ENERGY JUSTICE IN HOLENDRECHT

Taking energy justice as a guide to shape the transition towards sustainable heating by means of co-creation and visualization

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Abstract

As part of the Dutch energy transition the municipality of Amsterdam has drafted their Transition Vision Heat, indicating which sustainable heating sources can be used in Amsterdam as an alternative for natural gas. One of the alternative heating sources identified is residual data center heat. With the project 'Digital heat in the MRA' the municipality aims to create a showcase project to stimulate the large-scale use of this type of heating source. Recognizing that there is a strong social aspect to the transition the municipality of Amsterdam aims to facilitate a fair and equitable transition. An important element of this recognition is the understanding that without community support, projects can run into delays or even lawsuits. Therefore, municipalities are now looking into co-creation as a way to include stakeholders in the transition.

However, how to facilitate a fair and equitable co-creation process for the heating transition is still under debate and differs per project. Within the project 'Digital heat in the MRA' there is a focus on the role visuals could play to support the process of co-creation. To see if the conditions for a fair and equitable co-creation process are present in connecting two building blocks in Holendrecht this research draws on the insights from energy justice. Furthermore, as it is the organized stakeholders that shape the initial co-creation sessions, it is crucial to investigate if they identify issues with energy justice. In this way injustices can be identified from the start and be alleviated as much as possible to make sure the sessions are set up in an energy just manner. Therefore, the following research question has been formulated for this thesis: *What energy injustices are identified by organized stakeholders in the transition towards sustainable heating in Holendrecht and how are visuals used to communicate about energy injustices?*

By means of a review of energy justice literature a set of indicators has been synthesized to form the basis of the participatory observations and interviews conducted for this study and formed the springboard for the thematic analysis. In total 13 participatory observations and 5 interviews have been conducted. This led to the identification of 10 energy injustices and the visuals used to communicate about those injustices. These have been subdivided between the three tenets of energy justice namely distributional justice, recognition justice and procedural justice.

With regards to distributional injustice, net congestion, limited space in the subsurface, perceived availability of supply, financial differences between tenants and homeowners, and overlooking long-term impacts are identified as injustices impacting the fair and equitable transition. Regarding recognition justice, labeling tenants to only care about money and disturbance, and not including residents in the surrounding apartment blocks are identified as injustices. Lastly, the limited involvement of those directly affected, limited share of information and an imbalance in power are identified as injustices related to procedural injustice. Furthermore, it is found that visual communication regarding the injustices was mostly related to the physical infrastructure by means of maps and photographs.

By identifying these injustices, a first step is made towards creating the conditions for a fair and equitable co-creation process into connecting the two building blocks in Holendrecht to a district heating grid. Furthermore, the visuals identified are able to serve as tools to communicate about the energy justice surrounding the physical infrastructure. With this, insights are given into the challenge to create a fair and equitable transition from natural gas heating towards sustainable heating within the metropolitan context of Amsterdam.

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List of Abbreviations

5th GDHC	–	Fifth Generation District Heating and Cooling network
AMS	–	Amsterdam Institute for Advanced Metropolitan Solutions
ATES	–	Aqua Thermal Energy Storage
AWM	–	Amsterdam Heat Motor
EU	–	European Union
GHG	–	Greenhouse Gas
HvA	–	Applied University of Amsterdam
LIFE	–	Local Inclusive Future Energy
LT	–	Low Temperature
MRA	–	Amsterdam Metropolitan Region
NIMBY	–	Not In My Back Yard
PV-TE	–	Photovoltaic Thermal
RES	–	Regional Energy Strategy
RSW	–	Regional Structure Heat
TU Delft	–	Delft University of Technology
TVW	–	Transition Vision Heat
UvA	–	University of Amsterdam
WUP	–	Neighborhood Implementation Plans

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1. Introduction

1.1. Heat transition in the Netherlands

In June 2021 the European Climate Law has been taken into effect. With this law the member states of the European Union (EU) are committed to reduce net greenhouse gas (GHG) emissions by at least 55% by 2030, compared to the 1990 levels. Furthermore, it is stated that the EU becomes climate neutral by 2050 (European Commission, 2021).

