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Msc. Architecture, Urbanism and Building Sciences **(Urbanism Track)** | Delft University of Technology

R&D Studio: Spatial Strategies for the Global Metropolis | Msc - Q3

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Table of contents

Abstract

In order to achieve the national target of climate neutrality by 2050, the Netherlands needs to undergo an energy transition that will result in sweeping change to the energy system.

Within the current energy system, energy poverty plagues nearly 400.000 Dutch households, and 75-percent of those households reside in social housing. What if the systemic change inherent to the impending energy transition could be used as an opportunity to eradicate energy poverty in the Netherlands?

To answer this question, we design a vision and strategy to develop an affordable, renewable heating system in the region of Arnhem-Nijmegen, with the social housing community acting as both the social and organisational heart.

We call this ***Social Heating.***

The vision and strategy have been designed using a mixed-methods approach involving conceptual and technical literature reviews, along with news media, policy, case study, energy, organisational, and spatial analyses.

The result is a vision of an expanded, renewables-based district heating network extending to most of the Arnhem-Nijmegen region, delivered by a new, non-profit organisation, the Social Heating Association ("SHA"). An associated strategy details how the vision will be implemented through a combination of spatial and policy interventions, ordered over time in five phases extending to 2100. By harnessing the existing organisational capacity of social housing communities, and with careful planning and bold action, it is possible to provide affordable, renewable heating to all in the Arnhem-Nijmegen region.

Further, we believe this model for heating can be used as a template for implementation in similar regions across the Netherlands.

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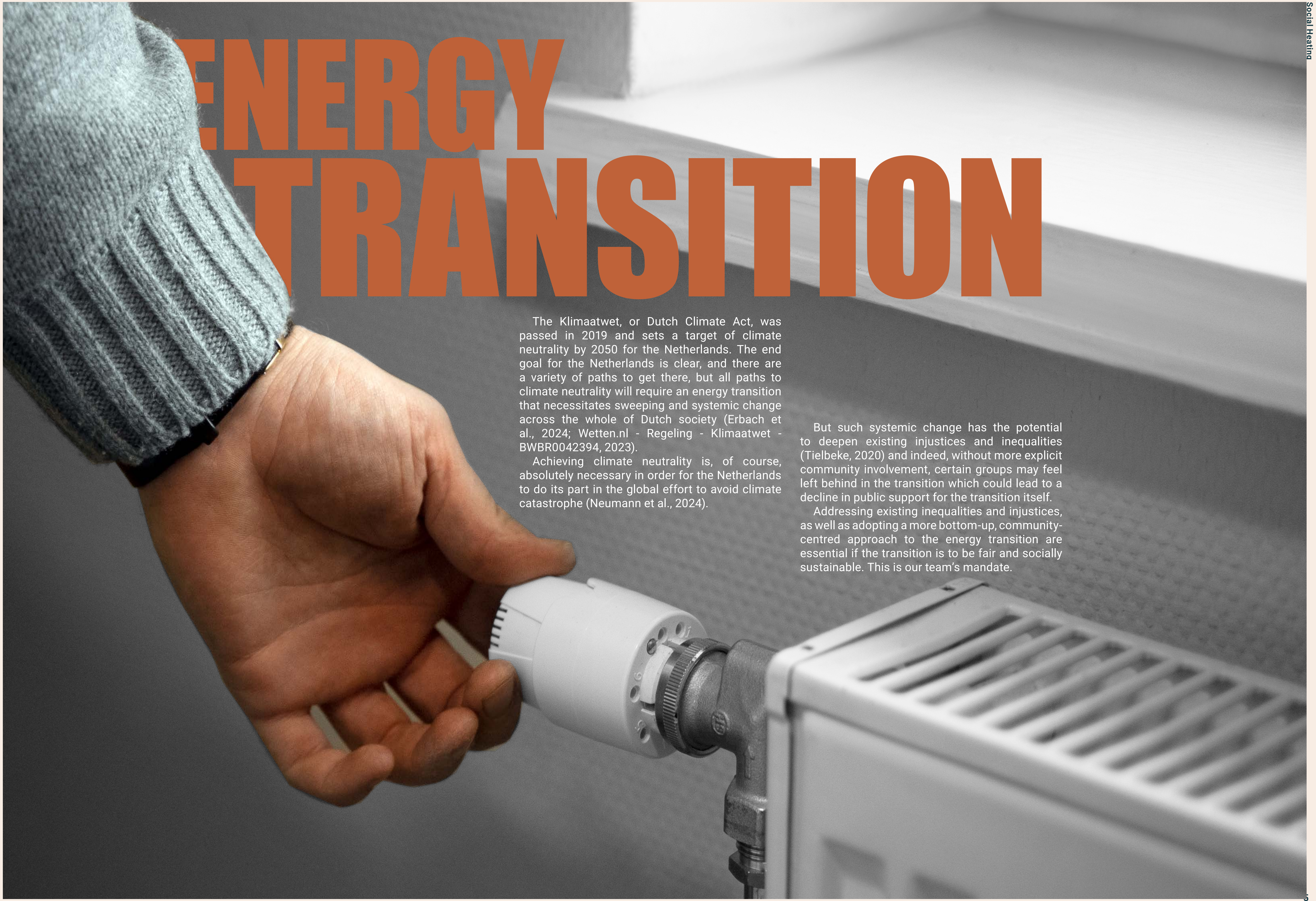
Chapter 1

Introduction.



ENERGY TRANSITION

The Klimaatwet, or Dutch Climate Act, was passed in 2019 and sets a target of climate neutrality by 2050 for the Netherlands. The end goal for the Netherlands is clear, and there are a variety of paths to get there, but all paths to climate neutrality will require an energy transition that necessitates sweeping and systemic change across the whole of Dutch society (Erbach et al., 2024; Wetten.nl - Regeling - Klimaatwet - BWBR0042394, 2023).

Achieving climate neutrality is, of course, absolutely necessary in order for the Netherlands to do its part in the global effort to avoid climate catastrophe (Neumann et al., 2024).

But such systemic change has the potential to deepen existing injustices and inequalities (Tielbeke, 2020) and indeed, without more explicit community involvement, certain groups may feel left behind in the transition which could lead to a decline in public support for the transition itself.

Addressing existing inequalities and injustices, as well as adopting a more bottom-up, community-centred approach to the energy transition are essential if the transition is to be fair and socially sustainable. This is our team's mandate.

Figure 1: Collage of Energy Transition

ENERGY

As a team, we are motivated by issues of justice. Energy justice is a concept that theoretically underlies most all of the work presented in this report. But it also encapsulates our collective motivation for this work as a team. Energy justice can be described as the application of justice principles to energy policy, energy production and systems, energy consumption, energy activism, energy security and climate change (Jenkins et al., 2016).

In content, the vision and strategy presented in this report focus mostly on energy policy, energy production, and energy consumption. Crucially, though, our team has considered how justice principles, including procedural, distributive, and recognitional justice, can be applied to these energy topics. These principles are elaborated further in the conceptual framework section of chapter three. The application of a justice lens to the energy transition led our team to identify one particular issue in the Dutch energy system: energy poverty. In the next chapter, the issue of energy poverty is contextualised within a specific community and region to form the problem statement which serves as the basis for the development of our vision: Social Heating.

JUSTICE !

procedural *distributive* *recognitional*

Chapter 2

Problem Statement.

Like stated in the previous chapter, our focus is on the nationwide issue of energy poverty. To delve deeper into this topic, we have chosen to concentrate on a specific community and region; the social housing community in the region of Arnhem-Nijmegen. In this chapter, we explain what energy poverty is and why we selected this particular community and region as the focus of our vision.

Issue

Energy poverty

Energy poverty, as defined by the European Commission, "occurs when a household must reduce its energy consumption to a degree that negatively impacts the inhabitants' health and wellbeing" (Energy Poverty, n.d.).

In the Netherlands, energy poverty affects around 390.000 households, using the LILEQ designation for energy poverty. LILEQ describes households which have both low income and low energetic quality, where low energetic quality refers to homes with poor insulation/weatherization and relatively high energy consumption.

Energy poverty afflicts only a subset of the population, thereby producing inequality and impeding a just energy transition. Historically, energy poverty has been considered an issue of income poverty and related income policy. But the two issues, energy poverty and income poverty, while strongly correlated, are not completely overlapping (Mulder et al., 2022). Therefore, energy poverty deserves, and in fact requires, its own set of measures, and the energy transition presents an excellent opportunity to introduce such measures.

For this reason, our team has chosen to focus on the issue of energy poverty, and specifically how it could be eliminated through the process of change inherent to the energy transition in the Netherlands.

Figure 2: Collage of Energy Poverty

Community

Social housing

In order to contextualise the issue of energy poverty in a way that would enable a grounded formation of a vision and strategy, we sought to identify a community of focus. As described in the previous section, energy poverty affects many households in the Netherlands, but it does not affect all communities equally. Of the 390.000 households experiencing energy poverty in the Netherlands, 75 percent can be found in social housing (Mulder et al., 2022). However, only 29 percent of all households in the Netherlands reside in social housing (Dashboard - Bouwen En Wonen - Aa En Hunze, n.d.). This means that energy poverty disproportionately affects the social housing community. Further, those in social housing are uniquely ill-equipped to lift themselves out of energy poverty due to the combination of low income (and therefore fewer resources to expend on home energy improvements) and a lack of control over their living space that is inherent to renting. For these reasons, we have chosen to focus our vision and strategy on this specific community: residents of social housing.

Social housing in the Netherlands is provided by a network of 284 different non-profit housing corporations. Housing corporations are private organisations that receive no direct subsidy from the Dutch government, however they do make use of long-term, low-interest government loans to fund construction projects. In total, there are 2.3 million social housing units in the Netherlands, all of which are rented for a maximum of € 880 per month as of 2024 (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2024; Van Deursen, 2023). Figure 5 at the right shows the current organisational structure of social housing in the Netherlands. Renters are represented formally by renters' associations, who communicate with housing corporations on behalf of renters, although renters of course are able to communicate directly with the housing corporations as well. Housing corporations participate in both national and regional partnerships such as HSPN (HSPN, n.d.).

Though social housing residents are among the most vulnerable with respect to energy poverty, the sheer size and pre-existing organisational capacity of the social housing community is a real asset for coordinating and affecting systemic change. Later in the Vision chapter of this report, we outline how this strength of the community can be harnessed to catalyse systemic change in the residential energy sector and alleviate energy poverty.

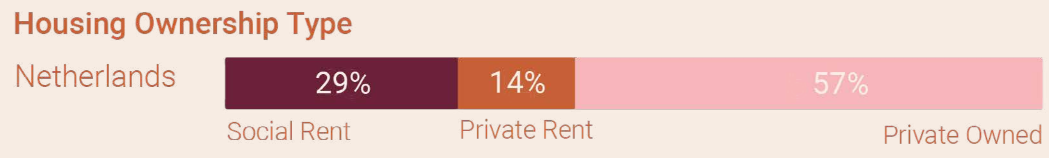


Figure 3: Graph of Amount of social housing

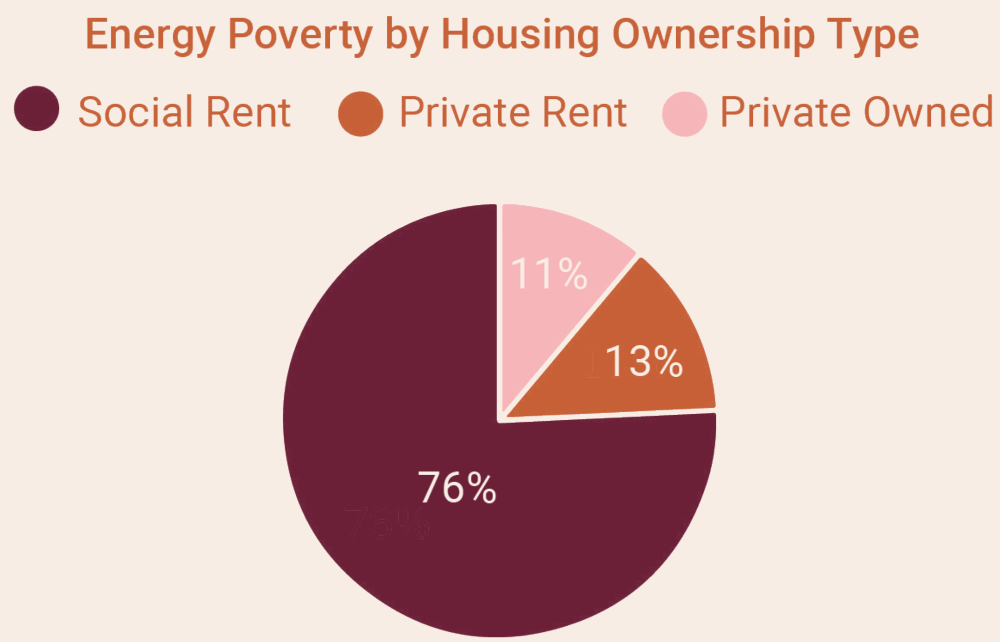


Figure 4: Graph of Energy poverty by housing ownership type

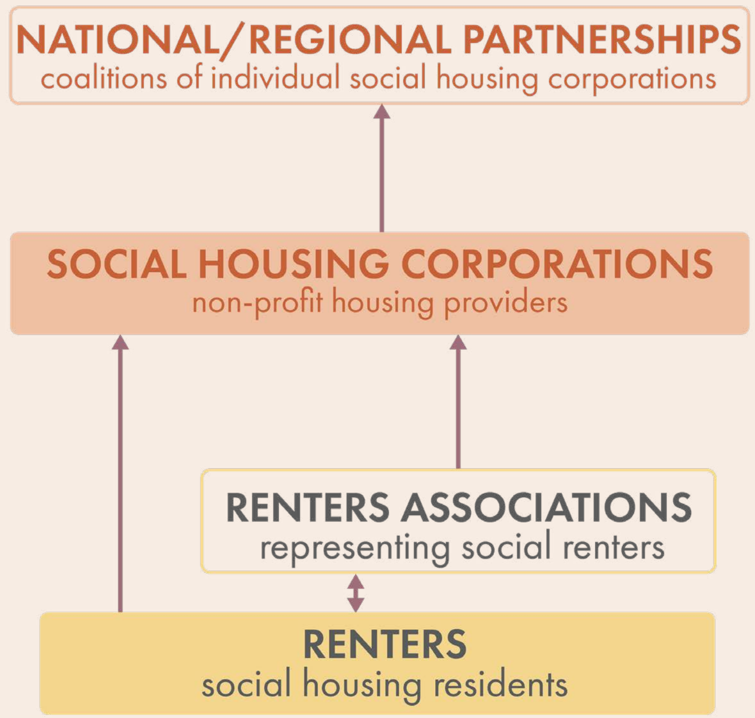


Figure 5: Hierarchical Organisation of Social Housing Community

Region

Arhnem-Nijmegen

The final step in contextualising the identified issue of energy poverty was to connect it, and the social housing community, to a specific region of the Netherlands. To do this, we set out to identify a region that is often overlooked, such that it might benefit more from our attention, that has a relatively high percentage of social housing, so that the social housing community is adequately represented, and that has some diversity in residential density, so that whatever we design may be easily translatable to other regions of the Netherlands.

Figures X and X on the right, shows the results of our analysis of news media and academic publications related to the energy transition (add note about method here). Broadly speaking, the south and east of the country receive less attention in news media and academic publications related to the energy transition compared to the north (Groningen) and the west (Randstad). This led us to shift our focus to the south and east of the Netherlands. Next, we mapped all municipalities with a higher-than-average share of social housing (greater than 35 percent), shown in Figure X. Within the south and east, there are a few clusters of higher social housing density near Arnhem-Nijmegen, Eindhoven, Maastricht, and Enschede. This led us to the final criteria, diversity in density. Of the five areas identified from the previous step, Arnhem-Nijmegen, highlighted in Figure X, contains the most diverse mix of small towns, mid-sized towns, mid-sized cities (Arnhem and Nijmegen), more dispersed rural and agricultural settlements, and nearly uninhabited natural areas (Veluwe). Further, Arnehm-Nijmegen is already well-defined as one of thirty Energy Regions in the Dutch Regional Energy Strategy ("RES"), which aims to coordinate relevant stakeholders in each region to develop a plan to achieve the goals set out in the national climate agreement (Dutch National Programme Regional Energy Strategies - Regionale Energiestrategie, n.d.).

The identified region, Arhnem-Nijmegen, is geographically defined by the same borders used to outline the region in the RES. Arnhem-Nijmegen lies within the province of Gelderland and is comprised of 17 different municipalities (shown in Figure X), with a total population of 765.000, divided amongst 355.000 households. The two largest cities, Arnhem and Nijmegen, contain 166.000 and 182.000 residents, respectively (Centraal Bureau voor de Statistiek, 2025). Spatially, the most prominent features of the region are its four major rivers, including the Rhine, the Maas, the Waal, and the Ijssel, as well as a large section of the Veluwe National Park in the North.

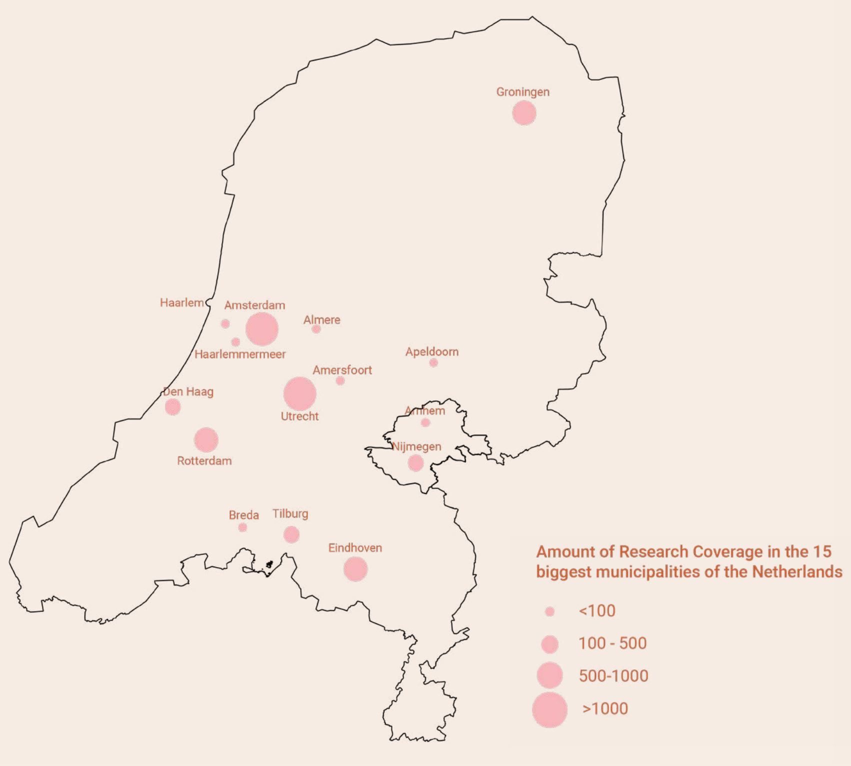


Figure 6: Research coverage

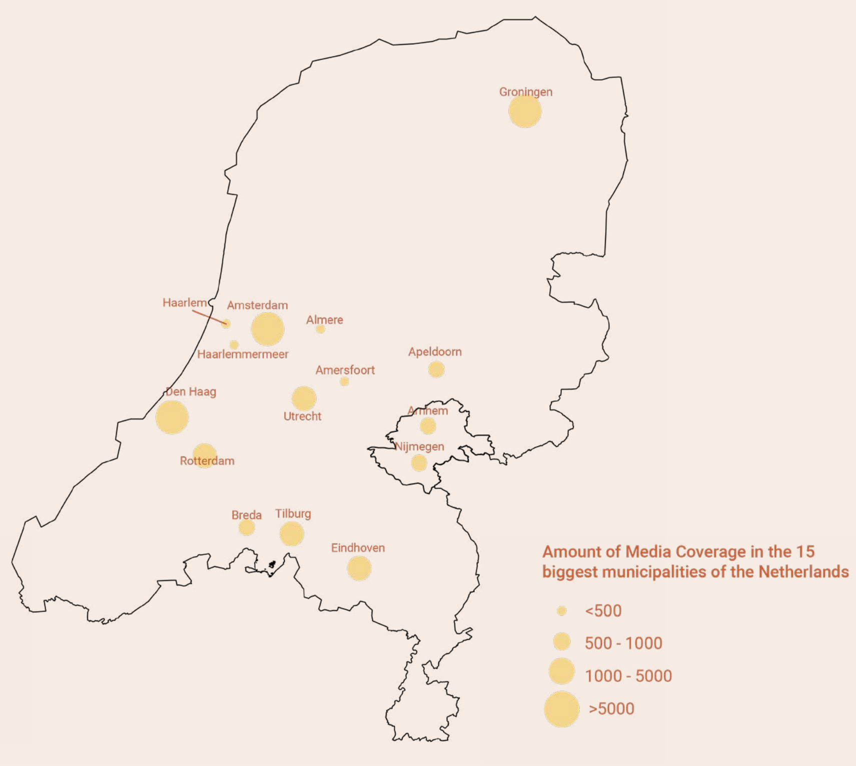


Figure 8: Media coverage

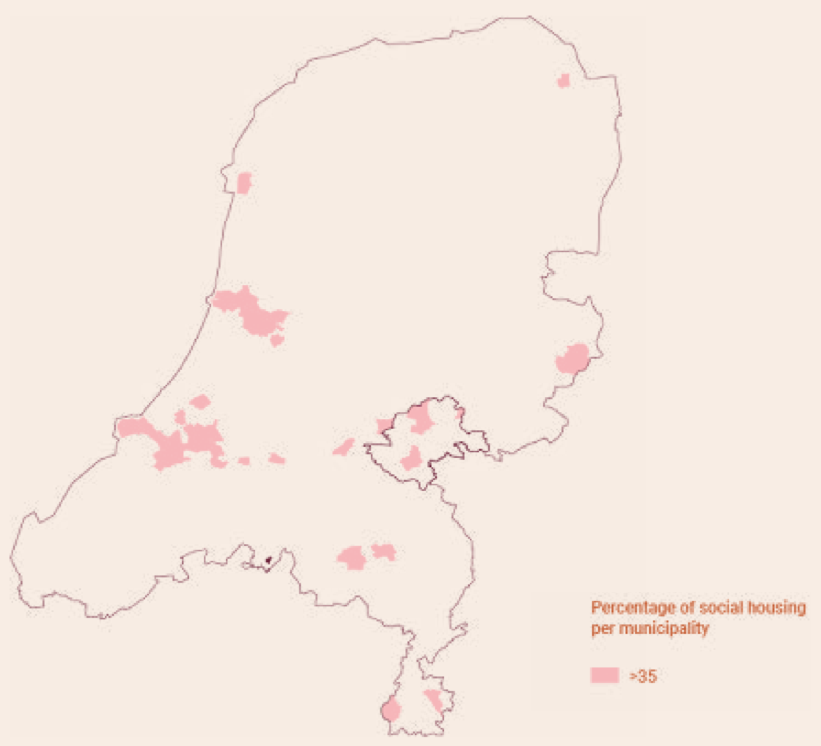


Figure 7: Social housing

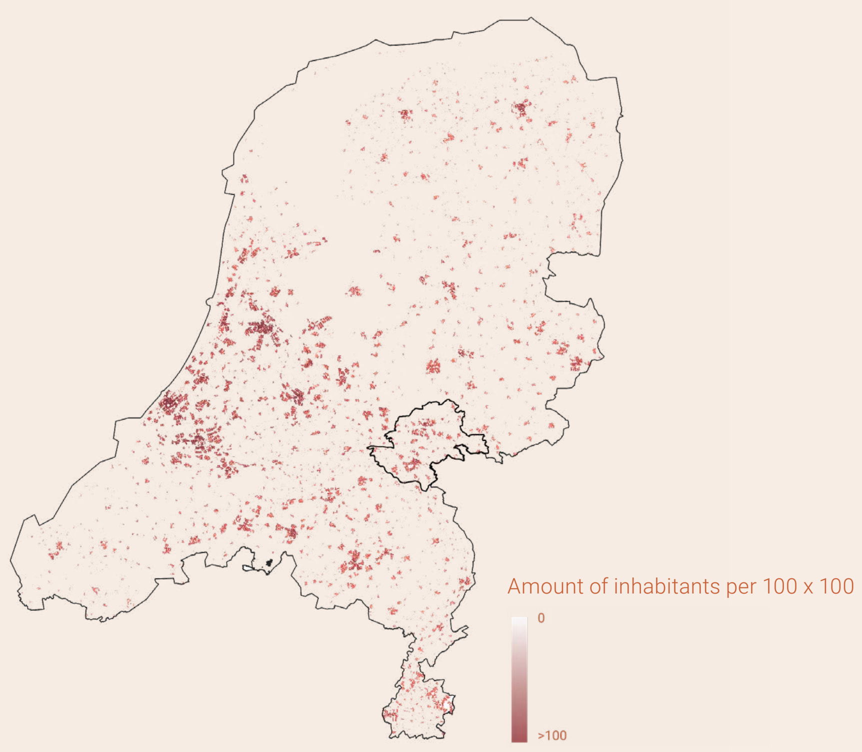


Figure 9: Population

Chapter 3

Approach.

In this chapter, we outline the approach used to develop our vision. The problem statement will be briefly repeated, followed by a discussion of the research questions that guided our work. Subsequently, we present the theoretical and conceptual frameworks, along with the methodology used by our group.

Figure 10: Collage of the problem statement

Problem Statement

Energy poverty in the Netherlands is a real issue that calls for serious change. With the identification of an issue, a community, and a region established in the previous chapter, the essential elements of our problem statement are complete. Using the energy transition as a vehicle for change, we aim to address the issue of energy poverty within the social housing community, in the region of Arnhem-Nijmegen. This problem statement sets the topical, social, and spatial boundaries for our work. In the next chapter, we use these boundaries to define a core research question therein, which establishes a framework for more detailed analysis, and ultimately leads to the development of our vision and associated strategy.

Research Question

In order to address the challenge of reducing energy poverty in the social housing community associated with using non-renewable sources for heating, a central research question was formulated to guide the design of a vision and strategy:

“How can we use the energy transition to alleviate energy poverty in social housing?”

This central question is accompanied by a set of other objectives that support the research question to address other issue:

1. What are the problems of citizens and communities living in social housing regarding the impacts of high energy costs, energy transition and environmental sustainability?

2. What type of organisational shift(s) in the roles of the housing corporations, local governments, and community will ensure a just energy transition?

3. What renewable energy solutions can effectively reduce energy poverty in social housing while maintaining stability?

4. What are the spatial implications of the diversification of heat sources and what does their integration into urban fabric look like?

Theoretical Framework

The transition to renewable energy is not merely a technical or economic challenge but also a socio-spatial one. As regulating policies and energy systems shift toward adopting sustainability, it is crucial to consider who benefits and who bears the burden of these changes (Rawls, 2005).

While focusing on energy justice within social housing, we must examine how the energy transition can be used to reduce energy poverty rather than deepen existing inequalities. To build a holistic conceptual framework, the project draws on theories of social and spatial justice, particularly the work of Nancy Fraser on justice dimensions and Charles Taylor on the politics of recognition.

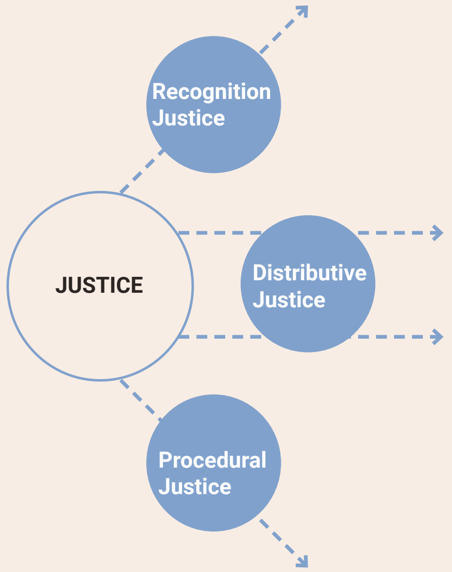


Figure 11: Theoretical Framework

Justice, as framed, consists of three interrelated dimensions: recognition justice (the acknowledgment of the social housing community in proposed transformations), distributive justice (the fair distribution of resources such as affordable renewable energy), and procedural justice (the fairness of decision-making processes in energy governance).

By integrating these theories of justice, the project develops a conceptual framework for energy justice that extends beyond purely technical solutions. In doing so, the theoretical framework provides a lens to establish the conceptual framework which is the foundation of "Social heating".

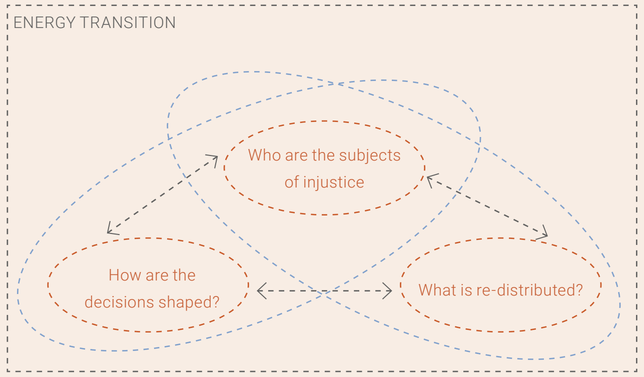


Figure 12: Addressing questions for a just transition

The energy transition demands a justice-oriented approach that integrates concepts of distributive and recognition justice (Fraser 1995; 2009), politics of recognition (Taylor, 1994). The argument that justice is twofold: it requires both the fair distribution of resources and the recognition of marginalized voices in decision-making (Rawls ,2005) is an interesting lens to adopt to look at the project.

At present, social housing residents often face energy poverty due to financial constraints and governance structures that limit their participation. This 'overlooking' mirrors what Taylor (1994) describes as a failure of recognition, where factors like market oriented development and emphasis on dominant groups over less dominant gourps dictate the current reality. A just energy transition, therefore, must not only address financial stability and affordability through redistribution but also ensure that social housing residents are actively engaged in the dictating some factors shaping their energy futures.

The current trajectory of the energy transition in the world risks creating new and exaggerating existing divides, where wealthier homeowners who can afford the initial investment of switching to renewable technologies with a huge upfront cost reap the benefits, while others remain the disadvantaged ones with not being able to switch despite having the will to do so.

The push to phase out gas and other fossil fuels will see an increase in energy bills in the near future (Dutchnews.nl, 2024) while disproportionately affecting these communities. Addressing this calls for structural changes, such as the redefinition of profit structures which don't necessarily see 'Access to heating' as a public good. To create a non-profit driven energy cooperative that puts affordability and access over profit, could be one possible solution out of this energy crisis.

Conceptual Framework

Using the Theoretical Framework for achieving Energy Justice, the main goals and actions required can be fleshed out.

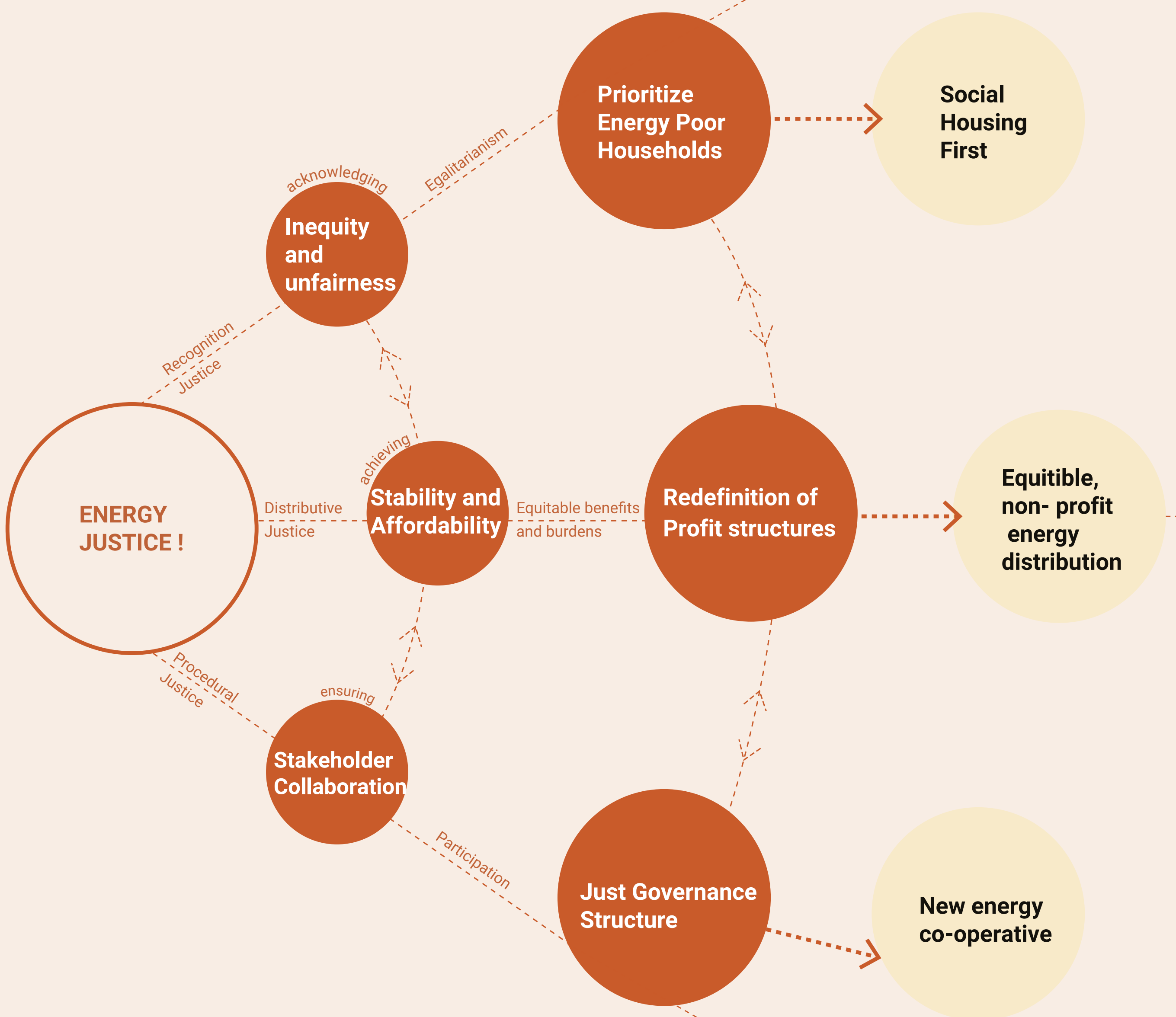


Figure 13: Conceptual Framework for the project

An integral approach in urbanism seeks to unify various theories and concepts in this project, across the scales of nation, region (Arneh and Nijmegen), and city (Nijmegen)

This framework humanizes these theories and applying them to urban planning by addressing both potential opportunities and existing challenges. Ensuring that urban development is responsive to the needs of all communities and not a top down design exercise.

Recognition justice emphasizes acknowledging the structural inequalities that have historically marginalized communities and ensuring that their voices are acknowledged (Fraser, 1995).

In the context of energy justice, this means recognizing the systemic barriers faced by energy-poor households, particularly those in social housing, who often lack financial agency and decision-making power in the energy transition. These communities frequently experience energy poverty, not due to a lack of willingness to adopt renewable energy, but because of financial constraints, limited access to infrastructure, and governance structures that exclude their voices (Bal et al., 2021).

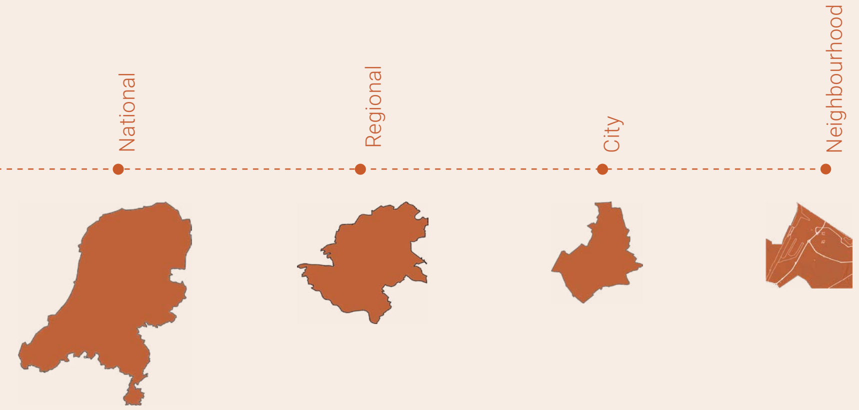
Prioritizing social housing in the transition towards renewable energy ensures egalitarianism, addressing not only economic disparities but also injustices in energy accessibility. This aligns with Taylor's (1994) Politics of Recognition, which argues that justice requires more than just resource distribution—it demands the validation and inclusion of marginalized communities in shaping their own futures.

Distributive justice in energy systems focuses on ensuring equitable access to energy, making it affordable for all. Achieving stability and affordability in energy pricing is crucial to preventing energy poverty, where low-income households bear disproportionate financial burdens. Stability (both economic and in energy systems) ensures affordability and guarantees that every household, including those in social housing, can access energy without compromising other basic needs. A key way to achieve this is by redefining the profit oriented energy sector. Shifting towards a non-profit energy production and distribution model can ensure that all communities benefit from the energy transition, advancing social equity.

Procedural justice ensures fairness in governance, transparency, and inclusive decision-making processes. In the context of a just energy transition, procedural justice calls for the active participation of diverse groups, ensuring that their concerns, needs, and perspectives are considered. A key mechanism for achieving a just governance could be formation of co-operatives. These facilitate a bottom-up governance system where stakeholders collaboratively manage resources and ensure that decision-making processes are equitable and participatory.

Methodology

M1: Across various scales



Before delving into the methodology in the following section, it is essential to provide an overview of the various scales that are relevant to this project. The research and analysis operate on multiple levels, starting with the broader scale of the European Union (EU) and the Netherlands, which sets the context for regional and national policies. The next level of analysis focuses on the specific region of Arnem and Nijmegen, as established in Chapter 2. The pilot project then zooms in on the city of Nijmegen, providing a focused case study. Finally, the smallest scale involves various neighborhoods within Nijmegen, where specific pilot projects will be implemented. These neighborhood-level pilots will be derived from the catalogue of strategies developed during the course of the project, ensuring that the solutions are tailored to local contexts while contributing to the broader goals of the research.

M2: Across various research methods

Data Collection

In this research we made use of various sources of secondary data:
1) Empirical data from National data sources like RES, Overzichtskaart, PDOK, Atlas Leefomgeving, and Klimaatmonitor was used to do spatial analyses in QGIS.
2) Academic and Research articles were read and analysed to draw the conceptual framework for our project.
3) News articles, from national and local news portals were collected using various search engines like Nexus Uni, etc.
4) Various case studies were studied to understand successful examples of energy transition and community cooperatives from across the world.

Data Analysis

For the spatial analysis, we followed the following steps to establish the vision for our project:
1)The news and media was analysed on the software Atlas.ti to test our assumptions and understated the community perspective.
2)The data gathered during data collection was culminated various potential maps, highlighting the feasibility of our vision and identifying various locations where our project can be envisioned.
3) Initially, the project's area of research and rationale was guided largely by intuition and ideas of justice. To reinforce our approach, we analyzed case studies to identify common patterns and assess the relevance of these insights to our proposed design solution.

Frameworks

To develop a comprehensive conceptual framework, this project approaches the energy transition not solely as a technical or economic issue, but as a fundamentally socio-spatial challenge. The framework is constructed through a critical lens of energy justice, aiming to explore how the transition can alleviate, rather than exacerbate, energy poverty.

Designing Strategy and Vision

The project envisions a just energy transition starting with social housing. It combines spatial analysis, justice theory, and stakeholder analysis to identify key areas of intervention. Centred around the creation of the **Social Heating Association**, the strategy focuses on organizing governance, diversifying renewable heat sources (geothermal, aquathermal, residual heat), and expanding distribution networks.

A phased approach links policy, spatial goals, and community needs through maps, diagrams, and a catalogue of interventions. The final vision offers a replicable framework—tested through pilot projects in Nijmegen—for future energy-just cities, ensuring affordable heating, improved livability, and increased resilience in the built environment.

Methodology

The systematic explanation of the methods deployed in the project can be best shown using the form of this curve. The methodological framework presents a structured approach to investigating energy poverty and developing a strategy.

We illustrate the curve in four key phases:

Basis, Investigate, Resolve, and Re-Investigate. The curve oscillates along two axes—Empirical to Conceptual Fragments on the vertical axis and a time line progression on the horizontal axis.

Basis (Initial Research & Problem Definition)	Investigate (Analysis & Conceptual Framework)	Resolve (Vision & Strategic Development)	Re-Investigate (Strategy & Implementation)
The foundation of the project built of the commonality in the area of interest and defining it (energy poverty). Includes observations and understanding issues of unjust energy transition systems. Incorporates primary data collection, policy reviews, and academic theoretical frameworks. Develops the problem statement and research question.	The focus of the project is established here. Develops a strong framework for basing the project based on existing theories Conducts analysis of various kinds with anchoring case studies and explores the various nuances of social housing and the current energy landscape. All these complied to identify synergies	The vision for a just energy transition is developed. Emphasizing the priority to social housing Organise energy co-operatives. Focuses on decentralised energy production and identifying potential regional synergies.	Defines a strategy to implement the vision, considering stakeholder organization, timelines, and a national network. Develops a prototype for mid-sized cities to scale the approach. Concludes with reflections, assessing the impact and refining the strategy.

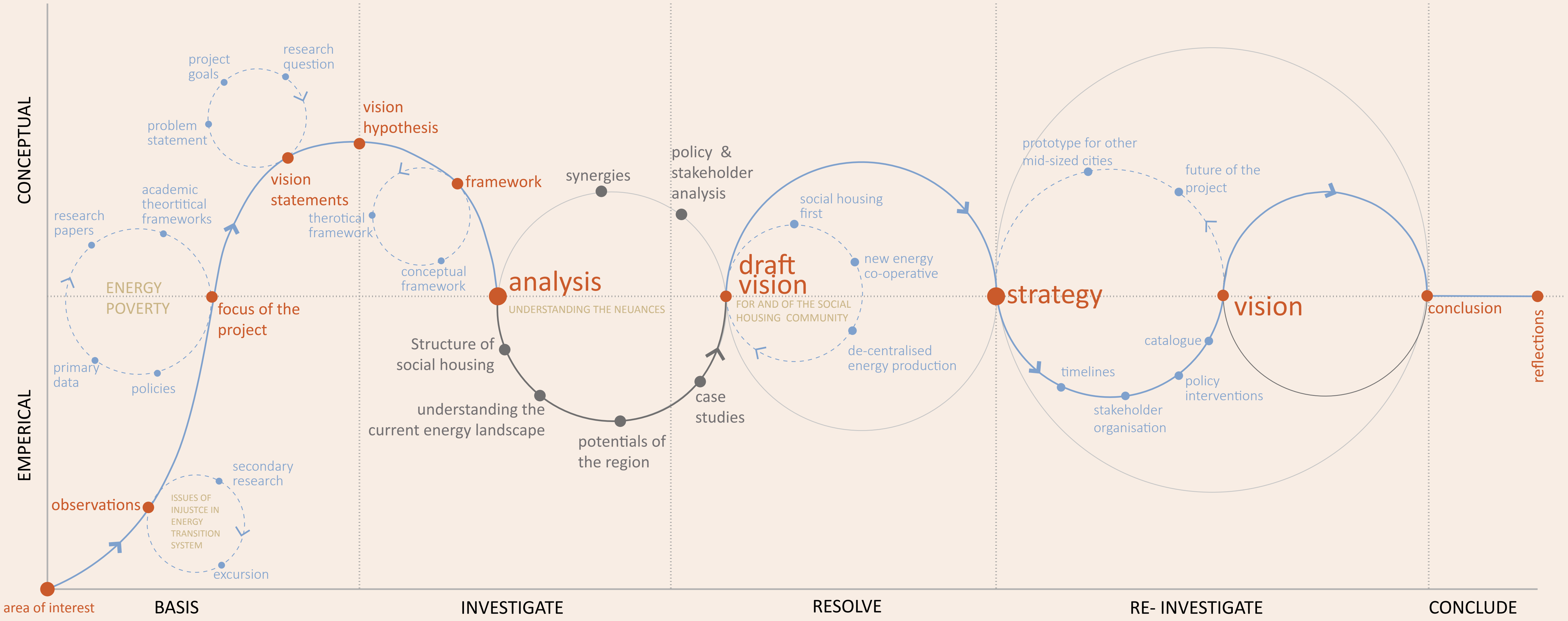


Figure 14: Methodological Framework

Chapter 4

Analysis.

To gain insight into the functioning of the current heating system and what the challenges faced by the social housing sector are, we analysed various factors relevant to our topic. To better understand the community, we conducted a theoretical analysis and held interviews with two key organizations in the region; housing corporation Talis and renters association HSPN. We also examined the existing heating system, its stakeholders, and the policies currently in place. Since our vision includes significant interventions in the region of Arnhem-Nijmegen, we aimed to better understand the landscape and its opportunities. To do this, we did a case study, analysing comparable cases from the Netherlands, Denmark, and England. At last, we explored the renewable energy potential and spatial implications specific to the region of Arnhem-Nijmegen.

Understanding our Community

Media Analysis

The media analysis is based on news articles highlighting the voice of residents living in social housing.

No stability for residents

As the transition to sustainable heating systems progresses, social housing residents are increasingly confronted with uncertainties. The long-term outcomes of renewable energy solutions often remain unclear, particularly regarding potential cost increases following housing renovations or the implementation of district heating systems (Suikerbuik, 2024). This lack of clarity contributes to a sense of instability, which can lead to heightened stress among residents.

