowledge can be obtained and what degree of influence participants have. Quantitative methods such as surveys can reach many people but may provide limited opportunities for participants to shape the discussion. Qualitative and collaborative methods can enable deeper exploration of experiences, concerns and conflicting perspectives, but generally require more time and resources (Beutel et al., 2017).

Co-creation is one particularly important approach within LLs. It can be understood as: 'An act of collective creativity that leads to learning or making something together' (Beutel et al., 2017; Mahmoud et al., 2021; Puerari et al., 2018). Co-creation can be formally organised by project initiators or emerge informally when actors need to collaborate to achieve shared objectives (Puerari et al., 2018).

Since participation methods can differ in the amount of time and resources needed, they should be selected according to the purpose of involvement, the type of knowledge required and the degree of influence that participants should have. However, it is important to realise that not all methods are effective to achieve different goals or lead to the empowerment of stakeholders.

2.5.5 CHALLENGES OF INVOLVING STAKEHOLDERS

While stakeholder involvement within LLs and FLs is related to successful innovations, previous research shows that achieving and maintaining such involvement can be challenging (Greve, 2019; Paskaleva et al., 2015; Puerari et al., 2018). The difficulty is not only in identifying relevant stakeholders, but also in attracting them to the project, maintaining their engagement over time, and creating opportunities for them to meaningfully contribute to the innovation process.

One main challenge that can be identified is making a project inclusive. Participation can favour actors who have sufficient time, resources, language skills, confidence or prior interest in the topic. When this is not accounted for, certain groups of actors may be excluded from participating in a project. Inclusive participation means that attention is paid to barriers that prevent certain groups from participating and to whether the participants represent the diversity of people affected by the innovation. This can be done by reducing practical barriers, using accessible communication, building trust and actively recruiting underrepresented groups (Epp et al., 2025; Laborgne et al., 2021). If only a narrow group of users participates, the project may create a misleading impression of acceptance while missing concerns experienced by other groups. Therefore, it is important that a broad range of affected stakeholders are involved (Dvarioniene et al., 2015; Laborgne et al., 2021).

Another challenge concerns the continuity of stakeholder involvement. Stakeholders may participate at particular moments in an innovation process without remaining actively involved throughout the project. This can be particularly challenging in LLs, where experimentation may involve long and iterative processes in which the interests, resources and availability of stakeholders can change over time (Paskaleva et al., 2015; Puerari et al., 2018). As a result, the presence of stakeholders in a project does not necessarily mean that they are continuously or actively engaged.

Moreover, stakeholder involvement does not necessarily translate into meaningful influence. Stakeholders can be informed or consulted without having substantial influence over decisions concerning the direction or implementation of an innovation. Greve (2019) and Puerari et al. (2018), for example, found that many LLs did not reach the high levels of stakeholder involvement that they envisioned. Users frequently remained relatively passive during innovation processes. This suggests a potential gap between the ideal of participatory experimentation and the way stakeholder involvement is realised in practice.

Recent research by Schubert et al. (2026) provides further insight into why stakeholder engagement can be difficult to achieve. They identified barriers for stakeholders to get involved in LL projects such as limited time and resources, unclear communication, bureaucratic and legal constraints, and a lack of clear strategic direction. Their findings also show that these barriers differ between stakeholder groups.

However, understanding stakeholder involvement also requires attention to the project side of the process. Project teams have to identify which stakeholders are relevant, find ways to reach them, decide

when and how they should be involved, and work within the time, resources and institutional conditions of the project. These processes may influence which stakeholders are ultimately involved and the extent to which their participation can become meaningful. Examining stakeholder involvement from this perspective can therefore complement existing research by considering not only barriers experienced by stakeholders, but also the challenges faced by projects in organising and facilitating stakeholder involvement. Understanding how projects identify and involve stakeholders, and what challenges they encounter in doing so, can provide insight into the conditions under which stakeholder involvement can contribute to developments beyond the pilot.

2.6 CONCEPTUAL FRAMEWORK

The literature reviewed above suggests that experimentation, scaling and stakeholder involvement are connected.

Figure 2.7 visualises this connection. It shows that before entering a testing environment, such as an LL and FL, innovations have a beginning state. This state can differ per project. Some innovations may already be developed and tested multiple times, but others may start with only a problem statement. This beginning state influences what a project in a testing environment looks like. After a project within a testing environment is finished, the new state of the innovation can be evaluated. This can be done using several transition pathways. An innovation can be evaluated through the TRL and the spreading of an innovation within a regime, but also through other pathways like broadening and deepening.

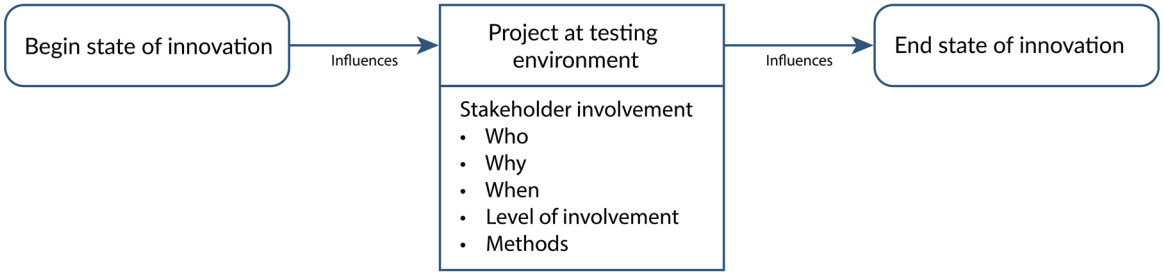


Figure 2.7: How an innovation moves from a beginning state to an end state through stakeholder involvement in projects at testing environments.

Whether and how an innovation develops and scales is related to the stakeholders that are involved in projects in testing environments. By involving different types of stakeholders, with different resources throughout a project, using methods that fit the level of involvement they are interested in, they can help identify problems and conflicts early, create learning and connect experiments to the contexts in which implementation eventually needs to occur.

3

METHODOLOGY

This chapter explains the methodological approach used to investigate the challenges that projects within Dutch LLs and FLs encounter when involving stakeholders. The chapter first explains the research design and case selection, followed by the data collection methods, including desk research, participant observations and semi-structured interviews. It then describes how the collected data were operationalised and analysed using abductive thematic coding. It explains how the within-case and cross-case analysis were performed to identify patterns within and across the cases. Finally, the chapter discusses the quality and limitations of the methodological approach.

3.1 RESEARCH DESIGN

This research uses a qualitative multiple-case study design to investigate how stakeholder involvement relates to scaling of innovation projects in LLs and FLs. A qualitative approach was considered appropriate because the research focuses on stakeholders' roles, perceptions, interactions, decision-making processes and experiences within their specific project contexts. These aspects are context-dependent and cannot be fully understood through quantitative measures alone.

Case study research can draw on multiple sources of evidence, allowing different perspectives and types of evidence to be compared within a case. This study therefore combines desk research, participant observations and semi-structured interviews. The use of multiple sources of evidence enabled the reconstruction of project trajectories and stakeholder involvement from different perspectives and supported the credibility of the case descriptions (Yin, 2014).

The research follows a multiple-case design in which three innovation projects were investigated as individual cases across two experimental environments: one LL and one FL. Two cases were situated within the FL and one within the LL. The cases were selected to provide variation in project context, stakeholder composition, forms of stakeholder involvement and scaling outcomes.

The research process was iterative. Initial desk research was used to understand the projects and identify potentially relevant stakeholders. This informed the selection of interviewees and the development of interview questions. Interview data and observations also provided additional information about stakeholder roles, involvement, decision-making and project outcomes. These insights were incorporated into the within-case and cross-case analysis. This iterative approach is consistent with the use of case study research, where data collection and analysis can inform one another (Yin, 2014).

The empirical research was designed around 3 sub-research questions concerning: (1) which stakeholders are involved in LL and FL projects, and why, when, and how are they involved; (2) what types of success do stakeholders aim to achieve in LL and FL projects, and how do these relate to different scaling pathways; and (3) how are power imbalances between stakeholders addressed in LL and FL projects. The research questions guided the selection of data, the interview topics and the subsequent coding and analysis.

3.2 CASE SELECTION AND CASE BOUNDARIES

The empirical cases were selected from projects taking place within LLs and FLs. The selection aimed to identify projects in which stakeholder involvement and the development or scaling of an innovation could be examined in practice.

The cases were selected based on the following criteria:

- The project had an intention to scale the innovation or its application after the experiment.
- The outcomes of the project could potentially affect or involve multiple stakeholder groups.
- Sufficient information about the project was available for desk research.
- Relevant stakeholders could reasonably be contacted for interviews.
- The project was completed or sufficiently advanced to allow reflection on its development and outcomes.

In addition to these selection criteria, variation between the cases was sought with respect to the project's scaling outcome, stakeholder diversity, stakeholder inclusion, project scale and the timing of stakeholder involvement. This variation was important because the research aims to identify patterns across different project circumstances rather than describe one particular type of pilot project.

3.3 DATA COLLECTION

3.3.1 DESK RESEARCH AND PARTICIPANT OBSERVATIONS

Desk research was conducted to develop an understanding of the projects, their development trajectories and the actors involved. Project documentation and publicly available information were used to reconstruct the project context, identify stakeholders and understand the stated objectives, activities and outcomes of the projects.

In addition to desk research, participant observations were conducted. These included participation in Community Days of Project EXTRA and two TGV project meetings. Observational information was not treated as a standalone source for determining stakeholder perceptions, but was used to complement information obtained from interviews and documents.

The combination of desk research, observations and interviews allowed the cases to be examined from multiple sources of evidence. This is consistent with Yin's emphasis on using multiple sources of evidence in case study research to strengthen the quality and credibility of the resulting case study (Yin, 2014).

3.3.2 STAKEHOLDER IDENTIFICATION AND INTERVIEWEE SELECTION

Before selecting interviewees, an actor and network scan was conducted for each case. Actor analysis can involve identifying stakeholders, differentiating and categorising them, and investigating relationships between them (Reed et al., 2009). In this research, the mapping exercise was used primarily to identify the stakeholder landscape and understand the roles and relationships relevant to each project.

The mapping was based on information from desk research, project documentation and observations. For each case, actors were identified together with their role in the project, their relationship with other actors, their responsibilities and the resources they could contribute. This information was organised into stakeholder tables and the relationships between the stakeholders were visualised in social network diagrams.

Within the social network diagrams, the stakeholders identified during the actor mapping formed the nodes of the network. An edge represented a relationship between two actors that was relevant to the project. These relationships included, for example, collaboration, information exchange, coordination, provision of resources or ex-

pertise, decision-making relationships, and other interactions that connected actors within the project.

For each identified relationship, the strength of the tie was estimated qualitatively. Strong ties were interpreted as relationships characterised by a higher degree of interaction and interdependence between actors, including the exchange of knowledge, resources or support, frequent or effective communication, shared understandings, and trust. Weaker ties represented more limited or less intensive relationships. Tie strength was assessed based on the available empirical evidence rather than through a quantitative network survey.

The diagrams visualised the actors, their stakeholder categories and the relationships between them. They were used to examine the overall structure of the stakeholder networks and to identify differences in the distribution and connectedness of actors across the cases.

The mapping exercise was not a formal social network analysis. No network survey, network metrics or statistical analysis of network structures was conducted. Instead, the exercise provided a qualitative overview of the actors, relationships, responsibilities and resources that were relevant to the development and scaling of each project. The actor and network scan therefore provided an overview of the stakeholder landscape and served as the basis for selecting interviewees.

Not all identified actors were interviewed. Interviewees were selected to represent different positions and perspectives within each case. By interviewing different stakeholder groups, both project-organisational perspectives and perspectives from actors situated differently within the stakeholder network were captured.

In total, 15 semi-structured interviews were conducted. The interviewees and their anonymised identification numbers are presented in Table 3.1. The interviews lasted approximately 60 minutes. The interviewees were anonymised using identification numbers (I1--I15).

3.3.3 SEMI-STRUCTURED INTERVIEWS

Semi-structured interviews were used as the primary source for understanding stakeholder perspectives. The interview format allowed comparable topics to be addressed across cases while providing sufficient flexibility to explore experiences that were specific to each project and interviewee.

The interviews were organised around four main themes: (1) the development and design of the project; (2) stakeholder involvement and collaboration; (3) decision-making, power and the distribution of influence; and (4) perceptions of project success and possibilities for scaling.

ID	ORGANISATION / ACTOR	CASE
I1	Cenergist	CF
I2	TGV - project manager 1	CF
I3	TGV - project manager 2	CF
I4	WoonFriesland	CF
I5	Heijmans	CF
I6	Municipality of Katwijk	CF
I7	Dreamhûs resident	CF
I8	Water Board Limburg	MFB
I9	STOWA	MFB
I10	GeoDesign Barriers	MFB
I11	Municipality of Amsterdam - project managers	DHN
I12	Woodencity	DHN
I13	Municipality of Amsterdam - G&O	DHN
I14	Municipality of Amsterdam - CWA	DHN
I15	ELZO	DHN

Table 3.1: Overview of interview participants per case study.

The specific questions were adapted to the role and involvement of each interviewee. The full interview guide is provided in Appendix A.

All interviews were audio-recorded with the participants' consent and transcribed using Microsoft Teams. The transcripts formed the main dataset for the coding and thematic analysis.

3.4 OPERATIONALISATION

3.4.1 CATEGORISING STAKEHOLDERS

To categorise the identified stakeholders, the Quadruple Helix model, described by Carayannis & Campbell (2009), was used. Stakeholders were classified into four broad groups:

- government
- industry
- academia
- civil society

This categorisation provided a consistent way of comparing the composition of the stakeholder networks across the three cases. Actors that could not be straightforwardly assigned to one category were categorised based on their primary role within the project.

3.4.2 PROJECT PHASES AND LEVEL OF STAKEHOLDER INVOLVEMENT

Stakeholder involvement was analysed according to the phase in which the involvement occurred and the intensity of participation.

The project phases were based on the life-cycle phases described by Friedrich et al. (2013) and applied to LL research by Menny et al. (2018): design, implementation and evaluation. The design phase refers to developing the project and determining its set-up; implementation refers to putting the project into practice; and evaluation refers to assessing outcomes and generating learning. These phases are analytical categories rather than strict chronological boundaries, as evaluation and learning can occur throughout a project (Menny et al., 2018).

The level of stakeholder involvement was categorised using the framework of Menny et al. (2018), which was adapted from Arnstein (1969), and distinguishes four levels: no participation, information, consultation and co-creation.

Menny et al. (2018), apply these participation levels across the design, implementation and evaluation stages of LLs (see Figure 3.1). For this research, each identified stakeholder was assigned a level of involvement for each relevant project phase based on evidence from interviews, observations and project documentation.

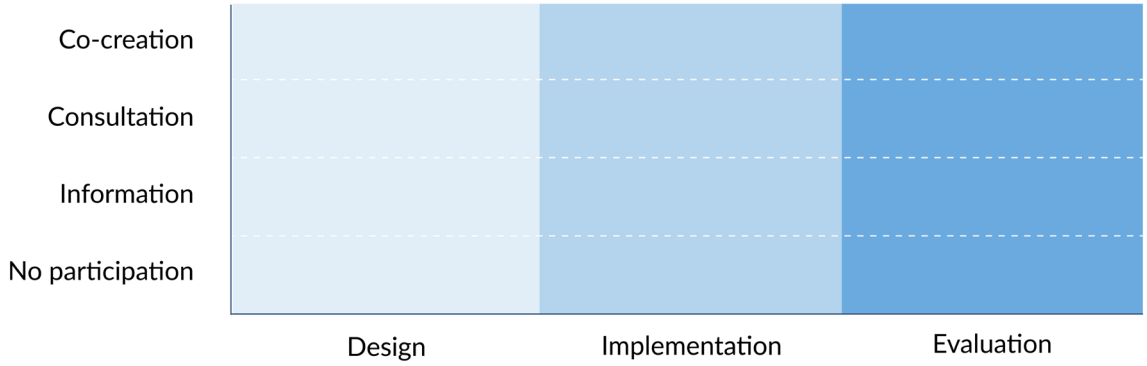


Figure 3.1: Level of stakeholder involvement within different stages of an LL or FL project. Following Menny et al. (2018).

3.4.3 SCALING PATHWAYS

To analyse how the projects contributed to wider change beyond the experimental setting, scaling was operationalised using the three pathways of spreading, broadening and deepening identified by Termeer & Metze (2019). These pathways were treated as categories for identifying different forms of development beyond the individual project.

The three pathways were not treated as mutually exclusive or as sequential stages. A project could contribute to multiple pathways simultaneously, and a pathway could occur without the others. During the analysis, interview statements concerning project outcomes, learning, adoption, replication, institutionalisation and changes in practices were coded according to these three categories. This allowed scaling to be analysed as more than the physical replication of an innovation and enabled different forms of project success to be compared across cases.

3.4.4 STAKEHOLDER RESOURCES AND SOURCES OF POWER

To analyse differences in influence and decision-making, the research examined the resources and forms of power available to stakeholders. For each relevant actor, the analysis identified resources or power sources that could provide influence over project decisions or implementation.

Four analytical categories were used, following Cunningham and Hermans (2018):

- **Financial power**, such as control over funding, procurement budgets or investment decisions;
- **Institutional power**, such as formal authority, regulatory responsibilities, control over access or organisational decision-making authority;
- **Technical power**, such as specialised knowledge, technical expertise or control over technological decisions;
- **Social power**, such as networks, relationships, representation of stakeholder groups or the ability to influence other actors.

These categories were used to structure the empirical analysis. Power can take multiple forms and can be relational and context-dependent. The analysis therefore considered the resources available to actors in relation to specific project decisions.

The analysis also considered whether stakeholders gained decision-making influence through their resources, expertise or position within the project network.

3.5 DATA ANALYSIS

3.5.1 ABDUCTIVE THEMATIC ANALYSIS

The interview data were analysed using an abductive approach to qualitative analysis. Abductive analysis moves iteratively between empirical observations and prior theoretical knowledge, allowing researchers to use existing concepts while remaining open to unexpected findings and tensions in the data (van Hulst & Visser, 2025). Rather than following a strictly deductive or inductive approach, the analysis moved between theoretically informed categories and themes that emerged from the empirical material.

The analysis initially used deductive codes derived from the research questions and theoretical concepts identified in the literature review. These included categories like stakeholder relevance, stakeholder roles, stakeholder involvement, decision-making, power, collaboration etc. The operationalised concepts of project phases, levels of stakeholder involvement, scaling pathways and sources of power provided predefined categories through which the interview data could be systematically examined. The complete codebook, including the code names, descriptions and coding structure, is provided in Appendix B. An example of a deductive code is ‘Stakeholder power’, which was

defined as the sources of power available to stakeholders that could influence project decisions or implementation. For example, a statement from the interviews was coded under this category because it described their institutional decision-making authority: 'we can decide whether projects can take place at Dreamhûs, we can give a *`green light'. All statements within 'Stakeholder power'* were later divided into the four categories of power defined by (Cunningham & Hermans, 2018).

Alongside this deductive coding, the interview material was also analysed using inductive coding to identify challenges and patterns that were not fully captured by the predefined theoretical categories. This coding was used to find recurring patterns in the difficulties of involving stakeholders across the cases. For example, one recurring challenge that emerged from the interviews was 'No shared problem'. This category captured situations in which stakeholders did not share a common problem or objective, making it more difficult to motivate them to participate. One interviewee described this as follows: *`If there isn't that common ground or shared objective, it does become more difficult to pull everyone away from their work every time and say: 'You really need to be here, because we're going to do some great things with... OK, I don't know exactly how yet, but it's going to be really great.*' This statement was therefore used to develop the inductive challenge category 'No shared problem'.

The deductive and inductive parts of the analysis were not treated as separate analytical stages. Instead, they informed one another throughout the research process. Findings emerging from the data were compared with the theoretical concepts used in the initial coding framework, while the theoretical framework also guided attention towards particular empirical observations. This iterative process supported the development and refinement of the interpretation of stakeholder involvement and its challenges.

The abductive approach also reflects the iterative character of the wider research process. Initial case understanding and theoretical concepts informed data collection and coding, while observations from the cases and emerging patterns in the interview data led to further refinement of the analysis. This iterative movement between empirical material, theoretical concepts and interpretation is consistent with the abductive approach described by van Hulst & Visser (2025).

3.5.2 WITHIN-CASE ANALYSIS

The analysis first focused on each case individually to identify how stakeholder involvement, power relations and scaling developed throughout the project. The operationalised categories described in Section X: operationalisation were used as analytical categories to structure the within-case analysis. For each case, stakeholders were categorised and examined across the different project phases of design, implementation and evaluation, considering their form and level of participation, degree of influence and relevant sources of power. Evidence concerning project outcomes and developments beyond the experimental setting was analysed using the scaling pathways of spreading, broadening and deepening.

The within-case analysis combined information from interviews, project documentation and observations.

3.5.3 CROSS-CASE ANALYSIS

Following the within-case analysis, the findings were compared across the three cases. The cross-case analysis combined the categories used in the deductive analysis with the challenges that were found through the inductive analysis.

First, the cases were compared with respect to stakeholder involvement across the project phases of design, implementation and evaluation. The analysis examined which stakeholders were involved, when they became involved, the form and level of their participation, and how their involvement related to their roles, resources and relationships within the project. The analysis also considered differences between participation and actual influence over project decisions.

Second, the analysis compared the different objectives stakeholders associated with successful project outcomes, to what extent these objectives were achieved and how they were related to the scaling pathways of spreading, broadening and deepening.

Third, the cross-case analysis examined how stakeholder resources and sources of power were distributed and how these related to opportunities for influence. The analysis compared financial, institutional, technical and social sources of power.

Finally, an inductive cross-case comparison was conducted to identify recurring challenges in stakeholder involvement. Relevant statements from the interviews were compared across cases to identify recurring patterns in the difficulties experienced by both project teams and stakeholders. The challenges were not imposed as predefined categories, but were developed through comparison of the empirical material across cases.

4

RESULTS

Within this chapter, background information will be given on the chosen LL and FL to understand their focus and way of working. Afterwards, the 3 case studies will be presented. This will be done following the three sub-research questions: (1) which stakeholders are involved in LL and FL projects, and why, when and how are they engaged; (2) what types of success do stakeholders aim to achieve in LL and FL projects, and how do these relate to different scaling pathways; and (3) how are power imbalances between stakeholders addressed in LL and FL projects? After discussing the three case studies separately, a cross-case analysis will be done discussing the similarities and differences of the cases per sub-research question. Finally, several challenges of involving stakeholders in LL and FL projects will be discussed.

4.1 EXPERIMENTAL ENVIRONMENTS

4.1.1 THE GREEN VILLAGE

The Green Village (TGV) is an FL on the campus of the TU Delft. They focus on creating a sustainable future through experimenting with new methods, techniques and technologies. The innovations on TGV are divided into 3 themes: building & renovating sustainably, future energy systems and climate adaptive cities (The Green Village, n.d.-b).