To reach these targets, the Dutch government has initiated the Regional Energy Strategy (RES), dividing the Netherlands in 30 energy regions. Through the RES the implementation of renewable energy and the needed infrastructure is brought into view for each region. As heating of the built environment is recognized as an important part of the Dutch energy consumption, sustainable heating sources are brought into view through the Regional Structure Heat (RSW), as part of the RES. The RSW has been integrated in the RES to make sure that a heat source (e.g., a geothermal well, aqua thermal source) that crosses municipal boundaries is not used twice or would remain unused (Nationaal programma RES, n.d.). Furthermore, moving away from natural gas requires a new heating source, one of which is electricity which is needed for electrified heating or to boost low temperature heating sources. As this impacts the regional energy infrastructure, it is important to coordinate the use of heat sources at the regional level as well (Nationaal programma RES, 2020). Because the municipalities of each energy region are in the lead regarding their road to sustainable heating, the RSW is set up in conjunction with the Transition Visions Heat (TVWs) to make sure the TVWs do not conflict or leave out potential sources. Within the TVWs each municipality identifies how they will transition to sustainable heat sources, what type of sources they aim to use, and select neighborhoods where they want to start the transition (Nationaal programma RES, 2021).

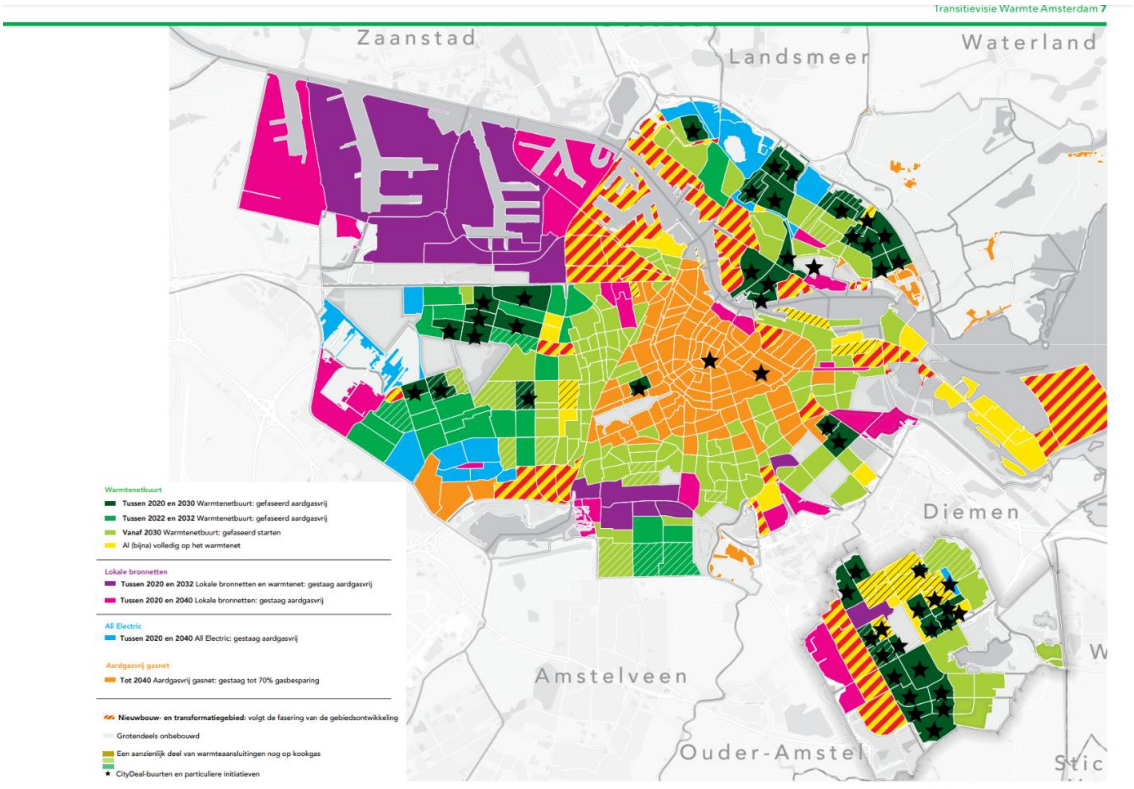

Figure 1. Overview of proposed sustainable heating source per neighborhood as stated in the TVW of Amsterdam. Source: Gemeente Amsterdam, 2020

At the beginning of 2022 municipalities have been asked to start with the development of the Neighborhood Implementation Plans (WUPs) of the neighborhoods identified in the TVWs. The WUPs are detailed plans, developed together with stakeholders and residents to decouple the neighborhood from natural gas before 2030, indicated in figure 1 in dark green (Gemeente Amsterdam, 2020).

1.2. The problem statement

One of the sustainable heat sources identified by the municipality of Amsterdam in their TVW is residual heat from datacenters. Within the project 'Digital heat in the MRA' Amsterdam and its partners within the Amsterdam Metropolitan Region (MRA) are researching and developing a low temperature heat grid based on residual datacenter heat in the yet to be redeveloped area Paasheuvelweggebied, in the Southeast of Amsterdam. Because there is more residual heat from the datacenter than needed for the redeveloped area, the municipality is looking to connect the adjacent existing neighborhoods of Holendrecht. Here, two large building blocks called "Senso 1 & 2" are up for renovation and are identified as the first building blocks in Holendrecht to be disconnected from the natural-gas grid and connected to the new heating grid (Firan B.V., 2021).