Lack of communication

In addition to the instability caused by unclear energy solutions, tenants have voiced frustrations over inadequate communication, which exacerbates their sense of uncertainty. The community has expressed concerns regarding the communication strategy employed by Talis in relation to the installation of district heating. Both the district heating provider, Firan, and the social housing corporation, Talis, issued a notification to residents just one day prior to the commencement of construction. As one resident, Maters, remarked, "That's ridiculous. Why now? And why are we only being informed so late? This has been the case throughout the entire process: no one listens to us, and everyone looks the other way" (Smid, 2024). In addition to grievances regarding communication surrounding energy improvements, tenants of social housing corporations have voiced further concerns to newsoutlet De Gelderlander (Suijkerbuijk, 2024), highlighting that they had received letters from Talis that were perceived as having a threatening tone.

Afgehaakt Nederland

Huurders van corporatie Portaal in rep en roer vanwege extreme stijging

Woede om energievoorschotten

Emergency solution after sky-high energy costs: Nijmegen pays bills of hundreds of tenants

Paying up to 5000 euros in additional charges for heating your home: tenants in Nijmegen were shocked when they saw their energy bills. The municipality is now coming up with an emergency solution. It will open its purse strings and pay their final bills.

There is a lot of criticism of the heating network, but the alderman fully believes in it: 'Residents can never be the victims'

The construction of heating networks should make natural gas even more redundant in Nijmegen. There has been unrest about this for some time in two Dukenburg districts. A conversation with alderman Tobias van Elferen about the resistance, future and guarantees. "I believe in it to my toes."

Zorgen over gasloos wonen

Ophef om 'dreigende' brief Talis

Arme wijken wachten langst op dubbel glas

Brief over warmtenet, dag later beginnen werkzaamheden

'Onredelijk hoe Talis dit heeft gedaan'

On average, 250 people are queuing for one social housing unit in Arnhem: 'There is a huge shortage'

The demand for social housing in Arnhem and the surrounding area is exploding. There are now an average of 250 interested parties for one available rental house.

Barriers at open house for rental apartments: 'Living has become a luxury product'

Komt het goed met aanpak verpaupering?

Will things ever improve with the decay in the 'forgotten part of Nijmegen'? This is how politics wants to prevent problems

Figure 15: Collage of newsarticals about the energy bill

High energy bills

In February, De Stentor reported a record-high increase in gas prices, surpassing even the levels seen during the energy crisis. To assist low-income households struggling with these rising costs, the municipality extended its emergency fund (Voermans, 2025). However, the impact of soaring energy prices isn't limited to those relying on gas heating. For example, Rob Careman, a tenant of the Portaal housing corporation, shared with De Gelderlander that his energy bill tripled after the introduction of a new district heating network (Suijkerbuijk, 2024). Portaal attributed this sharp increase in costs to an unfavorable energy procurement strategy, explaining that while they aimed to purchase energy efficiently, the market conditions at the time resulted in high prices. Shortly after, energy prices dropped, further complicating the situation. This fluctuation in energy costs has made it increasingly difficult for Portaal to provide affordable heating for its tenants. In response, the municipality of Nijmegen implemented an emergency measure later that year, covering all energy costs that exceeded 100 euros (Suijkerbuijk, 2024). Despite these efforts, Portaal emphasized that it is ultimately the government's responsibility to ensure households have sufficient income to cover essential expenses, including energy bills and rent.

Densification

As the demand for housing continues to escalate, the need for social housing has become increasingly pressing. In both Nijmegen and Arnhem, the waiting times for social housing exceed the national average in the Netherlands. According to data expert Jasper Hol, the average waiting time in this region is 22.6 years (Reith, 2023). Research further reveals that in Arnhem, there are 250 individuals on the waiting list for each available social housing unit (Mulder, 2023). Social housing corporations have reported a continued increase in this number. The housing shortage has effectively turned access to housing into a privilege, rather than a fundamental right (Huibers, 2025). In addition to the issues related to energy costs and communication, the housing shortage is also a critical factor influencing residents' stability and wellbeing. For new developments, it is crucial that municipalities aim for at least 30% social housing within new urban densification projects (Ministerie van Binnenlandse Zaken en Koninkrijksrelaties, 2023).

Liveability

Aedes, the overarching organisation responsible for all social housing, asserts that social housing in urban areas is currently unevenly distributed. This imbalance contributes to reduced liveability in neighbourhoods with a disproportionately high concentration of social housing (Van Hulten, 2018).

Vulnerable neighbourhoods are more likely to be "neglected." Media coverage in Nijmegen highlights this issue, with residents reporting to De Gelderlander that they experience feelings of insecurity, problems related to waste disposal, and a diminished sense of social cohesion (Suijkerbuijk, 2024). In addition to the housing shortage and issues related to energy costs and communication, these factors further erode the overall liveability for residents in these areas.

Understanding our Community

Interviews with HSPN and Talis

To gain a deeper understanding of the social housing community, interviews were conducted with representatives from both a social housing corporation and a renters' association. These interviews served to validate many of the issues identified during the media analysis, while also refining and expanding upon some of the initial findings.

The key insights derived from the interviews are summarized on the right. The renters' association confirmed that a significant number of tenants have experienced a threefold increase in their energy bills. Additionally, they reported that the emergency financial support previously available is no longer being provided. As a result of persistent negative developments in recent years, approximately 80% of tenants are currently unwilling to engage in further participatory initiatives, citing a lack of perceived benefit.

Contrary to some of the narratives identified in the media analysis, the social housing platform HSPN expressed strong confidence in the current state of communication among the housing corporation, the renters' association, and the tenants. They emphasized the presence of multiple direct communication channels, which they regard as a distinctive strength compared to other regions.

The social housing corporation Talis acknowledged the volatility of energy costs and their partial responsibility in this context. However, they also emphasized that they operate in accordance with municipal energy transition policies and do not play an active role in shaping or implementing the transition to alternative heating systems.

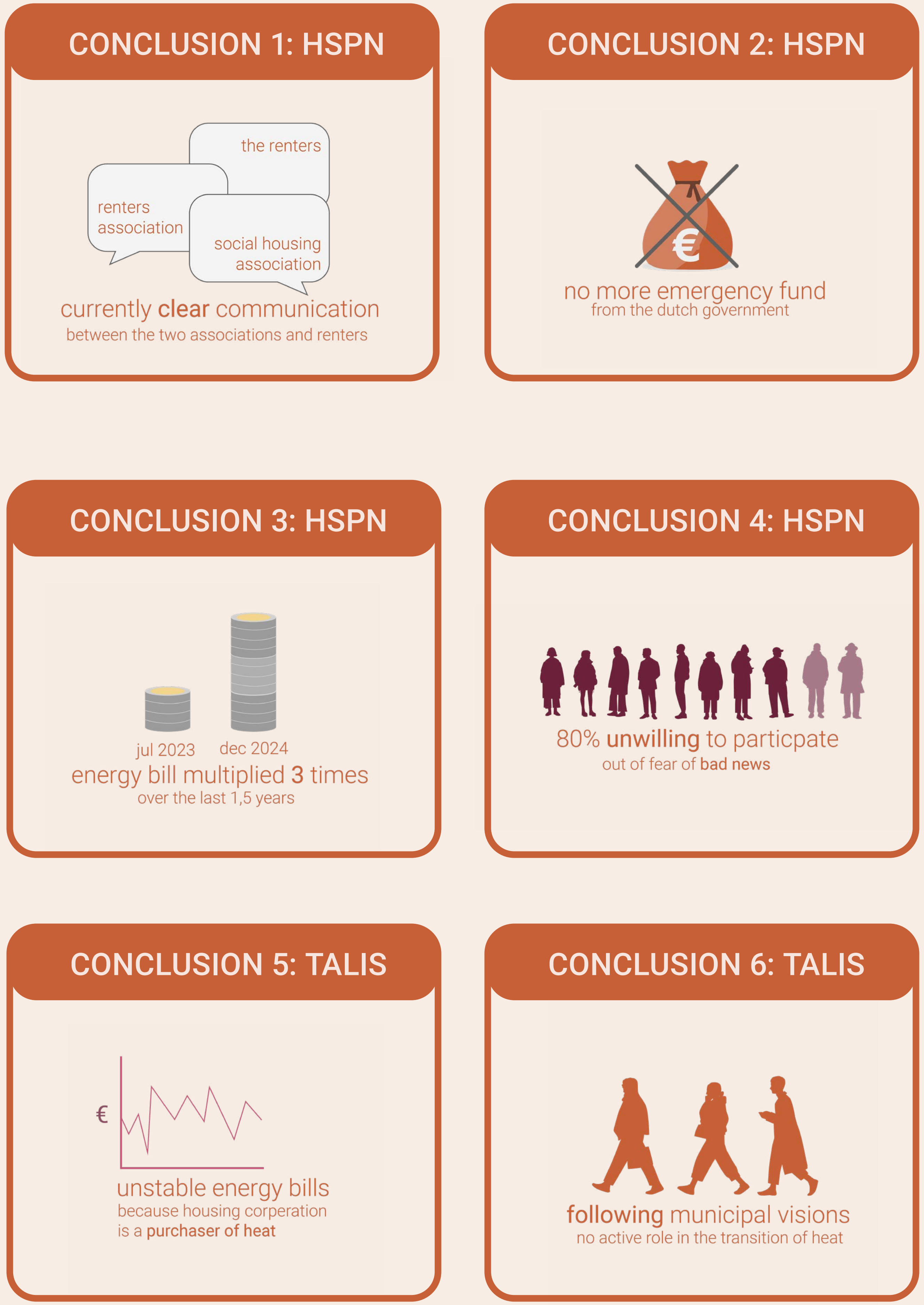


Figure 16: Understanding the community

Residential Heating System

Figure 17 on the right presents a visualization of the current heating system in the Netherlands. As of 2022, approximately 87% of the national housing stock was heated using natural gas (De Bondt et al., 2024). Historically, a significant portion of this gas was sourced from domestic gas fields, most notably the Groningen field. However, by 2022, less than one-fifth of the country's natural gas production originated from Groningen. With the official closure of the Groningen gas field in 2023, remaining production has shifted to smaller domestic fields (Centraal Bureau voor de Statistiek, 2023).

As a result of this shift, the Netherlands has become increasingly reliant on imported natural gas (Wolting, 2021), exposing the national heating infrastructure to greater vulnerability from global market fluctuations (Centraal Bureau voor de Statistiek, 2023). Imported gas is transported via the national transmission network, operated by Gasunie, and then distributed to regional operators such as Liander in the region of Arnhem/Nijmegen. This highlights the centralized nature of the gas transport system, which spans long distances and reinforces the country's dependence on international sources (Ministerie van Algemene Zaken, 2025).

In response to these challenges, the Netherlands is transitioning toward a decarbonized and decentralized heating system (Ministerie van Algemene Zaken, 2025). Although heat production traditionally takes place at the household level via individual gas-fired boilers, there is growing emphasis on sustainable alternatives. These include electric heat pumps for individual homes and district heating networks in more densely populated areas. In the Arnhem/Nijmegen region, several neighborhoods already utilize district heating, which is supplied by sources of residual heat. These locations are indicated on the map of figure 18.

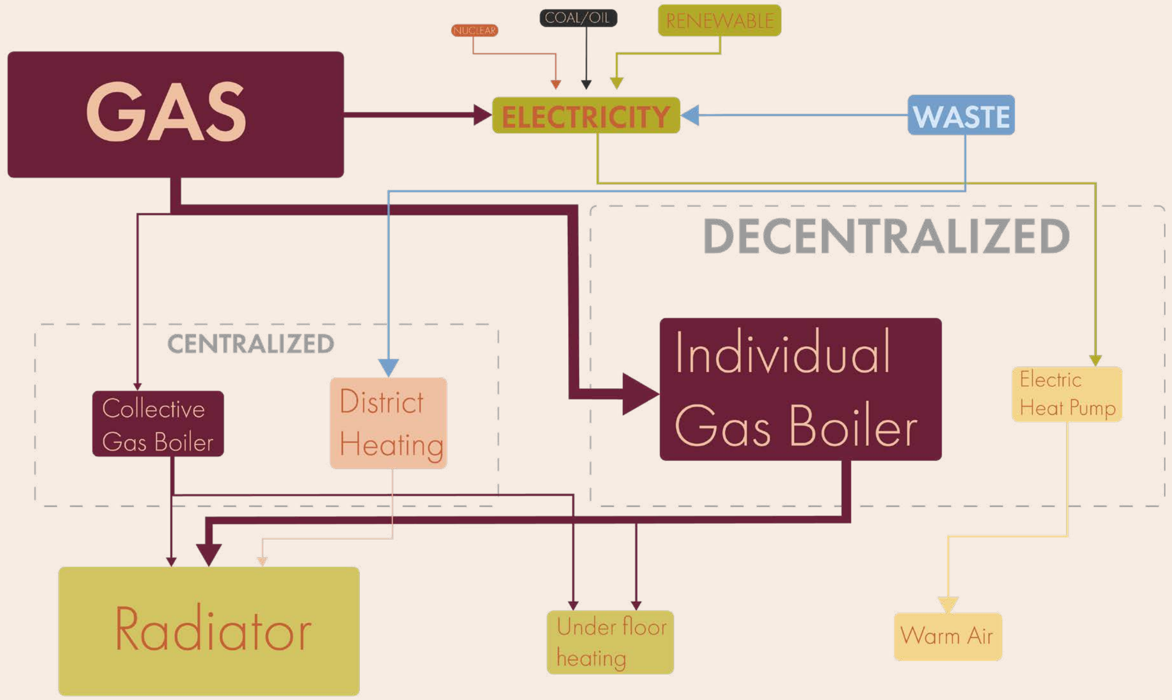


Figure 17: Current heating system scematic

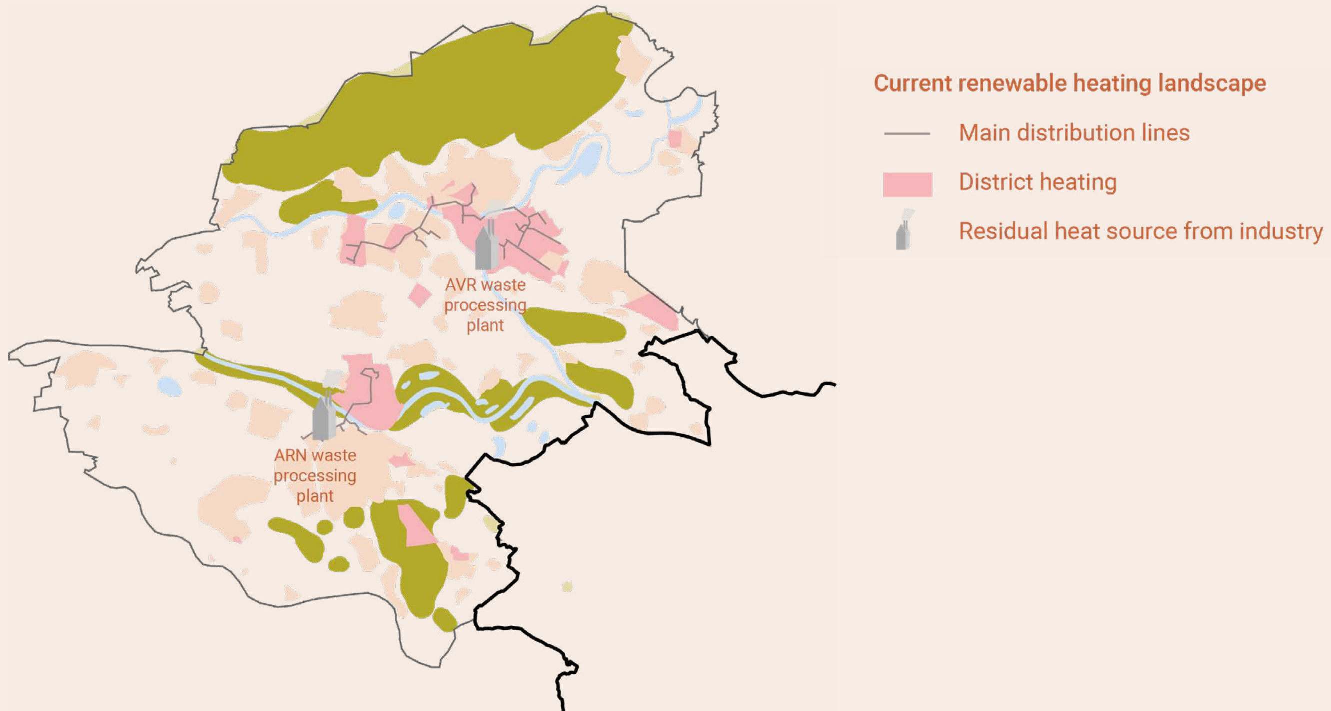


Figure 18: Current renewable heating landscape Arnhem-Nijmegen

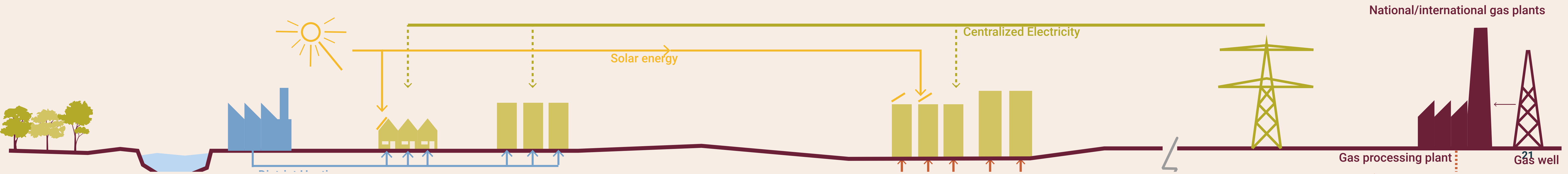
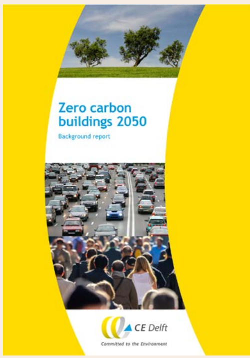


Figure 19: Schematic section of the current heating system

Existing Policies

To get a better understanding of the current situation and future plans, we conducted research into the following policies.



2050 all housing gas free

By 2050 the European Union aims to be climate-neutral (Going Climate-neutral by 2050, 2019).

In the Netherlands the main usages of gas is for the heating and cooling of the built environment with 87% (CE Delft et al., 2020 p.11, table 2). To have zero emission by 2050 all the exsisting housing has to have renewable heating sources.

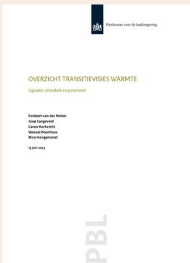
RES is looking into alternative heat sources and focuses on regional collaboration

To become a zero emission region the Regional Energie Strategy (RES) stated that every municipality in the region has to execute the goals for a climate agreement on a local scale ("Regionale Energie Strategie Arnhem - Nijmegen 2024 - Verrijking RES 1.0," 2024).

Most of the local descions are about the placing of the new heating network that will bring together different sources for the heat demand. The source of production needs to be close to the consumption site, this are local interventions in the landscape.

Local stakeholders are present for communication with the region and residents.

Production sites for electricty will be decided on regional to prevent them from being littering the landscape.



Heat visions created by municipality

Every municipality has created a heat vision stating until 2030.

In Arnhem the changes in the landscape will happen localy with participation of the residents (Wijkgerichte Energietransitie - Gemeente Arnhem, 2025). A heating network will be spread out in different neighbourhoods. Together with the network the livability will be upgraded and expandend.

Nijmegen looks at a network where multiple heating systems will come together to provide heating to the neighbourhoods (Gemeente Nijmegen & Royal HaskoningDHV, 2024). The network needs to be adaptable to future changes in the city. Similar to Arnhem the residents have a say in the changes of the landscape.

Municipality visions

The Green Metropolian Region (RES), which the cities Arnhem and Nijmegen are part of, have a densification strategy of two parts for the future of the region.

A total of 60.000 housing will be needed to housevest the growing population. Most the additions will be focused around the train stations (to improve mobility) and in the city centres.

In Part 1 (Meer Landschap Meer Stad Groene Metropool Arnhem Nijmegen Foodvalley 2040, 2023) of the booklet, the suggestion for locations of expansion of the residential areas is given. In the cities the densification is a mix of housing, work places and greenery. In the outskirts and the more rural areas energy production is added to the mix as well.

Part 2 (Opgavebeschrijvingen Verstedelijkingsstrategie Onderzoeksagenda Voor Gebiedsuitwerkingen, 2023) goes into detail of what this strategy means for the different municipalities. They, together with their residents, have the final say in the changing landscape.

Because of the spread apart layout of the city centres the densification will follow the exsisting structure.

Important for the municipality is that the region keeps it's green identity while expanding the capacity of residents.

All housing 2030 D or above

The government requires all housing to have an energy label of at least D by January 1st 2029 (Tweede Kamer der Staten-Generaal, 2025).

Currently around 1,5 million residential homes have a label of either E, F or G (How Existing Homes Are Given Energy Label a++++ | TNO, n.d.). The switch from gas heating to renewable sources will improve the energy label.

Fundings for energy poverty

All households in the Netherlands can be cut of from the electricity if they do not pay their bills in time. For the basic energy need they get a compensation of the government (European Climate Foundation et al., 2021 p.4).

The fundings from the government will priroitise the poorer neighbourhoods as there the housing generally have a lower energy label.

To subsides these people for their energy bill the government has created a Temporary Energie Fund foundation (Stichting Tijdelijk Noodfonds Energie (TNE)) which is a public-private foundation. From the government there is a sum of €60 Million to help out the households (Ministerie van Sociale Zaken en Werkgelegenheid, 2025).

This foundation has been helping households experiencing energy poverty since 2022. They've helped over 25% of the households in the Netherlands with their energy bills.

Stakeholder Analysis

The next step in the analysis involved identifying and positioning the various stakeholders involved in and affected by the social heating project. To do this, we employed a power-interest matrix, a strategic tool that allowed us to map stakeholders according to their varying levels of influence (power) and engagement (interest) in the project. This helped reveal the dynamics between public, private, and civic actors, and identifying the different treatments required for each sector.

Actors of the heating system: Conclusion

The stakeholder power-interest matrix reveals the imbalance within the energy transition landscape.

Civic actors— most notably Social housing renters and their associations demonstrate high interest but lack power, highlighting the need for empowerment and participatory governance. Meanwhile, disengaged citizens who show both low power and interest, require targeted awareness and capacity-building efforts and pointing to a need for wider outreach.

In contrast, private sector actors display a mixed status- while gas companies hold significant power but require to be encouraged to switch to cleaner energy production schemes. Renewable energy and district heating companies show opportunities to be engaged in the project and directed toward equitable and inclusive models. Other actors in the system like Electricity Grid Operators, Local Farmers, and Farmers Associations generally fall into the medium or low power and interest zones, with potential to be mobilized depending on their role in project.

Public sector actors, including national and local governments, are both highly powerful and interested, positioning them as pivotal agents for systemic change through policy support, infrastructure funding, and reform.

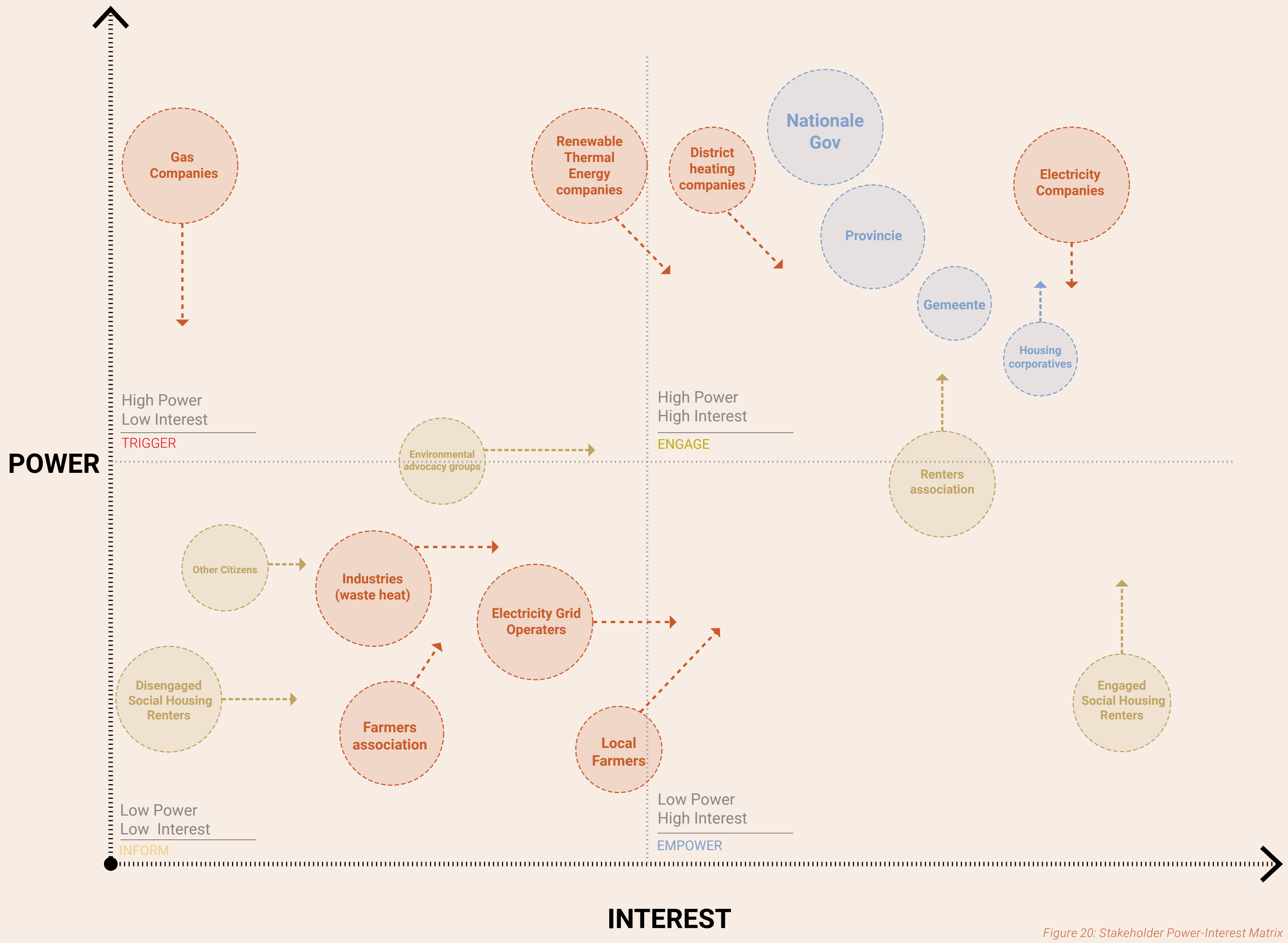


Figure 20: Stakeholder Power-Interest Matrix

- - - - → Desired position of the stakeholders

Public Sector — Nationale Government (National Government), Provincie (Province), and Gemeente (Municipality) occupy the high power–high interest quadrant, indicating they are crucial to engage with for policy alignment, funding, and implementation strategies. The Housing Corporatives are positioned with moderate power and interest, often acting as intermediaries between the state and renters.

Civic Sector — Social housing renters and their associations demonstrate high interest but lack power. Meanwhile, some portion of renters show both low power and interest. Environmental advocacy groups within the society are gaining interest and moderate influence, but lack attention and interest towards the social housing community.

Private Sector — Electricity Companies, District Heating Companies, and Renewable Thermal Energy Companies have high power, with varied degrees of interest. Their potential role as energy providers gives them leverage, though alignment with social goals may vary. Gas Companies maintain high power but are marked by low interest, due to the diminishing role of gas in a decarbonized future. Industries (emitting waste heat), Electricity Grid Operators, Local Farmers, and Farmers Associations generally fall into the medium or low power and interest zones.

Stakeholder Analysis

Organisation of the Current Heating System

The current organisational structure of the heating system can be seen in the diagram, along with the various roles and relationships among stakeholders involved in the heating transition.

At the core of the governance structure is the municipality, which plays an important role in shaping the local heat visions. Municipalities are informed by district heating companies and grid operators about the feasibility of energy infrastructure and supply options. This forms the foundation for municipal heat strategies.

Heat suppliers—primarily responsible for developing new energy sources operate alongside with constructors/operators/owners, which include district heating companies and grid operators. These actors not only develop the system, but also carry out the construction, operation, and expansion of the heating and electricity networks.

On the demand side, we see that the heat buyers, which includes the social housing corporations and other private housing entities. These actors are key intermediaries between suppliers and users. They are responsible for playing a communicative role with the heating users—notably the social housing community and renters' associations.

This organization highlights a sort of top-down dynamic in which technical and institutional actors (e.g., suppliers, operators, and municipalities) hold key decision-making power, while end users are the peripheral stakeholders.

Interestingly, within the energy landscape there can be other potential synergies with stakeholders who are not actively Involved in the current system.

Farmers and owners of empty or underused land have the potential to be included in the system but are currently not integrated. As such, they represent untapped potential.

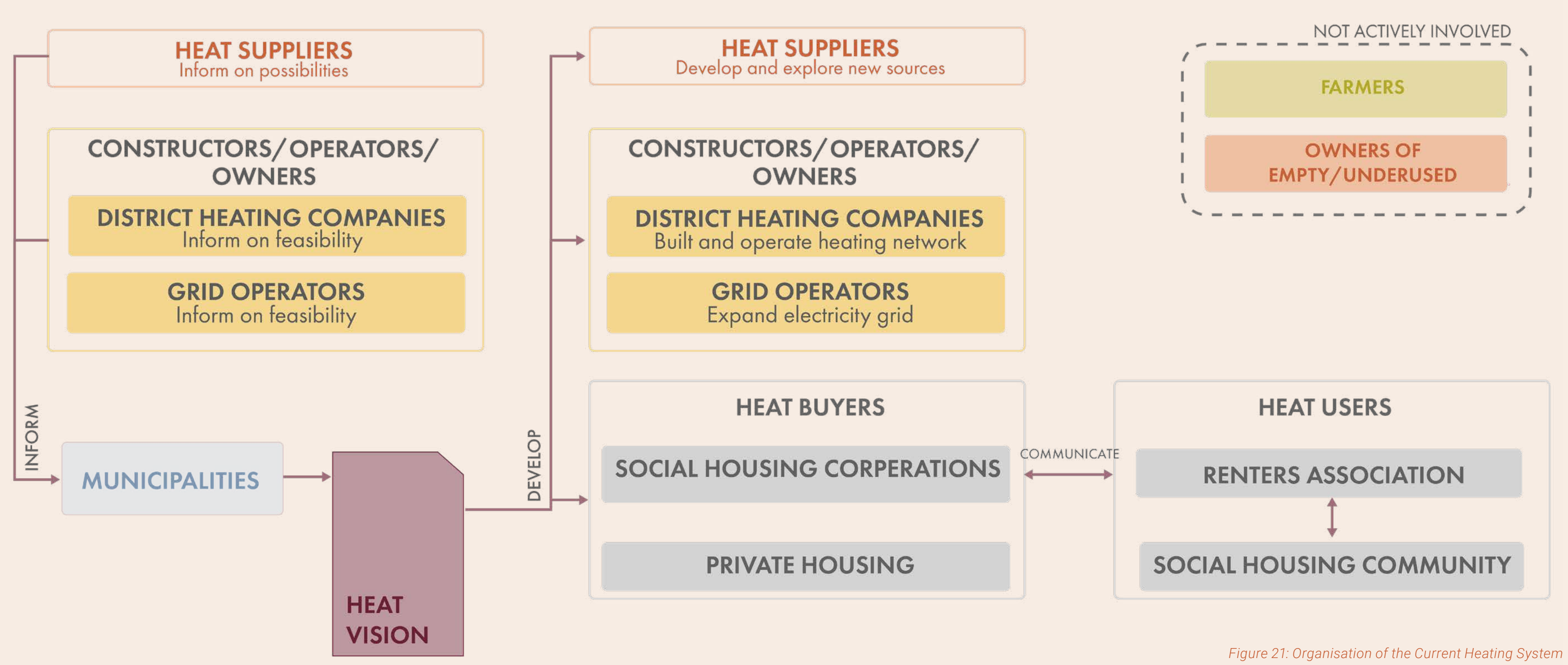


Figure 21: Organisation of the Current Heating System

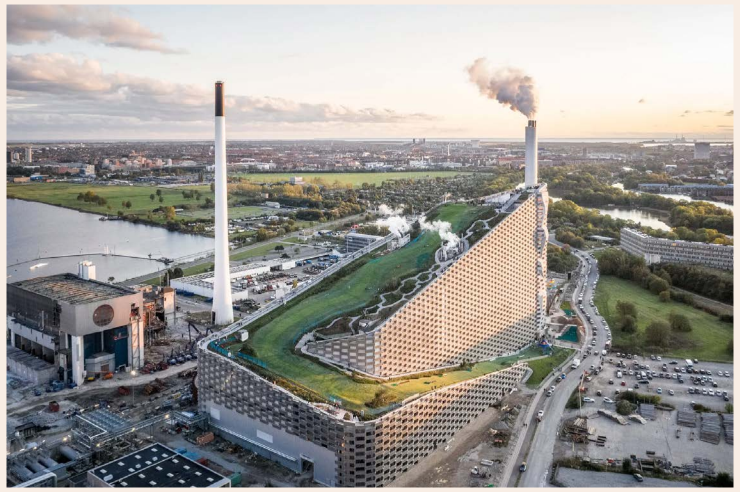
Case Studies

In order to gain a better understanding of renewables-based district heating, and to ground our proposed interventions with reference to real-world implementation, we analysed three case studies and reviewed two reference projects. The reference projects are production sites which besides production also have a public function as community space. One case study from Hvide Sande, Denmark proved the feasibility of a renewables-based district heating network, demonstrated the importance of integrating thermal energy storage, and made clear the benefits of diversifying thermal energy sources (Andersen et al., 2023). Another case study from the London Borough of Islington provided a proof of concept for public ownership of district heat production and distribution, as well as for public-private collaboration in heat network construction (Tilia et al., 2021/2022). Finally, the WarmtelinQ project in the Randstad illustrated the feasibility of a regional-scale thermal energy pipeline, designed to serve multiple communities and accommodate multiple thermal energy sources (WarmtelinQ, n.d.).

Energy Hubs as Community Spaces

Ski- slope hill, Copenhagen

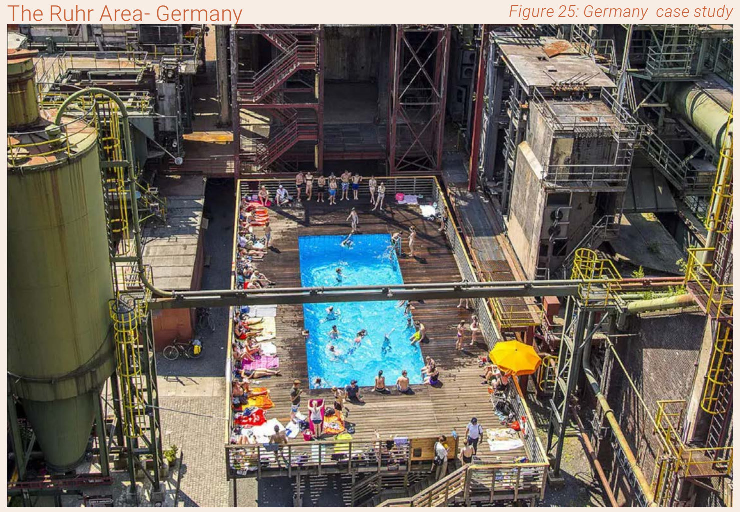
Figure 24: Copenhagen case study



In Copenhagen a 410-foot tall smoke stack is a turned to a ski hill, a tourist attraction.

The Ruhr Area- Germany

Figure 25: Germany case study



The Ruhr Area in Germany, turns Old Industrial into a tourist prescient

District Heating System- Denmark

In the village of Hvide Sande, Denmark, a local district heating company has established a district heating network that serves 1,637 customers with heat supplied by 92 percent renewable sources.

Figure 22: Denmark case study

Figure 23 shows the components of the district heating network which is comprised of two natural gas fired combined heat and power units (producing heat and electricity), three large wind turbines used to power electric boilers, a large heat pump used to produce hot water, a 9.500 m2 solar thermal array, and two hot water storage tanks with a combined capacity of 3.200 m3. The diversity of energy sources, coupled with ample energy storage capacity, means that the Hvide Sande district heating company is able to store thermal energy when it is produced but not immediately needed, and buy and sell electricity from/ to the grid dynamically based on real-time electricity prices (Andersen et al., 2023). This ultimately translates into lower heating costs for the residents of Hvide Sande, who in 2022 paid one-tenth of the average annual heating cost in Denmark (EMD International, 2024). source for adapted diagram

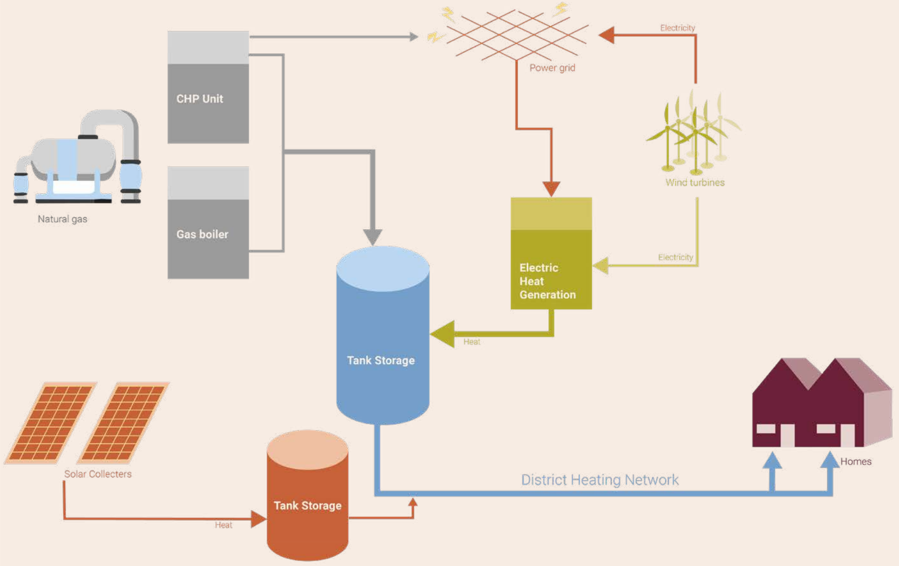


Figure 23: Denmark site

Case Studies

WarmtelinQ- Netherlands

Running from the port of Rotterdam to Leiden via the Hague, the WarmtelinQ, once completed, is a district heating pipeline that will connect residential, commercial, and agricultural (greenhouses) heat customers throughout the region with industrial waste heat sources in the port of Rotterdam. The pipeline is being constructed with multiple as-yet unconnected T junctions, such that future connections along the line can be accommodated in the future. Although currently there are only plans to connect industrial waste heat and heat from waste incineration plants to the pipeline, there is room in the future for geothermal sources to be added (WarmtelinQ, n.d.). Most relevant to our work, though, is the scale of this project. It runs a length of approximately 45 km in total, a distance that is similar to the length across the widest portion of our region, Arnhem-Nijmegen. This proves that a district heating pipeline of such a scale is indeed viable.

Figure 26: WarmtelinQ system plan

Energy Cooperative in Social Housing- England

The London Borough of Islington owns and operates an actively expanding district heating network that currently serves 1.400 residential units as well as a few commercial units (including a local primary school) and two leisure centres. Heat is provided by combined heat and power systems, along with a first-of-its-kind heat recovery system connected to the London Underground.

Figure 27: Bunhill 2 Energy Centre, London Borough of Islington, UK

Residential customers are primarily social housing residents in surrounding council housing estates. Though many stakeholders have been involved throughout the project, including the Greater London Authority, Transport for London, Celsius Project, and several private companies, heat production and distribution is entirely under the control of the Borough of Islington, a public, non-profit governing body (Tilia et al., 2021/2022).

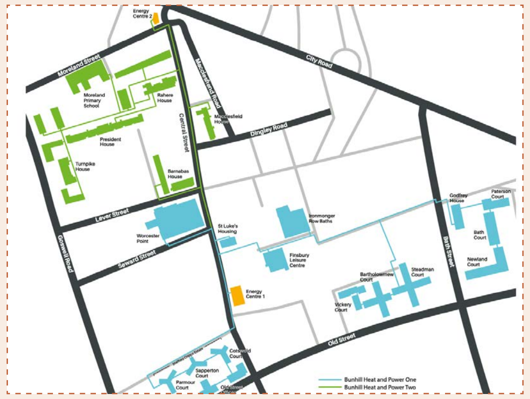


Figure 28: Map of the Bunhill Heat and Power Network

Energy potentials

Thermal potentials

Aquathermal

Aquathermal energy is a sustainable form of thermal energy harvested from bodies of water. In our vision, Social Heating, aqua thermal energy will mainly be used for heating. Research from CE Delft and Deltares in the Netherlands shows that aqua thermal energy has the potential to supply more than 40% of the heat demand of the built environment in the Netherlands. As a renewable alternative, aquathermal energy plays a key role in the heating of buildings and can make a significant contribution to the transition toward a gas-free future. By combining a heat exchanger with a heat pump, surface water can be used to deliver sustainable heating through district heating networks (Aquathermal-energy | AquaCOM, z.d.). There are three types of aqua thermal energy; energy from surface water, wastewater and drinking water. Wastewater and drinking water have lower potentials compared to surface water in the Netherlands (Energy.nl, 2024). In this strategy, only aquathermal energy from surface water will be used.

The four rivers that flow through the region of Arnhem-Nijmegen; Waal, Nederrijn, Ijssel and Maas-Waalkanaal, are giving the potential to use aqua thermal energy in this region. In addition, the port of Nijmegen offers suitable locations for aquathermal energy production sites.

Residual heat

Industry is a large sector in the Netherlands. Almost 20% of the Dutch economy is related to this sector (Van Gessel-Dabekaussen, 2018). These industries produce a lot of heat that goes to waste after their processes. Using this waste heat, also called residual heat, as a source for heat networks could be an interesting way to reduce emissions (Industrial Residual Heat | Energy Transition Model, z.d.).

In the region of Arnhem-Nijmegen, residual heat is already used and the province of Gelderland, the municipalities of Arnhem and Nijmegen, Nuon & Alliander DGO want to jointly promote the use of more sustainable residual heat (Nijmegen Aardgasvrij, 2025). The residual heat of waste burning facilities, condensation heat, sewage treatment heat and wastewater treatment heat are widely used throughout the region. But the goal is that residual heat is going to play a bigger role in the energy transition. The big clusters in and around the region of Arnhem-Nijmegen will play an important role in the future to achieve this. The NovioTech Campus in Nijmegen, the Greenport in Arnhem and the manufacturing industry of Achterhoek will become clusters where most of the residual heat would come from in the near future (Vestigingsklimaat - Gaaf Gelderland, z.d.).

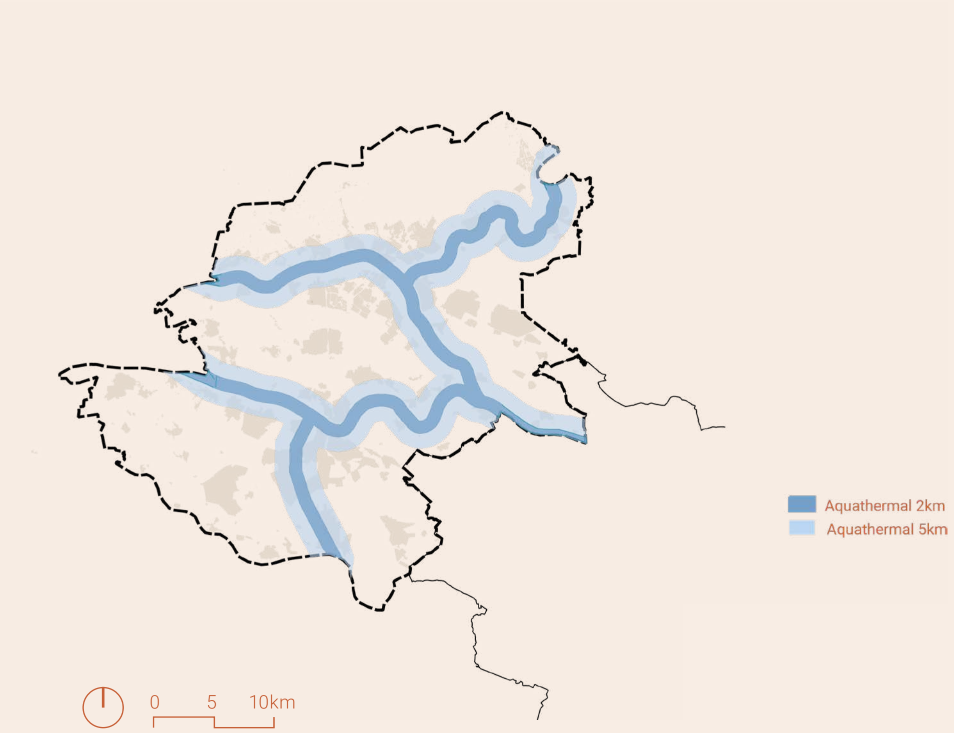


Figure 29: Aquathermal potential

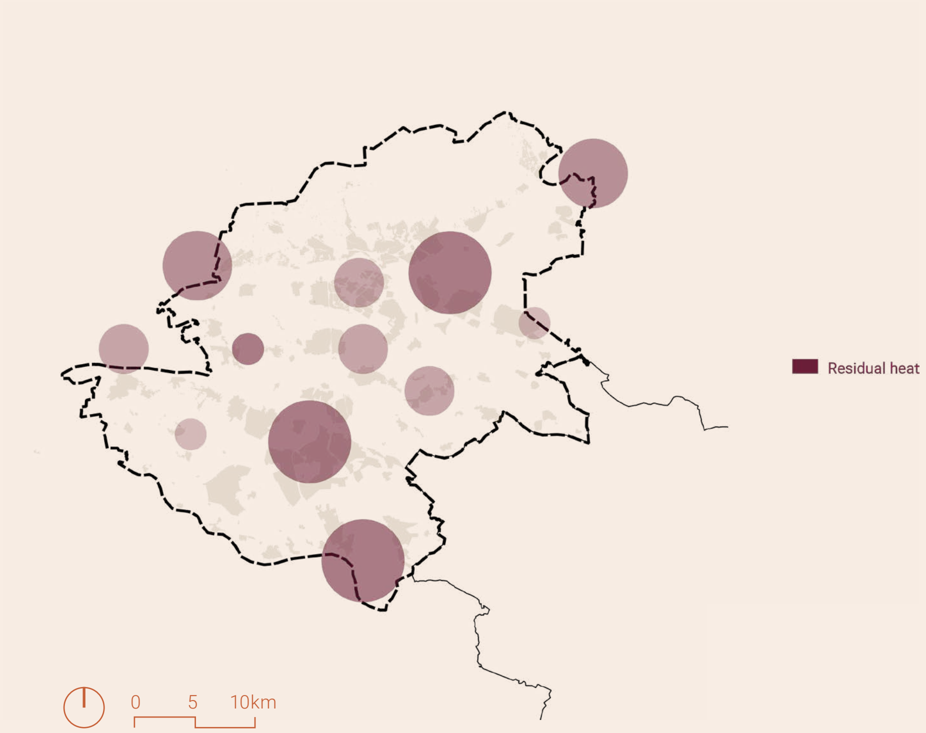


Figure 30: Residual heat potential

Thermal potentials

Geo thermal

Geothermal energy is a renewable resource that is harnessed from the heat stored in rocks and fluids within the Earth's crust. By drilling wells, this underground heat can be brought to the surface and used for various purposes, including electricity generation, district heating, water heating, and industrial processes (Geothermal Energy, z.d.). A key advantage of geothermal energy over other renewable sources is its independence from weather conditions, making it a more reliable and consistent energy supplier then solar panels and wind turbines for example.

