# *Technology and strategy roadmap development for connecting residential areas to district heating.*

Edzard Wentges

## Author

Edzard Wentges

**Graduation committee**
Chair: Dr.ir. van den Hende, E.A.
Mentor: MSc. Willemen, A.M.
Company mentor: BsC. von Dulmen Krumpelmann, E.H.

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# Abstract

By 2050, the Netherlands aims to achieve a climate-neutral society, but over 90% of buildings currently use natural gas or fossil fuel oil as their main resource of energy. To align with this goal, the Dutch energy company is taking measures to phase out natural gas and promote district heating. This research outlines a strategic path for the energy company to connect existing residential areas to district heating, utilizing a combination of roadmapping and the double diamond process model.

The initial phase involved stakeholder and competitor analysis, along with qualitative research through interviews with the energy company employees. Housing categories were established and prioritized, while the identified problems were refined. Additional interviews were conducted to look into the desirability of the to be developed solution.

The subsequent phase involved individual brainstorming and various workshops, utilizing different methods to select and further develop the most promising solutions. Roadmaps were created, outlining strategic directions and required activities. Simultaneously, a future vision is formulated through strategic trend scanning and clustering, providing a long-term perspective and comprehensive understanding of the broader picture of the energy business in 2050.

This study suggests the energy company to focus on five new innovations. All innovations propose the use of either new HIU's or ways of connecting district heating to the HIU. These solutions combined have the maximum potential of connecting 67.2 percent of the buildings.

Furthermore, the recommendation was made that, to meet future customer needs, the energy company should transition from their current role of organizing the energy transition to becoming a provider of knowledge and expertise.

Lastly, it was found that to overcome challenges in adopting district heating, the energy company should improve their communication about their process, progress, and the benefits of district heating to the residents.

# Table of content

**Glossary** ..... **6**
**Introduction** ..... **7**
Introduction ..... 7
Problem framing ..... 8
Context: district heating ..... 10
Scope of this research ..... 11
Roadmapping ..... 14
**Stakeholder analysis** ..... **17**
External stakeholders: district heating transition process ..... 17
Internal stakeholders: innovation process of the energy company ..... 19
The end customer (residents) ..... 23
**Market overview** ..... **24**
Product portfolio analysis ..... 24
Competitor analysis ..... 28
Competitive market overview ..... 28
Conclusion ..... 30
**Housing categories** ..... **31**
General research ..... 31
Interviews ..... 35
Discussion ..... 38
Conclusion ..... 38
**Prioritizing** ..... **40**
Interviews - difficulty ..... 41
General research - quantity ..... 42
Case study - timing ..... 43
Categories ..... 46
Discussion ..... 50
Conclusion ..... 50
**Identified problems** ..... **51**
Physical assessment ..... 51
Interviews ..... 52
Conclusion ..... 53
**Customer needs** ..... **54**
Valuable insights residents ..... 55
Valuable insights housing associations ..... 56
Discussion ..... 57
Conclusion ..... 57
**Cross-industry insights** ..... **58**
Discussion ..... 59
Conclusion ..... 59
**Individual ideation** ..... **61**

Method..... 61
Discussion..... 61
Conclusion..... 61
Results..... 62
**Workshops..... 63**
Methods..... 63
Discussion..... 66
Conclusion..... 66
Results..... 67
**Initial selection..... 69**
**Selection & development..... 70**
Conclusion..... 73
Relevance..... 73
**Communication..... 74**
General research..... 74
Interviews..... 75
Discussion..... 76
Conclusion..... 77
Suggestion..... 77
Product innovation roadmap (technical)..... 79
General roadmap (strategy)..... 86
**Future visioning..... 90**
Future context..... 90
Future vision..... 96
**Conclusion..... 98**
**Limitations & Recommendations..... 99**
Limitations..... 99
Recommendations..... 100
**References..... 101**
References..... 101
Appendix A..... 108
Appendix B..... 120
Appendix C..... 121
Appendix D1..... 125
Appendix D2..... 128
Appendix D3..... 134
Appendix E..... 135
Appendix F..... 136
Appendix G..... 138

# Glossary

Heat Interface Unit (HIU) = (Afleverset) Essentially serves the same purpose as a gas boiler. It transfers the heat from the distribution network into the home's central heating system. See Figure 10.
Grid operator = Owner of the distribution network (not necessarily also the supplier of heat)
Housing types = The type of building which already has been pre-defined. In this study the definitions of RVO have been used(Rijksdienst voor Ondernemend Nederland, 2022).
Housing categories = Self-defined categories to further distinguish the different housing types.
Residential areas = Region where the buildings on the land are residential and where people live or are domiciled.
Existing residential areas = Residential area which is being utilized by people and where no new buildings are being constructed
Climate neutral = Refers to the concept of obtaining net zero emissions of greenhouse gasses by balancing emissions to be equal to (or less than) emissions absorbed by the planet(unfccc, 2021).
Ground level building = Building with a maximum of three levels and each apartment's entrance is on the ground floor.
High-rise building = Multi-story building where every floor consists of multiple apartments.
Porch building = Multi-story building where the individual apartments can be entered through an open or closed porch.
Gallery building = Multi-story building where the individual apartments can be entered through an open or closed gallery.
Riser = Pipes that are being used to vertically transport hot or cold water
Crawl space = Area underneath the ground with limited height, giving access to wiring and plumbing.
Meter cupboard = Technical room in a building where various meters are installed
Bouwbesluit = The Dutch building decree, which is a collection of technical and other regulations that apply to the construction of a building, the state of an existing building and the commissioning or use of a building.
CLV = Combinatie luchttoevoer verbrandingsgasafvoer, which vertically links multiple gas boilers and releases the flue gas through a shared discharge pipe.
Plinth = The ground floor of a building that is used as the base to support the rest of the building.
OVN = Overvecht-Noord, a neighborhood in Utrecht

# Introduction

## Introduction

The energy company is an international company dedicated to accelerating the energy transition. Based on their mission ‘everyone’s sustainable energy’, they support consumers and businesses in making the conversion to sustainable energy. They have been involved in the energy industry for more than a century and are active in the Netherlands, Belgium, Germany, and the United Kingdom.

Together with their “Sustainability Strategy”, the energy company aims for climate neutrality by 2035 in both their own operations and the energy they supply to their customers. This “Sustainability Strategy”
outlines specific actions that the energy company is going to take in order to accelerate the energy transition. The following three actions are included:

1. “Radical electrification: large-scale electrification of industry, mobility and the built environment with exclusively renewable electricity from new wind and solar farms.”
2. “Phasing out natural gas: by converting or closing our gas-fired power stations and making natural gas-fired homes and buildings with home insulation, (hybrid) heat pumps, and heat networks more sustainable.”
3. “Accelerating sustainable heat: through innovation and investment in sustainable sources such as geothermal, aquathermal, electrode boilers, heat and cold storage, green gas, and green hydrogen.”

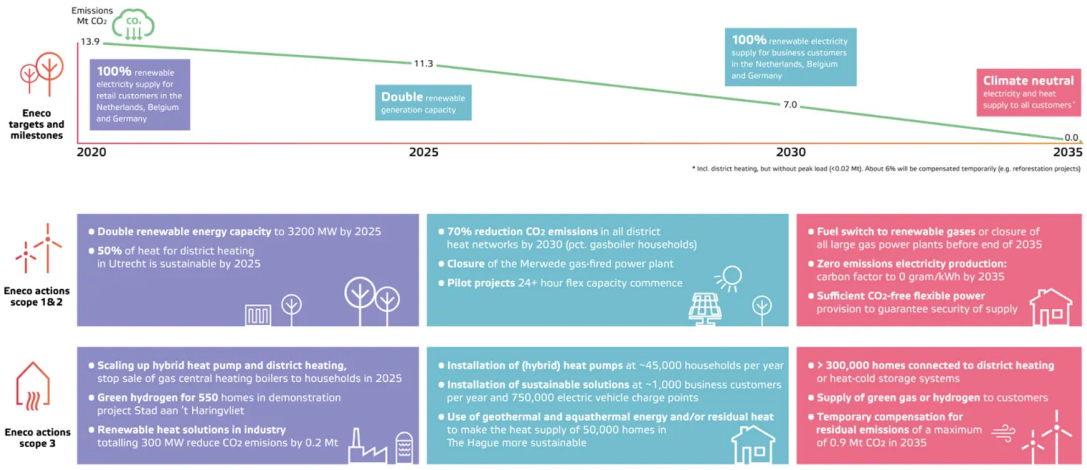



*Figure 1: The energy company’s high-level carbon strategy roadmap (the energy company, z.d.).*

Figure 1 shows the high-level carbon strategy roadmap that the energy company uses internally. Along with their “Sustainability Strategy”, it outlines the major objectives and activities. However, it does not provide all the solutions required to achieve climate neutrality by 2035.

To support the energy company in the design, construction, and operation of sustainable energy systems in the coming years, new innovations are required. Therefore, well-defined strategies and future visions are essential to effectively assist the energy company in their innovation efforts and achieve their goals outlined in the "Sustainability Strategy" and carbon strategy roadmap.

## Problem framing

By 2050, the Netherlands will have a society that is climate-neutral, as per the Climate Agreements’ declared objective (Aardgasvrij, 2018). As a result, municipalities in the Netherlands, including Rotterdam and Utrecht, have set a goal to be completely gas-free by 2050 (Aardgasvrije wijken en gebieden, z.d.),(Gemeente Utrecht, z.d.).

As previously mentioned, the energy company itself has the ambition to become climate neutral by 2035, together with their customers. One of their actions to get to this climate neutrality is “Phasing out natural gas”. However, before completely phasing out the use of natural gas, a number of different measures must be implemented.

Currently, over 90% of residential and commercial buildings in the Netherlands are using natural gas or fossil fuel oil for heating and cooking (Koster et al., 2022). Gas consumption has a negative impact on the environment and therefore does not fit in with the mission and ambition of the energy company and the set target of the government of the Netherlands(Martins et al., 2019). Due to this, the energy company plans on assisting these residential areas to get rid of gas by connecting them to district heating. District heating has a lower impact on the environment, depending on the heat supply methods, explained in the chapter: Context: district heating. When connecting to district heating, the gas boiler will be removed and replaced by a Heat Interface Unit (HIU), displayed in Figure 5. Installing the HIU also comes with connecting new pipes meaning that interior work will take place inside the homes.

Figure 2, presented on the following page, shows an example of how the energy company currently offers district heating for new housing estates. However, a completely different situation arises when already existing residential areas are connected to district heating. In order to connect existing residential areas to district heating new solutions should be developed. This leads to the main question, *what type of solutions does the energy company need to develop to connect already existing residential areas to district heating?*

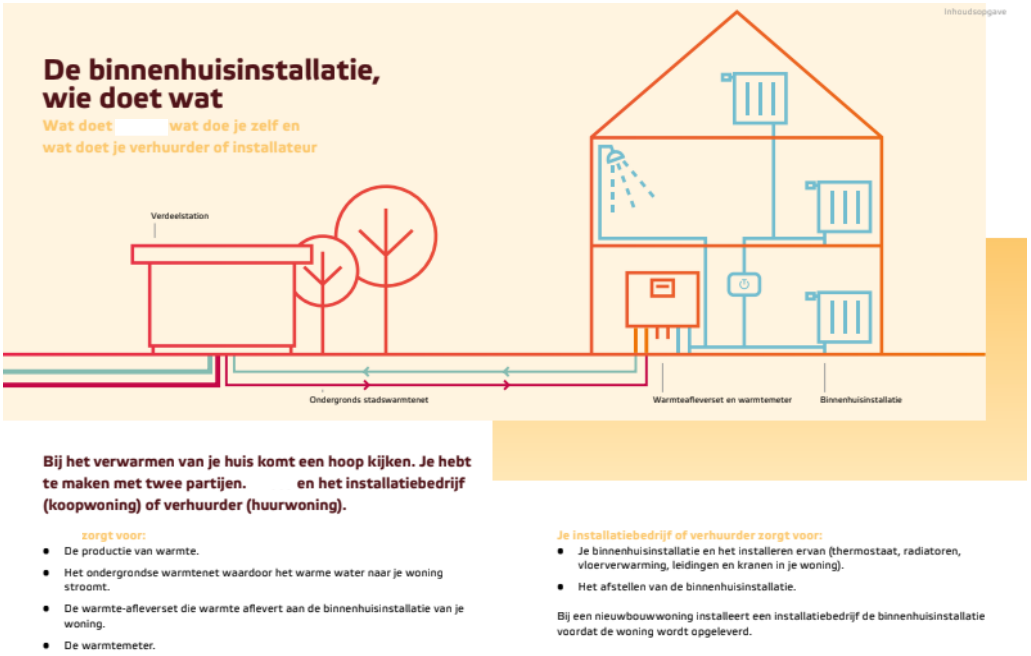



*Figure 2: The final step of district heating (heating supply) (the energy company, z.d.-b).*

Some businesses, including the energy company, are already testing the feasibility of connecting existing residential areas to district heating. However, at the moment, connecting these so-called "proeftuinen" calls for specialized services. In other words, new solutions are made for each individual house that is connected to district heating. The energy company intends to standardize the solutions per housing category because, in the end, all the current residential areas should get rid of gas and the majority of them are likely going to be connected to district heating. To connect these existing residential areas to district heating, it is necessary to first identify and categorize the various housing types, the heating systems that are currently in use (as well as how these are integrated into these homes), and the already existing solutions.

Second, to persuade the different relevant stakeholders, it is crucial to identify them and understand their requirements when implementing district heating. Mapping these requirements with the already existing solutions will lead to gaps where no standardized solution exists. From there, it can be identified what solutions have to be developed.

Third, the energy company wants to know when these various solutions should be designed, developed, and integrated. To do this, the various phases are ranked in order of importance and plotted on a timeline that results in a roadmap.

This leads to the assignment:

Develop a technology & strategy roadmap describing what the energy company should develop or master to connect existing residential areas to district heating. This roadmap should be a strategic path containing solutions that satisfy their stakeholders' needs, fit in with the strategy and capabilities of the energy company, put them in a strong market position, show the implementation of each different solution, and should include a future vision.

## Context: district heating

To understand the context of this research, this section elaborates on the core concept of district heating and the steps necessary for providing it.

According to Werner (2013), the core concept behind district heating is ‘to use local fuel or heat resources that would otherwise be wasted, in order to satisfy local customer demands for heating, by using a heat distribution network of pipes as a local marketplace.’

Worldwide, the total number of heating systems has been estimated to 80000 systems, with 6000 of those being in Europe (Werner, 2017). The first district heating project in the Netherlands took place in 1923 and therefore already has a long history (Schepers & van Valkengoed, 2009). However, for many years almost all the buildings kept on using gas as their primary heating supply. Since the eighties more district heating projects emerged due to the fact that the government offered grants to support district heating. From then onwards, more and more new residential areas were connected to district heating. Nevertheless, already existing areas kept using gas. As already explained before, to reach the Dutch climate agreements also existing areas should be connected to district heating. To understand the concept of district heating, the different steps including a short explanation are described below.

**Heat supply methods**

According to Wener (2017), there are four different heat supply methods. 1. Fossil fuels, direct use, 2. Renewables, direct use, 3. Recycled heat, renewables CHP (combined heat and power plant), and 4. Recycled heat fossils CHP and industries. From these heat-producing plants heated supply water is pumped to substations, visualized in Figure 3. Most of the district heating networks also include an auxiliary heating plant, which can be used to deliver extra heat whenever needed.

**Heat distribution**

In Europe, most customers are connected by substations to primary distribution networks supplying heat with the same supply temperature to all customers, presented in Figure 3 (Werner, 2017). This distribution network consists of the pipeline (neighborhood to neighborhood) and distribution pipes (neighborhood to homes) providing heat and cold to the customers (den Dekker et al., 2020).

**Heat delivery**

Substations deliver heat to buildings for space heating and hot water preparation, which can be done with or without a heat exchanger. A heat exchanger is a device that facilitates the process of heat exchange between two fluids that are at different temperatures and is part of the Heat Interface Unit (HIU) (Janna, 2018). This system is typically found within a home's meter cabinet. The full explanation of a HIU is described below Figure 6.

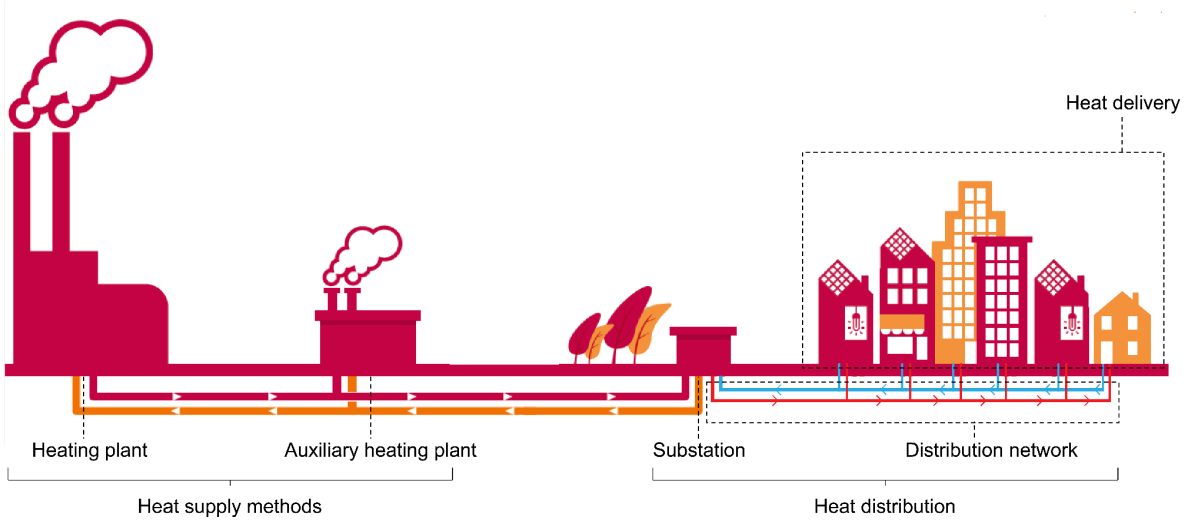



*Figure 3: The different steps of district heating (the energy company, z.d.-b).*

## Scope of this research

In this research, the main emphasis will be on the final step: heat delivery. However, before looking into how individual buildings will be connected to the distribution network, it is important to understand two main aspects. The first aspect is more general and includes the overall district heating approach and how the energy company operates as a company. The second aspect is more specific and includes the different types of buildings and their characteristics. Therefore the research scope is divided into three parts (illustrated in figure 4):

1. General district heating approach and how the energy company operates as a company.
2. Housing types and their architectural characteristics.
3. The identified problems within heat delivery.

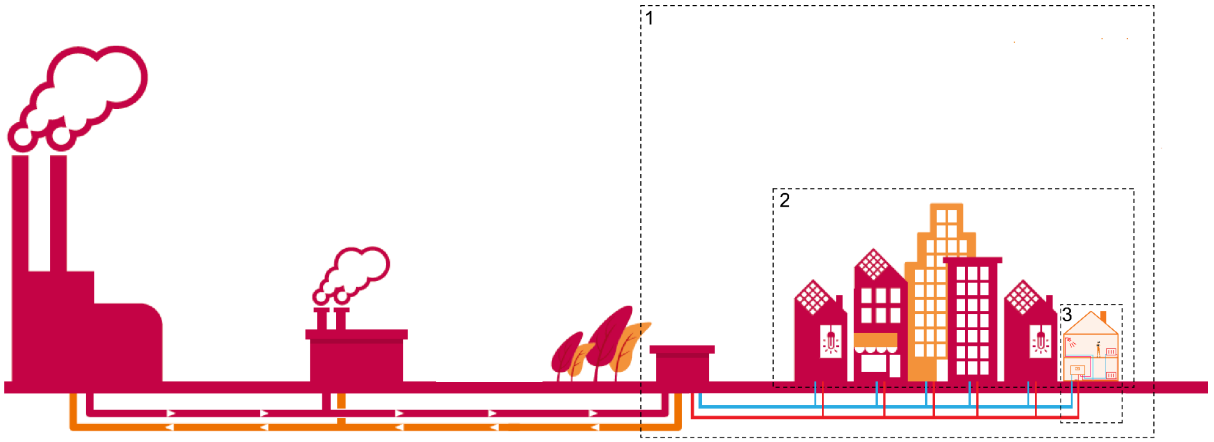



*Figure 4: The three different parts of the research scope.*

Since heat delivery is the main focus, the third part of the scope can be considered the primary focus of this research and the initial stage of the ideation phase. This final part is further divided into two sections: A) building-specific problems and methods of connecting to district heating, and B) customer needs and identified problems (visualized in Figure 5).

Section 3A) takes the following aspects into account (see Figure 5):

1. Possible differentiations of the HIU.
2. Position of the HIU.
3. Position of indoor pipes.
4. Connection of the HIU with the pipeline (distribution pipes).

Section 3B) emphasizes the needs of district heating customers and investigates the various challenges they encounter during the district heating process.

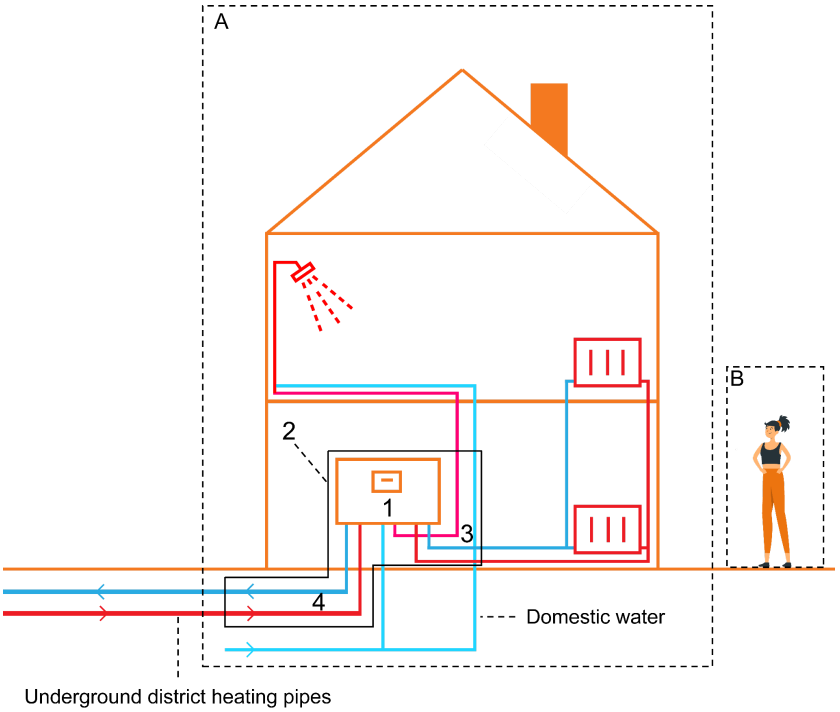
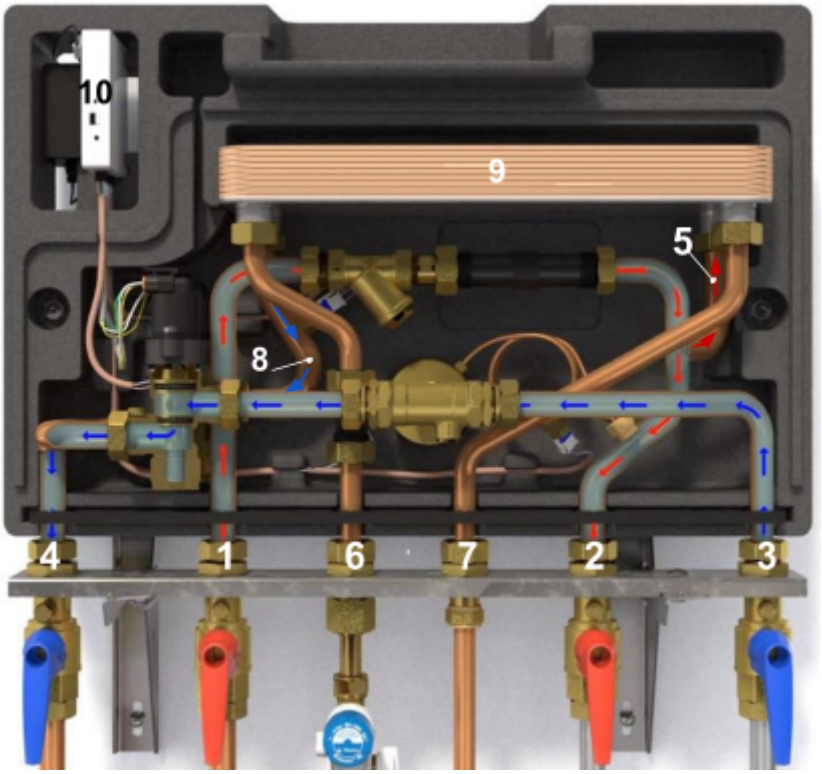



*Figure 5: Primary focus of this research, scope 3.*

To gain insights into the elements necessary for the final step of district heating, it is essential to understand the internal structure of the HIU. Therefore, the image below presents the inside of the HIU along with a description of its components. Moreover, this information is deemed necessary in support of the development of new solutions.




1. District heating supply
2. Heating supply
3. Heating return
4. District heating return
5. Heat exchanger supply
6. Domestic cold water
7. Domestic hot water
8. Heat exchanger return
9. Heat exchanger
10. Heat meter

*Figure 6: The inside of a Heat Interface Unit (HIU) (Kaizen energy, z.d.).*

The energy company does not deliver domestic hot or cold water and therefore always works with a heat exchanger. From the substations, hot district water is pumped into the HIU (1). This heat is used in two different ways:

- The heat is directly pumped into the radiators or underfloor heating of the building (2). This is the same water as from the distribution network, and after usage, it is returned (3) to the HIU and finally to the distribution network (4).
- The heat is also pumped into the heat exchanger (5) along with the domestic cold water (6). The heat of the distribution network is being used to heat the domestic water, without the fluids coming into direct contact. Domestic hot water is then returned to the homes (7), while the district heating water is returned to the distribution network (8).

To measure the amount of heat consumed by the customer, a heat meter (10) is used. This heat meter is connected to an Energy Connect Module (ECM) placed next to the HIU. Through the ECM, customers can monitor their consumption using an application.

## Roadmapping

The final deliverable of this study is a technology and strategy roadmap describing what the energy company should develop or master to connect existing residential areas to district heating. Therefore, this section elaborates shortly on what a design roadmap is and discusses the chosen approach to its creation.

According to Simonse (2018) a design roadmap is a visual portrayal of design innovation elements plotted on a timeline. Each roadmap has its particular format and visualization and uses the future vision as its destination.

The roadmap has three basic characteristics. It is (A) a visual portrait of the organization's future innovations, (B) outlined by user value, product-service, market, and technology elements (C) plotted on a timeline.

Within this research, a slightly different approach is chosen than the design roadmapping process as described by Simonse (2018), as the roadmap works towards solving a currently experienced problem instead of a future vision. Nevertheless, The process of this research is based on the roadmapping process combined with the double diamond process model, presented in Figure 7. The first two steps (Research and design) are mainly based on the double diamond process model and the last step (finalization) is based on the design roadmapping process by Simonse (2018).

As mentioned, this roadmap does not work directly towards a future vision as its destination is solving a current problem. However, a future vision is also incorporated to provide the energy company with valuable insights into the evolving energy landscape and what can be anticipated in the more distant future. The roadmap can be considered as the short-term destination (2030), while the future vision represents the long-term destination for the energy company (2050). This dual perspective allows the energy company to navigate both the present needs and anticipate future trends and developments in the energy business.

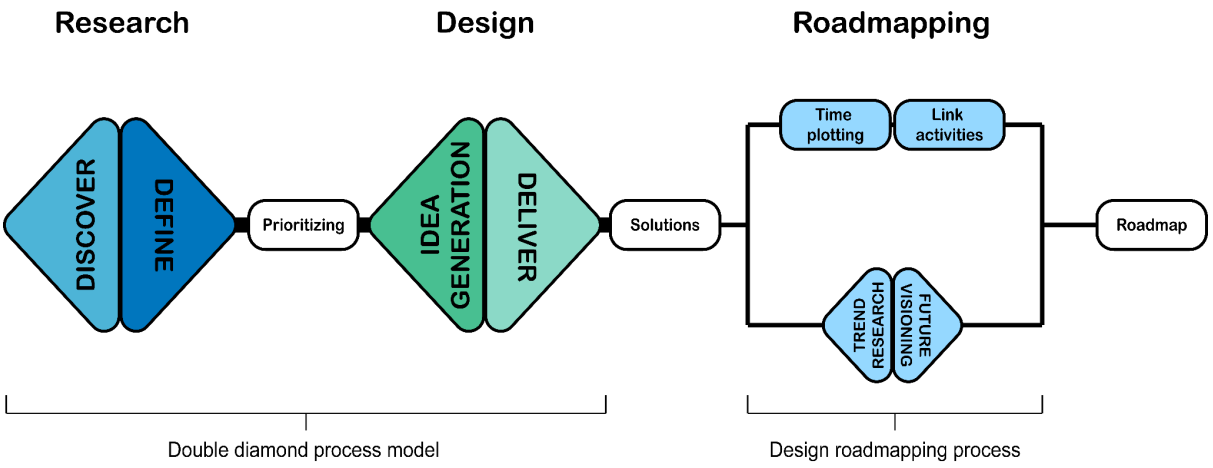



*Figure 7: The design and roadmapping process of this research.*

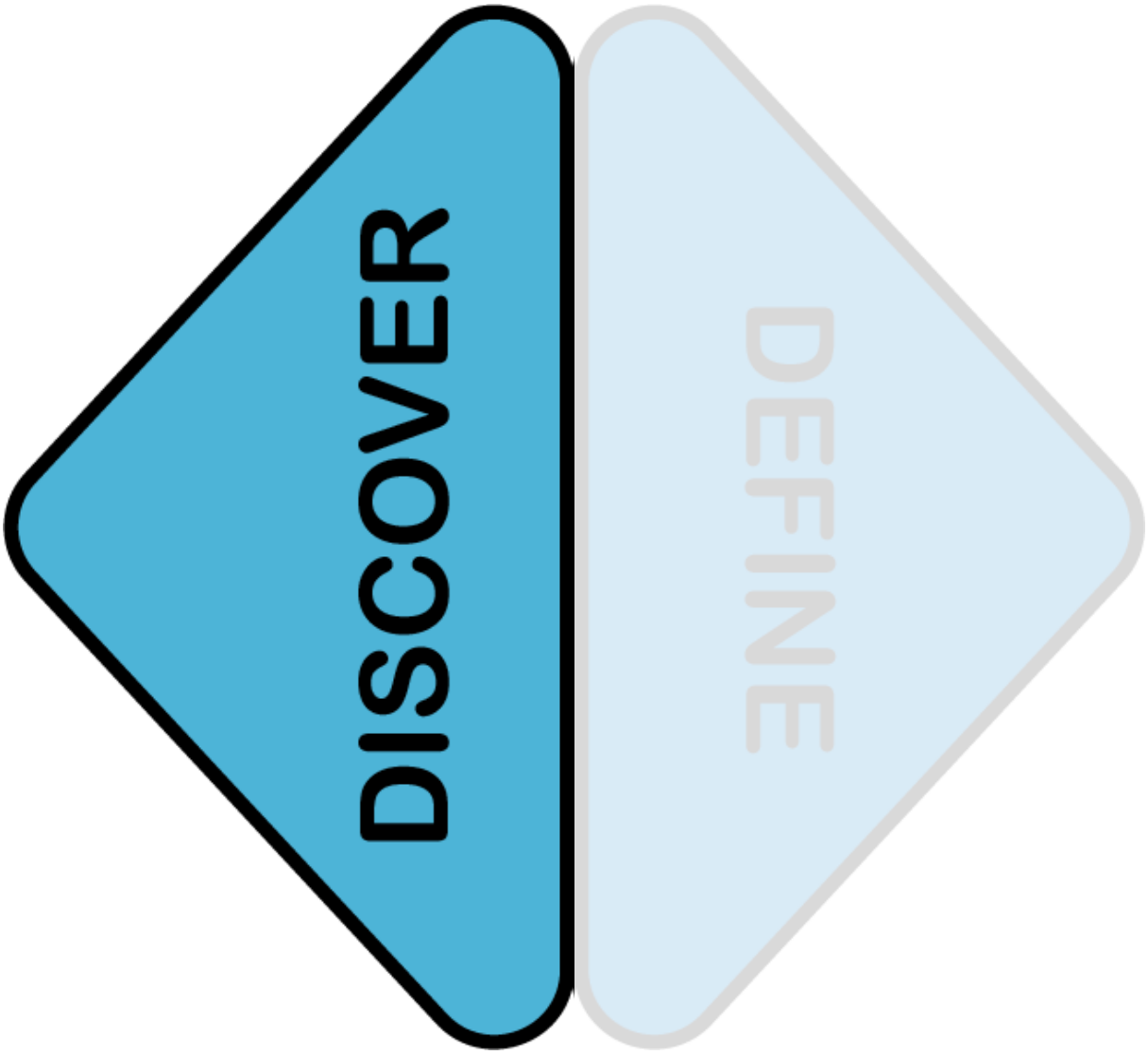
**Research**
The starting point of this study is the described problem of the energy company. The initial phase, ‘discover & explore’, involves conducting general research and interviews with employees from the energy company  to gain overall knowledge and valuable insights. Divergence occurs by gathering extensive information and identifying subproblems. To narrow down the focus, the second phase involves prioritizing the subproblems and further defining them. This process leads to the formulation of different problem definitions and the design direction.