Part of the research of the project 'Digital heat in the MRA' focuses on the use of visuals and their role in gaining community acceptance by means of co-creating visualizations of the proposed heating network infrastructure (Firan B.V., 2021). This because it is recognized that a lack of acceptance can lead to resistance by means of protests and lawsuits, leading to project delays (Sovacool & Dworkin, 2015; Itten et. al., 2021).

Because it is still in its design phase, opportunities arise for stakeholders to truly co-create a heating network. The inclusion of stakeholders at the start of renewable heating projects is also a practice that is increasingly being used by the municipalities. This stems from the recognition that the implementation of heating infrastructure, in the street and in buildings, requires many parties to be onboard to facilitate the transition (Itten et. al., 2021). Through actively engaging with a diverse set of stakeholders from the start issues can be identified early on resulting in an increase in the likely hood of a project to be implemented. This likelihood increases because more parties will have a say in the distribution of the physical heating infrastructure and services, are recognized in the process and will have access to the decision-making process (Sovacool & Dworkin, 2015; Jenkins et. al., 2016).

However, as mentioned by Itten et. al. (2021), there is a danger in using co-creation as window dressing if powerful stakeholders are not willing to share their power. Furthermore, as argued by Healey (1996), coming together with stakeholders to discuss a transformation in an urban area, such as the implementation of a heating grid, does not happen out of ether. This happens when key stakeholders identify a certain problem and an opportunity to change the current environment. This is crucial as it is here where the subjects of the meetings are decided upon (Bryson & Crosby, 1993). It is therefore essential to investigate if the conditions for effective co-creation are present within the process of connecting the Senso's to the proposed heating grid based on datacenter heating. To investigate whether the conditions for fair and equitable co-creation are present this study draws on the literature of energy justice. Furthermore, as mentioned by Mundaca, Busch and Schwer (2018), community acceptance can be linked to these issues of fairness and equity. Putting a strive for energy justice as a way to gain acceptance. Meaning, to facilitate a more just procedure through recognition and inclusion of a diverse set of stakeholders from the start, and together decide on the distribution of benefits and drawbacks of heating infrastructure and services (Sovacool & Dworkin, 2015; Jenkins et. al., 2016). It is important to take energy justice as a framework to guide the process

of implementing the proposed heating grid of the project 'Digital heat in the MRA' as fairness and equity are key to community acceptance.