In the province of Gelderland, a geothermal potential study was recently commissioned, partly based on seismic data collected by SCAN. The findings indicate that there's a relatively high potential for geothermal heat extraction around Arnhem and Nijmegen (EBN, 2023). While the province's overall potential is lower compared to other regions in the Netherlands, Gelderland is committed to utilizing every sustainable energy production opportunity available.

Solar thermal

Solar thermal energy is a type of renewable energy that captures sunlight to produce heat. Unlike photovoltaic (PV) systems, that convert sunlight into electricity, solar thermal systems use solar radiation to heat a fluid, called a heat carrier (most of the time is water), which can be used to supply thermal energy for industrial or residential use (Solar Thermal Energy: What It Is And Its Benefits, 2024).

To operate efficiently, solar thermal installations require large, relatively flat areas to absorb as much sunlight as possible. In the Arnhem-Nijmegen region, farmlands presents the most suitable option to develop solar thermal energy projects.

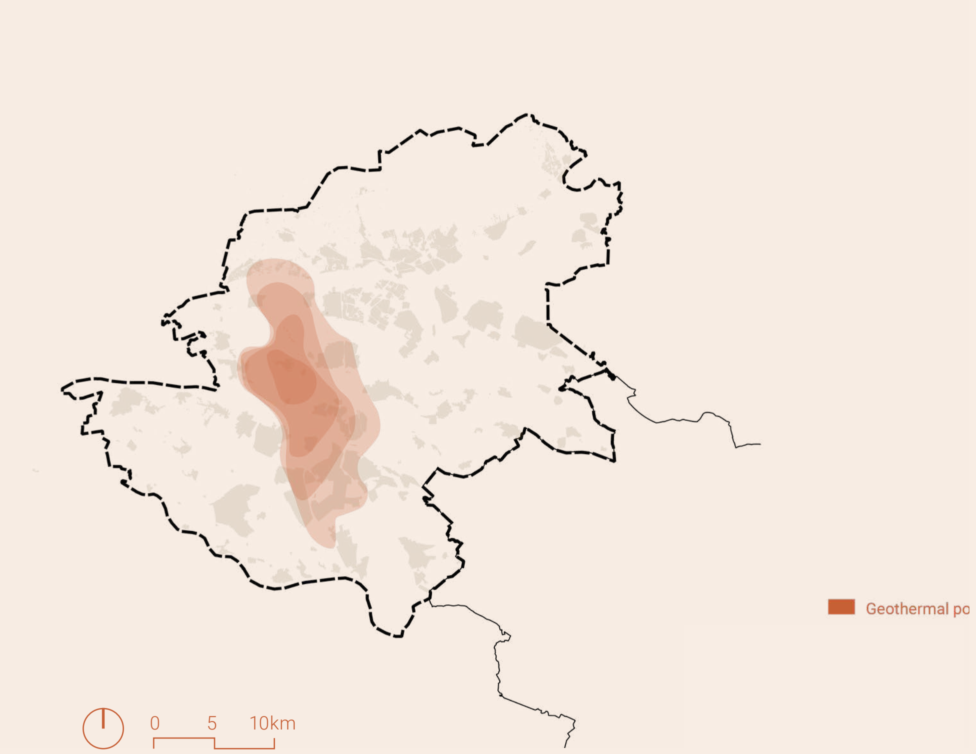


Figure 31: Geothermal potential

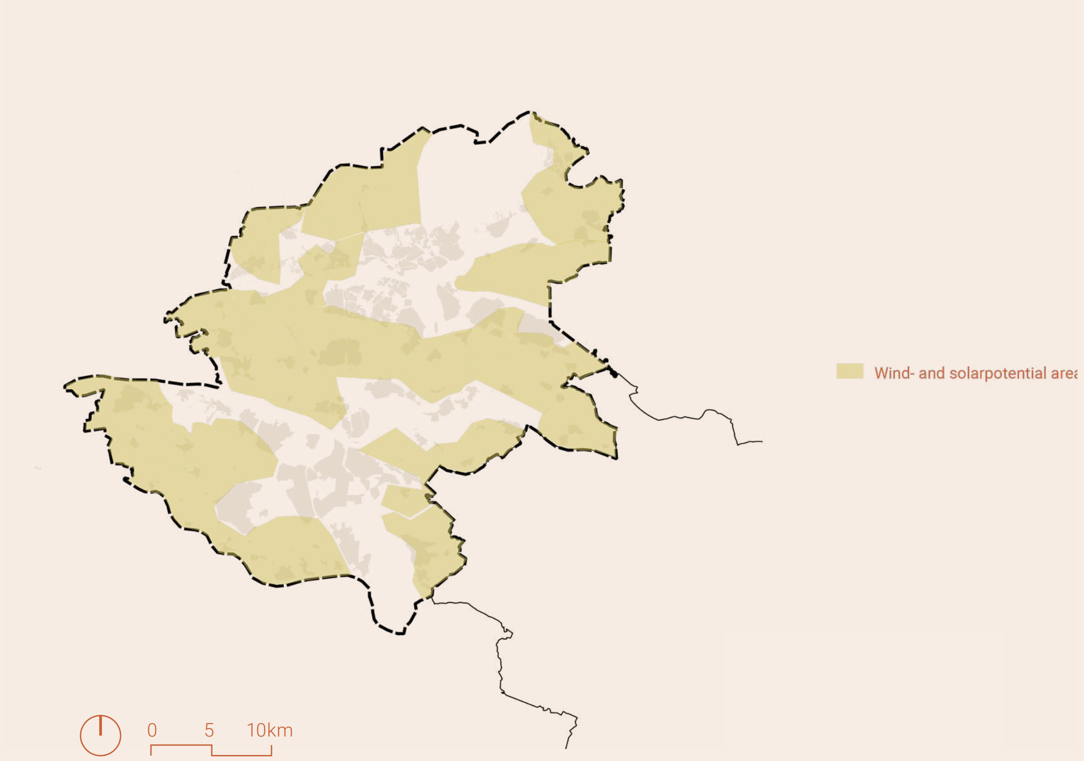


Figure 32: Solar thermal potential

Electricity Potentials

The current electricity production landscape of the region of Arnhem-Nijmegen consists of two big clusters of solar panels, wind turbines and electricity generation industries. These clusters are next to Arnhem and Nijmegen, the two cities with the largest energy demand in the region. Throughout the rest of the region, individual solar panel fields and a handful of wind turbines can be found.

To meet the electricity demands of the future, the energy landscape needs to expand. This will be done by the placement of more solar fields and wind turbines. Farmlands are, just like for the solar thermal energy production, potential areas for additional electricity production farmlands. There is more space there and the wind turbines will not pollute the view from the backyards of inhabitants too much.

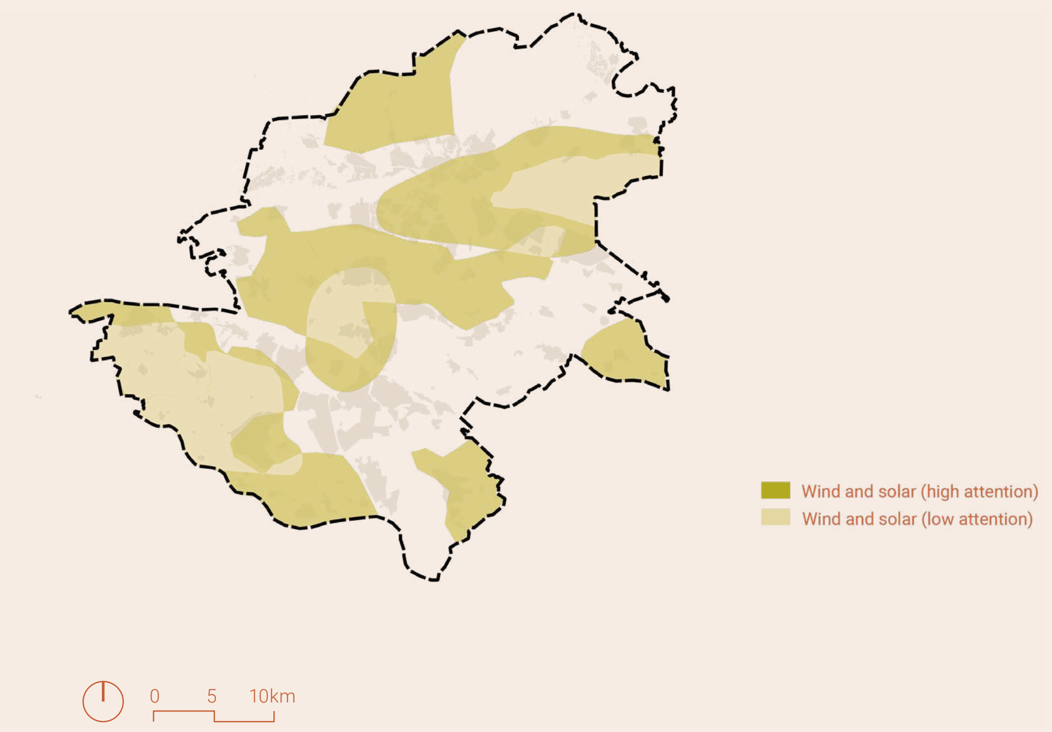


Figure 34: Wind and Solar potential

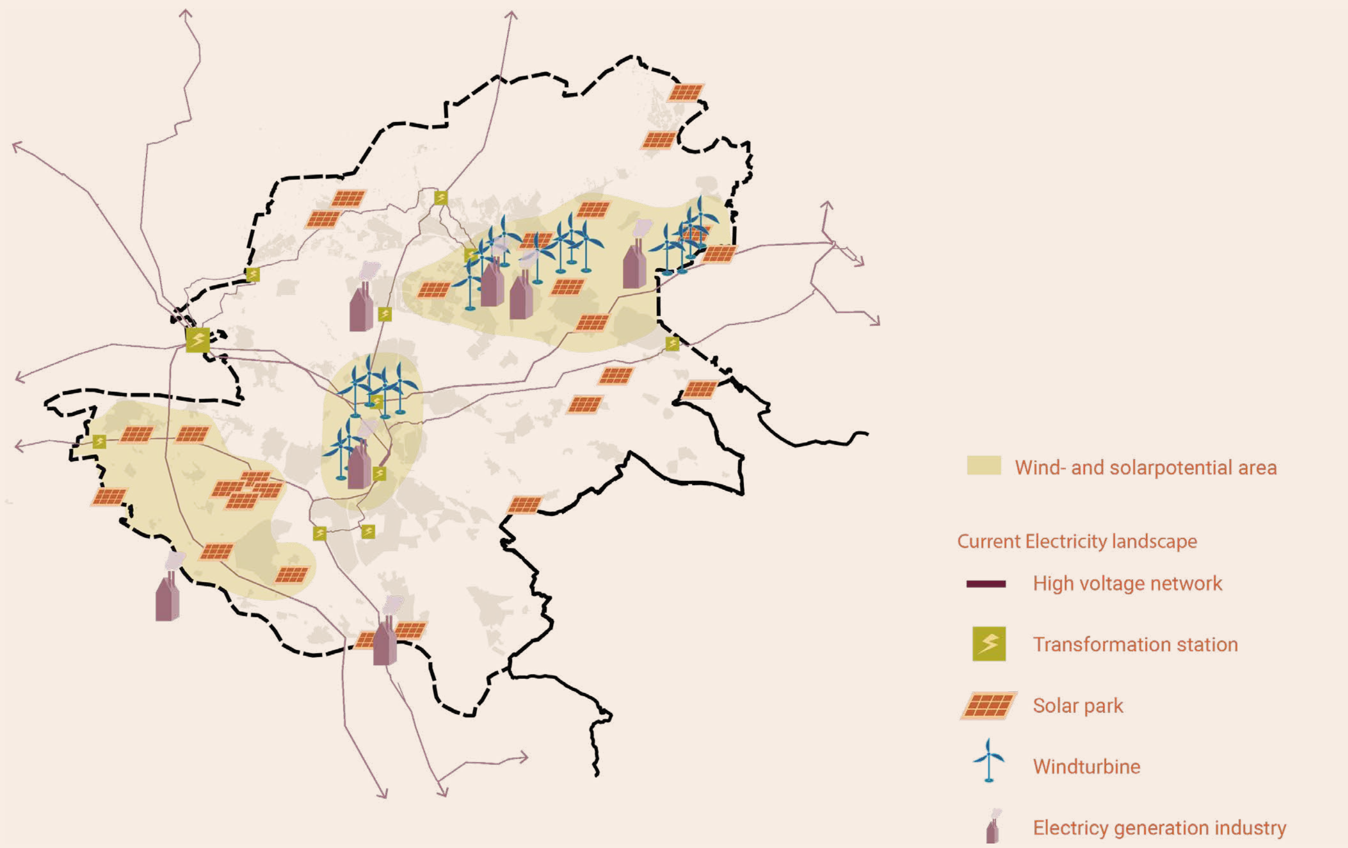
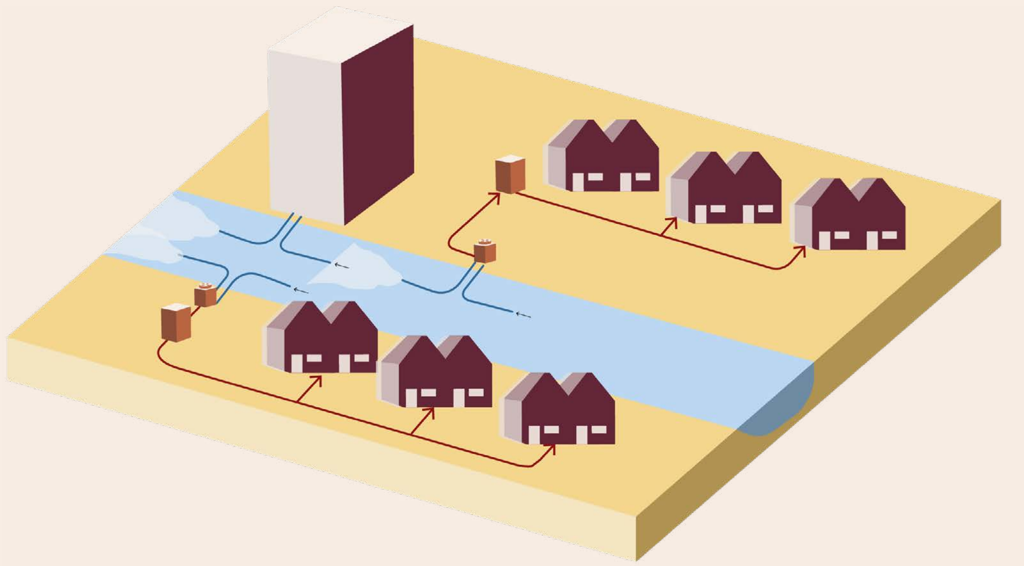


Figure 33: Electricity potential

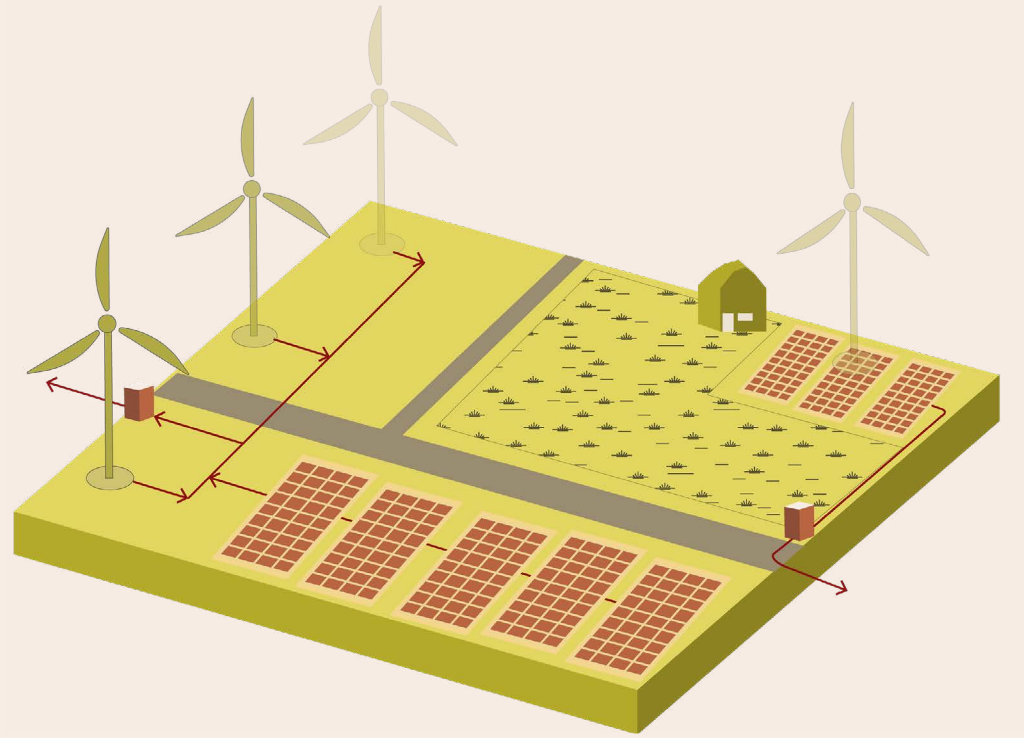
Spatial Implications

Decentralised energy production involves distributing energy generation across multiple locations, contrasting with centralised systems that concentrate production in a single site. This distribution allows energy sources to blend seamlessly into the landscape and urban settings, alleviating spatial constraints and reducing strain on individual production facilities.

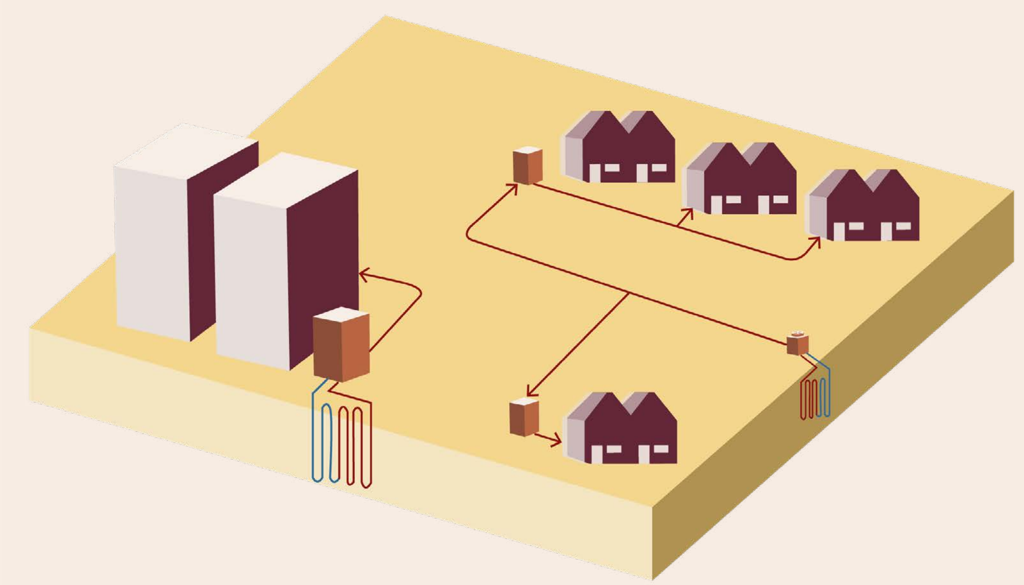
Integrating various renewable energy sources into urban planning necessitates thoughtful spatial consideration to ensure efficiency and minimal disruption to existing infrastructures. Here's an overview of key energy sources and their spatial requirements:



Aqua-thermal Heat Source:
Utilising water bodies as thermal energy sources involves extracting heat from bodies like rivers, lakes, or groundwater. This process requires pumps to circulate water and storage systems to manage thermal energy. Strategically positioning these systems near water bodies is essential to minimise energy loss and maintain system efficiency.

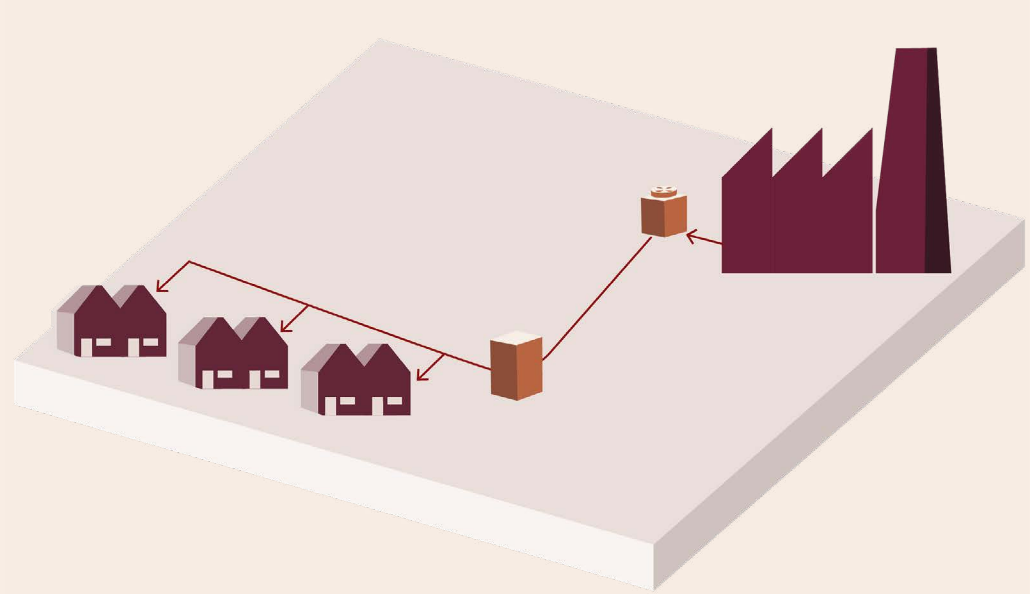


Solar and Wind Farms:
Solar photovoltaic panels and wind turbines require significant space, often necessitating locations in peri-urban or rural areas between cities. Wind turbines also need open landscapes with consistent wind patterns, making rural settings ideal.

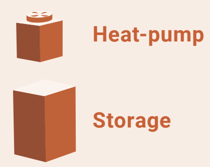


Geothermal Heating:
Geothermal systems harness the Earth's internal heat through ground-source heat pumps. Installing these systems requires drilling boreholes to significant depths, depending on geological conditions. The surface area needed is small compared to other more dispersed forms of energy collection, offering more flexibility in urban settings

Figure 35: Spatial implications of decentralised renewable heat and electricity production



Residual Heating:
Residual heating makes use of excess heat from existing factories and industrial processes. Incorporating this into urban heating systems involves connecting industrial sites to district heating networks.



Chapter 5

Vision.

This chapter outlines the goals and key interventions defined in our vision, called Social Heating. This includes the establishment of a new organization: the Social Housing Association, also known as the SHA. Additionally, we explore how renewable energy will be produced and distributed across the region. These strategies are examined both at the regional scale and in more detail within the scale of Nijmegen. A focused zoom-in on Nijmegen is included to provide a clearer understanding of how the vision and spatial interventions function at the city scale. Nijmegen has been picked for this purpose, because it is the most representative example to showcase this within the region.

Vision Statement

Social heating is needs-driven. The planet needs low carbon heating, and the people need affordable heating. By prioritizing social housing in the development of a region-wide heating transition for Arnhem-Nijmegen, Social Heating promises to deliver affordable, cost-stable, and low-carbon heating for all in the region. In this vision of a regional future, social housing communities form the spatial and organizational basis for a new, socialized residential heating system. Housing corporations and municipalities work together to control the production and distribution of heat through a renewables-based district heating network, extended first to social housing residents, where energy poverty is most concentrated, and later across the whole region.

By harnessing the existing organizational capacity of housing corporations, Social Heating will accelerate the heating transition, allowing the social housing community to serve as a springboard for region-wide deployment of low-carbon district heating. Where district heating is not feasible or practical, individual electric heating solutions will be implemented, such as on farms or very dispersed, small, and isolated residential areas. Heat production for district heating will come from a variety of sources, reflecting the diversity of thermal potential in Arnhem-Nijmegen. Geothermal, aqua thermal, solar thermal, as well as industrial waste heat sources will be utilized to deliver heat directly to the district heating network. To ensure cost and heat supply stability, electric heat generation (heat pump water heaters and electric boilers) and thermal energy storage systems will also be included in the system.

Creating an entirely new heating system provides a unique opportunity for the ownership of heat production and distribution to change hands. Social Heating envisions housing corporations and municipal governments, both non-profit organizations, presiding over the production and distribution of district heating. Crucially, this departure from the current system eliminates profit from the provision of an essential service, heating, and will ultimately ensure lower heating costs for residents.

Figure 36: Social Heating vision in Nijmegen

Goals

In order to create a vision, 5 goals were established based on the hopes and dreams of the social housing community. These are formed based on the analysis on understanding our community in chapter 4.

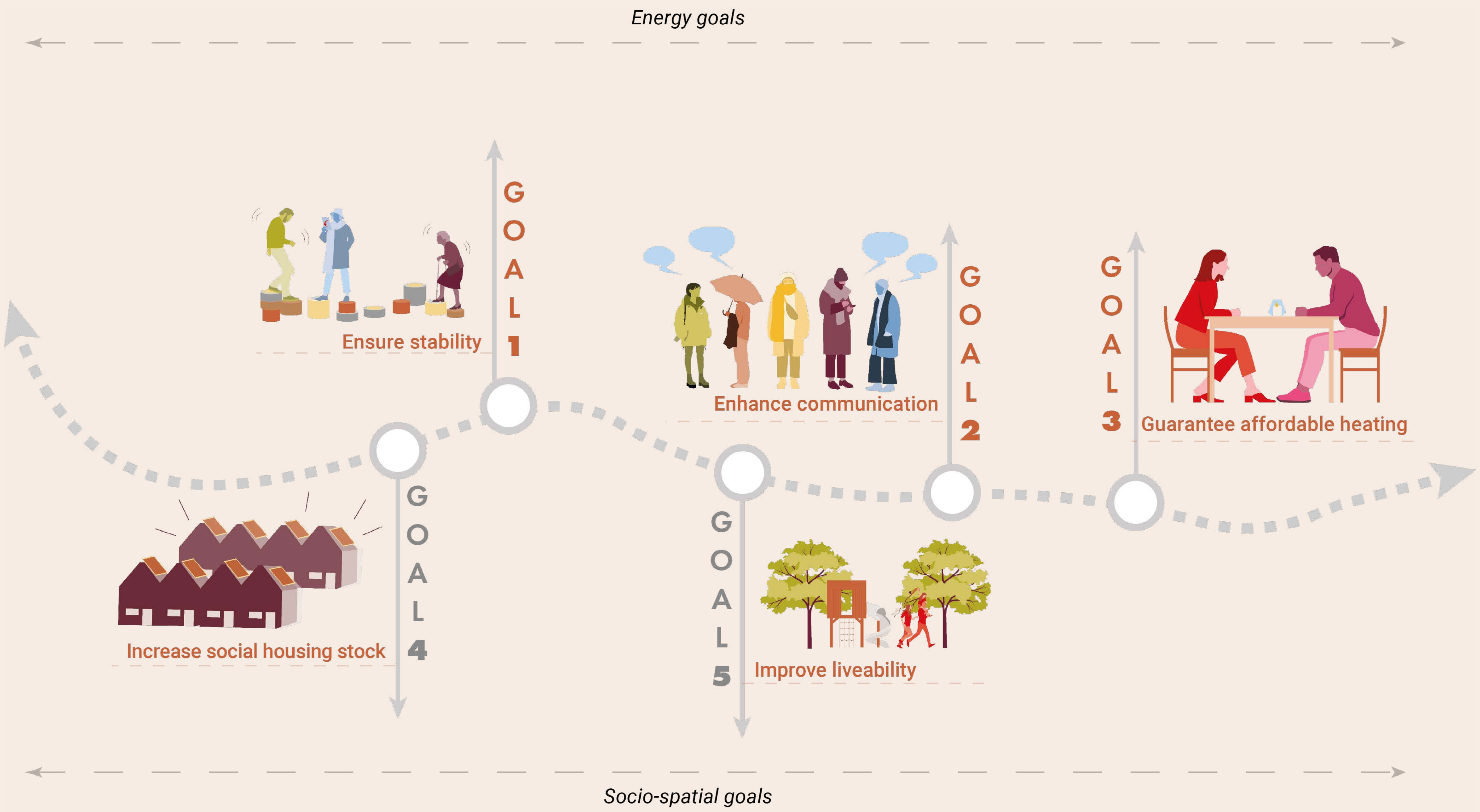


Figure 37: Project Goals

KEY INTERVENTIONS

1. ORGANISATION:

CREATING THE SOCIAL HEATING ASSOCIATION

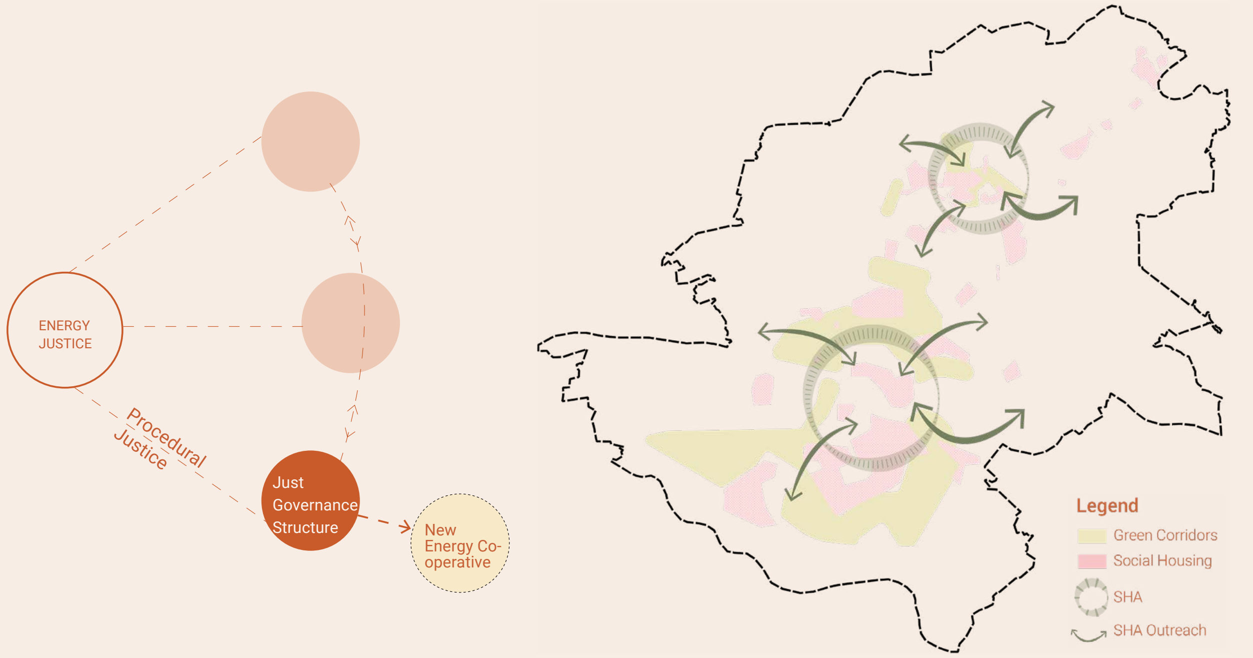


Figure 38: Creation of SHA

2. PRODUCTION:

DIVERSIFYING HEAT SOURCES

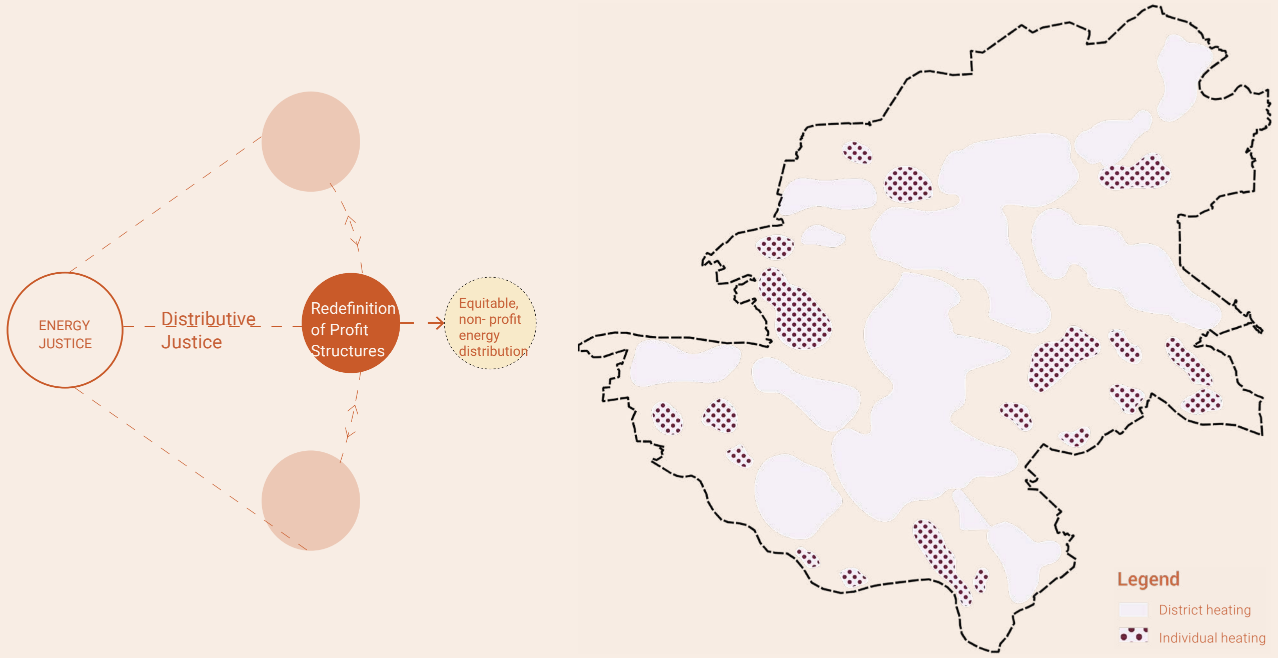


Figure 39: Diversifying Heat Sources

3. DISTRIBUTION::

EXPANDING RENEWABLE HEATING SYSTEMS

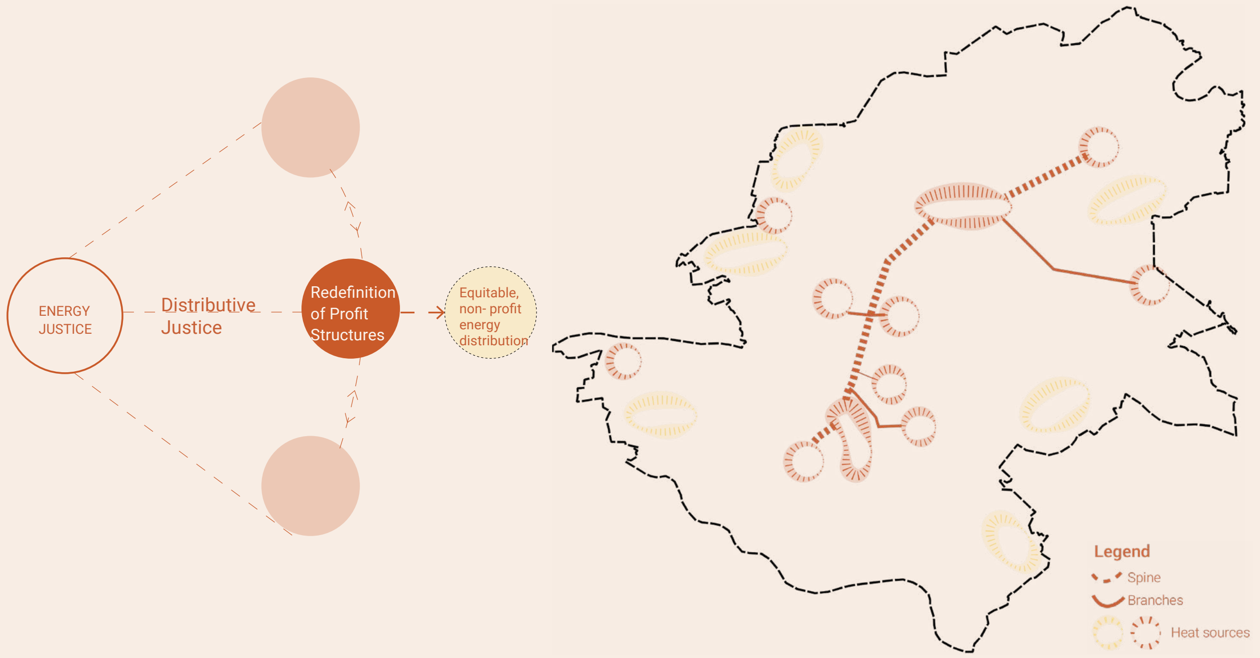


Figure 40: Expanding Renewable Heating Systems

PRIORITISATION:

SOCIAL HOUSING FIRST

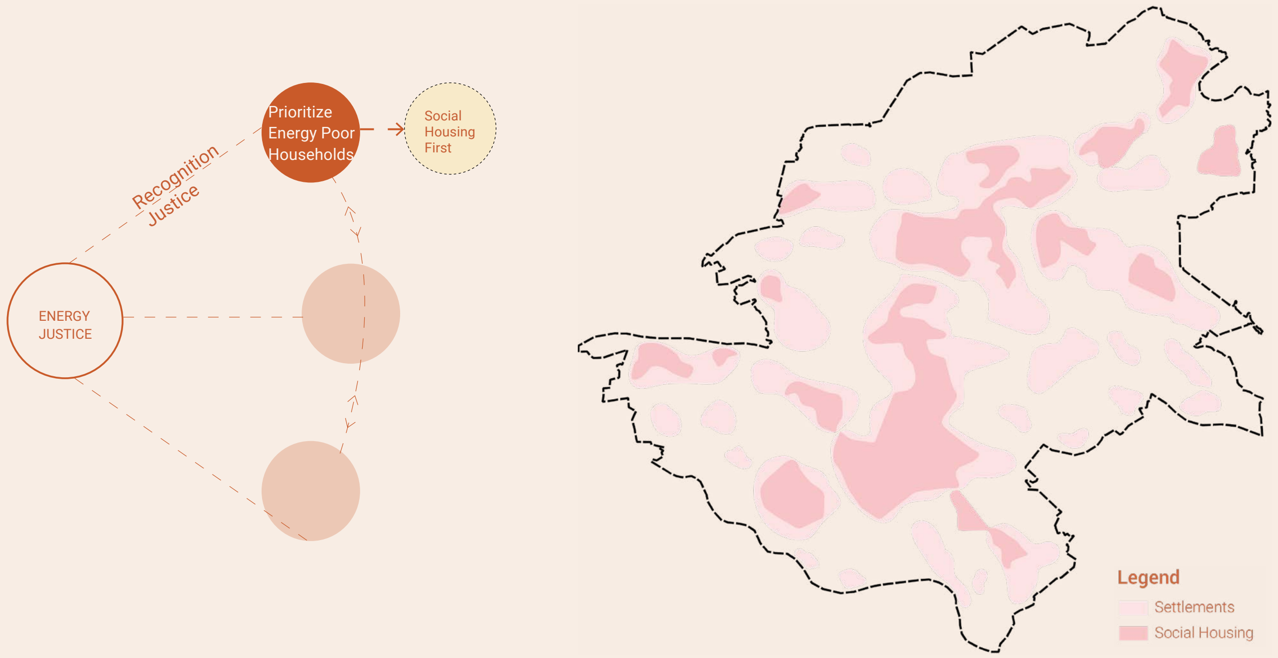


Figure 41: Social housing First

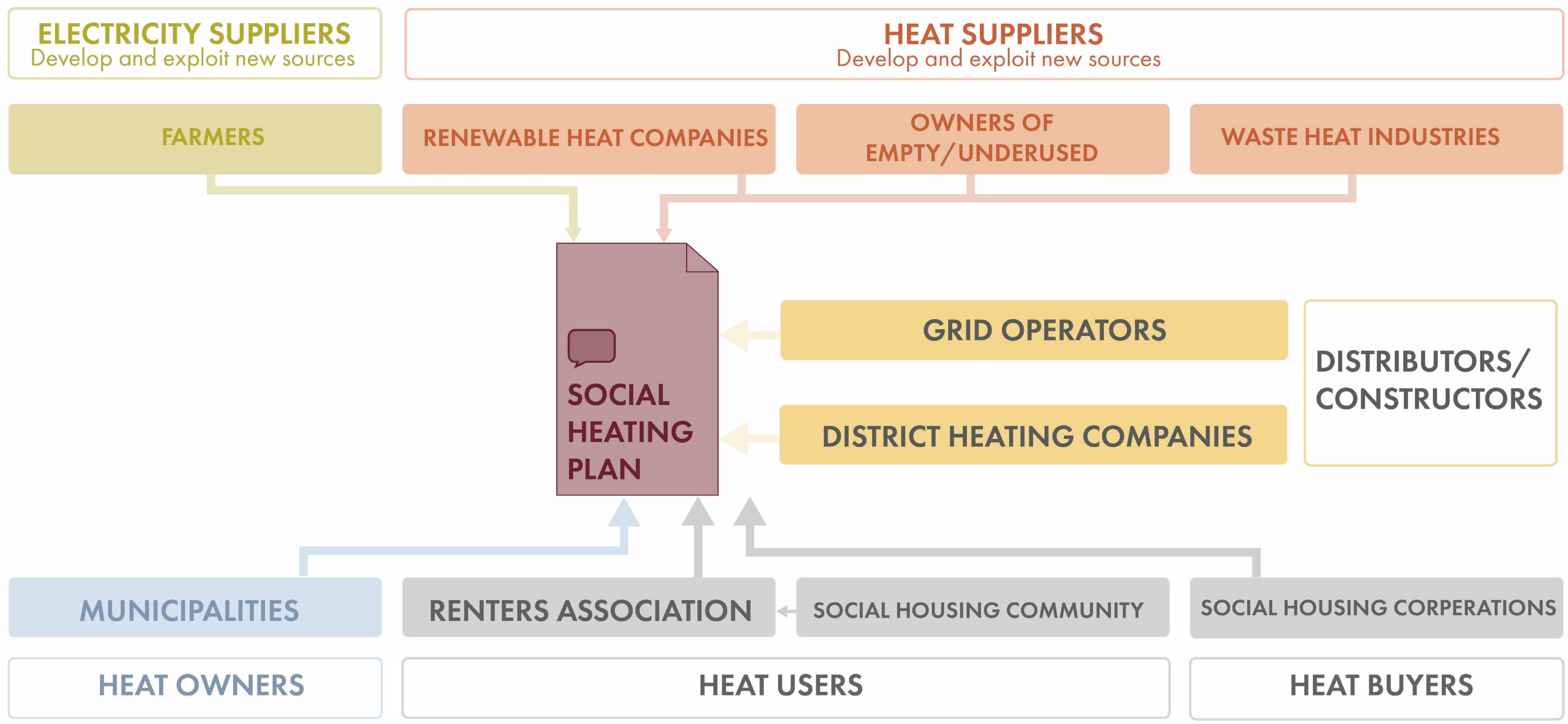


Figure 42: Systematic diagram of organisation of Social Housing Association

The first key intervention is the creation of a social heating association. This association forms the organization behind social heating and bring together the different stakeholder which are involved. Figure 38 shows the new way the social heating plan is organized and what the important stakeholders are. A big difference compared to the current heat planning is that the municipality, in coordination with social housing corporations, becomes the owner of the heating grid instead of private grid operators. As both the municipality and the housing corporations operate on a non-profit basis, this ensures that no profit will be made through providing heat. The current heat network operators will only be involved in the construction and maintance of the network. To actively involve farmers and owners of industries creates more support which makes it easier to produce the electricity and heat required for the heat network.