Most projects within TGV are carried out using the following structure (The Green Village, 2026):

- **Intake**: understanding if a project is doable
- **Preparation**: detailing the project plan for the next phase
- **Live@TGV**: research, testing & demonstrations
- **Moved on**: Follow-up

TGV is a foundation of TU Delft, which means that all employees working at TGV are officially employed by TU Delft and they are also partly financed by TU Delft (I2).

TGV often tries to involve actors from the quadruple helix model (see Figure 4.1) in innovation projects. Scientists from TU Delft regularly join projects running at TGV.

They also have a big network within the industry, municipalities and governmental actors and can test innovations with users (The Green Village, n.d.-a). Whether these actors are involved during the project differs depending on the goal of the project (I2, I3). Entrepreneurs coming to TGV with their innovation may decide for themselves whether they want to work together with additional actors (I3). This is not always the case. For example, sometimes smaller start-ups do not want to involve a big company, because they are afraid it will harm their business (I3). Furthermore, the innovations tested at TGV are often technology-focused and, although stakeholders sometimes are involved during testing, if a project is very technical, including different stakeholders is not always seen as relevant (I3).



Figure 4.1: Collaboration within The Green Village Following The Green Village (2026)

A model that is used by TGV to describe how an innovation moves towards large-scale implementation is the hop-step-jump model. (see Figure 4.2). This model describes three main steps that an innovation goes through before it reaches this state: the hop, step and jump. First, an innovation is tested theoretically & in a lab. Afterwards, it will be tested in a protected environment.

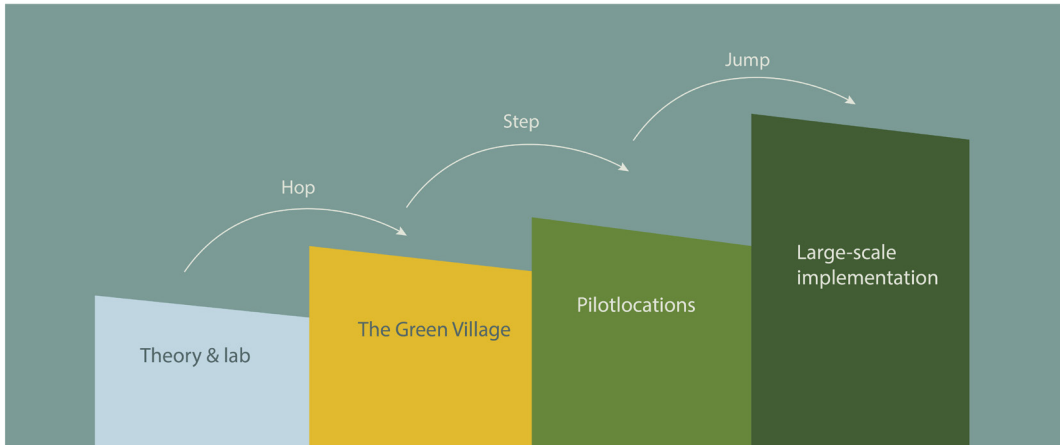


Figure 4.2: Positioning The Green Village in the hop-step-jump model. Following The Green Village (2026).

This environment is often an FL such as TGV. Moving from a lab to this new location is called the 'hop'. If this step is successful, an innovation can move towards a pilot location. This step is called the 'step'. When testing has finished at this location, it can be implemented on a larger scale: the 'jump' (TwynstraGudde, 2021).

4.1.2 ENERGIE-LAB ZUID-OOST

Energie Lab Zuid-Oost (ELZO) is an organisation that tries to make Amsterdam energy-neutral by 2040 in a social way. The institution was founded in 2020 in collaboration with the Amsterdam Institute for Advanced Metropolital Solutions (AMS), Delft University of Technology (TU Delft), Amsterdam University of Applied Sciences, the University of Amsterdam and the municipality of Amsterdam to create a just energy transition. They aim to work together with all stakeholders from the quadruple helix model and create knowledge that can be applied in and outside of Amsterdam (Energie Lab Zuid Oost, n.d.-c). ELZO does not have a specific testing location like TGV does, but is rather a network of people that ensures that they can work together on projects (I15).

All of their projects are tested within the South-East region of Amsterdam, where they have 4 LLs that work on different themes:

- **Life ArenAPoort** focuses on sustainable energy systems (Energie Lab Zuid Oost, n.d.-f).
- **Duurzame Renovatie Van Woningen** focuses on creating a circular building environment (Energie Lab Zuid Oost, n.d.-b).
- **Lage Temperatuur Warmtenetten** focuses on becoming free of natural gas by creating district heating networks (Energie Lab Zuid Oost, n.d.-e).
- **Just Prepare** focuses on how to create a just energy transition (Energie Lab Zuid Oost, n.d.-d).

The organisation behind ELZO consists of people from several backgrounds. Researchers from several universities are involved, as well as people from the municipality and several partner organisations (Energie Lab Zuid Oost, n.d.-a). Everyone who is connected to ELZO works at one of the organisations that are connected to ELZO.

Figure 4.3 shows the stakeholders involved with ELZO and the LLs that connected to them (Dijkstra & Joore, 2025). Within every LL, several research projects are done.

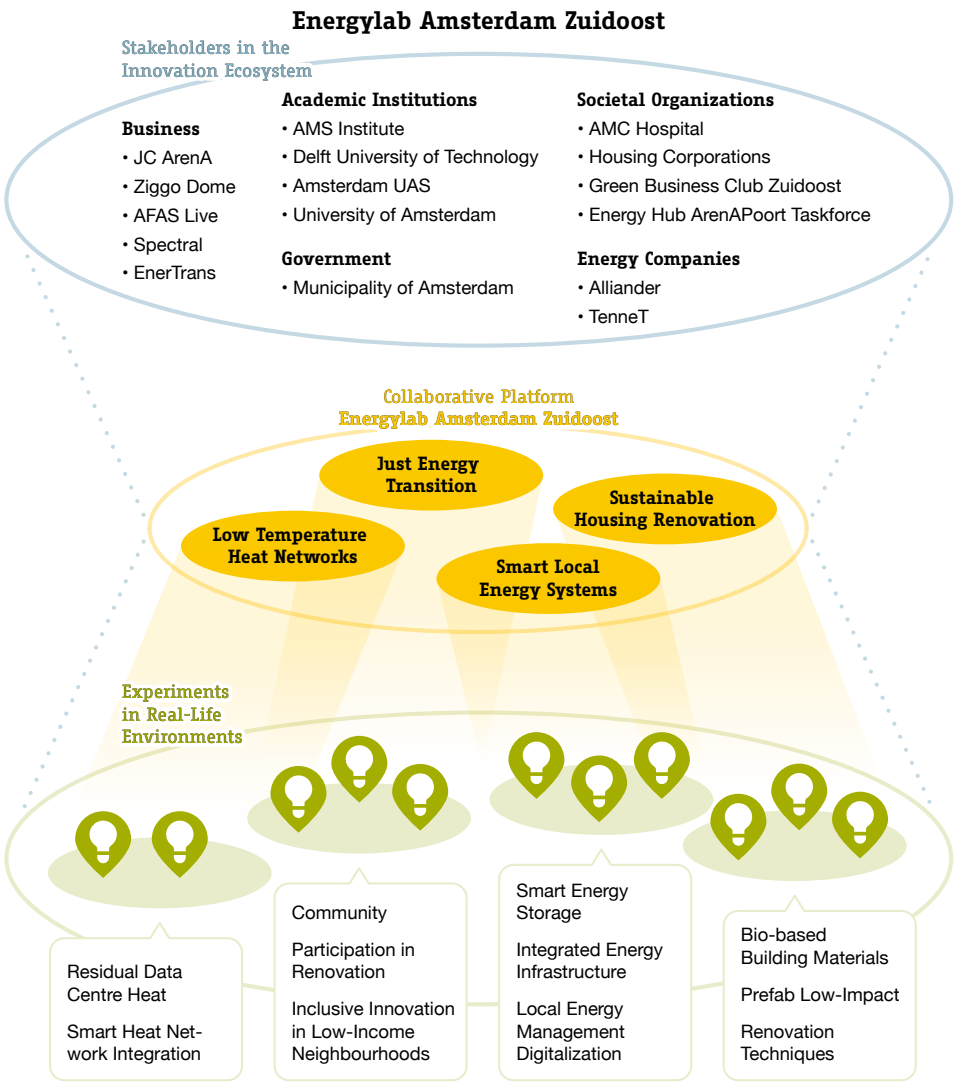


Figure 4.3: Energie Lab ZuidOost multilevel framework. Following Dijkstra and Joore (2025).

AMS methodology within ELZO

Within projects at ELZO, a methodology that was created within AMS is often used: the Urban Living Lab Way Of Working (ULLWOW) (I15). AMS developed a handbook on this method and presents a guide on how to coordinate LLs (Dijkstra & Joore, 2025). It consists of 8 iterative steps that are connected (see Figure 4.4). Within ELZO projects, AMS LL-coordinators are involved who apply the method from the start. This is not the case for every project, but AMS also gives training to other parties, such as the municipality, explaining the method and showing how it can be applied (I15). Through these trainings, the method plays a role even when AMS is not directly involved in the project.

The 8 steps as defined by Dijkstra & Joore (2025) are:

1. **(Re)Create Shared Mission**: Bring all key partners together to define a common problem and objective that will steer the ULL's efforts and shape the urban changes it wants to achieve.
2. **(Re)Design ULL Plan**: Develop or update a ULL plan by clarifying the ULL's purpose, assigning roles, and outlining how resources will be allocated.

3. **(Re)Design Experiments**: Plan targeted experiments to test new ideas in real-world conditions, ensuring each experiment is set up to generate actionable insights for the wider city.
4. **Implement Experiments**: Launch the experiments in the field—engaging local stakeholders, collecting data, and observing how solutions perform on the ground.
5. **Learn from Experiments**: Review the outcomes of experiments to determine what worked and what did not, capturing valuable lessons to guide your next steps.
6. **Integrate and Contextualise**: Connect the insights from your experiments back to the overall ULL's vision and urban goals, ensuring each lesson informs future actions.
7. **Disseminate Learnings**: Share your successes and learnings with a broader audience—both within your network and beyond—to drive wider adoption and scaling of solutions.
8. **Monitor Systemic Impact**: Continuously track your ULL's progress over time, measuring its ongoing impact on urban innovation and its contribution to lasting change in the wider city. (p.66)

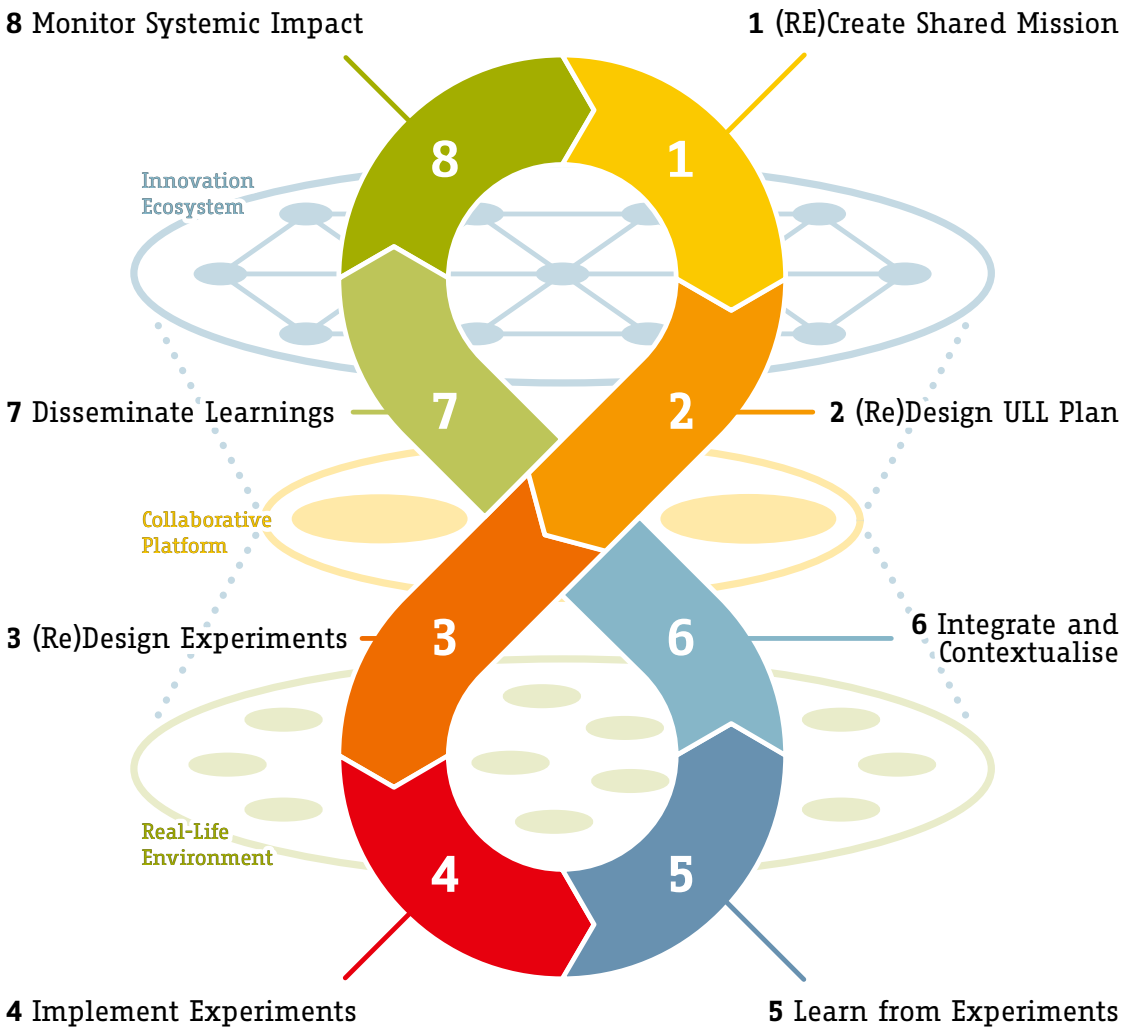


Figure 4.4: The Urban Living Lab Way of Working. Following Dijkstra and Joore (2025).

4.2 PROJECTS

One case study within ELZO and 2 case-studies within TGV have been chosen. The case study done within ELZO describes a project aimed to develop a district heating network. Within TGV two innovations were studied: the Control Flow (CF) and a mobile flood barrier. The CF did multiple projects within TGV, which is why this case study was split up into 3 parts. The other two cases are not split up.

The project of ELZO consisted of many collaborative meetings with several stakeholders over a 6-month period of time. At TGV, fewer collaborative meetings took place during analysed projects. Therefore, only one case study from ELZO was chosen and two case studies from TGV.

In the next section, the projects will be explained based on desk research, interviews and observational information. The sub-research questions will be answered per case.

4.3 THE CONTROL FLOW AT THE GREEN VILLAGE

4.3.1 WHAT IS THE CONTROL FLOW

The CF is an innovation that can save water and gas in residential buildings by reducing the water pressure to the legal limit and restricting the flow (I1,I2) (van de Griend & Stoker, 2024). In the Netherlands, drinking water companies deliver water at pressures significantly higher than required for daily domestic use to meet minimum supply standards (I1, I2). However, lowering the water pressure with the CF can save gas and around 10% of water (I1,I4). This aligns directly with Dutch national policy targets requiring a 20% reduction in per-capita water consumption by 2035 compared to 2022 levels (I1, I6) (van de Griend & Stoker, 2024).

4.3.2 HOW THE PROJECT CAME TO BE

The CF has been tested multiple times at TGV. First, it was tested at TGV in 2024, during which it was also implemented in Leeuwarden as a pilot project, and a report was written with the test results (I4) (van de Griend & Stoker, 2024). However, in March 2026, a new research project started testing the control flow within a consortium (I3).

Usually, developers come to TGV with an innovation they want to test. However, for this product it was different.

The CF was developed around 20 years ago by an employee of a drinking water company in Drenthe (I1). The product did not sell very well until Cenergist, a company specialised in water usage efficiency (Cenergist, n.d.), took it over. They sold the product widely in the UK because of beneficial subsidies of the government, but it was not very well known in the Netherlands yet (I1). To ensure the product did well on the Dutch market, they wanted to do objective research on how much water the product saved and if it was deemed comfortable (I1, I4) (van de Griend & Stoker, 2024).

To execute this research, Cenergist initially contacted the Centre of Expertise Water Technology (CEW), a company doing research on drinking water (I1). CEW advised Cenergist to partner with a housing association to secure real-world testing locations, leading Cenergist to approach social housing corporation WoonFriesland (I1, I4).



Figure 4.5: Dreamhûs on The Green Village (The Green Village., 2026)

WoonFriesland is also one of the founding partners of Dreamhûs (see Figure 4.5), together with Bouwgroep Dijkstra Draisma, Huurdersbelang Fryslân and TGV. Dreamhûs is a testing ground at TGV that consists of 3 replica homes from the 70's. In these homes, innovations are tested that can make homes more sustainable (Dreamhûs, n.d.). Several residents live in these 3 homes to test these innovations. At the beginning of Dreamhûs, these residents were representative of the population living in the housing units of WoonFriesland. However, after several safety rules were broken and TGV needed to act as wardens because of it, residents were chosen who were less representative, but interested in helping with innovation projects (I2). Since the residents are involved in many projects, TGV usually involves them after the design of the project is completed (I3).

The goal of Dreamhûs is to implement successful innovations in the social housing units that they represent in Friesland (I4). Whether this is the case is decided by WoonFriesland, Bouwgroep Dijkstra Draisma and Huurdersbelang Fryslân together (I2, I4).

WoonFriesland was willing to work together with Cenergist and mentioned that they could test the product in Dreamhûs as well (I1, I2, I4).

As Cenergist explained (I1): "We really wanted to have a Dutch water university that would collaborate with us on research into the effectiveness and acceptance of Control Flow on the Dutch market... CEW then said, "Great project, but you'll have to find a housing association on your own." So I called WoonFriesland, and they said, "Nice project, but we also have Dreamhûs, so maybe it would be good if you ran a pilot there as well."

4.3.3 PROJECT 1: TESTING AT THE GREEN VILLAGE

Within the first testing period at TGV, the goal was to understand how the product worked before implementing it in Leeuwarden, but also to understand what the minimum water pressure could be before residents would notice a difference in comfort (I1, I2, I4). WoonFriesland and Cenergist thought at first that they needed to provide the legal minimum water pressure standards when using the CF, but were not completely sure (I2). To understand the rules better, civil servants were contacted through old connections of employees of TGV. After talking with them, it became clear that this minimum standard is only relevant for supplying water to a home (I2). The water pressure can be lower after the water enters a home (I2). Therefore, it became interesting to understand how low the water pressure could go before comfort was compromised (I2). The product was tested for about a year in Dreamhûs. The project was successful and indicated that the water pressure could be lower than they had first expected it to be. However, a lower water pressure was only comfortable in households of 1-2 people, which is something WoonFriesland could not guarantee in their own social housing units. This is why the results were not implemented by them (I4).

Stakeholder involvement

To understand the stakeholder involvement during project 1 of the CF, it was analysed from two complementary perspectives. First, the analysis examined which stakeholders were involved and why they were considered relevant using an actor and network analysis. Second, it examined when and how stakeholders were involved throughout the project, using the involvement levels adapted from (Menny et al., 2018). The results are therefore presented in two subsections: stakeholder relevance and networks, followed by the timing and forms of involvement.

Relevant stakeholders and stakeholder networks

Within project 1 of the CF, six core stakeholders were identified across three primary Quadruple Helix categories: industry, academia and community (see Table 4.1). The public government was not represented in the project. The actors that were interviewed are shown with an interviewee ID in the table.

To create Table 4.1, a broader rudimentary actor and network analysis was performed (see Appendix C.1). Their roles and objectives were identified together with their sources of power and resources.

STAKEHOLDER	QUADRUPLE HELIX CATEGORY	ROLE WITHIN THE PROJECT	RESOURCES	INTERVIEWEE ID	SOURCES
Cenergist	Industry	Product owner; design, implementation & evaluation of experiment.	**Technical**: controls product knowledge, installation options, and experimental design; **Social**: commercial network.	I1	I1, I2, I4
TGV	Academia	Field-lab operator; facilitator of experimentation and site coordinator.	**Institutional**: controls site access and field-lab procedures; **Social**: extensive innovation network; **Technical**: testing setup knowledge.	I2, I3	I2, I3, I7
Woon-Friesland	Industry	Dreamhûs partner; primary asset owner and housing association.	**Financial**: funds Dreamhûs and controls procurement decisions; **Institutional**: controls access to social housing stock.	I4	I3, I4
Bouwgroep Dijkstra Draisma	Industry	Dreamhûs partner; construction sector partner.	**Financial**: co-funds Dreamhûs infrastructure; **Technical**: building construction expertise.	--	I2, I4
Huurdersbelang Fryslân	Community	Dreamhûs partner; tenant interest organization.	**Institutional**: tenant representation in governance; **Social**: social legitimacy among residents.	--	I2, I4
Tenants of Dreamhûs	Community	End-users; testing Control Flow in daily living environments.	**Technical**: user experience feedback.	I7	I7

Table 4.1: Relevant stakeholders within project 1 of testing the Control Flow.

All stakeholders provided important resources to the project. TGV provided a testing location, an extensive stakeholder network and technical knowledge on doing research and installation (I1, I2, I3); Cenergist created the research proposal, carried it out and analysed the data (I1, I2); partners of Dreamhûs financed the testing location, gave access to Dreamhûs and gave feedback on the research proposal (I4); lastly, the residents of Dreamhûs were important as they gave insights into their user experience through a survey (I1, I2, I4). Ideally, a scientist is involved in all projects of TGV, but due to time and budget constraints, this was not the case for the first project of the CF (I2). Furthermore, TGV mentioned that the stakeholders who are included in the projects are also dependent on their own network (I2).

Figure 4.6 visualises the social network structure of CF Project 1 based on the actor and network analysis. It shows that all involved stakeholders are well connected. Only the residents of Dreamhûs are less connected to the rest of the stakeholders. Their main communication goes through TGV.

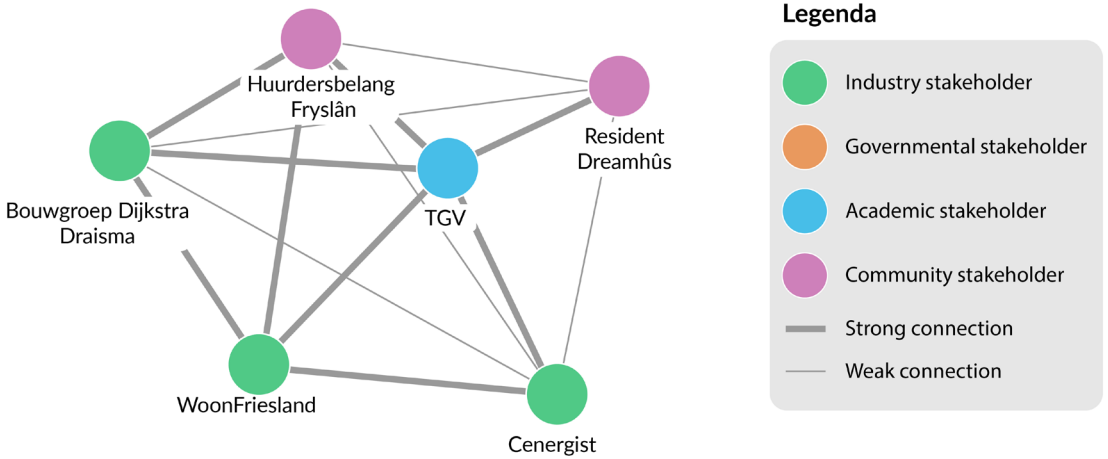


Figure 4.6: Social Network Diagram visualising relationships between relevant actors for project 1 of the Control Flow.