Whilst the call for stakeholder inclusion to facilitate an energy just heat transition is evident, how this is ought to be done and what this means differs per project (Rodhouse et. al., 2021). For this project it is sought how visualizations play a role in gaining insights into energy injustices. As the literature offers visualizations as a powerful way for stakeholders to gain an understanding of the intricate nature of analyzing and implementing heating grids (Itten et. al., 2020). This research aims to gain insights into energy injustices in the case of the transition towards datacenter heating in the case of Holendrecht and how visualizations are used to gain insights into energy injustices. This leads to the question: *What energy injustices are identified by organized stakeholders in the transition towards sustainable heating in Holendrecht and how are visuals used to communicate about energy injustices?*

2. Main research question and sub research questions

The aim of the project is to gain insights into the energy injustices identified by organized stakeholders within the transition towards sustainable heating in Holendrecht and how visuals are used by those stakeholders to communicate about energy injustices.

RQ - *What energy injustices are identified by organized stakeholders in the transition towards sustainable heating in Holendrecht and how are visuals used to communicate about energy injustices?*

SQ1 – What indicators for energy justice are found in the literature?

SQ2 – Which injustices are identified by organized stakeholders in the process of decoupling the Senso's from the gas grid?

SQ3 – What visuals are used to communicate about energy injustices regarding the process of decoupling the Senso's from the gas grid?

3. Theoretical Framework

In this chapter the academic background for the research is given by defining the key concepts used for analysis and describing how they relate to each other. First, the two main concepts are introduced with co-creation, and energy justice respectively.

3.1. Co-creation

One notion that is gaining attention is the concept of co-creation as a process to facilitate a more just process within the transition towards sustainable heating, especially within the public domain (Voorberg et. al., 2015; Brandsen & Honingh, 2018; Itten et. al., 2021). However, Voorberg et al. (2015) argue for more a concrete understanding of what co-creation means with regards to stakeholder inclusion in public decision making. They discuss co-creation in conjunction with co-production and synthesize three process stages mentioned in the literature: co-implementing, co-designing, and co-initiating. Voornberg et al. (2015) credit co-implementing to the notion of co-production and the latter two to the notion of co-creation. Yet, Brandsen and Honingh (2018) go a step further and only recognize co-initiating as part of co-creation. When a project goes into design and implementation stages, still directly involving stakeholders, co-production is the preferred terminology. However, both Itten et al. (2021) and Sillak et al. (2021) use co-creation as a more umbrella term with co-production, co-implementing, co-designing and co-initiating all as part of the co-creation process.

Whilst there is still ambiguity about the precise definition of co-creation it is evident is that co-creation is about active involvement of stakeholders at an early stage in the process in an equal, complementary, and respectful manner aimed at deepening the understanding of the intentions and needs of those involved in the process (Voorberg et. al., 2015; Brandsen & Honingh, 2018; Itten et. al., 2021; Sillak et. al., 2021).

It is within the process of co-creation issues with energy justice should be identified and aimed to be resolved. By taking energy justice, as explained in the next section, as a framework to guide the co-creation process it is sought to identify injustices early on and work on increasing fairness and equity. Increasing fairness and equity aids in the process of gaining community acceptance (Mundaca, Busch & Schwer, 2018), which is one of the goals of the project 'Digital heat in the MRA' (Firan B.V., 2021). Therefore, the concept of energy justice is set out in the next section.