**Design**
Building upon the various problem definitions, the ideation and development phase starts. The primary objective is to generate as many potential solutions as possible. This is achieved through individual brainstorming sessions and workshops involving the energy company employees. Subsequently, convergence takes place by selecting the most promising solutions and further developing those, leading to the final solutions.

**Roadmapping**
In the final step, a general roadmap (strategy) and a product innovation roadmap (technology) for each individual innovation are created. These roadmaps involve plotting the innovations on a timeline and linking the different activities needed to develop them. This step aims to provide a comprehensive overview that outlines a strategic direction for the upcoming years, along with the specific activities needed for each innovation.

Simultaneously with the previous step the future vision is formulated. This is done by doing strategic trend scanning, clustering the trends, and creating a future context, which finally is used to create the energy company’s future vision.

# Research - Discover



# Stakeholder analysis

Who are the different stakeholders and which ones should be taken into account when developing solutions for district heating?

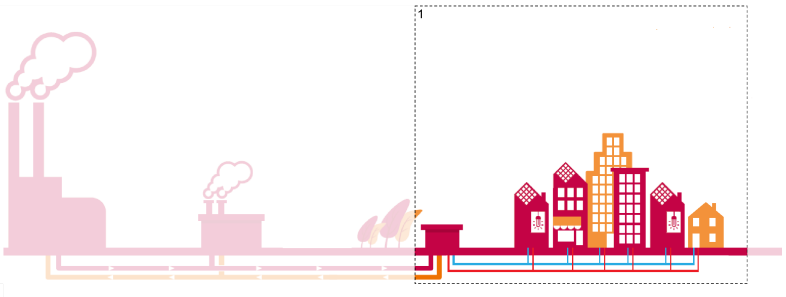


*Figure 8: Part 2 of the research scope: general district heating approach and how the energy company operates as a company.*

As the first part of the research scope is about the general district heating approach and how the energy company operates as a company, first the different stakeholders were identified by looking into the district heating transition process and the innovation process of the energy company. These different stakeholders have a significant impact on the acceptance of the proposed solution and therefore were taken into account during this study.

## External stakeholders: district heating transition process

The municipalities are responsible for the heat transition approach and therefore also decide which neighborhoods are going to be connected to district heating (*Transitievisie Warmte en Wijkuitvoeringsplan*, 2019). Together with property owners, residents, grid operators, and fellow government authorities, the municipalities have created heat transition visions (Transitievisie Warmte). These documents contain proposals for sustainable natural gas-free heating and cooking. It provides direction to the different approaches and also contains a neighborhood-by-neighborhood step-by-step plan that provides all parties with guidance for planning.

Below the step-by-step approach for the gas-free transformation of Rotterdam is described ("Rotterdam aardgasvrij", 2021). Every step is organized by the municipality.

1. Neighborhood analysis

Every area approach starts with a neighborhood analysis done by the municipality. The housing stock, the amount of space that is accessible above and below ground, and other details about the area and its residents (such as their age, income, and so on) are all brought to the table. Additionally, the residents' questions and concerns are gathered.

2. Engaging with coordinated opportunities

Based on the analysis, the aspects are determined which will be included in the area approach.

3. Designing the alternative for natural gas

During the design phase, the preferred alternative for natural gas is developed including an integration strategy. The guiding principle is to ensure proper spatial planning both above and below ground.

4. Phasing:

Based on the proposed alternative, an implementation plan is developed for the area approach. The sequencing and geographical scope of the area are determined.

5. Inspection

The structural characteristics of the most common types of housing are examined. Based on this analysis, the cost of transitions for the different housing types are calculated.

6. Business case for the area

Based on the design and property assessment, a business case is created for each specific area. This document outlines the costs and benefits, as well as the assessment of risks. Using the outcomes, to determine whether to proceed with the approach or not.

7. Offer for building owners

Every building owner will receive a personalized offer to switch to a gas-free system. The offer will include details about the costs involved and how the necessary arrangements for the works will be handled. This offer has been developed together with the stakeholders, such as the heating company, and in conjunction with potential landlords like housing associations. Building owners retain the freedom to accept or reject this offer.

8. Engaging the neighborhood with the offer

The communication channels of the neighborhood are utilized, information sessions are organized, and personal conversations are held to address questions from residents. Those who wish to participate in a collective alternative sign an expression of interest. Subsequently, we develop a connection plan and participants sign a contract with the heat company.

9. Establishing agreements

The outcomes of the entire process are documented in an area agreement. This agreement includes provisions on how the transition will take place, the responsibilities of each party, the timeline, and the conditions under which the activities will be carried out.

10. The transition

Finally, it is time for implementation. Construction activities take place in the public space and the homes of participants. Additionally, the necessary work for the transition to electric cooking is carried out during this phase.

## Conclusion

By analyzing the district heating transition process, the following three stakeholders were identified as important: municipality, landlords, and residents.

**Landlords**

(Housing associations, commercial building owners, privately-owned, rental companies, individual homeowners)

In this study the landlords are given significant importance, as they are not only the point of contact to determine the feasibility of district heating for the buildings, but they also decide which actions can be taken within the buildings.

**Resident**

(Owner & tenant)

The owner of the building and the resident are not necessarily the same. As the end customer, the resident is an important stakeholder as well. Their satisfaction with the product's aesthetics and usage is crucial for the final acceptance. Therefore, their needs and preferences are considered while developing the solutions.

**Municipality**

The municipality mostly plays an important role in the beginning of the process. As explained above, they often work in collaboration with other stakeholders to determine the suitability of neighborhoods for district heating and create the timeline for the connection process. The municipality is also responsible for overseeing specific rules and regulations.

## Internal stakeholders: innovation process of the energy company

The energy company’s innovation process, as displayed in Figure 9 on the next page, consists of four different phases, each comprising various steps aimed at assessing whether a project meets the criteria for further development. Following the intake phase, an evaluation is conducted to determine the project's priority based on its potential desirability, feasibility, and viability. Following the concept phase, a go/no-go evaluation is held to determine if the project fulfills the requirements to proceed to the implementation phase, taking into account lead time, budget, and quality considerations. Throughout each phase, different internal stakeholders are engaged. After the innovation process, the project will go through a soft launch and then the final launch.

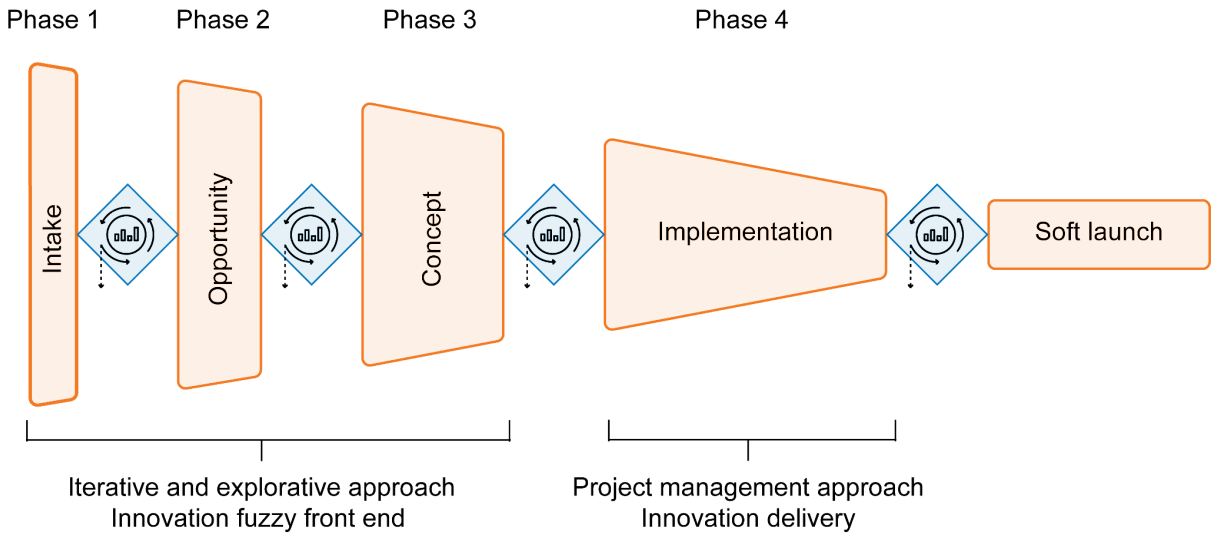



*Figure 9: The innovation process of the energy company*

The following section provides a description of the various phases, stakeholders included, and a time indication of an average project.

Description of stakeholders:
**AIT** (Asset Innovation & Transformation) = Supporting department for innovation and change for the different asset departments within the energy company.
**Business Owner** = Within the energy company, the department that takes on the responsibility and sponsorship of a project (such as project sales or WTP) and ultimately oversees the innovation implementation.
**TIB** (Technical Innovation Board) = Steering group that during the monthly meeting discusses and evaluates the portfolio of innovation. During this meeting, decisions are made on whether or not to proceed with each phase of the project.
**AM** (Asset Management) = Responsible for managing assets in terms of operation and safety. Within district heating the asset includes everything between the distribution network and the HIU.
**Standardization Committee** = During the implementation phase they decide if an innovation will be standardized or not.
**Engineering** = Design the new distribution networks of district heating.
**WTP** (Warmtetransitie Projecten = heat transition projects) = Business development team that is leading the heat transition projects in existing buildings.
**Realization** = Construction of new networks.
**Field Operation** = Maintenance and installation activities beyond the customers' premises.
**Legal** = Handles legal matters, including general contract terms, compliance with heat regulations, patents, etc.
**Procurement** = Responsible for procurement activities, negotiations, and sourcing.

**Intake (2 weeks)**
During the intake, all necessary insights are collected for the first idea presentation. The business owner, one of the energy company's asset teams is contacted for potential ownership from the concept phase until the launch.
*Stakeholders involved: AIT, Business Owner, TIB.*

**Opportunity (4 weeks)**
The opportunity phase further analyzes and identifies the problem and different stakeholders. The desirability, feasibility, and viability are tested by risk evaluation and assumption assessment.
*Stakeholders involved: AIT, Business Owner, TIB, AM, Engineering, WTP.*

**Concept (6 months)**
During the concept phase, the project is refined and validated by further assessing assumptions and risks. A minimum viable product (MVP) is developed and tested. During this phase, an innovation should be proven successful.
*Stakeholders involved: AIT, Business Owner, TIB, AM, Engineering, WTP, Realization, Field Operation, Legal.*

**Implementation (12 months)**
After the innovation proves to be successful, it becomes part of the the energy company's product portfolio. The Standardization Committee reviews and either approves or rejects the product or service as a standard. Subsequently, the energy company must adjust the product and incorporate it into its business model.
*Stakeholders involved: AIT, Business Owner, TIB, AM, Engineering, WTP, Realization, Field Operation, Legal, Procurement, Standardization Committee.*

**Soft launch (6 months)**
After the innovation process, the project will go through the soft launch phase where it is deployed on a small scale.
*Stakeholders involved: AIT, Business Owner, TIB, AM, Engineering, WTP, Realization, Field Operation.*

**Launch (∞ months)**
After a successful soft launch the real launch begins, making it an official project of the energy company.
*Stakeholders involved: AIT, Business Owner, TIB, AM, Engineering, WTP, Realization, Field Operation.*

## Conclusion

The innovation process of the energy company consists of four phases with multiple different stakeholders.
These phases, along with the stakeholders, are the basis of the innovation timeline and therefore will be included in the product innovation roadmaps, as described in the chapter: Product innovation roadmap.

In addition, for the sake of this research, the following stakeholders were identified as important and therefore were included in the design and roadmapping process:

**AM**
Asset Management plays a vital role in deciding whether a project is going to be further developed.

**Standardization Committee**
The standardization committee plays a vital role since it decides if a product is going to be standardized or not.

**Engineering & Field Operation**
The Engineering and Field Operation teams have the expertise in connecting houses to district heating and can provide the necessary information for the process. Additionally, they have to work with the standardized solutions.

**WTP**
As the team responsible for organizing the district heating approach in collaboration with the municipality and housing associations, WTP is a crucial stakeholder.

## The end customer (residents)

In addition to the product's viability and feasibility, the energy company also wants to assess the product's desirability. The end customer was identified as one of the most important stakeholder groups for the desirability of the HIU. To create a good overview of the factors affecting the acceptance of the to be developed product, literature research was done. The following factors were identified as important:

The research of Spetter and Stekelenburg (2021) has identified different factors playing a role while being connected to district heating. The authors looked into how homeowners experienced the approach to connecting to district heating by interviewing eighteen different homeowners from different municipalities. The interviews identified that the homeowners look at the total costs, level of sustainability, and living comfort. Additionally, they investigated the general attitude towards district heating. The authors conclude that people are not always satisfied with the three different mentioned factors and the overall approach.

The research of Kooger et al. (2023) works with three different phases: awareness, decision-making, and implementation. These three phases are all identified as important for the acceptance by the end customer. By doing in-depth interviews and sending out questionnaires to residents of different neighborhoods (which have been connected to district heating), Kooger found that people have a positive attitude towards living gas free. However, the process, including the activities necessary for installation, are seen as drastic and intensive. Kooger also identified that communication during all three phases is very important and should be straightforward.

Van Lidth de Jeugde and Kooger (2022) executed in-depth interviews with fourteen tenants of different residences which have been connected to district heating. They found that people mostly are satisfied with the heat delivery in general. However, they do have a negative attitude towards the physical changes inside their homes. The pipelines are seen as not being physically appealing. Their research also shows that people have different attitudes towards the activities needed for the installation. People complain about the way of working and the amount of time needed. Therefore, the installation time is also considered as an important factor

From the customer satisfaction report of the energy company (Resultaten Q4 2020, 2021), additional important drivers that should be taken into account, which were part of a survey they conducted, are price/ quality ratio, service, sustainability and insight into consumption.

From the previously done research, the following five factors were identified as important when considering the end customer: expenses, level of sustainability, comfort of living, aesthetics, and the time of installation. These factors will be used for the qualitative research before going into the ideation phase, as described in the chapter: Customer satisfaction. Additionally, the studies showed that communication should also be considered when looking at desirability.

# Market overview

What existing solutions does the energy company offer, who are the energy company's competitors, and what alternative solutions are currently available in the market?

Before looking into the new solutions that should be developed, it is important to assess the existing products offered by the energy company and their competitors. Therefore, a product portfolio analysis and competitor analysis were conducted, resulting in the creation of a competitive market overview.

## Product portfolio analysis

According to Mooij (2019) a product portfolio is the collection of products a firm has on the market. Portfolio management is the process of making decisions about the entire set of products that a firm has on the market and in development. A firm needs to decide which new products are going to be developed, which existing products will be supported, and which products might be deleted from the market. To make these decisions an overview of the energy company's current product portfolio (within district heating) was established.

**Heat Interface Unit (HIU)**

The energy company's portfolio consists of seven different types of HIU's. However, only the three on the left in Figure 10 (Arctic DP-120VK, Arctic DP-520VK, and Arctic-HEX-120/130) are going to be used within the coming projects. These HIU's only work with heat delivery (so not both heat and cold delivery), which is the most common situation. The other HIU's also work with both heat and cold or only cold delivery and will not be incorporated into the energy company's future projects for connecting existing residential areas.


*Figure 10: The HIU's from the energy company (the energy company, z.d.-b).*

**Position HIU**

Within the service of district heating, the position of the HIU also plays a major role. The Asset Management and Standardization Committee only permit specific locations for the HIU for a variety of reasons. In the section below the different standardized locations are described.


*Figure 11: Approved rooms to place a HIU (Williams, z.d.-b).*

The HIU can currently only be placed in the kitchen, hall, and utility room. The following factors currently prevent the other rooms from being approved:

- Bathroom, due to moisture issues.
- Toilet, due to hygiene issues.
- The bedroom and living room, due to noise pollution,
- Above the stairs, for safety reasons.
- Outside, due to issues with freezing throughout the winter.
- The attic, due to leakage problems.
- Via the crawling space, due to the amount of leaks and poor accessibility.
- Roof, due to the fact that people need to be trained to work on height.

It is important to keep in mind that these spaces currently are not approved, however with the right solutions they might be approved later. These factors preventing certain spaces for approval could be seen as opportunities.

The following solutions are approved as standard:

**Kitchen cabinet:**

Under the right circumstances, the HIU can be placed in the kitchen drawer. It should be easily accessible for the mechanic and not have any appliances such as a refrigerator underneath it. The bottom of the HIU should not be positioned higher than 150 cm from the ground.

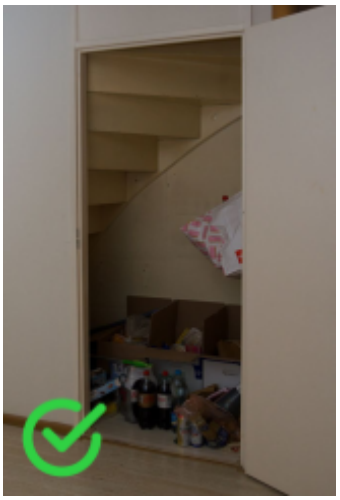
*Figure 12: Approved location: HIU placed in a kitchen drawer (image retrieved from the energy company).*

**Meter cupboard:**

Under the right circumstances, the HIU also can be placed in the meter cupboard. The HIU must be accessible for the mechanic and must have enough space for an escape route. Furthermore, there should not be any electronics located underneath the HIU.

*Figure 13: Approved location: the meter cupboard (image retrieved from the energy company).*

**Staircase cupboard**



The staircase cupboard is only permitted under the right circumstances. There must be sufficient room for the mechanic to safely work on the HIU (minimum height of two meters). Additionally, there must be room for an escape route. Only a few stair cupboards are suitable for the circumstances.

*Figure 14: Approved locations: staircase cupboard (Trapkast progress + plannen, z.d.)*

**Position of indoor pipes**

For high-rise buildings, the energy company also has two approved positions for the pipelines.

**Through the gallery**

Risers through the gallery are approved when having a protective cover. The pipes should still be accessible for mechanics for maintenance.

*Figure 15: Approved locations: risers through the gallery (image retrieved from the energy company).*

**Through the stairwell**

Risers through the stairwell are approved if they are securely fastened and prevent people from sliding down.

*Figure 16: Approved locations: risers through the stairwell (image retrieved from the energy company).*

## Conclusion

From the product portfolio analysis it can be concluded that at this moment the energy company only offers a few types of HIU's. Additionally, a limited number of locations are approved for the HIU and/or pipelines. This research will look into the extension of the energy company's product portfolio.

## Competitor analysis

Since the energy company is not the only company that is aiming to solve the problem of having too much customized work when connecting houses to district heating, it is important to look at the already existing solutions and concepts of competitors. By doing this, a better understanding of the market and the energy company's position in relation to its competitors can be obtained. Additionally, existing solutions can be a great source of inspiration. According to Kotler (2000), there are four levels of competition, based on the degree of product substitutability. For this analysis, the focus will be on the product form (brand competition) and product category (industry competition) levels since these are the only relevant level of competition. This is due to the fact that this research is focussing on product-specific solutions for a specific problem, and not looking into competitors of the energy company as a brand.

Furthermore, it is important to note that the district heating market does not consist of real competition due to the fact that the district heating regions are assigned to specific energy companies. However, the market is regulated by the ACM (Authority for Consumers and Markets), which prevents the energy company from obtaining a monopoly position.

Based on these two levels the following competitors were identified:

- Vattenfall
- Ennatuurlijk
- HVC
- SVP
- Engie

All of these companies are energy distribution and supplier companies involved in the last two steps of district heating: heat distribution and heat delivery (Schilling et al., 2020).

## Competitive market overview

For the competitive market overview product developers were also included. These are not direct competitors of the energy company since they do not develop their own products. They collaborate with these different companies to develop different innovations, however, these products are relevant for the market overview. See Appendix A for the full market overview including all solutions and concepts per company. Figures 17 and 18 show that the solutions can first be divided into the type of building (high-rise vs ground-level buildings) and then be categorized into the ways the pipes enter the building (underground, ground-level, facade, or roof).

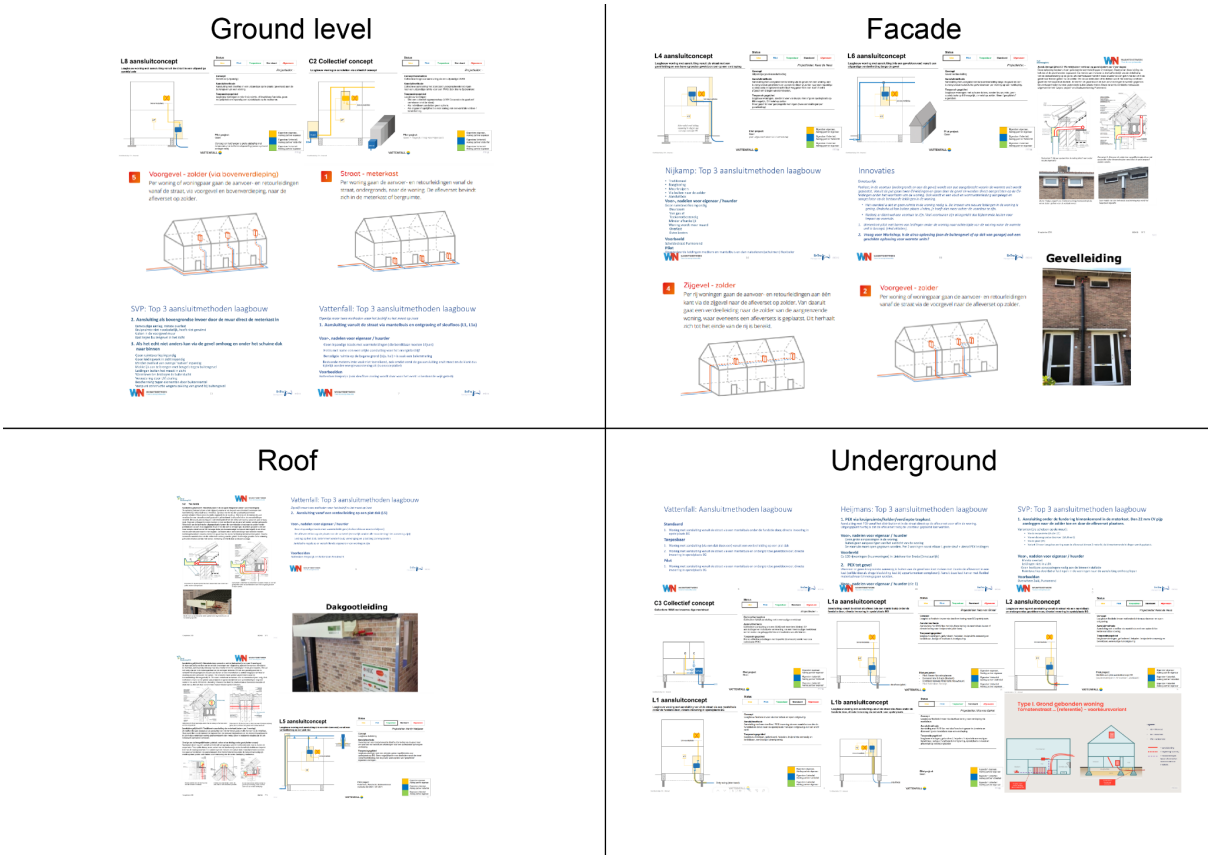



*Figure 17: Overview of the existing solutions and concepts of ground level houses.*

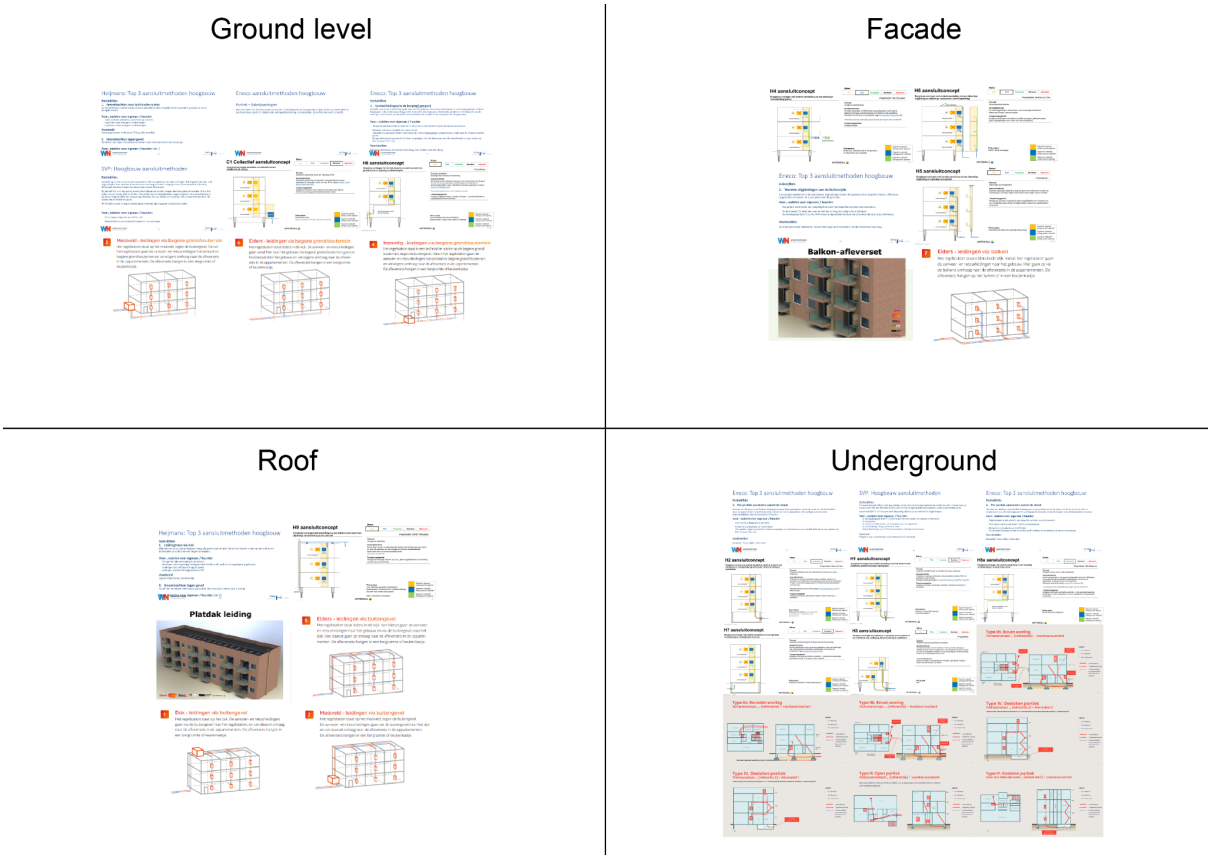



*Figure 18: Overview of the existing solutions and concepts of high-rise buildings.*

Some of the solutions in the competitive market overview are still concepts, indicating a dynamic market where various companies are trying to develop innovative solutions. The overview also reveals that other companies approve a wider range of products compared to the energy company. For ground-level buildings, the energy company exclusively approves connecting through the ground and the placement of the HIU at ground-level. However, the competitive market overview illustrates that other companies are already connecting through the roof and/or facade while locating the HIU in alternative positions such as the attic. For high rise, other companies are already looking into solutions from the roof, where the energy company does not approve this yet. Moreover, these diverse concepts serve as a source of inspiration during the ideation phase, where the challenge lies in exploring possibilities for standardization while securing approval from Asset Management and the Standardization Committee. Lastly, This competitive market overview will be used to assess the developed solutions on their novelty, described in the chapter: Selection & development.

## Conclusion

The competitive market overview highlights that the development of district heating solutions takes place in a dynamic market where multiple companies deal with the same challenges. Furthermore, Comparing this market overview with the energy company's product portfolio reveals that the energy company is trailing behind other companies in terms of innovation. It has yet to develop or approve new solutions for connecting buildings to district heating. To maintain a strong market position and create possibilities for connecting existing buildings to district heating, more room for innovation should be created. Therefore, this research will explore ways to create more opportunities for innovation and expand the energy company's product portfolio accordingly.

# Housing categories

What are the different housing types and what characteristics could be used to further categorize these different types?

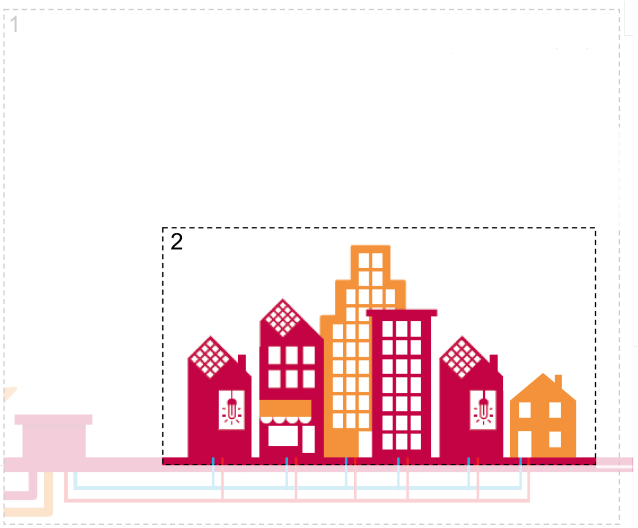



*Figure 19: Part 2 of the research scope: housing types and their architectural characteristics.*

Before going into the ideation phase, the second part of the research scope focuses on housing types and their architectural characteristics. This knowledge plays a significant role in developing suitable solutions for the existing residential areas. In addition to the fact that the type of solution may vary depending on the housing type, this information can also assist in determining which housing types should get priority, described in the next chapter.

## General research

First, general research was done to get an overview of the different characteristics used to distinguish the housing categories within the district heating areas. The following terms were used:

- District heating.
- Connection concepts district heating.
- Proeftuinen Nederland.
- Heat Interface Unit (HIU).

Analyzing the articles led to different relevant documents which contributed to the first part of the research and can be found in row one of table 1. Table 1 gives an overview of the different housing categories and different characteristics used by the different researchers.

| | (Meijer et al., 2022) | (Deverchere, 2021) | (van Hoogstraten, 2022) | (Tigchelaar et al., z.d.) | (Kruit et al., 2019) | (Roos & Manussen, 2011) |
|---|---|---|---|---|---|---|
| **Type of housing** | 1. Ground-level house<br>2. Porch apartment<br>- open porch<br>- closed porch<br>- ground floor house<br>- upstairs house | 1. Ground-level house<br>- Terraced house<br>2. High-rise<br>- apartment | 1. Single-family housing<br>2. Porch apartment<br>3. Gallery entrance flat | 1. Semi detached house<br>2. Multi Family house<br>- ground-level<br>- upstairs<br>- roof-level<br>3. Terraced house<br>- middle<br>- corner<br>4. Detached house | 1. Terraced house<br>2. Ground-floor house<br>3. upstairs house<br>4. Apartment | 1. Ground-level house<br>2. High-rise |
| ***Extra variables included*** | | | | | | |
| **Ownership** | | | | X | | |
| **Presence of crawl space** | | | X | | | |
| **Location HIU/gas boiler** | X | | X | | | |
| **Type of roof** | | | X | | | |
| **Type of heating system** | | | | | | X |
| **Construction period** | | X | | | X | |
| **Average gas consumption** | | X | | X | | |
| **Average living area** | | X | | | X | |
| **Energy label** | | | | X | X | |
| **Riser needed** | X | | X | | | |
| **Way of connecting pipes** | X | | | | | |

*Table 1: Different papers and their factors used for analyzing different types of buildings.*

The following section provides a description of the different characteristics presented in Table 1, along with an explanation of their relevance.

1. **Types of housing**

The first way to distinguish the different types of housing is by separating ground-level buildings from High-rise.

Ground-level buildings:

- Terraced house.
- Semi detached house.
- Detached house.

High-rise:

- Porch building.
- Gallery building.
- Flat (other).

The types of houses influence the layout of the house (horizontally and vertically) which has an influence on the position of the HIU, the entry of the hot and cold water pipes, and also the need for risers inside or outside the house.