Timing and forms of stakeholder involvement

To understand when and how stakeholders have been involved in the project, the model of (Menny et al., 2018) has been used (see Figure 4.7). The data used to fill in this model can be found in Appendix D.1.1.

Throughout project 1, Cenergist has been responsible for the design of the project and co-created with TGV during this process (I1, I2). Cenergist provided a testing plan, but the project and data managers of TGV gave feedback and provided tips on how to improve the plan and testing setup (I2). They can stop the testing if the plan or set-up is not good enough (I2). For example, the project manager provided feedback on the questionnaire for project 1 (I2). The communication mainly took place in the form of meetings and phone calls to ensure that everything was in order before the project started (I3). Dreamhûs partners could say whether the CF project was allowed to take place in Dreamhûs. Cenergist pitched their plan, after which Dreamhûs partners could ask questions and provide feedback (I2, I4). Residents were not involved in this phase, meaning that they had no influence over the design of the project, but were informed of the project design after it was finished (I2, I7).

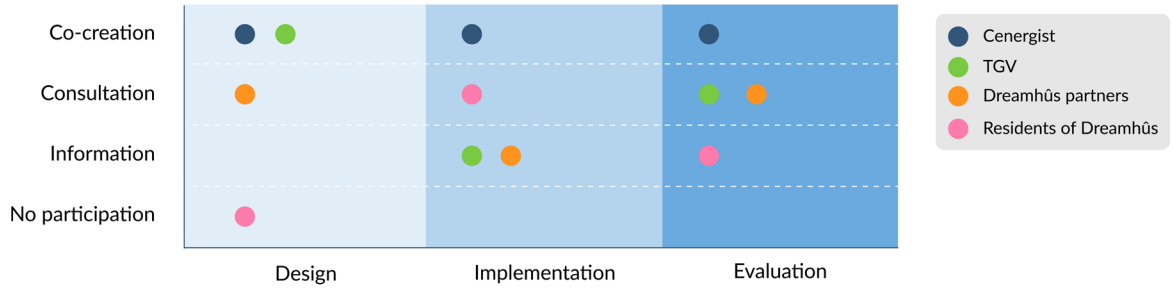


Figure 4.7: The level of involvement of stakeholder during different stages of project 1 of the Control Flow.

During the implementation of the project, Cenergist was in control of carrying out the project (I1, I2). TGV and Dreamhûs partners were informed of what was happening, but did not have specific tasks they needed to perform during the project. There was a halfway evaluation meeting where Cenergist shared their progress (I4). Residents were asked to fill in a survey when the project ended (I1, I7). Throughout the project, TGV brought Cenergist in contact with several external parties that might help them scale their project (I1, I2).

To protect resident privacy and prevent commercial intrusion, TGV enforced access protocols (I2). As an employee of TGV emphasised (I2): "*In a sense, residents are actually in a rather vulnerable position, because they have a lease, and that means innovations are taking place in their homes... We wanted to prevent entrepreneurs from walking into the living room at the drop of a hat. So if an entrepreneur wants to stop by, he has to give at least a week's notice.*"

Dreamhûs tenants expressed satisfaction with living in an experimental environment, though they noted sometimes they were not well informed during the implementation and evaluation phase. This is not necessarily the case for the CF project, but is their general experience living at Dreamhûs (I7): "*We're kept well informed, but it's a lot to keep track of everything... With some companies, you don't hear anything from them halfway through. It sometimes feels a bit like ghosting. A periodic update would be nice.*"

WoonFriesland also noted that they would ideally be updated more often, but that this can be hard, because they work in Friesland and are only present at TGV once every four weeks (I4).

In the evaluation phase, the research results were analysed by Cenergist and were shared with partners and residents of Dreamhûs and TGV (I1). Dreamhûs assessed the results and decided if the changes would be made in Friesland (I4).

Co-creation was limited throughout this project. It occurred between Cenergist and TGV, but Cenergist remained responsible for the project design (I1, I2). Other actors like Dreamhûs partners and tenants were consulted (I1, I2).

The methods used for user involvement were narrow. Feedback was sought through a survey. Other stakeholders were mainly involved through online and physical meetings. The meetings could involve both sharing information and asking for input. Furthermore, the end-users were engaged late in the implementation and evaluation phases (I1, I2, I7).

Types of success

Not all stakeholders are looking for the same type of success. Table 4.2 illustrates the definitions of success given during the interviews and intended scaling pathways per stakeholder. For Cenergist, the goal was to establish a comfort boundary and create the technical dataset needed to justify subsequent market adoption (I1).

WoonFriesland and Dreamhûs Partners viewed success through risk de-escalation; they needed to determine how low water pressure could go without triggering tenant complaints or maintenance liabilities before risking deployment in real social housing (I4).

TGV evaluated success based on providing a safe space to test these boundaries and connecting the innovator with housing partners (I2, I3). Dreamhûs tenants defined success through lived experience. They want to maintain comfort and contribute meaningfully to research (I7).

ACTOR	DEFINITION OF SUCCESS	TYPE OF SCALING	SOURCES
Cenergist	Determine how far water pressure and flow rates can be reduced before tenant comfort is compromised; generate empirical data to establish technical and comfort limits for market adoption.	**Spreading**: Providing technical boundaries to enable wider adoption across social and private housing stock. **Broadening**: Demonstrating flow reduction limits to utility providers and commercial building sectors.	I1, I2, I4
TGV	Provide a protected testbed environment to safely test technical parameters and facilitate the transition from lab testing to real-world pilot applications.	**Spreading**: Moving verified technology boundaries from the TGV testbed to external pilot sites (Leeuwarden/Ameland). **Broadening**: Connecting innovators with housing associations and municipal policy networks.	I2, I3
Dreamhûs Partners (WoonFriesland, Dijkstra Draisma, Huurdersbelang)	Identify the exact lower boundary of water pressure and flow reduction without provoking tenant dissatisfaction, maintenance issues, or plumbing risks before scaling.	**Spreading**: Establishing safe flow parameters to enable eventual roll-out across regional housing stock. **Deepening**: Transforming internal maintenance standards and tenant comfort risk assessments.	I4
Dreamhûs Tenants	Safe, comfortable testing experience, no disruption to daily living routines, and meaningful user contribution.	n.a.	I7

Table 4.2: The definitions of success from stakeholders and the related types of scaling in project 1 of the Control Flow

This project supports the small-wins framework argument that physical rollout (spreading) cannot occur without prior institutional and behavioural learning (deepening) (Termeer & Metze, 2019). By using Dreamhûs to determine the exact lower limit of water pressure acceptable to users (deepening), the project partners gained the technical confidence and risk reduction necessary to design subsequent real-world pilots.

Power imbalances

In Table 4.3, the critical resources and authority of all actors were described. It shows that Cenergist had a lot of influence over the decisions being made during the project compared to other actors (I1, I2, I4). They were responsible for designing, implementing and evaluating the research (I1). TGV & Dreamhûs partners had formal authority over whether the project proposal was acceptable and if Cenergist was allowed to test, but not over what decisions would be made on the outcomes (I2, I4). However, as they are the parties controlling the testing facilitation, they could influence the amount of formal authority they have.

Even though Dreamhûs partners had no formal authority over the decisions being made on the outcomes, Cenergist did welcome feedback from TGV and Dreamhûs (I1, I2). The Dreamhûs residents were not asked to be involved in the design phase of the project (I7). They are able to refuse participation in the project if they really do not want to (I2, I7), but it is expected of them by living on the FL (I2, I7). During the project, they were able to give feedback through a survey and had other informal channels through which they were able to give feedback (I7). They mentioned they did feel like their feedback was usually taken into account, but had no formal authority over the decisions being made (I7).

ACTOR	RESOURCES	FORMAL AUTHORITY	APPROACH	SOURCES
Cenergist	**Technical**: controls product knowledge, installation options, and experimental design; **Social**: commercial network.	Can design the project; can solely make design decisions about the product; can decide who is involved within the project.	Contacted CEW first; then TGV/ WoonFriesland through network.	I1, I2, I4
TGV	**Institutional**: controls site access and field-lab procedures; **Social**: extensive innovation network; **Technical**: testing setup knowledge.	Has veto power. Can decide which projects are run and which are not. Has power over who is included in Project 3.	Approached by WoonFriesland in Project 1. Initiated contact in Project 3.	I2, I3, I4
Dreamhûs	**Financial**: funds Dreamhûs and controls procurement decisions; **Institutional**: controls access to social housing stock.	Gives green/red light on whether the testing at Dreamhûs will take place and will be implemented at Leeuwarden.	Approached by Cenergist after CEW research planning.	I1, I4, I2, I3
Resident Dreamhûs	**Technical**: user experience feedback.	Has no direct decision-making power over the project.	Involved through Dreamhûs.	I7

Table 4.3: The resources and formal authority of stakeholders within project 1 of the Control Flow along with the way they were approached to join the project.

Cenergist was the initiator of the project and approached WoonFriesland. WoonFriesland contacted TGV, and TGV approached the residents.

4.3.4 PROJECT 2: TESTING IN LEEUWARDEN

As mentioned before, after half a year of testing in Dreamhûs a second project started in Leeuwarden (I4). For this test WoonFriesland selected around 150 houses that were suited for the pilot test, after which the product was installed in around 50 homes (I4) (van de Griend & Stoker, 2024).

The goal of this project was to test the amount of water and gas saved using the product and the level of comfort of the users (I1, I4).

The findings showed an average saving of around 10% of water when the CF was installed. 13 residents filled in a survey indicating they were mostly positive about the comfort level of the product (van de Griend & Stoker, 2024). WoonFriesland was happy with the results. To decide if the project would be implemented further in their housing units, a survey was put out by Huurdersbelang Fyslan where residents could give their opinion on the product (I2). Afterwards, the product was implemented in 300/400 housing units in Ameland (I4).

After the first project in Leeuwarden finished, they wanted to start a new research project that investigates the amount of water that would be saved if the product was placed at a different spot in the house.

STAKEHOLDER	QUADRUPLE HELIX CATEGORY	ROLE WITHIN THE PROJECT	RESOURCES	INTERVIEWEE ID	SOURCES
Cenergist	Industry	Product owner; design and implementation of the experiment	**Technical**: controls product knowledge, installation options and experimental decisions; **Social**: company network; **Institutional**: formal authority to make decisions about the product and research.	I1	I1, van de Griend & Stoker, (2024)
CEW	Academia	Research partner; design, implementation and evaluation of the experiment.	**Technical**: water-technology research expertise; **Institutional**: research credibility.	--	I1, van de Griend & Stoker, (2024).
WoonFriesland	Industry	Research partner; provides a testing location.	**Institutional**: controls access to the testing location and implementation decisions afterwards. **Financial**: is a potential buyer of the product	I4	I1, I4, van de Griend & Stoker, (2024).
Tenants in Leeuwarden	Community	Testing the Control Flow within Dreamhûs.	**Social**: contributes user experience.	--	I1, I4, van de Griend & Stoker, (2024).

Table 4.4: Relevant stakeholders within project 2 of testing the Control Flow.

However, before beginning the project, the parent company of Cenergist went bankrupt (I1).

Stakeholders Involvement

Relevant stakeholders and stakeholder networks

Within Project 2 of CF, 4 main stakeholders were identified: CEW, Cenergist, WoonFriesland, and Leeuwarden residents (see Table 4.4). The actors that were interviewed are shown with an interviewee ID in the table.

To create Table 4.4, a broader rudimentary actor and network analysis was performed (see Appendix C.1). Their roles and objectives were identified together with their sources of power and resources.

Cenergist was partly responsible for designing the project and collecting data (van de Griend & Stoker, 2024). WoonFriesland selected houses that were suitable for the project and CEW partly designed, carried out and fully evaluated the project. Lastly, the residents provided data by joining the project, answering questions throughout the project and completing a survey at the end (I2, I4) (van de Griend & Stoker, 2024).

During this project, TGV and the other partners of Dreamhûs were not included (I2, I4). No governmental actors were involved during this project.

Figure 4.8 visualises the social network structure of CF project 2 based on the Actor and Network Analysis. It shows that the involved stakeholders are well connected. Only the residents of the buildings are less connected to the rest of the stakeholders. Their strongest connection is with WoonFriesland.

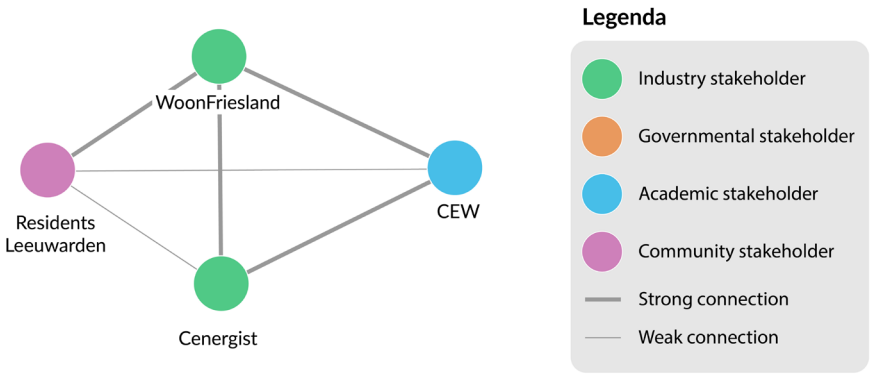


Figure 4.8: Social Network Diagram visualising relationships between relevant actors for project 2 of the Control Flow.

Timing and forms of stakeholder involvement

The model of (Menny et al., 2018) has been used to analyse how and when stakeholders have been involved throughout the project (see Figure 9). This figure has been created using interview data which can be found in Appendix D.1.2.

For the second project, Cenergist, CEW and social housing corporation WoonFriesland collaborated to design a research trial evaluating the CF (I1, I4). During the design phase, WoonFriesland selected 150 eligible social housing units in Leeuwarden (I4). CEW and Cenergist jointly designed the research methodology and a digital baseline questionnaire to collect household demographics and schedule baseline meter readings (I1, I4). Residents were not involved in designing the trial or formulating the research questions (I1, I4) (van de Griend & Stoker, 2024).

During the implementation phase, project activities included door-to-door visits and three measurement sessions per household across a two-month trial period (I1) (van de Griend & Stoker, 2024). One to two weeks prior to installation, residents received an explanatory letter outlining the project goals and benefits (I1, I4). CEW and Cenergist

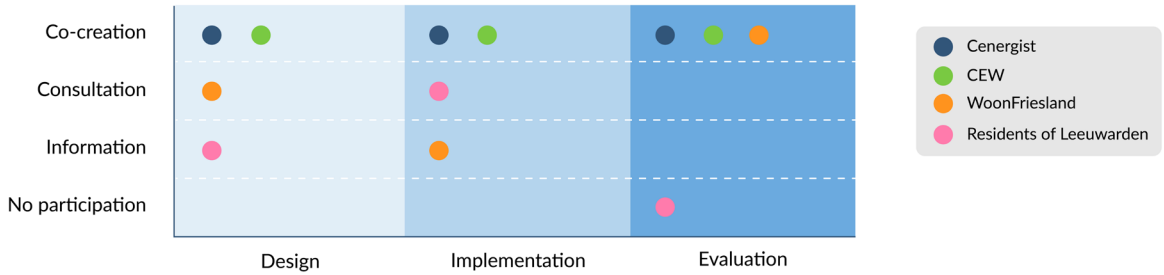


*Figure 4.9: **The level of involvement of stakeholder during different stages of project 2 of the Control Flow.***

staff then conducted personal door-to-door visits to build trust, record baseline water and gas meter readings, measure baseline shower and kitchen tap flow rates, and complete the digital questionnaire (I1). To ensure installation consistency and data reliability, two dedicated contact persons installed the CF across 50 participating homes (I1). CEW and Cenergist conducted a second visit one month post-installation to record intermediate meter readings (I1). A final visit occurred after two months to record final meter readings, re-assess household habits, and administer a digital tenant satisfaction survey measuring comfort loss, flow changes, and overall recommendations (I1) (van de Griend & Stoker, 2024).

In the evaluation phase, CEW processed and statistically analysed the meter data and survey responses, after which a report was produced and published (I1, I4). The results demonstrated gas savings, an average water saving of 10.3%, together with generally positive tenant feedback (I1, I4) (van de Griend & Stoker, 2024). Based on these findings, WoonFriesland evaluated the project as successful. Participating residents were not directly informed of the final published research results (I4). However, a survey was put out by Huurdersbelang Fryslân to ask the opinions of residents on the broader implementation of the product and afterwards it was decided to implement the CF across 300 to 400 housing units on Ameland (I1, I2, I4).

Co-creation occurred mainly between Cenergist and CEW (I1). WoonFriesland was consulted during the project, but was not directly involved in designing and implementing the project (I4). The residents were informed of the research design and were consulted during the implementation phase (I1, I4). The methods used during this project were again quite narrow (I1). Residents were involved through door-to-door visits and surveys, while other stakeholders mainly communicated through meetings (I1, I4). During this project end-users were engaged late in the process and were not informed of the results (I4).

Residents of other housing units were consulted after the project was finished.

Types of success

Table 4.5 illustrates the definitions of success and intended scaling pathways during the second CF project in Leeuwarden.

Project 2 showed a shift in scope compared to Project 1 (I1, I4). While Project 1 at Dreamhûs focused on determining how low water pressure could be turned down before tenant comfort was compromised, Project 2 focused on evaluating real-world water and natural gas savings and overall tenant satisfaction under standard, real-world social housing conditions (I1, I4). Cenergist defined success as commercial validation and proving operational performance in real domestic environments (I1). CEW defined success through carrying out objective, scientific research (I1, I4). WoonFriesland required evidence-based confirmation that installing the device at a

ACTOR	DEFINITION OF SUCCESS	TYPE OF SCALING	SOURCES
Cener-gist	Objective evidence that CF saves water and energy in Dutch homes without com-promising comfort; create a credible basis for market adoption.	**Spreading**: Wider adoption across Dutch social and private housing stock. **Broadening**: Coupling water reduction with gas/energy savings and expanding to com-mercial sectors (e.g., hotels, leisure). **Deepening**: Shifting industry standards away from high-flow norms.	I1, I4, van de Griend & Stoker, (2024)
CEW	Generating objective, scientif-ically sound empirical evi-dence on water savings, gas reduction, and tenant comfort to provide an independent basis for decision-making.	**Deepening**: Developing robust scientific measurement methodologies and objective evidence on flow-limitation impacts. **Broadening**: Disseminating research findings to inform housing associations, municipali-ties, and drinking water policy.	I1, I4, van de Griend & Stoker, (2024)
Woon-Friesland	Evidence sufficient to make confident housing-imple-mentation decisions without unacceptable tenant comfort or maintenance risks.	**Spreading**: Rollout across housing associa-tion stock. **Broadening**: Integrating water/energy conservation into corporate housing sustain-ability goals. **Deepening**: Transforming internal mainte-nance routines and tenant comfort policies.	I1, I4, van de Griend & Stoker, (2024)
Tenants Leeuwar-den	Lower utility bills, a safe and comfortable testing experi-ence, no disruption to daily living routines, and transpar-ent communication.	n.a.	I1, I4

Table 4.5: The definitions of success from stakeholders and the related types of scaling in project 2 of the Control Flow

standard setting would achieve meaningful water and energy savings without provoking tenant complaints or maintenance issues (I4). Tenants of housing units defined suc-cess through lower utility costs, uncompro-mised daily comfort, and minimal disruption during door-to-door installation visits (I1, I4).

This progression illustrates how deepening in a protected space (discovering comfort limits in CF 1) enables spreading (testing actual volume savings in 150 homes in CF 2) (I1, I4).

CEW's report confirmed a 10.3% average water saving and tenant acceptance (I1, I4) (van de Griend & Stoker, 2024). Because of these results, WoonFriesland decided to im-plement the CF across 300 to 400 housing units on Ameland, meaning the project led to successful spreading (I1, I4).

Power imbalances

As shown in Table 4.6, CEW and Cenergist shared the responsibility of designing the project and executing it (I1, I4). The analysis was done by CEW (I1, I4) (van de Griend & Stoker, 2024). As Cenergist funded the research, they had formal authority over the decisions being made and decided what was relevant to test (I1). However, as WoonFriesland controlled an important resource: the testing location, they had influence over the decisions being made as well (I4). The residents were informed of the product before being asked to participate (I1, I4). They were not compensated for their participation other than potentially saving money because of the product, but were free to decide whether they wanted to participate (I4). Furthermore, they were not asked to be a part of the design of the project (I1, I4). They were able to give feedback through a quantitative survey, but were not asked further questions and were not informed of the outcomes of the research project (I4).

ACTOR	RESOURCES	FORMAL AUTHORITY	APPROACH	SOURCES
Cenergist	**Technical**: controls product knowledge, installation options and experimental decisions; **Social**: company network; Institutional: formal authority to make decisions about the product and research.	Can design the project; can solely make design decisions about the product; can decide who is involved within the project.	Contacted CEW first; then TGV/ WoonFriesland through network.	I1, I4, van de Griend & Stoker, (2024)
WoonFriesland	**Institutional**: controls access to the testing location and implementation decisions afterwards; **Financial**: is a potential buyer of the product.	Gives green/red light on whether the testing at Dreamhûs will take place and will be implemented at Leeuwarden.	Approached by Cenergist after CEW research planning.	I4, I7, van de Griend & Stoker, (2024)
CEW	**Technical**: water-technology research expertise; **Institutional**: research credibility.	Gets decision-making power over the design of the project from Cenergist.	First stakeholder contacted by Cenergist for research.	I1, I4, van de Griend & Stoker, (2024)
Resident Leeuwarden	**Social**: user experience.	Has no direct decision-making power over the project.	Contacted by Cenergist through contacts of WoonFriesland.	I1, I4

Table 4.6: The resources and formal authority of stakeholders within project 2 of the Control Flow along with the way they were approached to join the project.

4.3.5 PROJECT 3: TESTING AT THE GREEN VILLAGE AGAIN

A third project was started when an employee of TGV saw that a new subsidy was available with the theme of water conservation and they thought of the CF (I3). Due to the bankruptcy of Cenergist, the CF was represented by another company: KDWS, a consulting company on drinking water safety (I3). Next to KDWS, TGV contacted several stakeholders who might benefit from saving drinking water and would be interested in doing research into the product and setting up pilot projects at a later stage (I3). Taking on the role of coordinator is not a very usual approach for TGV as it is very intensive, and they do not always have the time to do so (I3)

The goal of this new project was to gain more scientific insights on the use of the product in different scenarios (I3). After data is gathered in Dreamhûs, models will be made based on this data to predict the impact it will have on the area's development (I3). Based on these insights, conclusions will be drawn and a manual will be written (I3). The product will be installed in Dreamhûs and if the test results are positive, it will be implemented in buildings as a pilot project after the research at TGV is done (I3, I5, I6).