KEY INTERVENTION 1

ORGANISATION: CREATING THE SOCIAL HEATING ASSOCIATION

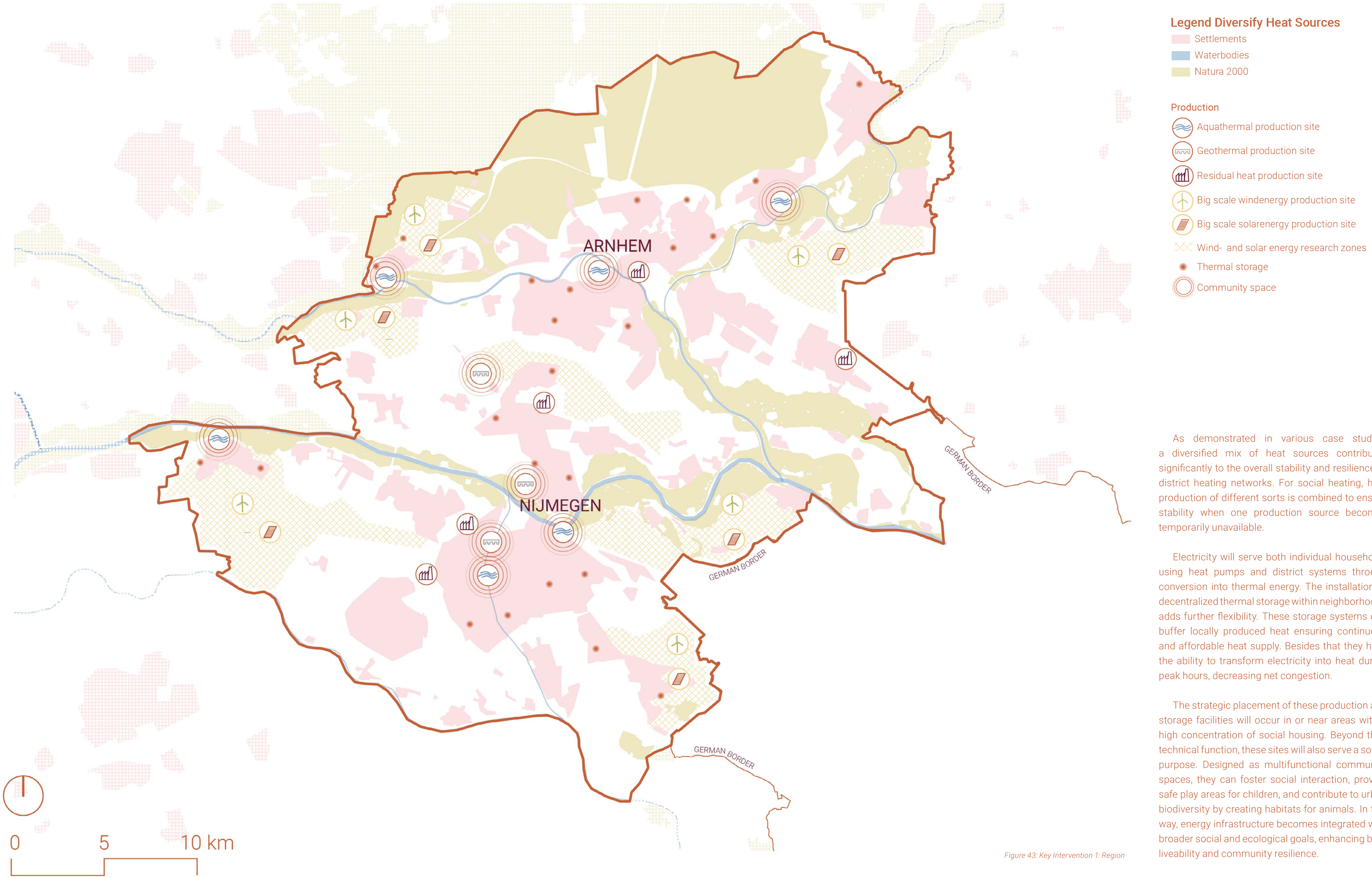


Figure 43: Key Intervention 1: Region

As demonstrated in various case studies, a diversified mix of heat sources contributes significantly to the overall stability and resilience of district heating networks. For social heating, heat production of different sorts is combined to ensure stability when one production source becomes temporarily unavailable.

Electricity will serve both individual households using heat pumps and district systems through conversion into thermal energy. The installation of decentralized thermal storage within neighborhoods adds further flexibility. These storage systems can buffer locally produced heat ensuring continuous and affordable heat supply. Besides that they have the ability to transform electricity into heat during peak hours, decreasing net congestion.

The strategic placement of these production and storage facilities will occur in or near areas with a high concentration of social housing. Beyond their technical function, these sites will also serve a social purpose. Designed as multifunctional community spaces, they can foster social interaction, provide safe play areas for children, and contribute to urban biodiversity by creating habitats for animals. In this way, energy infrastructure becomes integrated with broader social and ecological goals, enhancing both liveability and community resilience.

KEY INTERVENTION 2 - REGION

PRODUCTION: DIVERSIFYING HEAT SOURCES

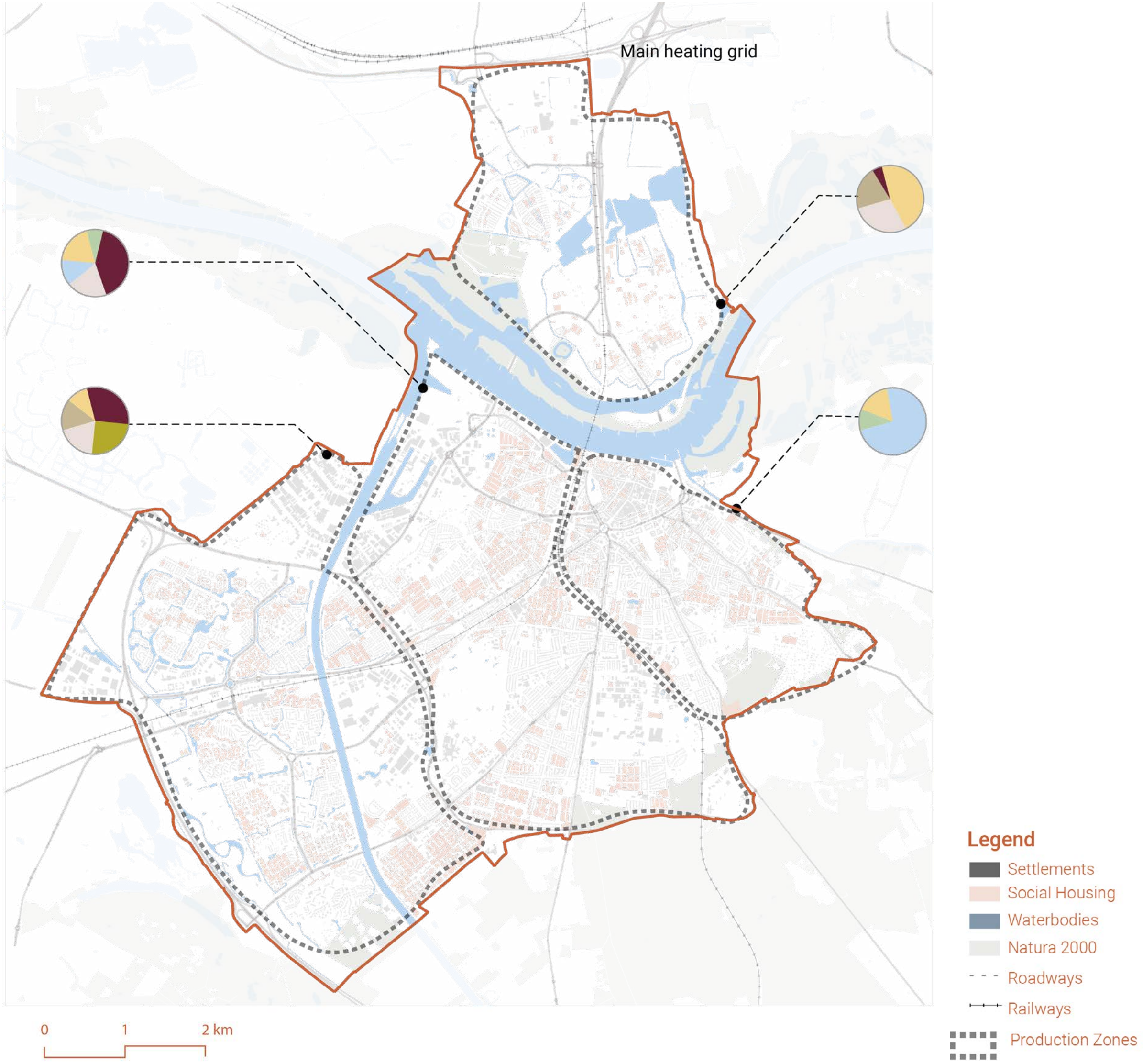


Figure 44: Key Intervention 1: Nijmegen ; Production Zones

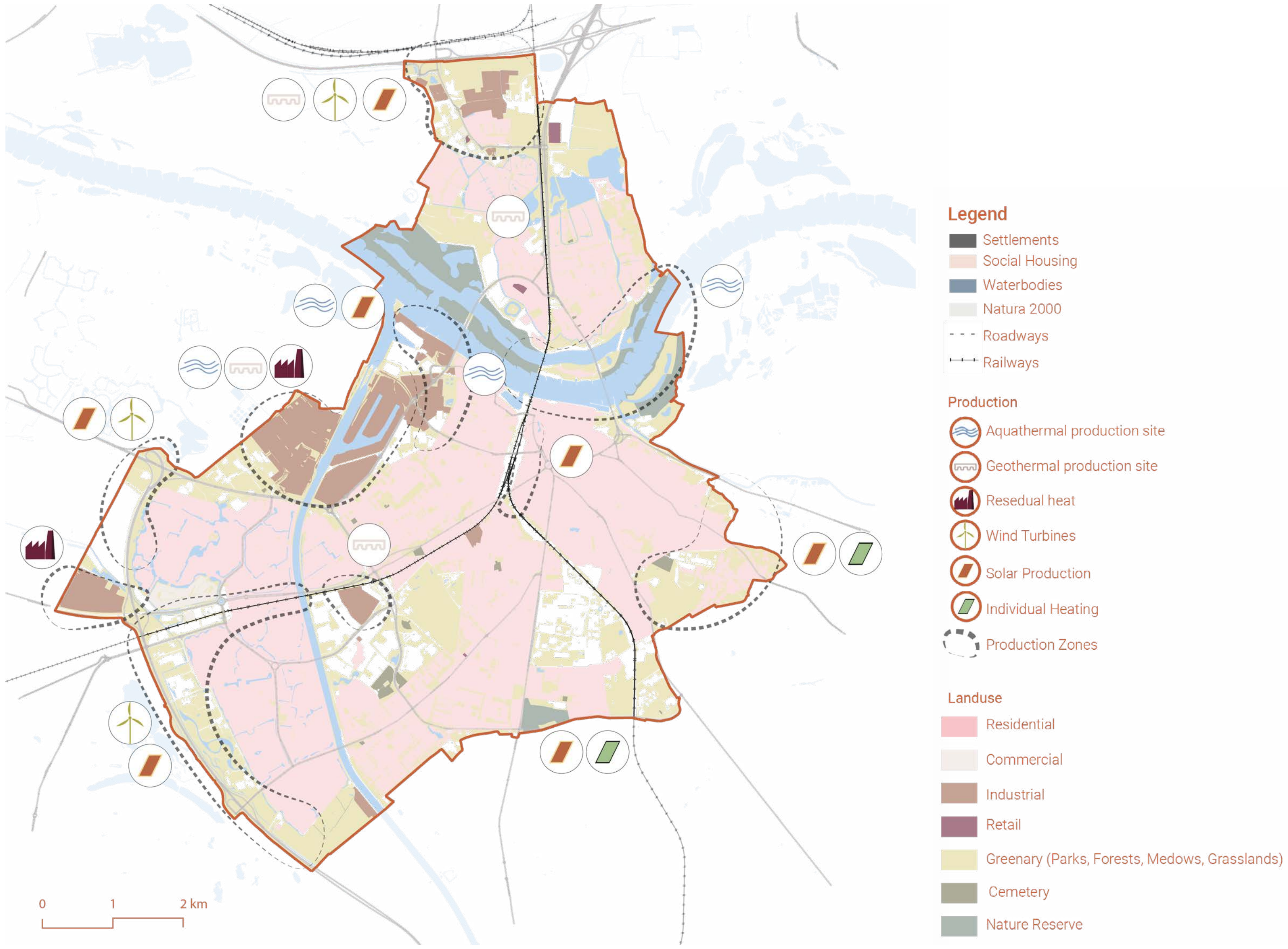


Figure 45: Key Intervention 1: Nijmegen ; Production Zones with Landuse

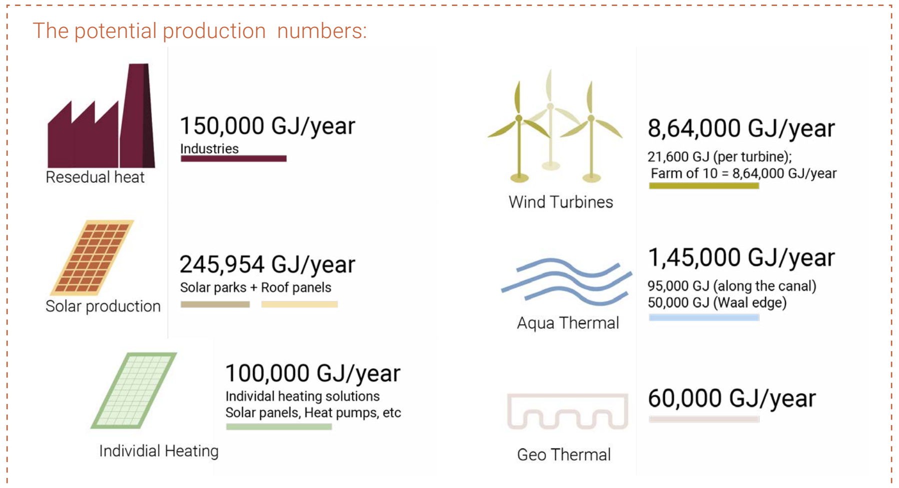


Figure 46: Potential Numbers

Understanding the diversification of heat sources and their spatial implications, Nijmegen is taken as a pilot city- which is one of the larger urban centers in the region. These renewable sources can be broken down in the amount of GJ of energy to be produced based on the potential consumption numbers, current and future.

The map presents a schematic spatial zoning of these decentralised sources of production. Furthermore, when the city is schematically divided into smaller sectors of about 5km as being an efficient diameter for possible distribution of these energy sources.

Basing these schematic zones in the urban fabric, it is defined by using the current landuse and possible locations of these new sources of production. This naturally locates all these sources to be on the periphery of the city where the industries and farm structures are.

KEY INTERVENTION 2 - NIJMEGEN

PRODUCTION: DIVERSIFYING HEAT SOURCES

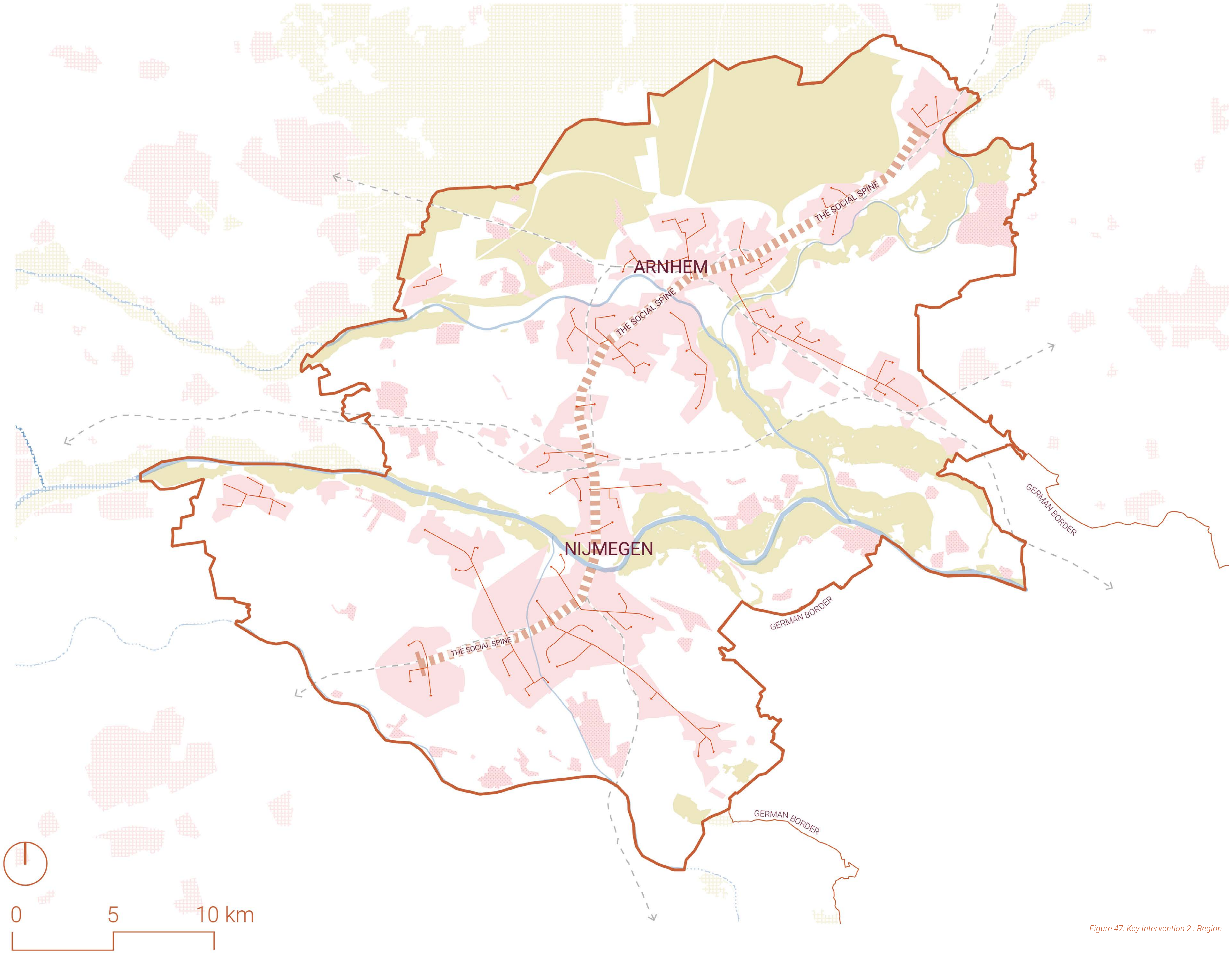


Figure 47: Key Intervention 2 : Region

The integration of diverse renewable heat sources, such as aquathermal energy, geothermal energy, and residual industrial heat, form the backbone of a resilient district heating network. These production sites, strategically distributed across the region, collectively enhance the stability and flexibility of the system. However, district heating is not universally applicable. In lower-density areas or locations distant from multiple renewable heat sources, individual heating solutions offer a more suitable alternative

Inspired by the successful implementation of a regional "heating spine" in the Den Haag–Rotterdam corridor, the Arnhem–Nijmegen region holds the potential for a comparable spine. This underground thermal corridor could extend from Dieren through Arnhem, Elst, and Nijmegen to Wijchen, connecting decentralized production sites to residential areas. Invisible to the eye yet vital to regional resilience, this network would branch out to supply entire neighborhoods with sustainable heat.

Crucially, the development of this heating infrastructure offers a unique opportunity to align energy transition goals with inclusive urban planning. Areas adjacent to the proposed heating spine are particularly suited for densification and correspond with municipal visions for future urban growth. Integrating new housing into this network increases planning efficiency and ensures that in future developments of social housing energy equity is ensured.

Moreover, as highlighted in the community analysis, vulnerable neighborhoods are often overlooked in large-scale infrastructural transitions. By prioritizing these areas in the deployment of district heating, municipalities can begin to redress this imbalance. The necessary streetworks involved in installing the heating network provide an opportunity to rethink public space. The opportunity arises to transform streets into safer, greener, and more inclusive environments that foster social cohesion.

KEY INTERVENTION 3

DISTRIBUTION: EXPANDING RENEWABLE HEATING SYSTEMS

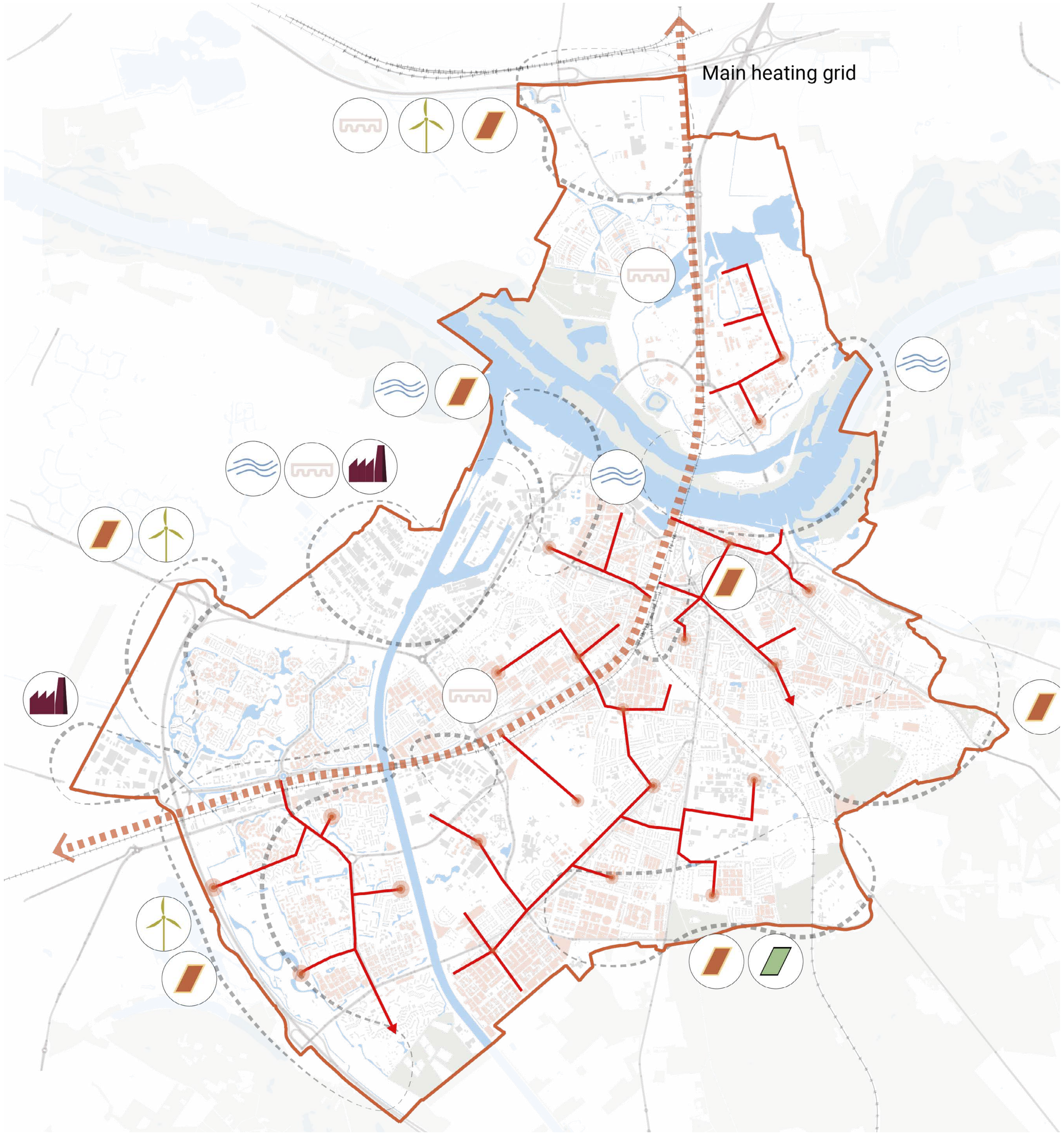


Figure 50: Key Intervention 1: Nijmegen ; Distribution of heat network

Legend variables

- Social Housing
- Waterbodies

Densification

- 1500 houses
- 6000 houses

Distribution

- Distance of the Grid from the Source Up to 5 km
- Distance of Storage Units Close to deman centers (within 500m-1km of consumers)
- Main Heating Grid
- Distribution Grid
- Storage Structures

Legend distribution

- Settlements
- Social Housing
- Waterbodies
- Natura 2000
- Roadways
- Railways

Production

- Aquathermal production site
- Geothermal production site
- Resedual heat
- Wind Turbines
- Solar Production
- Individual Heating
- Production Zones

Distribution

- Main Heating Grid
- Distribution Grid
- Storage Structures

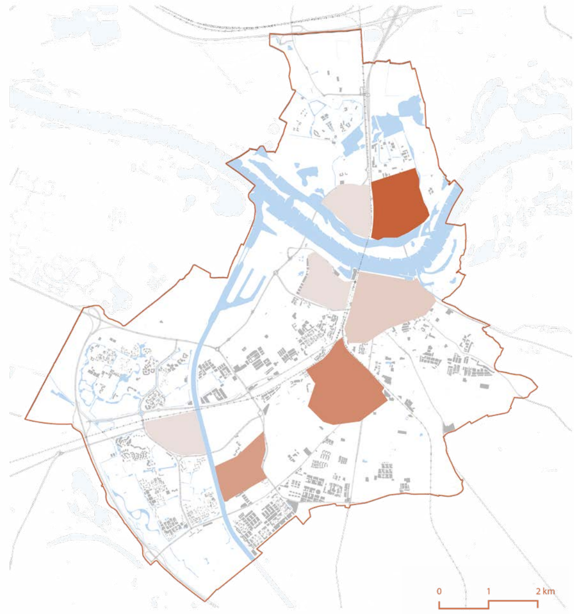


Figure 48: Densification in the future in Nijmegen

Figure 49: Distances production and storage

Fleshing the production zones further, into a possible network of distribution. Using the variables of current and future population densification, technical variables of distance from the production grid, and storage units, and using the municipalities vision of developing various areas into recreational/ commercial zones.

Based on these, a central spine of the heating grid along with branches in various neighbourhoods can be planned. This layout of the distribution grid is based on priorities social housing first, and eventually getting everything on the grid.

KEY INTERVENTION 3

DISTRIBUTION: EXPANDING RENEWABLE HEATING SYSTEMS

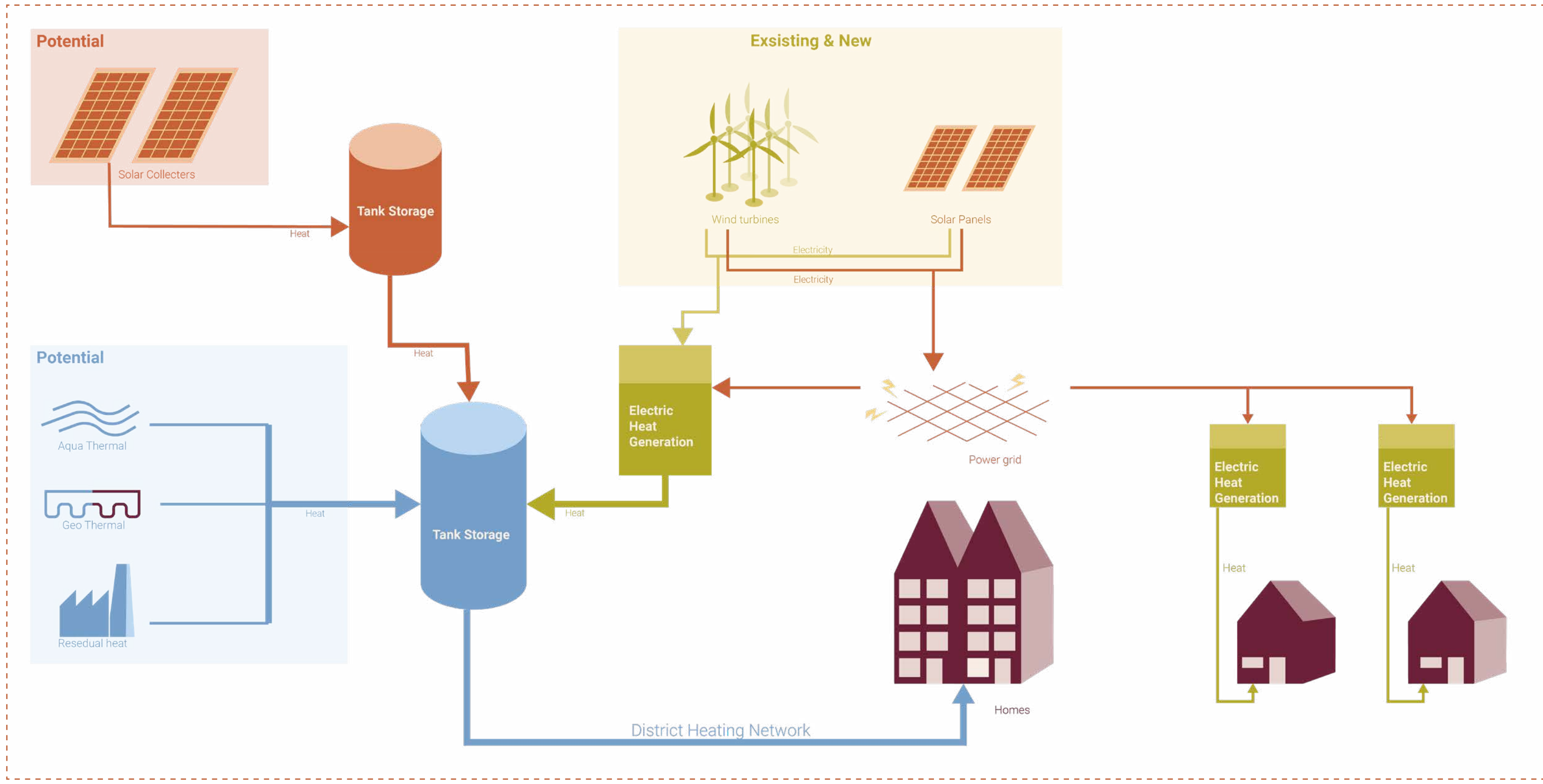


Figure 51: Diagram of the new heating system

The vision calls for diversifying heat sources and expanding the heating network grid. Drawing inspiration from successful case studies which have managed to do this in similar conditions, we developed a new heating system.

This new system calls for expanding the heat network by tapping into the potential sources like aquathermal, geothermal, and residual heat from industry, and exploring the potential of solar thermal collectors. This also accommodates existing renewable sources for electricity generation and envisions scaling up this production.

All of this collectively connects to the power grid which provides heat to homes. This new district heating network is renewable and will offer stability through affordability.

This decentralisation requires dispersed storage tanks at various locations which demands smart integration into the urban fabric.

Visualising the spatial implications of this diversified organisation of the heat vision allows us to have a systematic understanding of it.

These diversified renewable energy sources each come with unique spatial requirements, as outlined. The vision proposes strategically situating them across different parts of the urban fabric—near water bodies, within industrial zones, in peri-urban landscapes, and underground—ensuring minimal disruption and maximum integration. All sources will be linked to a central electricity grid managed and operated by the Social Heating Association (SHA), ensuring coordinated distribution, maintenance, and equitable access.

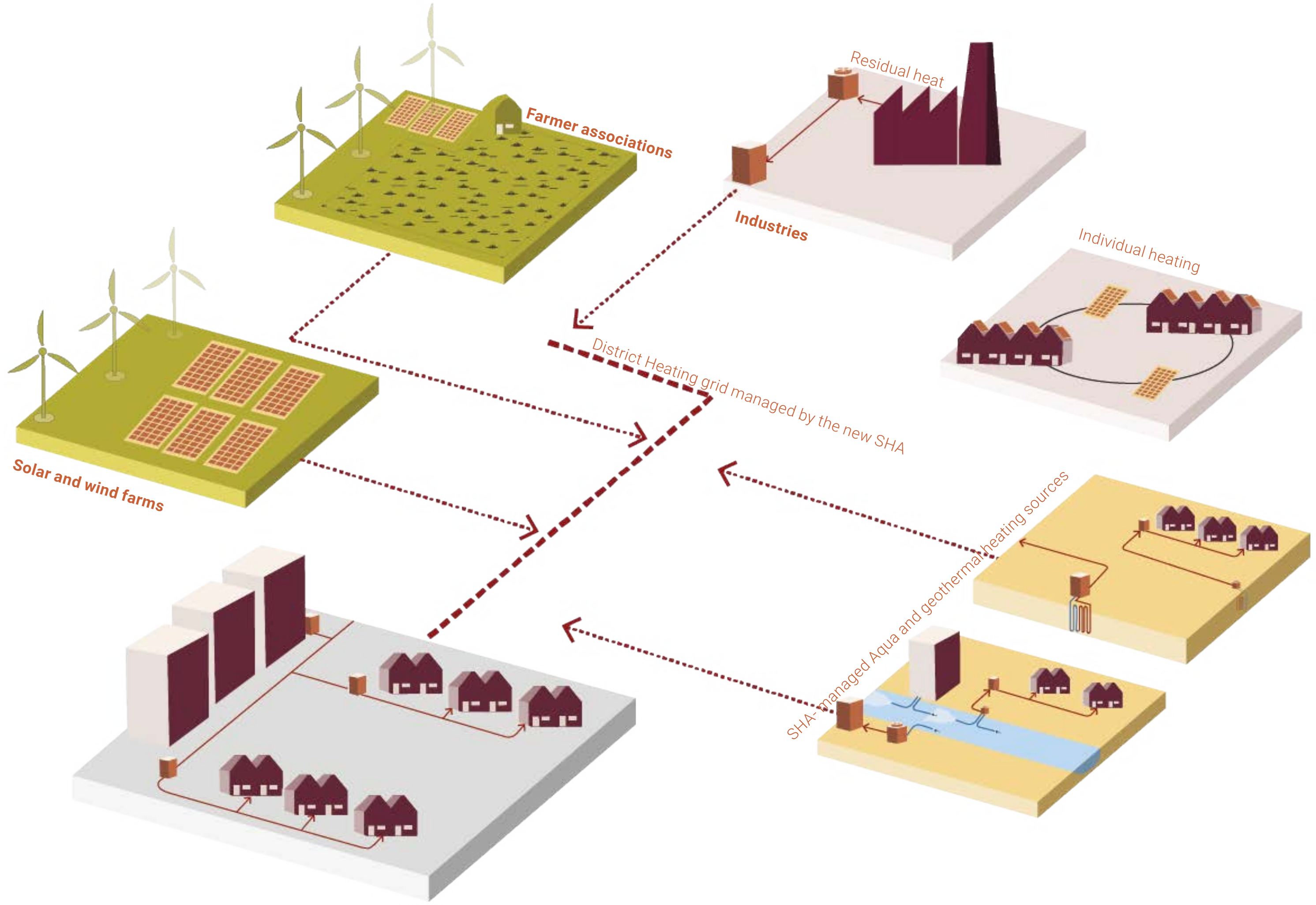


Figure 52: Specialisation of the new heating system

KEY INTERVENTION 2 + 3

PRODUCTION + DISTRIBUTION: SYSTEM AND SPATIAL IMPLICATIONS

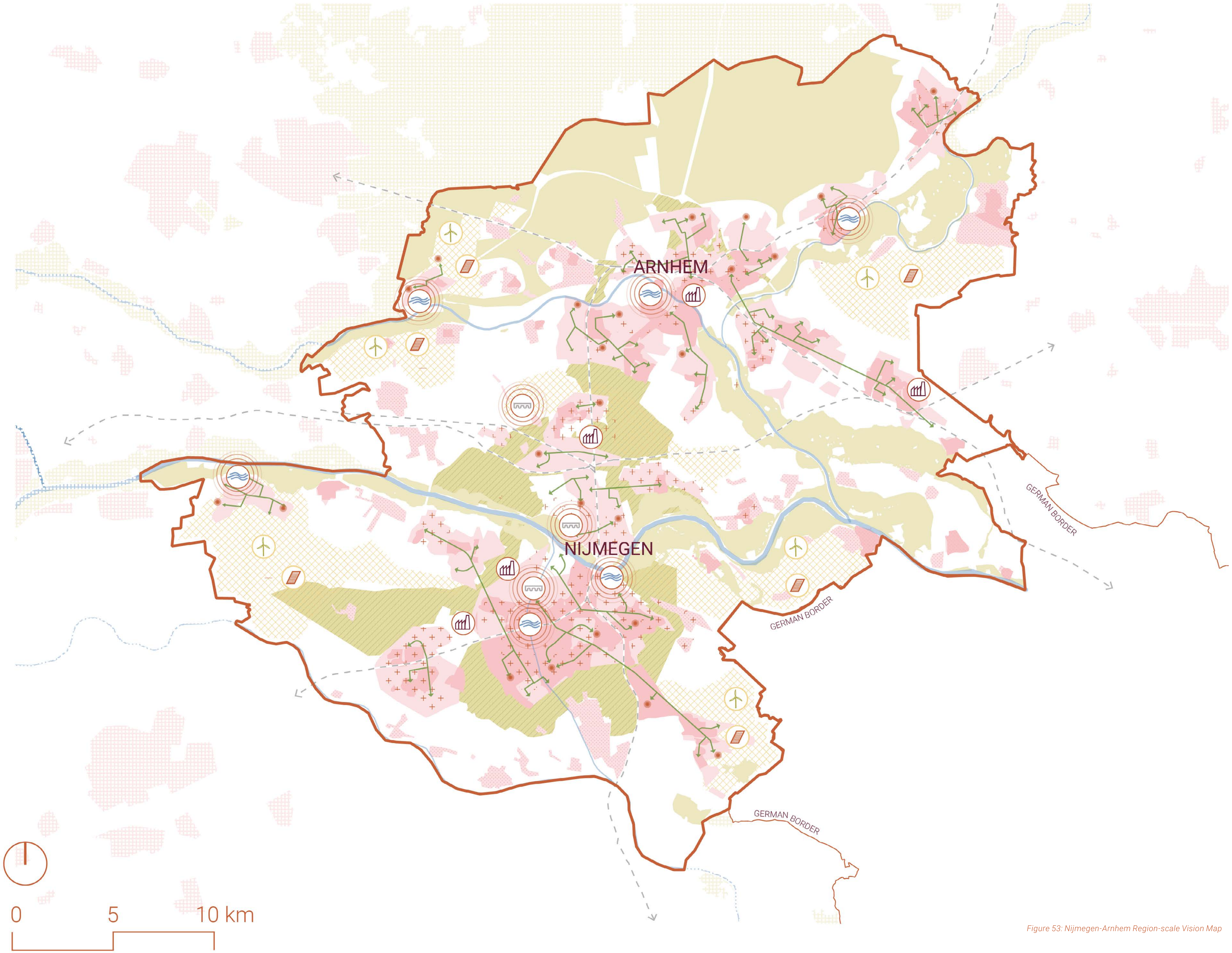


Figure 53: Nijmegen-Arnhem Region-scale Vision Map

When the three key interventions converge, a new landscape emerges, one that redefines both city and countryside. Heat production is no longer hidden on the outskirts but becomes an integrated, visible, and celebrated part of the urban fabric. These production sites, rooted in neighborhoods, serve not only as sources of energy but as vibrant social places to meet, play, and connect.

Beneath the Arnhem–Nijmegen region, a central heating spine flows, linking diverse production sites and branching into every neighborhood. It brings warmth to all, but first and foremost to those who need it most: the social housing community.

Above ground, the presence of the spine is felt in renewed streetscapes which are green, safe, and shared and lead to public spaces around energy hubs. As new housing rises along this spine, so too does the number of social housing residents. Their prioritization in this system fosters a sense of stability and care, living not on the margins, but at the heart of a thoughtful and equitable energy future.

NIJMEGEN-ARNHEM REGION

VISION: SOCIAL HEATING

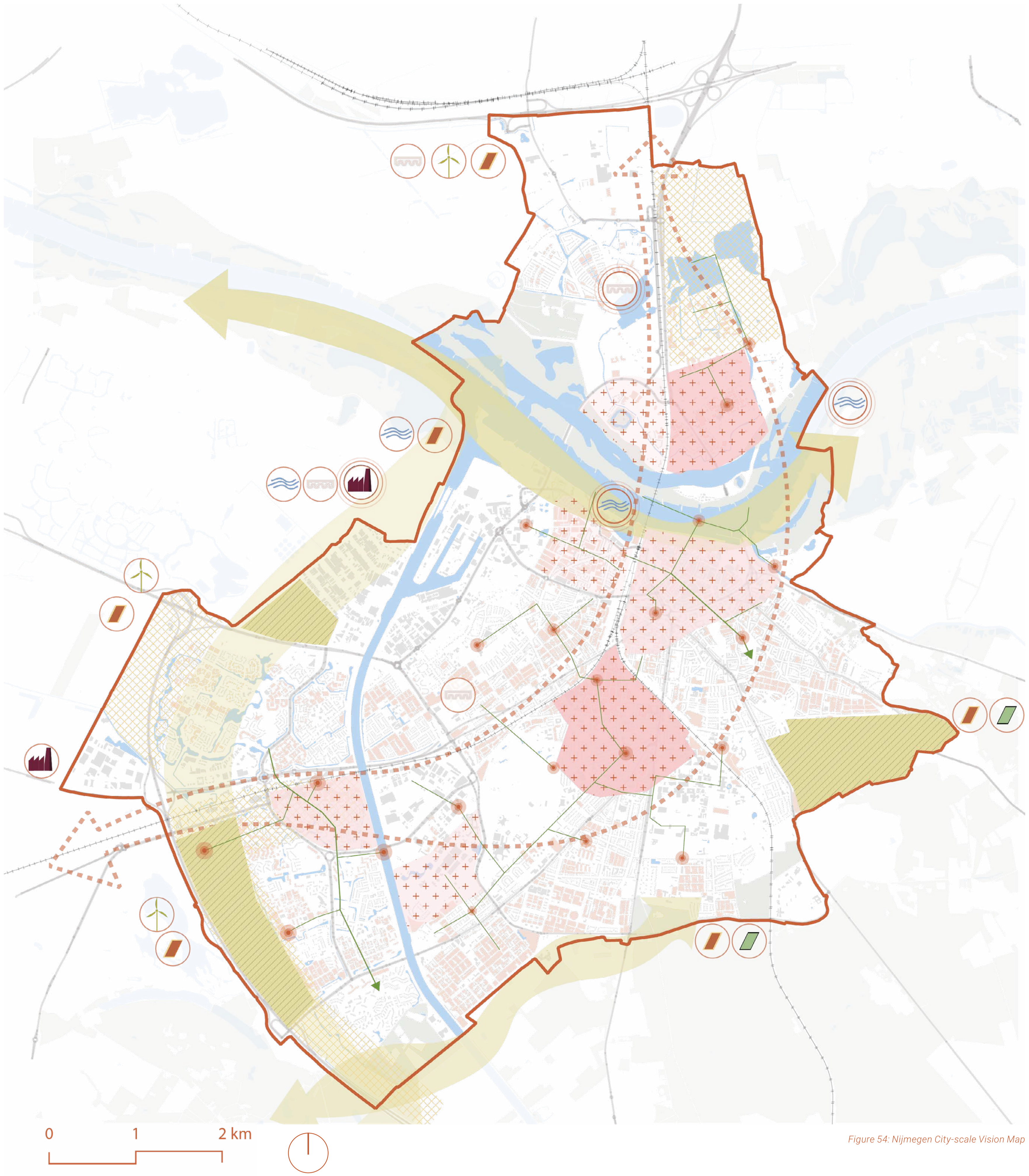


Figure 54: Nijmegen City-scale Vision Map

Legend Vision (2050)

- Settlements
- Social Housing
- Waterbodies
- Natura 2000

Production

- Aquathermal production site
- Geothermal production site
- Residual Heat
- Wind Turbines
- Solar Production
- Individual Heating
- Wind and solar energy research zones

Densify and greenify

1500 houses – 6000 houses: Densification

- Densification zone
- Densification Corridor
- New green recreational zones
- Green Corridor
- Railway

Fleshing out the production zones in more detail, using the variables of current and future population densification, distance from the production grid, and storage unit requirements, and referencing the municipality's vision of developing various areas into recreational/ commercial zones, we can see possible network of distribution coming together.
A central spine of the heating grid along with branches in various neighbourhoods can be planned. This layout of the distribution grid is based on the principle of *social housing first*, and eventually getting everyone on the grid.

NIJMEGEN

VISION: SOCIAL HEATING

Figure 55: Illustration of the Vision

Chapter 6

Strategy & Phasing.

Chapter 6 focuses on making the vision more tangible by explaining how the Social Housing Association will operate. This includes an explanation of its structure, the stakeholders involved, and the policies it will implement. To understand the policy framework and funding possibilities, we examined existing policies and financial instruments ranging from the scale of the European Union to the scale of local municipalities. We identified several conflicts and propose solutions to address them.

One of our key objectives is to transition away from fossil fuels by 2050. To support this, the chapter includes a phasing plan that outlines how our interventions, policies, and funding will phased till 2100. At last, we propose four types of spatial interventions across different scales: hotspots, electricity landscapes, regeneration corridors, and branches.

Stakeholder Mapping

Actors in and surrounding the 'Social Heating Association'

The updated Power-Interest Matrix shows the repositioning of stakeholders following the formation of the Social Heating Association (SHA).

This cooperative aims to create a more inclusive and just heating transition by realigning influence and engagement levels among key actors. Stakeholders are now grouped into core members and extended members, based on their proximity and commitment to the SHA vision.