Visualization in co-creation

With aiming for energy justice as a way to reach community acceptance within the co-creation of sustainable heating in Holendrecht, this section looks into visualization as a tool to aid this process. Visualization in this research is seen as "the representation of an object, situation or set of information in a diagram, photograph, or other sort of image, as well as forming a mental image" (Metze, 2020. p745). The imperative to use visualization in co-creation is to serve as boundary objects, creating a common image of a desired heat-grid whilst allowing all stakeholders to give their own meaning, values and needs to it. Generating such a boundary object can guide the communication and learning process around the creation of a heat-grid by means of having a shared understanding of what such a grid entails. Furthermore, it allows for the identification of issues that might have not been made explicit using other modes of communication (Singh, 2011; Metze, 2020).

3.2. Energy justice

The need to transition towards sustainable heating as part of the general transition to low-carbon energy to lower CO_2 emissions and mitigate climate change is evident. Furthermore, the shift from a fossil fuel-based energy system to a renewable energy-based system is often perceived as inherently good. However, as Sovacool et al. (2019) argue, it is important to be aware that the transition can also bring about new types of injustice and bring new vulnerabilities. Therefore, it should be critically examined to what extent a transition towards a new type of energy system brings about new or reinforces existing injustices. To do so the literature on energy justice can serve as a normative framework through which to investigate the current transition in Holendrecht.

In a conceptual review on the meaning of energy justice Jenkins et al. (2016) highlight three tenets of energy justice: distribution, recognition and procedure, also recognized by McCauley et al. (2019). First, distributional justice is concerned with the spread of benefits and ills of physical energy infrastructure and energy services. Second, recognition justice takes into account fair representation within a save environment. Third, procedural justice recognizes the need for access to the decision-making process and explicit attention to mobilizing local knowledge, disclosing information and being represented in institutions. The ordering of the principles follows the line of questioning argued for namely the 'what, who and how'. Energy justice then, is about examining emerging injustices in distribution, analyzing who are not being recognized, and how these injustices can be made explicit and reduced (Jenkins et. al., 2016).

Following the line of questioning from Jenkins et al. (2016), it is important for the co-creation process to first look into the 'what' there is to be distributed. Second, to investigate who is affected and who should be involved. Third, an inquiry has to be made as to how those affected and involved can work together on decisions about distribution.

Distributional justice

When analyzing the implementation of new heating technologies, it is important to look into the way in which benefits and ill are distributed. This distribution concerns both the physical and service infrastructure of the system as well as infrastructure externalities (Jenkins el. al., 2016). This ties in with the notions of availability and affordability. In this context availability means whether or not the heating system has the necessary physical infrastructure to be able to supply those who need heating, have a diversified heating value chain, and have a robust system that can withstand disruption. Affordability refers to the price of heating services in terms of low volatility in pricing and equitable pricing with regards to the percentage of income spend on heating (Sovacool & Dworking, 2015). Moreover, distributional justice also concerns the impacts and risks on future generations (McCauley et. al., 2019). This is also recognized by Sovacool and Dworkin (2015) who call this intergenerational equity. Moreover, they also argue for intragenerational equity, which is about the current division of goods, between who the goods are divided and on what basis they are divided.

It is the distribution of the benefits and ills of the physical and service infrastructure that give insights into who is affected and who should be involved in the decision-making process. This identification is the starting point of the co-creation process, as an inquiry into the to be build infrastructure can expose inclusionary and exclusionary mechanisms (Jenkins et. al., 2018). Because those directly affected by the infrastructure are place bound, local knowledge is crucial in order to identify who are affected.