This time, several new stakeholders are involved in the project (I3). A project team was set up with KDWS, the new product representatives, after Cenergist went bankrupt (I3). Furthermore, scientists from TU Delft and Rotterdam University of Applied Sciences are involved in setting up a scientific testing procedure (I3). The municipality of Katwijk is involved in the project as they hope to implement it in buildings in their area (I6). They also asked building company BPD to join the project (I6). Together with building company Heijmans, they might implement the CF in new construction projects if the results are positive (I5, I6). Dunea offers insights as they supply drinking water to households in the province of South Holland (I3) (Dunea, n.d.). Lastly, &Flux provides process leadership and knowledge on governance and policy (I3). Furthermore, &Flux is in contact with municipalities, developers, housing authorities, provinces, and water suppliers on how to save drinking water through an initiative called 'Bouwtafel Waterzuinige Wijken' (I3).

After the subsidy was obtained, the project started in March of 2026 and will run for 2 years (I3). As this information has been gathered (until August 2026), only 2 official meetings have taken place with the whole project team (I3). After the project started, and the CF needed to be installed at Dreamhûs, it became clear that it is useful to include the perspective of an installer in the project (I3, I5). That is why Heijmans contacted the installer Breman, who might join the project team (I3, I5).

Outside of the project team, some other stakeholders are involved in the project; the province, water authorities and residents of Dreamhûs might be consulted at different phases throughout the project (I3). TGV explained that the level of involvement of stakeholders relates to how urgent the problem of saving water is to them (I3). For example, municipalities have an urgent capacity problem with sewer pipes, which means that they are very interested in saving water and have a high level of involvement (I3). The province, however, has a policy to save drinking water, but this is less urgent for them. Therefore, they have a lower level of involvement in the project (I3).

Stakeholder involvement

Relevant stakeholders and stakeholder networks

Within project 3 of CF, 15 stakeholders were identified across all 4 Quadruple Helix categories (see Table 4.7). Most of the actors (TGV, &Flux, Dunea, BPD, Heijmans, Breman, TU Delft, Rotterdam University of Applied Sciences, & the municipality of Katwijk) are part of a project team, organised by TGV (TKI Bouw en Techniek, 2026). The actors that were interviewed are shown with an interviewee ID in the table.

To create Table 4.7, a broader rudimentary actor and network analysis was performed (see Appendix C.1). Their roles and objectives were identified together with their sources of power and resources.

After Cenergist's bankruptcy, KDWS took over the representation of the product (I3). They contribute expertise in drinking-water safety and plumbing engineering (KDWS, 2025). TGV acts as the primary intermediary and field-lab operator (I3).

&Flux brings expertise in governance and policy, and provides network brokering capabilities through their connections with actors connected to 'Bouwtafel Waterzuinige Wijken' (I3).

Real estate developers BPD and Heijmans plan to select pilot locations for the CF and evaluate how validated CF configurations can be embedded into standard residential new-build concepts (I3, I5). Heijmans brought plumbing contractor Breman into the project team to assess on-site installation (I5). Regional drinking-water company Dunea contributes technical system knowledge to evaluate how domestic flow regulation affects regional distribution pressure and grid management (I3).

TU Delft and Rotterdam University of Applied Sciences supply the methodological authority and scientific rigour required to build robust testing protocols in Dreamhûs (I3).

The Municipality of Katwijk serves as a prospective public adopter and boundary spanner, seeking empirical evidence to justify municipal water-conservation policies (I6). The Province of South Holland and Water Board Delfland provide policy and water-management perspectives, ensuring experimental outcomes align with broader regional spatial planning and climate adaptation agendas (I3).

Dreamhûs partners (WoonFriesland, Bouwgroep Dijkstra Draisma, and Huurdersbelang Fryslân), grant access to Dreamhûs (I4). Dreamhûs tenants provide direct user data by using the product (I3). Finally, future residents of Katwijk represent the ultimate end-user group. Their opinions on comfort and affordability can determine the feasibility of broader deployment.

Figure 4.10 visualises the social network structure of CF project 3 based on the actor and network analysis. It shows that the project team is strongly connected. There are some outliers like the province, water boards or Breman, whose connections to the project team are less strong. Furthermore, community actors like the residents of Dreamhûs and Katwijk are less connected to the project team. They are strongly connected to only a few actors in the network.

STAKE-HOLDER	QUADRUPLE HELIX CATE-GORY	ROLE WITHIN THE PROJECT	RESOURCES	INTER-VIEWEE ID	SOURCES
TGV	Academia	Field-lab operator; facilitator of experimentation.	**Institutional**: controls access to Dreamhûs and field-lab procedures; **Social**: extensive stakeholder network; **Technical**: knowledge of experimentation and test set-up.	I2, I3	I2, I3, I7
Woon-Friesland	Industry	Dreamhûs partner; decides what projects will take place.	**Financial**: funds Dreamhûs and can decide whether the product will be bought; **Institutional**: controls access to Dreamhûs and implementation decisions afterwards.	I4	I4
Bouwgroep Dijkstra Draisma	Industry	Dreamhûs partner; decides what projects will take place.	**Financial**: funds Dreamhûs; **Institutional**: controls access to Dreamhûs and implementation decisions afterwards; **Technical**: construction knowledge.	--	I2, I4
Huurders-belang Fryslân	Community	Dreamhûs partner; decides what projects will take place.	**Financial**: funds Dreamhûs; **Institutional**: controls access to Dreamhûs and implementation decisions afterwards; **Social**: representation of the tenants.	--	I2, I4
Tenants of Dreamhûs	Community	Testing the Control Flow within Dreamhûs.	**Social**: contributes user experience.	I7	I7
KDWS	Industry	Product representative after Cenergist bankruptcy.	**Technical**: product/advisory expertise; **Social**: sector network; **Institutional**: credibility in drinking-water safety.	--	I1, I3, (KDWS, 2025)
\&Flux	Industry	Provide knowledge on governance and financing. Share findings with network.	**Social**: network access and stakeholder connections; **Institutional**: influence over consortium/network process.	--	I3
Dunea	Industry	Drinking-water supplier.	**Institutional**: position in drinking-water provision; **Technical**: water-system knowledge; **Social**: sector network.	--	I3, (Dunea, n.d.)
BPD	Industry	Property developer.	**Technical**: construction/development knowledge; **Institutional**: control over pilot location; **Social**: development network.	--	I6

Table 4.7: Relevant stakeholders within project 3 of testing the Control Flow.

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STAKE-HOLDER	QUADRUPLE HELIX CATE-GORY	ROLE WITHIN THE PROJECT	RESOURCES	INTER-VIEWEE ID	SOURCES
Heijmans	Industry	Construction company; poten-tial implementation partner.	**Technical**: construction and installation knowledge; **Institutional**: ability to embed technology in projects; **Social**: access to development and installer network.	I5	I5
Breman	Industry	Installer	**Technical**: installation knowledge and practical constraints; **Social**: contractor network.	--	I3, I5
TU Delft	Academia	Scientific research partner.	**Technical**: scientific expertise and methodological authority; **Institutional**: university credibility.	--	I3
Rotterdam University of Applied Sciences	Academia	Research partner in new con-sortium.	**Technical**: scientific expertise and methodological authority; **Institutional**: research legitimacy.	--	I3
Province	Government	Public authority.	**Institutional**: public authority and policy influence; **Techni-cal**: knowledge on policies; **Social**: public-sector network.	--	I3
Water Board Delfland	Government	Public water-management actor.	**Institutional**: public role; **Technical**: water-system expertise.	--	I3
Municipality of Katwijk	Government	Potential public adopter; policy actor.	**Institutional**: policy-making and public procurement/im-plementation influence; **Social**: local stakeholder network; **Technical**: contextual knowledge.	I6	I6
Residents of Katwijk	Community	Future user group.	**Social**: lived experience.	--	I6

Table 4.7: Relevant stakeholders within project 3 of testing the Control Flow.

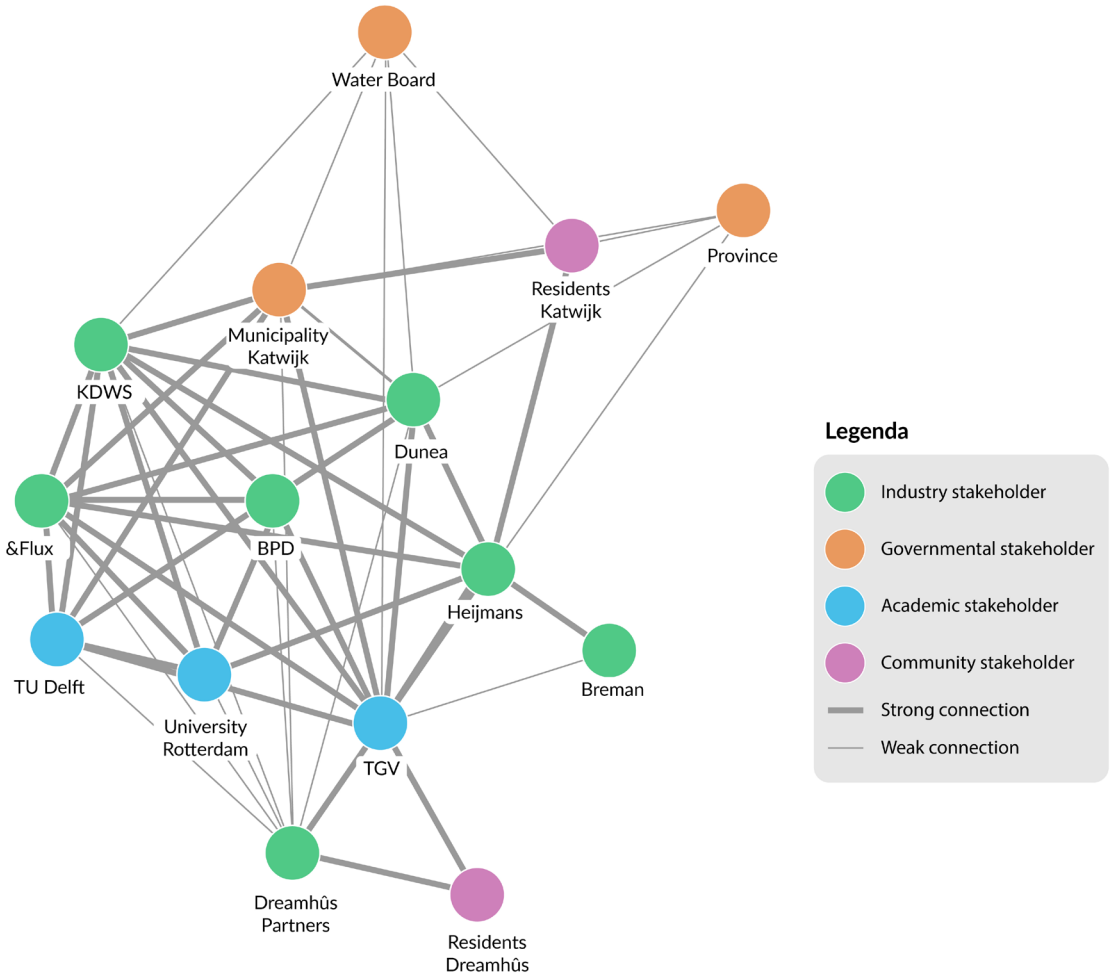


Figure 4.10: Social Network Diagram visualising relationships between relevant actors for project 3 of the Control Flow.

Timing and forms of stakeholder involvement

Figure 4.11 shows how and when stakeholders have been involved throughout the project. This Figure has been created using interview data, which can be found in Appendix D.1.3.

Since the third project has just started, it is not clear what is going to happen in the implementation and evaluation phases yet (I3). However, TGV started this project and worked on the design of the project together with all project partners (I3). 2 meetings have taken place with project partners to decide upon the project design (I3). Dreamhûs partners will be consulted, as the project will take place at Dreamhûs (I3, I4). Stakeholders outside of the project team, such as the residents of Dreamhûs and the province and water boards, are not yet participating (I3). Residents will be informed whenever the project design is clear (I3, I7). The province and water boards will only be contacted whenever there are specific questions from the project team (I3).

Co-creation is likely to take place between the members of the project team (I3). Parties like the residents and province or water boards might be consulted during the implementation phase of the project (I3). The methods used up until now have been

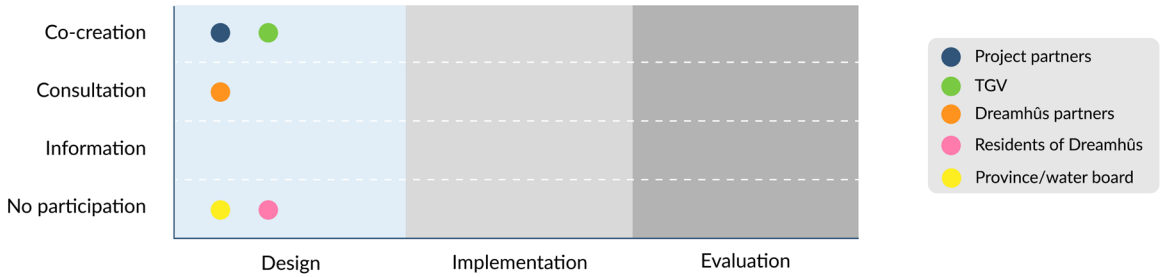


Figure 4.11: The level of involvement of stakeholder during different stages of project 3 of the Control Flow.

quite narrow (I3). TGV mentioned that they usually differ the communication method based on the preference of stakeholders or on the type of communication that needs to be done (I3). Furthermore, they try to imagine how pressing the issue is for each stakeholder and include them accordingly (I3).

Types of success

Table 4.8 outlines the success definitions for the third CF project. Project 3 represents a transition in project design compared to CF 1 and CF 2 (I3). The core objective expanded from product validation to generating comprehensive scientific insights, creating predictive models for regional water balances, and co-authoring a practical manual for water-conscious neighbourhood design (I3).

The multi-actor structure creates different definitions of success. Commercial and public partners (Heijmans, BPD, Breman, Municipality of Katwijk) aim for physical replication (spreading) by transitioning validated variants from TGV testbed scenarios into future residential construction projects in Katwijk (I3, I5, I6). Public authorities and utility providers (Dunea, Municipality of Katwijk, and &Flux) view success through broadening. By using empirical data to align with drinking-water scarcity policies, and regional area-development guidelines (I3, I6). Knowledge institutions (TU Delft, Rotterdam University of Applied Sciences) and technical leads (KDWS) focus on deepening by building robust models and technical safety benchmarks (I3).

Power imbalances

In the third project, TGV initiated the project and invited several stakeholders to join a project team (I3). TGV possesses the strongest formal authority within the project as they were the initiator of the project and have control over the testing environment (I3) (see Table 4.9). However, they balance power within the project team (I3). They mention that they would not feel comfortable making decisions that the other project team members do not agree with (I3). The other team members that were interviewed also perceive the decision-making process as democratic (I5, I6). The residents of Dreamhûs and Katwijk do not have influence over the design of the project (I3, I6, I7). One of the project team members mentioned they did think about what they would prefer themselves, as they all are potential users and changed their decision-making process based on it (I6). However, since they will not be subjects of the research project, they cannot fully provide their perspective. Furthermore, the other actors all have different objectives they want to achieve that do not match the objectives of the residents (I3, I5, I6).

ACTOR	DEFINITION OF SUCCESS	TYPE OF SCALING	SOURCES
TGV	Successfully coordinate a multi-stakeholder consortium, secure scientific data and transition proven CF variants from TGV to a real-world municipal pilot in Katwijk.	**Spreading**: Moving tested variants from TGV to pilots . **Broadening**: Brokering a broad consortium across public, private, and research domains.	I3, I7
Dream-hûs Partners	Provide a safe testing location and assess whether outcomes can inform future housing construction standards.	**Spreading**: Potential future integration across housing association stock.	I4
Dream-hûs Residents	A safe, comfortable testing experience across changing pressure scenarios with no disruption to domestic routines.	n.a.	I7
KDWS	Re-establish CF technical credibility after Cenergist's bankruptcy, and provide water-safety expertise for the practical manual.	**Spreading**: Re-opening Dutch commercial adoption pathways. **Deepening**: Developing standardized technical flow and drinking-water safety guidelines.	I3
&Flux	Create a scalable solution to save drinking water. Share these findings with members of 'Bouwtafel Waterzuinige Wijken' network to further support the innovation.	**Broadening**: Disseminating project findings across the members of the Bouwtafel network to integrate water-saving guidelines into standard spatial development and municipal policy frameworks.	I3
Dunea	Evaluate how household flow restriction impacts drinking-water distribution systems and supports regional water conservation goals.	**Broadening**: Aligning domestic water-reduction technologies with utility management policy and regional scarcity agendas.	I3
BPD	Identify technically viable and cost-effective CF installation variants to incorporate into standard new-build residential area developments.	**Spreading**: Rollout of CF across new-build residential projects. **Deepening**: Embedding water conservation into standard property development design templates.	I3, I6
Heijmans	Identify technically viable and cost-effective CF installation variants to incorporate into standard new-build residential area developments.	**Spreading**: Rollout of CF across new-build residential projects. **Deepening**: Embedding water conservation into standard property development design templates.	I3, I5
Breman	Ensure flow-limiting devices are practically installable, maintainable, and cost-effective for plumbing contractors during construction.	**Spreading**: Installer-level replication across housing projects. **Deepening**: Transforming standard plumbing installation routines and technical protocols.	I3
TU Delft	Develop robust scientific testing procedures, build predictive models for area-development water balances, and publish academic research.	**Deepening**: Advancing scientific modeling of urban water systems and evidence-based standards.	I2, I3

Table 4.8: The definitions of success from stakeholders and the related types of scaling in project 3 of the Control Flow

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ACTOR	DEFINITION OF SUCCESS	TYPE OF SCALING	SOURCES
Rotterdam University of Applied Sciences	Develop robust scientific testing procedures, build predictive models for area-development water balances, and publish academic research.	**Deepening**: Advancing scientific modelling of urban water systems and evidence-based standards.	I3
Province (South Holland)	Obtain empirical evidence on household water reduction to inform regional spatial planning and climate adaptation policies.	**Broadening**: Integrating water conservation data into regional policy frameworks and subsidies.	I3
Waterboard (Rijnland)	Assess whether household water reduction supports regional water balance strategies without causing sewer or system performance issues.	**Broadening**: Incorporating flow-limiting innovations into regional public water-management policies.	I3
Municipality of Katwijk	Determine how CF can be incentivised through municipal policy.	**Spreading**: Future pilot deployment in housing developments in Katwijk. Broadening: Formulating municipal policies for water-conscious urban development.	I3, I6
Residents of Katwijk	Ensure high indoor water comfort, lower utility costs.	n.a.	I6

Table 4.8: The definitions of success from stakeholders and the related types of scaling in project 3 of the Control Flow

ACTOR	RESOURCES	AUTHORITY	APPROACH	SOURCES
TGV	**Institutional**: controls access to Dreamhûs and field-lab procedures; **Social**: extensive stakeholder network; **Technical**: knowledge of experimentation and test set-up.	Has veto power. Can decide which projects are run and which are not. Has power over who is included in project 3.	Approached by WoonFriesland in project 1. Initiated contact in project 3.	I2, I3, I7
&Flux	**Social**: network access and stakeholder connections; **Institutional**: influence over network process.	Gets decision-making power over the design of the project from TGV.	Connected through TGV's stake-holder network.	I3
Dream-hûs	**Financial:** funds/controls Dreamhûs; **Institutional:** controls access to Dreamhûs and housing stock and implementation decisions; **Social:** representation of tenants; **Technical:** operational knowledge of housing, construction knowledge.	Gives green/red light on whether the testing at Dreamhûs will take place and will be implemented at Leeuwarden.	Approached by Cenergist after CEW research planning.	I2, I3, I4
Dunea	**Institutional**: position in drinking-water provision; **Technical**: water-system knowledge; **Social**: sector network.	Gets decision-making power over the design of the project from TGV, together with other project partners.	Contacted as relevant drink-ing-water stakeholder in new consortium by TGV.	I3
BPD	**Technical**: construction/development knowledge; **Institutional**: control over pilot location; **Social**: devel-opment network.	Gets decision-making power over the design of the project from TGV, together with other project partners.	Put forward by Municipality of Katwijk.	I3, I6
Heijmans	**Technical**: construction and installation knowledge; **Institutional**: ability to embed technology in projects; **Social**: access to development and installer network.	Gets decision-making power over the design of the project from TGV, together with other project partners.	Already connected to TGV; later contacted by TGV.	I3, I5
KDWS	**Technical**: product/advisory expertise; **Social**: sector network; **Institutional**: credibility in drinking-water safety.	Gets decision-making power over the design of the project from TGV, together with other project partners. Controls the rollout of the product.	Became representative of CF after Cenergist bankruptcy. Was contacted by TGV.	I3, I5

*Table 4.9: **The resources and formal authority of stakeholders within project 3 of the Control Flow along with the way they were approached to join the project.***

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ACTOR	RESOURCES	AUTHORITY	APPROACH	SOURCES
Breman	**Technical**: installation knowledge and practical constraints; **Social**: contractor network.	Gets decision-making power over the design of the project from TGV, together with other project partners.	Contacted by Heijmans when installation perspective became relevant.	I3, I6
TU Delft	**Technical**: scientific expertise and methodological authority; Institutional: university credibility.	Gets decision-making power over the design of the project from TGV, together with other project partners.	Approached by TGV.	I3
Rotterdam University of Applied Sciences	**Technical**: scientific expertise and methodological authority; **Institutional**: research legitimacy.	Gets decision-making power over the design of the project from TGV, together with other project partners.	Approached as research partner.	I3
Province	**Institutional**: public authority and policy influence; **Technical**: knowledge on policies; **Social**: public-sector network.	Has no direct decision-making power over the project.	Consulted through TGV/project network.	I3
Water authority	**Institutional**: public role; **Technical**: water-system expertise.	Has no direct decision-making power over the project.	Consulted through TGV/project network.	I3
Municipality of Katwijk	**Institutional**: policy-making and implementation influence; **Social**: local stakeholder network; **Technical**: contextual knowledge.	Gets decision-making power over the design of the project from TGV, together with other project partners.	Telephone contact from TGV.	I3, I6
Resident Katwijk	**Social**: user perspective.	Has no direct decision-making power over the project.	Not substantially approached yet; future involvement planned.	I6
Resident Dreamhûs	**Social**: user perspective.	Has no direct decision-making power over the project.	Involved through Dreamhûs.	I2, I3, I7

*Table 4.9: **The resources and formal authority of stakeholders within project 3 of the Control Flow along with the way they were approached to join the project.***

4.4 GEODESIGN BARRIERS AT THE GREEN VILLAGE

This section will explain what the innovation and context of the second case study entail. After the context is described, the 3 sub-research questions will be answered.