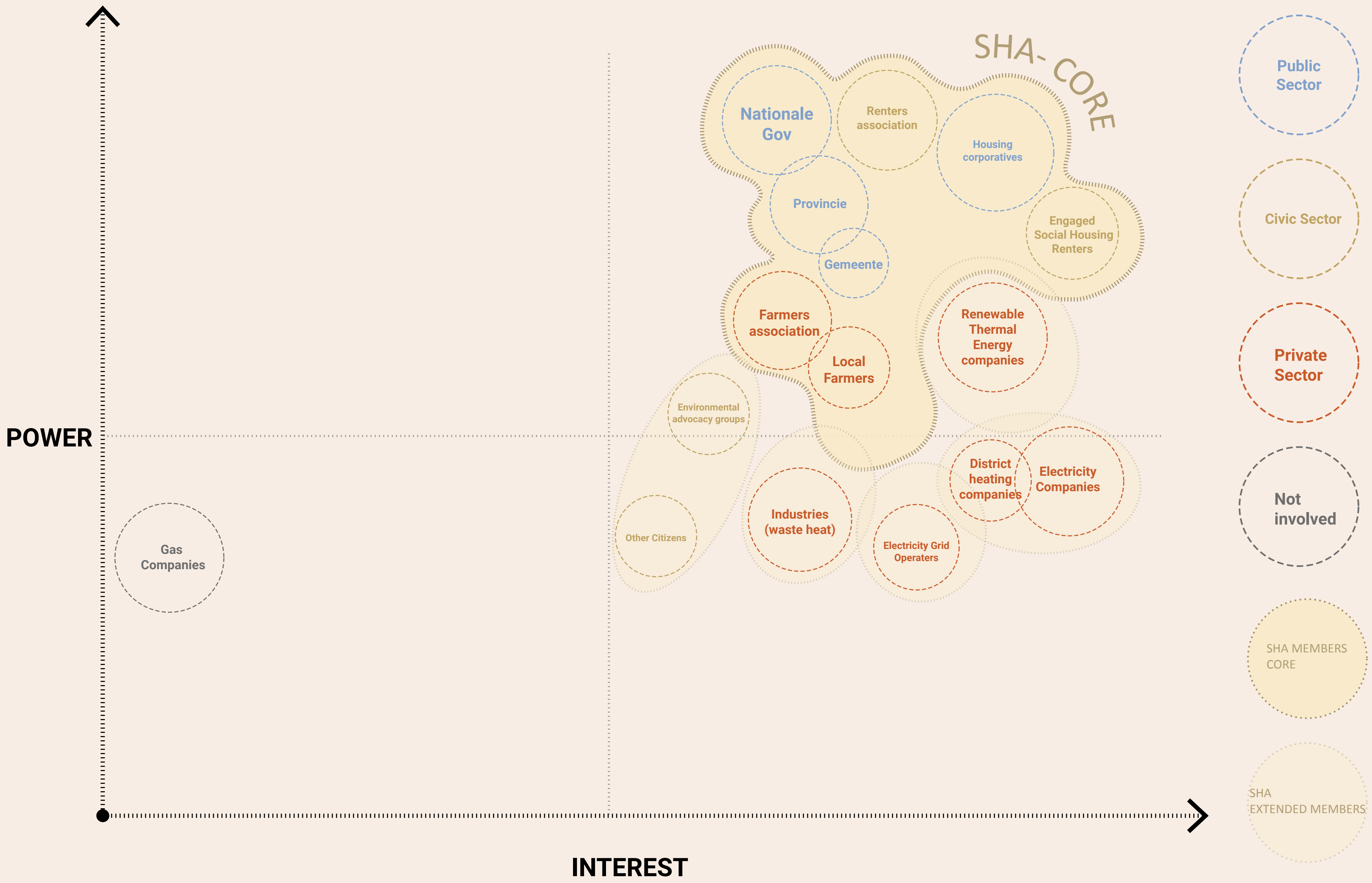


Figure 56: SHA Stakeholder Power-Interest Matrix

SHA Organisation

Organisation of the new Heating System

The new organizational structure of the heating system can be seen in the diagram, where the various stakeholders are assigned new roles and relationship as a part of the SHA which is formed.

The organisation of the system is not top down anymore, and is rather circular where each of the stakeholder involved has varied roles .

The decision making and governance structure is managed by the municipality, and housing corporation (who are the owners and distributors), renters association and the community (who are the users) together. All of these play an important role in shaping the local heat visions.

In this system envisions the electricity and heat suppliers to develop and explore new sources of generation. These stakeholders like the farmers cooperatives, renewable heat companies, industries producing waste heat, and individual land owners with the capacity to have producing units, are externals with active role in the SHA.

Perhaps the grid operators and district heating companies are part of the SHA, but with limited role in decision making. They partake in construction, maintenance and overseeing the operations of the system,

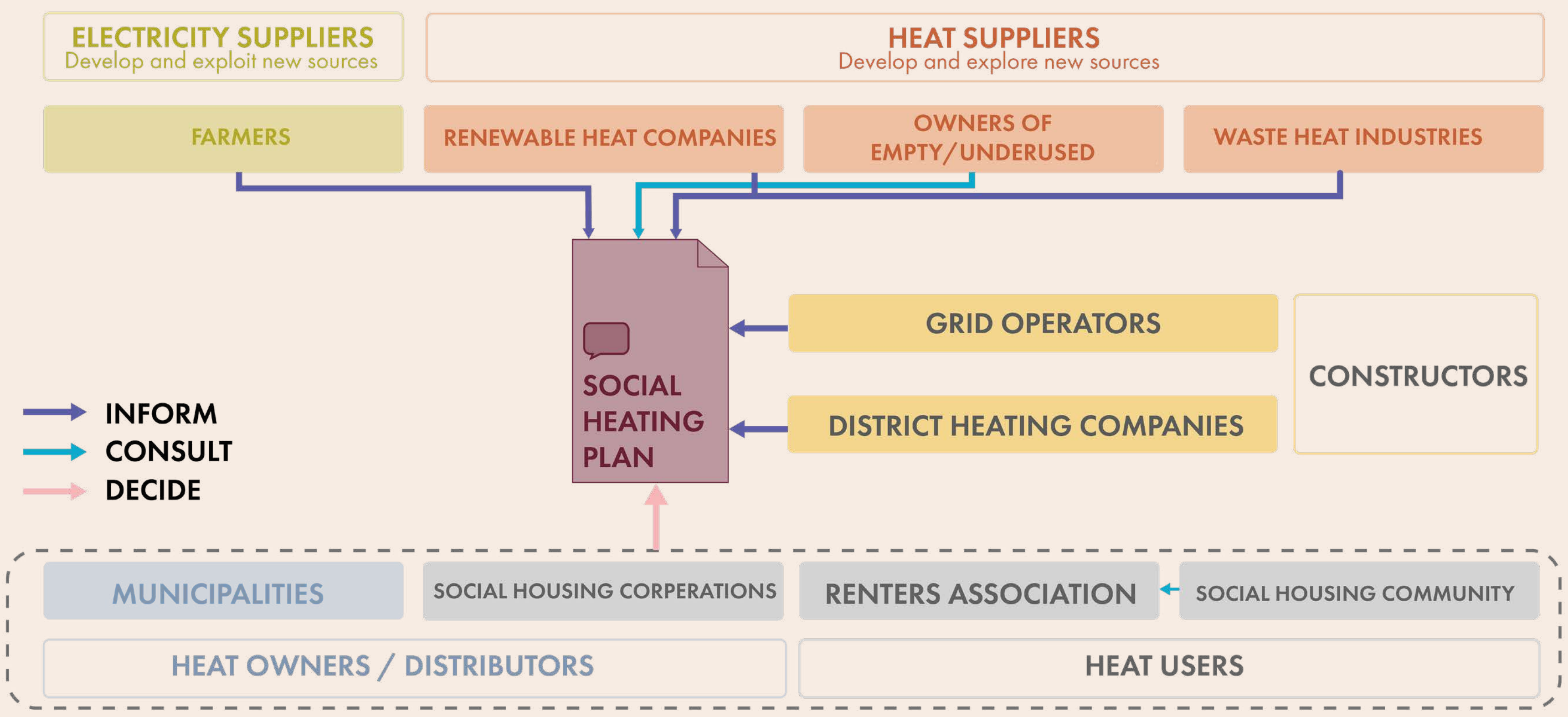


Figure 57: Stakeholder analysis

Policy Overview

To get a better understanding of the policies that are active in Arnhem-Nijmegen, we analysed policies from different institutions that have a governing role in the region. We looked at policies from the scale of the European Union to the scale of the different municipalities in the region.

Municipality

The municipalities want to transition from fossil fuels to sustainable heating, aligning with national and regional climate goals. This includes district heating, geothermal energy, residual heat from industry and aquathermal energy from surface water.

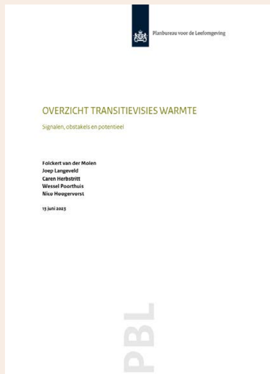
The municipalities are emphasizing the importance of neighborhood-specific approaches based on technical feasibility, affordability, and social acceptance.

Province

The province of Gelderland has a clear commitment to expand their social housing stock. However, funding issues and energy infrastructure limitations remain challenges for them. The province emphasizes the importance of energy efficiency and moving away from gas-based heating to make social housing more sustainable and affordable in the long term.

Region (RES)

The region wants to emit 55% less CO_2 than in 1990, as agreed in the National Climate Agreement and the Gelderland Energy Agreement. They see switching from fossil energy to renewable energy as the most important step in this is. They want to do this via solar fields, wind turbines and geothermal heat. To achieve this, they see the requirement of new infrastructure, like expanding the electricity and heat networks, as a key objective.

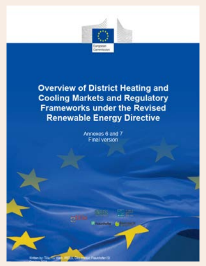


National Government

The Dutch government wants to increase their social housing stock and aim that 30% of the total housing stock consists of social housing.

The government supports different the transition to different types of renewable energy and are known to the importance of risk management, policy adaptation, and infrastructure investment.

Also, they see the challenges of the need for thermal storage, economic viability, and policy backing.



European Union

The European Union focuses not just on reducing energy consumption, but also on transforming heat production by transitioning from fossil fuels to renewable heating solutions. They planning to have an EU strategy to enhance DH networks and integrate renewable energy sources.

They European Union does not mention social housing specifically in connection with the Netherlands. However, they highlight that social housing companies play a role in district heating networks, particularly in communal heat networks.

Policy Analysis Summary

Compliments and Conflicts

SHA STAKEHOLDERS

LAWS - POLICIES - FRAMEWORKS - GOV'T STUDIES

			CIVIL SOCIETY		PUBLIC/ NONPROFIT		PRIVATE					Takes from the compliments and conflicts analysis
			Social housing community	Renters association	Housing corporations	Municipal governments	District heating companies	Renewable heat companies	Waste heat industries	Owners of empty / underused land	Farmers	
EU	Framework on district heating	Framework	+	+	+	+	+	+	+	○	○	EU is in support of more District Heating. It also states that more public ownerships involves more regulation and is often done to ensure consumerprotection.
EU	Framework on social housing	Funding	+	+	+	+	+	+	○	○	○	Multiple europeon fundings that support renewable innovations which decrease energy bills of people in social housing.
NATIONAL	Heat act	Policy	○	○	+	+	+	+	+			The act establishes price control for district heating, which is in line with the vision of the SHA.
NATIONAL	Collective heat act (proposed)	Policy	+	+	○	+	−	○	○			The act proposes that municipalities would get ownership over DH networks which lowers the profit, and therefor prices. This is in line with the vision of the SHA.
NATIONAL	Waste heat	-	○	○	○	○	○	○	○			
NATIONAL	Aquathermal heat	Report	+	+	+	+	+	+	−	○	○	The Netherlands has aquathermal potential however more research is necessary. The report also states that thermal storage solutions, economic feasibility and policiy support are essential.
NATIONAL	Geothermal guidelines	Policy			−	−	○	−				Geothermal undergoes a strict risk management and can not be used anywhere (ex. drinking water protection areas)
NATIONAL	Regulation of national EZK and LNV subsidies	Policy	−	○	−	○	−	○	○	○	○	Anyone can apply for subisdy for individual heat pumps even if district heating is proposed
NATIONAL	LAN	Recom			+	+	○	+				This report states that it is very difficult to expand networks. Part of the reason is that the procedure is long and complicated. The LAN proposes bulkpermits.

Policy Analysis Summary

Compliments and Conflicts

SHA STAKEHOLDERS

LAWS - POLICIES - FRAMEWORKS - GOV'T STUDIES

			CIVIL SOCIETY		PUBLIC/ NONPROFIT		PRIVATE					Takes from the compliments and conflicts analysis
			Social housing community	Renters association	Housing corporations	Municipal governments	District heating companies	Renewable heat companies	Waste heat industries	Owners of empty / underused land	Farmers	
PROVINCIAL	State of social housing	Report	+	+	+	+	+	+	+			The province acknowledges the lack of social housing and is using funding, the purchasing of land and repurposing existing buildings to increase the social husing stock.
REGIONAL (RES)	RES 1.0	Vision	○	○	○	+	+	+	+	○	○	The RES supports new forms of thermal production like geothermal and aquathermal.
MUNICIPAL	Port visions	Vision				+		+				In the current heat visions of municipalities, social housing is not prioritized.
	Heat visions	Vision	−	○	−	+	+	+	+	○	○	Economic visions of Arnhem and Nijmegen show that portside industries are underused. Both cities want to support water connected industries in the port.

The policy analysis carried out for this project culminated in a summary table of complements and conflicts. The columns of the table list all existing laws, policies, frameworks, and reports that we analysed to understand the current policy environment and state of research relevant to our focus on renewable district heating. The rows list all stakeholders that would participate in or advise with the Social Heating Association, as proposed. And the table cells mark the complements and conflicts between existing policy and the role of each stakeholder as they would act in the proposed Social Heating Association.

Form this analysis, we have concluded that there is broad support for, and much discussion of, the expansion of renewables-based district heating networks as a means to decarbonise residential heating at all levels of government, up to and including the European Union. This aligns well with our proposals. At the national level, the proposed Collective Heat Act (Wet Collectieve Warmte, Wcw) would cede majority ownership of district heating networks to municipalities thereby granting them effective control over the development and operation of district heating networks. This proposed law, which is due to enter force on January 1, 2026, also aligns very well with our proposed SHA structure where municipalities and social housing corporations work together as the majority owners and operators of district heating networks (Wet Collectieve Warmte (Wcw), 2025).

The main sources of conflict within the policy space are restrictions on where heat production can take place. With the proposed expansion of district heating, new thermal energy sources must be added to the region to ensure heat supply matches growing demand. There are a variety of renewable thermal energy sources with potential in the region, however they each come with their own set of restrictions on implementation. For example, the Dutch government will not issue permits for geothermal drilling in drinking water extraction areas (Staatssecretaris van Economische Zaken en Klimaat & Minister voor Klimaat en Energie, n.d.). These kinds of restrictions effectively shrink the thermal energy potential of the region and may also slow the process of developing new thermal energy production sites.

The Dutch government currently has incentives in place for individual homeowners who wish to install individual electric heat pumps to heat their home and/or water. These incentives are intended to accelerate decarbonisation by encouraging adoption of electric heat pumps, which can become fully carbon neutral with a decarbonised electricity supply (Investeringssubsidie Duurzame Energie En Energiebesparing (ISDE), n.d.). This incentive, although well-intentioned, conflicts with our vision of an expanded district heating network when more individual heat pumps are installed in areas that would otherwise be suitable for a district heating network – this decreases interest in, and support for district heating expansion. In short, incentives for heat pumps result in more heat pump adoption, and homeowners who have just installed a heat pump, are generally not interested in nullifying that investment by connecting to a new district heating network. These policy conflicts, along with other spatial and organisational conflicts identified, are addressed in Chapter X which outlines the phasing of interventions and our proposed policies.

Stakeholder Spatialisation

Schematic representation

The conflicts coming from the stakeholders and policies have an implication on the fabric of the region. In figure 58 the implications are made visual with the conflicts that occur.

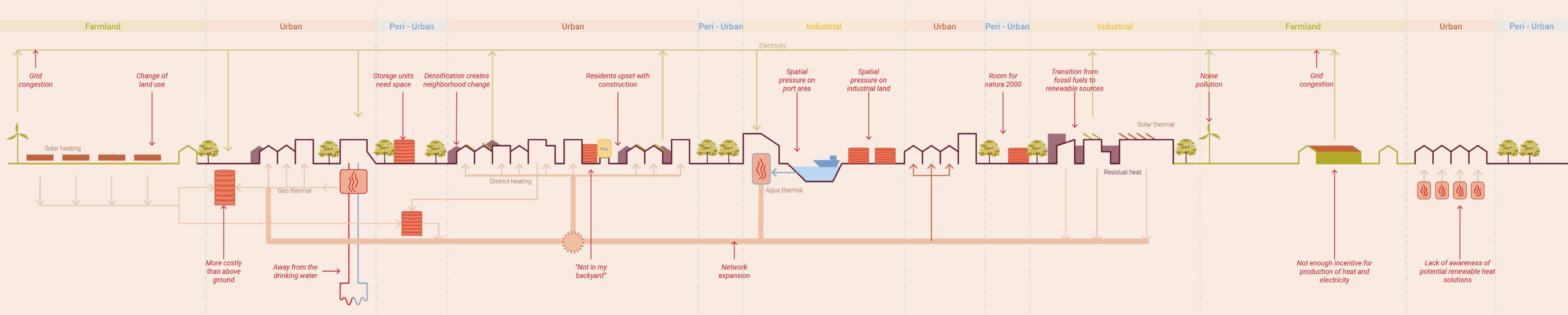


Figure 58: Schematic section with conflicts

Conflicts and Solutions

The conflicts conducted from the policy and stakeholder analysis all need a fitting solution in the timeline. Some solutions are organisational while others are technical. Organisational solutions are about t

Policy

CONFLICT	SOLUTION
Heat visions of municipalities	Change current heat visions from municipalities
Subsidies on individual heatpumps are affecting the feasibility of proposed DH areas	Stop individual heat pump subsidies for proposed proposed DH areas
Geothermal implementation procedure	Elaborate geothermal implementation procedure and research possible geothermal sites which are not in drinking water areas

Socio-spatial

Organisational

CONFLICT	SOLUTION
Not enough incentive for production of heat and electricity on farmland	Target incentives to farmland most suitable for heat/ electricity production and involve farmers in SHA
Lack of awareness of potential individual renewable heat solutions	Public awareness campaign individual heating
Residents upset with construction of streets	Implement community inclusive planning in design processes to transform streets to be more green, water permeable and safe
Densification creates neighborhoods change	Implement community inclusive planning in design processes to improve spatial quality of neighborhood alongside densification
Change of landuse	Participation with and compensation for involved farmers

Technical

CONFLICT	SOLUTION
Transition from fossil fuels to renewable sources	Assist industries in fuel switching and implement CCS where necessary/practical
Noise pollution from windturbines	Implement best available noise reduction strategies on windturbines and create sound buffers through vegetation
Heat network expansion creates competition for subsurface infrastructure space	Understand current subsurface infrastructure to expand heat network efficiently
Underground tank storage is costly and not possible everywhere	Soil research and study to possibilities Some storage tanks above ground
Storage units occupy public space	Storage tanks become integral part of public space through placemaking
Geothermal / aquathermal occupy public space	Building community spaces around production sites through placemaking

Phasing - Social Heating

PHASE 1: initiation (2025-2030)

In the first phase, the Social Heating Association (SHA), is initiated and there will be talks with other important stakeholders about their role in the association.

After the initiation of the SHA, district heating networks are expanded and the grid is will be prepared for more individual heating. At the same time, we want to gain knowledge of what implications will come with the project of the Social Spine. So the project will be simulated in a miniature form, called the Nijmegen Pilot Projects. The Nijmegen Pilot Projects consists of three pilot production sites, different community areas and upgraded streets.

There will be information and participation sessions for the community that gets affected by these developments. The SHA will explain their vision and people can participate in the design of the community spaces and streets of the Nijmegen Pilot Projects.

PHASE 2: acceleration (2030-2040)

In phase 2, the SHA is well-established. It can operate at full force, so the next steps of the vision can be set. The Nijmegen pilot Projects are successful and the SHA got a good understanding of the implications that will occur with the construction of the Spine. So the construction of the Social Spine, together with other renewable energy projects and its community spaces, can start. Also, along the construction of the Social Spine, there will be networkwide storage placement for the additional energy that needs to be stored.

Like phase 1, there will be information and participation sessions for the community that gets affected by these developments. The SHA will tell about the status quo of the project and people can participate in the design of the community spaces and streets of the Nijmegen pilot Projects.

PHASE 3: stabilisation (2040-2050)

This phase concludes the construction of the Social Spine and all renewable energy projects. The SHA will Information sessions for the affected community where they will explain about the future of the project.

PHASE 4: maturation (2050-X)

After the completion of the Social Spine, the region can move away from fossil fuels and switch to 100% renewable energy. Also, the use of residual heat will be phased out. Because the high amount of renewable energy that must be stored, the storage will be expanded.

The Social Spine, that was used for only residential purposes, will be expanded to industrial and commercial usage.

Information sessions for the industrial and commercial stakeholders will be held to inform them about the new usage of energy.

PHASE 5: adaptation (X-2100 and beyond)

After the completion and maturation of the project, the project needs to be ready for future (climatic) changes, and it is expected that new technological innovations will occur. To keep the high standard for project, it needs to adapt to these new innovations. This will be done by the new stakeholders, who were convoked in phase 4, that have knowledge about these new technologies and innovations. These adaptations will also help the project be resilient.

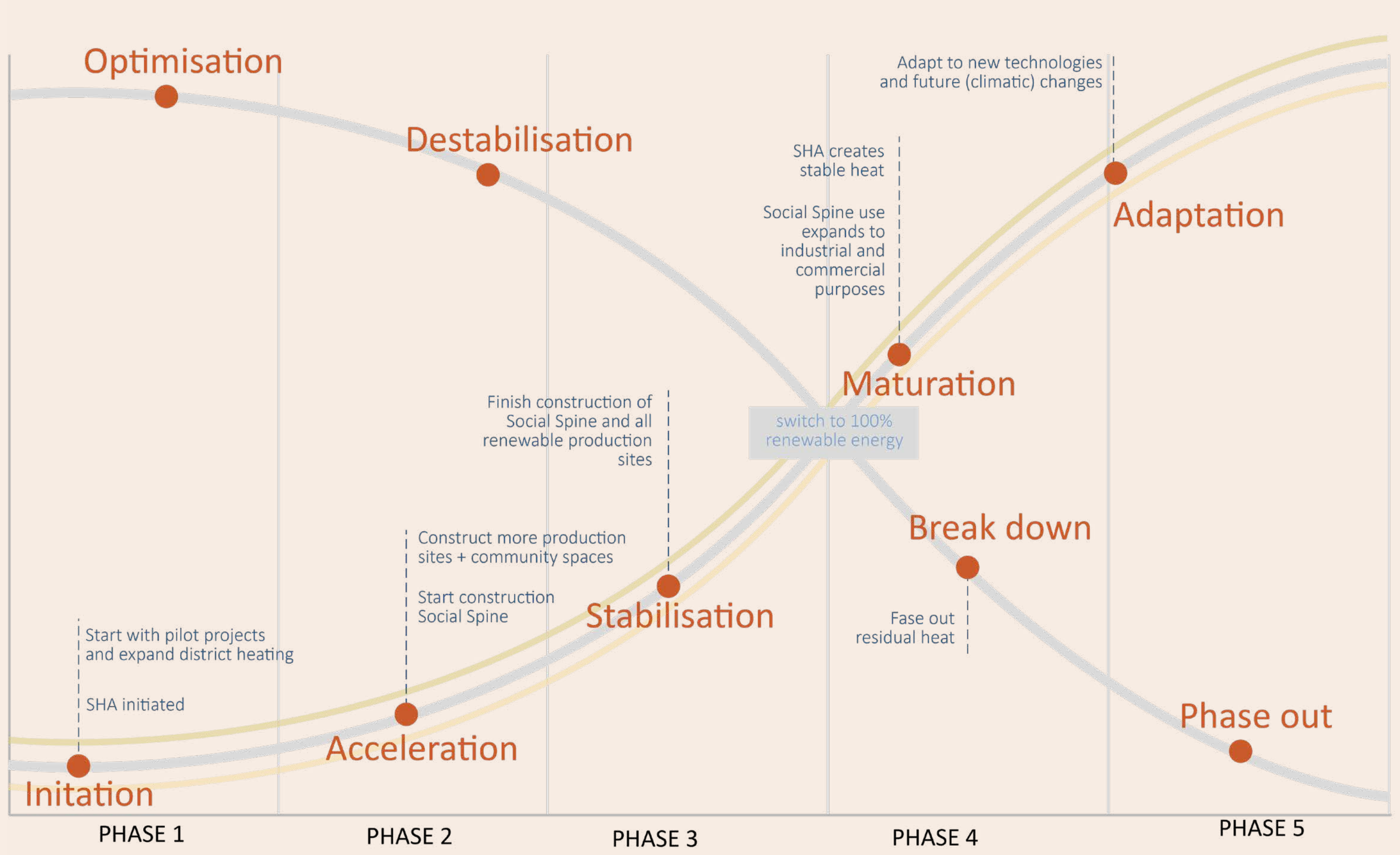
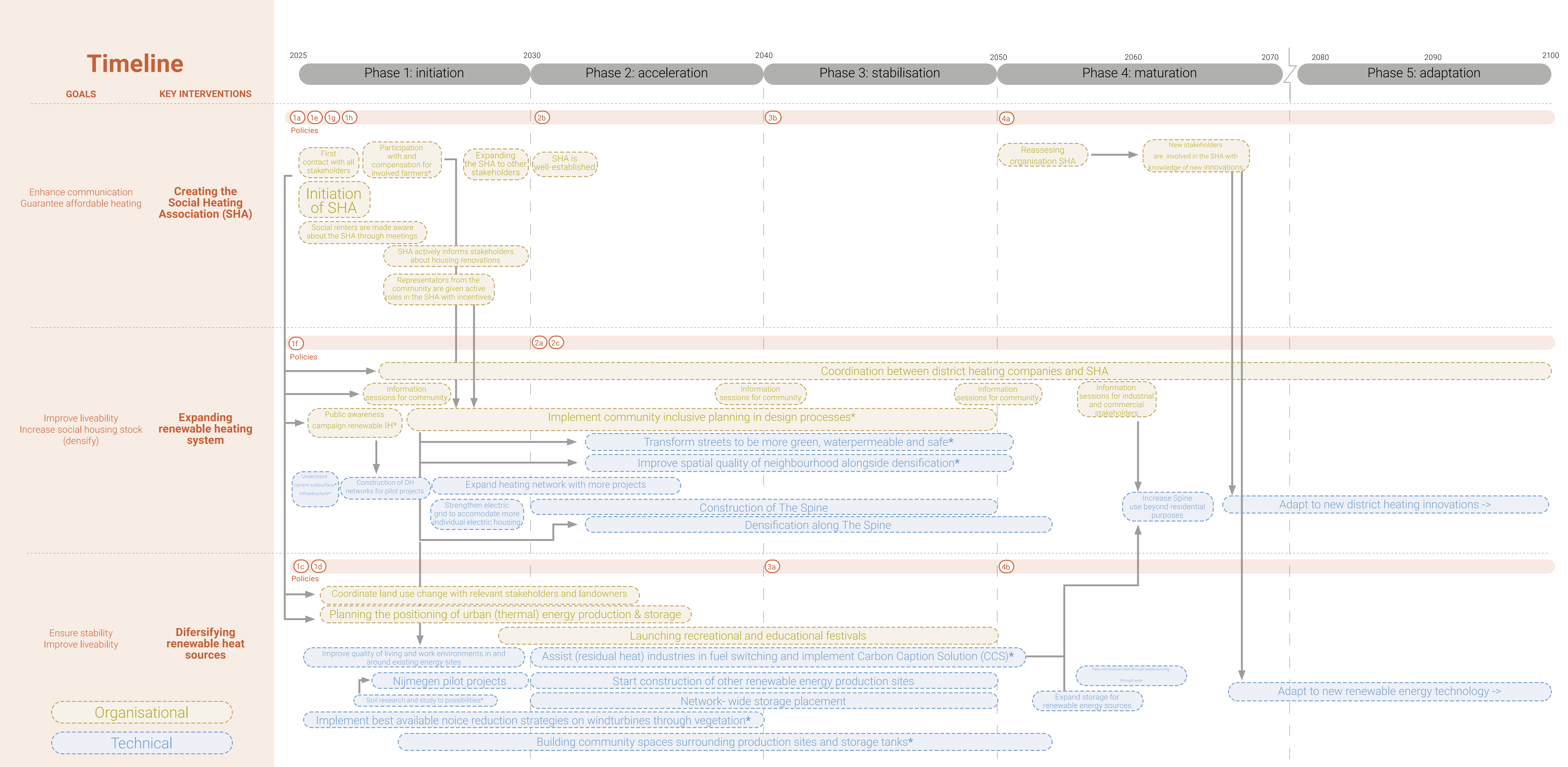


Figure 59: Phasing of the vision



POLICIES

Phase 1

- (1a) Change current heat visions from the municipalities*
- (1b) Stop individual heat pump subsidies for proposed DH areas*
- (1c) Elaborate geothermal implementation procedure*
- (1d) Allow use of river water for aqua thermal heat production
- (1e) Municipal heat transition instruments act (WGIW)
- (1f) Increase subsidies for individual heat pumps for proposed IH areas
- (1g) No more privately owned DH networks
- (1h) All new district heating network must be owned by municipalities

Phase 2

- (2a) All social housing in DH districts must be connected to The Spine
- (2b) Stable energy prices for all social housing communities
- (2c) Only residential buildings are allowed to use heating from The Spine

Phase 3

- (3a) All energy that's consumed comes from a renewable energy source
- (3b) Stable energy prices for all residential communities

Phase 4

- (4a) All buildings are allowed to use heating from The Spine
- (4b) No more use of residual heat

FUNDING

- Heat distribution (district/ individual heating)
- Sustainable energy production
- New community spaces and production sites as landmarks
- Transition of industries
- Affordable housing and densification

EU

- European Regional Development Fund (ERDF) 2021-2027
- Recovery and Resilience Facility (RRF) 2021-2026
- InvestEU Programme 2021-2027
- Social Climate Fund 2026-2032

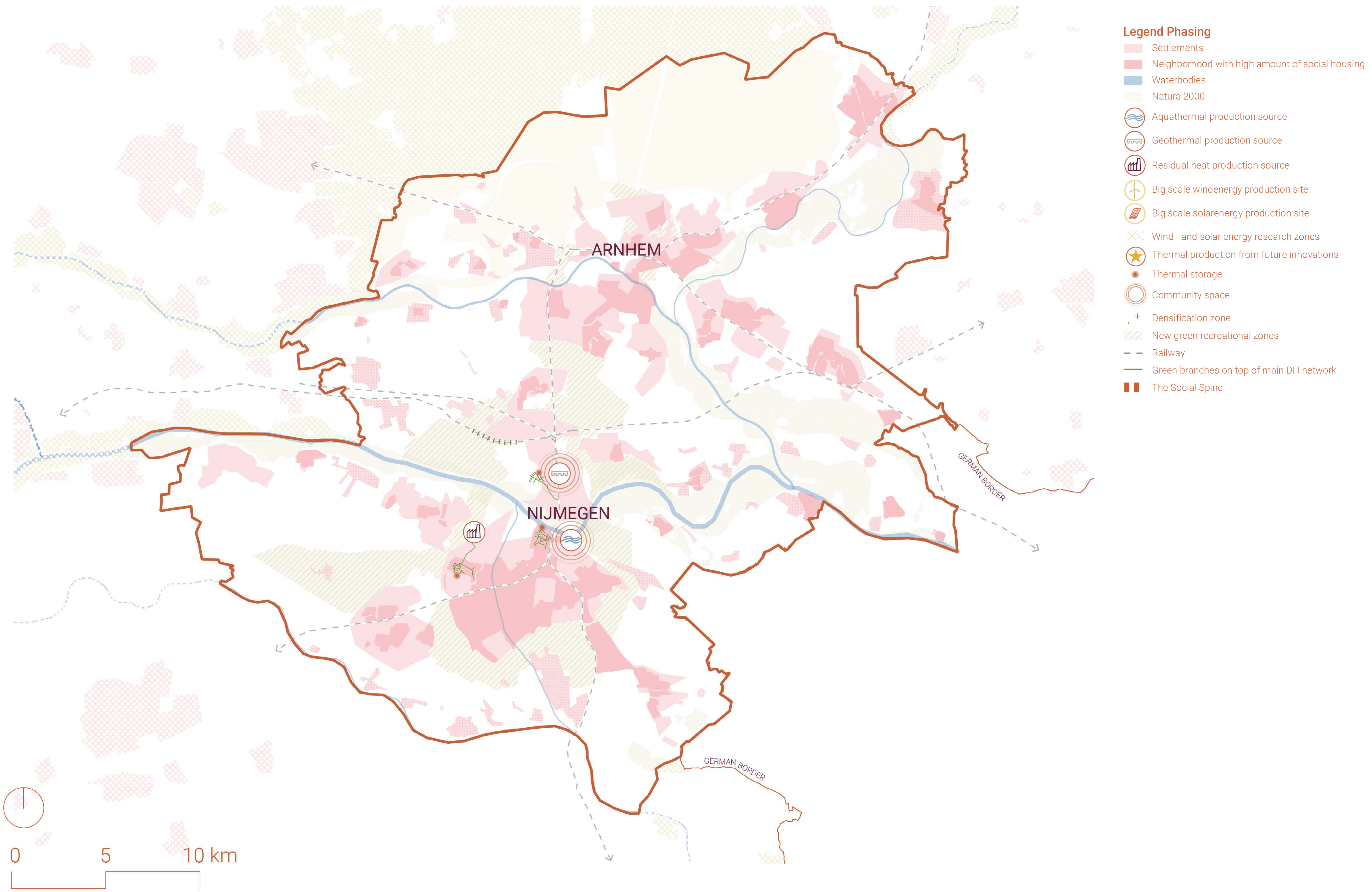
National government

- SDE++ (projects that helps reduce the CO2 emissions) 2026-2041
- Woningbouw impuls (building more affordable housing) 2025
- Warmtenetten Investerings Subsidie (WIS) 2025-2032
- ONB (iconic buildings in public space- landmarks) 2026
- Subsidie Ruimtelijke Kwaliteit 2026
- ISDE Individual heat pumps subsidy

Provincial

- Lokale hernieuwbare energieprojecten (Solar panels & wind energy) 2026
- Toekomstbestendige bedrijventerreinen (Future resistant industries)2026

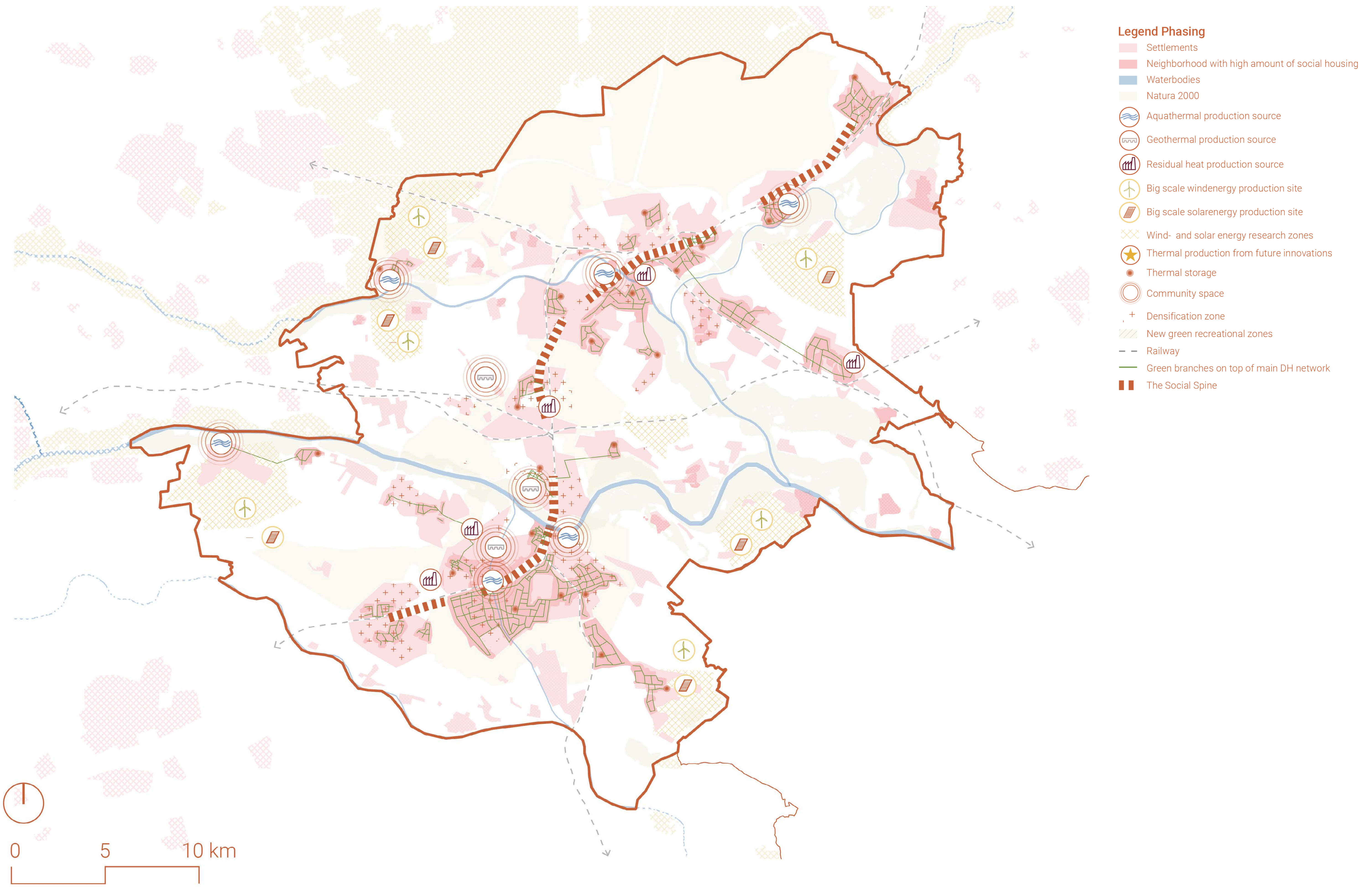
Figure 60: Phasing Time-line



2025-2030

PHASE 1: INITIATION

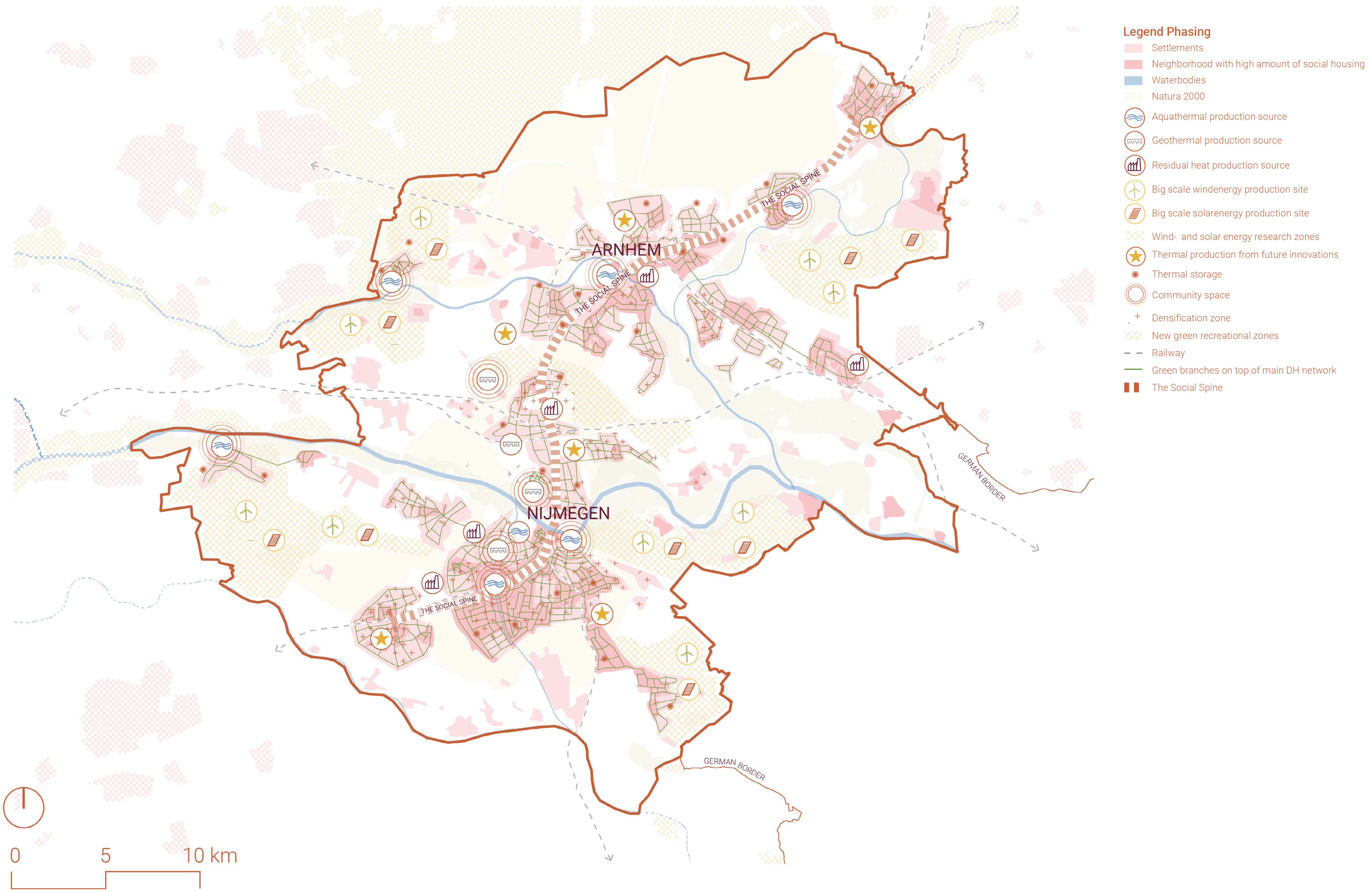
Figure 62: Phasing 2



2030-2040

PHASE 2: ACCELERATION

Figure 63: Phasing 3



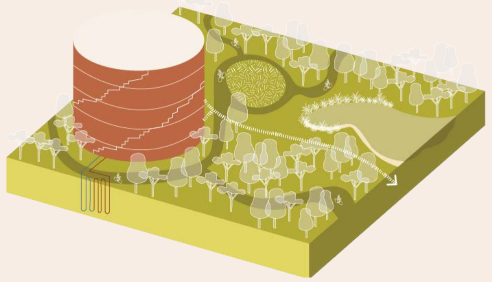
2040-2050

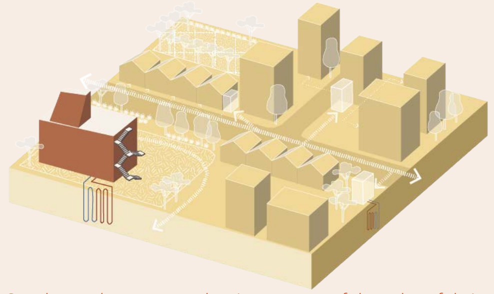
PHASE 3: STABILISATION

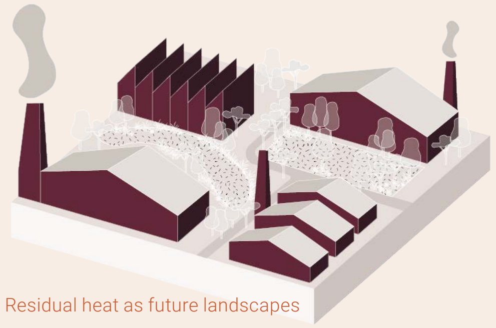
Catalogue of Interventions

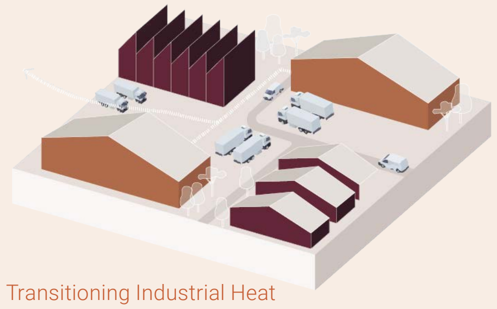
Figure 64: Catalogue of all Interventions

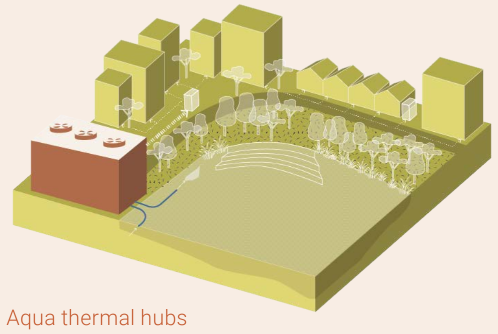
Hotspots :
Production and storage of heat

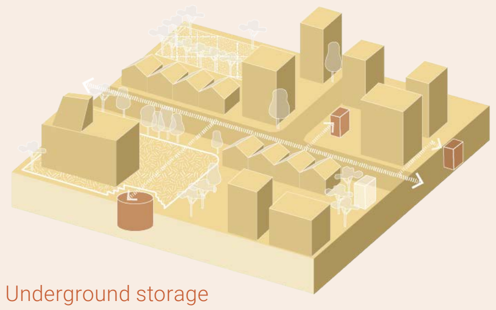

Geothermal sites as landmarks

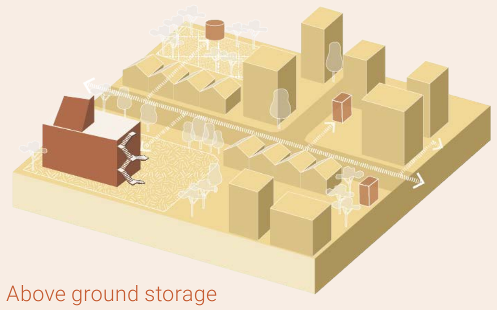

Geothermal energy production as part of the urban fabric


Residual heat as future landscapes

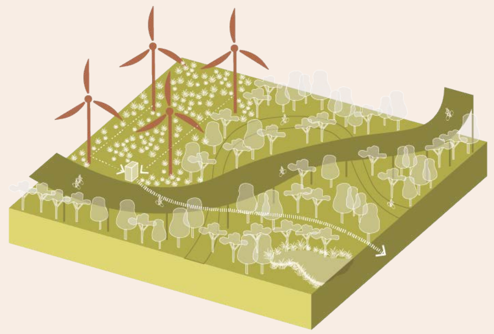

Transitioning Industrial Heat Production to Clean Energy Sources

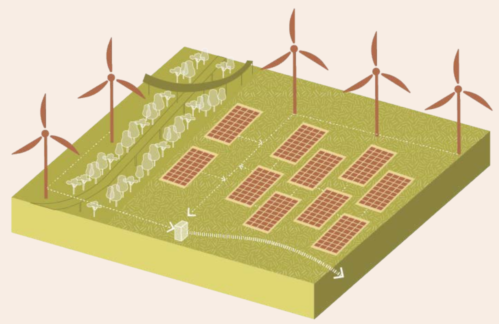

Aqua thermal hubs


Underground storage


Above ground storage

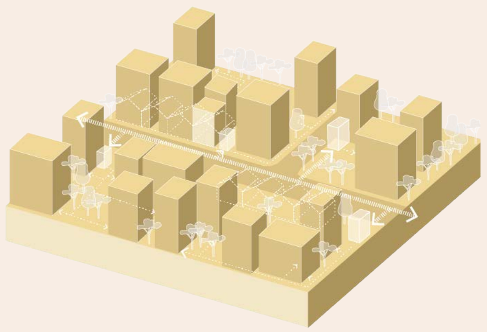
Electricity landscapes :
Production or electricity


Electricity production next to the city


Rural production of electricity- energy farming

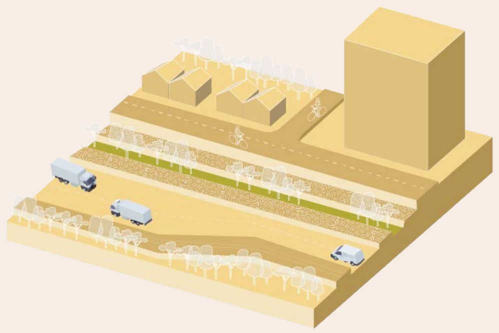

Rural production of electricity- with agriculture use

Regeneration Corridors:
Enhancing natural and built environments to create resilient and adaptive systems.