Recognition justice

McCauley et al. (2019) mention it is insufficient to only identify where the benefits and ills of the heating system are, when talking about justice. It is also necessary to identify who are being affected

and who the focus should be on. Jenkins et al. (2016) share this perspective and argue to avoid non-recognition, misrecognition and disrespect. When transitioning towards sustainable heating it is important to take into account groups with different heating needs such as the elderly and infirm to avoid non-recognition. This can be done either to directly include them or by recognizing them within the decision-making process. With regards to the avoidance of misrecognition and disrespect attention has to be paid to labeling certain groups as 'not-in-my-back-yard' (NIMBY) as is often done by developers or municipal actors. This causes misrecognition of those who live in a certain place as self-interested and assumes a 'deficit model' in which citizens are assumed to not have the knowledge and wider perspective. Sovacool and Dworkin (2015) add to this the notions of sustainability and responsibility. With sustainability they refer to the recognition of the environment and future generations dependent on this environment. With responsibility is meant to minimize negative externalities that affect the environment and people as well as social and environmental costs by those constructing and operating the heating system.

Procedural justice

Procedural justice is about both formal and informal involvement in decision-making. This involvement is aimed at delivering more equitable outcomes by taking those affected by the production and consumption of heating into account and together deciding on where to place certain infrastructure and going over alternatives. With regards to the formal processes, it should be aimed at recognition and inclusion of affected individuals. The informal processes take time and will change through changing norms, values and cultures (McCauley et al., 2019). Involving stakeholders in decision-making with regards to interventions that affect them is also mentioned by Sovacool and Dworkin (2015) who call this 'due process'. They further mention good governance as a requirement for procedural justice, meaning that corruption should be minimized, information should be easily accessible and transparent. The disclosure of information and the mobilization of local knowledge are also recognized by Jenkins et al. (2016) who argue for information disclosure from governments and industry but also from households with regards to heating consumption patterns. Lastly, they add representation in institutions to the dimension of procedural justice where the institutions that govern certain aspects of the heating system should be representative of the population that is affected and governed.

4. Research Methodology

To find an answer to the question what energy injustices are identified by organized stakeholders in the transition towards sustainable heating in Holendrecht and how visuals are used to communicate about energy injustices a case study has been conducted.

Table 1 gives an overview of what the research aim per sub question is, the methods used to gather the needed data, and how the data has been analyzed.

Table 1. Data collection method and type of analysis per sub-question

What	Method	Analysis
Indicators of energy justice	Literature	Literature review
Injustices as identified by organized stakeholders in the transition towards sustainable heating in Holendrecht	Literature Participatory observations Interviews Documents	Thematic analysis
Visuals used to discuss sustainable heating	Participatory observations Interviews Documents	Thematic analysis

4.1. Operationalization of the concepts

To gain insights into the injustices identified by the organized stakeholders regarding the heating transition in Holendrecht the concepts explained in the theoretical framework are further set-out to show how they have been made operational for this study. To operationalize the concept of energy justice three papers on what energy justice entails have been analyzed on their tenets and aspects of energy justice, as shown in appendix A, table A.1. All use distributional, recognition and procedural justice as the main pillars of energy justice (Sovacool & Dworkin, 2015; Jenkins et. al., 2016; McCauley et. al., 2019). However, Sovacool and Dworkin (2015) and McCauley et. al (2019) add cosmopolitan justice as a possible fourth tenet.

Having identified the tenets and aspects used in the papers of Sovacool & Dworkin (2015), Jenkins et. al. (2016) and McCauley et. al. (2019) the explanations have been given for each aspect, as shown in appendix A table A.2. By means of comparing the explanations of the aspects given by the authors the aspects are combined and structured between the three main tenets as shown table 2.

Table 2. Synthesized aspects of energy justice per tenet

Tenet	Element	Aspect
Distributive justice	Physical infrastructure	Ability to supply those who need heating
		A diversified heating value chain
		A robust system that can withstand disruption
	Service infrastructure	Low volatility in pricing
		Equitable pricing regarding percentage of income spend
	Intergenerational equity	Impacts on future generations
		Risks on future generations
Recognition justice		Non-recognition

		Misrecognition
		Disrespect
Procedural justice	Informal involvement	Norms
		Values
		Cultures
	Formal involvement	Inclusion of those affected
		Minimized corruption
		Free share of information
		Representation in institutions

The synthesized aspects shown in table 2 formed the basis for the participative observations and interviews conducted in this study.