4.1.1 WHAT IS THE GEODESIGN BARRIER

The GeoDesign Barrier is a mobile flood barrier (MFB). When the Netherlands is in danger of flooding due to extreme weather, usually sandbags are used to protect buildings from water coming in. However, this method is not ideal (I8, I10). While it is relatively cheap, working with sandbags is heavy work, takes relatively long, they must be laid in a specific way for it to work, cleaning up the sandbags can be problematic, and they can only be used once (Heil, n.d.; STOWA, n.d.-b, 2025).

Therefore, the interest in MFBs has grown (I8, I10) (STOWA, 2025). MFBs are often stronger, protect for longer periods of time, are easier and quicker to set up, can be reused and take up less space to store. However, it is more expensive and they are not suitable in every situation (STOWA, n.d.-b). Furthermore, it is important to practice with setting up the product; otherwise, it is not likely to be used in critical situations (I8).

One of these MFBs is the 'GeoDesign Barrier' (see Figure 4.12). It was developed in Sweden over 30 years ago (I10). Since then, it has been purchased in the VS, UK and the Netherlands by companies such as ExxonMobil, Duke Energy, ASML, and the Water Board of Limburg.

The GeoDesign Barrier comes in different heights for different applications of the product. The lower heights are quicker to set up and are more suitable for homeowners, municipalities, or companies, while the higher heights take longer to set up, but can be used in extreme situations (GeoDesign Barriers, 2025; STOWA, 2025).

4.1.2 HOW THE PROJECT CAME TO BE

After extreme flooding took place in Limburg in 2021, the Water Board of Limburg decided to look for a suitable MFB (I8, I10). They organised testing days, in which selected producers could showcase their products (I8). After those testing days, they put out a tender with the help of European subsidies (I8). One of the MFBs that was submitted for the tender was the GeoDesign Barrier (I8, I10) (STOWA, 2025).



Figure 4.12: The GeoDesign Barrier (GeoDesign Barriers (2025).

The water board had set up a list of requirements for the barriers, including that the product needed to be reusable (I8, I10). To meet the requirements, some changes needed to be made to the design of the GeoDesign Barrier (I8, I10). However, in order for them to know if the changes worked, they needed to be tested (I8, I10).

One of the locations where MFBs can be tested is Flood Proof Holland (FPH), a testing ground connected to TGV & TU Delft (I8, I9, I10). Several producers of MFBs have tested their products here, and several parties, such as water boards and the military, come to practice setting up different types of barriers to be prepared (I8, I9, I10). Furthermore, research is being done by STOWA in collaboration with TU Delft and TGV on flooding at FPH, since various situations can be simulated here (I9). STOWA

recently released a report in collaboration with Deltares on the requirements of MFBs and whether they are functional on different types of terrain (I9) (Förster, 2026). For this report, FPH was an important testing location (I9).

GeoDesign Barriers have tested some changes in materials for the tender in Limburg at FPH (I8, I10). The changes were successful, and they won the tender (I8, I10). They have now supplied the water board with multiple kilometres of MFB (I8, I10). They are the first water board in the Netherlands with this amount of mobile flood barrier in their possession (I8, I10). As Water Board Limburg noted (I8):

"*Following the 2021 floods in Limburg, we conducted a market consultation and a competitive bidding process for mobile flood barriers... We needed to find solutions that could be deployed more quickly and were reusable. GeoDesign Barriers adapted their product to our requirements and tested it at Flood Proof Holland. We are now the first to have so many kilometres of mobile flood barriers in stock.*"

4.4.3 THE ROLE OF THE GREEN VILLAGE

TGV takes a different approach to MFBs compared to their other cases (I8, I9, I10). All entrepreneurs are still supervised by someone from TGV, and research is being done on the barriers together with researchers and students from TU Delft (I10). However, TGV addresses the problem of increased risk of flooding more comprehensively (I9, I10). They do not only provide a location for testing products and doing research, but they also organise events that inform actors who could have an impact about the problem and different possibilities, with the hope that they will take action (I9, I10). For example, they organised a visitor day on the alternatives to sandbags together with the Water Board of Delfland and STOWA (I9) (STOWA, n.d.-a). Other water boards, Deltares, EDF and other international contacts were invited (I9). Furthermore, they organise demonstrations where entrepreneurs are invited to showcase their barriers to several parties (I9, I10). But this is not all; they also invite insurers like Nationale Nederlanden to discuss what role they might play in the future in relation to flooding (I9, I10). They are interested in exploring this because they paid compensation for the flooding in Limburg, but do not want to do this in the future (I9, I10). Therefore, they need to understand what needs to be done to prepare for those situations and what role MFBs could play (I9, I10). Despite these efforts, the barriers are not yet widely adopted in the Netherlands (I8, I9, I10). Reasons that are mentioned are that it is difficult to trust a new product, the price of the product, not prioritising protection for flooding because people do not expect flooding to happen in their own area, or it is not always clear who is responsible for buying and managing the product (I8, I9, I10).

For the remainder of this report, this case will be referred to by the abbreviation MFB.

4.4.4 STAKEHOLDER INVOLVEMENT

Relevant stakeholders and stakeholder networks

Several stakeholders can play a role when trying to scale MFBs (see Table 4.10). Important stakeholders identified are: GeoDesign Barriers, TGV, TU Delft, Water Boards, Insurers, STOWA, and other potential buyers. The actors that were interviewed are shown with an interviewee ID in the table.

STAKEHOLDER	QUADRUPLE HELIX CATEGORY	ROLE WITHIN THE PROJECT	RESOURCES	INTERVIEWEE ID	SOURCES
GeoDesign Barriers	Industry	Product developer/manufacturer; adapts, tests, and demonstrates mobile barriers at FPH to meet market and tender specifications.	**Technical**: owns product expertise and decides product adaptations; **Institutional**: has authority to make decisions on alterations and research objectives.	I10	I10
Water Boards within the Netherlands	Government / Community	Flood-risk managers and potential buyers; define operational needs and attend demonstration days.	**Institutional**: flood-management mandate and public responsibilities; **Financial**: potential procurement budgets; **Social**: can influence opinions of other waterboards.	--	I8
Water Board Limburg	Government / Community	Public buyer/end-user; conducted market consultation, formulated tender requirements, and procured mobile barriers following the 2021 floods.	**Financial**: procurement budget; **Institutional**: flood-management role and tender authority; **Technical**: ability to define technical requirements; **Social**: can influence opinions of other waterboards.	I8	I8
Potential Buyers: airports, hospitals etc.	Industry / Community	Prospective commercial end-users needing site-specific physical protection for assets.	**Financial**: control budgets.	--	I10
Insurers	Industry	Secondary commercial actor interested in flood damage prevention, risk mitigation, and claims reduction strategies.	**Financial**: influence through insurance claims prevention; **Institutional**: risk assessment mechanisms.	--	TGV
STOWA	Academia	Knowledge broker for Dutch water boards; funds and coordinates research projects, demonstration days, and technical guidance reports.	**Technical**: research and knowledge expertise; **Social**: sector network; **Institutional**: convening role among water boards.	I9	I9
TU Delft	Academia	Academic research partner; conducts scientific testing and technical evaluations at Flood Proof Holland.	**Technical**: scientific flood-risk knowledge; **Institutional**: research legitimacy and academic credibility.	--	I9, TGV
TGV	Academia	Operates FPH, coordinates visitor and demonstration days, and connects barrier developers with public authorities.	**Institutional**: controls FPH facility; **Social**: connects actors and organises access; **Technical**: testing infrastructure.	--	TGV

Table 4.10: Relevant stakeholders within Mobile Flood Barriers.

To create Table 4.10, a broader rudimentary actor and network analysis was performed (see Appendix C.2). Their roles and objectives were identified together with their sources of power and resources.

GeoDesign Barriers offers the product, while water boards are the main parties that are interested in buying it (I8, I10). STOWA provides scientific information on the barriers and informs water boards on how they can be used (I9). Next to water boards, other possible buyers can be companies or hospitals trying to prepare for extreme weather (I10). The product is not focused on individuals, as it is relatively expensive, takes quite some place to store and it is complicated to build on your own (I10).

Within this project, individual citizens are absent because the MFB is purchased and managed at the institutional and regional level (I8, I9, I10). Therefore, water boards and companies take on the role of users (I8, I10).

Figure 4.13 visualises the social network structure of the Mobile Flood Barriers based on the actor and network analysis. It shows that several actors are connected to TGV. Only potential buyers outside of water boards are not closely connected to the TGV.

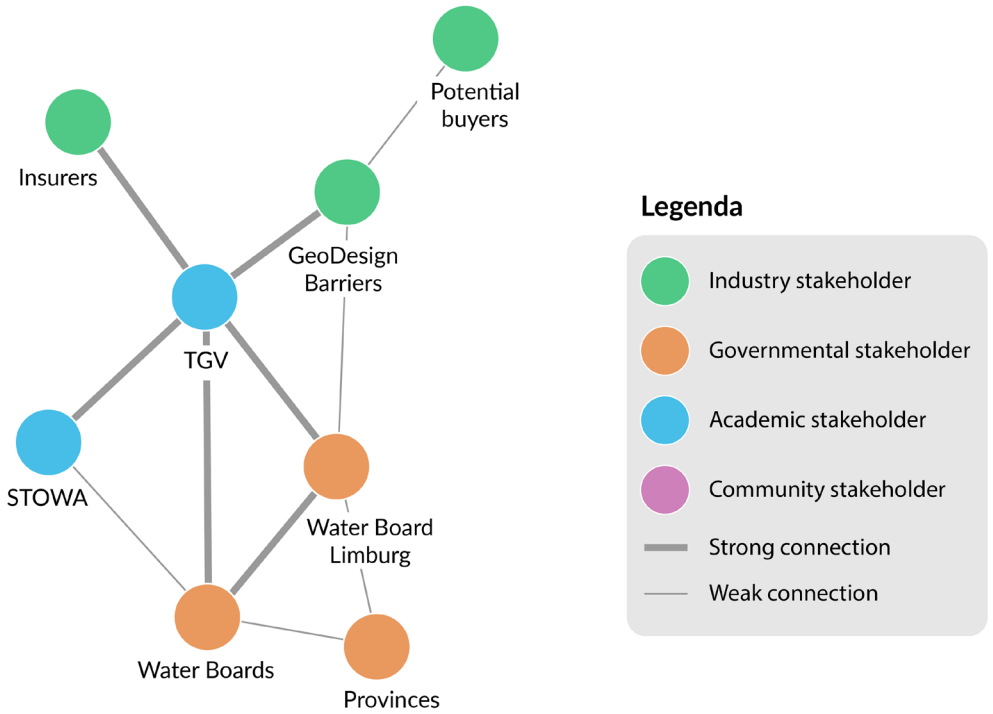


Figure 4.13: Social Network Diagram visualising relationships between relevant actors for Mobile Flood Barriers.

Timing and forms of stakeholder involvement

Unlike structured single-project pilots, stakeholder involvement in the MFB cannot be neatly divided into discrete phases. Instead, MFB focuses on physical testing, and live demonstrations (see Figure 4.14). The data on which this figure is based can be found in Appendix D.2.

TGV plays a central facilitating role by offering a physical location (FPH) where realistic flooding conditions can be simulated (I8, I9, I10). FPH serves as a platform bringing together technology developers, knowledge institutions, and public authorities (I8, I9, I10). Manufacturers, such as GeoDesign Barriers, use the facility to perform technical tests, validate



Figure 4.14: The level of involvement of stakeholder during different stages of Mobile Flood Barriers

performance, and adapt barrier materials to meet public specifications (I10). All manufacturers are supervised by someone from TGV and students and scientists from TU Delft do research on their products (contact with TGV). Knowledge organisation STOWA has been involved long-term at FPH, conducting scientific research on flood risk management together with TU Delft, organising dedicated demonstration days, and disseminating technical guidance to Dutch water boards (I9) (Förster, 2026; STOWA, n.d.-a).

Public authorities and prospective buyers engage mostly through demonstrations and information exchange (I8, I9, I10). Water boards are invited to FPH visitor days and demonstration sessions to observe barrier performance, compare different products, and practice emergency deployment routines (I8, I9). While stakeholder engagement is generally observational, crisis events can lead to actors wanting to buy the MFBs (I8, I10).

Other potential stakeholders, including insurers and emergency services, are periodically involved during visitor events to build broader awareness around flood risks and insurance coverage, though they do not participate in product co-design or technical decision-making on the MFBs (I9, I10). Overall, stakeholder inclusion relies on long-term relationship building, live demonstrations, and experiential learning rather than formal co-creation across sequential project phases (I8, I9, I10).

Co-creation mainly occurs between knowledge institutions (STOWA, TU Delft) (I9). The manufacturers of the barriers consult TU Delft and TGV, but have authority over what decisions are being made (I10). Water Boards are informed of what is going on at TGV during demonstration days (I8, I9). Several methods are being used to promote the MFBs (I9, I10). These include physical demonstrations, hands-on assembly practice, technical report dissemination (STOWA/Deltares guidelines) and visitor days (I9, I10). The methods used are tailored to the stakeholders (I9, I10). Most stakeholders have interacted with FPH over multiple years, but for some stakeholders (insurers, Water Board Limburg) their involvement is triggered unpredictably by landscape shocks (such as the flooding in Limburg in 2021) (I8, I10). While all actors of the quadruple helix model are involved with the problem, they are not all involved when testing and improving the products (I8, I9, I10).

4.4.5 TYPES OF SUCCESS

Table 4.11 gives the definitions of success and scaling pathways of key stakeholders in the Mobile Flood Barriers case.

Water boards across the Netherlands prioritise cost-effective flood protection that is easy to use and reliable (I8, I9). While the GeoDesign Barrier can provide this, widespread market adoption or spreading faces two obstacles:

1. Because MFBs represent a non-traditional flood defence mechanism, water boards remain hesitant about long-term reliability and deployment speed under crisis conditions (I8, I9).
2. Regional water authorities have limited budgets that block the purchase of MFBs (I8). However, water boards benefit from spreading primarily when it occurs through shared regional emergency depots. This allows barriers to be pooled and lent between water boards during extreme weather events instead of requiring individual investments (I8).

In contrast, end-use buyers care for localised protection rather than broader socio-technical scaling (I8, I10). Their definition of success is project-bound: securing reliable barriers to guarantee safety during flooding (I8, I10). These actors do not profit from systemic market growth (I8, I10).

Knowledge intermediaries such as STOWA target broadening and deepening by developing national technical guidelines, while TGV evaluates success by its ability to work together with several stakeholders and maintain FPH as an active demonstration platform connecting technology suppliers with public buyers (I9, I10).

4.4.6 POWER IMBALANCES

Power in the MFB case is divided across public authorities, knowledge institutions, and private manufacturers. It is not concentrated in a project team (see Table 4.12). Product developer GeoDesign Barriers has technical and institutional power over the product design and material modifications, choosing when and how to demonstrate its technology (I10). As GeoDesign Barriers noted regarding decision authority (I10):

"*TGV and TU Delft provide advice on how we can approach certain issues, but they never play a decisive role. Decisions regarding product modifications and commercial choices are made entirely by us.*"

Water boards hold financial and institutional power, control procurement budgets and define technical requirements (I8). Because water boards share information across regional networks, the decision of a pioneering board can influence sector-wide adoption (I8, I9). Other commercial buyers (airports, hospitals) hold private financial power, while insurers possess institutional power by setting coverage conditions and incentivising risk prevention (I9, I10).

TGV acts as a neutral intermediary; it has control over FPH and can organise demonstration and visitor days (I9, I10). Through collaboration with STOWA and TU Delft, objective research reports, instructional videos, and practical testing protocols for water boards are created, and advice is given to water boards (I9).

Despite knowledge sharing, decision-making authority over procurement remains concentrated among water boards (I8). Many water boards remain hesitant to purchase MFBs because of unfamiliarity with them and risk aversion (I8, I9). Water Board Limburg noted that because TGV is viewed as an objective, trustworthy actor with hands-on testing experience at FPH, water boards would benefit if TGV provided more direct, situational advice regarding which barrier types perform best under specific operational conditions (I8).

Because the MFB does not operate as a time-bound co-creation project (I8, I9, I10), inclusion is open and accessible. All interested public authorities, commercial vendors, researchers, and insurers are welcome to participate in FPH events and observe live testing (I8, I9, I10). However, formal decision-making power over product design is not shared or with the end-users (I8, I9). Stakeholders are consulted, but the focus lies on knowledge exchange and demonstrations rather than collaborative governance (I8, I9, I10).

ACTOR	DEFINITION OF SUCCESS	TYPE OF SCALING	SOURCES
GeoDesign Barriers	Commercial product acceptance, reliable operational performance during testing.	**Spreading**: Wider commercial adoption across regional water boards and private entities. **Deepening**: Building market trust and proving technical reliability via FPH.	I8, I9, I10
Water Boards	Deployable, reliable flood protection without excessive capital cost or operational complexity; establishing shared regional barrier reserves.	**Spreading**: Regional procurement and shared depot deployment **Broadening**: Embedding mobile barriers into regional emergency management protocols.	I8, I9, I10
Potential buyers: airports, hospitals, companies	Site-specific asset protection and risk mitigation against local flooding events.	**Spreading**: Localised adoption and physical barrier installation on commercial property.	I10
Insurers	Reduction of flood damage claims and enhanced risk prevention among commercial and private policyholders.	**Broadening**: Integrating mobile barrier adoption into underwriting criteria and risk models.	TGV
STOWA	Knowledge dissemination, objective evaluation, and building sector-wide awareness to encourage water boards to take action on mobile flood defences.	**Broadening**: Embedding technical insights into national guidelines and sector standards. **Deepening**: Shifting institutional mindsets regarding temporary flood defences.	I9
TGV	Provide a functional, realistic demonstration infrastructure (Flood Proof Holland) that connects technology developers with public and private buyers.	**Spreading**: Transitioning innovations from test site to real-world application. **Broadening**: Facilitating multi-actor networks across public authorities and industry.	I8, I9, I10
Water Board Limburg	Rapid procurement and stocking of reliable mobile barriers meeting strict tender criteria.	**Spreading**: Buying mobile flood barriers. **Deepening**: Developing internal operational routines and emergency deployment training.	I8

Table 4.11 The definitions of success from stakeholders and the related types of scaling in the Mobile Flood Barriers

ACTOR	SOURCE/TYPE OF POWER	AUTHORITY	APPROACH	SOURCES
GeoDesign Barriers	**Technical**: owns product expertise and decides product adaptations; **Institutional**: has authority to make decisions on alterations and research objectives.	Can solely make design decisions about the product; can decide whether they want to demonstrate their project.	Existing relationship with Flood Proof Holland/TGV in earlier projects; Limburg later invited them to participate in the tender.	I10
Water Boards	**Institutional:** flood-management mandate and public responsibilities; **Financial**: potential procurement budgets; **Social**: can influence opinions of other waterboards.	Can decide on requirements of the product and decide what will be purchased.	Invited by TGV and producers on demonstration days.	I10
Potential buyers: airports, hospitals, companies	**Financial**: control budgets.	Decides on what product is purchased.	Approach not established.	I10
Insurers	**Financial**: influence through insurance claims prevention; **Institutional**: risk assessment mechanisms.	Decide what risks will be covered in their insurance policy.	Invited by TGV for visitor days.	TGV
STOWA	**Technical**: research and knowledge expertise; **Social**: sector network; **Institutional**: convening role among water boards.	Decides what type of research projects will be done and what information will be shared with water boards.	Does research at FPH together with TU Delft. Organised a demonstration day at FPH, together with TGV.	I9
TGV	**Institutional**: controls FPH facility; **Social**: connects actors and organises access; **Technical**: testing infrastructure.	Decides the events that are organised around FPH and who is invited.	Existing field-lab network.	TGV
Water Board Limburg	**Financial**: procurement budget; **Institutional**: flood-management role and tender authority; **Technical**: ability to define technical requirements; **Social**: can influence opinions of other waterboards.	Authority to decide on requirements and winner of the tender.	Invited to FPH by TGV.	I8

Table 4.12: The resources and formal authority of stakeholders within the Mobile Flood Barriers along with the way they were approached to join the project.

4.5 DISTRICT HEATING NETWORK WITH ENERGIE LAB ZUIDOOST

This section will explain what the innovation and context of the second case study entail. After the context is described, the 3 sub-research questions will be answered.

4.5.1 WHAT DOES THE PROJECT ENTAIL

This project is part of the "Lage Temperatuur Warmtenetten" initiative under Energie-Lab Zuidoost (ELZO). The focus of the project is creating a collective district heating network (DHN) in the ArenAPoort and Amstel III neighbourhoods in Amsterdam, utilising waste heat from data centres (Energie Lab Zuid Oost, n.d.-e).

For the remainder of this report, this case will be referred to by the abbreviation DHN.

The project was initiated as Eleven Square, a development area in Amsterdam, tried to make the area as sustainable as possible and reach specific sustainability goals (I13). To reach those goals, they needed a sustainable heating source. Since Vattenfall already operated an existing district heating and cooling infrastructure in the area, the plan was to add a sustainable energy source to the existing infrastructure (I13). This sustainable energy source came from a local data centre. A Letter of Intent (LoI) was signed between a local data centre and the municipality that they would provide waste heat for this project (Correlje et al., 2025). To help Eleven Square with their sustainability goals, the municipality launched a procurement process: a construction team phase (I13).

Several departments of the municipality were involved in the project. Each with its own responsibilities:

- **Grond & Ontwikkeling (G&O)**: Acted as the primary client and commissioner of the public tender. G&O allocated the municipal co-funding, managed area development objectives, and set land-issuance conditions for real estate developers (I13).
- **Engineering Firm**: Executed the tender on behalf of G&O, performed initial technical and financial feasibility calculations, and provided the concession management team that actively represented the municipality inside the weekly construction team working sessions (I13).
- **Collectieve Warmte Amsterdam (CWA)**: Served as the dedicated municipal program team designated to take over formal contract management, operational oversight, and concession ownership once the tender and construction team phase were finalised (I14).
- **Project Managers**: Managed the broader spatial development of Amstel III and ArenAPoort, making critical decisions regarding building plot releases, construction sequencing, and local spatial integration (I11).

The municipality set aside a budget of 4.5 million euros that was intended to bridge the initial investment risk of the energy companies. Instead of a traditional concession tender, the municipality selected a private energy company, Eteck, to collaboratively design the heating network, formulate a viable business case over a six-month period (Correlje et al., 2025). As energy companies are often not familiar with area development processes and area developers are often not familiar with heat networks, this way of working helped both parties (I14). The goal was to reach a mutually acceptable concession agreement for the construction of the network (Correlje et al., 2025). By including Eleven Square, Vattenfall and the data centre as launching parties that Eteck had to work with, this is an exceptional tender. Usually, the energy company has to decide with whom it wants to do business (I14).

Several critical stakeholders were involved. Eteck needed to establish agreements with both heat providers and heat consumers. On the provider side, Eteck explored extracting waste heat from local data centres, primarily an existing data centre called AM7 and a planned data centre called AM9, furthermore, Woodencity (an intended development partner from Eteck covering around 4,000 housing equivalents) also intended to build their own data centre. On the consumer side, potential off-takers included Eleven Square, Woodencity, and the Bullewijk district. Furthermore, Eteck engaged with Vattenfall, because they operate the existing district heating and cooling infrastructure in the area of Eleven Square (Correlje et al., 2025).