2. **Ownership**

Secondly, categorizing can be done by looking into the ownership of the different houses. The following ownerships are taken into account

- Privately owned/owner-occupied housing.
- Rental (e.g. housing associations).

3. **Presence of space underneath the ground floor**

The presence of space underneath a building indicates if it is possible to enter a house with pipes for district heating underneath the ground floor.

This means that for ground-level houses an accessible and sufficiently high crawl space is underneath the entire ground floor not divided by partitions and for porch, gallery flats and apartments the lowest building layer consists entirely of storage rooms and/or garage boxes. This layer can not be partly consisting of homes or shops for example (van Hoogstraten, 2022).

4. **Location HIU/gas boiler**

The preferred location of the HIU is at the gas meter and meter cupboard and/or at the location of the gas boiler (Meijer et al., 2022). Therefore, the position of the gas boiler (horizontally and vertically) is an important factor. This position indicates if horizontal and/or vertical heat pipes through different rooms are necessary if the HIU is placed at the same location.

5. **Type of roof**

The type of roof has an influence on the connecting possibilities since there are opportunities to go over and through the roof with the heating pipes.

6. **Type of heating system**

The type of heating system has an influence on the type of HIU needed.

The following three types of heating systems are identified (Roos & Manussen, 2011):

- Collective system for space heating and individual system for tap water.
- Individual system for both space heating and tap water.
- Collective system for both space heating and tap water.

7. **Construction period**

The methods used to construct and design homes have been evolving over time (JET Digital Media, 2020). Hence, the construction period reveals something about a home's design, which is important knowledge when examining possible connections to district heating. In addition, the construction period suggests additional details, such as the type of insulation.

8. **Average gas consumption**

The gas consumption can provide insights into both the insulation level of the homes and an indication of the heat demand.

9. **Average living area**

The average living area gives an indication of the gas consumption and could also indicate the amount of renovation needed.

10. **Energy label**

The energy label could indicate the type of insulation of a home.

11. **Riser needed & way of connecting pipes**

Both variables are very important when connecting a home to district heating. Like the position of the gas boiler, it can indicate if horizontal and/or vertical heat pipes through different rooms are necessary.

## Interviews

Secondly, to validate the characteristics mentioned above, to make a selection of the most important ones, and to gain more insight into why these are important, qualitative research was done by doing semi-structured interviews. Interviews were held with three employees, two employees from Engineering, and one person from Field Operation. Additionally, two Architecture PhD students from TU Delft were interviewed.

**Goal of interview (Engineering & Field Operation)**

- Confirm and identify the characteristics that are considered important in connecting buildings to district heating.
- Confirm and identify the characteristics currently used to distinguish buildings.
- Gain more insights into the engineering process of district heating.

**Interview method (Engineering & Field Operation)**

- Introduction.
- General questions (2).
- Questions about building characteristics (3).
- Questions about the connecting process (3).

**Valuable insights (Engineering & Field Operation):**

Information is considered valuable when it establishes a direct connection with one of the interview goals provided above. Furthermore, they are either mentioned by multiple individuals or are individually remarkable.

***Type of housing is considered important***

The primary method of distinguishing or categorizing buildings is by examining the different types of housing. This provides much information and offers an initial indication of whether a certain solution is applicable or not. Within these housing categories, similarities are often found.

*quote interviewee:*

> *"Porch houses are very common and they often look alike."*
> *“The layout per building is often different, although there are many flats with similarities.”*

***Type of ownership***

All three interviewees emphasized that examining the ownership can reveal a lot about a building. Buildings owned by housing associations tend to have the same layout as they strive for standardization. Renters are not allowed to make changes to these properties. On the other hand, privately owned apartments or buildings often undergo renovations, resulting in unique floor plans.

*quote interviewee:*

> *"Housing associations always try to standardize, even before the Bouwbesluit came."*

***Presence of crawl space***
Two interviewees mentioned that the presence of a crawling space is always checked since this could be a great opportunity for pipes to go through.

***Position of gas/heat boiler***
The interviewees all highlighted the importance of the gas boiler's position. It is crucial to determine if the HIU can be placed there and whether horizontal and/or vertical piping is required.

*quote interviewee:*

> *"The position of the gas boiler is very important if you want to connect a building to district heating, both vertically and horizontally."*

***Type of roof***
Two interviewees stated that, preferably, solutions should be implemented through the roof. This is because, in ground-level buildings, the gas boiler is typically located in the attic. Therefore, accessing the attic allows for the installation of the HIU in the same location as the gas boiler, avoiding the need for additional indoor pipes.

*quote interviewee:*

> *"Entering through the roof would be the ideal solution, as in many homes the gas boiler is upstairs."*

***Construction period***
All of the interviewees mentioned that the construction period is regarded as highly valuable as it provides substantial information about the building. It can also indicate whether certain regulations, such as Bouwbesluiten, have been applied to the buildings. After 1980, specific elements of houses began to resemble one another due to these regulations. The older the buildings are, the more variations can be expected, including those resulting from renovations.

*quote interviewee:*

> *"The construction year is very important and provides a lot of information about the building."*
> *"From 1990, the way buildings were constructed became quite uniform, and standardized designs emerged within homes."*

**Goal of interview (PhD Architecture)**

- Gain more insights into the building characteristics.
- Confirm and identify the characteristics that are considered important when distinguishing buildings.

**Interview method (PhD Architecture)**

- Introduction.
- General questions (2).
- Questions about building characteristics (5).

**Valuable insights (Architecture):**

Information is considered valuable when it establishes a direct connection with one of the interview goals provided above. Furthermore, they are either mentioned by multiple individuals or are individually remarkable.

***Type of housing***

Both interviewees mentioned that the type of housing provides general information. Additionally, it is observed that within high-rise buildings apartments are often standardized.

*quote interviewee:*

> *"I would say that more than 50% of the time you can standardize an apartment within one building."*

***Ownership***

Both interviewees mentioned that when buildings or apartments are rented, there is a higher chance of standardized floor plans. This is due to the fact that as a tenant you are not allowed to just change something within the apartment.

*quote interviewee:*

> *"The type of ownership does influence this, housing corporations and associations have a lot of control over the buildings (also the VVE). If you rent something you are not allowed to just change something."*

***Construction period***

The construction period can provide different information about a building, like insulation, design, and floor plan. One of the interviewees mentioned that historic city centers are a really big challenge.

*quote interviewee:*

> *"The construction year gives you information about insulation properties, what type of construction style the house might have, the Bouwbesluit can also give you information about the floor plan due to the regulations."*
> *"Standardized solutions for buildings in historic city centers is a very big challenge."*

***Energy label***
One of the interviewees mentioned that Energy Labels are not going to impact the way buildings are going to be connected.

*quote interviewee:*

> *"I do not think energy labels or gas consumption is something you have to look into, it doesn't really affect the way you want to connect."*

***Similarities***
One of the interviewees advised to look at the similarities of different buildings rather than ways to distinguish them. Many buildings have overlapping characteristics. When developing a solution, it is beneficial to consider solutions that can be applied to a wide range of buildings.

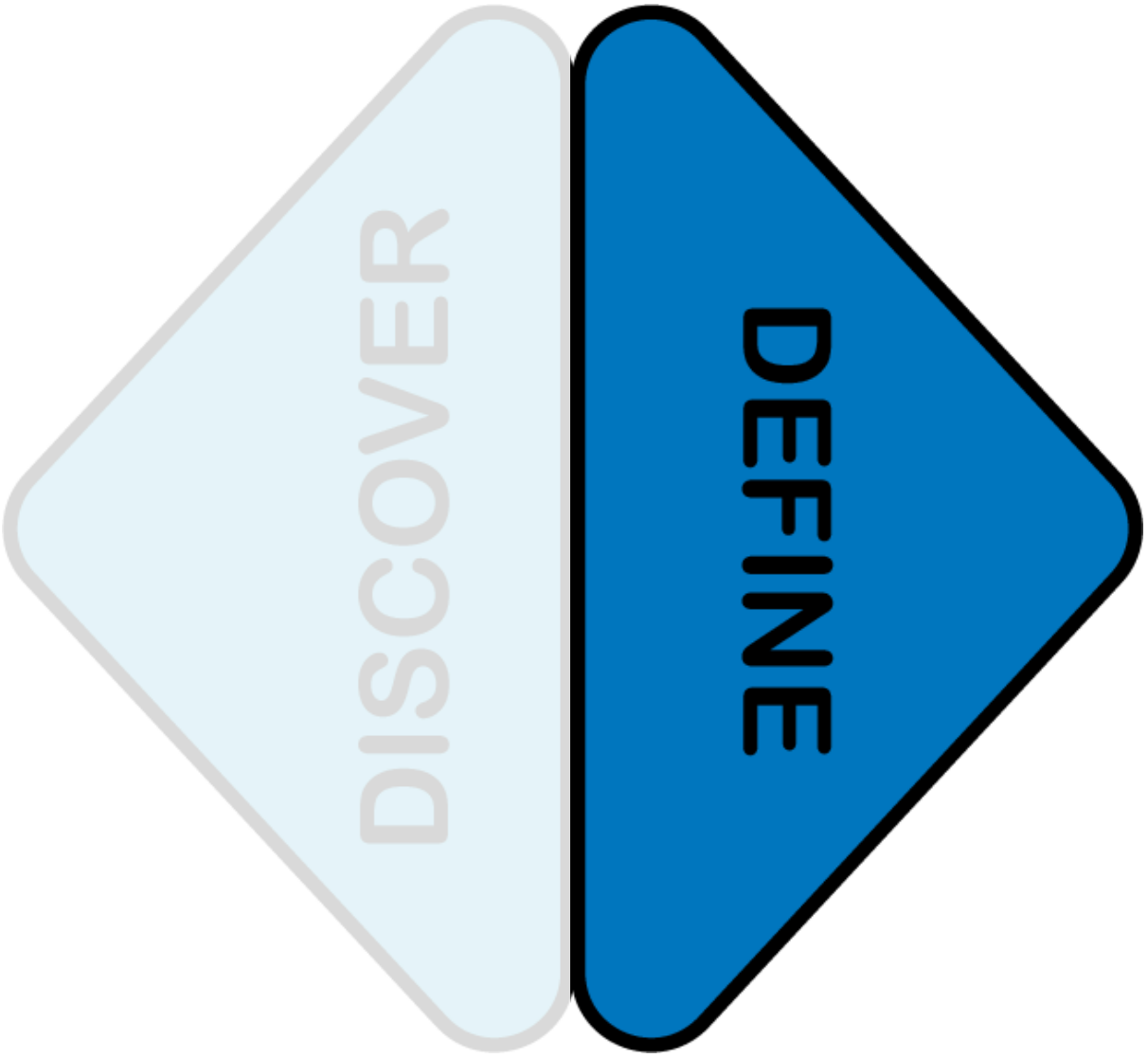
## Discussion

The interviews gave useful insights into the important characteristics of buildings when connecting to district heating. A great general overview of these characteristics was generated by the information. However, further research is recommended to gain more insight into the connecting possibilities within the different housing types identified. This could be accomplished through qualitative research with architectural experts. The primary objective should be to further refine the distinctions among various housing types and their unique characteristics. This information can also be used to validate the applicability of new solutions.

## Conclusion

The general research and semi-structured interviews show that the housing type, the construction year, and the type of owner are considered to be the most important factors when creating different housing categories. These factors have the biggest impact on the design of the buildings, including the floor plan, and will be utilized for prioritizing the categories, as elaborated in the next chapter. The presence of space underneath the building, the position of the gas boiler/HIU, the type of roof, and the type of heating system are seen as relevant factors when looking for a solution to connect to district heating and will be used during the ideation phase. Lastly, gas consumption, average living area, and energy labels are excluded from this research as they are considered irrelevant to the design of the building or for the type of solution.

# Research - Define



# Prioritizing

Which housing types are the most interesting for the energy company to focus on, looking at the difficulty, quantity, and timing?

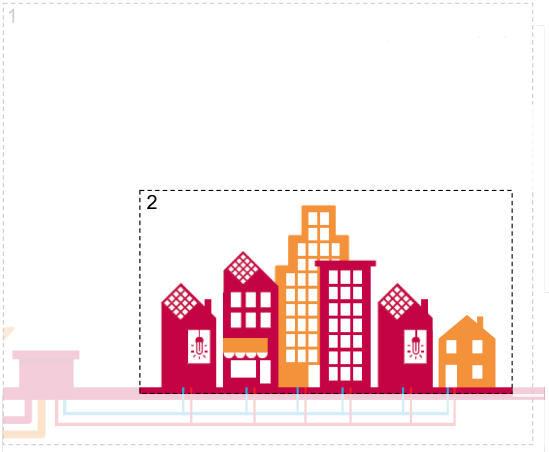



*Figure 20: Part 2 of the research scope: housing types and their architectural characteristics.*

Given that solutions may vary depending on the housing type and the time constraints preventing the development of customized solutions for each type, it is necessary to prioritize the housing types prior to the ideation phase. Therefore, this part of the define phase still focuses on the second part of the research scope.

The following three factors were chosen as the most important when prioritizing the different housing types:

**Difficulty:** refers to the amount of work required to create a standardized solution for that particular housing type or category. Meaning that when the difficulty is high, it will be very challenging to find a standardized solution. This must be considered because it shows whether it is worth developing a particular solution and how much effort it might require (also an indicator of time).
**Quantity:** refers to the amount of buildings of that particular housing type or category in the Netherlands. This illustrates how interesting it is to develop a standardized solution also considering future plans of district heating. It also illustrates whether standardizing for that particular housing type or category can be seen as feasible.
**Timing:** refers to the amount of buildings of a particular housing type or category that will be connected to district heating first, looking at Rotterdam, Utrecht, and Den Haag (further discussed in the section: Case study - timing)

## Interviews - difficulty

To determine the level of difficulty interviews were held with three employees, two employees from Engineering and one person from Field Operation.

**Goal of interviews**

- Gain more insights into the problems engineers encounter when connecting homes to district heating.
- Look into the solutions already in use.
- Find the gaps between problems and solutions.

**Interview method**

- Introduction.
- General questions (2).
- Questions about the problems engineers encounter (1).
- Questions about existing solutions (3).

**Valuable insights**

Information is considered valuable when it establishes a direct connection with one of the interview goals provided above. Furthermore, they are either mentioned by multiple individuals or are individually remarkable.

It is determined that, in general, we can assume that it is more challenging to develop a standardized solution when a home is privately owned. This is the case because buildings that are privately owned more frequently undergo renovations and frequently have their unique floor designs, to begin with.

*quote interviewee:*

> *"Privately owned homes are being renovated more often, you cannot rely on the information if certain cabinets or walls are still there."*

Additionally, it also is determined that developing a standardized solution for rental houses is easier. This is a result of rental companies frequently using the same floor plans for the houses in their buildings. Particularly housing associations, as they possess a large number of buildings as well as residences that share a common floor plan.

*quote interviewee:*

> *"Housing associations tend to standardize their buildings, therefore you often find similarities, also before the nineties."*

Also, it is concluded that it is most likely significantly harder to develop a standardized solution for privately owned homes before 1992. This is due to the fact that before 1992 there were no strict building orders (Online Bouwbesluit, z.d.) and the older the homes, the higher the chance of it being renovated (Carney Properties, 2019).

*quote interviewee:*

> *"For homes, after 1992 it is a lot easier, the challenges lie in the older houses where the way of building is not the same."*
> *"Houses after the first Bouwbesluit are probably the easiest to connect."*

Lastly, it is concluded that detached and semi-detached houses are more challenging since they mostly do not have the same floor plans, also due to the fact that most of them are privately owned (presented in the chapter: Case study)

*quote interviewee:*

> *"The floor plans of the homes within the same building are often the same, in case of apartments, terraced houses and flats."*

## General research - quantity

To determine the quantity of the different housing categories the information of Rijksdienst voor Ondernemend Nederland (RVO) has been used (Rijksdienst voor Ondernemend Nederland, 2022).

| Type of building | Quantity |
|---|---|
| Detached house | 15.5 % |
| Semi-detached house | 11.8 % |
| Terraced house | 40.2 % |
| Maisonnette | 5.5 % |
| Gallery house | 9.8 % |
| Porch house | 11.1 % |
| Flat (other) | 6.1 % |

*Table 2: The number of buildings (in percentage) per housing type in the Netherlands.*

The percentage of buildings for each housing type in the Netherlands are shown in Table 2. According to this information the most interesting types of houses, when looking at quantities are: Terraced Houses, Detached houses, Semi-detached houses, Porch houses, and Gallery houses (in order of largest to smallest quantity).

## Case study - timing

Rotterdam, Den Haag, and Utrecht were used for a case study to determine the timing of the different housing categories. It is decided to focus on these municipalities as the energy company is already operating district heating here and the question is whether they will further expand on this in the future. This is due to the legislation to be developed around district heating, which gives the municipality primary ownership of the distribution network. Meaning that the energy company does not have control over the distribution network, making the investment no longer worthwhile. The existing networks and network expansion do not fall under this legislation.

For each municipality, the Transitievies Warmte was utilized to determine which neighborhoods would be initially connected to district heating. Rotterdam and Den Haag work in two phases while Utrecht works in three. This information, along with the energy company's GEOdata, provides a general idea of how many housing categories will be connected during each phase. Appendix B elaborates on the Excel instructions. These different phases will also be utilized for the general roadmap, as they form the basis for the timeline of the transition of district heating. Additionally, the number of buildings per category to be connected during each phase will also be incorporated within the roadmap, as it provides insights into the viability of the to be developed solutions.

Below the average percentages of the three municipalities combined are presented per factor, per phase. The third column represents the percentage of houses per housing type. Then, the percentages of privately owned buildings, rental buildings, buildings owned by housing associations, and buildings constructed before 1992 are presented in relation to the total amount per housing type. .

Source Utrecht: (“Transitievisie Warmte deel 1”, 2021), (“Transitievisie Warmte deel 2”, 2021)
Source Rotterdam: (“Rotterdam aardgasvrij”, 2021)
Source Den Haag: (“Transitievisie warmte Den Haag”, 2022)
Geodata: 20230322 Woninginformatie Utrecht.xlsx, 20230323 Woninginformatie Den Haag.xlsx, 20230323 Woninginformatie Rotterdam.xlsx

| Phase one (before 2026) | Type of building | Total amount | Amount privately owned | Amount rental | Amount housing associations | Amount <92 |
|---|---|---|---|---|---|---|
| High-rise | Flat (other) | 47.5% | 28% | 72% | 56% | 78% |
| | Gallery house | 3.5% | 26% | 74% | 83% | 41% |
| | Maisonnette | 8.5% | 27% | 73% | 52% | 85% |
| | Porch house | 5.5% | 8.5% | 91.5% | 93.5% | 92% |
| Ground-level | Terraced house | 28.5% | 53% | 47% | 29.5% | 79% |
| | Semi-detached house | 6% | 53% | 47% | 30% | 76% |
| | Detached house | 0.5% | - | - | - | - |

*Table 2: Overview of the amount per housing type that will be connected to district heating before 2026, together with the most important supplemental data.*

| Phase two (before 2032) | Type of building | Total amount | Amount privately owned | Amount rental | Amount housing associations | Amount <92 |
|---|---|---|---|---|---|---|
| High-rise | Flat (other) | 48% | 34% | 66% | 49% | 58% |
| | Gallery house | 4% | 17% | 83% | 87% | 28% |
| | Maisonnette | 8% | 36% | 64% | 49% | 73% |
| | Porch house | 4% | 16% | 84% | 75% | 80% |
| Ground-level | Terraced house | 26% | 50% | 50% | 35% | 42% |
| | Semi-detached house | 9% | 59% | 41% | 26% | 39% |
| | Detached house | 1% | 81% | 19% | 0% | 25% |

*Table 3: Overview of the amount per housing type that will be connected to district heating before 2032, together with the most important supplemental data.*

| Phase three (After 2032) | Type of building | Total amount | Amount privately owned | Amount rental | Amount housing associations | Amount <92 |
|---|---|---|---|---|---|---|
| High-rise | Flat (other) | 63% | 40% | 60% | 32.5% | 67.5% |
| | Gallery house | 5% | 19% | 81% | 72% | 51.5% |
| | Maisonnette | 10.5% | 31% | 69% | 52.5% | 49% |
| | Porch house | 2% | 15.5% | 84.5% | 77.5% | 80% |
| Ground-level | Terraced house | 16% | 56.5% | 43.5% | 28.5 | 85% |
| | Semi-detached house | 3% | 54.5% | 45.5% | 28% | 64% |
| | Detached house | 0.5% | - | - | - | - |

*Table 4: Overview of the amount per housing type that will be connected to district heating after 2032, together with the most important supplemental data.*

Remarks on the data:

- In phases one and two there are some occasions when the amount of housing corporation is higher than the amount of rental, which shouldn't be possible. This could be attributed to the combination of multiple smaller datasets.
- When compared to the Netherlands as a whole, the amount of Flat (other) is improbable high. This could be due to an incomplete dataset or the combination of multiple smaller datasets.
- The numbers are rounded except when exactly .5
- These percentages represent the three municipalities' averages. There are, however, occasionally significant variances between these municipalities. Thus, the original Excel sheets indicated above should be used when looking per municipality.
- Only the information of 50% of the buildings is included within this data set. However, this still gives a good impression of the distribution of the different housing types.

## Categories

From the interview, general research, and case studies all the housing categories were rated. The detailed rating with explanation can be found in Appendix C. The following section presents the excluded categories and the reasoning behind their exclusion, followed by the included categories, along with the reasons for their selection, building characteristics, and floor plans.

**A. Flat (other)**
In the Netherlands there is a relatively low quantity of buildings classified as “Flat (other)” . Also, this category does not have a clear description of the building and therefore lacks a clear indication of the building's design and/or floor plan. This category is being used for different types of buildings that do not fit in with the other categories, therefore making standardization very difficult. When looking at the timing, flat (other) should get a high prioritization, however as already mentioned before, these percentages are improbably high.

**C. Maisonnette**
Maisonnettes are the lowest in quantity within the Netherlands and therefore are not interesting to focus on. Additionally, this type of building does not have priority when looking at the timing of the different municipalities. Rented maisonnettes within the same building have the potential to be standardized due to the fact that there is a high chance of similarities within the floor plans. However, because of the reasons mentioned above, maisonnettes do not have priority.

**F. Semi-detached house**
In the Netherlands there are relatively many semi-detached houses. However, they all have their individual floor plans leading to a high difficulty when looking at standardization. When looking at time, this type of building does not have priority. Semi-detached houses are therefore excluded within this research.

**G Detached house**
Detached houses all have their own design, also in terms of floor plans. Most of them are privately owned meaning that the chance of renovations is high. They are high in quantity but do not have any priority when looking at the timing of the municipalities. Standardizing is therefore not possible. Detached houses are therefore not included in this research.

**B. Gallery building**

In the Netherlands there are quite some porch buildings (9.8%), the second highest amount of high-rise buildings. They are not among the highest numbers when it comes to timing. However, they are high-rise and primarily rented, indicating that within the buildings homes will be comparable and therefore more easy to standardize.

*Figure 21: Example of a Gallery building (Rijksdienst voor Ondernemend Nederland, 2022).*


*Figure 22: Floor plan of a typical Gallery building (Referentiewoningen nieuwbouw, 2006).*

Two to four rooms[1]
One floor[1]
Entrance from open or closed gallery[1]
Often horizontal roof (over 80%)[2]
If over five levels, always an CLV-system[3]

*1 (Rijksdienst voor Ondernemend Nederland, 2022)*
*2 20230309 Woninginformatie Nederland.xlsx*
*3 Interview. field operations -installation*

*Figure 23: Main characteristics of a Gallery building.*

**D. Porch building**

In the Netherlands there are quite some porch buildings (11%), especially when looking at the other high-rise types of buildings (their average is 7%). They are not among the highest numbers when it comes to timing. However, they are high-rise and primarily rented, indicating that within the buildings homes will be comparable and therefore easier to standardize.

*Figure 24: Example of a Porch building (Rijksdienst voor Ondernemend Nederland, 2022).*

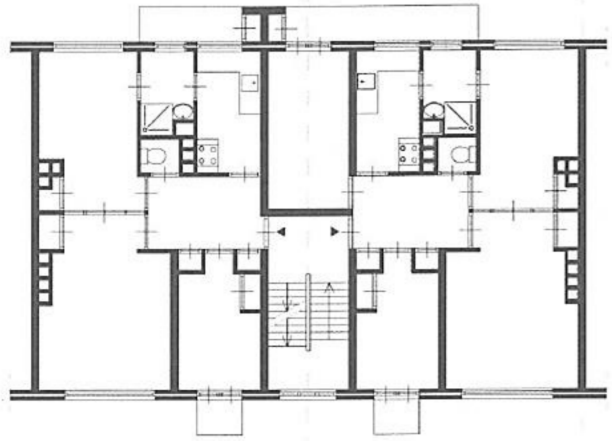


*Figure 25: Floor plan of a typical Porch building (van Hoogstraten, 2022).*

Two to four rooms[1]
One floor[1]
Entrance from open or closed porch[1]
Often horizontal roof (over 80%)[2]
If over five levels, always an CLV-system[3]
Plinth is usually used as storage room, bicycle shed or garage[4]

*1 (Rijksdienst voor Ondernemend Nederland, 2022)*
*2 20230309 Woninginformatie Nederland.xlsx*
*3 See interview field operations -installation*
*4 (van vlaenderen, 2011)*

*Figure 26: Main characteristics of a Porch building.*

**E. Terraced house**

Within the Netherlands there are significantly more terraced houses than other buildings, making standardization interesting. When looking at timing, Terraced houses are the highest amount within the first two phases and second highest in the third phase (when excluding flats (other)). Terraced houses are not high-rise, still almost 50% are rented, indicating that there is a good probability that they will share similar floor plans.

*Figure 27: Example of a terraced house (Rijksdienst voor Ondernemend Nederland, 2022).*

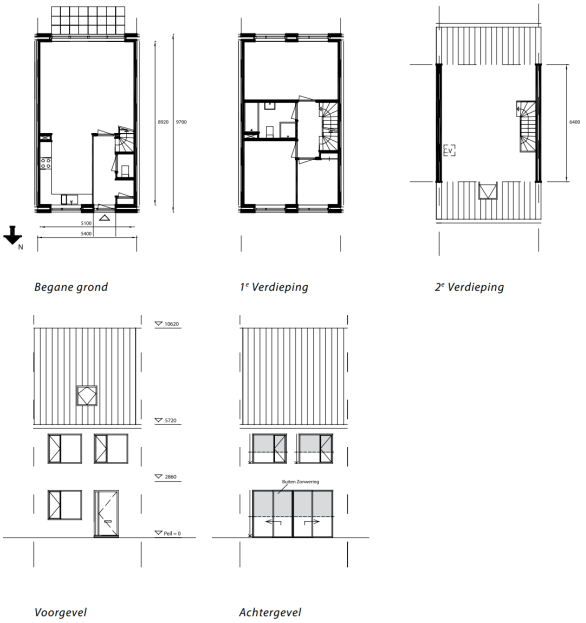



*Figure 28: Floor plan of a typical terraced house( Referentiewoningen nieuwbouw, 2006).*

Three to five rooms[1]
Two or three floors[1]
Entrance directly from ground floor[1]
Often slanted roof (over 65%)[2]
Often crawl space[3]
Often gas boiler in the attic[3]

*1 (Rijksdienst voor Ondernemend Nederland, 2022)*
*2 20230309 Woninginformatie Nederland.xlsx*
*3 Interviews, see Housing categories*

*Figure 29: Main characteristics of a Terraced house.*

## Discussion

The interviews, general research, and case study provide valuable insights into the difficulty, quantity, and timing of the to be developed solutions. However, there are some points of discussion, such as the incomplete data set for the case study. It is recommended to further expand and refine this dataset by implementing a program that collects all the necessary data through analysis or by aggregating various publicly available datasets. Another approach is to collaborate with organizations that already possess the relevant data. Additionally, more research could be done by further investigating the difficulty of the to be connected housing types by interviewing more employees from Engineering and Field Operation and incorporating more building specific questions.

## Conclusion

Based on the interviews, general research, and the case studies, the following three housing categories are seen as the most relevant: terraced house, porch building, and gallery building. All three housing categories were selected based on their quantity, difficulty to develop a standardized solution, and the timing of being connected to district heating. These three housing types, including the described characteristics, will be the starting point of the ideation phase.

Moreover, the timelines and quantities derived from the case studies will be utilized for the general roadmap as they form the basis for the timeline of the transition of district heating and provide insight into the feasibility and viability of the to be developed solutions.

# Identified problems

## What are the different problems when connecting the housing types to district heating?

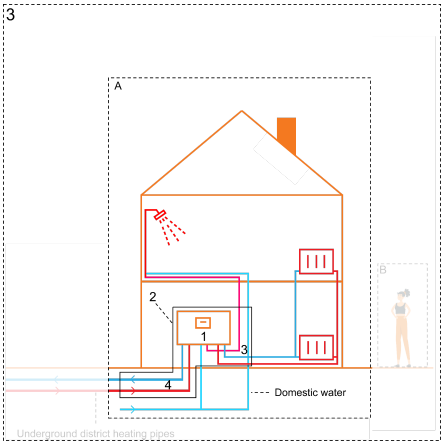



*FIgure 30: Part 3A of the research scope: building-specific problems and methods of connecting to district heating.*

The third part of the research scope focuses on the building-specific problems and methods of connecting to district heating. To ensure effective problem-solving for each housing type during the ideation phase, it is necessary to identify the specific problems arising when connecting to district heating. Therefore, physical assessments were conducted and information from the semi-structured interviews with the three company employees, two employees from Engineering and one person from Field Operation, was used.

## Physical assessment

Physical assessments were done by visiting eight different homes that are going to be connected to district heating. Along with members of the Innovation team, the municipality, the housing association, engineers, and mechanics, this fieldwork was completed. Viewing of these homes provided additional information on the issues when connecting existing residential areas to district heating. Also, information about the various stakeholders' perspectives was acquired. Together with these stakeholders problems and potential solutions were explored.

Type of building

- Porch building (3).
- Terraced building (5).

The following problems were identified, for porch buildings, during the viewing:

- Gas boilers were (vertically) not located at the same location. Therefore you cannot use a straight riser.
- There was not enough space in the hall to place the HIU.
- Due to the Law on Working Conditions the crawl space was not desirable.
- From the roof is not really being discussed since this is not yet approved.
- There was not enough space to let the pipes go underneath the ceiling.

The following problems were identified, for terraced buildings, during the viewing:

- Gas boilers were all located in the attic.
- Inside the homes no room was available for risers.
- Limited space available at the front door hall.

## Interviews

From the semi-structured interviews the following problems were identified when connecting existing residential areas to district heating:

Placement of pipes: The key consideration, not just the HIU type.

*quote interviewee:*

> *"The challenge often lies not with the HIU itself, but rather with determining the optimal placement of pipes and how to enter the homes."*

Space constraints: Insufficient room for HIU and pipes.

*quote interviewee:*

> *"Many times small corridors cause problems. You need enough space for the HIU, as well as enough space to make a turn with the pipes (due to the radius of the turn)."*

**For Terraced buildings:**
Boilers are often located in the attic.

*quote interviewee:*

> *"Boilers are often located in the attic, while you want to enter the house's ground floor."*

Varied Nature of Crawl Spaces.

*quote interviewee:*

> *"Due to the inherent variability in crawl spaces, achieving standardization can be challenging."*

Risers inside the house are almost always too complicated.

*quote interviewee:*

> *"With really old homes, the floor plans are always very different, we need a standardized riser from the outside."*

**For porch and gallery buildings:**
Porch and Gallery Buildings (below five floors): Challenges in Vertical Alignment of the gas boiler.

*quote interviewee:*

> *"Boilers often aren't above each other in buildings. Because of this, you can't just go up vertically. Going horizontal with the pipes is often difficult because you have the problem that you need to go through the ceiling/floor which costs a lot of effort and is not always possible."*

Diverse CLV systems

*quote interviewee:*

> *"There is a lot of variety within the CLV systems and therefore it can be difficult to find a standardized solution working with it."*

## Conclusion

From the different steps taken, the problems per housing category were identified. These different sub-problems all are a part of the main research questions. In conclusion, conducting interviews and viewing the houses helped to identify the following main problems: The HIU frequently cannot be placed at the approved locations. As a result, alternative locations must be found, leading to the installation of internal pipes that run horizontally and/or vertically through the homes. Yet, there are no standardized solutions for these pipelines. Additionally, it is evident that while most problems are common across all buildings, the solutions may vary depending on the specific characteristics of each building. These problems will be addressed during the ideation phase.