Densification


Green Corridor

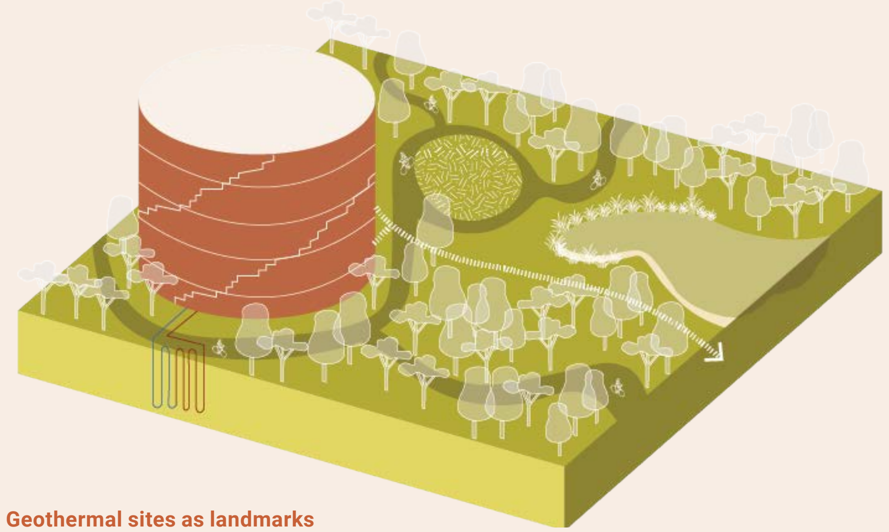
Branches :
Place making and improving street environment


Electricity production next to the city

Production Hotspots

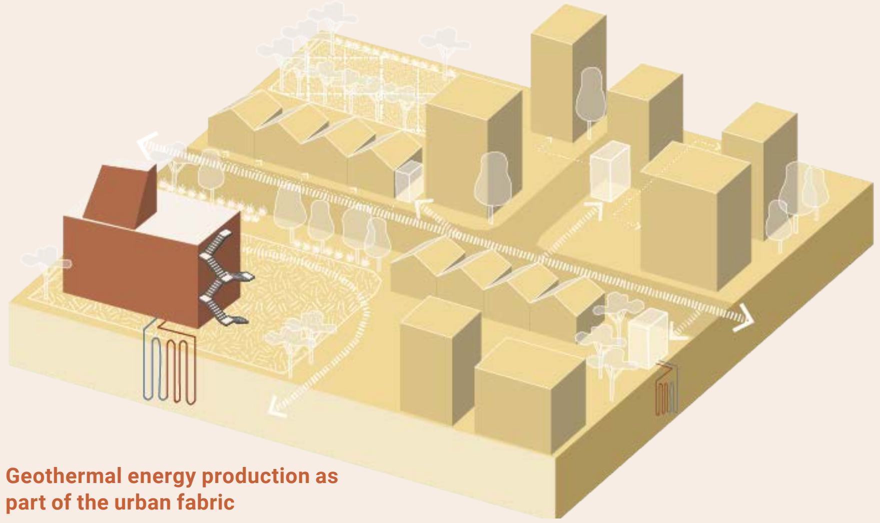
Hotspots :
Production of heat

Figure 65: Catalogue of Production Hotspots



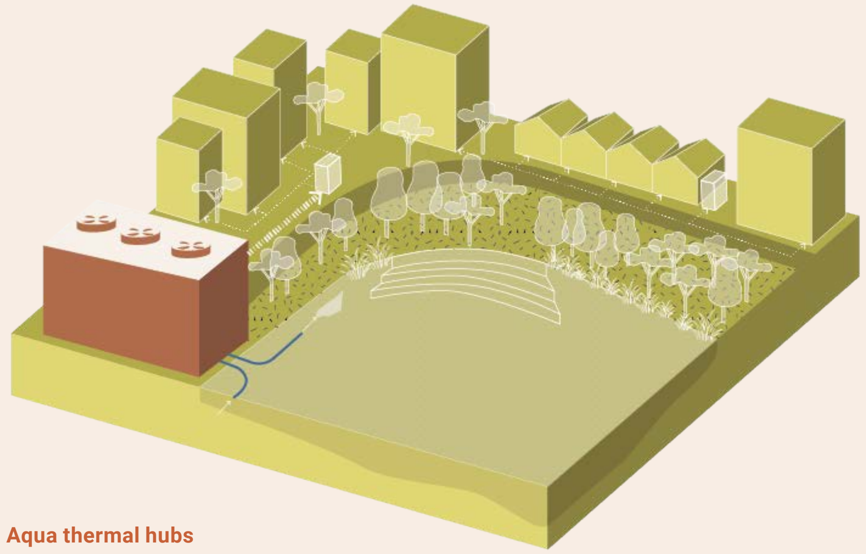
Geothermal sites as landmarks

Geothermal sites can be transformed into landmarks by integrating them within green corridors , for example along cycling tracks. Combining energy production with recreation, learning, and ecological value. These multifunctional spaces invite public interaction, making energy infrastructure a visible and engaging part of everyday life.



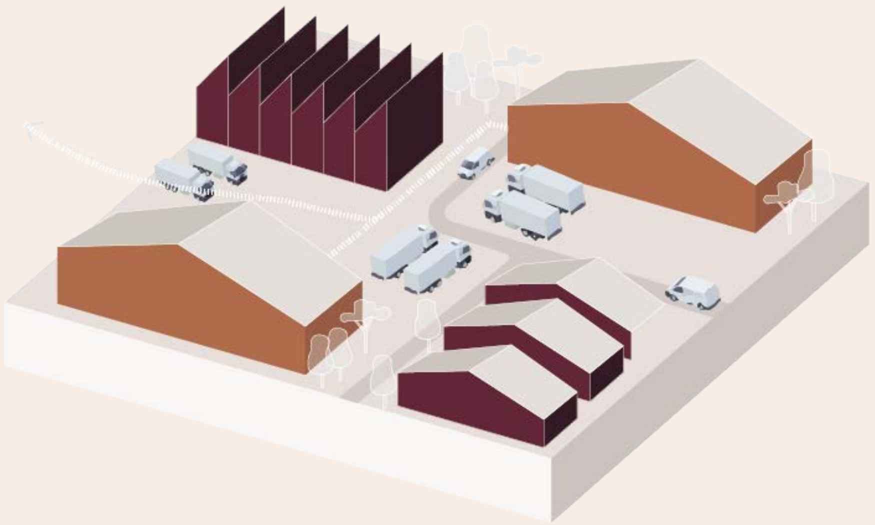
Geothermal energy production as part of the urban fabric

Integrating geothermal energy hubs within the dense urban fabric allows them to serve beyond their technical function—as public spaces that offer recreation and learning. These sites become active, visible components of the city's energy landscape.



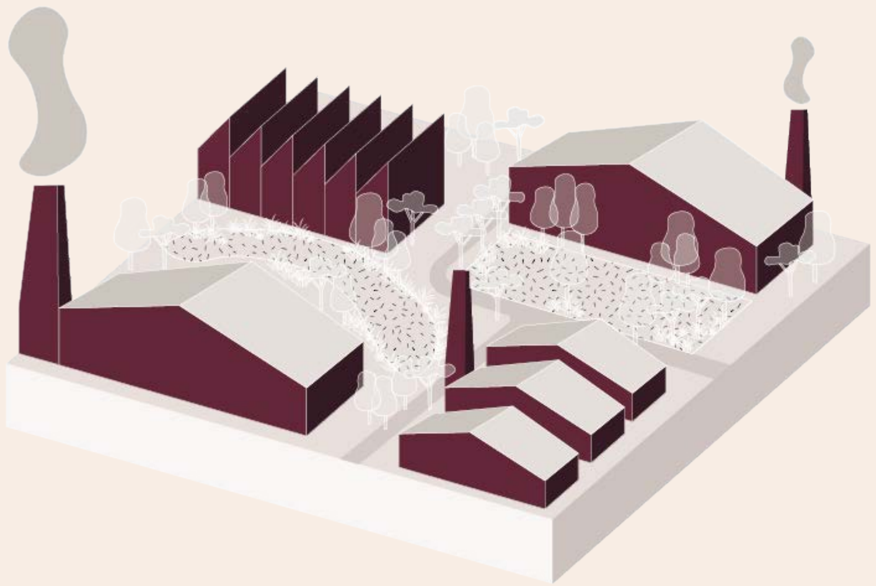
Aqua thermal hubs

Located along water bodies, aqua-thermal hubs combine thermal energy extraction with public spaces. These hubs can host recreational activities like swimming, thermal baths, sunbathing, etc. Thus turning waterfronts into attractive, multifunctional zones.



Transitioning Industrial Heat Production to Clean Energy Sources

As industries shift from fossil fuels to clean energy alternatives like hydrogen, factories can continue to function as residual heat production sites without carbon emissions. This transition not only maintains the availability of residual heat for various applications but also significantly reduces the environmental impact of industrial operations.



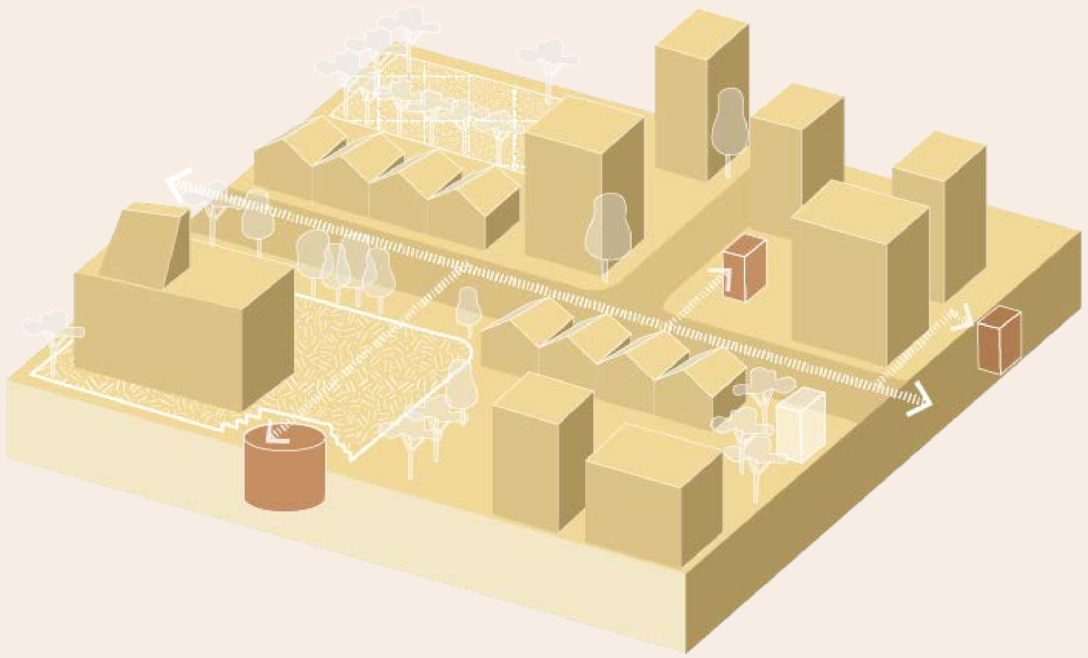
Residual heat as future landscapes

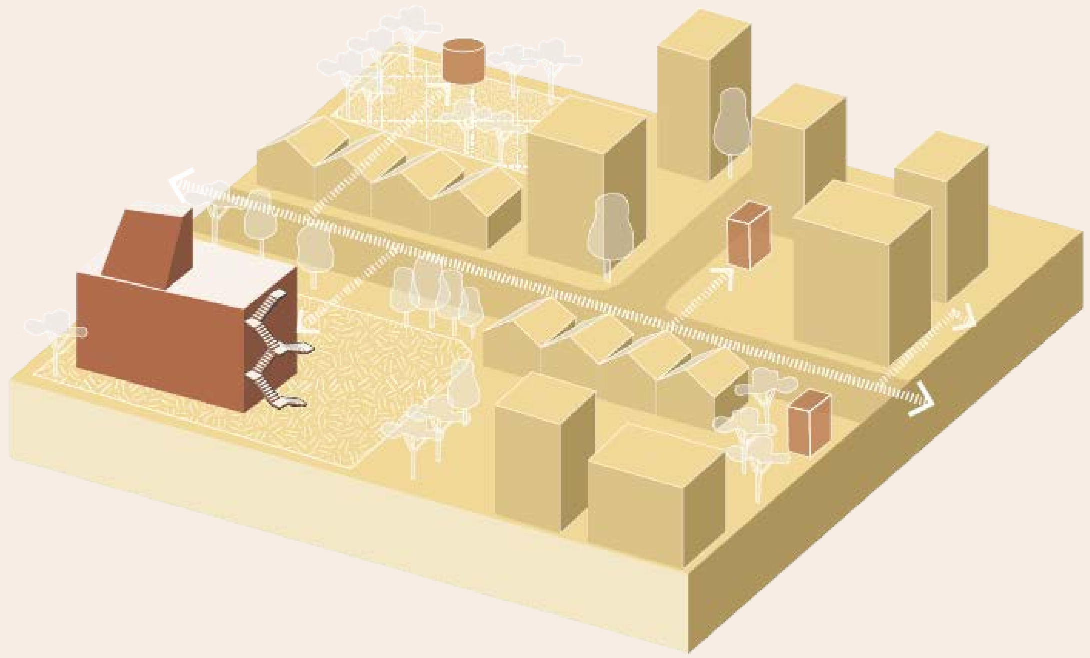
As industries transition to clean energy, many factories relying on fossil fuels will either switch to clean energy alternatives or become obsolete. These former industrial sites, once defined by carbon emissions and residual heat, hold immense potential for adaptive reuse in the near future. Rather than being abandoned, they can be re-imagined as social hotspots—hosting artisans' workshops, public exhibitions and community events.

Storage Hotspots

Hotspots :
Storage sites

Figure 66: Catalogue of Storage Hotspots





Underground storage

Integrating geothermal and aqua-thermal energy hubs into urban landscapes and requires creation of decentralized storages. Underground storage can be used in dense city centres or spaces which do not have space to host them within the fabric. These can be coupled with multifunctional spaces for recreation and learning.

Above ground storage

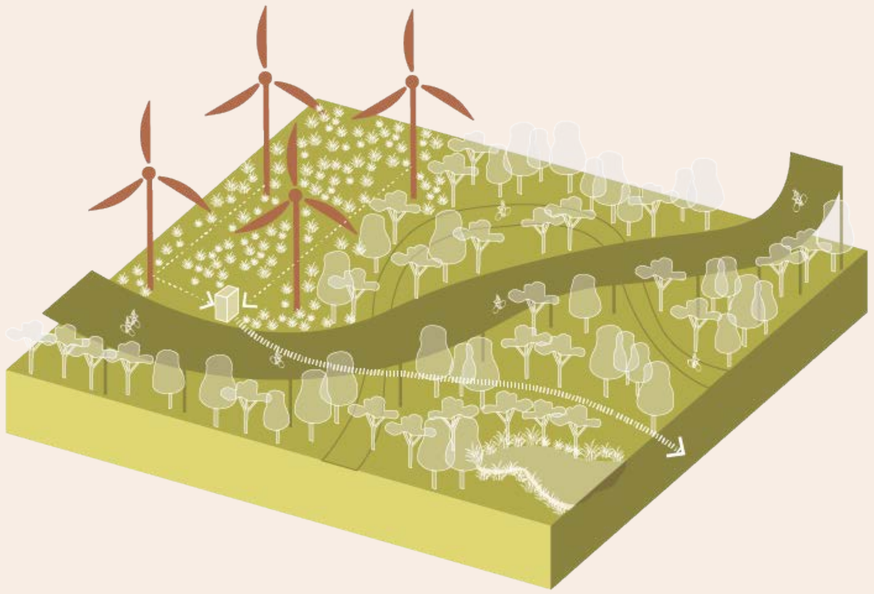
Integrating above-ground thermal energy storage units within the urban environment presents an opportunity to transform functional infrastructure into engaging public spaces.

Similarly, above-ground storage facilities can be reimagined as multifunctional structures that not only serve their primary purpose of energy storage but also offer recreational and educational spaces. For instance, these structures could incorporate observation decks, exhibition areas, or community gathering spots, thereby fostering public engagement and enhancing the urban fabric

Electricity Landscapes

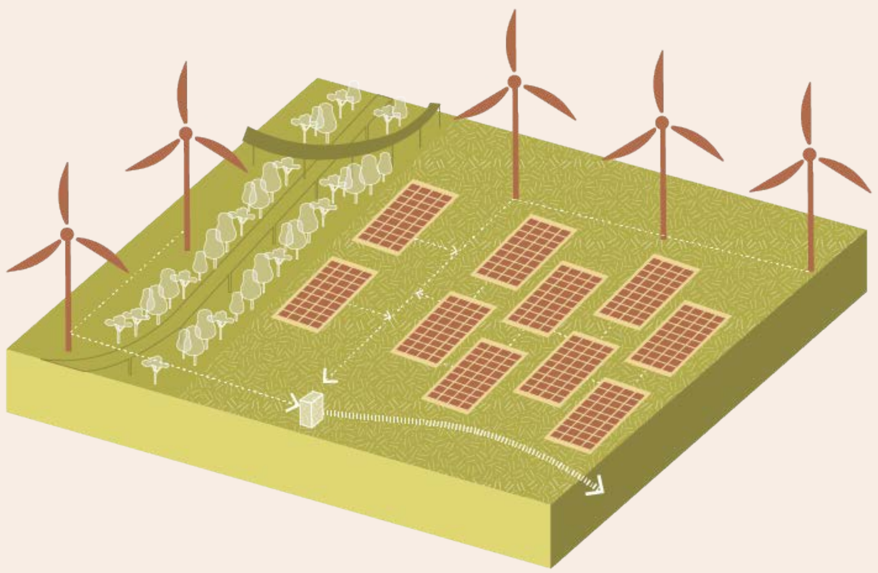
Production of electrictricity

Figure 67: Catalogue of Electricity Landscapes



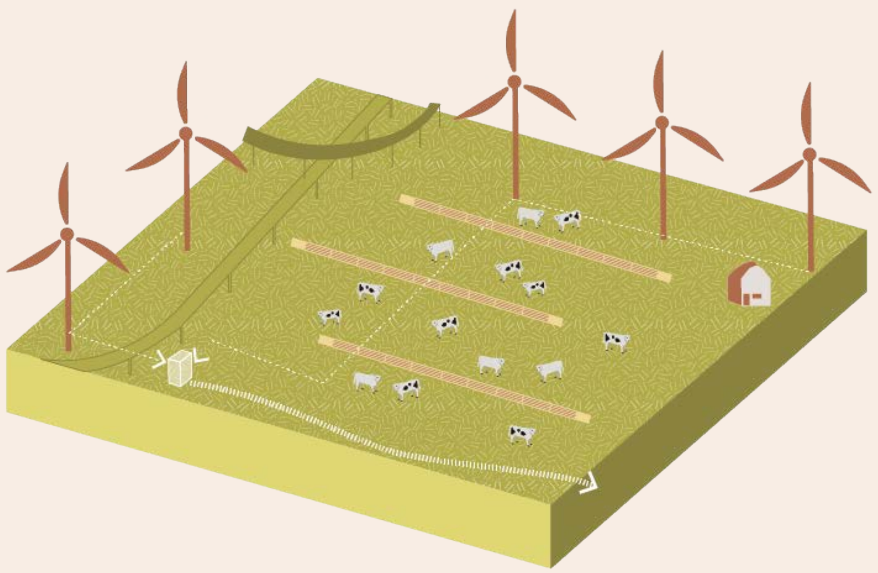
Electricity production next to the city

Integrating renewable energy production, such as wind turbines and solar farms, into the peri-urban areas bordering cities offers a sustainable approach to meet urban energy demands. Placing these energy sources along bicycle tracks and green corridors not only utilizes available space efficiently integrates energy into landscape.



Rural production of electricity- energy farming

Encouraging farmers to participate in energy production through solar farming offers a sustainable income source and promotes community-based renewable energy initiatives. By joining the SHA cooperative, agricultural landowners, independent farmers can partake in energy production.



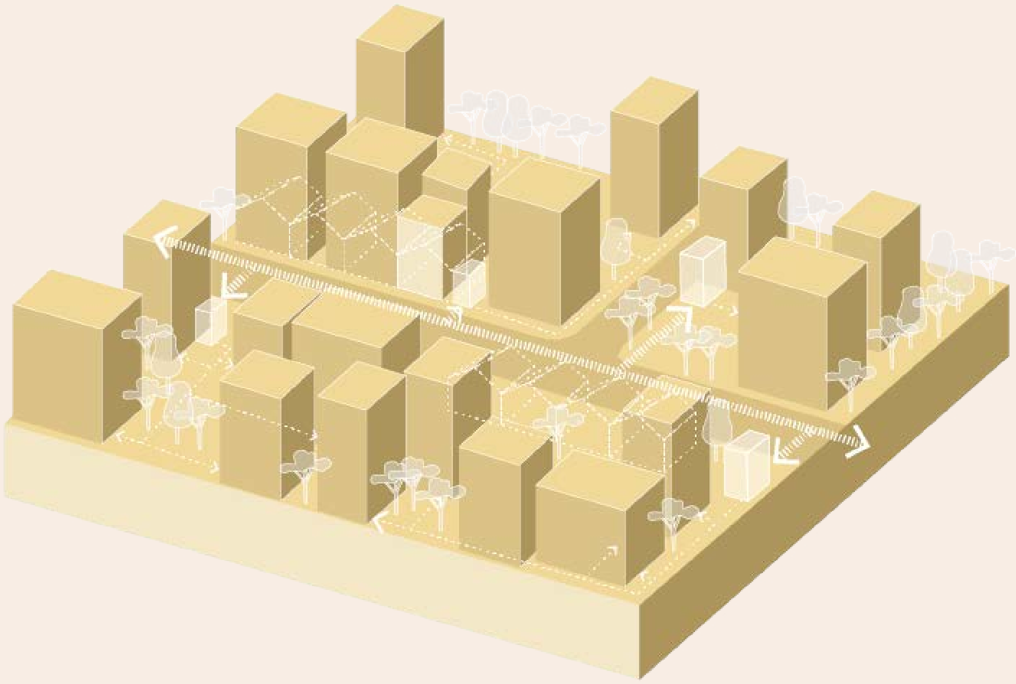
Rural production of electricity- with agriculture use

Integrating renewable energy production with traditional agricultural practices offers allows for farmers to expand their production means. Innovations like vertical solar panels enable farmers to harness solar energy without significantly their animal grazing activities.

Regeneration Corridors

Enhancing natural and built environments along intervention corridors.

Figure 68: Catalogue of Regeneration Corridors



Densification

Urban densification requires increasing population and building density within existing urban areas, thereby enhancing housing availability, including social housing.

Green Corridor

Green corridors, which are ecological or biodiversity corridors designated to run across the region.
These corridors enhance ecological value and biodiversity by linking isolated ecosystems. They become the essential ecosystem infrastructure of the city, important for climate regulation and future resilience.

Branches

Local placemaking and improving street environment

Figure 69: Catalogue of Branches

Place making and improving the street environment

Re-doing the energy infrastructure requires opening the streets and rebuilding them al together. This provides a great opportunity to enhance the street quality. Enhancing urban street quality involves implementing measures such as permeable pavements to manage storm-water and reduce runoff, dedicated lanes for various transportation modes to improve safety and efficiency, and soil health improvements to support urban greenery and biodiversity. These strategies collectively contribute to more sustainable, efficient, and livable urban environments.

Nijmegen

To get a better understanding of the construction of the Social Spine, the process will be simulated on a small scale. This test project will be called the Nijmegen Pilot Projects and will take place in, like the name suggests, Nijmegen.

In five years, three renewable energy production sites will be constructed during the pilots; a geothermal, aqua thermal and residual heat site.

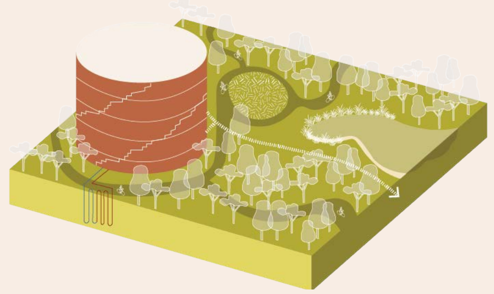
Figure 70: Pilot projects in Nijmegen

Pilot projects

Waalsprong - Geothermal

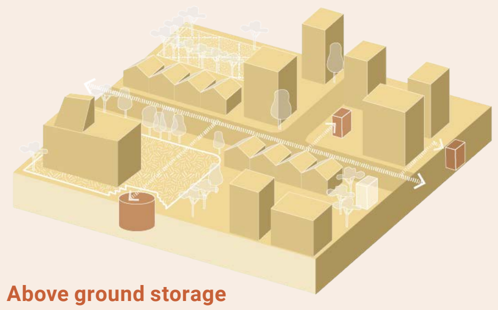
The geothermal pilot project will be located on the northern edge of Nijmegen, in the Waalsprong neighbourhood. It will provide sustainable heat for approximately X homes. The site is positioned on an unused grass field within a natural setting, making it a visible and distinctive feature in the landscape.

Beyond its technical function, the site will also serve the community. A large open grass field will remain next to the installation to preserve the natural atmosphere. Local residents will be encouraged to shape its use through their own initiatives. Possible activities include small markets, sports events, or food festivals.



Geothermal sites as landmarks

Figure 73: Axo Geothermal



Above ground storage

Figure 74: Axo storage

Place making and improving street environment

Figure 75: Axo branches

Figure 71: Pilot project in Nijmegen

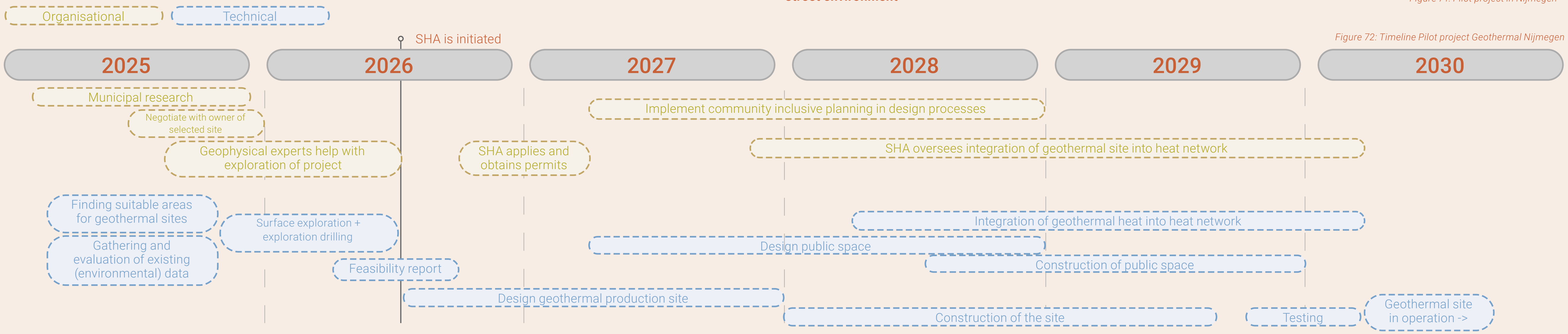


Figure 72: Timeline Pilot project Geothermal Nijmegen

Figure 76: Catalogue: Pilot Project, Geothermal

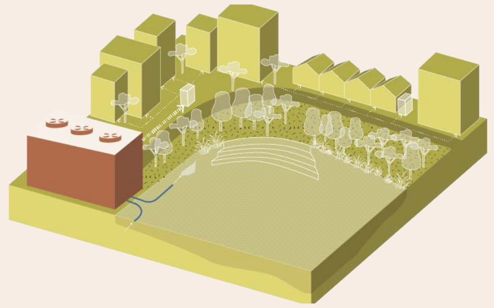
Waalsprong - Geothermal

Pilot projects

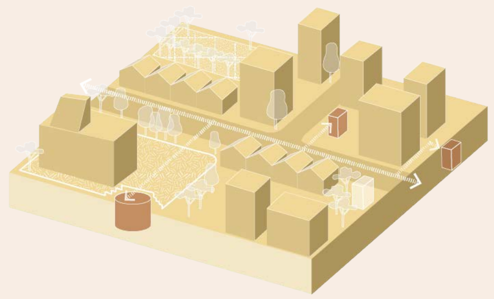
Port Area - Aquathermal

The aquathermal pilot project will be constructed in the port area of Nijmegen. The site will supply approximately 6.000 dwellings.

The site will have a community function. Because of the port and the aquatic function, people are allowed to swim in the water near the production site and there will be a café with beautiful views over the water. In addition, people can come to the production site to learn about the energy transition and aqua thermal energy. The aquathermal site becomes a place where people connect with each other and water.



Aqua thermal hubs *Figure 78: Axo aquathermal*



Underground storage *Figure 79: Axo storage*

Place making and improving street environment *Figure 80: Axo branches*

Figure 77: Pilot project in Nijmegen

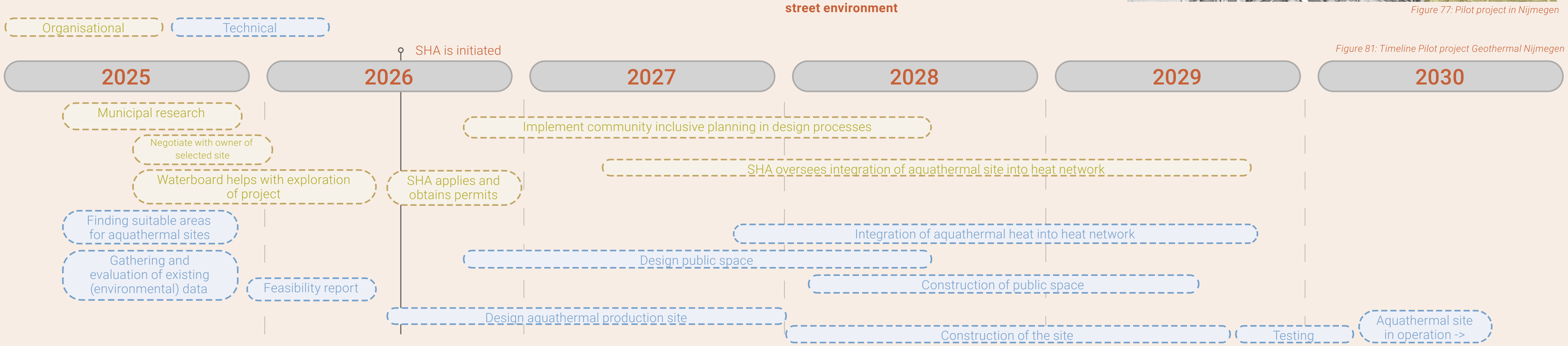


Figure 81: Timeline Pilot project Geothermal Nijmegen

Nijmegen Port Area - Aquathermal

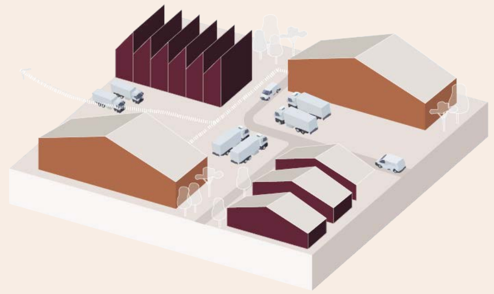
Figure 82: Catalogue: Pilot Project, Aquathermal

Pilot projects

ARN - Residual Heat + CCS

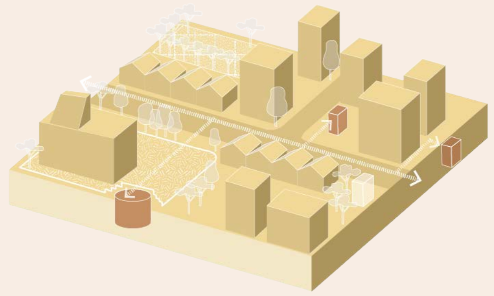
The residual heat pilot project will be constructed at an existing waste incineration site, ARN Nijmegen. At this site, we propose an implementation of CCS, or carbon capture and storage. This will allow the ARN waste incineration site to continue operation as part of a carbon-neutral district heating network. The area will be made more accessible by foot and bike. This will be done by connecting it to the near neighbourhoods, through the placement of a recreational parc and by improving the connecting of the site through bike paths. The new green corridor creates a healthier living and working environment.

Like the aqua thermal site, people can come to the production site to learn about the energy transition and the residual heat industry.



Transitioning Industrial Heat Production to Clean Energy Sources

Figure 84: Axo



Above ground storage

Figure 85: Axo

Green Corridor

Place making and improving street environment

Figure 86: Axo

Figure 83: Pilot project in Nijmegen

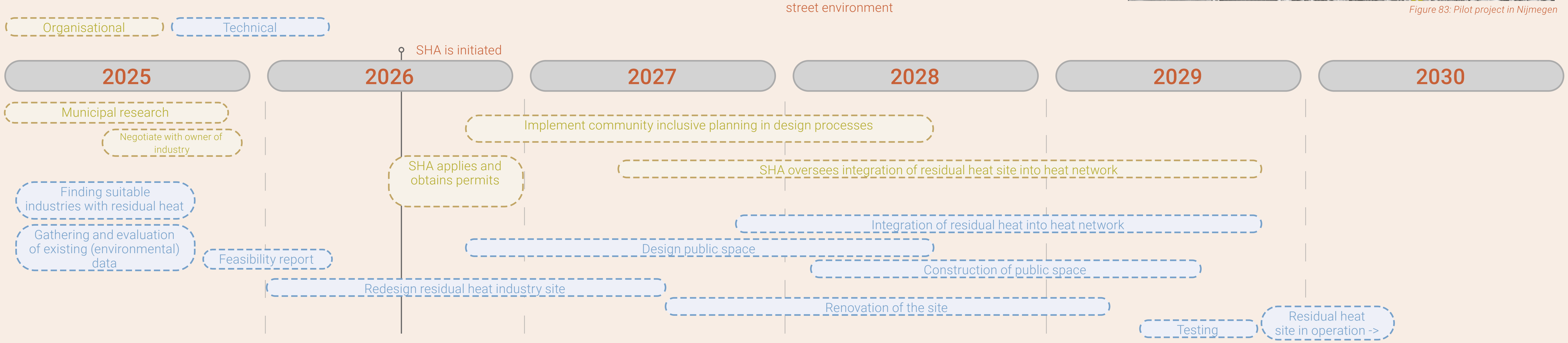


Figure 87: Catalogue: Pilot Project, Residual Heat

ARN - Residual Heat + CCS

Chapter 7

The future of Social Heating.

Chapter 7: Future of social heating
The vision is intended to function as a template for other regions in the Netherlands. Once the project in Arnhem-Nijmegen has successfully been completed, other regions can replicate the process and adapt it to their local context. This chapter outlines which regions are suitable to use the Social Heating concept and how this vision can be adopted by them.

Exporting the Social Heating Model

Setting a systemic template

Our regional vision and strategy focus on addressing energy poverty in overlooked mid-sized regions, particularly within social housing. These areas, often outside the Randstad, present a unique opportunity for a scalable and context-sensitive energy transition. By targeting these regions, we aim to develop a replicable prototype that can serve as a systemic template for other parts of the country.

To identify potential Social Heating Association (SHA) units, we used two key variables: **cities with similar population densities**—suggesting comparable urban fabric and infrastructure—and those with a **higher proportion of social housing** stock. This dual-filtered approach allowed us to pinpoint cities that not only share spatial characteristics but also social urgency. These cities, when grouped according to their geographic proximity, can form new SHA units across the Netherlands. By doing so, we can tailor energy strategies that are both place-specific and easily transferable, ensuring an equitable and efficient transition. This model emphasizes the importance of systemic thinking—where spatial, social, and institutional dimensions align—laying the groundwork for a nationwide energy cooperative that is deeply rooted in local realities but guided by a shared, scalable framework.

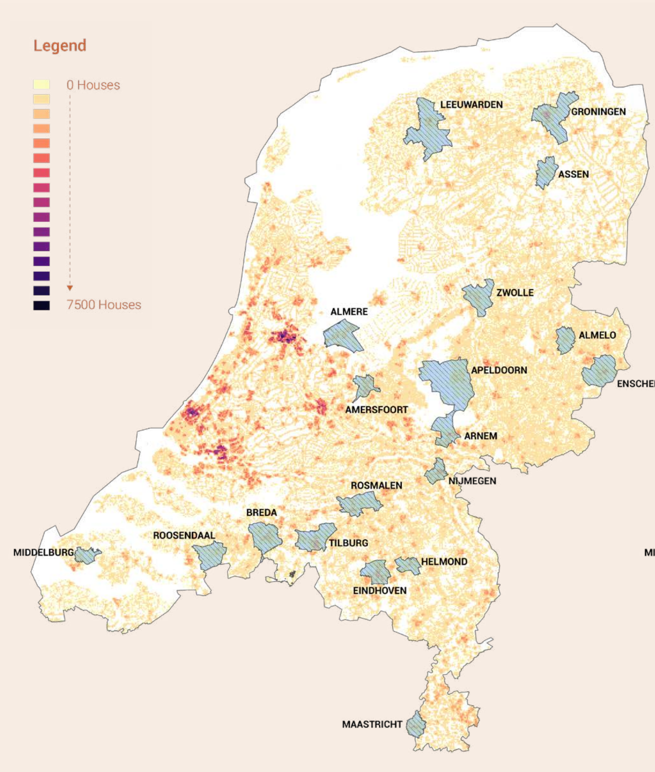


Figure 89: Population Density

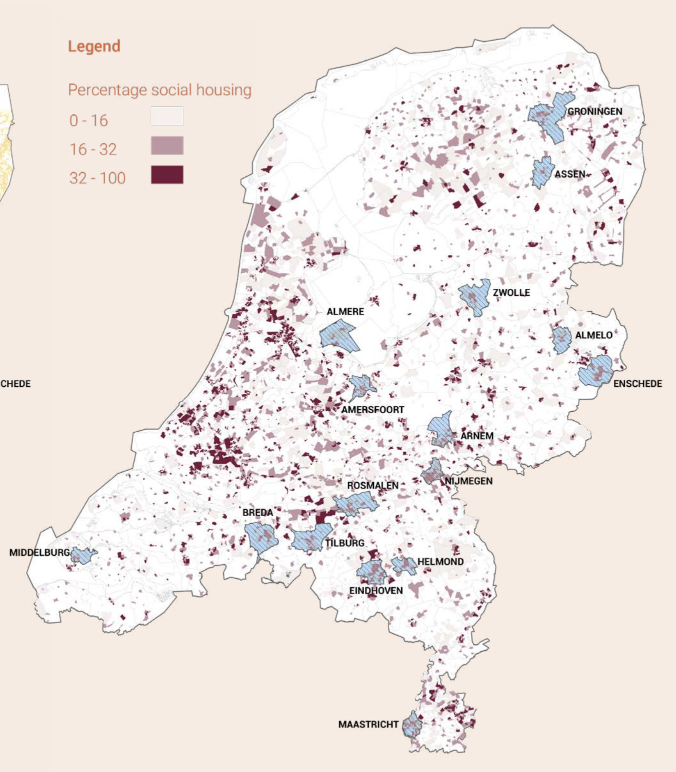
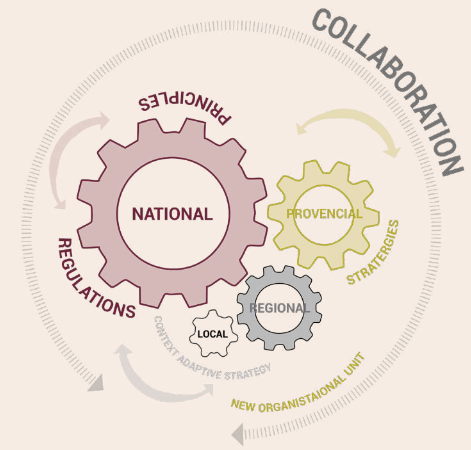


Figure 88: Amount of social housing



The energy cooperative operates as a multi-scalar system where each one plays a distinct yet interconnected role in shaping the energy transition. At the national level, broad principles and regulatory frameworks are established to provide consistency, clarity, and long-term vision.

These foundational guidelines are not necessarily strict directives but rather set the stage providing for dynamic interaction across regions and provinces. Moving to the provincial level, these principles are translated into strategic directions of the SHA that consider geographic, economic, and socio-political specificities, creating room for adaptation while staying aligned with larger goals. At the regional and local scales the SHA interprets these strategies contextually and develops localized solutions as per the potential sources of energy, available infrastructures and based on the need .

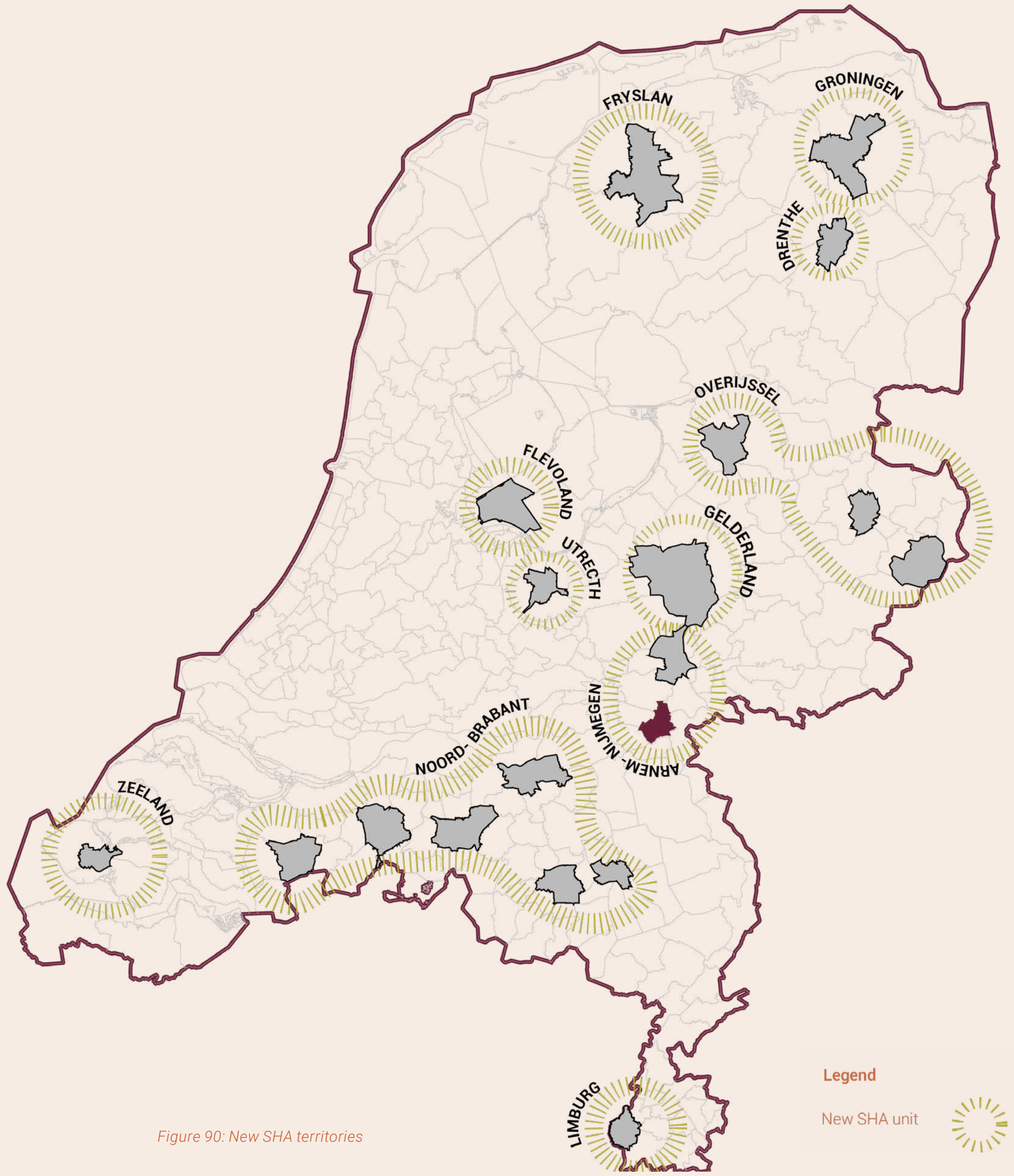


Figure 90: New SHA territories

Chapter 8

Reflections.