The collaborative process revealed external uncertainties and misaligned stakeholder arrangements. Woodencity went bankrupt, which significantly reduced projected heat demand. Negotiations with Vattenfall stalled since the tariffs they proposed to Eteck were unviable for Eteck's business case. Additionally, the technical demarcation points and extraction costs dictated by the data centre were unfavourable for Eteck and significantly more expensive than initially estimated. Because Eteck was unable to secure necessary subsidies without finalised contracts and definitive source selections, they concluded the business case was not commercially viable. Therefore, Eteck withdrew from the project in September 2024. Despite this, the municipality did attain 'learning success' by acquiring insights into the technical, financial, and organisational complexities of urban heating networks (Correlje et al., 2025).

4.5.2 THE ROLE OF ENERGIE LAB ZUIDOOST

The role of ELZO within this project is less obvious compared to TGV, because ELZO does not provide a testing location (I15). Through the connections of ELZO within the municipality of Amsterdam, researchers from AMS and TU Delft were allowed to be present at meetings with the building team (I13, I15). The Municipality of Amsterdam and Eteck were both interested in research insights and therefore both paid half of the costs of the research project. As ELZO Representatives highlighted (I15):

"*This entire research project wouldn't have been possible without Energie Lab Zuidoost... Because that trust in the ecosystem had been built up beforehand, researchers from TU Delft and AMS were allowed to sit in on all those construction team meetings as observers. It's not easy to get permission to join such a closed-door construction team.*"

The researchers did not coordinate the project or apply the ULLWOW, but were able to go in depth on the way of working within this project (I15). Since this project was one of the first projects done since ELZO was founded in 2020, the ULLWOW was not yet created (I15). But while the method was not used directly, the steps were implicitly applied (I15).

The research showed how several stakeholders were involved within the project (Correlje et al., 2025) and therefore is very relevant for this report as well.

Through ELZO, several other student research projects on the optimal configuration of heating networks (I15) (Duurzame warmte, 2026) were carried out; however, these research projects did not influence Eteck's decisions throughout the project (I15).

The goal of involving researchers in the project was to understand what can be learned from a project like this and share these insights with others so they can learn from it in further projects (I15). The research did not directly influence the decisions being made within the building team (I11, I13, I15).

4.5.3 STAKEHOLDER INVOLVEMENT

Relevant stakeholders and stakeholder networks

Table 4.13 shows what stakeholders were involved during the project on the district heating network. For this case, the relevant stakeholders identified are: the municipality of Amsterdam, Eteck, ELZO, heat providers and heat consumers.

To create Table 4.13, a broader rudimentary actor and network analysis was performed (see Appendix C.3). Their roles and objectives were identified together with their sources of power and resources.

The municipality of Amsterdam provided a budget, gave technical and juridical advice and provided connections to Eteck. The heat providers had control over the heat source. Eteck formulated a business case, and real estate developers had control over the purchase of the heat and acted as a proxy for future residents, as they were not yet known.

Figure 4.15 visualises the social network structure of the DHN based on the actor and network analysis. It shows that there are some strong connections between the main actors like the municipality, Eteck, Vattenfall and the data centre. Several other connections are made within this project, but these are not very strong.

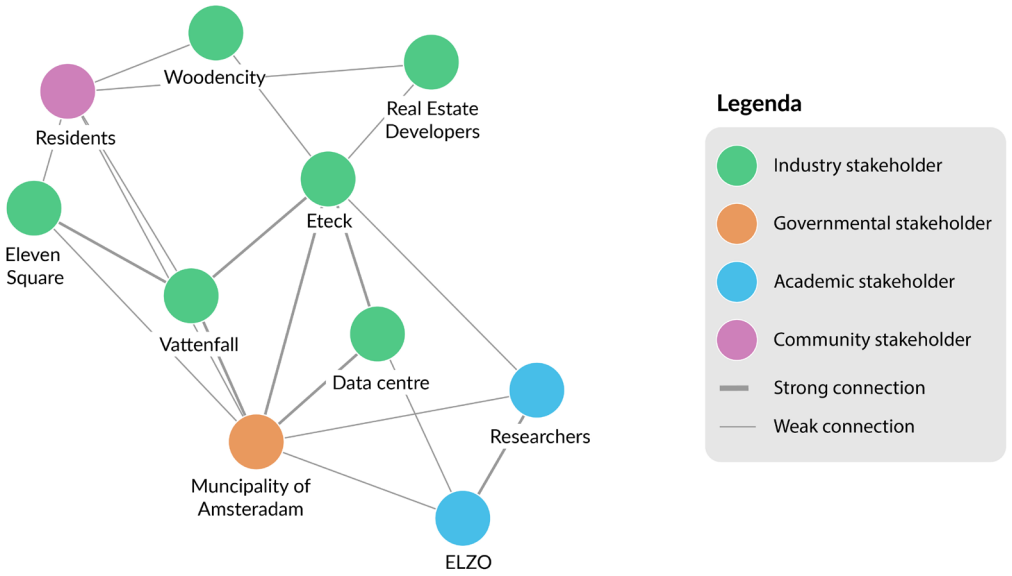


Figure 4.15: Social Network Diagram visualising relationships between relevant actors for the District Heating Network

Timing and forms of stakeholder involvement

Figure 4.16 shows how and when stakeholders have been involved throughout the project. This figure has been created using interview data and desk research. Further information on how this figure was created can be found in Appendix D.3.

During the design phase, the Municipality of Amsterdam was responsible for initiating and structuring the project, drafting the tender, allocating the €4.5M budget, and setting the scope for a low-temperature district heating network. To prepare the tender, the municipality organised a market consultation day and a market dialogue day with potential energy companies to discuss the construction-team setup. The municipality had full control over the decisions being made. The municipality also signed a LOI with data centre regarding heat extraction terms and secured an initial heat off-take agreement for the Eleven Square development. Eteck submitted the winning bid, designating property developer Woodencity

STAKEHOLDER	QUADRUPLE HELIX CATEGORY	ROLE WITHIN THE PROJECT	RESOURCES	INTERVIEWEE ID	SOURCES
Municipality of Amsterdam	Government	Public authority and initiator of the tender; provided legal, spatial, and technical advice, managed area development, and allocated municipal co-funding.	**Institutional**: Official municipal authority and regulator that designed the tender, holds final concession granting authority; **Financial**: Controlled the €4.5M municipal contribution/loan intended to bridge initial investment and fill-up risk.	I11, I13, I14	I11, I13, I14, (Correlje et al., 2025)
Energie Lab Zuidoost	Academia	Intermediary living-lab platform; connected academic research, industry and municipal departments.	**Institutional**: Intermediary living-lab platform embedded in municipal and university governance structures; **Social**: Strategic network position connecting academic research, municipal departments, and local community initiatives.	I15	I15
Eteck	Industry	Private energy concessionaire and building team partner; responsible for designing the low-temperature heat grid, formulating the business case, and evaluating financial/technical feasibility.	**Technical**: Engineering and modeling expertise in low-temperature networks; authored the technical design, business case, and risk dossier; **Financial**: Corporate investment capital authority and the sole commercial power to withdraw from submitting a final concession offer.	--	(Correlje et al., 2025)
Vattenfall	Industry	Existing regional heat supplier; operates high-temperature heat grid infrastructure in the area of Eleven Square.	**Financial**: Commercial ownership of existing district heating/cooling infrastructure and control over customer tariffs; **Institutional**: Holds pre-existing delivery agreements with key developments like Eleven Square.	--	(Correlje et al., 2025)
Woodencity	Industry/Community	Real estate developer; intended major heat off-taker and potential data centre heat provider; acted as commercial proxy for future residents.	**Technical**: Development expertise; **Financial**: Controlled a major share of initial heat demand and potential supply.	I12	(Correlje et al., 2025)
Data centre	Industry	Data centre operator; potential waste heat source provider for the low-temperature heat network.	**Technical**: Operational control over data centres and physical heat availability/extraction parameters.	--	(Correlje et al., 2025)
Real Estate Developers	Industry/Community	Real estate developer; intended heat off-taker; acted as commercial proxy for future residents.	**Financial**: Property development budget; **Technical**: Control over building plot design and heat demand connection points; **Institutional**: Commercial representation of future end-users.	--	(Correlje et al., 2025)

Table 4.13: *Relevant stakeholders within the District Heating Network*

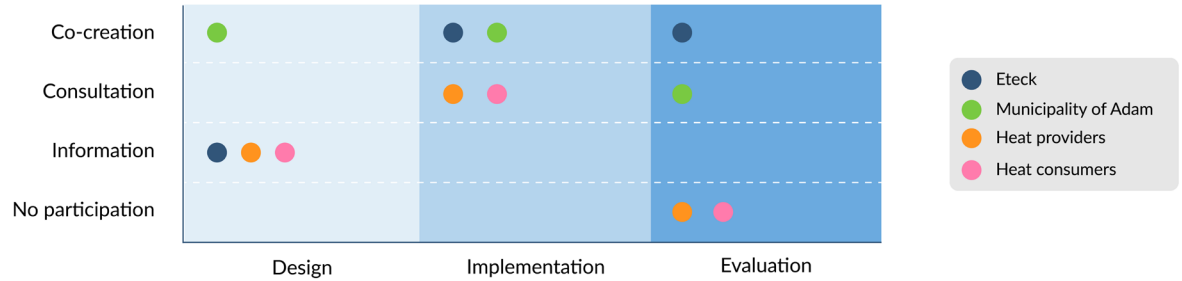


Figure 4.16: The level of involvement of stakeholder during different stages of the District Heating Network

as an exclusive partner for heat demand and supply. Future residents and end-users were not involved during this design phase (Correlje et al., 2025).

During the implementation phase, Eteck took control of formulating the technical design, business case, and risk dossier, while the municipality provided supportive input and technical/legal advice. The partners interacted through multiple structured meeting formats (Correlje et al., 2025):

- **Kick-off meeting**: Held to align project goals and establish the construction team workflows.
- **Weekly construction-team meetings**: Regular working sessions between Eteck and municipal team members to coordinate technical layouts, financial models, and spatial planning.
- **Monthly progress meetings**: Structured progress reviews where workflow status and risk profiles were evaluated using progress reports and tracking matrices.
- **Ad-hoc bilateral negotiations**: Eteck conducted direct bilateral meetings with heat providers (data centre, regarding extraction costs and physical demarcation boundaries) and potential off-takers/developers (Woodencity, Flow, and Vattenfall regarding supply conditions for Eleven Square). Joint meetings with Vattenfall to explore combined heat and cold models stalled due to tariff constraints.
- **Mid-term milestone session**: Eteck presented its progress to a broader group of municipal stakeholders, followed by an internal joint reflection session led by an external process coordinator to evaluate collaboration dynamics.

Woodencity's involvement ended during this phase due to bankruptcy. Residents were not consulted or involved during implementation, as end-users were represented indirectly by real estate developers and municipal guidelines.

In the evaluation phase, Eteck compiled and submitted the preliminary deliverables (Business Case, Preliminary Design, and Risk Dossier). Evaluation took place across several meetings, like a recapitulation meeting, reflection review session and post-delivery process evaluation (Correlje et al., 2025).
During this final phase, the municipality shifted from a collaborative partner to a formal assessor role, evaluating the deliverables against tender requirements.

Only the municipality was involved in the design of the construction phase, which is an exception for an LL. The other stakeholders were involved during the implementation and evaluation phases. End-users were not engaged during these phases. Residents who were already living in the area would have been involved after the plans were defined. In that sense, this project could also be structured differently: the construction team phase could be seen as the design of the project, after which the implementation phase never took place.

ACTOR	DEFINITION OF SUCCESS	TYPE OF SCALING	SOURCES
Municipality of Amsterdam	Realize an open, affordable low-temperature heat grid utilizing data centre waste heat, explore public governance models, and gain organizational learning.	**Spreading**: Replicate waste heat extraction across 13,000 housing equivalents in Amstel 3 and ArenAPoort. **Deepening**: Build internal municipal governance capacity for heat transitions.	(Correlje et al., 2025)
ELZO (Living Lab Platform) / Researchers	Facilitate collaborative learning within the building team, generate actionable insights on ULL governance, and evaluate public-private risk distribution models.	**Deepening**: Institutional capacity building and process learning regarding urban heat concessions. **Broadening**: Disseminating ULL governance insights and decision frameworks to broader municipal policies.	(Correlje et al., 2025)
Eteck	Build a commercially viable, low-temperature heat grid with market-conform financial returns, manageable operational risks, and a supportive public partnership.	**Spreading**: Expand connected volume across adjacent real estate plots. **Deepening**: Develop internal organizational expertise on urban heat transitions.	(Correlje et al., 2025)
Data centre	Re-use data centre waste heat cost-neutrally to fulfil corporate sustainability goals without threatening core data centre uptime or operational focus.	**Spreading**: Replicate waste-heat extraction across other data centre facilities. **Broadening**: Embed data heat re-use into standard IT industry sustainability practices.	(Correlje et al., 2025)
Vattenfall	Greening their existing high-temperature heat grid while safeguarding existing customer market share, asset investments, and tariffs.	**Spreading**: Supply blended/greened heat to new development plots such as Eleven Square. **Deepening**: Establishing asset protection precedents under evolving heat market regulations.	(Correlje et al., 2025)
Woodencity	Secure affordable, reliable heating for their 4,000-home development to achieve required EPC building ratings via an integrated local energy model.	**Spreading**: Lower connection costs across all neighbourhood residential clusters. **Broadening**: Combine commercial real estate plots with shared energy infrastructure.	(Correlje et al., 2025)
Heat Consumers (Future Residents)	Affordable, reliable, and sustainable indoor heating and hot water with transparent tariffs, low financial risk, and zero service interruptions.	n.a.	(Correlje et al., 2025)

Table 4.14: The definitions of success from stakeholders and the related types of scaling in the District Heating Network

4.5.4 TYPES OF SUCCESS

Table 4.14 outlines the definitions of success and intended scaling pathways across the primary stakeholder groups in the district heating case study.

The Municipality of Amsterdam prioritised public value creation and policy broadening. They were interested in capturing low-temperature data centre waste heat and scaling across around 13,000 housing equivalents in Amstel 3 and ArenAPoort to meet municipal decarbonisation targets (Correlje et al., 2025).

Eteck defined success through financial viability and risk management. They wanted a bankable business case with market-conform returns without taking on high and long-term fill-up risks. The data centre evaluated success through reaching sustainability goals without spending too much money. Vattenfall defined success as greening their existing heat grid without it leading to higher costs. Woodencity focused on sustainable building and affordability for future residents. Heat consumers remained absent from negotiations. They were represented by commercial developers acting as proxies (Correlje et al., 2025).

Evaluating DHN only on spreading would categorise the project as a failure, as Eteck ultimately withdrew from the concession due to unviable business economics. However, the project achieved "learning success" and institutional deepening by generating process learning on the building team collaboration process and learning lessons about trying to develop DHNs.

4.5.5 POWER IMBALANCES

During this project, the municipality of Amsterdam had full authority over the design of the project (see Table X) (I13, I14). They decided on the building team approach and the terms and conditions of the project (I13, I14) (Correlje et al., 2025).

During the project, Eteck had authority over decisions being made, who was contracted, and what direction to go in during the project (I13, I14). The municipality advised and tried to help them, but had a supporting role (I11, I13, I14) (Correlje et al., 2025). However, while Eteck had power over who would be involved in the project, they did not have full power over the prices (I13, I14).

Collaboration and sharing formal authority during the design of the project was hard to achieve due to the Dutch tender law. This prohibited the Municipality from collaborating with heat suppliers before the tender publication to prevent uncompetitive advantages (I14). This blocked early Quadruple Helix co-design. The municipality mentioned that it would be ideal to talk to the real estate developers before the tender was written, but they are often not known at the start of a project, and the municipality had no formal authority over who would be contracted (I14).

During the construction team phase, Eteck and the municipality worked together on the project, but Eteck was responsible for deciding who would become a contracted partner (I14). This was a requirement within the tender. The commercial actors and Eteck needed to negotiate the terms under which they would work together. They both had an equal say in the decision being made. The municipality had no power over these decisions during the implementation phase (I14). The residents of future buildings were not yet known, and were therefore represented by real-estate developers (I11, I13). Furthermore, as no contracts were signed during the construction team phase, it was not clear if any existing residents would come into contact with the district heating network. Existing residents were not included in the building team phase, but would be in later stages if contracts were signed, following existing regulations (I13).

ACTOR	SOURCES/TYPE OF POWER	AUTHORITY	APPROACH	SOURCES
Municipality of Amsterdam	**Institutional:** Official municipal authority and regulator that designed the tender, holds final concession granting authority; **Financial:** Controlled the €4.5M municipal contribution/loan intended to bridge initial investment and fill-up risk.	Decided tender conditions, spatial planning, zoning permits, allocation of municipal funds, and held final authority on whether to request or grant a concession.	Public tender.	I11--I14, (Correlje et al., 2025)
Energie Lab Zuidoost	**Institutional:** Intermediary living-lab platform embedded in municipal and university governance structures; **Social:** Strategic network position connecting academic research, municipal departments, and local community initiatives.	Authority was limited to researchers being able to be present at meetings of the building team.	Embedded via municipal and academic collaboration.	I11--I14, (Correlje et al., 2025)
Researchers	**Technical:** Specialized expertise; **Social:** Discursive legitimacy and objective process evaluation, though holding no formal contractual authority.	Advisory authority only; made decisions regarding research design, data collection, and evaluation methodology, but possessed no decision-making power over project execution or commercial terms.	Approached through ELZO and municipal research agreements.	I11--I14, (Correlje et al., 2025)
Vattenfall	**Financial:** Commercial ownership of existing district heating/cooling infrastructure and control over customer tariffs; **Institutional:** Holds pre-existing delivery agreements with key developments like Eleven Square.	Controlled decisions regarding access to their existing heating/cooling grid.	Pre-existing municipal contacts and market consultation.	I11--I14, (Correlje et al., 2025)
Eteck	**Technical:** Engineering and modeling expertise in low-temperature networks; authored the technical design, business case, and risk dossier; **Financial:** Corporate investment capital authority and the sole commercial power to withdraw from submitting a final concession offer.	Full autonomy over the technical configuration, business case parameters, risk allocation, contractor selection, and the decision to submit or withhold a concession proposal.	Selected as RFP winner.	I11--I14, (Correlje et al., 2025)
Data centre	**Technical:** Operational control over data centres and physical heat availability/extraction parameters.	Decided physical demarcation boundaries, on-site spatial allocation for heat pumps/exchangers.	Identified as potential heat provider via municipal LOI.	I11--I14, (Correlje et al., 2025)

Table 4.15: The resources and formal authority of stakeholders within the District Heating Network along with the way they were approached to join the project.

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ACTOR	SOURCES/TYPE OF POWER	AUTHORITY	APPROACH	SOURCES
(Future) Residents	**Social:** End-user heat demand, lived experience, and public acceptance regarding heat affordability and comfort; however, future occupants were not yet identifiable or represented during the planning phase.	Possessed no decision-making power during the pre-construction phase, as future residents were unidentifiable and represented indirectly by real estate developers and municipal guidelines.	Not directly approached during the pre-construction phase.	I11--I14, (Correlje et al., 2025)
Woodencity	**Technical:** Development expertise; **Financial:** Controlled a major share of initial heat demand and potential supply.	Decided private master planning, building connection choices, and on-site data centre integration until bankruptcy removed their operational influence.	Direct contacts and joint bidding agreement with Eteck.	I11--I14, (Correlje et al., 2025)
Eleven Square	**Institutional:** Launching customer real estate development bound by municipal erfpacht sustainability requirements; **Financial:** Controlled a share of initial heat demand and potential supply.	Controlled building-level mechanical designs and contractor selection, constrained by pre-existing municipal delivery agreements and tariff caps.	Identified as launching customer by Municipality.	I11--I14, (Correlje et al., 2025)
Other real-estate developers	**Financial:** Control over individual building connection decisions and private development budgets; **Institutional:** Controlled a share of initial heat demand and potential supply.	Full decision-making authority over whether to sign connection agreements with the collective network or install individual standalone WKO systems on their plots.	Approached by Eteck during heat demand acquisition.	I11--I14, (Correlje et al., 2025)

Table 4.15: The resources and formal authority of stakeholders within the District Heating Network along with the way they were approached to join the project.

4.6 CROSS-CASE ANALYSIS

This section compares the findings of the three cases described in the previous sections using the sub-research questions: 1) which stakeholders are involved in LL and FL projects, and why, when and how are they engaged; (2) what types of success do stakeholders aim to achieve in LL and FL projects, and how do these relate to different scaling pathways; and (3) how are power imbalances between stakeholders addressed in LL and FL projects. Afterwards, challenges of involving stakeholders within LL and FL projects will be presented.

4.6.1 STAKEHOLDER INVOLVEMENT

Across all three cases, stakeholder involvement was dynamic rather than static. The relevance and involvement of actors changed as the projects progressed through different development stages. Stakeholders became relevant when their knowledge, resources, responsibilities or feedback were needed for a particular project activity or subsequent development phase. Therefore, stakeholders were not necessarily involved continuously from the design stage through implementation and evaluation. Instead, involvement was often organised around the purpose and needs of the project at a particular moment.

Across the cases, different forms of involvement were used, including information exchange, meetings, demonstrations, consultation, technical testing, feedback and co-creation. The degree of involvement varied both between stakeholders and across project phases. For example, community actors in CF could provide feedback during implementation, while industry actors could influence decisions when proposed approaches were considered technically infeasible. In MFB, stakeholder involvement was strongly connected to testing and demonstrating the technology and exchanging knowledge about its potential application. In DHN, involvement largely took place through coordination and negotiation between organisations involved in developing the district heating tender and assessing its technical and financial feasibility.

The cases further show that stakeholder involvement did not automatically result in decision-making influence. Some stakeholders primarily provided information, technical knowledge or feedback, while important decisions remained with a smaller group of project actors. This distinction was particularly visible for end-users. End-users were generally recognised as relevant for the eventual acceptance and use of the innovations, but they did not influence the decisions being made in LL and FL projects. In CF, residents were involved during implementation through surveys and door-to-door visits, but were less involved in earlier design and decision-making processes. In MFB, end-users were largely absent from the design and testing activities. In DHN, future residents were indirectly represented through real-estate developers, rather than participating directly in the development of the project. Thus, although end-users were considered relevant to the eventual outcomes and long-term acceptance, they held minimal critical resource power.

The cases therefore demonstrate different approaches to stakeholder involvement, but a common pattern was that involvement was selective and phase-dependent. Stakeholders were generally involved when their expertise, resources or responsibilities became relevant to a particular project activity. Although the forms of involvement ranged from information exchange to consultation, testing and co-creation, direct co-creation with end-users was limited across all three cases. Moreover, participation itself did not necessarily translate into influence over project decisions. Stakeholder involvement therefore varied not only in timing and form, but also in the extent to which actors could affect project decisions.