# Customer needs

## What has to be taken into account when looking at the desirability of the product?

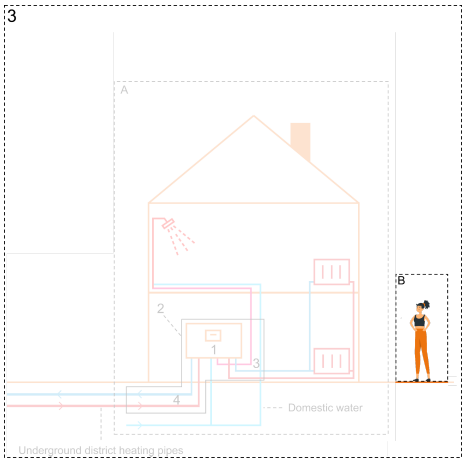



*FIgure 31: Part 3B of the research scope: customer needs and identified problems.*

Part 3B of the research scope involves identifying the needs of customers and examining the problems encountered during the district heating process. Therefore, three interviews were held with residents of Utrecht Overvecht-Noord (OVN) who are actively involved in the residents' advisory group for the OVN transition project. Additionally, two more interviews were held with Dutch housing associations, who also own buildings in OVN. OVN is a neighborhood in the municipality of Utrecht that is going to be connected to district heating in the coming years.

**Goal of the interviews:**

- Confirm and identify the factors that are considered important when connecting to district heating.
- Test the assumptions made by the energy company in approving or declining new solutions.
- Explore the reasoning behind the thoughts and decision-making processes.
- Investigate the communication dynamics among the energy company, housing associations, and the residents.

**Interview Method:**

A structured interview was conducted, focusing on three main themes:

- Introduction.
- General questions (6 questions).
- Communication-related questions (4 questions).
- Questions regarding the important factors to consider (5 questions).
- Questions about the areas suitable for the HIU and/or pipes (13 questions).

## Valuable insights residents

Information is considered valuable when it establishes a direct connection with one of the interview goals provided above. Furthermore, they are either mentioned by multiple individuals or are individually remarkable.

| **Shielded due to sensitive information** |
| --- |

## Valuable insights housing associations

| Shielded due to sensitive information |
| --- |

## Discussion

The conducted interviews provided valuable insights into the customers' perspectives. However, one of the primary concerns regarding these in-depth interviews is the limitation in the sample size due to time constraints. Therefore, it can be questioned whether data saturation is achieved. Data saturation means that a point is reached at which additional interviews no longer generate new insights. Further research should focus on exploring the concept of data saturation within the context of this study. This can involve conducting additional interviews or employing alternative methods, like quantitative research, to ensure a comprehensive understanding of the research topic. Additionally, it can be argued that there is some bias present as the interviewees from OVN are in the residents' advisory group. This means that the findings and conclusions found during the interviews may not represent the perspectives of the broader population. Further research should explore this by implementing a random sampling technique when selecting participants for interviews or surveys.

## Conclusion

To overcome challenges in adopting district heating, the energy company should improve their communication about their process, progress, and the benefits of district heating to the residents.

For housing associations, the monthly cost is the biggest problem when looking at district heating. However, the monthly cost is not part of this research. They do not believe that the answers lie within the technical solution. Developing suitable products may help to convince the end customers, however, the biggest problem lies with the current distrust around district heating at the moment. Being more transparent and directly communicating to the end customer could help solve this problem.

Additionally, factors such as aesthetics, required renovation, duration of renovation, and space requirements are seen as important factors from the customer's point of view. These factors will be taken into account during the ideation phase. Furthermore, the interviews show that residents are willing to make compromises to look into different types of solutions. Under the right circumstances, such as when the noise of the HIU is limited and does not take up valuable space, different areas can be used for the HIU and/or pipes. This proves that, from the customer's perspective, there is room for innovation. However, it is crucial to develop appropriate solutions and persuade the Asset Management and Standardization Committee to provide more room for innovation.

# Cross-industry insights

## What can be learned from optical fiber network companies?

To gain valuable insights and inspiration, an additional interview was conducted with an optical fiber network company. This company connects homes to optical fiber networks for various network providers. There are many parallels between connecting to district heating and connecting to optical fiber. In both scenarios, households need to be connected to the distribution network by entering the homes and reaching a specific location.

**Goal of the interview**

- Explore the process of connecting to the optical fiber network.
- Determine the assumptions made prior to physical viewing and connection.
- Investigate the analysis conducted beforehand.
- Understand the company's communication methods with end customers.
- Identify reasons why people may refuse to connect to the optical fiber network.
- Extract lessons that can be learned from their process.

**Interview Method**

A structured interview will be conducted, focusing on three main themes:

- Introduction.
- General questions about the company's process (6 questions).
- Questions about their analysis and assumptions (8 questions).
- Questions specifically related to communication (2 questions).

**Valuable insights**

Information is considered valuable when it establishes a direct connection with one of the interview goals provided above. Furthermore, they are either mentioned by multiple individuals or are individually remarkable.

***Significance of physical viewing***

Physically viewing every home is crucial for two reasons. First of all, this is an opportunity to physically reach out to your customers. You can use this to persuade them to sign up for the offered service and provide customer service. Second, all information required to connect these various homes can be acquired, smoothening the process later on.

***Standardizing connecting methods***

Every customer wants their own customized solution. It’s important to consider what you can and are willing to offer. Only the standardized solutions that are best for the company providing the service should be presented. The optical fiber network provider chose to limit their options and only offer facade connecting options to high-rise buildings since doing so makes connecting much more efficient.

***Importance of communication***
Marketing and communication is one of the crucial aspects throughout the entire process. Persuading people to buy the services requires effective communication of information and physical customer service. When people are convinced of the service, they do not care as much about the technical solution.

***Laying pipes to the last meter***
Even if homes do not want to connect to district heating, it is advisable to lay the pipes up to their houses. This ensures that if the customer decides to connect later on, the only step that has to be taken is the final one. This avoids additional costs, like opening up the streets again.

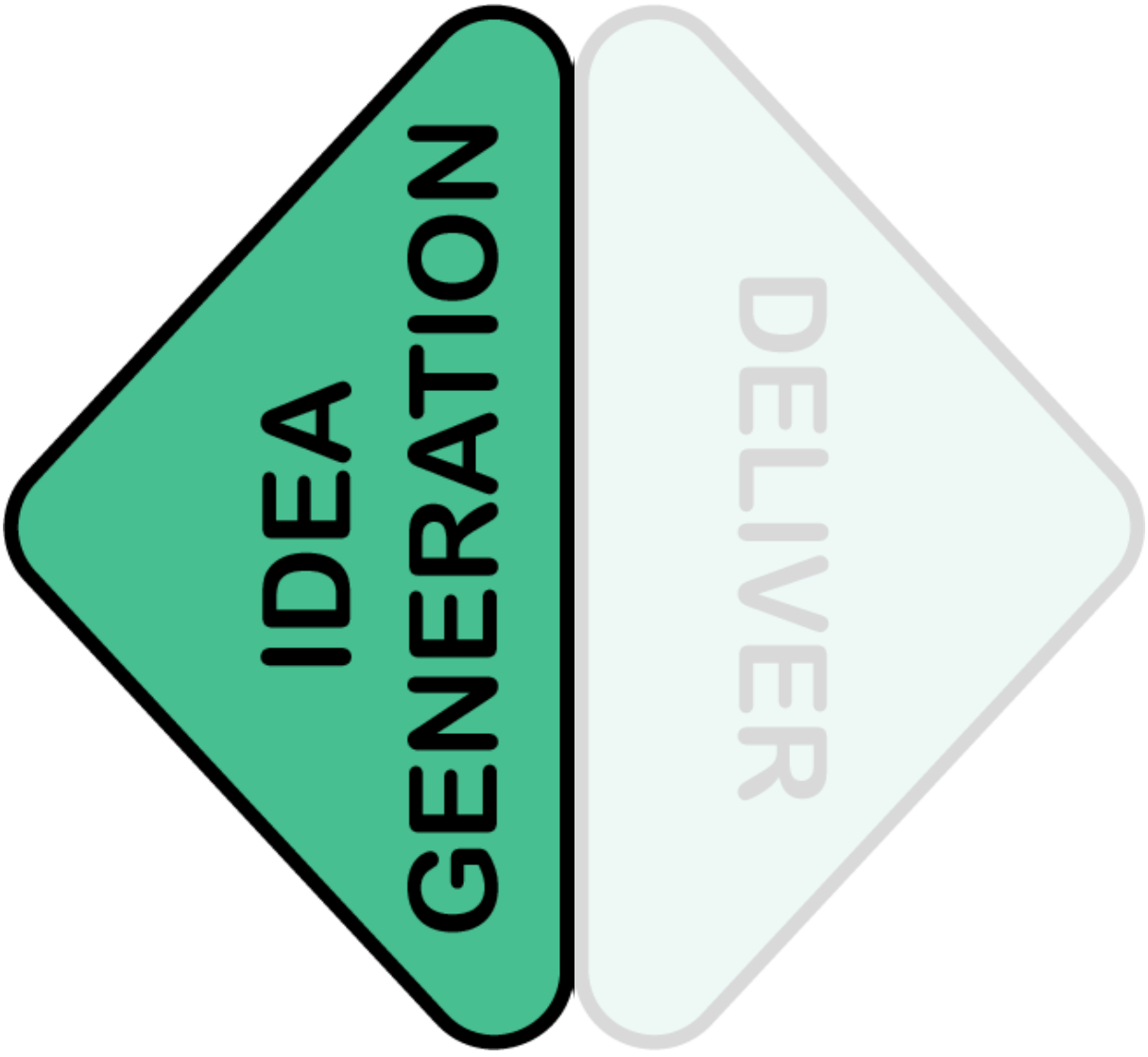
## Discussion

While connecting to optical fiber has a lot in common with connecting to district heating, it is important to acknowledge the differences between the two processes. Therefore, it cannot be assumed that the learnings can be directly implemented. The limited number of individuals interviewed for the optical fiber network perspective should also be acknowledged. While their insights provide valuable considerations, it is necessary to gather a broader range of perspectives to ensure a comprehensive understanding and applicability to district heating.

## Conclusion

For customer outreach, persuasion, and information collection necessary to connect buildings efficiently, a physical inspection of each residence is advised. By standardizing connection techniques, the energy company can realize more efficient service delivery for themselves. Lastly, it is emphasized that marketing, client persuasion, and satisfaction all depend on effective communication throughout the whole process, but mostly before starting any physical activity in the streets.

# Design - Idea generation



# Individual ideation

## What are the possible solutions to the different described problems?

The ideation phase builds on the problems identified in the previous section, the third part of the research scope. The initial stage of the ideation phase involves generating my own individual solutions to these identified problems. The primary objective was to generate a diverse range of solutions that contribute to the final deliverable. The reason to conduct a brainstorm before the group workshop is to prevent thoughts or ideas of others influencing my own design process.

## Method

This brainstorming session was divided into three different parts.

1. Start with HKJ (“Hoe kun je”)
    a. Think of all the different ways to solve the problems by creating mind maps.
2. Free Drawing
    a. Set a timer for a short period and draw continuously specific ideas or that might solve the problem.
3. Review and Refine
    a. After the brainstorming session, review the generated ideas and identify the most promising ones. Consider their feasibility, relevance to the research topic, and potential for further exploration. Group similar ideas or identify possible subtopics that can be explored in the thesis.

## Discussion

Individual brainstorming can serve as a great starting point of the ideation phase, making it possible to generate the individual ideas of a person while minimizing external influences. However, this method could lack diverse perspectives and does not include immediate feedback, open discussions, and interactions that group sessions could offer.

## Conclusion

From the individual brainstorming, nineteen ideas for high-rise buildings and twenty ideas for ground-level buildings were generated, presented in Figure 32 and Figure 33. The ideas primarily focus on new methods of connecting the HIU. Additionally, some new potential locations for the HIU are suggested. Only a few ideas consist of differentiations of the HIU. These ideas will be further explored in the refining phase, as discussed in the chapter: Initial selection.

# Results

### Ground-level building

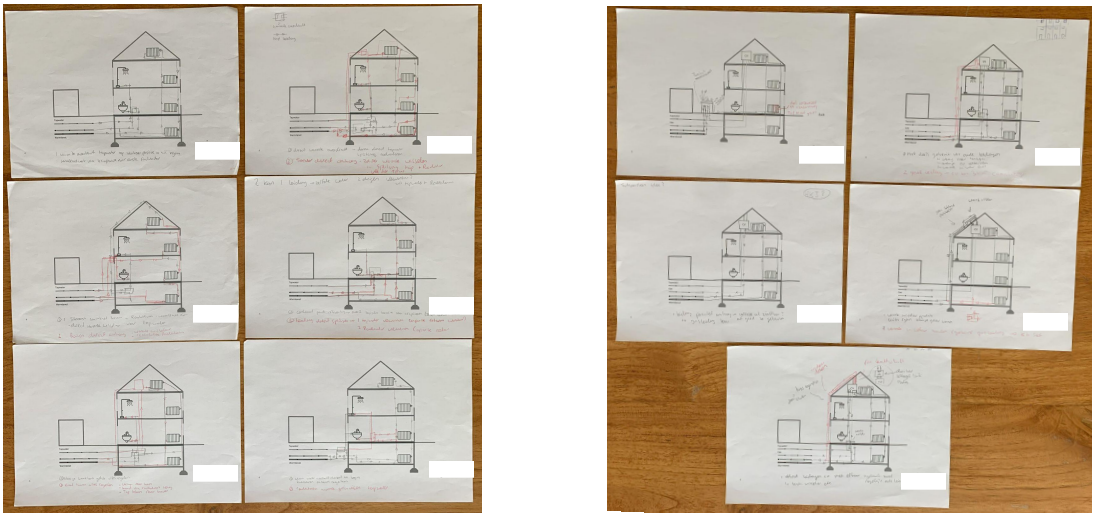


*Figure 32: Overview of all the solutions drawn for ground-level buildings during the individual brainstorming (two solutions per paper).*

### High-rise building

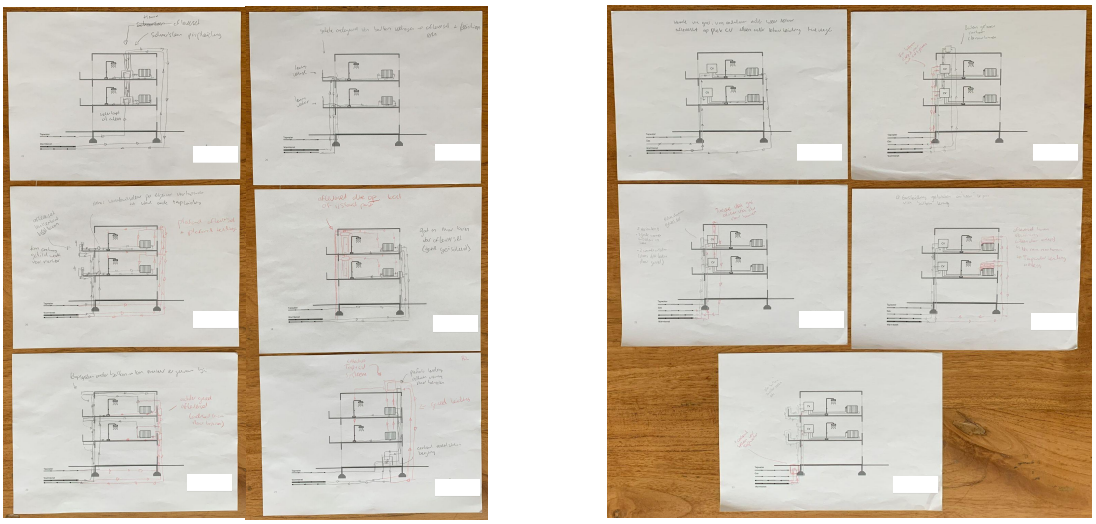


*Figure 33: Overview of all the solutions drawn for high-rise buildings during the individual brainstorm (two solutions per paper).*

# Workshops

## What are the possible solutions to the different described problems?

After the individual brainstorming phase, three different workshops were held with the main goal of producing a significant amount of ideas. To achieve this, three different approaches were adopted involving diverse participants, which also encourages a wide range of perspectives and insights. Furthermore, doing multiple workshops results in having the space to experiment and reflect on the process. As a result, after each workshop, not only the drawn solutions but also the lessons learned were documented. These learnings served as valuable contributions to the other workshops, shaping and enhancing the overall ideation process.

## Methods

**Workshop 1: Creative session**
Participants: three TU Delft IDE graduation students

The primary goal of the first workshop was to produce a large number of creative ideas and to give a practice session before implementing them with the energy company employees. The anticipated outcome was twofold: a list of new solutions and a collection of insights gained throughout the workshop, as well as participant feedback.

A quick introduction with minimum contextual information was given to enable maximum creativity, with the goal of not constricting the students' innovative thinking. The workshop was run without any precise workshop rules because it was considered that the students were already experienced with creative sessions and did not need any more instructions.

Due to time construction, the workshop was divided into one session with three different parts (see appendix D1 for the full program). Meaning that through the workshop only the terraced houses were included.

1. Free drawing
    a. Every participant got multiple papers with the framework where they could sketch all the ideas that came to mind. Additionally, the participants were provided with a floor plan of the building and a description of its characteristics (see Appendix D2 for all the material).
2. Problem-solving
    a. Every participant got multiple papers with a framework including the different identified problems.
3. Brainstorm
    a. A group brainstorm was held to generate extra solutions to the identified problems.

Lessons learned:

1. The importance of effective time management emerged as a key learning from the workshop. It became clear that precise communication of a well-defined schedule, as well as the use of a timer during the workshop, are critical.
2. Participants stated a desire for more context information in order to begin their creative activities. Numerous initial questions indicated confusion or lack of clarity among the participants.
3. Clear instructions and well-defined rules were found to be essential in enhancing creativity.
4. Participants need to be encouraged to step out of their comfort zones and create more creative ideas.
5. To enhance visual clarity different colors should be used for the drawings.

**Workshop 2: Pragmatic session**

Participants: four employees. two from Engineering, one from Asset Management, and one from Project Management.

The primary objective of this workshop was to generate high-quality ideas, focusing on qualitative rather than quantitative outcomes. The workshop aimed to leverage the expertise and knowledge of the participants in the field of district heating and HIU installation to gain valuable insights.

Given the participants' extensive experience and deep understanding of the subject matter, a brief introduction was sufficient, as they already possess knowledge of the identified problems and potential solutions. While these participants may exhibit a slightly lower openness to creativity due to their prior knowledge, they could contribute to the generation of high-quality ideas.

To mitigate the potential obstacle of existing knowledge on generating creative ideas, the workshop incorporated the "shedding the know" technique by Marc Tassouls (2019). This technique was used to set aside their previous ideas. Subsequently, participants had to do a free drawing exercise to further stimulate their creativity.

Additionally, the workshop included the basic rules for idea generation by Tassoul (2019) (see Appendix D3 for the full explanation):

1. Ownership of ideas.
2. Postpone judgement.
3. Dare to freewheel.
4. Quality through quantity.

The rules aim to reduce skepticism towards unique or unconventional ideas, creating a setting that is helpful for creative idea generation. The main goal is to create a setting where people may freely express their views and feelings while encouraging a positive environment.

Lastly, ‘the supporting questions by identifying and breaking assumptions’ were used. This was done by examining the common elements among the ideas generated so far and asking questions that aim to break the assumptions or rules that participants have created in their minds. The goal was to uncover hidden biases or limitations and encourage fresh perspectives.

The workshop was divided into two sessions with three different parts (see appendix D1 for the full program):

1. Problem-solving
    a. Every participant got multiple papers with the framework including the different identified problems. Additionally, the participants were provided with a floor plan of the building and a description of its characteristics.
2. Free drawing
    a. Every participant got a paper with the framework where they could sketch all the ideas that came to mind.
3. Brainstorm
    a. A group brainstorm was held to generate extra solutions to the identified problems.

Lessons learned:

1. A different method should be used to encourage the participants to go beyond their comfort zone and stimulate creativity.
2. Incorporating more co-creation methods could stimulate the generation of new ideas by combining participants' knowledge and expertise.

**Workshop 3: Creative session**

Participants: Six the energy company employees who have listed creativity as one of their skills on their company profile.

The primary objective of this workshop was to cooperatively generate a significant amount of creative ideas. The desired outcome was a list of new and unexpected ideas.

An introduction with some contextual information about the problem was given, minimizing the amount of questions during the workshop. Subsequently, the basic rules of Tassoul (2019) were described to stimulate a creative environment.

This workshop was divided into two sessions including only one part:

1. Brainsketching

Brainsketching is an idea generating technique, based on brainwriting, that uses sketching as the primary means of generating ideas. Participants sketch their ideas individually and after a few minutes, the participants explain their idea sketches, switch places and continue sketching. Usually, about five such rounds of idea sketching take place (Van der Lugt, 2002).

Again, every participant received multiple papers with the framework including the different identified problems. Additionally, the participants were provided with a floor plan of the building and a description of its characteristics.

Lessons learned:

1. Due to the Brainsketching technique people get out of their comfort zone and create new (sometimes not realistic) ideas.
2. At a certain stage, some people reach a point of giving up as they cannot think of new ideas or are unwilling to create something that lacks logical coherence.

## Discussion

The different workshops were a great contribution to the ideation phase, as the main goal was to generate a significant amount of ideas. Furthermore, these workshops not only facilitated the testing and refinement of various methods but also provided insights from different perspectives, which are valuable to this project.

However, the level of uniqueness and novelty of the ideas was lower than expected. To improve future workshops, the following suggestions were made:

1. Divide the workshops into separate sessions, providing more time overall. This allows participants to gain a better understanding of the different building's characteristics and their specific solutions. However, it is important to ensure that participants are willing to dedicate the required amount of time for the workshops.
2. Incorporate different visualizations of the problems. The material provided during the workshops can influence the ideas generated. By presenting information in a different way, alternative perspectives can be stimulated.
3. Use different workshop methods. It was observed that participants often required clear instructions, and a longer duration was necessary to encourage them to enter a creative working phase. While brainsketching proved to be a useful technique in stimulating creativity, additional methods should be explored to further stimulate people's creativity.
4. Mix the type of participants. An interesting approach would be to create workshops that include participants with both creative and pragmatic mindsets. By fostering a co-creative environment that embraces these different perspectives, new ideas can be generated. However, it is important to consider the possibility of these mindsets working against each other.

## Conclusion

Through the different workshops 111 ideas were generated, a full overview of these ideas is presented below. All these ideas will be further analyzed and selected in the next chapter. Additionally, the workshop gave some insights on how to be a better creative facilitator. Key insights were, importance of effective time management, the desire for clear contextual information to start people's creative process, the provision of clear instructions, and the need for well-defined rules to enhance creativity.

# Results

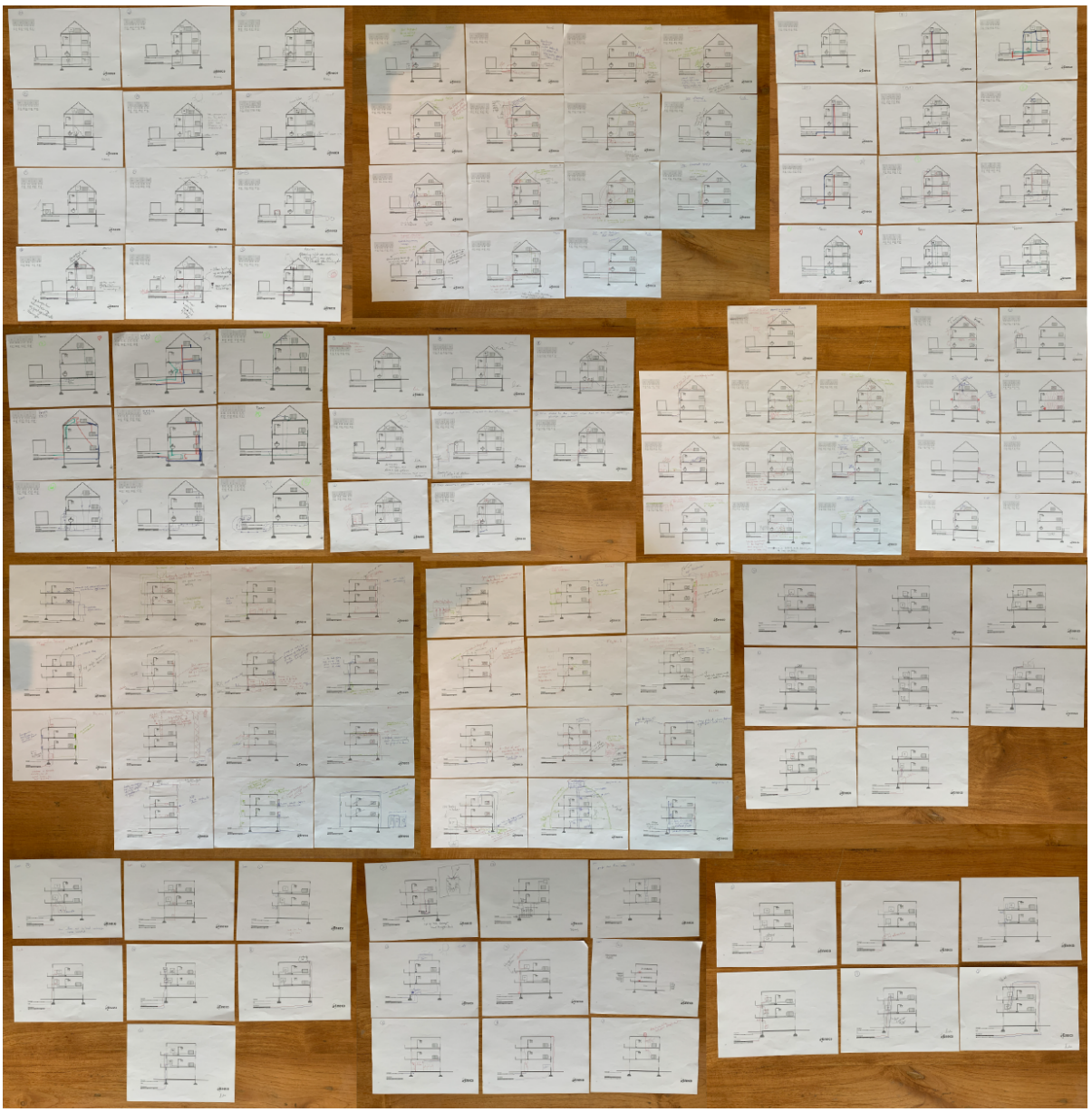
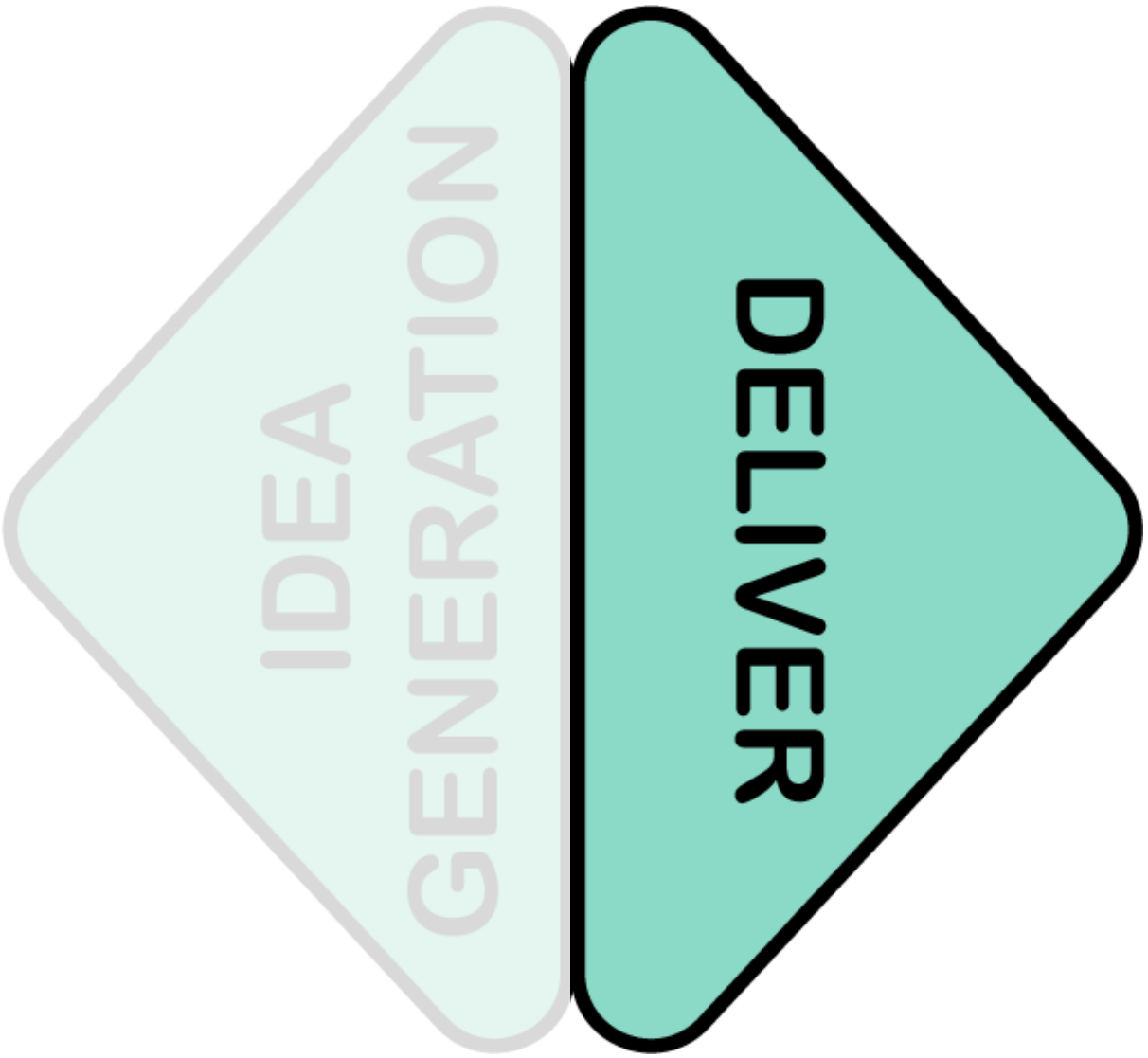


*Figure 34: Overview of all the different solutions drawn during the workshops.*

# Design - Deliver



# Initial selection

## Which ideas should be selected for further development?

To analyze the various ideas generated and select the most promising ones for further development, an initial selection was made from the pool of 150 ideas generated through both individual brainstorming and workshop sessions. This selection was done by using the intuitive technique - iii (Tassoul, 2019), which uses the following criteria:

- Interesting.
- Innovative.
- Inspiring.

By selecting the ideas that stood out at one or more of the criteria points, a list of 39 ideas was generated, comprising 10 ideas from my individual brainstorming session and 29 ideas from the workshops. These ideas were then clustered by looking at their unique selling points, resulting in an overview of the different types of solutions for the identified problems. The solutions were further reviewed and refined resulting in a list of ten ideas.

The following section presents the ten ideas along with a brief description highlighting their unique selling point. Later on, these ideas will be further narrowed down to five ideas which will be further developed in the next chapter.

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# Selection & development

## Which ideas have the highest potential and therefore should be incorporated into the roadmap?

To determine which ideas should be further developed and be included in the roadmap, a final selection was made by choosing the top five ideas using a Harris profile (Van Boeijen et al., 2014). The requirements of the Harris profile are based on the factors from the customer research:

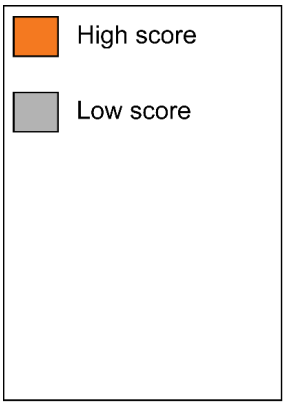
1. The amount of renovation needed inside the house.
2. The time of installation.
3. The amount of space needed inside the house.
4. Aesthetics.

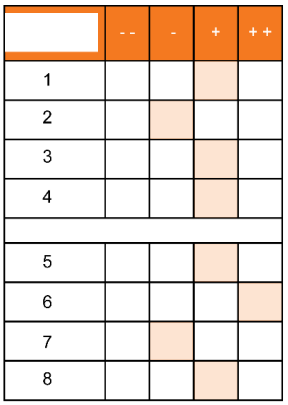
And based on the factors from the energy company's perspective:

5. Costs for the energy company (product development).
6. Accessibility (for installation + maintenance).
7. Risk (any risk compared to a normal HIU placed inside the house).
8. Quantity (how applicable it is).

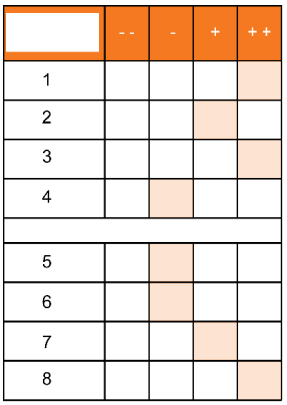
It is important to highlight that in this research, each criterion is given equal importance, and as such, the order of the requirements within the Harris profile is not significant.