The visuals are collected on the basis of their use during the meetings when the communication touches upon one of the identified aspects as mentioned in table 2. The visuals studied are extant to the research in the sense that they have not been produced for the research itself. It is important to be aware of the context in which the visuals are created and the multiple interpretations a visual can have based on the different socio-cultural backgrounds of people. The images used are taken up as data themselves and as found images. Meaning that they respectively form an important part of the fieldnotes and that they have been analyzed as a tool used by participants to discuss what is in the image (Bryman, 2016).

4.2. Participative observation

For this research, an internship has been done at the municipality of Amsterdam from the 28th of March to the 28th of July. During this internship several meetings and activities have been attended as seen in table 3. These meetings and activities were used to collect data on the visualizations used when discussing heating grids and the concepts used to describe those. Furthermore, these activities served as a way to identify the challenges those who participated ran into and the opportunities they saw, connected to sustainable heating. The observed activities are shown in table 3. To collect the data an observation guide has been made to give structure to what was being observed, as seen in appendix C.

Table 3. Participatory observations conducted for this study

Date	Activity	Role	Location
13-04	Joining a flyer campaign about infrared panels from the Groene Hub, going door to door	Active participant	Gein
02-05	Webinar: Designing cities for all – Together we design: making tangible impact	Observer	Online
12-05	Symposium Amstel III Zuid Oost	Observer/ Participant	De Entree
17-05	Meeting on placement of electricity cables	Observer	Hybrid
18-05	Meeting on low temperature heat grid Amstel III business area	Observer	Online
19-05	Meeting on Energy Lab Southeast	Observer	Online
24-05	Meeting on cable routing and placement of TenneT and Alliander substations in Southeast	Observer	Online
25-05	Meeting Project group landscape architecture Paasheuvelweggebied	Observer	Online
25-05	Meeting on Energy transition – Topic: (1) Heating networks in existing neighborhoods and (2) Drag in heating networks	Observer	Online

31-05	Meeting on NvO Paasheuvelweggebied	Observer	Online
01-06	Meeting Energy transition – Topic: Innovations and developments in heat-networks	Observer	Online
13-06	Meeting project group landscape architecture Paasheuvelweggebied	Observer	Online
23-06	Congress on Positive energy districts	Observer/ Participant	HvA & Arena

4.3. Documents

Besides the participatory observations, documents are also used to gain insights into the envisioned futures of the different stakeholders. These are documents that have come up or been shown during the observations, those additionally provided by the participants, and those available on the respective websites of the organizations involved or present on open research. These documents consist of subsidy requests, presentations, and policy documents.

4.4. Interviews

To obtain expert information from the interviewees, semi-structured interviews have been used. This because it allows for the extraction of detailed information and the perception of the interviewee regarding the transition towards sustainable heating. Whilst there is a certain structure to the interview and some questions have been thought of in advance, the open-ended nature of the questions still allows for a detailed response on a certain question. The structure of the interviews allows for a more steered conversation, limiting the time of the interview and thus the amount of time asked from the interviewee, increasing the likelihood of availability and willingness (Schmidt, 2004). In total six interviews have been conducted each taking 30 to 60 minutes. The interviewees and setting of the interviews are shown in table 4. The structure for the interviews is seen in appendix B.

Table 4. Interviews conducted for this study

Individual meetings / interviews		
When	With whom	Location
Biweekly	Meeting representative engineering bureau of the municipality of Amsterdam	Online (Ms Teams)
19-05	Meeting representative spatial planning of the Municipality of Amsterdam	Online (Ms Teams)
09-06	Meeting representative of the Groene Hub	Groene Hub
22-06	Meeting representative of Firan	Phone
05-07	Meeting representative participation management in Holendrecht of EigenHaard	Online (Ms Teams)
18-07	Meeting representative sustainability of EigenHaard	EigenHaard

4.5. Data analysis

The data analysis has been conducted through a thematic analysis (Bryman, 2016). The initial codes used are those identified within the energy justice literature, shown in the appendix D tables D.1 and D.2. Other codes are identified throughout the data analysis process, and some have been removed during the iterative process of coding. This analysis strategy is described by Yin (2014, p139) as “developing a case description”. This relies on having a certain structure before the data collection, in

this case the three tenets of energy justice, as a basis for grouping of the data. Hereafter a process of pattern matching was used to identify patterns in the data within the framework of the three tenets of energy justice.