4.6.2 TYPES OF SUCCESS

The empirical findings across the three cases show that several different definitions of success were exhibited. The cases demonstrate that transformative change does not only occur through large-scale implementation (spreading), but also through other pathways like broadening and deepening.

Spreading

Spreading of the innovations was achieved in two of the three cases. The CF achieved spreading when positive testing results prompted housing association Woon-Friesland to install the flow-reduction device across 300–400 homes on Ameland. MFB achieved spreading through targeted procurement when Water Board Limburg purchased several kilometres of barriers following live trials. DHN failed to achieve spreading because the network construction was commercially unviable.

These findings illustrate the claim of Schagen et al. (2023) that spreading relies heavily on mechanisms of stabilisation and professionalisation; when commercial or financial conditions fail to stabilise, physical scaling halts.

Broadening

Broadening was achieved in the CF case by demonstrating that reduced shower flow rates also lower natural gas usage. This alloweed the innovation to align with housing association goals and municipal climate agendas. MFB achieved broadening by integrating empirical testing results into national STOWA guidelines, shifting water board emergency response protocols nationwide. Lastly, DHN attempted broadening by trying to align data heat extraction with municipal spatial policies, though market friction blocked realisation.

This reflects the mechanisms of partnering and embedding described by (Schagen et al., 2023), where connecting niche innovations to broader policy priorities enables systemic relevance.

Deepening

Deepening was achieved in the CF case through discovering the exact technical and behavioural thresholds where domestic flow reduction intersects with tenant comfort during protected testing at Dreamhûs. MFB achieved deepening by establishing technical reliability through FPH testing, successfully shifting water board mindsets regarding the operational speed and trust of temporary flood defences. Lastly, while DHN failed to achieve spreading, it achieved deepening and "learning success". The building team process generated organisational learning for the municipality regarding heat company cost structures, technical demarcations, and the necessity of public coordination.

The cases reflected how deepening was achieved through the mechanisms of learning by doing (Schagen et al., 2023; Termeer & Metze, 2019).

These findings demonstrate that physical project failure (spreading failure in DHN) does not equal transition failure. Standard evaluation metrics centred strictly on TRL or market adoption would classify projects like DHN as failures. However, adopting a small-wins perspective shows that projects generate transformative impact through non-linear mechanisms. As Schagen et al. (2023) and Termeer & Metze (2019) emphasise, deepening and broadening provide complementary pathways toward system-wide change.

4.6.3 POWER IMBALANCES

Differences in stakeholder influence were visible across all three cases. Actors who controlled resources that were critical to the continuation of a project generally had greater influence over project decisions.

Industrial actors could exercise influence over technological choices because they possessed technical expertise and controlled aspects of the innovation. Public organisations, housing organisations and other institutional actors could influence projects through their authority, budgets, procurement responsibilities or access to implementation contexts. Academic actors such as researchers and TGV had influence over the design of the research and contributed by connecting stakeholders and facilitating communication.

The cases also demonstrate that participation and influence were not equivalent. Some stakeholders were given opportunities to provide information or feedback without having formal authority over the decisions that followed from this input. This was particularly relevant for community actors such as residents. Their experiences could inform the project, but they generally did not hold formal decision-making authority over the development of the innovation.

The findings therefore indicate that stakeholder involvement was not necessarily accompanied by an equal distribution of influence. Rather, influence remained related to the resources and responsibilities that actors controlled within the project.

4.6.4 CHALLENGES OF STAKEHOLDER INVOLVEMENT

Across the cases, several practical, organisational and institutional challenges affected stakeholder involvement. These challenges occurred from both sides of the involvement process: some concerned the ability of project teams to identify, reach and involve stakeholders, while others concerned the willingness or ability of stakeholders to participate. Some challenges affected both sides simultaneously. Table 4.16 distinguishes between these perspectives and summarises the challenges identified across the cases. The challenges are discussed in the same order in the following sections.

1. Limited resources and capacity

A first challenge concerned the availability of time and resources for stakeholder involvement. This challenge occurred on both sides of the involvement process. Project teams had limited time, capacity and financial resources to involve additional actors, while stakeholders themselves could also have limited capacity to participate.

For project teams, limited time was an important constraint. For example, within the third CF project, organising the project team required additional time and effort. TGV explained that they did not always have sufficient time to take on a coordinating role:

"*We don't usually take on the role of a coordinator, because it's simply very time-consuming. And we don't always have time for it*." (I3)

Similarly, financial resources could limit the range of stakeholders that could be involved. Within the first CF project, there was no additional budget available to include a researcher. As explained by TGV:

"*Ideally, we would also bring in a researcher for each project, but in this case the research was fairly straightforward and there was no additional budget.* " (I2)

The cases also showed that stakeholders themselves could have limited capacity to participate. Dreamhûs residents, for example, participated in multiple FL projects and therefore did not necessarily have the time to maintain a high level of involvement in every project. Importantly, this constraint could operate from both sides: project managers could also limit involvement because

OVERARCHING CHALLENGE	SPECIFIC CHALLENGE	PERSPECTIVE	HOW IT CONSTRAINED INVOLVEMENT	EXAMPLE FROM THE CASES
1. Limited resources and capacity	Limited time	Project team	Project teams had limited time to organise and maintain stakeholder involvement.	CF project 3: organising the project team required additional time and effort.
	Limited financial resources	Project team	There was insufficient funding to involve additional stakeholders.	CF project 1: insufficient budget to include scientists.
	Limited capacity of stakeholders	Both	Stakeholders did not have sufficient time or resources to participate.	Dreamhûs residents participate in many FL projects and do not have the time to have a high level of involvement in every project.
	Geographical distance	Both	Distance could make repeated collaboration more difficult for project teams and stakeholders.	WoonFriesland indicated that the distance between Friesland and TGV makes it harder to collaborate.
2. Identifying and reaching relevant stakeholders	Dependence on existing networks	Project team	Stakeholder identification partly depended on project managers' existing connections.	CF: governmental actors were reached through an existing TGV contact.
	Difficulty involving realistic representatives	Project team	Practical constraints can lead to the involvement of less representative actors.	DHN: future residents were not known yet, which led to developers representing residents.
3. Perceived relevance and willingness to participate	No shared problem	Stakeholder	Stakeholders had less reason to participate when they did not recognise how the project contributed to their interests or responsibilities.	MFB: actors are more willing to invest and collaborate on mobile flood barriers after a flooding accident happens.
	Uncertainty about innovation	Stakeholder	Stakeholders hesitated to get involved when the innovation was new and its effectiveness was uncertain.	MFB: the buyer bears responsibility if the product does not work.
4. Meaningful participation and influence	Poor communication	Project team	Poor communication could lead to disappointment among participants and reduce their motivation to remain actively involved.	Dreamhûs residents indicated that they are more actively engaged when they receive updates on how the innovation improves and what their contribution is.
	Limited choice in participation	Project team	Stakeholders were not always able to determine how they wanted to participate, which could limit active participation.	Dreamhûs residents indicated that they were not involved during the design of projects and therefore could not always give nuanced feedback using their preferred methods.
	Method selection	Project team	Methods chosen to involve stakeholders could limit the ways in which stakeholders could contribute to the project.	MFB: barriers were shown to stakeholders using demonstrations, without methods to actively gather feedback on the barriers.

Table 4.16: Identified challenges constraining stakeholder involvement across the cases

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OVERARCHING CHALLENGE	SPECIFIC CHALLENGE	PERSPECTIVE	HOW IT CONSTRAINED INVOLVEMENT	EXAMPLE FROM THE CASES
5. Institutional and commercial constraints	Tender requirements	Project team	Procurement rules restricted collaboration before the tender.	DHN: because of strict procurement rules, it was not possible to collaborate with stakeholders on the design of the tender.
	Commercial interests	Both	Commercial interests could influence which stakeholders were involved and how much influence or control was shared.	TGV indicated that not all entrepreneurs were interested in working with all stakeholders.
6. Project purpose and development stage	Technical research objective	Project team	A technical project objective could limit the perceived relevance of broader and high-level stakeholder involvement.	CF project 2: because the research objective was to gather data on water and gas consumption, reaching a high level of involvement for residents was not seen as a priority.
	Changing stakeholder relevance	Project team	Stakeholders were considered relevant at different stages depending on project needs.	CF project 3: residents were ideally involved after the design phase of the project.

Table 4.16: Identified challenges constraining stakeholder involvement across the cases

they were concerned that residents might become fatigued if they were asked to participate too often.

Geographical distance could create an additional constraint. WoonFriesland indicated that the distance between Friesland and TGV made collaboration more difficult, particularly when repeated interaction was required.

2. Identifying and reaching relevant stakeholders

A second challenge concerned the identification and reach of relevant stakeholders. Stakeholder identification partly depended on the existing networks of people within project teams. TGV mentioned that the people who became involved in projects depended on the connections that project managers had themselves. For example, during CF project 1, governmental actors became involved because an employee of TGV had previously worked at a ministry and still had contacts there. This suggests that existing relationships could facilitate access to stakeholders, but could also shape which actors were reached.

The cases also showed that identifying an appropriate representative could be difficult. In DHN, future residents were not yet known and could therefore not be directly involved. Involving a realistic group of future residents would require more time and resources than allowing real-estate developers to represent their interests. A similar issue occurred at TGV. Residents of Dreamhûs did not directly represent the residents of the housing units in Friesland. Being a representative resident was initially a criterion for living at Dreamhûs. However, some residents broke TGV's safety rules, which meant that TGV needed to spend additional time acting as wardens. As a result, TGV decided that being a representative resident would no longer be a criterion for living at Dreamhûs.

3. Perceived relevance and willingness to participate

A third challenge concerned the willingness of stakeholders to participate. Interviewees indicated that stakeholders were more likely to engage when they recognised the problem addressed by the project and considered the innovation relevant to their own interests or responsibilities. When there was no shared problem or objective, it could be more difficult to motivate stakeholders to invest time and effort in the project.

This was particularly visible in the MFB case, where actors were considered more likely to invest in and collaborate on mobile flood barriers after a flooding accident had occurred. The perceived urgency of the problem could therefore influence stakeholders' willingness to participate. In addition, because innovations are new, stakeholders sometimes had to take a leap of faith and trust that the innovation could lead to a successful outcome. In MFB, for example, the buyer would bear responsibility if the product did not work. Uncertainty about the innovation could therefore make stakeholders more hesitant to become involved.

4. Meaningful participation and influence

A fourth challenge concerned whether participation enabled stakeholders to contribute in meaningful ways. Three related issues emerged: communication, the choice stakeholders had in how they participated, and the methods used to involve them.

First, communication could influence stakeholders' motivation to remain involved. Dreamhûs residents indicated that they were more actively engaged when they received updates about how the innovation was improving and what their contribution was. Furthermore, limited communication could lead to disappointment among participants and reduce their motivation to remain actively involved.

Second, stakeholders did not always have a choice in how they participated. Dreamhûs residents indicated that they were not involved during the design of projects and therefore could not always provide nuanced feedback using their preferred methods. Although residents could provide feedback and reported that their feedback was generally considered, they did not have formal decision-making authority over the project or over how they participated. Being invited to participate therefore did not necessarily mean that stakeholders had influence over project decisions or could determine the form of their participation.

Third, the methods selected by project teams could limit the ways in which stakeholders contributed. In MFB, for example, barriers were demonstrated to stakeholders, but no methods were used to actively gather their feedback on the barriers. The form of participation therefore focused primarily on informing or demonstrating rather than creating opportunities for stakeholders to contribute their own perspectives.

5. Institutional and commercial constraints

A fifth challenge concerned institutional and commercial conditions that could restrict stakeholder involvement independently of the willingness of individual actors. In DHN, tender requirements limited the possibility of bringing potential market actors together before the tender was issued. This restricted the possibility of jointly defining the problem or developing the tender with all relevant actors.

Commercial interests could also influence which stakeholders were involved and how much influence or control was shared. TGV indicated that not all entrepreneurs were interested in working with larger companies,

because this could negatively affect their own company or work. Commercial interests could therefore shape both stakeholders' willingness to participate and the way in which collaboration was organised.

6. Project purpose and development stage

Finally, the purpose and development stage of a project influenced which stakeholders were considered relevant and how intensively they were involved. In CF project 2, for example, the research objective was primarily technical and focused on gathering data on water and gas consumption. As a result, reaching a high level of involvement among residents was not considered a priority. Community actors were therefore involved to a limited extent because their contribution was not considered necessary for the specific objective of this project stage.

At the same time, stakeholder relevance could change as a project progressed. In CF project 3, for example, residents were considered more relevant after the design phase of the project. This illustrates that stakeholder relevance was not necessarily fixed throughout a project, but could depend on the knowledge, resources, responsibilities or perspectives required at a particular stage.

5

DISCUSSION

This chapter interprets the empirical findings of this study in relation to existing literature on LLs, FLs, transition pathways, and power dynamics. First, it will be discussed whether all the case studies align with the definitions of LL and FL projects. The rest of the discussion is structured around the findings of the sub-research questions and main research question. Afterwards, recommendations will be given to LL and FL practitioners and the societal and scientific contributions will be discussed.

5.1 CASE CHARACTERISTICS

The cases chosen were very different from each other. To better understand whether the cases aligned with the definitions of LL and FL projects, this section evaluates the characteristics of each case and how these characteristics relate to the testing environment in which the projects were conducted.

5.1.1 CONTROL FLOW

The CF is a solution based on an 'enabling technology' that tries to achieve an alternative to current unsustainable practices. It is a product that is being tested in TGV, a physical, protected space, to see if there are problems that need to be fixed in order to move on to a pilot phase. This project aligns with the definition of an FL (ZorgTech, n.d.). The project follows the "hop-step-jump" model: initial testing occurred at TGV (hop), followed by a real-world pilot in social housing in Leeuwarden (step), which led to implementation on Ameland (jump). In this sense, the project demonstrates spreading, as the technology was successively applied in different locations and contexts. At the same time, the different project iterations generated learning and changes in the way the technology was developed and applied, indicating elements of deepening. Connections with new actors and application contexts also created opportunities for broadening. However, Cenergist's bankruptcy forced the project back to TGV for a third iteration under KDWS. The case therefore shows that scaling does not necessarily follow a linear progression from experimentation to wider implementation, but can involve iterative movement between FL testing and real-world application.

5.1.2 MOBILE FLOOD BARRIERS

This is a less traditional project of TGV. There are solutions based on an 'enabling technology' that are tested, but the products are not moving from the FL to the pilot location; they are skipping this step. MFBs may not have a defined pilot location, which makes it less typical.

Furthermore, for this project, TGV uses their environment to teach people how to apply the solution. Some actors that are involved by TGV are not invited to test the technology together, but are approached to look at the products and demonstrate how they work. This also fits in the definition of a field lab (ZorgTech, n.d.). TGV does go further than only showing how to apply the barriers. They are also trying to engage stakeholders to take action in the broader problem of flooding. This goes outside of the definition as FL.

5.1.3 DISTRICT HEATING NETWORK

This project is formally categorised as an Urban Living Lab within ELZO. As it was a time-bound contractual partnership focused on financial and technical feasibility, the project had certain restrictions. Not all key partners could be together to define a shared problem statement, as not all partners were already known, and energy companies could not be informed or work together to design the tender before it was shared. Furthermore, through the design of the tender, co-creation was important for the municipality and Eteck, but user co-creation was limited. The goal of this project for ELZO was to gather insights on what the obstacles are when trying to implement a district heating network and share those

insights with a broader audience. There is no clear experiment, as the construction team is already widely used and the technology is also mature, but it is the combination that gives insights for other parties.

By not being able to co-create with all stakeholders in the project phases and the methods being negotiating rather than cooperating, this project is not typical and does not fully align with the definition of an LL (Vervoort et al., 2022).

5.2 STAKEHOLDER INVOLVEMENT

LL literature shows the importance of early and continuous involvement of all Quadruple Helix actor groups to achieve transformative success (Berberi et al., 2026; Duisterwinkel & Butter, n.d.; Huang et al., 2024; Mahmoud et al., 2021). The empirical findings show that these ideals are not always achieved in practice. While all four Quadruple Helix categories were represented across the cases, their inclusion was dynamic and phase-dependent rather than early and continuous.

The timing and level of stakeholder involvement varied significantly depending on the project development stage and structural setup. Project initiators engaged specific actor groups primarily when their specialised knowledge, resources or authority became necessary to achieve a particular goal. Community actors and end-users were consistently engaged late in the project lifecycle. They were typically involved during the implementation or evaluation phases, where their participation was confined to providing user feedback or completing quantitative surveys. True co-creation, defined by Menny et al. (2018) and Arnstein (1969) as active collaboration with shared decision-making power, was not achieved with community actors within the cases, even though this is a central characteristic of LLs (Ballon & Schuurman, 2015; Galway et al., 2022). Instead, involvement for less powerful actors stopped at consultation or information provision, while co-design remained concentrated within a small group of industry, municipal or research actors. This confirms the empirical observations of Greve (2019) and Puerari et al. (2018), who noted that real-world testbeds frequently fail to achieve the high levels of continuous user co-creation envisioned in Living Lab theory.

Furthermore, the range of methods used in all cases was narrow compared to the extensive participatory toolkits described by Huang et al. (2021) and key enabling methodologies (KEM, n.d.). Interaction relied heavily on formal administrative meetings, technical presentations, and standardised surveys.

5.3 PATHWAYS TO SUCCESS

Conventional evaluation metrics, such as TRL, assess project success through quantitative market uptake or physical spreading (Olechowski et al., 2020). When researchers rely only on these frameworks, experimental projects that fail to achieve physical replication are often categorised as failures. However, by applying the Small Wins Framework (Schagen et al., 2023; Termeer & Metze, 2019) different types of success can be distinguished, and project outcomes of LL and FL projects can reveal how transformative impact accumulates across multiple scaling pathways.

The cross-case comparison demonstrates that the three scaling pathways by (Termeer & Metze, 2019), spreading, broadening, and deepening, are pursued in practice, driven by specific underlying mechanisms (Schagen et al., 2023). First, spreading was realised in CF through housing association adoption across 300 to 400 social housing units on Ameland, and in MFB through direct procurement by Water Board Limburg. In line

with Schagen et al. (2023), these empirical outcomes show that spreading relies on the mechanism of stabilisation (securing binding contracts or long-term housing association commitments). If stabilisation failed due to commercial unviability, as happened within DHN, physical spreading stalled. Second, broadening occurred in CF when water flow reduction was linked to domestic gas savings and municipal decarbonisation goals, and in MFB when test data were integrated into national STOWA guidelines. This confirms the framework of Schagen et al. (2023), since the cases demonstrate that broadening is driven by partnering and embedding. Third, deepening was present across all three cases, driven by the mechanism of learning by doing, which aligns with (Schagen et al., 2023; Termeer & Metze, 2019). CF identified the precise technical and comfort boundaries of tenants at Dreamhûs, and DHN produced organisational learning for the Municipality of Amsterdam regarding heat company cost structures, technical demarcations, and public risk coordination.

The cases also show that success can be reached without achieving the ideals of stakeholder involvement. In project 2 of CF, the device was successfully deployed across hundreds of homes on Ameland despite residents acting primarily as passive feedback providers rather than active co-creators. This confirms the claim by Menny et al. (2018) that while broad stakeholder inclusion is valuable for long-term social embedding, it is not a strict prerequisite for achieving spreading of an innovation.

Finally, CF also shows that failing to scale at one point in time does not mean failing forever. Standard innovation frameworks and linear field-lab models, such as the "hop-step-jump" model (TwynstraGudde, 2021), show scaling as a continuous movement from protected testing to pilot project. However, after the bankruptcy of the original commercial owner (Cenergist) after the second project of CF, scaling came to a halt. Nevertheless, rather than resulting in permanent transition failure, the successes (deepening was reached by proving technical effectiveness and comfort benchmarks & broadening was reached through connections with TGV) of previous projects allowed the technology to re-emerge at TGV with a new broad project team. This demonstrates that scaling is not always linear, but can be iterative. Organisational collapse at the firm level does not destroy the accumulated small wins of an innovation. When deepening and broadening are achieved, it can lead to new projects in a later stage.

5.4 POWER IMBALANCES

Literature on LLs emphasises that stakeholder influence is influenced by the distribution of critical resources and formal institutional authority. The empirical results confirm that decision-making power across all three cases was related to these resource dependencies. Industrial developers had control over technical design choices due to specialised engineering knowledge, while public authorities, housing corporations, and municipal departments dictated scaling conditions through procurement budgets, land allocation, and statutory authority.

While TGV and ELZO attempted to manage differing interests through informal facilitation, open communication, and consensus-building within project teams, explicit formal mechanisms to balance or redistribute decision-making authority, such as the "power banking" frameworks proposed by Nguyen et al. (2022), were absent across all cases. Formal decision rights remained concentrated among the project team.

Furthermore, there was a distinction between actors who shaped strategic project choices and those who only provided feedback or user data. Community actors and end-users (such as residents in Dreamhûs or Leeuwarden) were invited to fill out surveys or share lived experiences, but

had no formal authority over experimental conditions, trial design, or design decisions. In DHN, future residents were unrepresented during the building team phase, acting solely through commercial proxies such as real estate developers.

These findings align with the analysis of co-production by Turnhout et al. (2020). They observe that elite institutional actors often define the project scope, problem framing, and decision parameters, while community actors participate as unpaid volunteers, lack the capacity to define the scope or challenge technical premises, and are confined to consultative roles. As Turnhout et al. (2020) and Metze et al. (2026) emphasise, power dynamics should be explicitly acknowledged to understand the hierarchies that are present.

5.5 CHALLENGES OF STAKEHOLDER INVOLVEMENT

The cross-case findings answer the central research question: What challenges do projects within Dutch Living and Field Labs encounter when involving stakeholders to support scaling beyond the pilot?

The findings show that challenges of stakeholder involvement occur on both sides of the involvement process. Project teams face difficulties in identifying, reaching and involving relevant stakeholders, while stakeholders may have limited time, capacity or motivation to participate. These challenges were reflected in six categories: (1) limited resources and capacity, (2) identifying and reaching relevant stakeholders, (3) perceived relevance and willingness to participate, (4) meaningful participation and influence, (5) institutional and commercial constraints, and (6) project purpose and development stage.

When looking at a challenge within the 3rd category, 'a shared problem', an insight emerges. In CF and DHN, projects started with a relatively defined technological solution or project scope rather than with a problem statement that was formulated with together with stakeholders, after which a solution was designed. This is interesting for an LL case, because this way of working differs from descriptions of LLs, such as the ENoLL framework, which emphasise user-centred innovation and collaboration between Quadruple Helix actors in addressing complex societal challenges (ENoLL, n.d.; Vervoort et al., 2022). If LL projects adhered more strictly to the ENoLL ideal of starting upstream with shared problem definition instead of a solution, this specific challenge might be less relevant.