The ratings for each idea are presented below, with the ideas having the highest scores highlighted in orange.

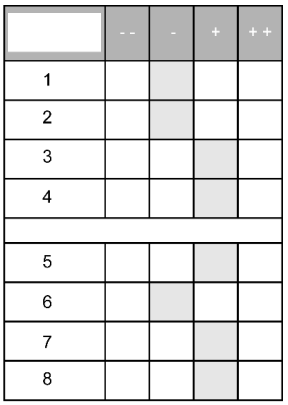


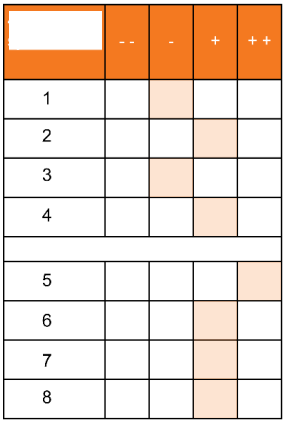

Score: 5



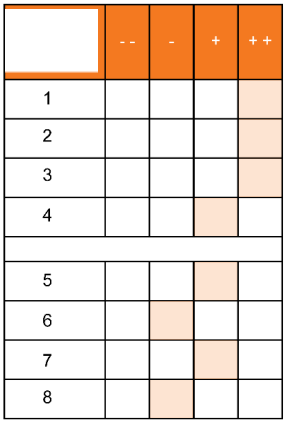

Score: 5



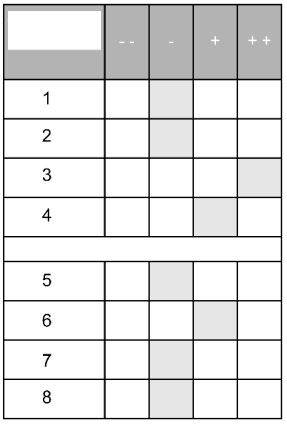

Score: 2



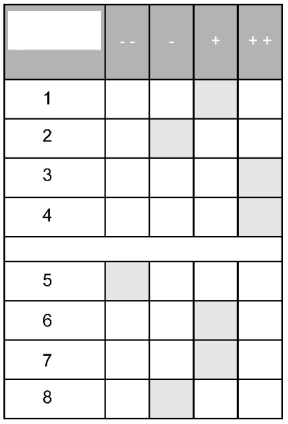

Score: 5



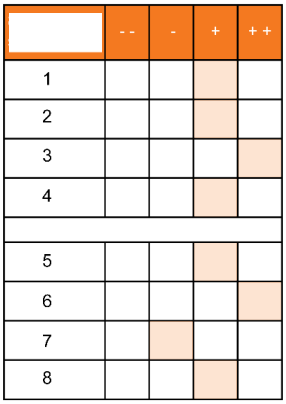

Score: 7



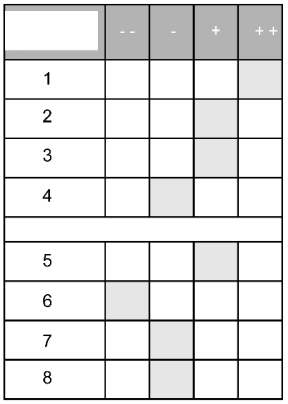

Score: -1



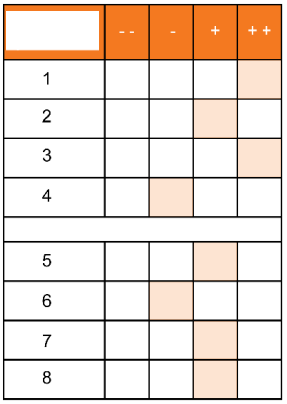

Score: 3




Score: 8




Score: 0




Score: 6

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Below the five solutions with the highest score on the Harris profiles are further developed.

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| --- |

## Conclusion

Based on the conducted research, the recommendation for the energy company is to develop five solutions. These solutions are essential to effectively connect a significant number of buildings, particularly those of terraced, gallery, and porch types.

The solutions will be further developed by looking into the development of the specific components required for each solution, suggesting the internal and external collaborations necessary, defining the innovation timelines, and determining the priority order between the different solutions. These different aspects will also be incorporated into the different roadmaps.

By integrating these recommendations into the product innovation roadmap, the energy company will have a clear and structured framework that outlines the specific steps, timelines, and focus areas for realizing these solutions.

## Relevance

To assess the value of the five ideas, they were evaluated based on their applicability and novelty.

Since the different solutions will be assessed on their feasibility and viability through the innovation process (mentioned in the chapter: Internal stakeholders: innovation process of the energy company), it is currently hard to give a precise estimation of their applicability. However, their full potential can be estimated by considering the quantity (described in chapter: General research - quantity).

If the solution A, B, and C reach their maximum potential and will cover all the terraced buildings, it would mean that they can connect 40.2 percent of the buildings. For solution D and E, if covering all high-rise buildings, it would mean that they can connect 27 percent of the buildings. This means that the five solutions together could potentially connect 67.2 percent of the buildings.

Please note that these calculations are based on the assumption of full implementation and actual results may vary. Additionally, the solutions have the potential to achieve even higher coverage as they can also be applied to connect other types of buildings.

Additionally, the five different solutions were assessed for their novelty by comparing them with the competitive market overview (described in chapter: Competitive market overview). This evaluation aims to determine if the energy company can differentiate themself by developing these solutions and also identify opportunities to learn from existing solutions that have already been developed or implemented.

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# Communication

## What does the communication from the energy company look like, and how can it be improved?

Based on the literature review and the interviews conducted with the end customer, the housing association, and the Dutch optical fiber network company, it is concluded that effective communication plays a crucial role in the process of connecting to district heating. Although not directly within the scope of this research, communication emerges as a significant aspect of product and process acceptance. Therefore, a supplementary study is included to provide recommendations on how the energy company can integrate communication effectively into their innovation process.

### General research

The energy company works with three different levels of acceptance:

- Sociopolitical acceptance: Acceptance of the societal plans for becoming gas-free.
- Process acceptance: Acceptance of the way residents have been approached regarding the transition to gas-free.
- Product acceptance: Acceptance of the changes in the home and agreement to connect to a collective heat network.

For this research product and process acceptance are seen as relevant. Sociopolitical acceptance is excluded as it does not have a direct effect on the to be developed products.

In OVN, the energy company works with a joint communication and participation team consisting of communication experts from the municipality, and housing associations. Together they create a community and participation approach.

The approach consists of the following phases:
Phase 0.1: Analyze neighborhoods and create profiles
Phase 0.2: Create communication and participation strategy

Phase 1: Informing - The municipality informs residents about the transition to a gas-free neighborhood and the preferred district heating solution, including details on support, alternatives, costs, and sustainable measures.

Phase 2: Dialogue - Engaging in conversations with homeowners and tenants to discuss available options, allowing homeowners to understand alternatives, subsidies, and the impact of the district heating network on their properties.

Phase 3: Decision-making - Housing associations assist tenants in making informed choices, providing explanations about contracts, costs, home modifications, construction timelines, and obtaining support. the energy company and housing associations establish necessary agreements for connection and supply.

Phase 4: Implementation - Scheduling and executing construction work in the neighborhood and individual homes, with Stedin (gas distribution system operator) disconnecting residents from gas and coordinating with them, while the energy company connects residents to the district heating network and maintains communication throughout the process.

Phase 5: Service and Aftercare - The energy company ensures residents' satisfaction by offering a warm welcome, standard communication, and services such as a welcome package, 24/7 troubleshooting support, and access to consumption and cost information, consolidating their role as a trusted heat provider.

This community and participation approach can also be utilized to inform residents about new innovations and receive feedback on the solutions being developed.

## Interviews

To gain more insight into the communication of the energy company, a semi-structured interview was held with a Community Engagement employee of the energy company.

**Goals**

- Gain more insight into the communication process of the energy company.
- Gain more insight into the energy company's perspective on the impact of communication.
- Gain more insight into product acceptance.
- Find points of improvement for communication.

**Method**

- Introduction.
- General questions about the Community Engagement team (3).
- Questions about the impact of communication (1).
- Questions about the community communication process (3).
- Questions about product and process acceptance (2).
- Questions about points of improvement (2).

**Valuable insights**

Information is considered valuable when it establishes a direct connection with one of the interview goals provided above. Furthermore, they are either mentioned by multiple individuals or are individually remarkable.

- The Community Engagement team at the energy company is actively involved in facilitating a social energy transition where stakeholders are actively engaged in the entire process.
- There is potential for improved collaboration between the energy company and the municipality.
- Personalized approach and resident participation are considered crucial when talking about process and product acceptance.
- Due to a personalized approach and active resident participation, the energy company consistently achieves a sufficient level of product and processes acceptance.

- There is room for increased collaboration between the Community Engagement team and other internal teams at the energy company, particularly in areas like innovation

Additionally, an open discussion was held with three WTP employees to address the insights gathered from interviews with OVN residents and housing corporations and gain more insight into the communication process.

**Goals**
Manage stakeholder relationship with WTP.
Obtain insights into the collaboration between WTP and Community Engagement.
Identify areas for improvement in the communication and participation process.

**Method**
- Introduction.
- Summary of interview insights.
- Discussion on interview insights.
- Discussion on the communication process.

**Valuable insights**
Information is considered valuable when it establishes a direct connection with one of the interview goals provided above. Furthermore, they are either mentioned by multiple individuals or are individually remarkable.

- There appears to be limited collaboration within the energy company between the Community Engagement team and other teams.
- There is no centralized platform for external individuals to access information on the innovation process and ongoing projects and developments.
- The collaboration between WTP and the municipality could be enhanced.
- Overall, there is room for improvement in the collaboration and communication among various stakeholders.

## Discussion

This supplementary study gives valuable insights into the communication process of the energy company and how it can be utilized for the different levels of acceptance. Due to time constraints, only a limited number of people were interviewed and limited general research was done. Therefore, to get a deeper understanding of the relationship between communication and product and process acceptance, it is recommended to conduct literature review. This involves exploring existing studies and research to gather information on effective communication and its influence on acceptance. Additionally, conducting a quantitative survey with a larger sample size and engaging in in-depth interviews or focus group discussions with both satisfied and dissatisfied customers can provide a better understanding of the specific relationship between the energy company's communication approach and the acceptance of district heating products and processes.

## Conclusion

As observed from the interviews with residents, housing corporations, and the optical fiber company (described in the chapters: Customer satisfaction and Cross-industry insights), it is concluded that communication plays a major role in product and process acceptance of district heating. To achieve optimal satisfaction and to connect a larger number of buildings, the energy company should not only focus on the development of new solutions but also on improving their communication approach. At the innovation level, there still is room for improvement in terms of product and process acceptance. This can be achieved through enhancing communication at the energy company, fostering collaboration among the energy company teams, and strengthening cooperation with the municipality.

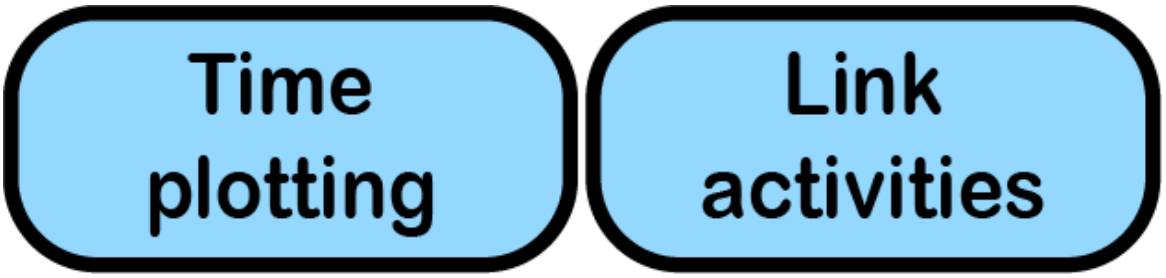
## Suggestion

During the open discussion with the WTP team, it was suggested that the energy company should look into an effective way of communicating and interacting with residents, while also gathering extra information about their end customer. As part of the discussion, the idea was generated to create a centralized communication platform.

Therefore, it is suggested to  develop a platform that effectively communicates the relevant upcoming and ongoing projects and innovations. Specifically, in the context of district heating, the Community Engagement team, WTP, and Innovation team could make use of this platform by sharing updates on product development, neighborhood approaches, and general information regarding district heating. Additionally, residents can use this platform to explore suitable solutions or concepts for their homes. They can upload information about their building and living situation, along with photos, which the energy company could use to provide personalized advice while also expanding their database.

It should be noted that this idea is stated as a suggestion, as no research or design process has been conducted as validation. Therefore, it is recommended to further explore this idea in more detail by doing viability and feasibility studies and looking into the design and implementation of the platform.

# Roadmapping



# Timeline plotting & Link activities

What are the necessary activities involved in the development of these solutions and how should the energy company incorporate them?

To assist the energy company in the development of the five solutions the product innovation roadmap and general roadmap were created. The various steps undertaken during this research have resulted in the creation of these roadmaps which are described below.

## Product innovation roadmap (technical)

The product innovation roadmap provides an overview of the necessary components to be developed, the associated workload, and the required internal and external collaborations necessary for each innovation. It mostly serves as a planning for the Innovation team. Additionally, this tool can be used to update the relevant teams or companies on what to expect in the coming period when talking about innovation.

Below the different elements of the roadmaps are described.

**Components**
For each component, the roadmap specifies the phase (described in chapter: Internal stakeholders: innovation process of the energy company) it needs to undergo and the required time for development, represented by the length of the corresponding bar. The estimation of the timeline for each phase is determined by the Innovation team, considering factors such as the complexity of the components and the time needed to test specific assumptions, described in Appendix E. If a component has already undergone the innovation process as part of another solution, it is made transparent as it does not need to go through the process again.

**External Collaboration**
The second row illustrates the external collaborations, indicating the suggested companies that should be involved in each phase for a certain component. This stimulates effective collaboration with external partners throughout the innovation process.

**Internal Collaboration**
The third row represents internal collaborations. As outlined in the stakeholder analysis, various teams within the energy company play a role in the innovation process. The roadmap provides a clear overview of which teams should be involved in each phase, facilitating smooth internal collaboration and coordination.

**Community Engagement**
As a suggestion, the roadmaps also include community engagement. This integration aims to enhance collaboration between the community Engagement team and other relevant teams within the energy company. During the implementation phase, the Community Engagement team can utilize the roadmap to effectively communicate the development of new innovations to the community.

**Workload**
The roadmap includes an assessment of the workload per phase, indicating the number of hours required. This estimation is based on previous projects and the complexity of the different components. This enables the evaluation of whether a specific innovation is feasible within the given process and assists in estimating the associated costs.

**Timeline Innovations**
In collaboration with the Innovation team, specific timelines were established for each innovation. Every component of the solution undergoes the various phases of the innovation process. The duration of each innovation differs and is further detailed in Appendix E.

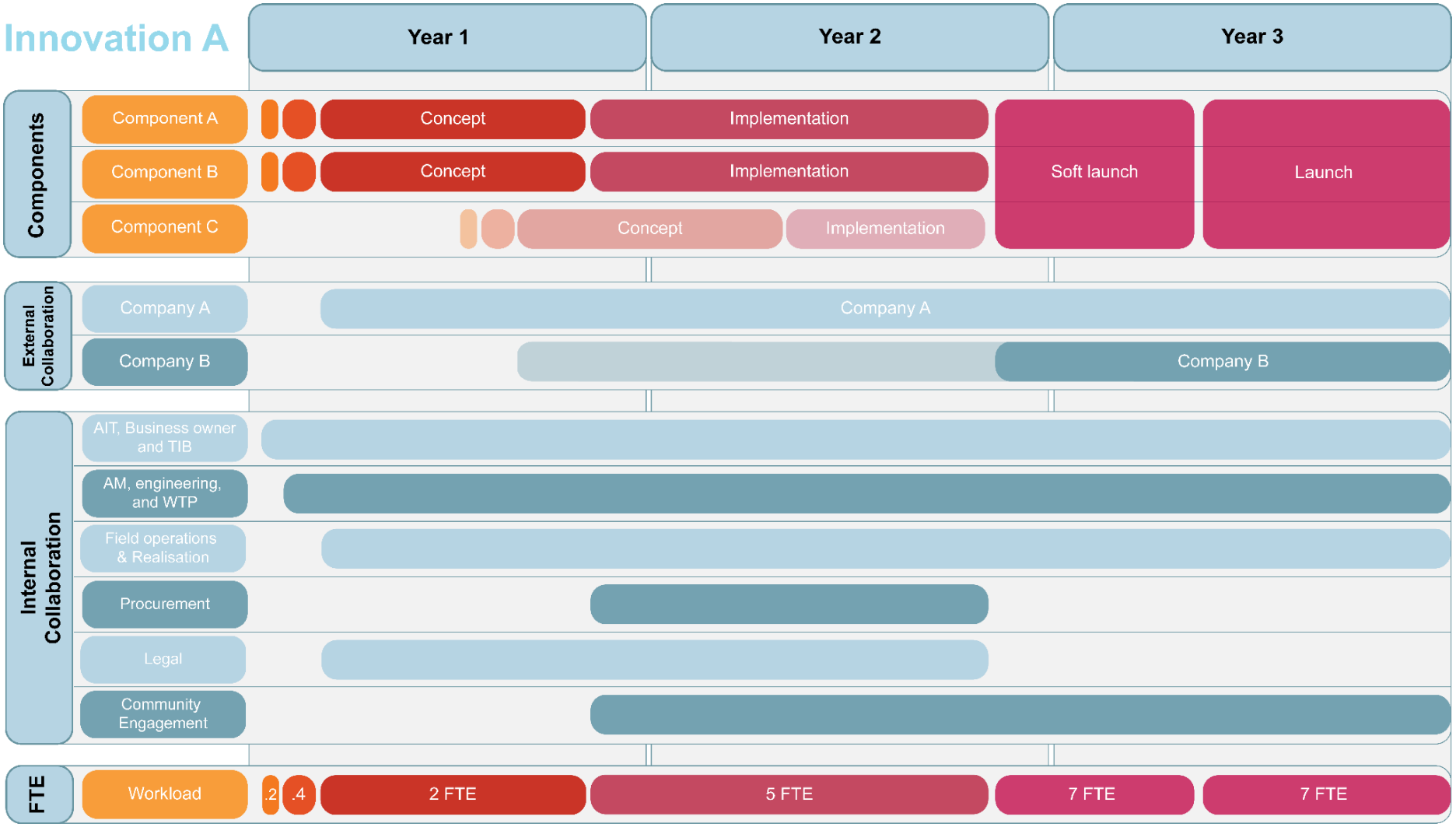
**Roadmap employment**
When a solution is going to be developed one person from the Innovation team takes on the role of project manager. This person will also be responsible for the product innovation roadmap of that particular solution. The roadmap can assist the project manager with the planning as it provides a clear overview of what needs to happen and when. Whenever the timeline or another variable of the roadmap changes, it is this person's responsibility to update it.

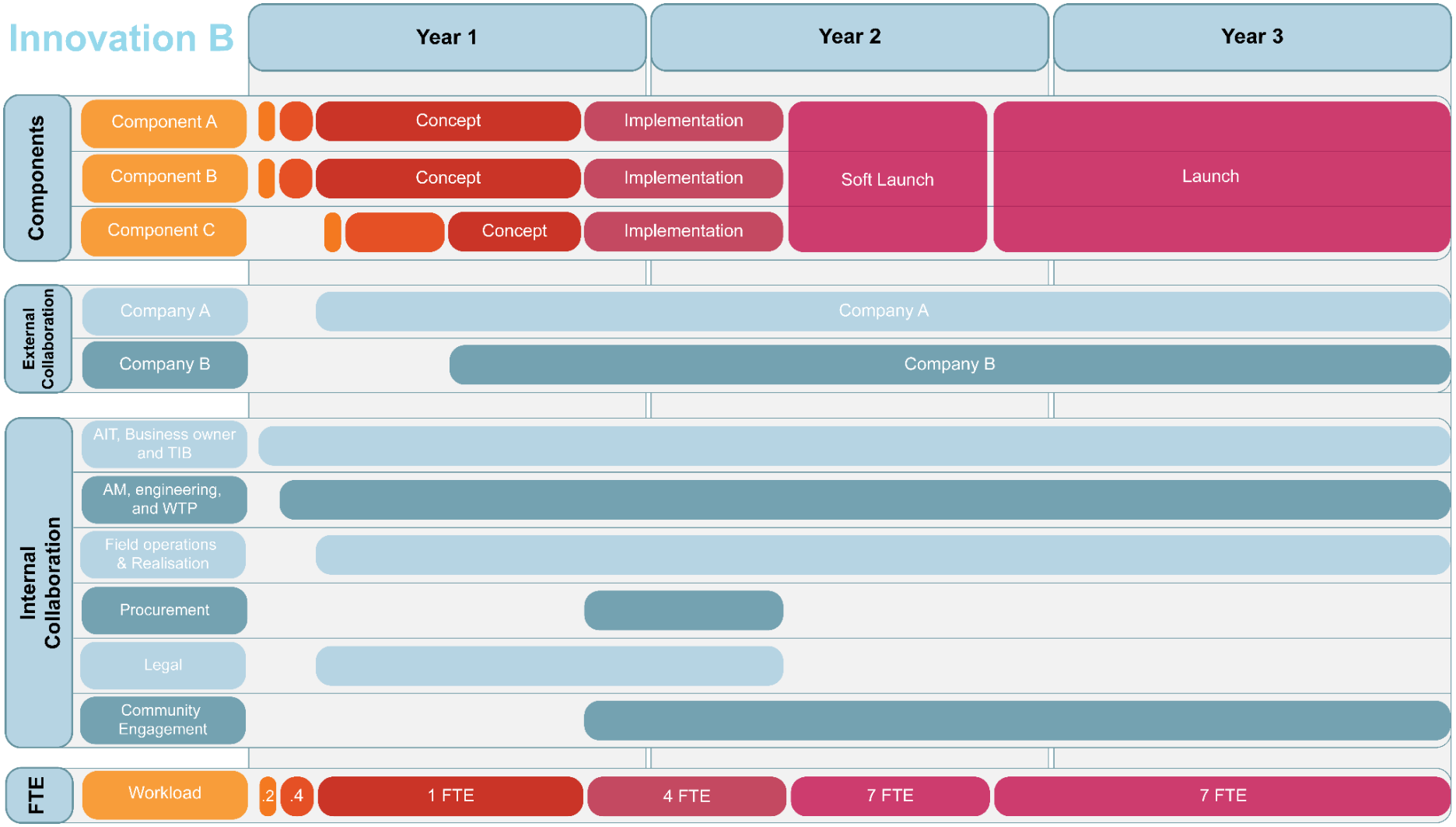
The roadmap will be delivered as an Adobe Illustrator file. Within the Innovation team, some people can work with Adobe Illustrator, as does the energy company facilitate this program. Additionally, a PowerPoint version is made, as a more editable document (see appendix F). In case people are unable to work with the Illustrator file in the future, they can utilize the PowerPoint version. It is important to acknowledge that the PowerPoint version is simpler to edit but less visually appealing.

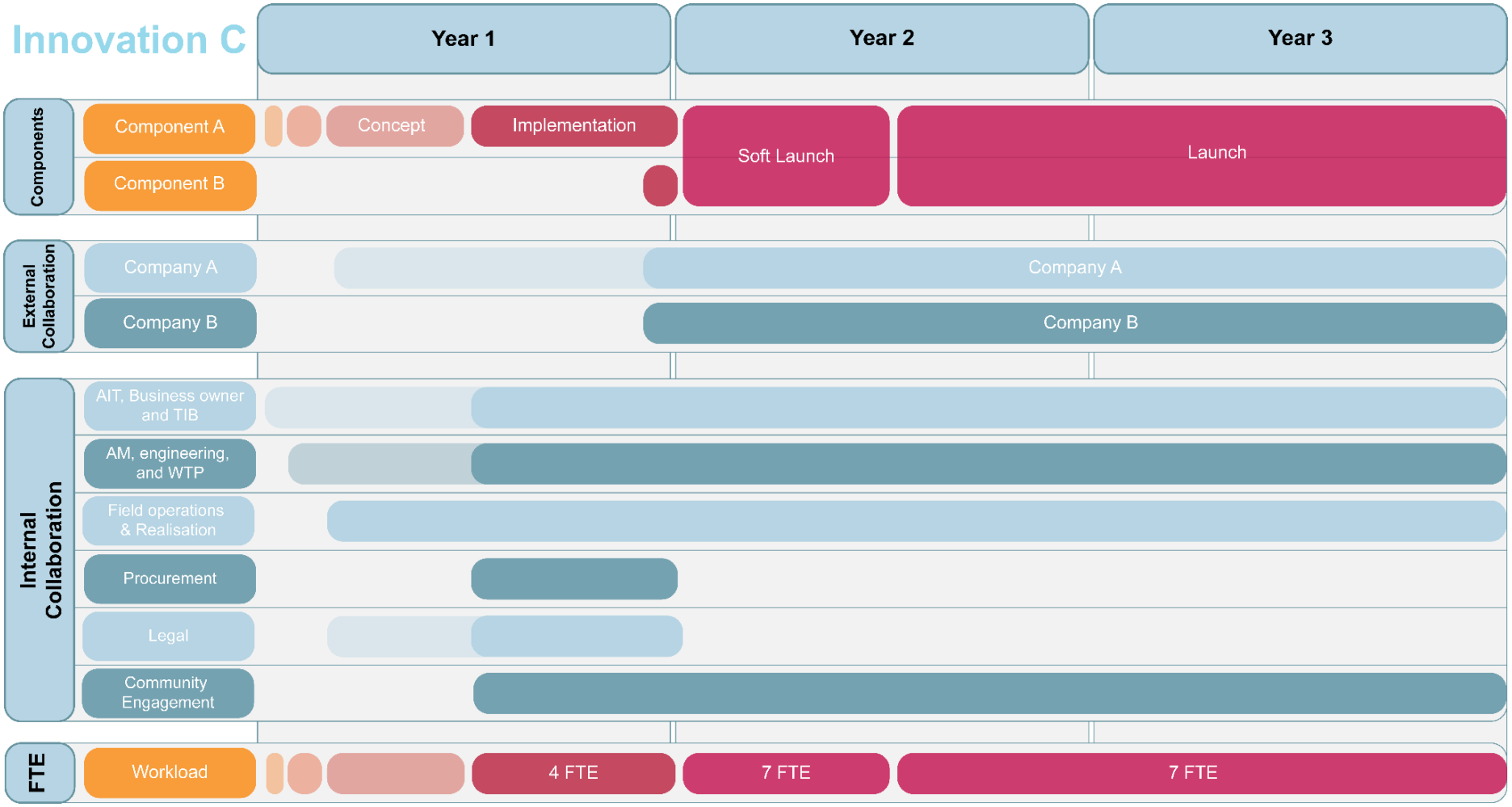
Whenever a new project arises, the same framework can be used to create the product innovation roadmap, where only the names, length of the bar, and the number of rows have to be changed.

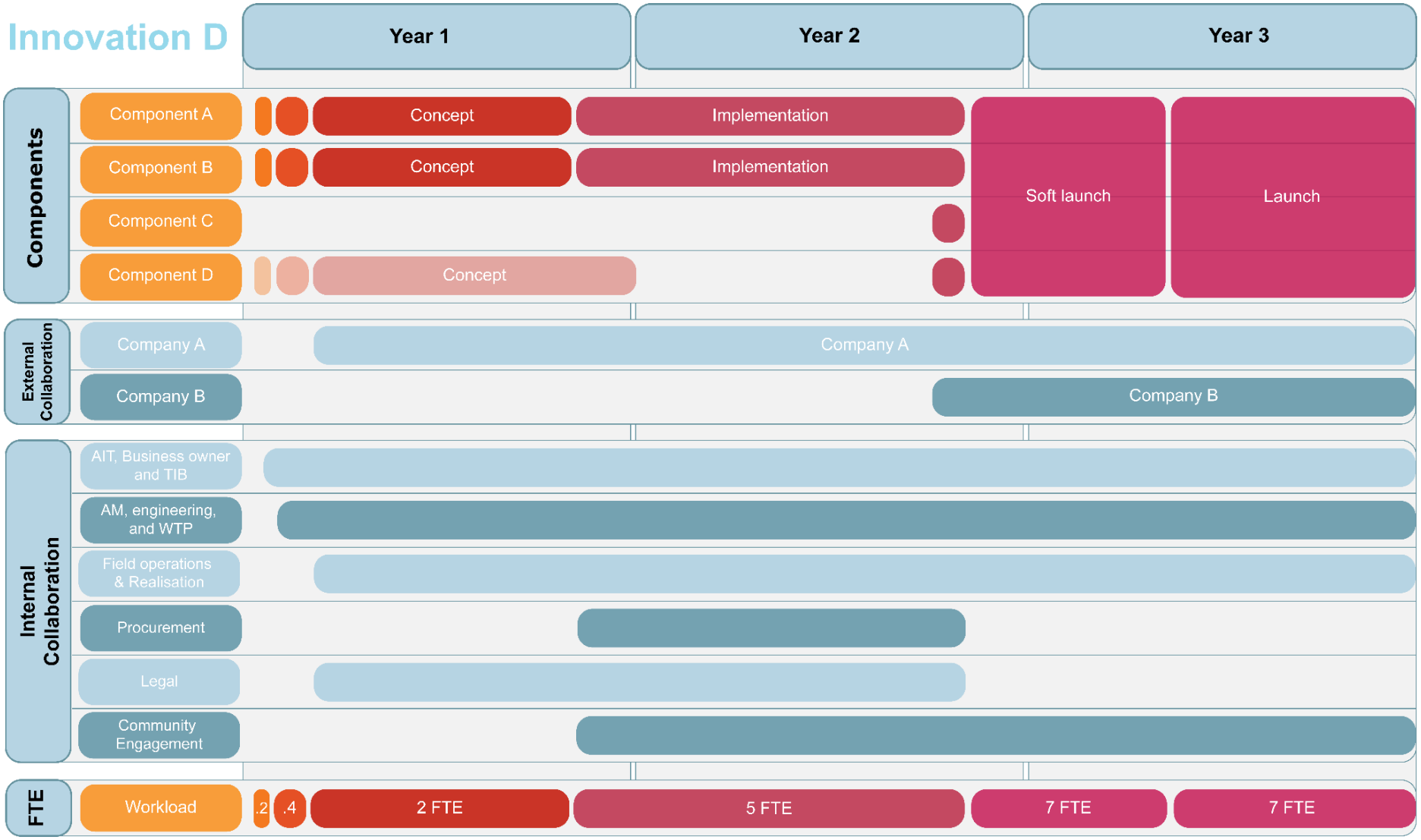
The bars can be adjusted by vertically moving it and/or changing its length where 6.7 mm represents one month. A new variable can be added by extending the height of the component bar and adding a new bar by copying it from the one above.