This chapter concludes our project by answering the research question. To position our work we used the SDG framework and we have reflected on our project in terms of ethical, societal and theoretical complementations and limitations. We finish the chapter with personal reflections on the course.

Conclusion

Answering our Research Questions

The social housing sector faces significant challenges in the context of the energy transition, including unstable energy systems, limited communication among stakeholders, and rising energy costs. These energy-related concerns are compounded by a persistent shortage of affordable housing and declining quality of life in many neighborhoods where social housing is concentrated. Our project responds to these complex issues through a comprehensive approach that integrates reform of energy production and distribution systems with morals of justice. A key component is the establishment of a new cooperative which is responsible for a non-market based approach.

The project aims to lower energy costs while ensuring greater public accountability. In combination within the framework of district heating expansion , the project also promotes targeted densification of social housing. This spatial strategy focuses on energy justice while addressing housing shortages. Simultaneously, the urban renewal is embedded in the process, like transforming streets during construction to improve safety, introduce more green spaces, and enhance overall livability. All of these factors break away the factors making certain regions "overlooked"- whilst trying to uplift them. The Arnhem-Nijmegen region possesses a diverse mix of renewable thermal energy sources that can be harnessed through a regional district heating network. Drawing from successful models from throughout the world through case studies, the project envisions a diversified, publicly owned, and operated system that ensures stable, affordable heat for residents.

The diversification of heat sources and the shift toward decentralized energy production have spatial implications. Unlike centralized systems that require vast, singular sites, decentralized systems distribute energy generation across neighborhoods and buildings, allowing renewable technologies to blend into urban fabric. In our project, with diversifying various renewable sources and spatial distribution, we reduce the pressure on infrastructure, increases resilience to the future scenarios and upcoming technologies. Our project accounts for the visibility, accessibility, and impact of energy infrastructure while encouraging synergies with public functions.

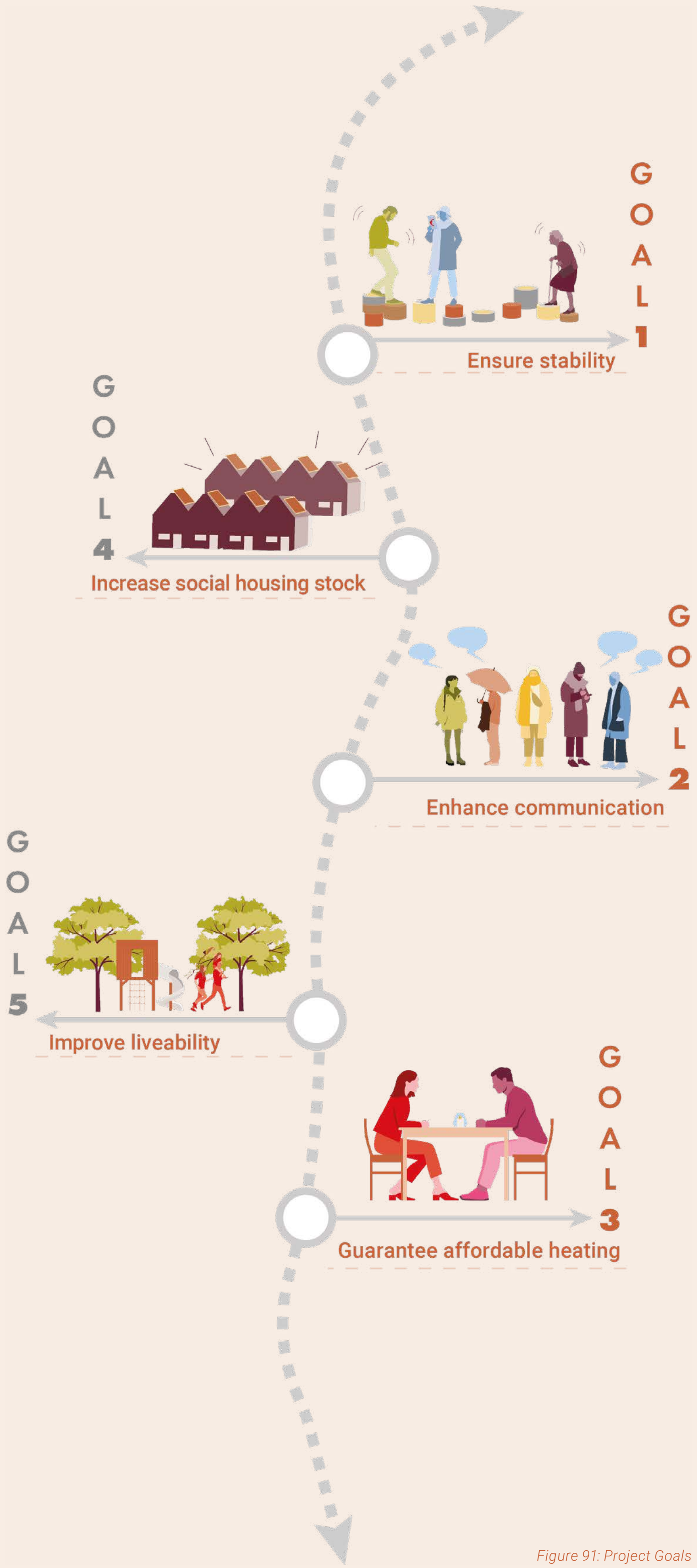


Figure 91: Project Goals

"How can we use the energy transition to alleviate energy poverty in social housing?"

Evaluating our work

UN Sustainable Development Goals

Evaluating our work in terms of the UN's Sustainable Development Goals ("SDGs"), we believe Social Heating can address goals one, three, seven, nine, ten, eleven, twelve, and thirteen.

Goal 1 No Poverty

Social Heating aims to eliminate at least one form of poverty, energy poverty, through the introduction of a non-profit, renewables-based district heating network which prioritises the community with the highest level of energy poverty: social housing residents.

Goal 3 Good Health and Well-being

Energy poverty has been shown to lead to negative social effects for residents, including health issues (Mulder et al., 2022). By working to eliminate energy poverty, Social Heating will also result in improved health and well-being for residents of our region, Arnhem-Nijmegen.

Goal 7 Affordable and Clean Energy

Affordable, clean energy is at the very core of this project. The main intervention, an expanded district heating paired with renewable thermal energy sources, is designed explicitly to provide affordable and clean energy to residents of Arnhem-Nijmegen.

Goal 9 Industry, Innovation, and Infrastructure

By introducing a very large new infrastructure project, the so-called social spine and connected district heating networks, Social Heating serves as an excellent opportunity to spur industrial and infrastructural innovation in the region.

Goal 10 Reduced Inequalities

Social Heating is aimed squarely at reducing inequality by alleviating energy poverty. Energy poverty is most concentrated among residents of social housing (Mulder et al., 2022), and therefore creates a kind of inter-community inequality. The more energy poverty is alleviated, the more the inequality is reduced.

Goal 11 Sustainable Cities and Communities

Sustainable cities and communities require energy supply that is both socially and environmentally sustainable. Social Heating does just that. By centring the most vulnerable group, social housing residents, and explicitly including renewable thermal energy sources in the proposed district heating network, Social Heating provides a more socially and environmentally sustainable alternative to the status quo.

Goal 12 Responsible Consumption and Production

By transitioning the region from a natural gas-based heating system to a renewables-based heating system, Social Heating serves to increase responsibility of energy consumption in Arnhem-Nijmegen.

Goal 13 Climate Action

Social Heating, by socialising and carbon-neutralising heating supply, constitutes a form of climate action. By reducing CO2 emissions in the residential heating sector, Social Heating helps Arnhem-Nijmegen do its part in the global fight to mitigate the worst effects of climate change.

Collective reflection

Critical Reflection on Social Heating

Social Heating constitutes a radical reimagination of the way homes are heated compared to the status quo in the Netherlands. Currently, heat is delivered as a market good, just the same as petrol, or jeans. Implicit in the vision and strategy presented in this report is a reclassification of heating as a public good. As a group, we feel strongly that this reclassification is justified. We believe that an adequately heated home is a basic human right, and no one should have to choose between warmth and financial security. By effectively socializing heat production and distribution, we aim to ensure everyone has access to affordable heating. These are the societal implications of our work. And what about the ethical implications? Though we have tried to be as honest as possible in lifting up the concerns of our community, social housing residents, we are limited by the method of our community analysis. Because we did not actually speak to any social housing residents, only to the renters' associations which represent them, it is possible that our vision may not accurately reflect their own. This raises some ethical concerns since we are presenting our work here with the social housing community, along with their concerns, hopes, and dreams as the centrepiece of the project. Theoretically speaking, we make use of three justice frameworks: procedural, distributive, and recognitional. Using this framework, we humanise this theory of justice and apply them to urbanism by addressing both potential opportunities and existing challenges. Ensuring that urban development is responsive to the needs of all communities and not a top-down design exercise.

In terms of content, we believe Social Heating sets forth a viable pathway to alleviating energy poverty in social housing through a re-envisioning of the residential heating system in Arnhem-Nijmegen. But we must also acknowledge the limitations to vision and strategy, as presented in this report. Because we have been tasked with all aspects of what would normally be a multi-disciplinary project, there are certain aspects of our project which have not been fully fleshed-out. Though we did conduct a policy analysis, it was not as thorough as we would have liked, and it is certainly possible that there are more relevant policies which we did not consider. We also did not have the opportunity to conduct a full financial analysis, with estimates of how much the full implementation of our vision would cost, and where exactly the money would come from. Because our project became quite technical, with our focus on an inherently technical system, residential heating, we frequently ran up against a lack of geotechnical/engineering expertise. For that reason, the technical aspects of our envisioned heating system have not been fully elaborated.

Group dynamics and Q3 reflection

Overall, we feel our group worked together quite well. We operated on a consensus basis, with no clear dictator, and any disagreements that did arise were settled through respectful discussion. We worked together in-person nearly every day and at the end of the quarter, we are all left with the sense that everyone genuinely cares about the project and the quality of our work. Apart from commitment to the work, one of our greatest assets as a team has been the complementarity of our individual strengths. Throughout the quarter, through the simple process of regular collaboration, we realized our comparative strengths, and found that they complemented each other quite well. Some of us were very efficient with mapmaking, others with graphic design, and others with research and writing. Of course, we all collaborated on everything, and spend countless hours refining our narrative, making small tweaks here and there, but when it came time to produce, we were able to delegate tasks very effectively.

Although our willingness to collaborate and discuss issues as they arose was a real asset in developing our narrative and strengthening our rationale, it also slowed us down at times. Throughout the quarter, we found it difficult to balance time between group discussion and individual production. This is something we all hope to be more mindful of in future group work to ensure there is an appropriate balance between the two. In terms of the work itself, the regional scale of this quarter was quite new to all of us, and pushed us out of our comfort zones, both in terms of research and design.

Regarding the organization and structure of the quarter as presented to us by the course coordinators; we thought the assignment was very interesting but noted a few aspects that we felt could benefit from future modification. The visit to the site was very early in the quarter. For an assignment that is so research heavy, it seemed impossible to develop a well-informed regional focus by the time we were expected to actually go and visit that region. For our team, this meant that we visited a region which did not end up being our focus for the project. The community-first design approach was a very interesting intellectual exercise for us, and we certainly learned from it. However, it did result in less time being available for other technical and policy analyses, and design. Further, we found that one inherent limitation of the approach is that in focusing so much on one community, other communities are, almost by necessity, often overlooked. We often wondered how fair it is to prioritise one community in a planning and design process. On the whole, though, we feel proud of our work, and most importantly, that we all learned a lot this quarter.

Personal reflections

Juliette Feldbrugge
5313473

In our project we explored how the concept of spatial justice can be used in regional design process for the energy transition. With a specific focus on the social housing community. Drawing on the theoretical framework of the Triangle of Spatial Justice (Rocco, 2023), our project addressed distributive, procedural, and recognitional justice within an often overlooked yet highly vulnerable group in the energy transition.

As social housing communities are widely dispersed across the region, it was sometimes difficult to define them spatially. Their challenges, such as energy poverty, are often addressed through fragmented policies like temporary financial support or building-level renovations. Our project aimed to go beyond these short-term fixes, consider the systemic causes of energy inequality and create an urbanist vison. From the SDS lecture series, we used the discussions on commons and the role of governance to discuss the question why heating is a commodified good in the first place. If access to a warm home is a basic human need, why is it treated as a market-driven luxury?

These reflections informed our vision: a regional strategy that treats heat as a collective right rather than an individual expense. However, aligning this justice-driven vision with broader stakeholder interests proved challenging. The SDS workshops emphasized the importance of understanding the hopes and dreams of communities in regional design. This vision guided our project with all the decisions we made. Yet, due to time constraints, we had limited engagement with other stakeholder groups beyond our selected community. As a result, while our project prioritized the needs of social housing residents, it risked sidelining other households, companies, or local actors, raising critical questions about procedural justice and representation.

This process highlighted the interdependence of spatial, social, and governance dimensions in regional design. A change in one layer, such as introducing new spatial pilot projects or creating a new energy cooperative can have effects on others. The SDS workshops and lectures made it clear that regional design is not only about spatial solutions, but also about negotiating values, power, and agency. In future projects I hope to bring this insight to create more interdisciplinary designs.

In summary, this project challenged me to think beyond traditional energy solutions and consider how design can address structural inequalities. By applying the lens of spatial justice and engaging with interdisciplinary insights from the SDS course, I developed a deeper understanding of how regional design can serve as a tool for systemic change. Designing for an energy community encourages thinking outside of the box and goes beyond the existing mindsets and policies. However in the process of doing this, we should not forget to design for all energy communities. Perhaps if we design for each community and bring those new ideas together, a design benefiting all communities can be established.

Drew Harris
5960797

Elaborating our team's vision of Social Heating throughout this quarter has been an enlightening, fulfilling, and humbling process. Collectively, we translated what was, at the beginning of the quarter, a strong justice orientation and a few disconnected ideas into, by the end of the quarter, a clear vision of an affordable, renewable energy future for the social housing community in Arnhem-Nijmegen. The process of sharpening our vision, narrative, and ultimately strategy was a very difficult task that required everyone's active participation. But in the end, I feel confident in the work we produced as a team. Now that we have spent a few months deep in the intellectual trenches of vision and strategy making, it is worth considering – what is the role of a vision in planning processes, and how does it inform or affect the strategy?

In the quarter guide for this course, a spatial vision is defined as a "desirable spatial future" and "guiding normative principle for the development strategy". For our vision, Social Heating, this definition generally holds true. The vision certainly constitutes a desirable spatial future, a future in which affordable, renewable heat is delivered to all across the whole of the Arnhem-Nijmegen region. And indeed, the vision did serve as a guiding normative principle for our development strategy; all spatial and policy interventions proposed as part of the strategy were designed to make our vision real, whether spatially or organisationally. This is fairly straightforward. What is perhaps more interesting, for the structure of this course in particular, is the question of who the vision belongs to?

From the beginning of this quarter, and in a completely new approach for this studio, we were tasked with forming a vision from the perspective of an identified energy transition community. Not to form a vision for a specific community, but actually to design from their perspective. The challenge, for a group of first year master's students with ten weeks to complete the entire project, is how to acquire a deep enough understanding of the identified community such that our vision is an honest reflection of their perspective on the energy transition. Ideally, this would be done through a combination of news media analysis, literature review, and most importantly lots of interviews with real people in the community. If the vision is to belong to the identified community, these steps are crucial. The lack of time for a thorough (or for any) community interviewing process is an obvious limitation of the community-first visioning in this course. In that sense, I am unsure who our vision, Social Heating, really belongs to. We did perform a media analysis, but what we found in the media analysis conflicted in some ways with what we learned from interviews with renters' associations – more investigation through outreach was required to arrive at a complete understanding of the community. Further, the entire vision making process was performed without any members of our community, social housing residents, present. It is my opinion that for a vision to be made from a community's perspective, members of the community should be present. That said, it was still a tremendous learning process and academic exercise to take such a specific and bottom-up approach to vision making.

Whatever we envision as planners, no matter the scale, topic, or scope of work, is a vision for real people. We may think we know how to create a desirable future, but we cannot know unless we engage with the people who will actually inhabit the future we envision. This is the lesson I take from this quarter – one of humility. As planners, designers, urbanists, it is our duty to do everything we can to really understand the concerns, hopes, and dreams of the communities we design for. That much is a good start.

Personal reflections

Xavier Kioe-A-Sen
5443997

In the beginning of this course, our group struggled to find a topic and community to focus on. This was mainly because nobody had ever done a project on the regional scale. There is so much that comes with this scale, you have to think about everything you've been taught and even more.

The importance of having a vision got brought to light to me in AR2U086. After establishing our vision, we could make concrete elaborations on the project. Having a vision is not only important for the people working on it. It's also important for all the sectors and stakeholders that are affected by the project. The vision is a great source of information to get a grip on the matter. With such a big scale as the regional scale, organisation and coordination are both important. In practise, these are two of the biggest challenges. Different sectors focus on their own specialization and are managed separately. A well-developed, inclusive vision that connects these sectors and shows how they can function together is an important first step toward successful project.

Another important factor in shaping a vision is the community that is focused on. Some will argue that focusing on a transition community will help with making a concrete and well-developed vision. The danger with this is that, in my view, transition communities mostly will consist of progressive people (left). They would accept why making changes in their lifestyle would benefit the energy transition for example. The group of people who would be against these changes will most likely be more conservative (right). They would not change their behaviour or would not accept massive changes in their lifestyle that the energy transition needs. I think that different interventions attracts different (political) ideologies. Some design interventions are the dream of one community, but the nightmare for another community.

In my opinion, picking a specific community to design for won't work in practise. Although it would help the design process to be more efficient, focused and probably more drastic, there would be a large amount of people against the proposal. Humans do not accept drastic interferences that changes their lifestyle, in their perception negatively, easily.

This is why understanding the hopes and dreams from, not just one, but multiple communities in the design area is crucial to me. This understanding could be achieved by implementing communicative planning. Communicative planning is a way of planning that puts the emphasis on the engagement of stakeholders/communities in the decision-making process. This is done by having clear communication and letting every stakeholder/community participate in the design process. In this way, there will be more procedural justice. And because all stakeholders/communities have an active role in the design process, distributive justice can also be achieved more easily.

The topics discussed in this reflection are the elements that stood out the most to me when looking back on AR2U086. In particular, I was struck by how deeply we had to understand the communities we were designing for. This was something I had never done in such depth before. Gaining a comprehensive understanding of the hopes, dreams and concerns of affected communities is something I will definitely carry into future design projects.

Additionally, I now fully recognize the value of having a clear and well-developed vision as basis for any project. It provides a solid foundation that makes later stages of design much more easy and effective to elaborate.

Fleur Kool
6101143

Creating a regional strategy requires a collaboration of many different aspects. This being working together in a group as well as going through the many stages involved in the design process. One of these stages is arguably the most important one as it is the division between ideation and strategy. This is of course the vision of the project. A way to communicate the ideas and preferred outcomes with an audience. This vision that is created will be further explored with additional research, analysis and design. It leaves room for feedback and growth as not everything is finalised.

In our project the creation of the vision shaped our project and had great influence on the strategy, as is the case in every project. The idea we started with at the beginning of the quarter shifted from the consumption narrative to a production narrative. This change in narrative gave us a different perspective of showing the ideas that we had and created a stronger argument for what we had envisioned. The Social Spine.

The idea of a heating network developed first in neighbourhoods where the residents experience more energy poverty is a change to the existing policies written by the municipalities as they focus mostly on dense areas.

While our community is more specific opposed to the general community who are most often the main focus, designing for a transition community helps keep a clear understanding of the hopes and dreams. Sure strategy might not benefit everybody involved equally it will ensure a more equitable approach.

In order to design for a transition community research needs to be done in the community. These can be done through research, media analysis or surveys. Out of these most beneficial are the in person surveys as those are done directly with the members of the community themselves. These answers will provide a personal insight of the region and the situation that the community is in. Because these answers are very personal, more interviews are required to have a better insight in the community as a whole.

Together with surveys media-analysis are a great way to gather information about the community. It needs to be added that the news articles written about the subject are mostly extreme cases.

Because of the small time frame that we had to create the project we mostly used media analysis as our way to gather the homes and dreams of the community. Our community, which we picked out specifically for being overlooked, did not have too many articles about their situation. The articles, however, did confirm our suspicion of them being left behind in the discussion of the new heating system.

Starting my master with a regional design strategy was a very interesting insight into urbanism. It gave me a better understanding about the values of urban planning and especially doing it from the perspective of a community. It was very helpful to work in a group while adjusting to work at a completely different scale.

Personal reflections

Jaee Naik
6240909

The last eight months have been a steep learning curve for me, but this quarter has undoubtedly been the most transformative leg of my journey so far. I had been anticipating this project since I first learnt about it, and it indeed was one of the core reasons I chose to transition from architecture to urbanism. This project allowed me to align my principles, values and concerns into a tangible regional design project.

This project has definitely shaped my growing interest in the urban scale with an opportunity to engage with systemic issues and design for society at large. Besides, studying urbanism in the Netherlands comes with me getting in terms with the shift of the urban 'concerns'- where back in India energy transition is not a conversation on the table yet. Working in this scenario where energy transition is a goal which seems quite achievable, was an exciting and utopian working ground for me. Not to mention, learning from Dutch architecture and urban design, that demonstrates a higher degree of basic societal dignity and wellness.

A key moment in this quarter was understanding the role of **vision as a compass** to guide regional design. It became clear to me early on that our approach had to go beyond technical or bureaucratic framings of the energy transition. This value-based approach was the basis of our group with amazing like-minded people coming together, with a shared vision that prioritized socially embedded transition solutions. Our common vision helped us reconcile short-term infrastructural feasibility with long-term community resilience and participatory governance. The group work intensive studio was exhausting but a deeply enriching experience. Working across cultures and ideologies didn't just improve our vision, it broadened my own perspective.

The second key moment in my journey this quarter was definitely the understanding of different complexities which come with this **regional scale**, a skillset which I lacked in my academic and professional career before this. While our project focused on social housing communities, understanding the broader institutional and other power-interest dynamics and solving the various variables required to draw the vision was eye-opening. It made me realize that visioning at this scale is not simply about grand visions, but about navigating conflicting interests and integrating bottom-up strategies. Community-centered design, while embedded in European (especially Dutch) planning culture, was also a new enriching lesson for me. Additionally, drawing learnings through lectures, case studies, and team discussions helped me grasp the nuance, which has further reinforced my interest in urbanism which allows for regional design in a capacity to adopt **integrative frameworks** that bridge institutional and neighborhood levels. A strong framework is the foundation which can be retrofitted with various strategies to fulfill a particular vision!

The final and perhaps most important realization this quarter was about the **importance of making space for community voices**. Regional design, by nature, risks becoming abstract and detached from reality. For example- certain vulnerable communities may not dream of being carbon-neutral citizens; their more immediate concerns—like control over energy costs or reliable heating—must be understood within their lived realities. It is the urbanists job to read in between the lines of assumptions, media bias, and lopsided data to consider the 'overlooked'. This calls for **humility and care** in design.

This experience has sharpened my interests as I move a step closer to my graduation project and, eventually, back into practice, with renewed clarity and many new questions to explore.

Chapter 9

References.

References

Figure

All figures used are made by the team unless stated otherwise

References

Chapter 1: Introduction

Erbach, G., Noor Dewulf, & EPRS. (2024). Roadmap to EU climate neutrality – Scrutiny of Member States (Report PE 767.176). https://www.europarl.europa.eu/RegData/etudes/BRIE/2024/767176/EPRS_BRI(2024)767176_EN.pdf

Jenkins, K., McCauley, D., Heffron, R., Stephan, H., & Rehner, R. (2016). Energy justice: A conceptual review. In University of St Andrews, Queen Mary University of London, & University of Stirling, Energy Research & Social Science (Vol. 11, pp. 174–182). http://dx.doi.org/10.1016/j.erss.2015.10.004

Neumann, A., European Climate Pact Photo Competition / European Union, European Commission, & Pollard, V. (2024). Progress Report 2024. In Climate Action.

Tielbeke, J. (2020, June 24). De mythe van de groene consument. De Groene Amsterdammer. https://www.groene.nl/artikel/de-mythe-van-de-groene-consument

Wetten.nl - Regeling - Klimaatwet - BWBR0042394. (2023, July 22). https://wetten.overheid.nl/BWBR0042394/2023-07-22

Chapter 2: problem statement

Centraal Bureau voor de Statistiek. (2025, March 26). Kerncijfers wijken en buurten 2024. Centraal Bureau Voor De Statistiek. https://www.cbs.nl/nl-nl/maatwerk/2025/13/kerncijfers-wijken-en-buurten-2024

Dashboard - Bouwen en wonen - Aa en Hunze. (n.d.). https://www.waarstaatjegemeente.nl/mosaic/dashboard/bouwen-en-wonen

Dutch National Programme Regional Energy Strategies - Regionale Energiestrategie. (n.d.). Regionale Energiestrategie. https://www.regionale-energiestrategie.nl/english/default.aspx

Energy poverty. (n.d.). Energy. https://energy.ec.europa.eu/topics/markets-and-consumers/energy-consumers-and-prosumers/energy-poverty_en

HSPN. (n.d.). thome. https://hspn.nl/

Ministerie van Binnenlandse Zaken en Koninkrijksrelaties. (2024, November 14). Rented housing. Housing | Government.nl. https://www.government.nl/topics/housing/rented-housing

Mulder, P., Longa, F. D., & Straver, K. (2022). Energy poverty in the Netherlands at the national and local level: A multi-dimensional spatial analysis. Energy Research & Social Science, 96, 102892. https://doi.org/10.1016/j.erss.2022.102892

Van Deursen, H. (2023). The People's Housing: Woningcorporaties and the Dutch Social Housing System Part 1: The History(By Joint Center for Housing Studies).

Wetten.nl - Regeling - Klimaatwet - BWBR0042394. (2023, July 22). https://wetten.overheid.nl/BWBR0042394/2023-07-22

Chapter 3: approach

Assai, H. (2014). Charles Taylor_The Politics of Recognition. Ufma. https://www.academia.edu/6612669/Charles_Taylor_The_Politics_of_Recognition

Dutch News. (2024, January 19). Households not leaving gas network can expect significantly higher bills from 2030. https://www.dutchnews.nl/2024/01/households-not-leaving-gas-network-can-expect-significantly-higher-bills-from-2030/

Fraser, N. (1995). From Redistribution to Recognition? Dilemmas of Justice in a "Post-Socialist" Age. New Left Review, 212, 68-93.

Rawls, J. (1971). A theory of justice. Belknap Press/Harvard University Press.

Bal, M., Bryson, J. R., & Van Loon, J. (2021). Social Housing and the Energy Transition: Barriers, Challenges, and the Role of Governance. Energy Policy, 156, 112345.

Rocco, R. (2025, April 4). Spatial justice. CENTRE FOR THE JUST CITY. https://just-city.org/team/spatial-justice/

Taylor, C. (1994). The Politics of Recognition. In A. Gutmann (Ed.), Multiculturalism: Examining the Politics of Recognition (pp. 25-74). Princeton University Press.

Chapter 4: Analysis

aquathermal-energy | AquaCOM. (z.d.). AquaCOM. https://aquacom.nweurope.eu/aquathermal-energy

Andersen, A. N., Aalborg University, & EMD International. (2023). RESILIENT AND SUSTAINABLE DISTRICT HEATING USING MULTIPLE HEAT SOURCES. In HOTCOOL: Vol. no. 2. https://www.emd-international.com/wp-content/uploads/2023/03/HotCool-2023-3-Resilient-and-sustainable-DH-using-multiple-heat-sources.pdf

CE Delft, Pien van Berkel, & European Climate Foundation. (2020). Zero Carbon Buildings 2050. In Katja Kruit, Joeri Vendrik, Fenneke van der Poll, Frans Rooijers, Quentin Jossen, Hugues de Meulemeester, Renée Bruel, Stijn Carton, Adeline Rochet, Ting Zhang, Pallas Agterberg, Meredith Annex, Antoni Bielewicz, Femke de Jong, Erica Hope, Clemence Hutin, Alexandra Langenheld, Paola Mazzucchelli, Thomas Pellerin-Carlin, . . . Peter Sweatman, CE Delft. https://cedelft.eu/wp-content/uploads/sites/2/2021/03/CE_Delft_190376_Zero_carbon_buildings_2050_Def.pdf

Centraal Bureau voor de Statistiek. (2023, augustus, 30). Verdere afname winbare aardgasreserves. Centraal Bureau Voor De Statistiek. https://www.cbs.nl/nl-nl/nieuws/2023/35/verdere-afname-winbare-aardgasreserves

de Bondt, H., Van Middelkoop, M., & Mangnus, M. (2024, 14 februari). 4. Verschillen tussen huishoudens. Centraal Bureau Voor de Statistiek. https://www.cbs.nl/nl-nl/longread/diversen/2024/de-energierekening-januari-2024/4-verschillen-tussen-huishoudens?

EBN B.V. (2023, 13 juli). Potentieonderzoek geothermie Gelderland - EBN. EBN. https://www.ebn.nl/feiten-en-cijfers/kennisbank/potentieonderzoek-geothermie-gelderland/

EMD International. (2024, October 2). Resilient district heating using multiple heat sources [Press release]. https://stateofgreen.com/en/solutions/resilient-district-heating-using-multiple-heat-sources/

Energy.nl. (2024, 6 november). Aquathermal - Energy.nl. https://energy.nl/data/aquathermal/

European Climate Foundation, Milieudefensie, & CE Delft. (2021). Energiearmoede in de warmtetransitie (By P. Van Berkel, K. Kruit, & J. Dehens) [Report]. https://ce.nl/wp-content/uploads/2021/12/CE_Delft_200304_Energiearmoede_in_de_warmtetransitie_DEF.pdf

European Climate Law. (n.d.). Climate Action. https://climate.ec.europa.eu/eu-action/european-climate-law_en

Gemeente Nijmegen & Royal HaskoningDHV. (2024). Warmtevisie Nijmegen 2024 [Report]. https://nijmegen.nl/aardgasvrij

Gemeente Arnhem. (2021). Transitievisie Warmte gemeente Arnhem. In Arnhemspeil. https://arnhemspeil.nl/docs/2021-11-09-gemeente-arnhem-transitievisie-warmte.pdf

Geothermal energy. (z.d.). Energy. https://energy.ec.europa.eu/topics/renewable-energy/geothermal-energy_en

Hermans, F. (2018, may 29). Zorgen over gasloos wonen. De Gelderlander. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a5SF4-6131-DYRY-X233-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

How existing homes are given energy label A++++ | TNO. (n.d.). tno.nl/en. https://www.tno.nl/en/newsroom/insights/2022/12/existing-homes-energy-label-a

Huibers, S. (21, februari 2025). Dranghekken bij open huis voor huurappartementen: 'Wonen is een luxeproduct geworden'. De Gelderlander. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a6F5T-C683-RSXP-92Y5-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

Industrial residual heat | Energy Transition Model. (z.d.). https://docs.energytransitionmodel.com/main/residual-heat-industry/

Juncker, J.-C., Arias Cañete, M., & European Commission. (2018). Going CLIMATE-NEUTRAL by 2050: A STRATEGIC LONG-TERM VISION FOR a PROSPEROUS, MODERN, COMPETITIVE AND CLIMATE-NEUTRAL EU ECONOMY.

Kleiwegt, E., & De Coo, W. (2018). Handreiking aquathermie: hoe gaan we verder met TEO en TEA? In STOWA. Stichting Toegepast Onderzoek Waterbeheer. Geraadpleegd op 30 maart 2025, van https://www.stowa.nl/sites/default/files/assets/PUBLICATIES/Publicaties%202018/STOWA%202018-47%20handreiking%20aquathermie.pdf

Nijmegen Aardgasvrij. (2025, 22 januari). Nijmegen aardgasvrij. https://aardgasvrij.nijmegen.nl/

Solar thermal energy: what it is and its benefits. (2024, 22 may). REPSOL. https://www.repsol.com/en/energy-and-the-future/future-of-the-world/solar-thermal-energy/index.cshtml

Tilia, TU Wien, IREES, Öko-Institut, & Fraunhofer ISI. (2022). Overview of District Heating and Cooling Markets and Regulatory Frameworks under the Revised Renewable Energy Directive. In European Commission (Report ENER/C1/2018-496; First edition). European Commission. https://doi.org/10.2833/96390 (Original work published 2021)

van der Burgh R., Kuijpers, K., van der Pol, L., Obbink, H. (2021, november 24). Arme wijken wachten langst op dubbel glas. Trouw. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a6451-07R1-DYRY-X4FS-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

Van Gessel-Dabekaussen, G. (2018). Het industriële landschap van Nederland. CBS. Geraadpleegd op 5 april 2025, van https://www.cbs.nl/-/media/_pdf/2018/31/2018ep33-industriele-landschap.pdf

Vestigingsklimaat - Gaaf Gelderland. (z.d.). https://provincie.gelderland.nl/gaaf-gelderland/vestigingsklimaat

Meer landschap meer stad Groene Metropool Arnhem Nijmegen Foodvalley 2040. (2023).

Ministerie van Algemene Zaken. (2025, februari 21). Overstap naar duurzame warmtebronnen. Duurzame Energie | Rijksoverheid.nl. https://www.rijksoverheid.nl/onderwerpen/duurzame-energie/duurzame-warmtebronnen

Ministerie van Sociale Zaken en Werkgelegenheid. (2025, February 14). Groen licht voor energiefonds in 2025. Nieuwsbericht | Rijksoverheid.nl. https://www.rijksoverheid.nl/actueel/nieuws/2025/02/14/groen-licht-voor-energiefonds-in-2025/

van der Meulen, D., foto ANP KOEN VAN WEEL. (2024, december 21). Afgehaakt Nederland. Leeuwarder Courant. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a6DPG-STS3-RT4C-R1F7-00000-00&context=1519360&identityprofileid=Q6FFCK68393

Opgavebeschrijvingen Verstedelijkingsstrategie Onderzoeksagenda voor gebiedsuitwerkingen. (2023). [Report].

Reith, M. (2023, 3 april). Zo ernstig staat het er écht voor met de sociale huur: Jasper laat zien wat Entree verborgen houdt. De Gelderlander. https://www.gelderlander.nl/nijmegen/zo-ernstig-staat-het-er-echt-voor-met-de-sociale-huur-jasper-laat-zien-wat-entree-verborgen-houdt~a3eeadbc/

References

Regionale Energie Strategie Arnhem - Nijmegen 2024 - Verrijking RES 1.0. (2024). In M. Bos, Regionale Energie Strategie Arnhem - Nijmegen 2024 - Verrijking RES 1.0. https://raad.renkum.nl/Vergaderingen/Raadscommissie/2025/15-januari/20:00/RES-2024/Bijlage-1-Regionale-Energiestrategie-Arnhem-Nijmegen-2024-verrijking-RES-1-0-RES-2024-1.pdf

Smid, M. (2024, november 22). Brief over warmtenet, dag later beginnen werkzaamheden. De Gelderlander. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a6DG9-8371-JC8X-628H-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

Suijkerbuijk, M. (2024, april 10). Ophef om 'dreigende' brief Talis. De Gelderlander. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a6BS3-P311-JC8X-60H4-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

Suijkerbuijk, M. (2024, april 30). Woede om energievoorschotten. De Gelderlander. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a6BXC-3MR1-DYRY-X2MT-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

Suijkerbuijk, M. (2024, july 2). Noodoplossing na torenhoge energiekosten: Nijmegen betaalt rekeningen van honderden huurders. De Gelderlander.nl. https://advance-lexis-com.tudelft.idm.oclc.org/api/document?collection=news&id=urn%3acontentItem%3a6CCW-CDJ1-DY0X-92KJ-00000-00&context=1519360&identityprofileid=Q6FFCK68393

Suijkerbuijk, M. (2024, october 25). Komt het goed met aanpak verpaupering?. De Gelderlander. https://advance.lexis.com/api/document?collection=news&id=urn%3acontentItem%3a6D89-X9G1-DYRY-X55R-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

Suijkerbuijk, M. (2024, november 7). 'Onredelijk hoe Talis dit heeft gedaan'. De Gelderlander. https://advance-lexis-com.tudelft.idm.oclc.org/api/document?collection=news&id=urn%3acontentItem%3a6DC3-PCD1-DYRY-X0NB-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

Suijkerbuijk, M. (2025, february 8). Op het warmtenet is veel kritiek, wethouder gelooft er helemaal in: 'Inwoner kan nooit de dupe worden'. De Gelderlander.nl. https://advance-lexis-com.tudelft.idm.oclc.org/api/document?collection=news&id=urn%3acontentItem%3a6F30-0633-RW57-X2N1-00000-00&context=1519360&identityprofileid=Q6FFCK68393.

The European Green Deal. (2021, July 14). European Commission. https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_en

Tweede Kamer der Staten-Generaal. (2025). Verduurzaming gebouwde omgeving.

Wijkgerichte energietransitie - Gemeente Arnhem. (2025, March 28). Gemeente Arnhem. https://www.arnhem.nl/alle-onderwerpen/duurzame-energie/wijkgerichte-energietransitie/

Voermans, T. (2025, 13 februari). Gasprijs voor consument naar recordhoogte: boven oude prijsplafond. De Stentor. Geraadpleegd op 4 april 2025, van https://www.destentor.nl/home/gasprijs-voor-consument-naar-recordhoogte-boven-oude-prijsplafond~a7577114/?referrer=https%3A%2F%2Fwww.google.com%2F

Warmteatlas. (z.d.). Warmteatlas. https://www.warmteatlas.nl/viewer/app/Warmteatlas/v2?debug=false

WarmtelinQ. (n.d.). Over WarmtelinQ - Waarom leggen we de leiding aan? https://www.warmtelinq.nl/over-warmtelinq

Wolting, H. (2021, augustus 3). Waar komt ons aardgas eigenlijk vandaan? Gasunie. https://www.gasunie.nl/gasinfrastructuur/blog-247-energie/waar-komt-ons-aardgas-eigenlijk-vandaan?

Chapter 6: Strategy and phasing

Acm. (2025, 27 maart). Tarieven warmte en koude. ACM.nl. https://www.acm.nl/nl/energie/warmte-en-koude/warmtetarieven/tarieven-warmte-en-koude

Actie Programma Netcongestie. (2025, 24 maart). Voortgangsrapportage. actieprogrammanetcongestie.nl. https://actieprogrammanetcongestie.nl/voortgangsrapportage-2/

CE Delft. (2021, 12 april). Nationaal potentieel van aquathermie - CE Delft. https://ce.nl/publicaties/nationaal-potentieel-van-aquathermie/

CE Delft. (2025, 7 februari). Restwarmte, de stand van zaken - CE Delft. https://ce.nl/publicaties/restwarmte-de-stand-van-zaken/

European Commision. (z.d.), from https://ec.europa.eu/regional_policy/funding/erdf_en

Flóvenz, O. (z.d.). Phases of geothermal development. ísor. Geraadpleegd op 30 maart 2025, van https://www.esmap.org/sites/default/files/esmap-files/Flovenz%20Day%201%20-WB-2-phases-final.pdf

Fonds ONB voor Architectuur en Bouwkunst - het Cultuurfonds. (z.d.). Cultuurfonds. https://www.cultuurfonds.nl/fondsen/fonds-voor-architectuur-en-bouwkunst

Gemeente Arnhem. (2019). Visie nieuwe haven. https://www.arnhemspeil.nl/docs/2019-12-03-gemeente-arnhem-definitieve-versie-visie-op-de-nieuwehaven.pdf

Gemeente Nijmegen. (2019). Document Nijmegen - Economische Visie 2020-2025 #KansvoorNijmegen. https://nijmegen.bestuurlijkeinformatie.nl/Agenda/Document/ed8ab0da-142a-4e79-94aa-d8c40f34ce69?documentId=b4a18053-4818-4381-a772-31900aa603cd&agendaItemId=1457e12d-44ef-4ea1-8e3a-42c41fd846d6

Gemeente Nijmegen & Royal HaskoningDHV. (2024). Warmtevisie Nijmegen 2024 [Report]. https://nijmegen.nl/aardgasvrij

Gemeente Arnhem. (2021). Transitievisie Warmte gemeente Arnhem. In Arnhemspeil. https://arnhemspeil.nl/docs/2021-11-09-gemeente-arnhem-transitievisie-warmte.pdf

Jongerius, J., Cuypers, R., & TNO Public. (2024). Innovatieroadmap warmteopslag voor de gebouwde omgeving in Nederland. In TNO Public (Vols. 3–82) [Report]. TNO Public. https://topsectorenergie.nl/documents/1314/TNO_Innovatieroadmap_warmteopslag_voor_de_gebouwde_omgeving_in_Nederland_v241007_final.pdf#page=29&zoom=100,152,144

Horizon Europe. (2025, 20 maart). Research And Innovation. https://research-and-innovation.ec.europa.eu/funding/funding-opportunities/funding-programmes-and-open-calls/horizon-europe_en

Ministerie van Algemene Zaken. (2025b, maart 4). Plan kabinet: meer huizen en gebouwen aansluiten op collectieve warmte. Rijksoverheid.nl. https://www.rijksoverheid.nl/onderwerpen/energie-thuis/plan-kabinet-meer-huizen-en-gebouwen-aansluiten-op-collectieve-warmte

Investeringssubsidie duurzame energie en energiebesparing (ISDE). (n.d.). RVO.nl. https://www.rvo.nl/subsidies-financiering/isde

InvestEU programme. (z.d.). InvestEU. https://investeu.europa.eu/investeu-programme_en

Lokale hernieuwbare energieprojecten. (z.d.). Provincie Gelderland. https://www.gelderland.nl/subsidies/lokale-hernieuwbare-energieprojecten

Ministerie van Economische Zaken en Klimaat. (2022, 25 oktober). Beleidsbijlage Overzicht en toelichting van beleid voor het omgaan met fysieke risico's en onzekerheden bij geothermie. Rapport | Rijksoverheid.nl. https://www.rijksoverheid.nl/documenten/rapporten/2022/10/20/beleidsbijlage-overzicht-en-toelichting-van-beleid-voor-het-omgaan-met-fysieke-risicos-en-onzekerheden-bij-geothermie

Publications Office of the European Union. (2024). Social housing and beyond : operational toolkit on the use of EU funds for investments in social housing and associated services.

Publications Office Of The EU. https://op.europa.eu/en/publication-detail/-/publication/042f7559-fd3f-11ee-a251-01aa75ed71a1/language-en

Publications Office of the European Union. (2022b). District heating and cooling in the European Union : overview of markets and regulatory frameworks under the revised

Regeling nationale EZK- en LNV-subsidies. (2025, 1 januari). www.wetten.overheid.nl. https://wetten.overheid.nl/BWBR0035474/2025-01-01

Planbureau voor de Leefomgeving. (2023, 13 juni). Overzicht transitievisies warmte.

Planbureau Voor de Leefomgeving. https://www.pbl.nl/publicaties/overzicht-transitievisies-warmte

Recovery and Resilience Facility. (2021, 12 februari). European Commission. https://commission.europa.eu/business-economy-euro/economic-recovery/recovery-and-resilience-facility_en

Regionale Energie Strategie Arnhem - Nijmegen 2024 - Verrijking RES 1.0. (2024). In M. Bos, Regionale Energie Strategie Arnhem - Nijmegen 2024 - Verrijking RES 1.0. https://raad.renkum.nl/Vergaderingen/Raadscommissie/2025/15-januari/20:00/RES-2024/Bijlage-1-Regionale-Energiestrategie-Arnhem-Nijmegen-2024-verrijking-RES-1-0-RES-2024-1.pdf

Renewable Energy Directive. Publications Office Of The EU. https://op.europa.eu/en/publication-detail/-/publication/4e28b0c8-eac1-11ec-a534-01aa75ed71a1/language-en

Social Climate Fund. (z.d.). Climate Action. https://climate.ec.europa.eu/eu-action/eu-emissions-trading-system-eu-ets/social-climate-fund_en

Stimulering duurzame energieproductie en klimaattransitie (SDE++). (z.d.). RVO.nl. https://www.rvo.nl/subsidies-financiering/sde

Toekomstbestendige bedrijventerreinen – Realisatie fysieke maatregelen. (z.d.). Provincie Gelderland. https://www.gelderland.nl/subsidies/toekomstbestendige-bedrijventerreinen

Warmtenetten Investeringssubsidie (WIS). (z.d.). RVO.nl. https://www.rvo.nl/subsidies-financiering/wis

Warmtewet. (2025, 1 januari). wetten.overheid.nl. https://wetten.overheid.nl/BWBR0033729/2025-01-01/0#Hoofdstuk2_Paragraaf2.1_Artikel5

Wet collectieve warmte (Wcw). (2025, March 5). Nationaal Programma Lokale Warmtetransitie. https://www.nplw.nl/wet-en-regelgeving/wet-collectieve-warmte-wcw

Wetten.nl - Regeling - Beleidsregeling subsidies budget investeringen ruimtelijke kwaliteit - BWBR0014631. (2008, 1 juli). https://wetten.overheid.nl/BWBR0014631/2008-07-01

Woningbouwimpuls (WBI). (z.d.). RVO.nl. https://www.rvo.nl/subsidies-financiering/woningbouwimpuls

Chapter 7: The future of social housing

Chapter 8: Reflections

Rocco, R. (2023). What's Spatial Justice. Centre for the Just City. https://just-city.org/about/spatial-justice/

Mulder, P., Longa, F. D., & Straver, K. (2022). Energy poverty in the Netherlands at the national and local level: A multi-dimensional spatial analysis. Energy Research & Social Science, 96, 102892. https://doi.org/10.1016/j.erss.2022.102892

References

Datasets

ArcGIS Gasuni - https://www.arcgis.com/home/item.html?id=1df1d043d70e43989f0715343181e5d5

ArcGIS Gelderland - https://geoportaal.gelderland.nl/portaal/apps/webappviewer/index.html

ArcGIS warmteatlas Gelderland - https://www.arcgis.com/apps/instant/filtergallery/index.html?appid=4d1f90bdf1bc47d08760442789327e3f

ArcGIS Tenet - https://www.arcgis.com/home/item.html?id=02d4cfaf2a9241b68f9520748081d7e9

Data portal Gelderland - https://opendata.gelderland.nl/catalogue/srv/dut/catalog.search#/home

Klimaatmonitor - https://klimaatmonitor.databank.nl/jive

Klimaateffectatlas - https://www.klimaateffectatlas.nl/nl/

Opendata Nijmegen - https://opendata.nijmegen.nl/

Pdok - https://www.pdok.nl/

TU Delft given geopackage dataset 2025 - https://surfdrive.surf.nl/files/index.php/s/cGOnPkx5yWZrQ5h

Warmteatlas. (z.d.). Warmteatlas. https://www.warmteatlas.nl/viewer/app/Warmteatlas/v2?debug=false

Wijk- en buurtkaart - https://www.cbs.nl/nl-nl/dossier/nederland-regionaal/geografische-data/wijk-en-buurtkaart-2024

AI as tool for spelling checks and to come up with wordplays for titles

ChatGPT - https://chatgpt.com/

Notebooklm - https://notebooklm.google/

Chapter 10

Appendix.