The findings are also consistent with recent research on barriers to stakeholder engagement. Schubert et al. (2026), for example, identify limited time and resources, communication difficulties, bureaucratic constraints and a lack of clear strategic direction as barriers to engagement. Similar challenges were found across the Dutch cases, including resource constraints, communication issues and institutional requirements. At the same time, the cases in this study highlight the importance of the project side of stakeholder involvement. Project teams have to decide which stakeholders are relevant, how they can be reached and when their involvement is needed. These decisions are influenced by existing networks, project objectives, available resources, procurement requirements and commercial interests. This complements research that focuses primarily on the conditions shaping stakeholders' willingness and ability to participate.

Furthermore, comparing the different cases shows that opportunities for stakeholder involvement differed between the cases. Legal requirements could restrict

collaboration before procurement, while commercial interests could limit the extent to which organisations were willing to share decision-making power. In other situations, stakeholder capacity or a lack of perceived relevance was more important. The challenges of stakeholder involvement are therefore context-dependent rather than universal barriers that can be addressed through one participation method.

The cases show that broad and continuous stakeholder involvement is not always feasible due to the conditions in which LL and FL projects operate. At the same time, limited involvement can mean that projects miss relevant perspectives or opportunities for longer-term development. Therefore, it is important to consider how the barriers to stakeholder involvement can be addressed and how involvement can be organised in ways that are both feasible for the project and meaningful for the stakeholders involved.

5.6 RECOMMENDATIONS FOR LLS AND FLS

The challenges that are identified across the cases point towards several ways in which project teams can improve stakeholder involvement. The recommendations focus on how project teams can make deliberate choices about whom to involve, when to involve them, and how participation can be organised. Table 5.1 links the identified challenges to possible actions for LL and FL project teams.

The recommendations can be grouped into several broader principles concerning how project teams organise stakeholder involvement. These principles highlight that improving stakeholder involvement does not necessarily mean involving more stakeholders or increasing the intensity of participation. Instead, it requires project teams to make the choices surrounding stakeholder involvement more explicit and to adapt these choices to the project context and to the stakeholders involved.

1. Balance the effort of involvement with its potential value

A recurring issue across the cases was the limited time, financial resources and capacity available for stakeholder involvement. The recommendations therefore focus on reducing the burden of participation and explicitly considering whether the expected value of stakeholder involvement justifies the resources required.

This does not mean that stakeholder involvement should always be reduced when resources are limited. Instead, project teams can consider whether less resource-intensive methods are sufficient for particular purposes or show how stakeholder involvement can add value and lead to a better chance of long-term success. Stakeholders can contribute insights, relationships or implementation opportunities that might not be immediately necessary for the project but may become relevant later.

2. Make choices about stakeholder involvement explicit

Several challenges emerged because decisions about stakeholder involvement were implicit rather than explicitly discussed. This concerns, for example, which stakeholders are considered relevant, why some stakeholders are represented by others, what level of participation is considered appropriate, and which methods are used to involve them.

Making these choices explicit can create opportunities to identify perspectives that would otherwise remain outside the project. For example, when future residents are represented by developers, project teams can explicitly consider which resident perspectives are represented and which are not and whether they can include actors that can represent the end-user better. Furthermore, if residents are only involved during the implementation or evaluation phase, project teams can discuss why this level of participation is considered sufficient and what might be lost by not involving them earlier.

This also applies to power. Explicitly considering who has financial, institutional, technical or social resources can reveal which stakeholders have opportunities to influence decisions and which stakeholders may be less able to do so. Project teams can discuss how to address these power imbalances and what it could mean for the innovation.

3. Tailor participation rather than applying one involvement method

The cases indicate that stakeholders differ in their available time, interests, resources and preferred forms of participation. A single participation method is therefore unlikely to be equally suitable for all stakeholders.

RECOMMENDATION CATEGORY	CHALLENGE	RECOMMENDATION FOR PROJECT TEAMS
1. Balance the effort of involvement with its potential value	Geographical distance	Discuss expectations and preferred ways of working with stakeholders.
	Limited financial resources	Make the value of stakeholder involvement explicit when allocating project resources.
	Limited time	Reduce the time and coordination effort required to involve stakeholders.
	Technical research objective	Consider what stakeholder involvement can add beyond the immediate technical objective.
2. Make choices about stakeholder involvement explicit	Commercial interests	Make stakeholder interests, contributions and conditions for collaboration explicit.
	Difficulty involving realistic representatives	Make exclusions and representation choices explicit and critically assess their consequences.
3. Tailor participation rather than applying one involvement method	Limited capacity of stakeholders	Tailor the level and form of involvement to stakeholders' available capacity.
	Limited choice in participation	Give stakeholders opportunities to influence how they participate.
	Method selection	Use a broader range of participation methods where appropriate.
	Poor communication	Establish transparent and predictable communication.
	Tender requirements	Gather stakeholder perspectives before institutional constraints restrict collaboration.
4. Build shared understanding, trust and visible value	No shared problem	Develop or clarify a shared problem, objective or value proposition.
	Uncertainty about innovation	Make uncertainties and risks explicit and discuss how they can be addressed.
5. Look beyond the existing project network	Dependence on existing networks	Look beyond the project's existing network when identifying stakeholders.
6. Reassess stakeholder involvement throughout the project	Changing stakeholder relevance	Reconsider how stakeholder involvement could influence the project throughout its development.

Table 5.1: Recommendations for improving stakeholder involvement based on the identified project challenges

Project teams can therefore discuss stakeholders' preferred ways of participating and offer different forms of engagement. For example, some stakeholders may like to contribute through a workshop, while others may provide feedback through a short interview, demonstration or conversation. Providing different forms of participation can also make it possible to involve stakeholders who would otherwise be excluded because of time, distance or other constraints.

Importantly, tailoring participation does not mean that project teams should decide what is best for stakeholders. Asking stakeholders how they prefer to participate can itself become part of the involvement process. This can help project teams understand what creates value for different stakeholders and can support longer-term commitment.

4. Build shared understanding, trust and visible value

If there is no shared problem between stakeholders or it remains uncertain whether an innovation is useful, stakeholders are less willing to participate.

To prevent this from happening, LLs and FLs could start by gathering stakeholders to define a problem statement and afterwards come up with a solution.

Whenever this is not possible and an innovation is already developed, it is still important to focus on creating a shared problem statement at the beginning of a project to describe the relevance for each stakeholder and feel involved.

Furthermore, uncertainties surrounding an innovation can be discussed explicitly. Asking stakeholders what makes them hesitant to participate, adopt or purchase an innovation can reveal risks that may otherwise remain implicit. Demonstrations, testing and dialogue can then be used not only to present the innovation, but also to understand and address stakeholder concerns.

5. Look beyond the existing project network

The cases showed that stakeholder involvement partly depended on the networks of individual project managers.

Existing relationships can be very valuable because they make it easier to reach relevant actors. However, it could also mean that other interested stakeholders remain unidentified or are reached only later.

Project teams can therefore do an actor and network scan at the beginning of each project to consider who could be affected by, contribute to or influence the innovation. This is particularly important for less powerful actors, since they might not control resources that are immediately useful to the project but may nevertheless be affected by its outcomes.

This recommendation also relates to the question of representation. A stakeholder does not necessarily need to control a critical project resource to be relevant. Involving affected stakeholders can provide perspectives on acceptance, consequences and implementation that may otherwise remain absent.

6. Reassess stakeholder involvement throughout the project

Finally, the cases showed that stakeholder involvement was often organised around the resources or knowledge that stakeholders could provide at a particular stage. While this can be a practical way of organising a project, it can also mean that stakeholders are only involved when their contribution is considered immediately useful to the project.

Project teams could therefore consider if the project set-up is procedurally fair. Do all stakeholders who are affected by the project have a formal and equal say in the decisions being made in the project? Do we forget to consider perspectives of different

stakeholder groups in some stages of the project? How could we improve this?

Early involvement of a broad range of stakeholders can provide additional perspectives and lead to a bigger chance of long-term success.

Evaluating recommendations

Many of these recommendations involve trade-offs. More inclusive involvement requires time and resources, while excessive participation can contribute to fatigue. Tailoring participation can improve accessibility, but different forms of participation require additional coordination. Involving more affected stakeholders can improve the diversity of perspectives, but may make decision-making more complex. The recommendations should therefore not be interpreted as a prescription to maximise stakeholder involvement. Instead, they suggest that project teams should consciously balance the resources required for involvement with the potential value of different forms of participation, while considering whose interests and perspectives may otherwise remain excluded.

To balance these trade-offs, it is important to explicitly discuss questions that otherwise remain implicit. These are questions like: Who is relevant and why? Who has the most power to influence the project? Whose perspective is missing? What does each stakeholder want to achieve? How much time can they realistically invest? How do they prefer to participate? And what influence do they have over decisions being made in the project? Making these questions explicit can help project teams identify what they find important and how stakeholders can be involved well throughout projects.

5.7 SOCIETAL CONTRIBUTION

The cases illustrate that achieving the ideals of broad and meaningful stakeholder involvement is not always realistic in practice. Time and financial constraints, legal and procurement requirements, commercial interests, difficulties reaching relevant stakeholders, and limited stakeholder capacity can all shape who is involved in an LL or FL project and how they can participate. Recognising these constraints can help LLs and FLs consider more deliberately which stakeholders are relevant at different stages of a project and what forms of participation are meaningful and feasible in a given context.

While more stakeholder involvement is not always desirable or realistic, selective involvement can have societal implications. When participation is limited, certain perspectives, particularly those of end-users and other actors with less influence over critical project resources, may be represented less directly in project decisions. If these perspectives are not taken into account because they are not directly contributing to a project, it can harm inclusiveness and representation, but also long-term acceptance. The findings therefore suggest that decisions about who is involved, when and how should be made deliberately rather than being determined solely by practical constraints or the immediate needs of the project.

For practitioners operating LLs and FLS, the findings provide several practical directions for improving stakeholder involvement. The findings suggest that improving stakeholder involvement is not necessarily about involving more people, but about creating more deliberate, transparent and reciprocal forms of participation. Next to focusing on how stakeholder involvement can lead to more effective scaling, project teams can consider not only what stakeholders can contribute to the project, but also what the project can provide to partic-

ipating stakeholders, such as opportunities to influence decisions, gain knowledge, test solutions or address issues that affect them. This way, the findings can support LL and FL practitioners in balancing the practical realities of experimentation with the broader societal goals of inclusive and just innovation.

Furthermore, projects can balance stakeholder power by providing accessible opportunities for stakeholders with low power to contribute and by communicating how their input has been used. Low-burden feedback channels, different participation formats and closed-loop communication can make participation more meaningful without requiring all stakeholders to be continuously involved. This is particularly important when stakeholders have limited time or capacity to participate, or when they have less direct influence over project decisions.

5.8 SCIENTIFIC CONTRIBUTION AND NOVELTY

This research contributes empirical evidence on how stakeholder involvement operates in different Dutch LL and FL projects. Existing LL literature often emphasises user involvement, co-creation and upstream participation as important characteristics of living lab experimentation (Huang et al., 2024; Innella et al., 2024; Schubert et al., 2026; Vervoort et al., 2022). The cases studied here show that these ideals cannot always be fully achieved in practice. Stakeholder involvement is shaped by a range of practical, institutional and relational conditions, including limited time and financial resources, difficulties reaching relevant stakeholders, legal and tender requirements, commercial interests, uncertainty about the relevance of stakeholders, and the availability and capacity of stakeholders to participate. By identifying these conditions and examining how they shape stakeholder involvement, this research provides an understanding of how involvement operates in practice.

The findings contribute to existing research on stakeholder engagement in LLs by refining how the challenges of stakeholder involvement are understood. Schubert et al. (2026), for example, show that stakeholder engagement is influenced by diverse motivations, barriers and enablers, including time and resource constraints, communication, institutional conditions and differences between stakeholder groups. The present study confirms several of these challenges across three Dutch LL and FL projects, including limited time and resources, perceived relevance, communication and institutional constraints.

Additionally, while Schubert et al. (2026) have examined barriers and enablers from the perspective of stakeholder engagement, this research shows that challenges can emerge from both sides of the involvement process. Low stakeholder involvement can result not only from an unwillingness or inability of stakeholders to participate, but also from constraints faced by project teams, such as identifying, reaching and involving stakeholders, including limited resources, reliance on existing networks, uncertainty about stakeholder relevance, and institutional restrictions.

By understanding these challenges, solutions can be designed to overcome them.

Furthermore, the research answers three sub-research questions. The answers show that stakeholder involvement is dynamic. Stakeholder involvement was not fixed

throughout the projects, but changed as project activities and resource needs changed. Actors became relevant when their knowledge, resources, responsibilities, relationships or access to implementation contexts became important for the next stage of development. This finding is in line with research that shows stakeholder roles and relationships change throughout living lab processes (Huang et al., 2024). The present study contributes by analysing how changes in project needs and the resources required at different development stages influenced which stakeholders were considered relevant and when they were involved.

The findings also contribute to the connection between stakeholder involvement and scaling. Rather than treating scaling as a single process of physical replication, the analysis distinguishes between spreading, broadening and deepening, following Schagen et al. (2023). The cases demonstrate that a project can generate learning or broader effects even when physical implementation does not occur. This supports the broader understanding of scaling as a process that can involve changes in practices, relationships, knowledge and contexts rather than only the replication of an innovation (Schagen et al., 2023; Termeer & Metze, 2019).

Lastly, the study shows that power imbalances were present in all cases. The amount of power and influence in a project was related to the distribution of critical resources across stakeholders, with less powerful stakeholders, community actors, often having less influence over decisions being made. The findings align with the findings of Turnhout et al. (2020), who describe community actors as often not being able to define a scope, not being able to define what is considered relevant and not being paid for their contributions.

6

CONCLUSION

This thesis investigated the challenges projects in LLs and FLs face when trying to involve stakeholders to support scaling beyond a pilot project. This chapter will give answers to the sub and main research questions. Afterwards, the limitations of the study will be discussed and directions for future research will be given.

6.1 ANSWERS TO THE SUB-RESEARCH QUESTIONS

The first sub-research question was:

Which stakeholders are involved in Living Lab and Field Lab projects, and why, when, and how are they engaged?

Stakeholder involvement was dynamic rather than static throughout the cases. While all 4 categories of the Quadruple Helix model were involved, the level of involvement of actors changed as the projects progressed through different development stages and different resources were needed. Rather than engaging actors continuously from design through evaluation, projects brought stakeholders on board when their specific technical expertise, funding, or regulatory authority became necessary to move the initiative forward.

Different forms of involvement were used, including information exchange, meetings, demonstrations, consultation, technical testing, feedback and co-creation. The degree of involvement varied between stakeholders and project phases. The results show that involvement does not automatically lead to influence in the decision-making process or the balancing of power between stakeholders. For example, residents were often consulted late in implementation and were only asked to provide feedback; they were represented indirectly through real-estate developers; or they were absent from design altogether. Stakeholder involvement therefore varied not only in timing and form, but also in the extent to which actors could affect project decisions.

The second sub-research question was:

What types of success do stakeholders aim to achieve in Living Lab and Field Lab projects, and how do these relate to different scaling pathways?

The cases showed that project success was understood in different ways. For some actors, success was associated with technological performance and physical implementation. For others, learning, knowledge development, institutional connections or policy relevance were important outcomes.

These different understandings of success corresponded with different scaling pathways. Spreading involved replication or expansion to additional locations, projects or users. Broadening involved connections to other institutional, policy or societal contexts. And deepening involved learning and changes in knowledge, practices, relationships or understandings within an existing context.

Therefore, the outcomes show that physical project failure (spreading failure) does not equate to transition failure. While conventional metrics centred on Technology Readiness Levels or market uptake would classify stalled implementations as complete failures, a small-wins perspective demonstrates that institutional deepening and policy broadening can act as seeds for future socio-technical transitions.

The third sub-research question was:

How are power imbalances between stakeholders addressed in Living Lab and Field Lab projects?

Across all three cases, decision-making influence was related to the distribution of critical resources across stakeholders. Industrial actors exercised controlled technical choices due to their specialised expertise, while public authorities, housing corporations, and municipal bodies influenced the project conditions through regulatory mandates, procurement budgets, and control over physical implementation contexts. Intermediaries and researchers could influence the research set-up and contributed by facilitating communication and bridging stakeholder networks. However, explicit mechanisms to discuss or redistribute formal decision-making power were largely absent.

As a result, stakeholder participation did not translate into equal influence. A clear distinction emerged between actors who shaped project choices and those who merely provided information or experiential feedback. Community actors and end-users, in particular, were given opportunities to share user experiences or respond to surveys, but were excluded from early framing, trial design, and strategic decision-making. Furthermore, participants were not always informed about how their feedback was used or how final project decisions were reached.

6.2 ANSWER TO THE MAIN RESEARCH QUESTION

Main research question was:

What challenges do projects within Dutch Living and Field Labs encounter when involving stakeholders to support scaling beyond the pilot?

The findings show that projects within Dutch LLs and FLs encounter challenges in involving stakeholders to support scaling beyond the pilot. These challenges occur on both sides of the involvement process. Project teams face constraints in identifying, reaching and involving stakeholders, including limited time, financial resources and organisational capacity, dependence on existing networks, difficulties identifying appropriate representatives, and institutional restrictions such as tender requirements. Stakeholders, in turn, may have limited capacity or willingness to participate when they do not perceive a shared problem or sufficient relevance to their interests and responsibilities, face uncertainty about the innovation, or have limited opportunities to influence the project. Communication, participation methods and commercial interests can further shape whether involvement remains meaningful. The cases therefore show that stakeholder involvement is not simply a matter of whether stakeholders are willing to participate, but is shaped by the conditions under which project teams organise participation and by the opportunities stakeholders have to contribute. Therefore, the challenge is to meaningfully involve stakeholders while overcoming barriers that limit this.

These challenges are relevant to scaling because stakeholders can provide knowledge and resources that can support developments beyond the pilot. However, the findings do not indicate that stakeholder involvement automatically leads to scaling. Rather, stakeholder involvement forms part of the conditions through which projects may develop opportunities for spreading, broadening or deepening their innovation beyond the experimental setting.

6.3 LIMITATIONS

This research has several limitations that should be considered when interpreting the findings. First, the study is based on three qualitative cases selected from projects within LLs and FLs. The cases were selected to provide variation in project context, stakeholder involvement and scaling outcomes, but they do not represent all types of LL and FL projects. The cases also differed in their objectives, organisational structures, technological maturity and development trajectories. This variation enabled comparison across different project circumstances, but it also limits the extent to which similarities and differences can be ascribed specifically to the LL or FL setting.

Second, the stakeholder perspectives captured in the research were limited by the selection of interviewees. Although the actor and network scan was used to identify relevant stakeholders and interviewees were selected to represent different positions within each case, not all identified stakeholders were interviewed. Especially, the perspectives of actors who were not involved in the case studies but were affected by the project were not included in this research. This introduces a selection bias towards the perspectives of actors who were included in or closely connected to the projects. The findings primarily reflect the perspectives of the actors who were involved and available to participate in the research. Stakeholders who were absent from the projects, chose not to participate, or were difficult to reach may have experienced the challenges of stakeholder involvement differently. Understanding their perspective could lead to new insights on challenges for stakeholders to participate in LL and FL projects.

Third, the study relies on retrospective analysis of project development. Interviewees were asked to reflect on stakeholder involvement, decision-making, challenges and project outcomes, which means that their answers may be influenced by their position within the project and by their recollection of events. Retrospective interviews introduce a risk of recall bias, as participants may misremember events, overlook conflicts, or rationalise past decisions based on their current understanding of the project. Different actors may also interpret the same involvement process differently. The use of desk research and observations provided additional sources of evidence and enabled comparison between accounts, but these sources could not fully eliminate differences in perception, retrospective bias or gaps in the available information.

Fourth, the operationalisation of stakeholder involvement, power and scaling required complex project dynamics to be represented through predefined analytical categories. Stakeholder involvement was classified according to the phases of design, implementation and evaluation and the levels of information, consultation and co-creation. Power was analysed through financial, institutional, technical and social resources, while scaling was examined through spreading, broadening and deepening. These categories provided a consistent structure for comparing the cases, but they cannot capture every dimension of stakeholder relationships, influence or change.

Finally, the cross-case analysis identifies patterns and relationships between stakeholder involvement and developments beyond the pilot, but the research does not establish causal relationships between stakeholder involvement and scaling. The cases indicate that stakeholder involvement can provide access to knowledge, resources, relationships and implementation contexts that may support development beyond the pilot. However, scaling outcomes are also shaped by factors outside stakeholder involvement. The findings should therefore be interpreted as identifying challenges and

relationships that help explain how stakeholder involvement takes place in these projects, rather than demonstrating that particular forms of stakeholder involvement cause particular scaling outcomes.

6.4 DIRECTIONS FOR FUTURE RESEARCH

The findings of this study point towards several directions for future research.

First, future research could investigate the perspectives of stakeholders who are not involved in LL or FL projects but could be relevant. The present study looks at the perspectives of actors who were directly involved in or closely connected to the cases. Stakeholders who were not reached, chose not to participate, or were not identified within this study may experience different barriers to participation. Including these actors in future research could present additional challenges and provide insight into what would make participation more accessible and valuable.

Second, further research could examine how procedurally just stakeholder involvement can realistically be achieved. The cases demonstrate a tension between meaningful participation and the limited time, financial resources and capacity available to projects and stakeholders. Future research could investigate what minimum conditions are required for affected stakeholders to have meaningful opportunities to influence relevant decisions, and how this can be achieved without requiring continuous participation. This also includes investigating how different participation methods can balance stakeholder burden with the level of influence they provide.

Third, future research could investigate stakeholder involvement in projects where a solution already exists. This is often the case for FL projects, which means that co-creating an innovation based on a shared problem statement is not always possible. This could affect stakeholder ownership, perceived relevance and longer-term uptake. Research could therefore examine how projects can compensate for the absence of early co-creation and therefore minimise possible negative impacts.

Fourth, future research could explore how stakeholder involvement can balance low participation burden with meaningful influence. The findings indicate that stakeholders differ in their available time, capacity and preferred ways of participating, while more intensive forms of involvement can provide greater opportunities for influence. Future research could therefore compare different participation methods and investigate how they affect stakeholder burden, quality of input and decision-making influence. Particular attention could be given to end-users, who may not have the capacity or motivation to participate continuously but may nevertheless be directly affected by the experiment.

Fifth, public procurement provides a specific context in which stakeholder involvement requires further investigation. In both the MFB and DHN case, a tender was written to create a solution to a problem, but this way of working may restrict collaboration with a broad range of stakeholders. Future research could examine how stakeholders can effectively be involved in these projects to understand how shared problem definitions can be developed without distorting competition, and how co-creation can take place in procurement-driven projects.

Finally, future research could develop and test a practical tool for identifying missing and powerful stakeholders. Such a tool could combine stakeholder mapping with assessments of affectedness, resources, influence and representation to identify

who is included, who is absent and who has disproportionate influence over project decisions. Importantly, it could also provide guidance on what project teams can do in response, such as seeking additional perspectives, adapting participation methods or reconsidering decision-making arrangements.

Together, these directions point towards research focused on making stakeholder involvement both meaningful and realistic. Future research could investigate how relevant and affected stakeholders can be identified, how differences in power and capacity can be addressed, and how meaningful opportunities for influence can be provided within the constraints of real-world experimentation.

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