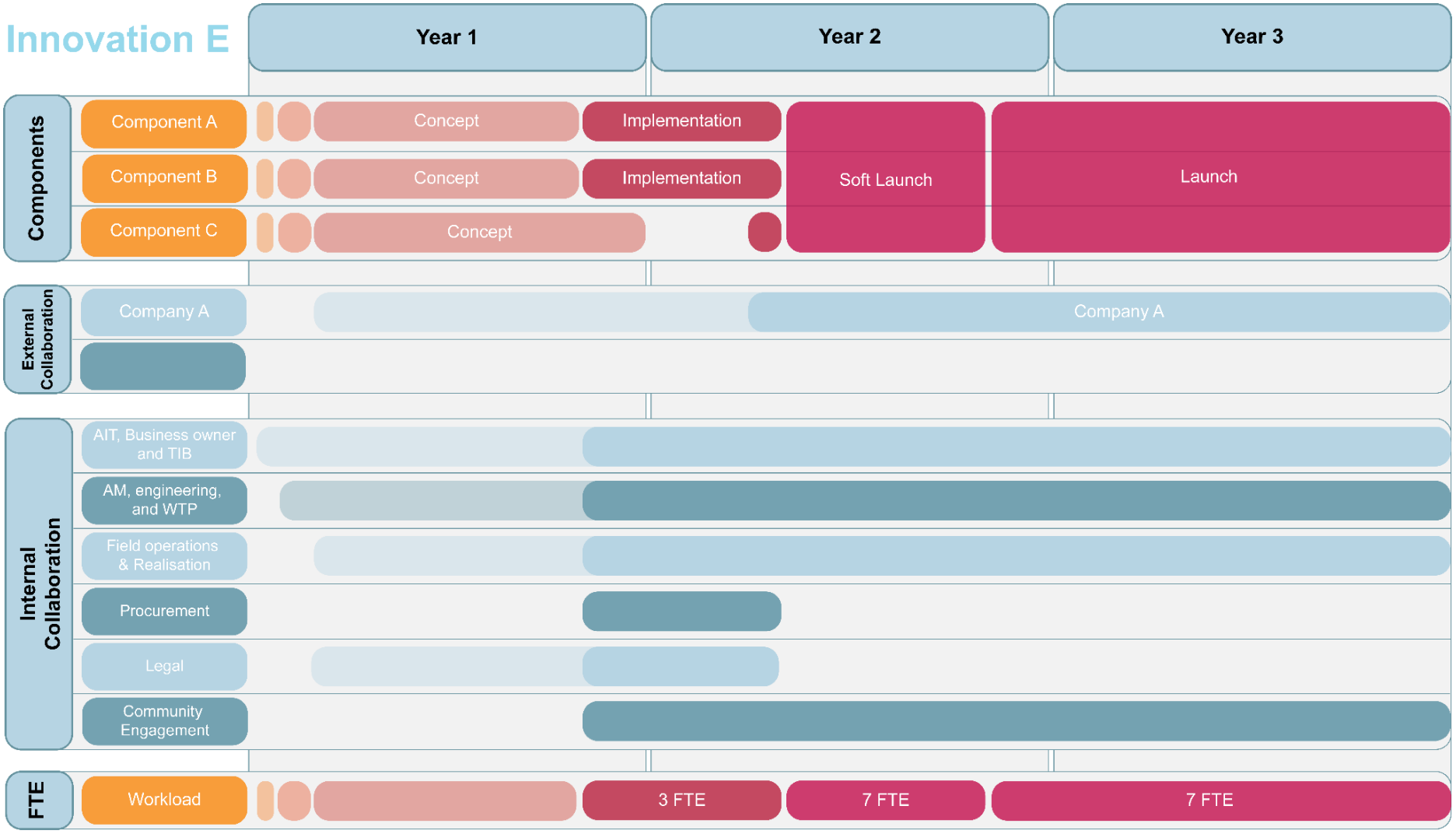
Below the roadmaps per innovation are presented.


Innovation A
Year 1
Year 2
Year 3
Components
Component A
Component B
Component C
Concept
Implementation
Soft launch
Launch
External Collaboration
Company A
Company B
Internal Collaboration
AIT, Business owner and TIB
AM, engineering, and WTP
Field operations & Realisation
Procurement
Legal
Community Engagement
FTE
Workload
.2
.4
2 FTE
5 FTE
7 FTE
7 FTE


Innovation B
Year 1
Year 2
Year 3
Components
Component A
Component B
Component C
Concept
Implementation
Soft Launch
Launch
External Collaboration
Company A
Company B
Internal Collaboration
AIT, Business owner and TIB
AM, engineering, and WTP
Field operations & Realisation
Procurement
Legal
Community Engagement
FTE
Workload
.2
.4
1 FTE
4 FTE
7 FTE
7 FTE


Innovation C
Year 1
Year 2
Year 3
Components
Component A
Component B
Concept
Implementation
Soft Launch
Launch
External Collaboration
Company A
Company B
Company A
Company B
Internal Collaboration
AIT, Business owner and TIB
AM, engineering, and WTP
Field operations & Realisation
Procurement
Legal
Community Engagement
FTE
Workload
4 FTE
7 FTE
7 FTE


Innovation D
Year 1
Year 2
Year 3
Components
Component A
Component B
Component C
Component D
Concept
Implementation
Soft launch
Launch
External Collaboration
Company A
Company B
Internal Collaboration
AIT, Business owner and TIB
AM, engineering, and WTP
Field operations & Realisation
Procurement
Legal
Community Engagement
FTE
Workload
.2
.4
2 FTE
5 FTE
7 FTE
7 FTE


Innovation E
Year 1
Year 2
Year 3
Components
Component A
Component B
Component C
Concept
Concept
Concept
Implementation
Implementation
Soft Launch
Launch
External Collaboration
Company A
Company A
Internal Collaboration
AIT, Business owner and TIB
AM, engineering, and WTP
Field operations & Realisation
Procurement
Legal
Community Engagement
FTE
Workload
3 FTE
7 FTE
7 FTE

## General roadmap (strategy)

The general roadmap, presented below, serves as an effective tool for the innovation team at the energy company, outlining the strategic direction for the upcoming years. It provides guidance for different teams within the energy company to connect various types of buildings to district heating. The timeline on the x-axis is determined by considering both the municipal approach timelines and the energy company's innovation timelines.

Not only does this roadmap give a clear overview of the ongoing and upcoming projects within district heating for the Innovation team itself, but it also works as a communication tool to update other teams on what is going on within the district heating innovation process. Therefore this roadmap can also be used to give updates to the WTP, Communication, and Participation team who can use it to communicate relevant innovations to their stakeholders.

**Innovation**
The first row represents different innovations. The length of the bar indicates the time required before launching the product. The specific steps involved in each innovation are described in the product innovation roadmap. The blue line connecting different innovations represents an overlapping phase where the same component has to be developed. As explained, If an innovation has gone through all the necessary steps of the innovation process and has received approval, the same components do not have to go through this entire process again. This leads to a shorter and less resource-intensive innovation process. The darker red color signifies the priority, with higher priority innovations being on the top.

Within the innovation section also an ongoing innovation of the energy company is included.

As mentioned in the innovation process (described in chapter: Stakeholder analysis), innovations may be rejected for various reasons. When an innovation is rejected, it is removed, and a new innovation is placed in the bottom row of the innovation section.

**Collaboration**
The second row includes external companies that are involved in the innovation process. These companies are responsible for developing specific components of the innovations and are also included in the product innovation roadmap.

**Municipality Approach**
The third row represents the different municipalities' approaches of Utrecht, Rotterdam, and Den Haag. It Is essential information not only for the collaboration between the energy company and the municipalities but also to indicate the phase of each project and provide an indication for the quantity, useful for the viability per innovation.

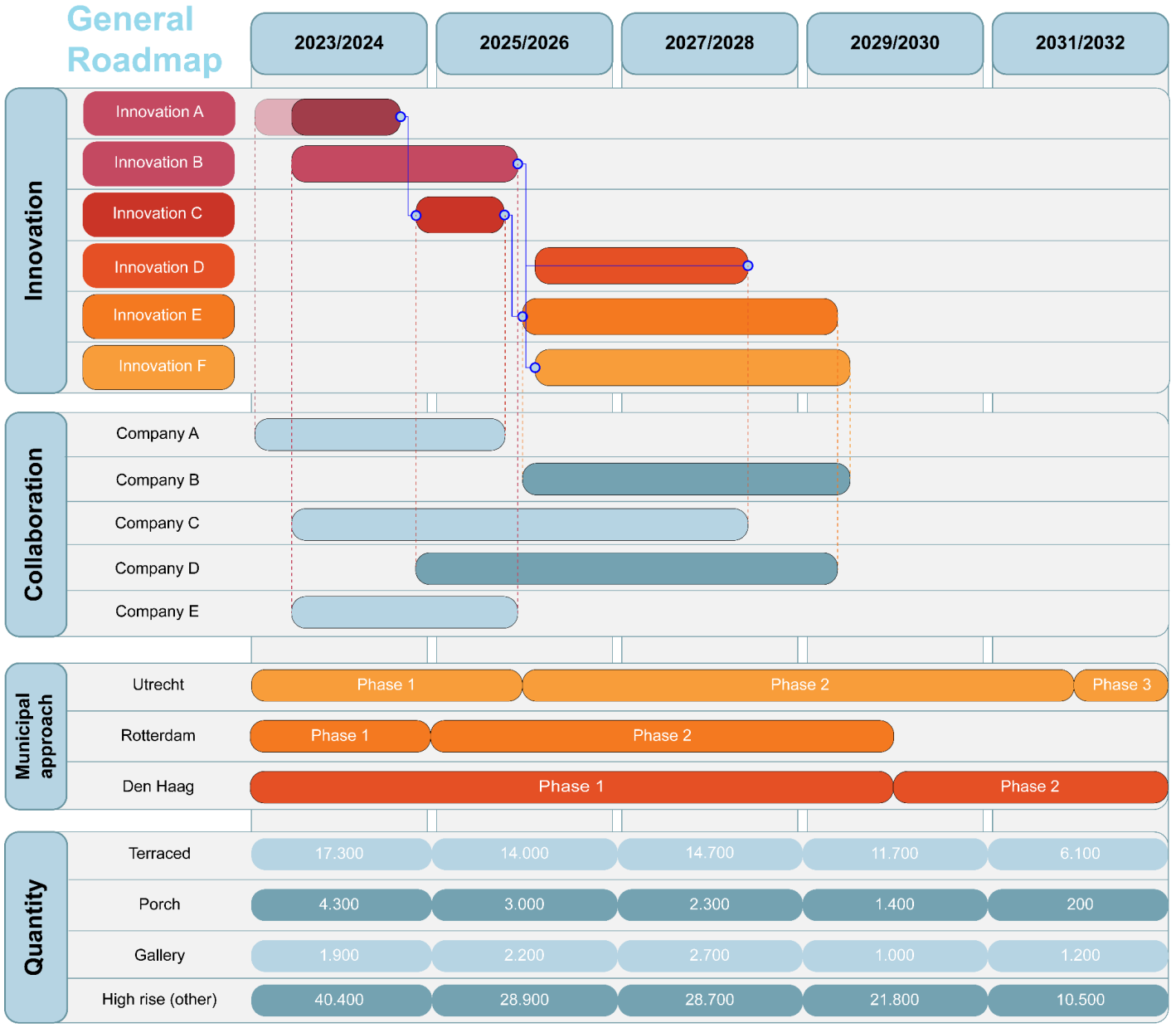
**Quantity**
The quantity row indicates the number of buildings, categorized by housing type, that will be connected to district heating. This visualization highlights the importance of developing solutions for different housing types and is crucial for assessing the viability of each innovation in the business case.

**Roadmap employment**
Within the Innovation team one person will be responsible for updating the general roadmap every quarter. This person is responsible for making necessary adjustments to project timelines, removing rejected projects, and incorporating new projects. Additionally, any new external collaboration should be updated as well.

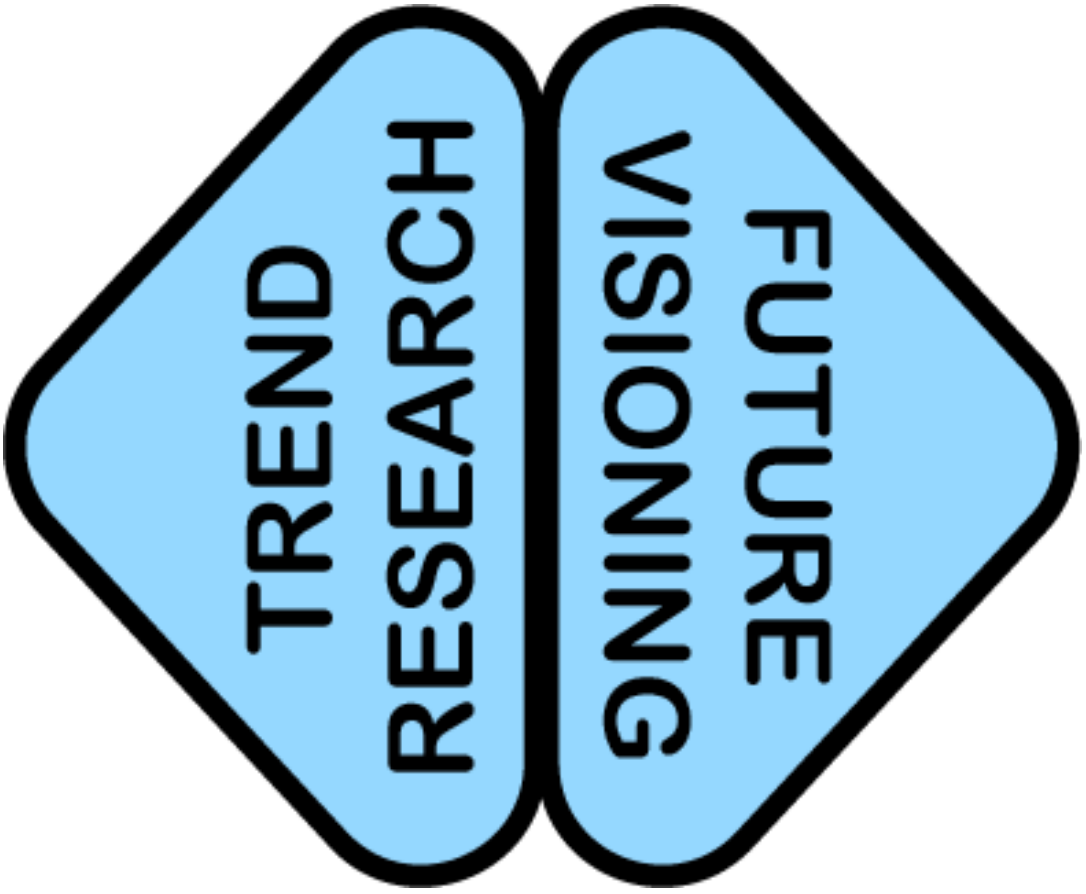
The roadmap will be delivered as an Adobe Illustrator file. Within the Innovation team, there are people who can work with Adobe Illustrator, as does the energy company facilitate this program. Additionally, a PowerPoint version is made, as a more editable document (see appendix F). In case people are unable to work with the Illustrator file in the future, they can utilize the PowerPoint version. It is important to acknowledge that the PowerPoint version is simpler to edit but less visually appealing.

The bars can be adjusted by vertically moving it and/or changing its length where 3.3 mm represents one month. A new variable can be added by extending the height of the component bar and adding a new bar by copying it from the one above.

Below the roadmap is presented.


General Roadmap
2023/2024
2025/2026
2027/2028
2029/2030
2031/2032
Innovation
Innovation A
Innovation B
Innovation C
Innovation D
Innovation E
Innovation F
Collaboration
Company A
Company B
Company C
Company D
Company E
Municipal approach
Utrecht
Phase 1
Phase 2
Phase 3
Rotterdam
Phase 1
Phase 2
Den Haag
Phase 1
Phase 2
Quantity
Terraced
17.300
14.000
14.700
11.700
6.100
Porch
4.300
3.000
2.300
1.400
200
Gallery
1.900
2.200
2.700
1.000
1.200
High rise (other)
40.400
28.900
28.700
21.800
10.500

# Roadmapping



# Future visioning

As mentioned in the chapter: Roadmapping, a future vision will be proposed. This future vision will extend to the long term, approximately around 2050. The energy company can utilize this vision as an additional source of inspiration and as a future destination. While addressing the current challenges with the general and product innovation roadmaps, the future vision provides the energy company with a broader perspective and understanding of the future business of energy.

First, the future context was created. The future context describes the factors that will shape the environment in which the energy company operates. It includes the Demographical, Economical, Sociocultural, Technological, Ecological, and Political aspects that will influence future developments.

Based on this future context, the future vision was created. The future vision outlines the desired en envisioned outcome of the energy company in 2050. It mostly serves as a source of inspiration and as a guiding principle to inspire and align efforts towards this desired future state (Simonse, 2018).

## Future context

To initiate the future context, the strategic trend scanning method by Simonse, (2018) was done. The DESTEP framework was used to identify Demographical, Economical, Sociocultural, Technological, Ecological, and Political developments. The goal was to identify different potential trends which provide a unique opportunity for the future business of the energy company.

Doing online research and reading multiple different reports about future trends and future visions, led to a list of 52 trends that were utilized for clustering (presented in Appendix G).

Afterwards, a co-creation session with fellow Strategic Product Design (SPD) students was held. Co-creating unlocks new perspectives on factor clustering and increases idea and opportunity generation (Sanders & Stappers, 2012). The following clusters, constructing the future context, were created:

**Growing stakeholder engagement**

Figure 50 illustrates the expected growth in stakeholder involvement. Not only is the number of various stakeholders growing, as is the extent to which they are involved with the entire business model. Trends like mass-inclusive brands (*The Future 100: 2023*, 2023), stakeholder capitalism (Sokutu, 2023), and new ways of engaging with citizens and residents support this notion (Oecd, 2023).


*Figure 50: The increase in stakeholder engagement.*

**Increasing energy demand**

Figure 51 represents the increasing importance of energy. The demand for energy is currently growing and will continue to do so (McKinsey, 2023), meanwhile the energy transition is gaining more and more attention ("Trend outlook 2023," 2022). Trends also indicate that renewable energy will play a more important role (Allianz, 2023) and that the price of it will decrease (De Correspondent, 2023), showing a more green approach.

*Figure 51: The increasing importance of energy.*

**Rising transparency**

Figure 52 illustrates the growing significance of transparency, which is already a significant topic and is predicted to become even more important in the future (Kavakli, 2021). Businesses will be forced to be transparent, as new policies are being developed towards a more transparent supply chain (MVO Nederland, 2022). Additionally, the expectation of data exchange will increase as well ("When Atoms meet Bits," 2023).

*Figure 52: The rise of transparency.*

**Fulfilling needs locally**

Figure 53 represents the new opportunities that will arise by focusing on local problems and therefore fulfilling needs on a more local basis. Not only will there be an increase in distributed energy resources, but there will also be more self-organizing citizens at a local level, along with decentralization efforts at a national level ("Trend outlook 2023," 2022). Additionally, there will be a greater emphasis on individualization ("Trends, dilemma's en beleid," 2000).


*Figure 53: The fulfillment of needs locally.*

**Effective technology deployment**

Figure 54 demonstrates the increasing importance for businesses to effectively leverage technology as it continues to advance. Trends suggest that companies should make use of AI for success (Tech Trends 2023; "When Atoms meet Bits," 2023). Furthermore, technological development will have a more informative character ("Trends, dilemma's en beleid," 2000).


*Figure 54: The effective deployment of technology.*

**Increasing international collaboration**

Figure 55 highlights the increasing impact of EU cooperation, influenced by the rise in international collaboration ("Trend outlook 2023," 2022) and the outcomes of COP conferences. COP27 revealed plans by the World Bank to explore reforms that allow for taking on more risk and engaging in more money lending (Sokutu, 2023).

*Figure 55: The increase of international collaboration.*

**Amplified focus on well-being**

Figure 56 visually represents the future's increased focus on the well-being of the earth and humanity. Whilst meaningful entrepreneurship is gaining ground (Van Leeuwen, 2022), and conscious consumers are following nature-minded brands, this trend predicts society to start seeing the Earth as a stakeholder (The Future 100: 2023). Additionally, there is a growing focus on the quality of the living environment, with a shift from prosperity to overall well-being ("Trend outlook 2023," 2022).

*Figure 56: The increasing focus on well-being.*

**Evolving business models**

Figure 57 represents the changing business models and value chains that will experience a transition from ownership to usage, compelling industries to reinvent themselves ("Trend outlook 2023," 2022; Redirecting, z.d.). Additionally, part of this change is about digitization, as companies pursue new economic activities in virtual online markets (Sarson, 2019).

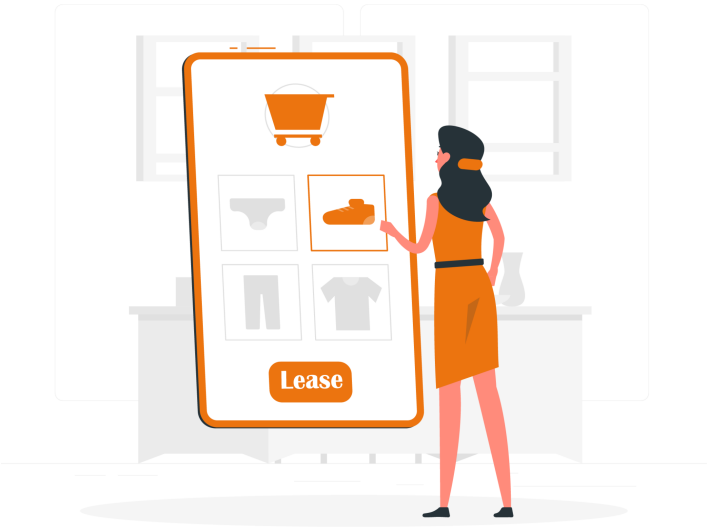



*Figure 57: The shift in business models.*

**Limitations of growth**

Figure 58 emphasizes the importance of acknowledging that technological innovation is not always the solution to certain problems (Sokutu, 2023; The Future 100: 2023). Additionally, it is believed that even growth has its limits. While challenges are posed by the way energy is stored, transformed, and transported (the energy company, 2023), the new concepts and innovations that are introduced might not actually solve the existing problems.

*Figure 58: The limitations of growth.*

**Importance of choosing focus**

Lastly, Figure 59 illustrates that businesses need to prioritize and outsource to remain relevant in the market. Enhancing the resilience, diversity, and economic competitiveness of clean energy supply chains will be essential (International Energy Agency, 2023), and countries must choose specific areas of focus within relevant clean energy supply chains (International Energy Agency, 2023).

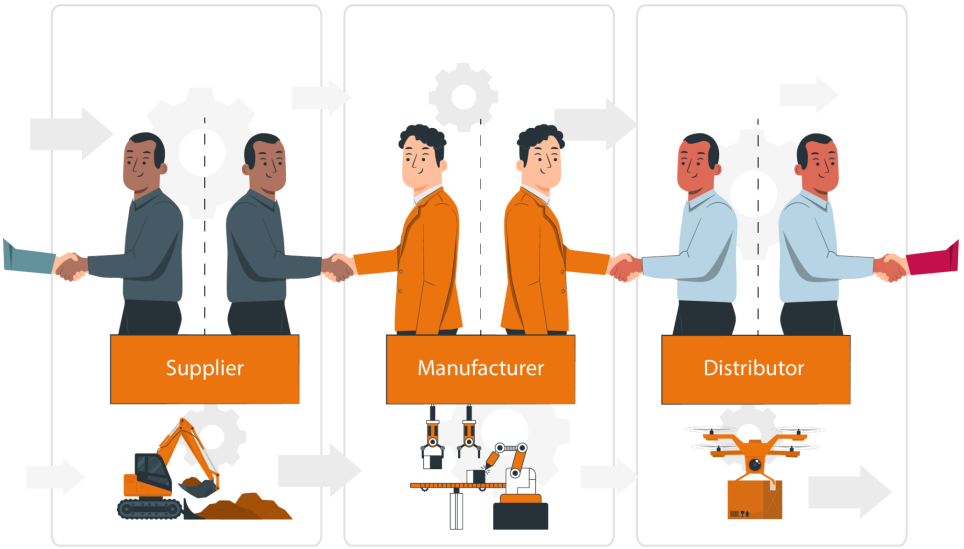



*Figure 59: The importance of outsourcing.*

## Future vision

Based on the future context and the main findings of the research, I conducted an individual brainstorming session to create the future vision. During this brainstorming, different clusters were combined to create potential future scenarios. This process continued until no new scenarios could be identified. Subsequently, these scenarios were reviewed, refined, and then combined again to create the future vision.

The following future vision for the energy company was created:

### “Local energy service”


*Figure 60: Future vision of the energy company: Local energy service.*

Figure 60: illustrates the future vision of the energy company where, in 2050, the energy company will no longer have the role of organizing the energy transition as it currently does. In the proposed approach, the energy company shifts to being a provider of knowledge rather than an organizing and decision-making entity. This transition positions the energy company as a background player during the development phase of the transition vision and neighborhood approaches. With a more consultative role, the energy company will offer expertise, knowledge, and data to empower individuals in creating their own transition visions and neighborhood approaches. By doing this not only the energy transition process will become more transparent, the energy company as a provider will become more transparent as well.

Communities can apply for "Local energy service" through the company's website. A community consists of individuals from the municipality, housing corporations, private building owners, and residents. Together, they will explore the best options for their neighborhood, with the energy company providing support as needed. This service anticipates on the trend growing stakeholder engagement, as residents collectively work towards their own energy transition. Moreover, it enables small-scale neighborhood approaches, making it possible for each neighborhood to devise its most suitable strategy. As a result, individual needs will be resolved locally.

Only during the implementation phase will the energy company assume the organizing role. The neighborhood approach is developed by the community, and the energy company will organize the implementation process. They will execute the plan and provide all the necessary equipment for installation. The business model will be based on a "product-as-a-service" concept, as the energy company retains ownership of all the assets. Therefore, the energy company will also be responsible for the installation and execution.

This results in a decentralized approach with numerous smaller assets spread across the country. As a result, the energy company will move from working with large energy supply assets to working with smaller diverse energy supply assets. To accomplish this, the energy company will make use of the Virtual Power Plant (VPP) platform to connect all the smaller and larger assets together. Combining these assets makes it possible to control and optimize all assets from a central point. This is a unique step that the energy company itself is developing at the moment and by doing so they effectively leverage technology as it continues to advance. This platform facilitates more flexibility to maintain balance on the electricity grid, as it can turn assets on or off within a few seconds. During high energy production periods, the VPP can activate various charging stations across different assets, thereby optimizing grid capacity. Additionally, during times of shortage on the grids, it can facilitate the return of electricity. Therefore, the energy company is able to acquire a powerful position where they can anticipate on the predicted increased energy demand.

# Conclusion

To achieve the energy company's goal of being climate neutral by 2035 through their "Sustainability Strategy" and the high-level carbon strategy roadmap, the energy company must develop new innovative solutions for the provision of energy. The "Sustainability Strategy" outlines specific actions that they are going to take in order to accelerate the energy transition. One of the actions is "Phasing out natural gas." However, before completely phasing out the use of natural gas, a number of different measures must be implemented.

This research proposes five solutions as necessary to transition porch buildings, gallery buildings, and terraced buildings from gas to district heating. By implementing these solutions, there is the potential to connect 67.2 percent of the existing building areas.

To facilitate the development of these solutions, two types of roadmaps are provided. The general roadmap serves as a valuable tool for the energy company's Innovation team, outlining the strategic direction for the upcoming years. It provides guidance to different teams within the energy company on connecting the different housing types to district heating. The product innovation roadmap offers an overview of the necessary components, associated workload, and required internal and external collaborations for each solution. Additionally, both roadmaps can be used to update relevant teams within the energy company or external companies on upcoming innovations.

Furthermore, a future context and vision are created to provide a long-term destination, providing a comprehensive perspective and understanding of the broader picture of the energy business in 2050. In addition to the suggested solutions, the energy company can focus on innovating their company to meet future expectations. With the future context, the recommendation is made that, to meet future customer needs, the company should transition from their current role of organizing the energy transition to becoming a provider of knowledge and expertise.

Lastly, it is concluded that to overcome challenges in adopting district heating, the energy company should improve their communication about their process, progress, and the benefits of district heating to the residents. It is found that the problem does not only lie with not having the right product portfolio for connecting existing housing types but also in the overall acceptance and understanding of district heating.

# Limitations & Recommendations

## Limitations

This section discusses the main limitations encountered in this research. It is important to note that since this research includes various small studies, specific limitations, and recommendations are described in their individual discussions.

- Research sample and selection: The customer research is limited due to the small sample size, which also hasn't been selected randomly. This may limit the generalizability of the findings and to make broader conclusions about the target population

- Lack of previous research: There was limited prior research available to support the literature review on the architecture of buildings before 2006. Therefore, further categorizing different buildings within their housing type was limited.

- Limited availability of data: The research faced challenges due to the lack of data availability. Insufficient data limited the ability to further categorize buildings and explore their different characteristics. Additionally, this also resulted in difficulties in assessing the feasibility and viability of the proposed solutions.

- Time constraints: Due to time constraints the different workshops did not delve deeper into the different housing categories and their characteristics. This may result in more generalized solutions.

- Limited literature research and sample size: Time constraints led to limited literature research on communication, product, and process acceptance. Additionally, the sample size was also limited as only a few people were interviewed.

## Recommendations

This section provides recommendations for future research based on the findings of this study. While this study has provided valuable insights into the research topic, different areas are suggested for further exploration.

- Explore the relation between communication and product and process acceptance by conducting literature research and quantitative research with the energy company customers. Leading to a better understanding of the specific impact of the energy company's communication and product and process acceptance.

- Investigate how housing categories can be further defined to test the feasibility of the solutions and eventually to make more specific solutions. This approach can also facilitate the creation of a database that suggests standardized solutions per specific housing category.

- Conduct additional research into the decision-making process of the Asset Management and Standardization Committee, aiming to better understand and influence the decision-making process effectively.

- Incorporating quantitative research methods to make the findings more reliable and objective. This strengthens the research's analytical rigor.

- Validate the proposed solutions and assess customer satisfaction through customer validation, allowing for testing and refinement based on the feedback and experiences of end customers.

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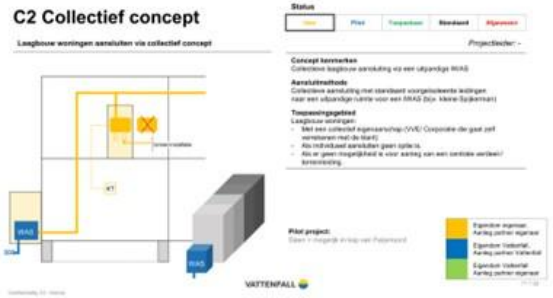
# Appendices

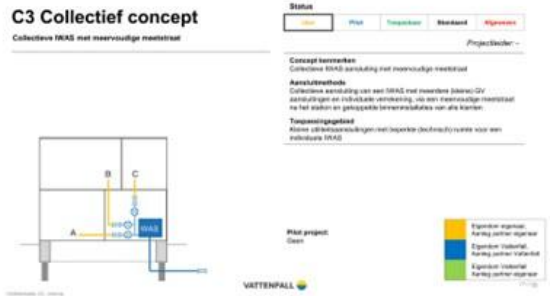
Appendix A

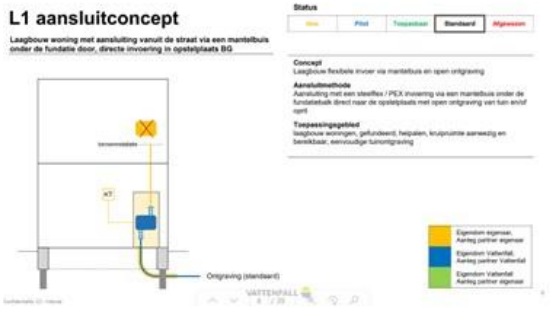

29

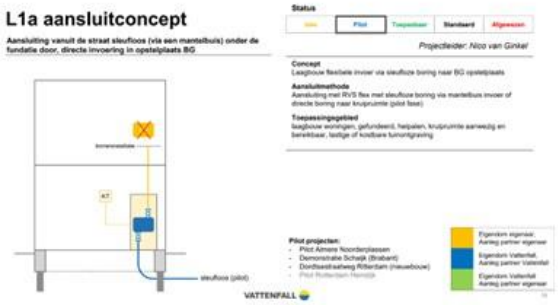
# Vattenfall

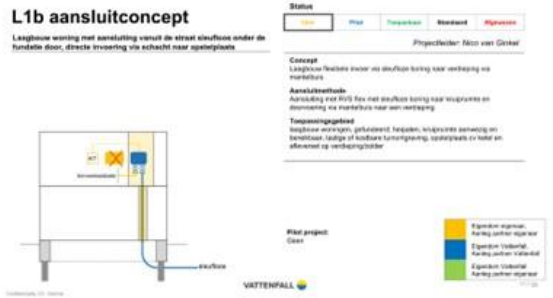
## Grondgebonden - laag

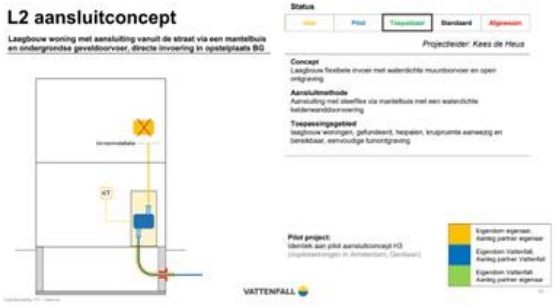


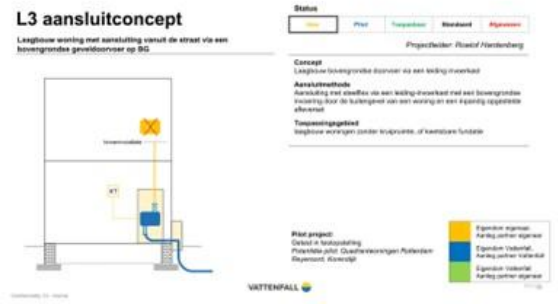



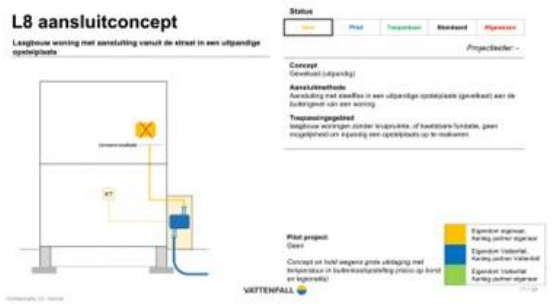



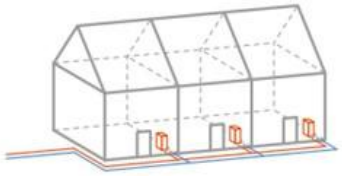



# Ennatuurlijk & impulsadvies

## Grondgebonden - laag

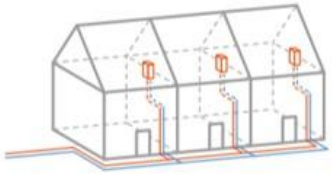
**1** Straat - meterkast

Per woning gaan de aanvoer- en retourleidingen vanaf de straat, ondergronds, naar de woning. De afleverset bevindt zich in de meterkast of bergruimte.