Appendix

Interview housing corporation Talis - part 1

1 You are a tenants' association and the interests of the tenants come first. How is the contact between you and the tenants?

"Yes, it depends a bit on the issues. Right now, we are extremely busy because there are some very essential matters. We've made a real effort to present ourselves better to the tenants. And that contact is getting better and better. We've really worked hard on improving the approach and communication of renovation projects, new construction projects, and similar matters. What we're doing in collaboration with tenants is really going well."

2A And with the housing corporations, is your relation with them good, or is the communication with them more difficult?

"It's going very well. I have a lot of direct lines with the people within the housing corporation, and we have periodic meetings where development plans are discussed thoroughly. The contact is quite unique, I must say, because I hear other things about other regions in the Netherlands."

2B So the housing corporations don't need to improve their communication with you?

"No, definitely not."

3A And when we look at the energy transition, what kind of renovation projects are your tenants currently dealing with?

"We're encountering a few issues. One of them is that the municipalities have recently stopped the old emergency fund. People who depend on block heating and similar systems are now getting enormous bills because gas prices have increased significantly. So, we are working on all fronts to see how we can assist the more vulnerable tenants. At the moment, we're very involved in renovation projects related to sustainability. We're involved from the start of the project until the final result. "

Do you have any examples of these? What kind of renovation projects are these?

"These mainly involve roof and wall insulation, double glazing, ventilation, and similar measures to lower heating costs for people. We also want to improve the comfort of living in the homes, which is of course an important point. Every insulation model also has its consequences, naturally."

3B Are there also works in the surrounding areas, outside the building, for these types of renovations? Are residents facing problems with this?

"No, I must say that this is within the housing corporation's responsibility, and it is really well communicated. In Nijmegen, we are also very involved in replacing sewers, as well as some points regarding connections to district heating. Our experience is that communication with the residents is going really well. I must say that Nijmegen is a bit ahead in this regard when compared to other housing corporations in other regions. Here we really have a solid policy."

Are you referring to regions outside the Arnhem-Nijmegen area?

"Yes, we have central consultations with organizations in places like Leiden, Utrecht, Arnhem, etc."

3C Again about the work outside the buildings. There are also more sustainable techniques emerging, which sometimes require extra space outside. Are your tenants facing any issues with that?

"Yes, there are significant issues with a renovation project where heat pumps are being installed. These heat pumps are being placed at the front of the houses. There has been some trouble with that because they are large units. One of the most significant was the noise pollution. One of the disadvantages of installing an outdoor unit with connections to the inside is that you need to ensure everything is sealed properly. In one project where this was done with heat pumps, people had a lot of problems with mice because they came inside via the heat pump and the piping system. This has been solved now, but these are typical practical issues you can run into. It's quite normal."

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Appendix

Interview housing corporation Talis - part 2

4 And when we look at the biggest concern of the residents. You mentioned earlier that energy prices are going up. Is that really the biggest concern for the residents so far?

"Well, when it comes to homes, you should always distinguish between two things. There's the person who has an independent unit to heat and ventilate their house. They can influence a lot of things themselves, including the price, if they buy their energy in advance, for example. But there are also many more complex cases, in Arnhem-Nijmegen and also nationwide with Portaal, where things are often done with block heating. I don't know if you're familiar with what block heating is, but basically, it means a complex of 100-150 homes sharing one installation for hot water and heating. Block heating is the predecessor of district heating. And here you see that this creates a difference in costs for each resident in the same complex. For example, someone who lives in the middle of the complex and always keeps their heating on is paying for the heating of neighbouring homes. If you look at the prices from the last year and a half, it's clear that this has had a major impact on housing costs. These total housing costs have risen by almost 20% in the last year and a half. That is very concerning."

Is that the only concern of the tenants? Or are there also smaller things they are dealing with?

"Well, in every complex, after a renovation, there are usually complaints about certain things. But these are generally resolved quickly. Again, if you have an individual unit, you can influence your living costs, and you pay exactly for what you consume. But we notice that, especially in apartment situations, living costs are getting out of hand. Then, of course, there are also the projects with solar panels, so-called EPV homes, but especially with the reverse costs that the residents have to pay. This is now a major discussion because the government has not really addressed this properly. Look, the panels are owned by the housing corporations and they have to pay them back through a certain system. However, in the energy contracts that the residents sign themselves, it states that THEY are responsible for paying this back.
To give you a simple example: a house that's fully equipped with solar panels will have a reverse cost of 150 euros. This means that the government has a system where residents pay for the so-called benefits, while it brings more extra costs for them. This is, of course, a major point of concern."

4A Do you often receive complaints from the tenants themselves?

"Well, Portaal has a good complaint system for the residents. But we do receive quite a few complaints about things not being resolved or being solved too late. I think that, as a tenants' organization, we handle about 50-60 complaints per month, with our 12,000 tenants."

What type of complaints are these?

"Ventilation, intercom systems, lifts that are not working, noise complaints... It's often in older homes, so there's a lot of noise between neighbours. But also issues like heat stress and other similar things."

So these aren't necessarily complaints related to the energy transition developments?

"No. Again, there are many complaints and questions about energy prices and what's going to happen with that."

4B Can you estimate how much of the residents are concerned about these price increases?

"I think it's about 20 percent."

And would you say that the other 80 percent are not interested in this, or do they not have enough knowledge about this topic?

"I think it's ignorance, but also unwillingness due to everything they've been faced with over the past years. They only get signals about gas prices increasing, electricity prices increasing, etc. Because of this, they don't want to hear more about this topic. As individual residents, they can't influence it. They are dealing with force majeure."

5A What do you think is the best solution to address these complaints?

"We're working hard to make block heating more efficient. I don't know if you are familiar with the block heating system, but you can install a heat meter on the radiators, which can be measured individually. However, you cannot install a meter on the hot water supply because it needs to provide hot water 24/7. This means that these systems are always running. We've made analyses to see how much energy the hot water supply uses annually in comparison to total costs. It's about 45 percent. That's why we're now looking into whether we can transition away from gas and install electric boilers in homes where that's possible. This would allow the resident to control how much the hot water supply runs. Our first indication is that this could save between 600 to 800 euros per year per home. And for social housing, these are very interesting amounts."

5B Is it the case that with this solution you are working on that housing corporations have an opposing opinion, or are you working closely together?

"Yes, very closely. We are very clear about the collaboration. Regarding sustainability, we can take the initiative to push this forward with the housing corporations. And I must honestly say, it's being taken very seriously."

Appendix

Interview renters association HSPN

1A What is the relationship between Talis with the municipality and/or other government agencies?
"We need each other. As a purchaser of heat, we are following the Municipality's heat transition. We act in accordance with the 'startmotorkader' (a framework) of Aedes, the sector organisation."

1B How does Talis deal with rules and policies imposed on you? And do you yourselves have a say in them?
"No policy has been imposed yet. Legislation is being prepared whereby the municipality can enforce switching to gas-free home ownership. If this comes about, then there will be a persistence power."

1C What is Talis' relationship with Liander regarding planning new heat networks and renovations for the electricity network?
"Liander deals with power and grid congestion. We have no influence on that. We are customers. We are in contact with a Liander subsidiary regarding a public heat network in an area where we rent homes. This involves ARN, the municipality and Firan, among others."

2A There is a big task for housing associations to make the social housing sector energy neutral. In what way are you working on this?
"We are. We're doing a lot in this: (re)insulating, gas-free cooking, new buildings without natural gas, preparing for a heat network where possible, etc. Thanks to our active programme, most existing homes have had energy label B for some time now, making us one of the frontrunners."

2B Do you think the goal of a climate-neutral Arnhem-Nijmegen will be achieved by 2050? If so, what is Talis' approach?
"Like the provious answer, there are still considerable challenges ahead."

If no, what are the major challenges Talis is currently facing?
"For tenants, the price has to be right because of the importance of affordability. We need and want to be keen on that. So we need a good and sharp offer."

2C Can you give an indication of what the cost tag looks like to participate in the energy transition? What are the biggest kind of investments Talis is facing?
"In outline:
BAK - contribution connection costs
Fixed charge contribution (part is on behalf of the corporation), this is much higher than CV currently.
Delivery set rental
Insulation strategy (all costs you have to deal with behind the delivery set)"

3A What are Talis' biggest concerns regarding the energy transition?
"How we keep the costs manageable, so that we also keep it affordable for tenants. We are now embracing heat networks because that is currently the cheapest option."

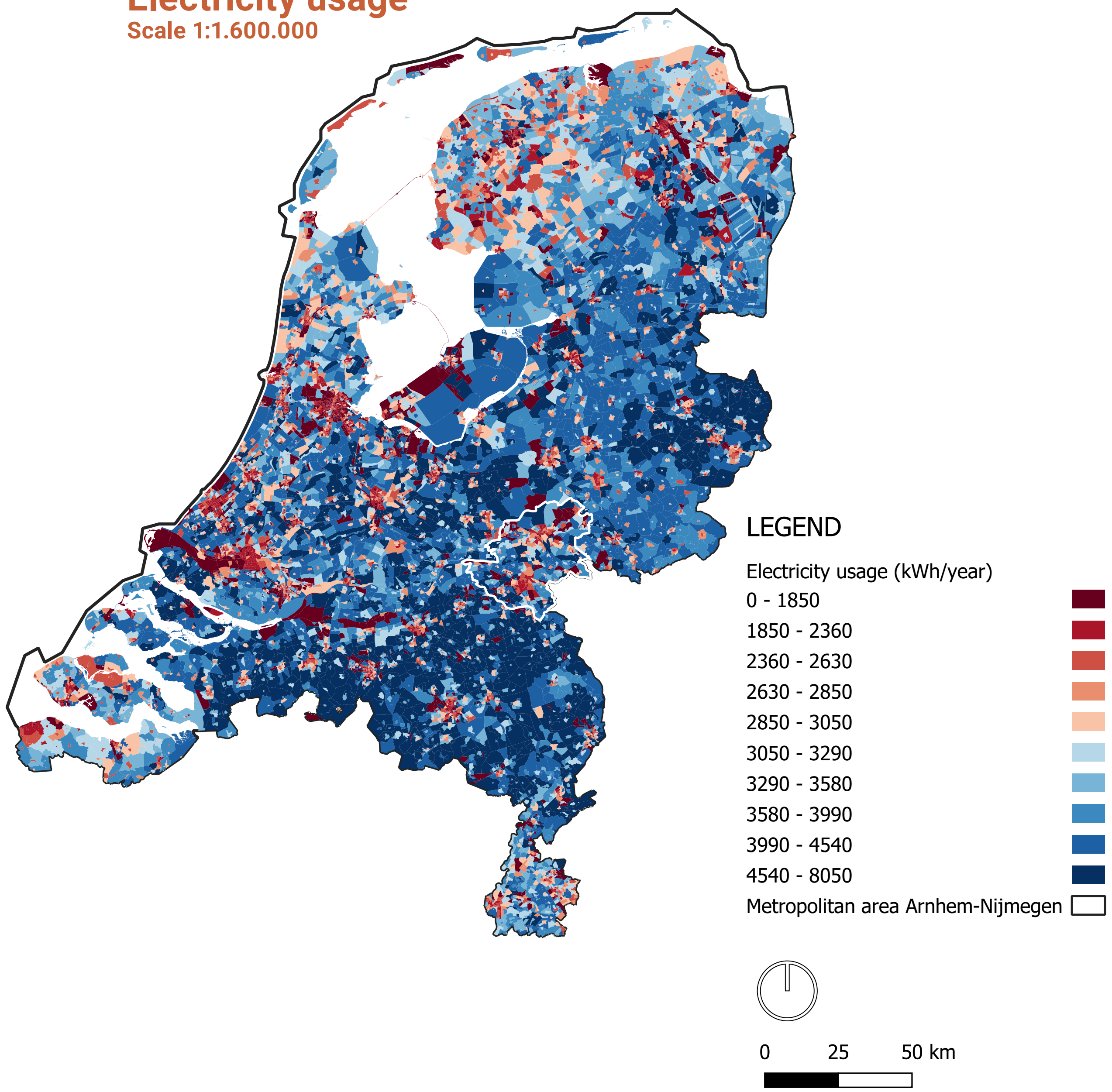
3B Many social tenants are facing rising energy costs these days. How is your contact with tenants on this?
"The important thing is that, in a fluctuating market, we buy as well as possible for people for whom we conclude the energy contract given the type of housing (homes with block heating and the complexes with communal areas). Despite our commitment to competitive contracts, we cannot avoid having to deal with rising tariffs, and tenants notice this. Of course, that's not nice. So there are more questions about that too from tenants."

3C The costs of sustainable renovations are high. How does Talis deal with this? Do the costs of these kinds of renovations play a role in residents' changing rents and energy bills?
"In view of affordability agenda: sustainable renovations are indeed costly. Costs are hefty when combined with other tasks: maintenance, new construction, liveability and sustainability tasks and energy transition. It is a puzzle for corporations. You can only spend money once, so you have to be very alert to that."

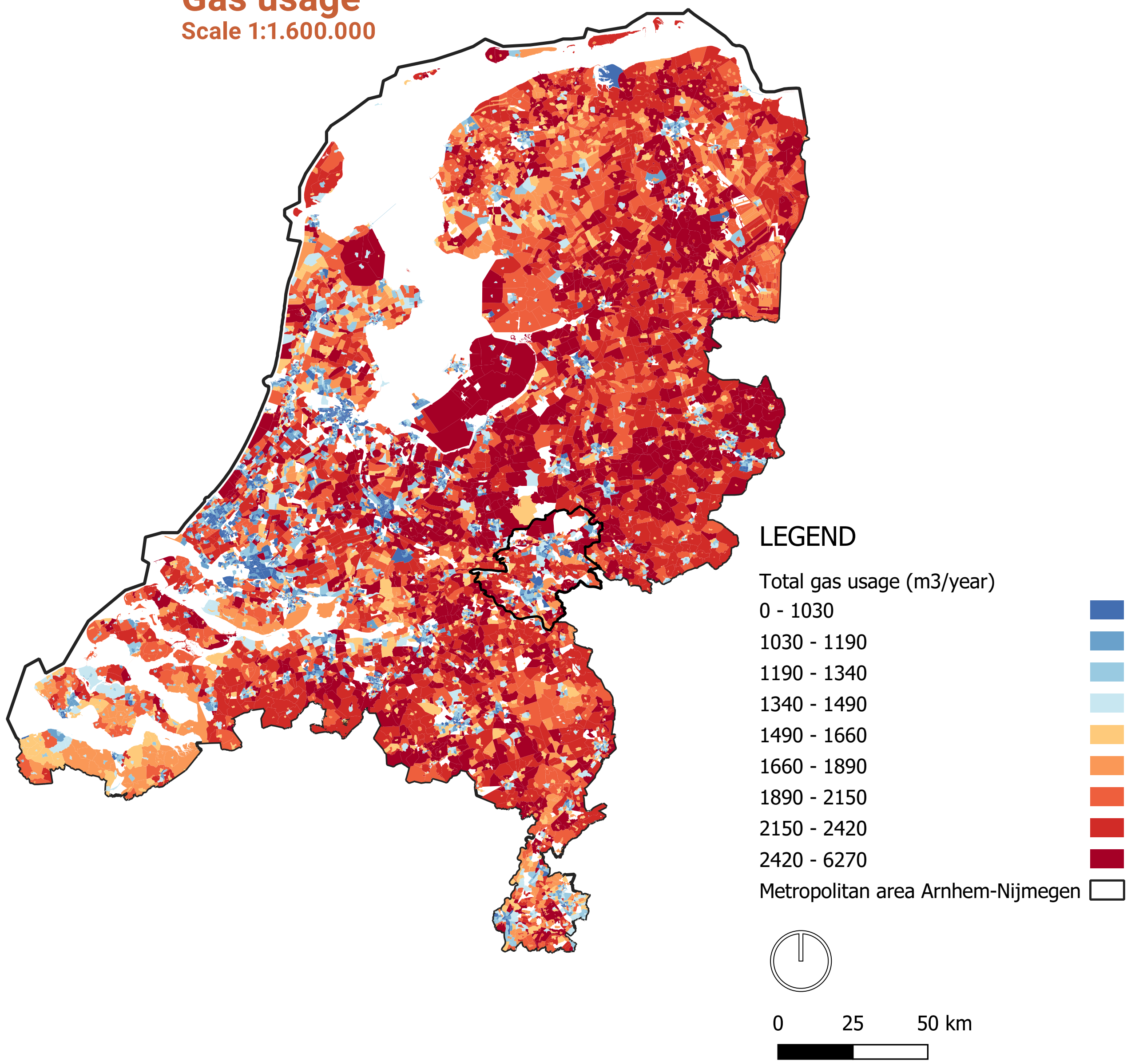
Appendix

Energy consumption

Electricity usage
Scale 1:1.600.000



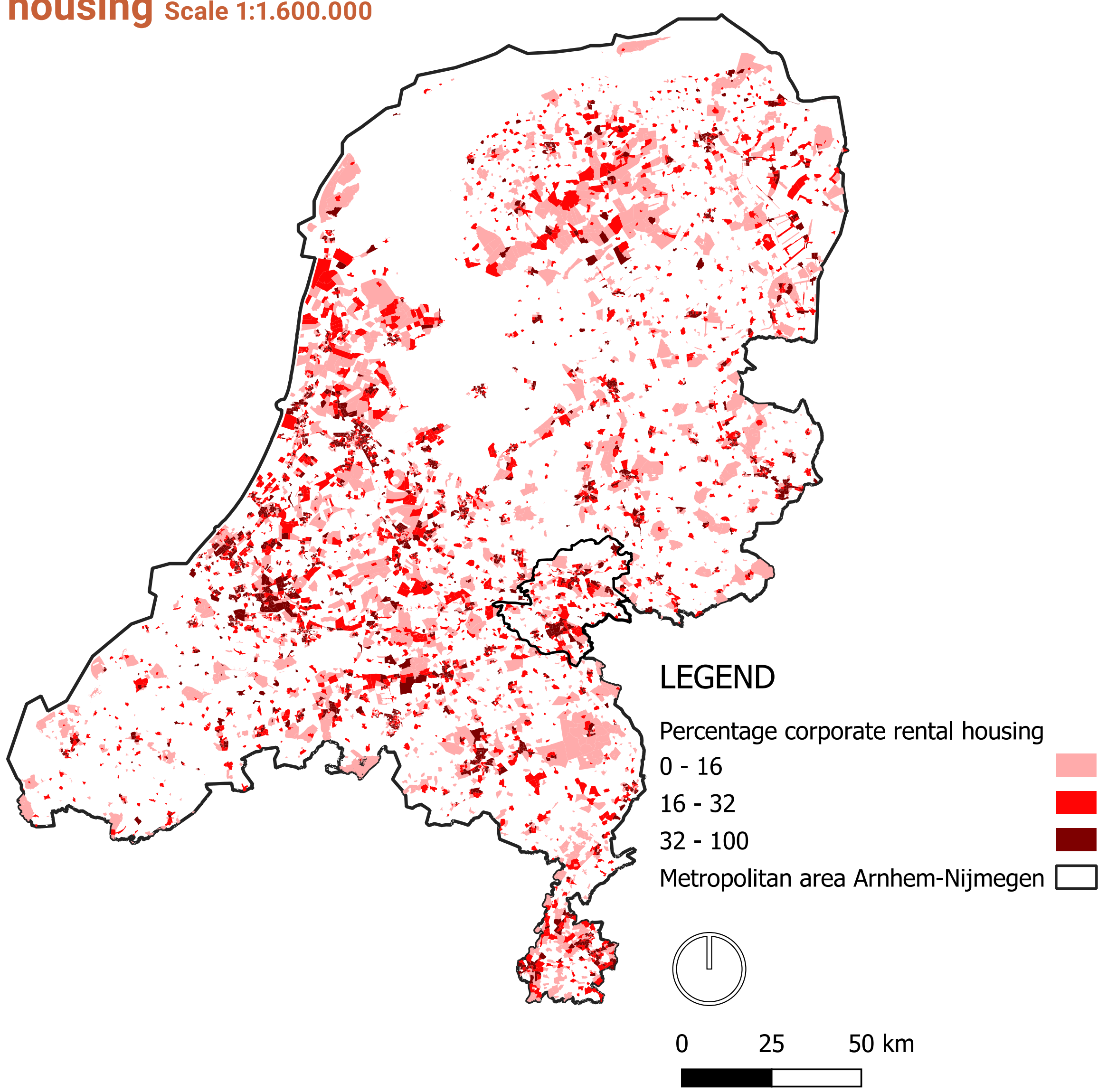
Gas usage
Scale 1:1.600.000



Appendix

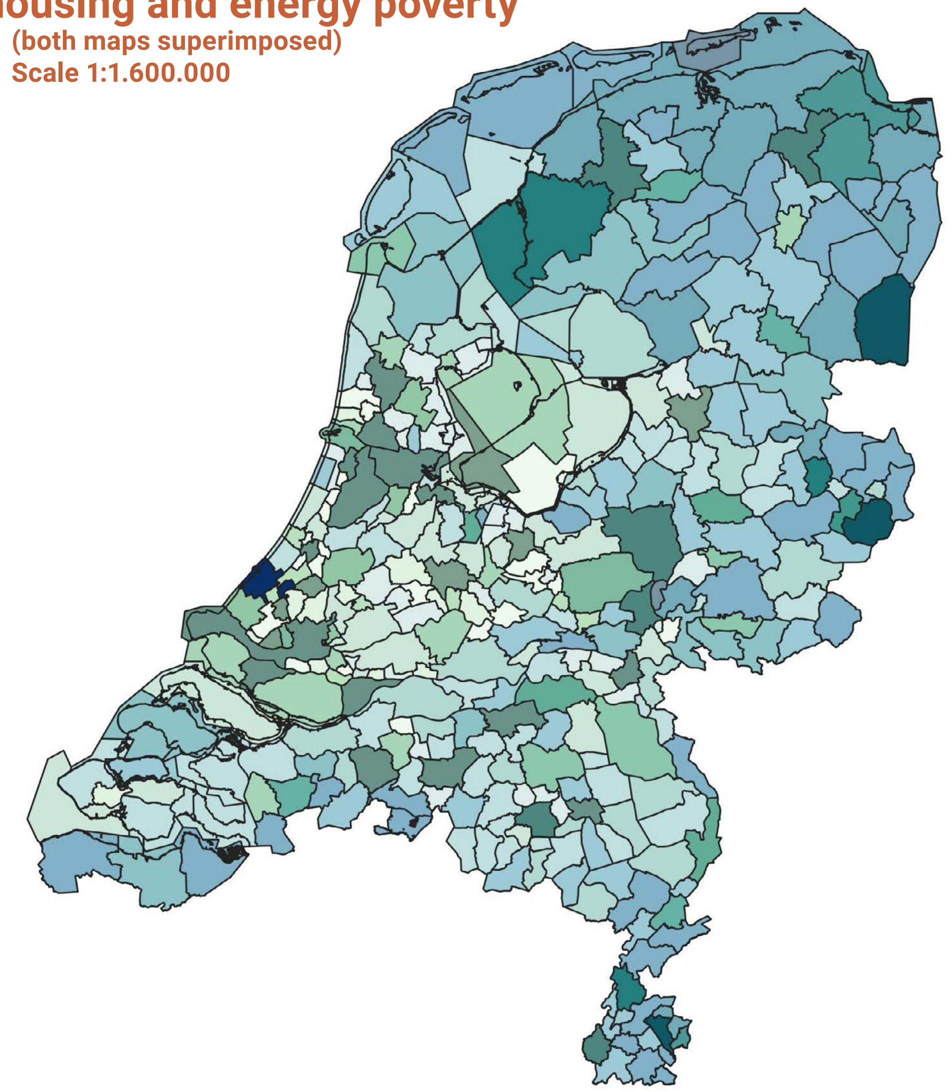
Housing

Corporate rental housing Scale 1:1.600.000

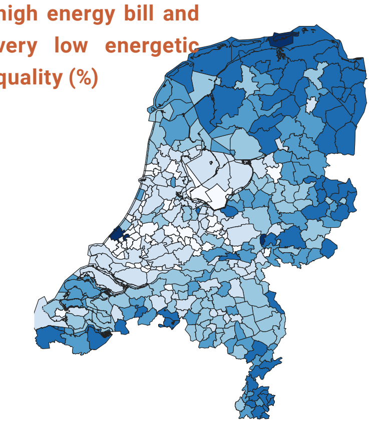


Municipalities with social housing and energy poverty

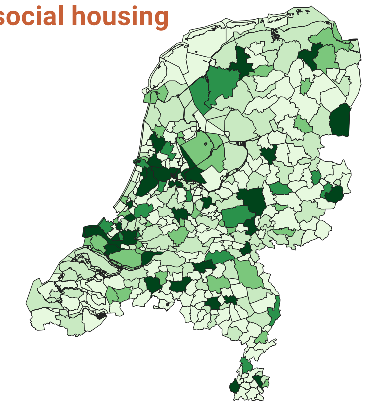
(both maps superimposed)
Scale 1:1.600.000



Households with low income, high energy bill and very low energetic quality (%)



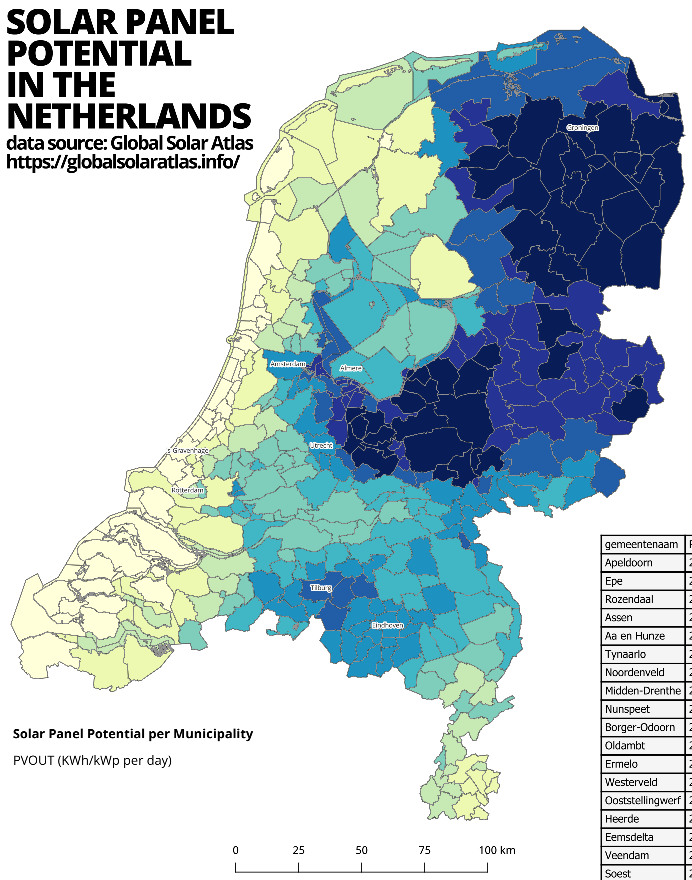
Amount of social housing



Appendix

Renewable energy production

Solar panel potential
Scale 1:1.600.000



gemeentenaam	PV_mean
Apeldoorn	2,7409255811410356
Epe	2,7515436274893332
Rozendaal	2,7525600147247316
Assen	2,754086965359516
Aa en Hunze	2,756115025182381
Tynaarlo	2,75709155243887
Noordenveld	2,759284260309287
Midden-Drenthe	2,762196704074069
Nunspeet	2,764392709925107
Borger-Odoorn	2,764825517196369
Oldambt	2,7648899117741017
Ermelo	2,7671963144665117
Westerveld	2,768378928055825
Ooststellingwerf	2,7690751666631677
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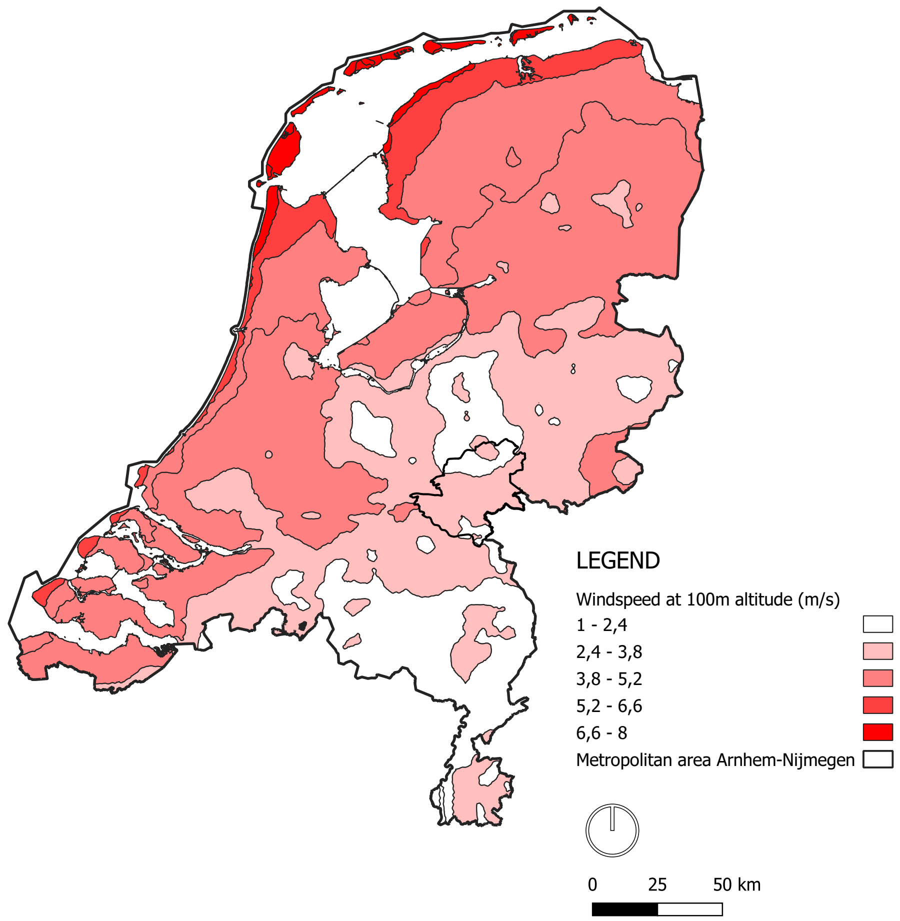
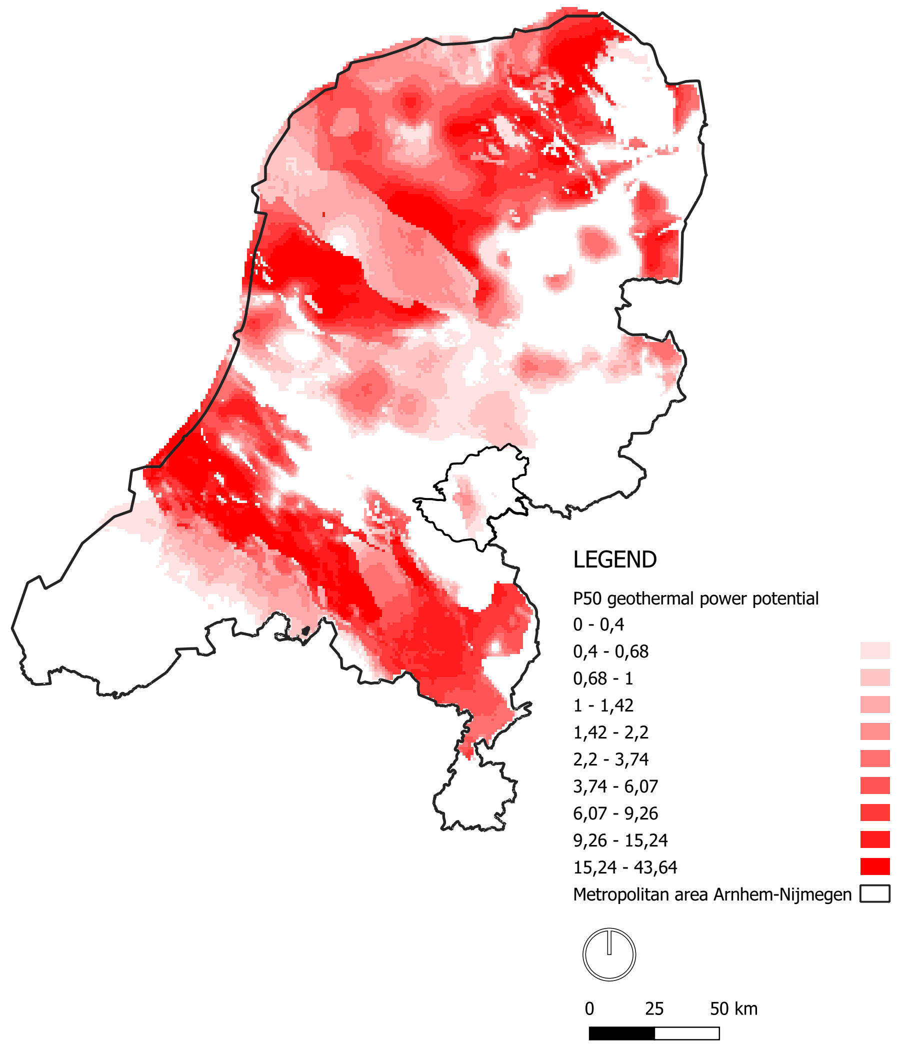
Veendam	2,7698542929643035
Soest	2,771136373281479
Groningen	2,7714304223503032
Zeist	2,7722500018451526

Wind energy potential
Scale 1:1.600.000



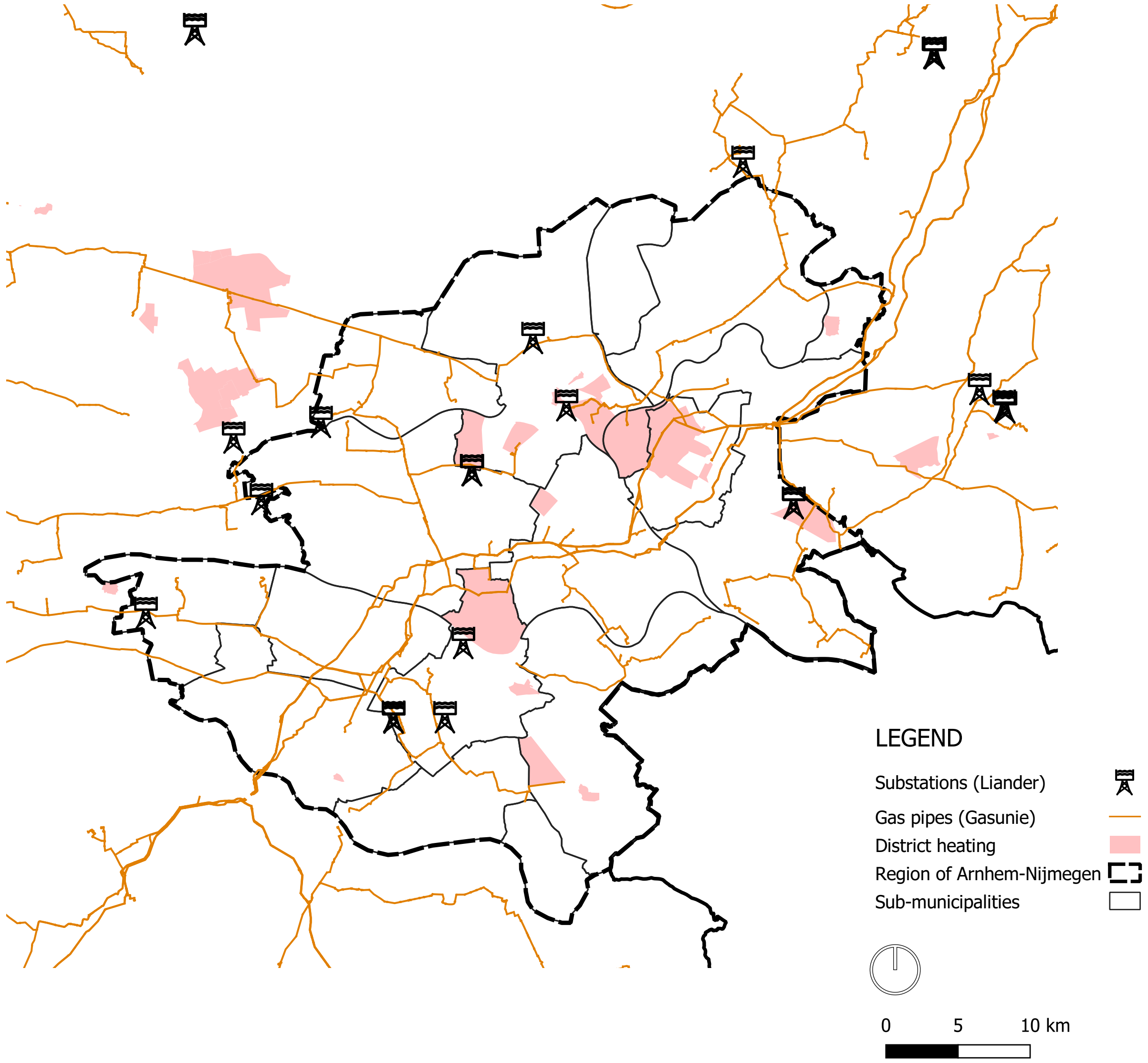
Geothermal potential
Scale 1:1.600.000



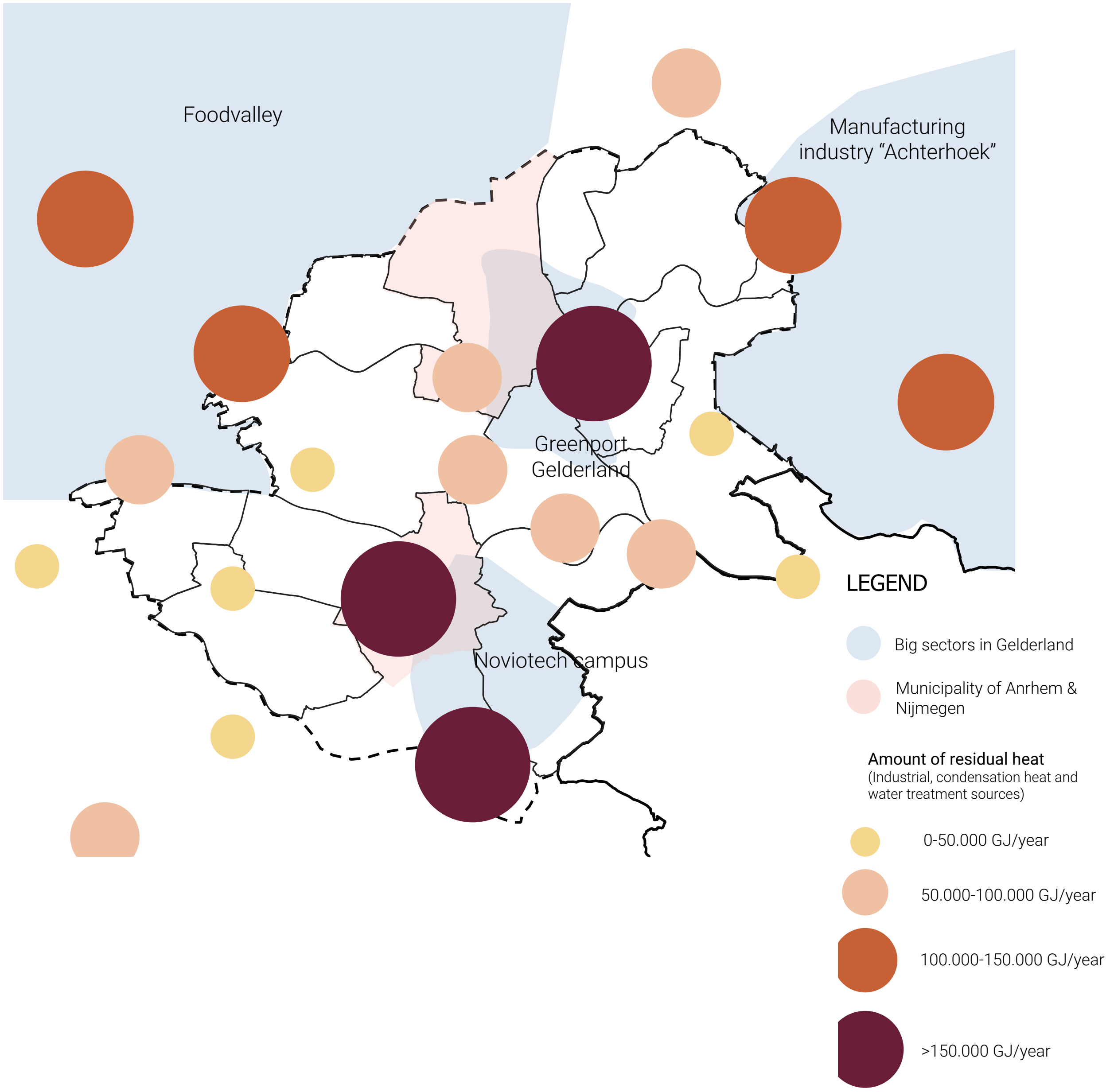
Appendix

Energy

Current gas network Arnhem-Nijmegen
Scale 1:300.000



Current residual heat zones Arnhem-Nijmegen
Scale 1:300.000

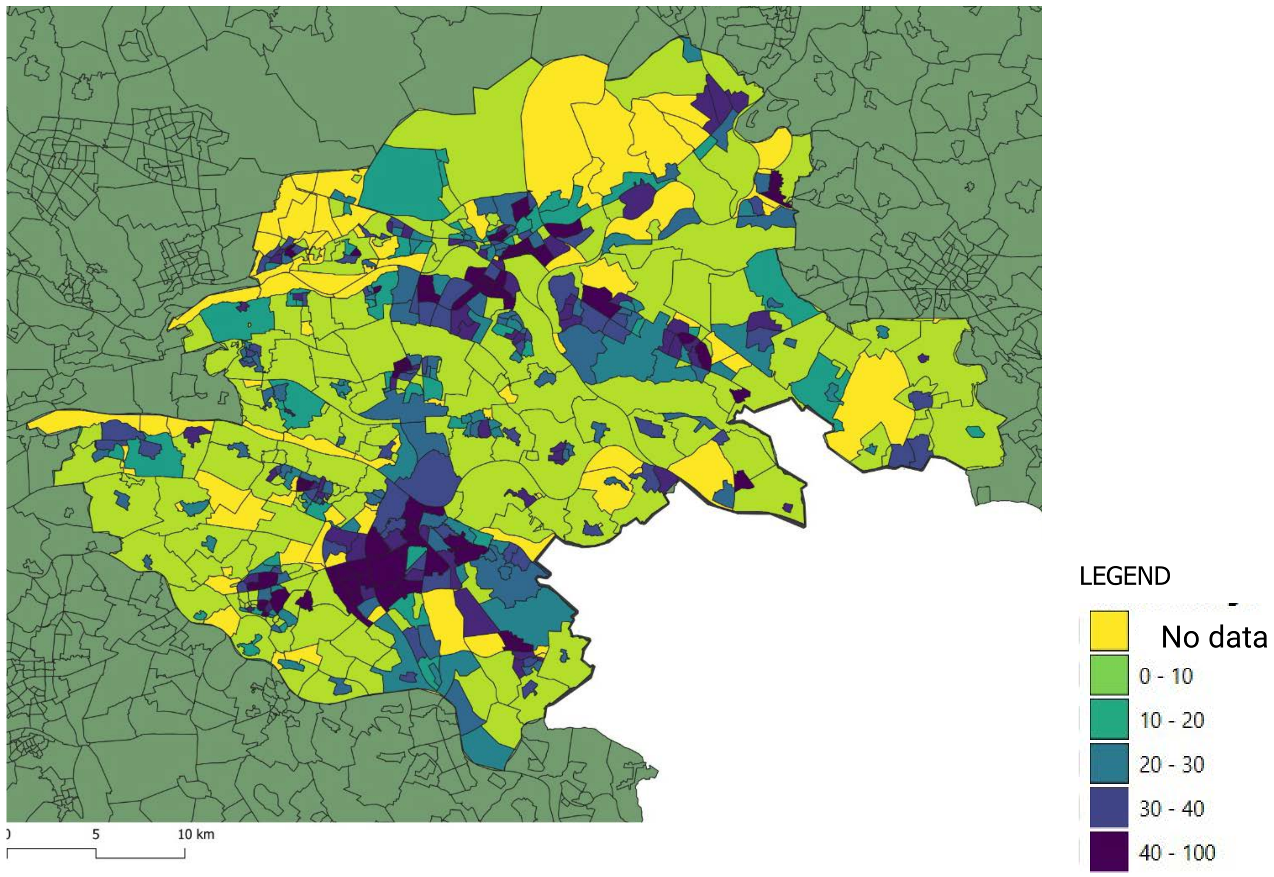


Appendix

Social housing

Percentage social housing per neighbourhood

Scale 1:300.000



Social housing in Nijmegen

Scale 1:50.000