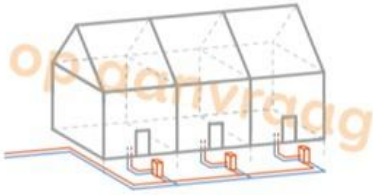
**5** Voorgevel - zolder (via bovenverdieping)

Per woning of woningpaar gaan de aanvoer- en retourleidingen vanaf de straat, via voorgevel en bovenverdieping, naar de afleverset op zolder.



**3** Straat - voortuin (ondergronds)

Per woning gaan de aanvoer- en retourleidingen naar een afleverset die zich in een put voor de woning bevindt. Vanuit hieruit worden ze aangesloten op o.a. de dichtstbijzijnde radiator, bijvoorbeeld in de hal.




# SVP & Heijmans

## Grondgebonden - laag

### Heijmans: Top 3 aansluitmethoden laagbouw

**1. PEX via kruipruimte/kelder/verdiepte trapkast**

Aansluiting met PEX vanaf het distributienet in de straat direct op de afleverset voor of in de woning. Uitgangspunt hierbij is dat de afleverset nabij de voordeur geplaatst kan worden.

**Voor-, nadelen voor eigenaar / huurder**

- Geen grote aanpassingen in de woning
- Buiten geen aanpassingen van het aanzicht van de woning
- De voortuin moet open gegraven worden. Per 2 woningen naast elkaar 1 grote sleuf + viertal PEX-leidingen

**Voorbeeld**

Ca 100 rijwoningen (huurwoningen) in Liniekwartier Breda (Ennatuurlijk)

**2. PEX tot gevel**

Wanneer er geen kruipruimte aanwezig is buiten aan de gevel een kast maken met daarin de afleverset in een kast (zelfde idee als droge blusleiding kast bij appartementen complexen). Vanuit deze kast kan er met flexibel materiaal naar binnen gegaan worden.

**Voor-, nadelen voor eigenaar / huurder** (zie 1)





### SVP: Top 3 aansluitmethoden laagbouw

**1. Aansluiting onder de fundering binnenkomend in de meterkast. Dan 22 mm CV pijp aanleggen naar de zolder toe en daar de afleverset plaatsen.**

Varianten (zie schetsen op de muur):

- Via de kruipruimte (1A t/m 2C)
- Via een bovengrondse doorvoer (3A, B en C)
- Via de gevel (4A)
- Variant 5A voor bungalow woning waar de afleverset binnen 2 meter bij de binnenkomende leidingen wordt geplaatst.

**Voor-, nadelen voor eigenaar / huurder**

Minste overlast
Leidingen niet in zicht
Geen kostbare aanpassingen nodig aan de binneninstallatie
Ruimteverlies doordat er leidingen in de woningen naar de aansluiting omhoog lopen

**Voorbeelden**

Overwhere Zuid, Purmerend



### SVP: Top 3 aansluitmethoden laagbouw

**2. Aansluiting als bovengrondse invoer door de muur direct de meterkast in**

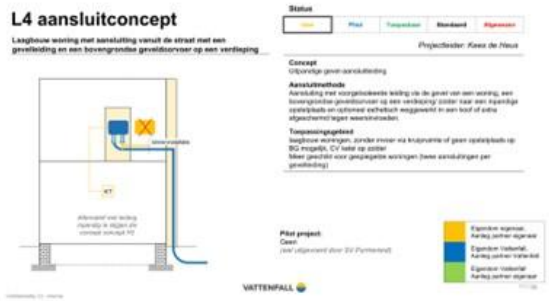
Eenvoudige aanleg, minste overlast
Kruipruimte niet noodzakelijk, hoeft niet geruimd
Gaten in de voorgevel muur
Kast tegen buitengevel in het zicht

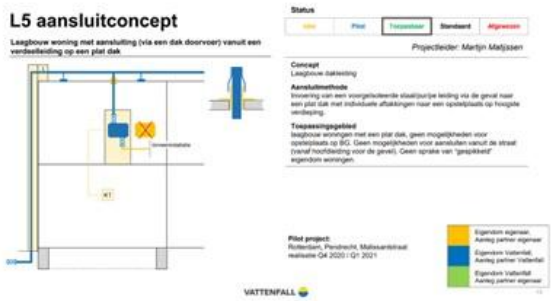
**3. Als het echt niet anders kan via de gevel omhoog en onder het schuine dak naar binnen**

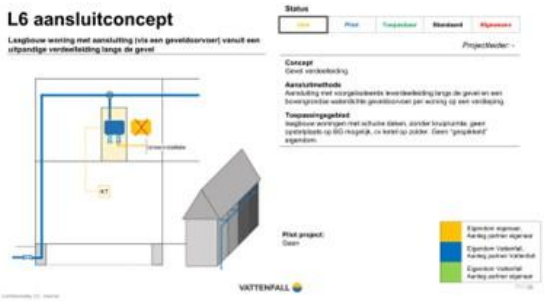
Geen ruimteverlies inpandig
Geen leidingwerk in zicht inpandig
Minder overlast van overige 'nutsen' inpandig
Makkelijk aan te brengen met beugels tegen buitengevel
Leidingen buiten het meest in zicht
Warmteverlies leidingen in buitenlucht
Veroudering door UV straling
Bescherming tegen elementen door buitenmantel
Vastpunt constructie wegens zakking van grond bij buitengevel

# Vattenfal & ennatuurlijk

## Grondgebonden - hoog

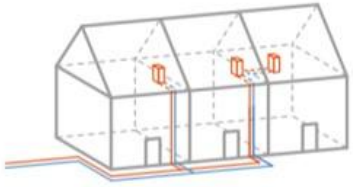


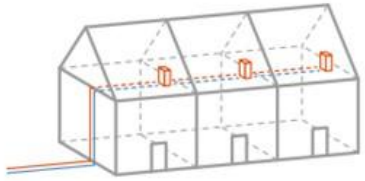

**2** Voorgevel - zolder

Per woning of woningpaar gaan de aanvoer- en retourleidingen vanaf de straat via de voorgevel naar de afleverset op zolder.



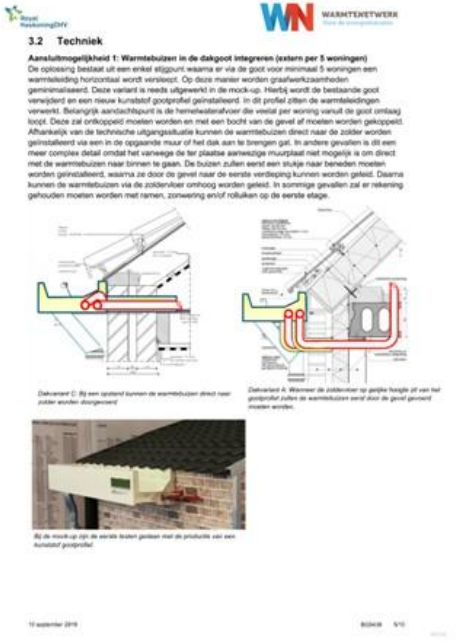
**4** Zijgevel - zolder

Per rij woningen gaan de aanvoer- en retourleidingen aan één kant via de zijgevel naar de afleverset op zolder. Van daaruit gaat een verdeelleiding naar de zolder van de aangrenzende woning, waar eveneens een afleversets is geplaatst. Dit herhaalt zich tot het einde van de rij is bereikt.



# Warmtenetwerk

## Grondgebonden - hoog



3.2 Techniek

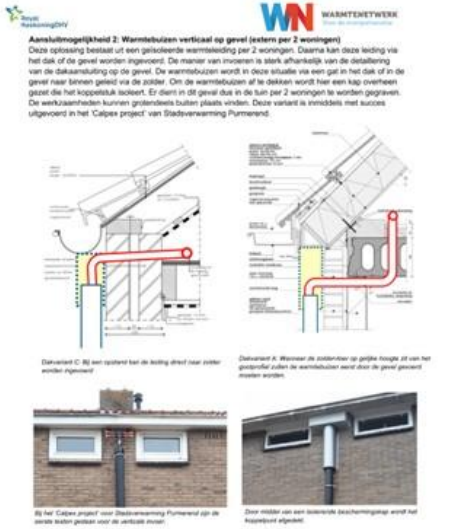
**Aansluitmogelijkheid 1: Warmtebuizen in de dakgoot integreren (extern per 5 woningen)**

De oplossing bestaat uit een enkel stijgpunt waarna er via de goot voor minimaal 5 woningen een warmteleiding horizontaal wordt versleept. Op deze manier worden graafwerkzaamheden geminimaliseerd. Deze variant is reeds uitgewerkt in de mock-up. Hierbij wordt de bestaande goot verwijderd en een nieuw kunststof gootprofiel geïnstalleerd. In dit profiel zitten de warmteleidingen verwerkt. Belangrijk aandachtspunt is de hemelwaterafvoer die veelal per woning vanuit de goot omlaag loopt. Deze zal ontkoppeld moeten worden en met een bocht van de gevel af moeten worden gekoppeld. Afhankelijk van de technische uitgangssituatie kunnen de warmtebuizen direct naar de zolder worden geïnstalleerd via een in de opgaande muur of het dak aan te brengen gat. In andere gevallen is dit een meer complex detail omdat het vanwege de ter plaatse aanwezige muurplaat niet mogelijk is om direct met de warmtebuizen naar binnen te gaan. De buizen zullen eerst een stukje naar beneden moeten worden geïnstalleerd, waarna ze door de gevel naar de eerste verdieping kunnen worden geleid. Daarna kunnen de warmtebuizen via de zoldervloer omhoog worden geleid. In sommige gevallen zal er rekening gehouden moeten worden met ramen, zonwering en/of rolluiken op de eerste etage.

*Dakvariant C: Bij een opstand kunnen de warmtebuizen direct naar zolder worden doorgevoerd*

*Dakvariant A: Wanneer de zoldervloer op gelijke hoogte zit van het gootprofiel zullen de warmtebuizen eerst door de gevel gevoerd moeten worden.*

*Bij de mock-up zijn de eerste testen gedaan met de producten van een kunststof gootprofiel.*



**Aansluitmogelijkheid 2: Warmtebuizen verticaal op gevel (extern per 2 woningen)**

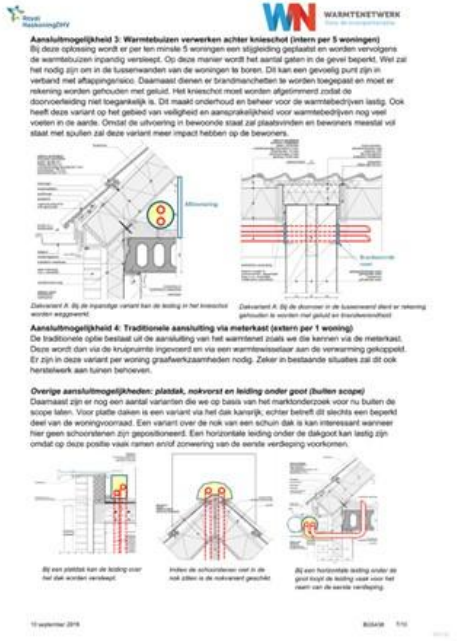
Deze oplossing bestaat uit een geïsoleerde warmteleiding per 2 woningen. Daarna kan deze leiding via het dak of de gevel worden ingevoerd. De manier van invoeren is sterk afhankelijk van de detaillering van de dakaansluiting op de gevel. De warmtebuizen wordt in deze situatie via een gat in het dak of in de gevel naar binnen geleid via de zolder. Om de warmtebuizen af te dekken wordt hier een kap overheen gezet die het koppelstuk isoleert. Er dient in dit geval dus in de tuin per 2 woningen te worden gegraven. De werkzaamheden kunnen grotendeels buiten plaats vinden. Deze variant is inmiddels met succes uitgevoerd in het 'Calpex project' van Stadsverwarming Purmerend.

*Dakvariant C: Bij een opstand kan de leiding direct naar zolder worden ingevoerd*

*Dakvariant A: Wanneer de zoldervloer op gelijke hoogte zit van het gootprofiel zullen de warmtebuizen eerst door de gevel gevoerd moeten worden.*

*Bij het 'Calpex project' voor Stadsverwarming Purmerend zijn de eerste testen gedaan voor de verticale invoer.*

*Door middel van een isolerende beschermingskap wordt het koppelpunt afgedekt.*



**Aansluitmogelijkheid 3: Warmtebuizen verwerken achter knieschot (intern per 5 woningen)**

Bij deze oplossing wordt er per ten minste 5 woningen een stijgleiding geplaatst en worden vervolgens de warmtebuizen inpandig versleept. Op deze manier wordt het aantal gaten in de gevel beperkt. Wel zal het nodig zijn om in de tussenwanden van de woningen te boren. Dit kan een gevoelig punt zijn in verband met aftappingsrisico. Daarnaast dienen er brandmanchetten te worden toegepast en moet er rekening worden gehouden met geluid. Het knieschot moet worden afgetimmerd zodat de doorvoerleiding niet toegankelijk is. Dit maakt onderhoud en beheer voor de warmtebedrijven lastig. Ook heeft deze variant op het gebied van veiligheid en aansprakelijkheid voor warmtebedrijven nog veel voeten in de aarde. Omdat de uitvoering in bewoonde staat zal plaatsvinden en bewoners meestal vol staat met spullen zal deze variant meer impact hebben op de bewoners.

*Dakvariant A: Bij de inpandige variant kan de leiding in het knieschot worden weggewerkt*

*Dakvariant A: Bij de doorvoer in de tussenwand dient er rekening gehouden te worden met geluid en brandweereisen/test*

**Aansluitmogelijkheid 4: Traditionele aansluiting via meterkast (extern per 1 woning)**

De traditionele optie bestaat uit de aansluiting van het warmtenet zoals we die kennen via de meterkast. Deze wordt dan via de kruipruimte ingevoerd en via een warmtewisselaar aan de verwarming gekoppeld. Er zijn in deze variant per woning graafwerkzaamheden nodig. Zeker in bestaande situaties zal dit ook herstelwerk aan tuinen behoeven.

***Overige aansluitmogelijkheden: platdak, nokvorst en leiding onder goot (buiten scope)***

Daarnaast zijn er nog een aantal varianten die we op basis van het marktonderzoek voor nu buiten de scope laten. Voor platte daken is een variant via het dak kansrijk, echter betreft dit slechts een beperkt deel van de woningvoorraad. Een variant over de nok van een schuin dak is kan interessant wanneer hier geen schoorstenen zijn gepositioneerd. Een horizontale leiding onder de dakgoot kan lastig zijn omdat op deze positie vaak ramen en/of zonwering van de eerste verdieping voorkomen.

*Bij een platdak kan de leiding over het dak worden versleept.*

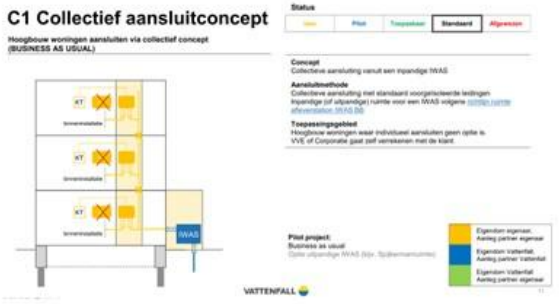
*Indien de schoorstenen veel in de nok zitten is de nokvariant geschikt*

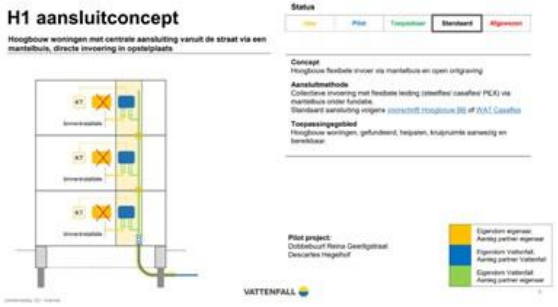
*Bij een horizontale leiding onder de goot loopt de leiding vaak voor het raam van de eerste verdieping.*

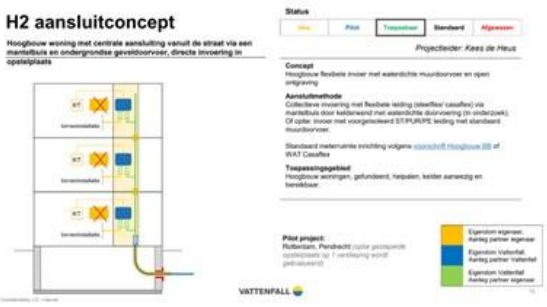

35

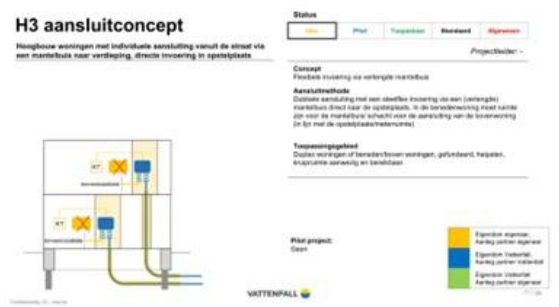
# Vattenfall

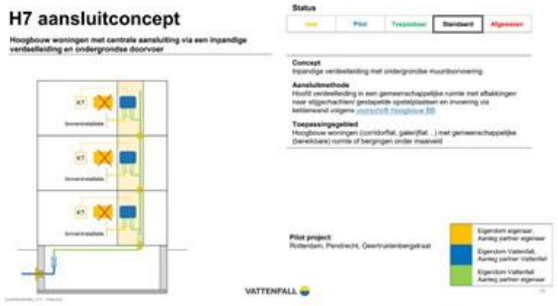
## Hoogbouw - leiding via BG

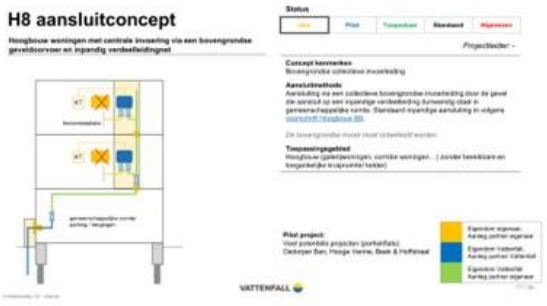


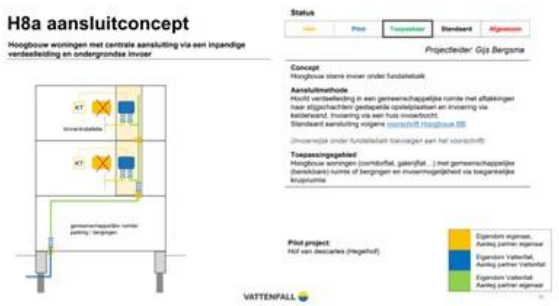



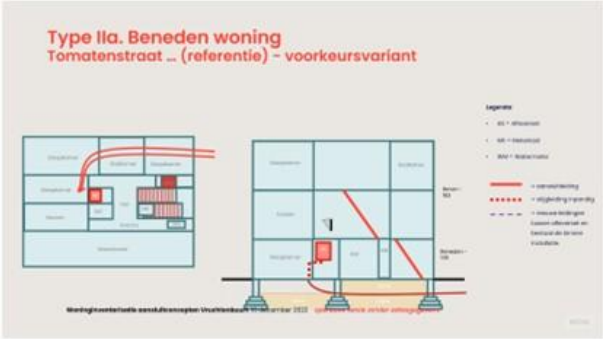



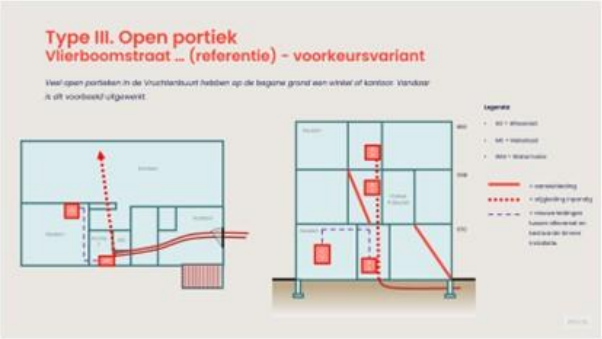



# Impulsadvies

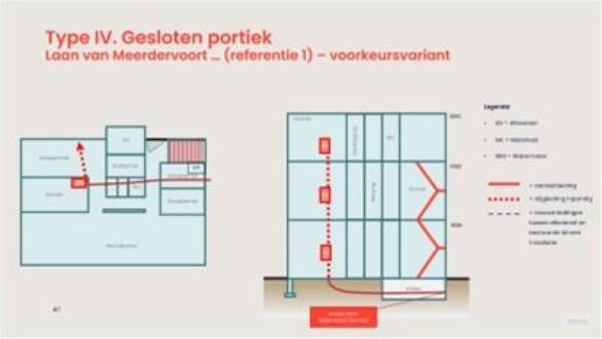
## Hoogbouw - leiding via BG









# Heijmans, SVP & Ennatuurlijk

## Hoogbouw - leiding via BG

### Heijmans: Top 3 aansluitmethoden hoogbouw

**Portiekflats**

**1. Invoerbochten naar technische ruimte**

Vanuit technische ruimte huidig systeem gebruiken (alleen mogelijk indien warmte in gebouw centraal geregeld wordt)

**Voor-, nadelen voor eigenaar / huurder**

- Enkel centrale installatie overzetten op warmte
- In gebouw nagenoeg geen aanpassingen
- In gebouw nagenoeg geen aanpassingen

**Voorbeeld**

Diverse gebouwen in Breda en Tilburg (Ennatuurlijk)

**2. Invoerbochten tegen gevel**

Vanaf hier woningen individueel aansluiten met materiaal anders dan st-pur-pe

**Voor-, nadelen voor eigenaar / huurder** (zie 1)

### SVP: Hoogbouw aansluitmethoden

**Galerijflats**

In bestaande galerijflats is ook erg weinig ruimte. Als invoer is staal gebruikt tot onder de vloer. Daarna over op Calpex UNO wat iets flexibeler is dan staal om wat lastige obstakels te passeren. Daarna aansluiting op de opvoerset (SVV ?). Hierna over met dikwandig stalen buis als verdeel en stijgleidingen.

**Voor-, nadelen voor eigenaar / huurder:**

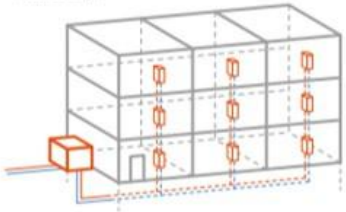
- Zo weinig mogelijk boren in funderingen en constructief belangrijke onderdelen
- Ruimteverlies
- Er moet een technische ruimte komen voor de opvoerset
- Verdeelleidingen langs plafond in zicht
- Wettelijke hoogte van 2,10 in bouwbesluit is lastig te handhaven

**Voorbeeld**

Project is nog in uitvoering in Overwhere Zuid Purmerend

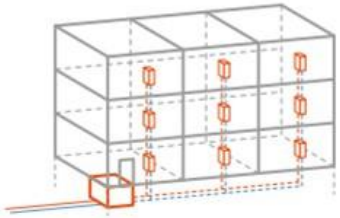
### 3 Maaiveld - leidingen via begane grond/souterrain

Het regelstation staat op het maaiveld, tegen de buitengevel. Vanuit het regelstation gaan de aanvoer- en retourleidingen horizontaal via begane grond/souterrain en vervolgens omhoog naar de afleversets in de appartementen. De afleversets hangen in een bergruimte of keukenkastje.



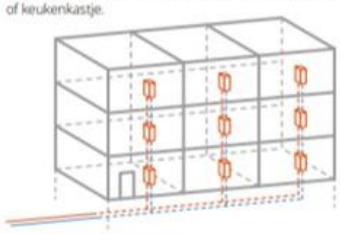
### 4 Inpandig - leidingen via begane grond/souterrain

Het regelstation staat in een technische ruimte op de begane grond/ souterrain, tegen de buitengevel. Vanuit het regelstation gaan de aanvoer- en retourleidingen horizontaal via begane grond/souterrain en vervolgens omhoog naar de afleversets in de appartementen. De afleversets hangen in een bergruimte of keukenkastje.



### 6 Elders - leidingen via begane grond/souterrain

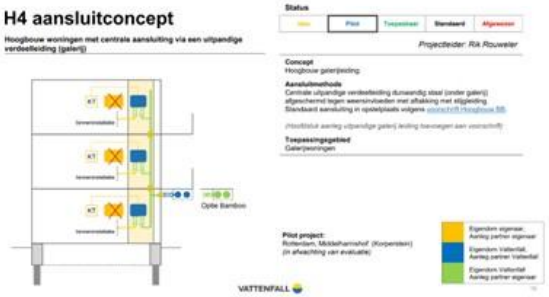
Het regelstation staat elders in de wijk. De aanvoer- en retourleidingen gaan vanaf hier naar het gebouw. Via begane grond/souterrain gaan ze horizontaal door het gebouw en vervolgens omhoog naar de afleversets in de appartementen. De afleversets hangen in een bergruimte of keukenkastje.

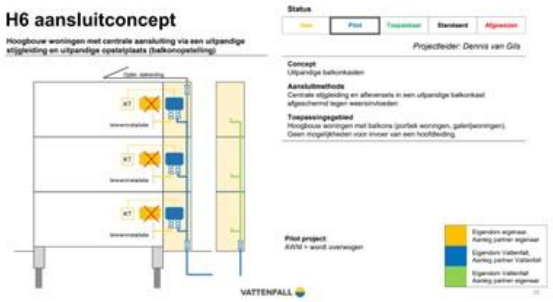


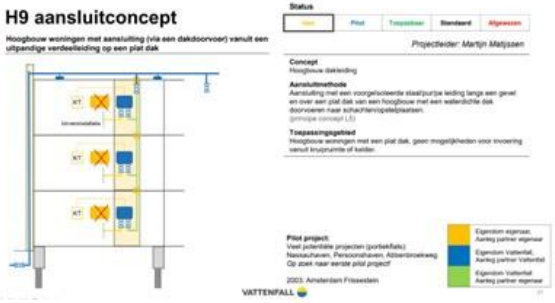
38

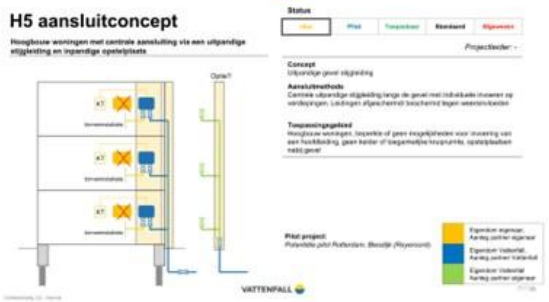
# Vattenfall, Nijkamp & Heijmans

## Hoogbouw - Leiding via dak/gevel




### Nijkamp: Top 3 aansluitmethoden hoogbouw

- Traditioneel
- Boogboring
- Muurkruipers
- Via buiten naar de zolder
- Aansluitbox
- Portiekflats: verslepen door portiek
- Galerijflats: verslepen door galerij

**Voor-, nadelen voor eigenaar / huurder**

Geen ruimteverlies inpandig
- Duurzaam
- Van gas af
- Toekomstbestendig

Minder afhankelijk
Woning wordt meer waard
- Overlast
- Extra kosten

**Voorbeeld**

### Heijmans: Top 3 aansluitmethoden hoogbouw

**Galerijflats**

**1. Leidingtrace via dak**

Middels een st-pur-pe leidingtrace langs de gevel naar het dak. Vanaf technische ruimte op het dak en/of individueel via schachten woningen aansluiten.

**Voor-, nadelen voor eigenaar / huurder**
- Tot op het dak eenvoudig te realiseren
- Verslepen van inpandige leidingen arbeidsintensief (vaak icm energiesprong gebouw)
- Leidingen zijn zichtbaar langs de gevel
- Leidingen worden blootgesteld aan UV

**Voorbeeld**

(Spelaarflats Breda (Ennatuurlijk)

**2. Invoerbochten tegen gevel**

Vanaf hier woningen individueel aansluiten met materiaal anders dan st-pur-pe

**Voor-, nadelen voor eigenaar / huurder** (zie 1)

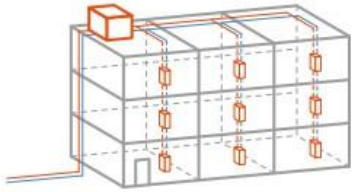
39

# Ennatuurlijk

## Hoogbouw – leiding via dak/gevel

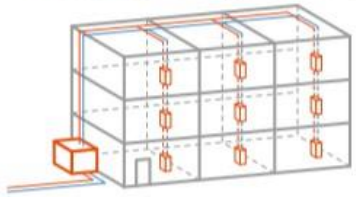
**1** Dak - leidingen via buitengevel

Het regelstation staat op het dak. De aanvoer- en retourleidingen gaan via de buitengevel naar het regelstation, en van daaruit omlaag naar de afleversets in de appartementen. De afleversets hangen in een bergruimte of keukenkastje.



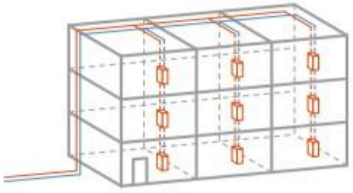
**2** Maaiveld - leidingen via buitengevel

Het regelstation staat op het maaiveld, tegen de buitengevel. De aanvoer- en retourleidingen gaan via de buitengevel naar het dak en van daaruit omlaag naar de afleversets in de appartementen. De afleversets hangen in een bergruimte of keukenkastje.



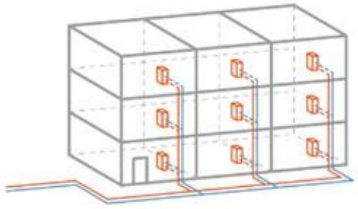
**5** Elders - leidingen via buitengevel

Het regelstation staat elders in de wijk. Van hieruit gaan de aanvoer- en retourleidingen naar het gebouw en via de buitengevel naar het dak. Van daaruit gaan ze omlaag naar de afleversets in de appartementen. De afleversets hangen in een bergruimte of keukenkastje.



**7** Elders - leidingen via balkon

Het regelstation staat elders in de wijk. Vanuit het regelstation gaan de aanvoer- en retourleidingen naar het gebouw. Hier gaan ze via de balkons omhoog naar de afleversets in de appartementen. De afleversets hangen op het balkon of in een keukenkastje.



# Appendix B

Excel data files used:
20230322 Woninginformatie Utrecht.xlsx
20230323 Woninginformatie Den Haag.xlsx
20230323 Woninginformatie Rotterdam.xlsx
20230309 Woninginformatie Nederland.xlsx

How to extract the right data:
Information per region:

1. Choose the data file with the right municipality
2. Select the right sheet (each phase has its on sheet)
    a. Within this sheet, the right neighborhoods are selected - (BUURT_NAAM, select the neighborhoods from Warmtetransitie visie files and include it within Filters).
    b. Within this sheet, the right buildings types are selected -(GEBOUWTYPE, select the right housing types, exclude empty cells & apartments and include in Rows)
3. Select the variable you want presented and include in values, to get percentages go to value Field settings.

Now the variable is presented per housing type

Information from the Netherlands:
Same steps as above except there are no different phases and therefore no different sheet per timing

# Appendix C

| Category | Type of building | Owner | Year of construction | Difficulty | Quantity | Time | Comment |
|---|---|---|---|---|---|---|---|
| **A.1.1** | flat (other) | Privately owned | <92 | --- | -- | ++ | Standardizing is difficult since the buildings are very diverse. Also it is not clear what different sub categories are included. Next to that, privately owned houses have a higher chance of having different floor plans, especially when they are built before 1992. This type of building is in low quantity but a priority when looking at time |
| **A.1.2** | flat (other) | Privately owned | 92> | --- | --- | ++ | Standardizing is difficult since the buildings are very diverse. Also it is not clear what different sub categories are included. Next to that ,privately owned houses have a higher chance of having different floor plans, however after 1992 this decreases. This type of building is in low quantity but a priority when looking at time |
| **A.2** | flat (other) | Rental | [-] | --- | - | +++ | Standardizing is difficult since the buildings are very diverse. Also it is not clear what different sub categories are included. These floor plans are in low quantity within the same building. This type of building is in high quantity but a priority when looking at time |
| **B.1.1** | Gallery building | Privately owned | <92 | 0 | -- | --- | Privately owned houses have a higher chance of having different floor plans, especially when they are built before 1992. This type of building has some quantity and has no priority when looking at time. |
| **B.1.2** | Gallery building | Privately | 92> | ++ | --- | --- | Privately owned houses have a higher chance of having different floor plans, |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | | owned | | | | | however after 92 this chance decreases. This type of building has some quantity and has no priority when looking at time. |
| **B.2** | Gallery building | Rental | [-] | +++ | - | -- | Standardizing is possible since rental companies often use the same floor plan for their buildings. These floor plans are in high quantity within the same building. This type of building has some quantity and has no priority when looking at time. |
| **C.1.1** | Maisonnette | Privately owned | <92 | --- | -- | 0 | Privately owned houses have a higher chance of having different floor plans, especially when they are built before 1992. This type of building is in less quantity and less priority when looking at time. |
| **C.1.2** | Maisonnette | Privately owned | 92> | - | --- | 0 | Privately owned houses have a higher chance of having different floor plans, however after 92 this chance decreases. The buildings are not in high quantity and no priority when looking at time |
| **C.2** | Maisonnette | Rental | [-] | - | - | 0 | Standardizing is possible since rental companies often use the same floor plan for their buildings. However the buildings often do not have many apartments included. The buildings are in less quantity and less priority when looking at time. |
| **D.1.1** | Porch building | Privately owned | <92 | 0 | - | --- | Privately owned houses have a higher chance of having different floor plans especially when they are built before 1992. However the housing type are in some quantity but no priority when looking at time |
| **D.1.2** | Porch building | Privately owned | 92> | ++ | -- | --- | Privately owned houses have a higher chance of having different floor plans. However the buildings are not in high quantity and no priority when looking at time |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **D.2** | Porch building | Rental | [-] | +++ | 0 | -- | Standardizing is possible since rental companies often use the same floor plan for their buildings. These floor plans are in high quantity within the same building. However the buildings are in some quantity and no priority when looking at time |
| **E.1.1** | Terraced house | Privately owned | <92 | -- | +++ | 0 | Privately owned houses have a higher chance of having different floor plans, especially built before 1992. High in quantity when looking at total (however there are more rental terraced houses). Higher priority when looking at the time. |
| **E.1.2** | Terraced house | Privately owned | 92> | 0 | ++ | 0 | Privately owned houses have a higher chance of having different floor plans. Lower in quantity when looking at total (however there are more rental terraced houses). Higher priority when looking at the time. |
| **E.2** | Terraced house | Rental | [-] | 0 | +++ | + | Standardizing is possible since rental companies often use the same floor plan for their buildings. High in quantity when looking at total. Higher priority when looking at the time. |
| **F** | Semi-detached house | [-] | [-] | -- | + | - | Difficult since all the buildings have an individual floor plan (less difficult than a detached house since there might be a chance that within one building the same floor plan exists) (few rentals). high quantity but when looking at time has a low priority |
| **G** | Detached house | [-] | [-] | --- | ++ | --- | Difficult since all the buildings have an individual floor plan (almost no rental). high quantity in total and don't have a priority when looking at time. |

*Difficulty* = Indicates how difficult it is to standardize for that specific housing category. Meaning that [---] indicates that it is very difficult to find a standardized solution and [+++] indicates that there is a high possibility of finding a standardized solution.
*Quantity* = Indicates how many buildings of that specific housing category relatively are in the Netherlands (see table 1). Meaning [---] indicates that there are relatively few buildings of that category in the Netherlands and [+++] indicates that relatively there are many buildings of that category in the Netherlands.
*Timing* = Indicates which type of building is the most interesting to focus on when looking at the timing of Warmtetransitie visies of Rotterdam, Utrecht and Den Haag (see table 2,3,4). Meaning [---] indicates that there relatively is a small number of buildings that will be connected first to district heating and [+++] indicates that relatively there are many buildings of that category that will be connected first to district heating

# Appendix D1

Workshop 1

| Part | Element | Time | Material |
|---|---|---|---|
| 0 | Project brief | 10 min | Slide deck |
| | Problem statement | | |
| 1 | Individual idea generation 1 | 10 min | framework + pens |
| | Group brainstorm 1 | 10 min | White board |
| | Individual idea generation 2 | 10 min | framework + pens |
| | Group brainstorm 2 | 10 min | White board |
| | Group brainstorm 3 | 15 min | White board + paper and pens |

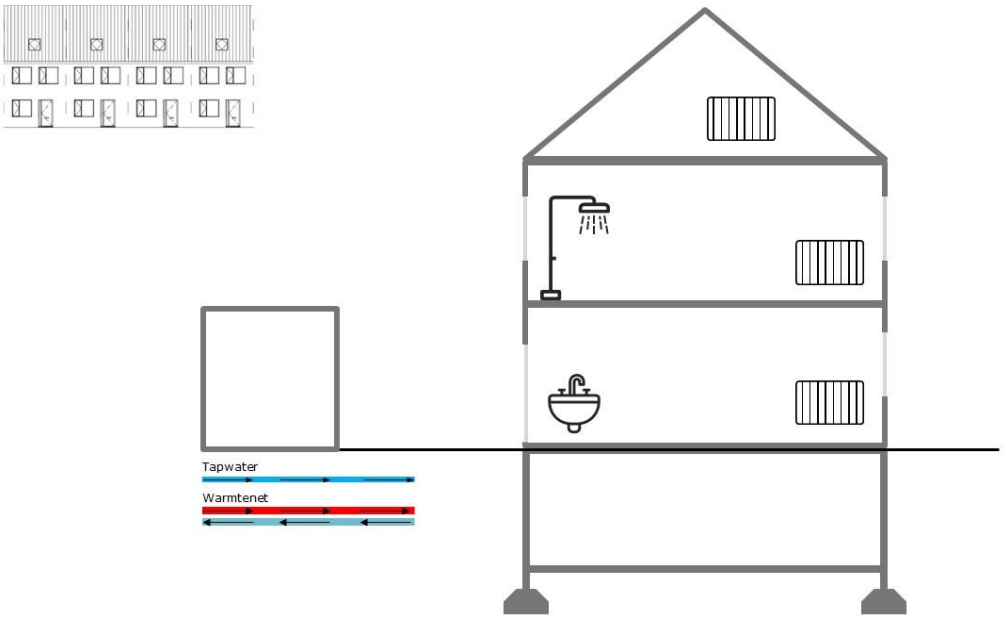
Workshop 2

| Part | Element | Time | Material |
|---|---|---|---|
| 0 | Project brief | 10 min | Slide deck |
| | Problem statement | | |
| | Rules | | |
| 1 | Individual idea generation 1 | 10 min | framework + pens |
| | Group brainstorm 1 | 10 min | White board |
| | Individual idea generation 2 | 10 min | framework + pens |
| | Group brainstorm 2 | 10 min | White board |
| | Group brainstorm 3 | 15 min | White board + paper and pens |
| 2 | Individual idea generation 1 | 10 min | framework + pens |
| | Group brainstorm 1 | 10 min | White board |
| | Individual idea generation 2 | 10 min | Framework + pens |
| | Group brainstorm 2 | 10 min | White board |
| | Group brainstorm 3 | 15 min | White board + paper and pens |

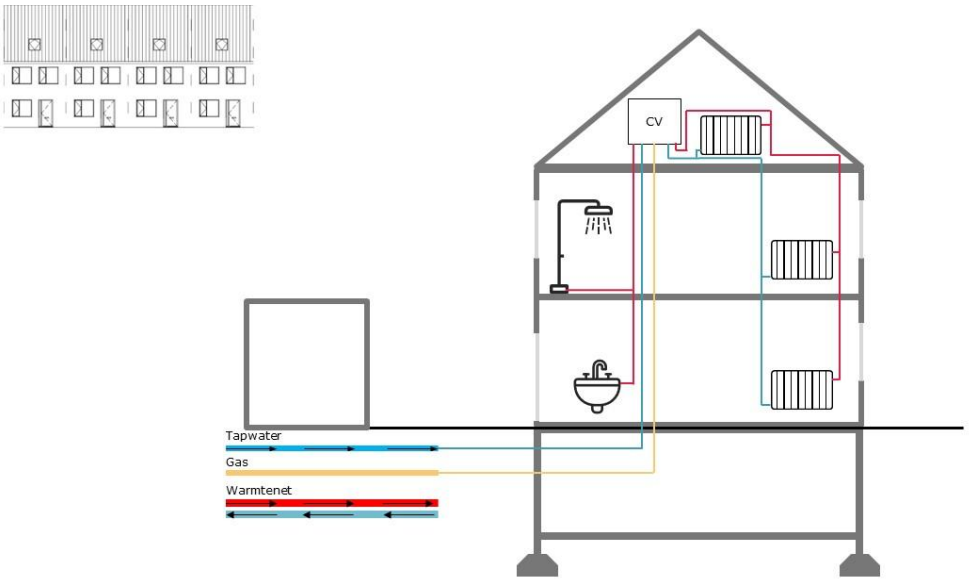
Workshop 3

| Part | Element | Time | Material |
|---|---|---|---|
| 0 | Project brief | 10 min | Slide deck |
| | Problem statement | | |
| | Rules | | |
| 1 | Individual idea generation 1 | 10 min | Paper with framework + red pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + blue pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + green pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + black pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + pencil |
| | per person present most promising idea | 15 min | - |
| 2 | Individual idea generation | 10 min | Paper with framework + red pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + blue pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + green pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + black pen |
| | Switch drawings and change 1 thing | 5 min | Drawing + pencil |
| | per person present most promising idea | 15 min | - |

# Appendix D2

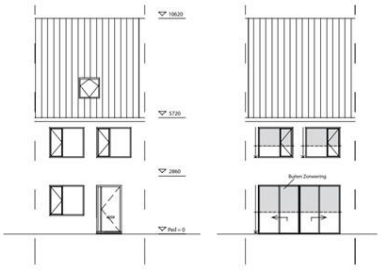



1

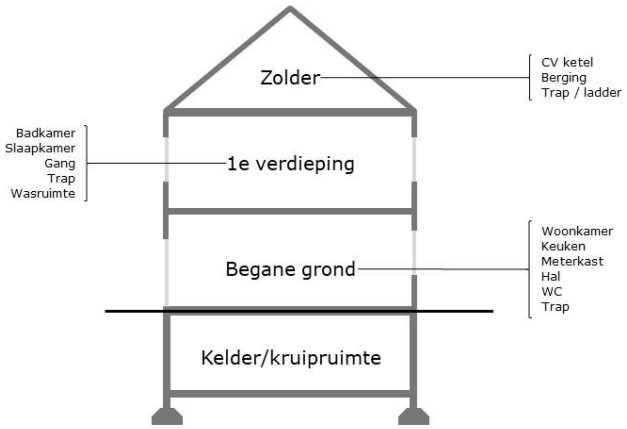



2

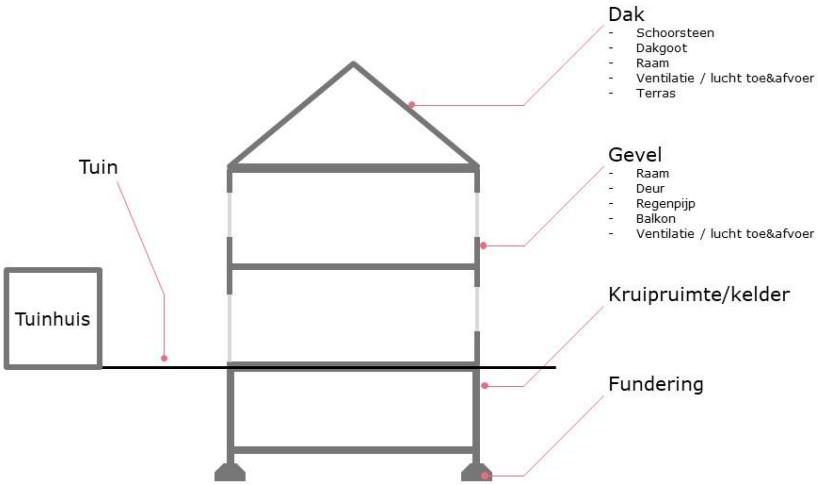
*Begane grond* *1e Verdieping* *2e Verdieping*



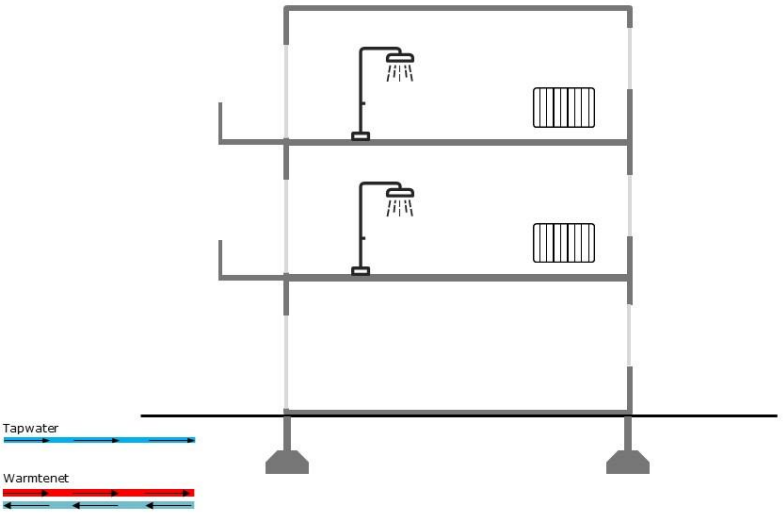
*Voorgevel* *Achtergevel*



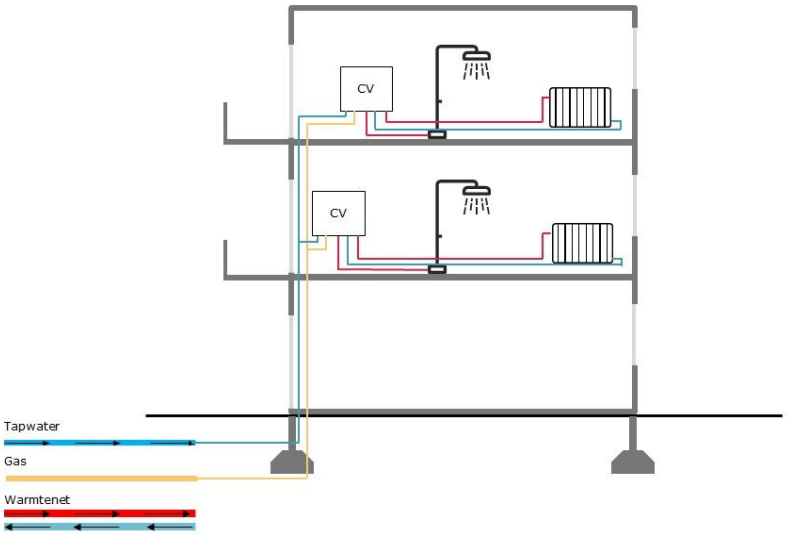

4


Dak
- Schoorsteen
- Dakgoot
- Raam
- Ventilatie / lucht toe&afvoer
- Terras
Gevel
- Raam
- Deur
- Regenpijp
- Balkon
- Ventilatie / lucht toe&afvoer
Kruipruimte/kelder
Fundering
Tuin
Tuinhuis

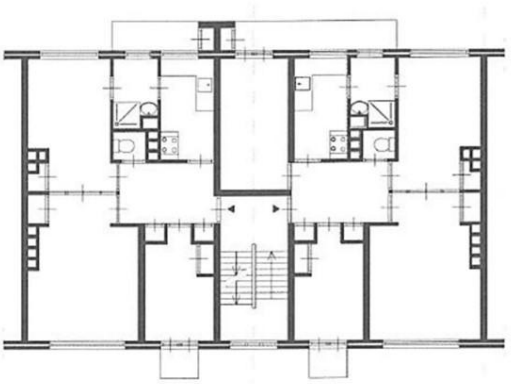
3


Tapwater
Warmtenet

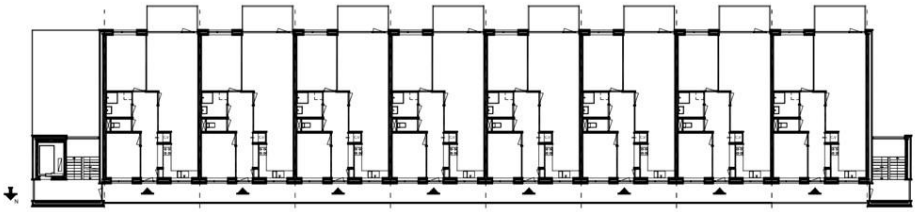
7




6

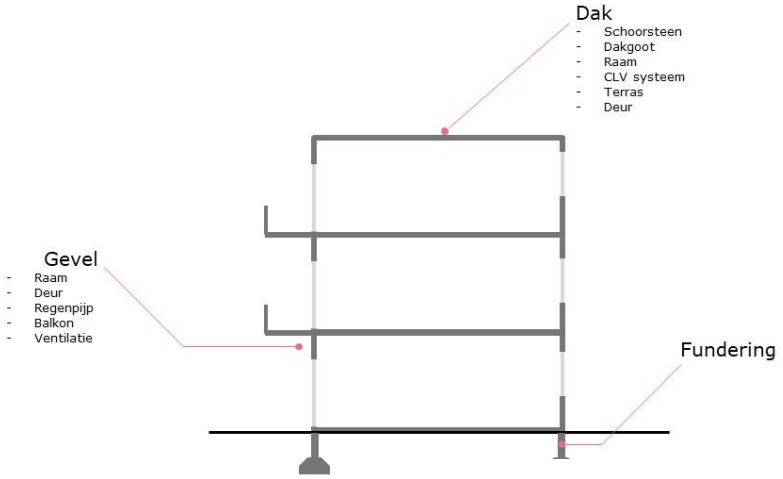


11

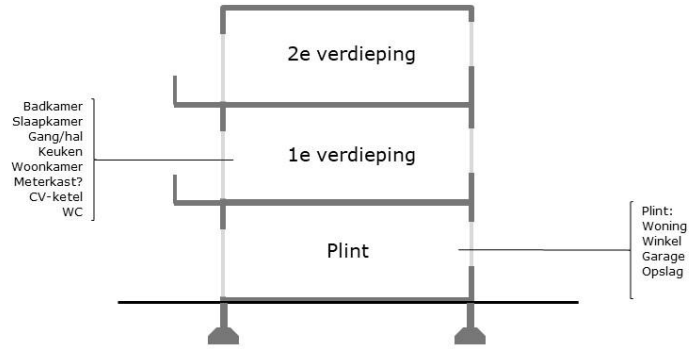


*Plattegrond 1e t/m 4e verdieping*


*Voorgevel*



Extra ruimtes
- Lift Schacht
- Trappenhuis




9

# Appendix D3

The basic rules by Tassoul, 2019

1. Ownership of ideas

During the workshop ideas belong to everyone in the group and each can do whatever they want with them. This not only prevents the discussion on whose idea it was but also creates a safe environment where no one has to be careful to be responsible for a bad idea.

2. Postpone judgment

In the introduction it is made clear that we are only creating ideas, nothing more. Meaning that there should not be any binary good/bad judgment. “Binary judgments are necessary for actions - we either do it or we don’t. But ideas as such are only words and pictures - they do not change anything in the real world” (Nolan 1989).

3. Dare to freewheel

One of the goals is to push people to free themselves from existing ideas and concepts. During this workshop this is done by introducing a start up, which has no rules, where people are working instead of their company. Now they have to think of new ideas to compete with their own companies' ideas.

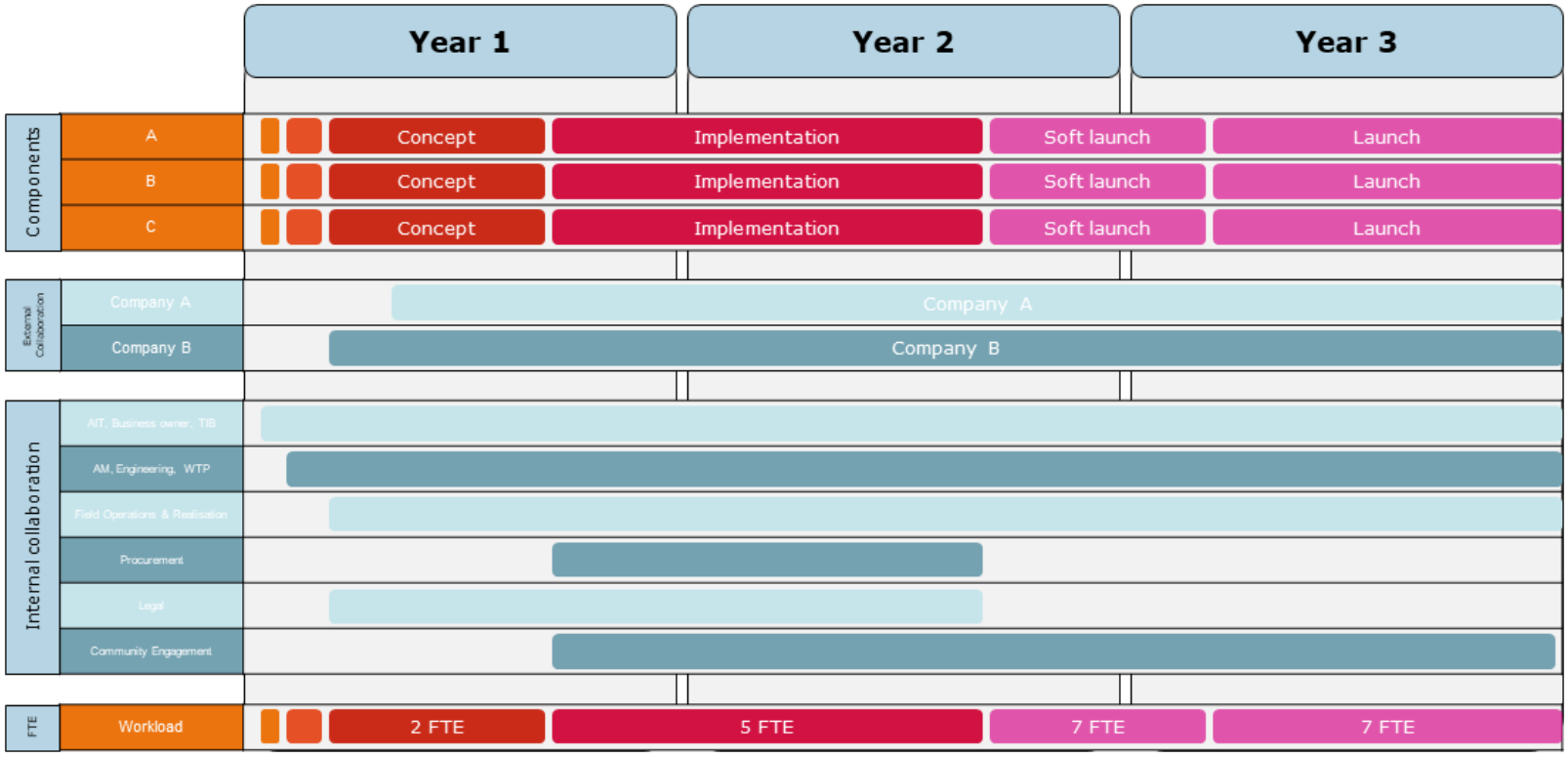
4. Quality through Quantity

By concentrating on quantity, the qualitative aspect of an idea is moved to the background. This qualitative aspect focuses on judgment. And as explained before, this could stop people from being creative and throw away ideas that haven’t had the time to be properly adopted.

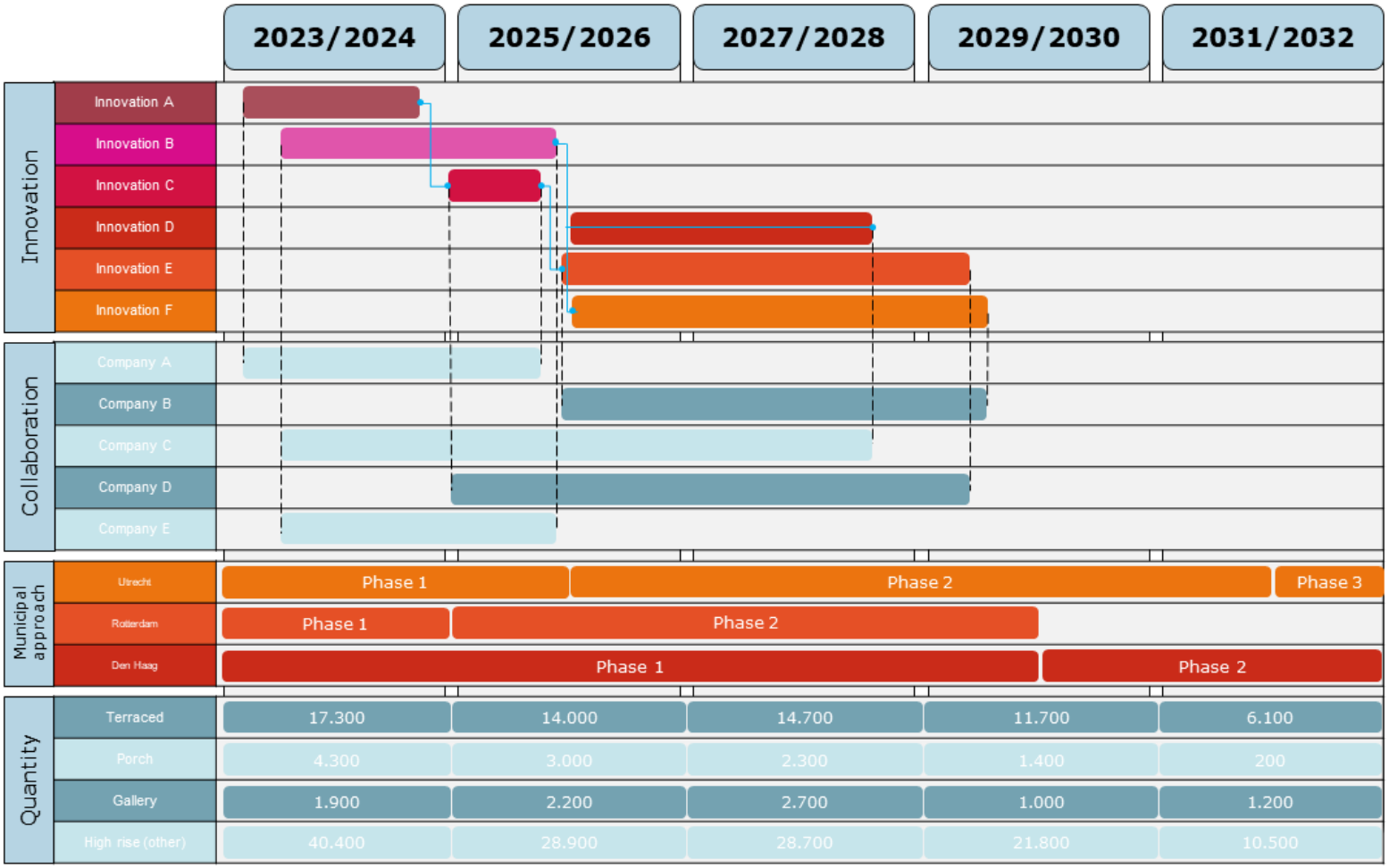
# Appendix E

**Shielded due to sensitive information**

# Appendix F


Year 1
Year 2
Year 3
Components
A
B
C
Concept
Implementation
Soft launch
Launch
External Collaboration
Company A
Company B
Internal collaboration
AIT, Business owner, TIB
AM, Engineering, WTP
Field Operations & Realisation
Procurement
Legal
Community Engagement
FTE
Workload
2 FTE
5 FTE
7 FTE
7 FTE

1


2023/2024
2025/2026
2027/2028
2029/2030
2031/2032
Innovation
Innovation A
Innovation B
Innovation C
Innovation D
Innovation E
Innovation F
Collaboration
Company A
Company B
Company C
Company D
Company E
Municipal approach
Utrecht
Phase 1
Phase 2
Phase 3
Rotterdam
Phase 1
Phase 2
Den Haag
Phase 1
Phase 2
Quantity
Terraced
17.300
14.000
14.700
11.700
6.100
Porch
4.300
3.000
2.300
1.400
200
Gallery
1.900
2.200
2.700
1.000
1.200
High rise (other)
40.400
28.900
28.700
21.800
10.500

2

# Appendix G

**Growth in stakeholder involvement**
Not only is the number of various stakeholders growing, as is the extent to which they are involved with the entire business model.
The next generation of digital communities centers around creativity. (*The Future 100: 2023*, 2023)
mass inclusive brands (*The Future 100: 2023*, 2023)
Next era of retail see users co creating brands (*The Future 100: 2023*, 2023)
Tech need to be accessible (*The Future 100: 2023*, 2023)
Stakeholder Capitalism (Sokutu, 2023)
New ways of engaging citizens and residents (Oecd, 2023)

**The importance of energy will keep increasing**
Energy becoming a digital currency (*10 Hot Consumer Trends: Life in a Climate-Impacted Future*, 2023)
Electricity remains the mainstay of the transition ("Energy transition outlook 2022", 2022)
The evolving future of nuclear power (*Energy Transition Trends 2023*, z.d.)
The energy transition is gaining more and more attention ("Trend outlook 2023", 2022)
Demand for energy is growing (McKinsey, 2023)
Half of the future energy needs will be met by renewables (Allianz, 2023)
Decreasing price of renewable energy (De Correspondent, 2023)

**Transparency becoming a requirement**
your data, my data, our data ("When Atoms meet Bits", 2023)
Service delivery: back to basic (Van Leeuwen, 2022)
Policies towards more transparent supply chains (MVO Nederland, 2022)

**fulfilling needs locally**
Increase of Distributed Energy Resources (Sokutu, 2023)
increase of self-organizing citizens ("Trend outlook 2023", 2022)
increase of decentralization ("Trend outlook 2023", 2022)
Individualization. ("Trends, dilemma's en beleid", 2000)

**Even growth has a limit**
Challenges persist in energy storage, transformation and the transportation of energy. (the energy company, 2023)

**Deploying technology effectively**
Increase of smart grids (Sokutu, 2023)
Above the clouds: Taming multicloud chaos (*Tech Trends 2023*, z.d.)
learning to trust our AI colleagues (*Tech Trends 2023*, z.d.)
New mindsets will drive future success (*Redirecting*, z.d.)
Generalizing AI ("When Atoms meet Bits", 2023)
Technological development will largely have an informatized character. ("Trends, dilemma's en beleid", 2000)

**Increasing impact of EU cooperation**
Increase of international collaboration (“Trend outlook 2023”, 2022)
COP27 and a strategic transition to decarbonization (Sokutu, 2023)
COP27 outcomes revealed plans by the World Bank to explore reforms that allow for taking on more risk and engaging in more money lending (Sokutu, 2023)

**Increasing focus on earth and human well-being**
Meaningful entrepreneurship is gaining ground. (Van Leeuwen, 2022)
Conscious consumers are following nature-minded brands (*The Future 100: 2023*, 2023)
From prosperity to well-being. (“Trend outlook 2023”, 2022)
Earth as stakeholder (*The Future 100: 2023*, 2023)
Companies Focus On Sustainability (Howarth, 2023)
growing focus on the quality of the living environment (“Trend outlook 2023”, 2022)
Preserving and enhancing the livability of society and the country. (“Trends, dilemma’s en beleid”, 2000)

**The media playing an important role for climate knowledge**
The brand activism of Patagonia and Oatly are examples of successfully using media to create attention (Latana,2022). Moreover, celebrities are playing an increasingly significant role in the climate debate. Public figures like Carice van Houten are drawing attention to environmental issues (DeVolkskrant, 2023).

**Changing business models and value chains**
From ownership to usage. (“Trend outlook 2023”, 2022)
Industries will be forced to reinvent with upskilling and reskilling (*Redirecting*, z.d.)

**Tech innovation is not always the solution**
Consumer-led shifts (Sokutu, 2023)
Climate optimism (*The Future 100: 2023*, 2023)

**Prioritizing and outsourcing becoming important**
Enhancing clean energy supply chain resilience, diversity, and economic competitiveness.(International Energy Agency, 2023)
Countries need to choose a focus within the relevant clean energy supply chains (International Energy Agency, 2023)