The visuals have been analyzed on the basis of their use during the discussion of the participants to identify the meaning they give to the visuals. It is than both on what they show within the visuals as how they are used. The interviews serve as a method for triangulation in order to gain more information on the thoughts of those present or called into presence in the meetings.

4.6. Ethics

Because this research is situated in a real-life context and uses the insights individuals as source of data, it is important to take into account the ethics of the research. The units of research are the interviewees and those present at the participative observation sessions. This because it is their interests, values and needs within that are investigated, also those represented in the visualizations. Because this is a social phenomenon, Bryman (2016) highlights the need to consider ethical issues within the research. Therefore, he quotes Diener and Crandal (1978|2016) who set out four categories of consideration:

1. *Whether there is harm to participants;*
2. *Whether there is a lack of informed consent;*
3. *Whether there is an invasion of privacy;*
4. *Whether deception is involved.*

To avoid causing harm to participants of the interviews and those present in the participative observation sessions, the sound recordings of the interviews and the session will be deleted after the completion of this research. In this way the likelihood of damage to the participants is reduced (Bryman, 2016). Furthermore, the identity of the participants is protected through referring to the organization they are representing and their connection to the case but not their name or identifiable trades.

Because the second and fourth point are closely related both are addressed through making sure the participants are aware of the aim of the research to make sure they can make an informed decision to participate (Bryman, 2016). This is done by means of a short description of the research in the invitation of the interviews as well as a short description of the nature of these methods. Furthermore, before the start of each interview a short introduction is given, repeating the research aim and nature of the conversation. In this way it is made clear what the research is about, preventing deception (Bryman, 2016).

To guarantee the privacy of the participants before each recording they are asked whether or not they allow the recording. Furthermore, it is made clear that they do not have to answer a question if they are not willing to and that at any point they can stop whit the interview. Lasty, it is made clear that if they which to be excluded from the research at a later stage, they are free to do so.

5. Case study: context

This thesis is situated within an area redevelopment project within the metropolitan context of Amsterdam. In this chapter an outline is given of the context in which this research takes place by first introducing Energy lab Southeast. Hereafter, the project 'Digital heat in the MRA' is presented. Then, the specific research area is introduced namely Paasheuvelweggebied and Holendrecht. Lastly, the proposed heating grid based on residual datacenter heat is set out in detail.

5.1. Energy lab Southeast

This thesis is part of a larger academic project called "Energie Lab Zuidoost" or Energy Lab Southeast. The main collaborative parties of the Energy Lab Southeast are the municipality of Amsterdam, Delft University of Technology (TU Delft), Amsterdam Institute for Advanced Metropolitan Solutions (AMS), the University of Amsterdam (UvA), and the Applied University of Amsterdam (HvA). Besides these main parties, partnerships have been made with a variety of different organizations on a project basis. The main focus of the Energy Lab Southeast is creating a social energy transition. Meaning to move away from viewing the energy transition as a technical endeavor and highlighting its intrinsic social character. To achieve this the Energy Lab Southeast consists of four sub projects namely 'Just prepare', 'Local Inclusive Future Energy (LIFE) City platform', 'Retrofit Reigersbos', and 'Digital Heat in the MRA' (Nienhuis, n.d.). In figure 2 an overview is given of the spatial focus of the four projects. This research is part of the project 'Digital Heat in the MRA'.

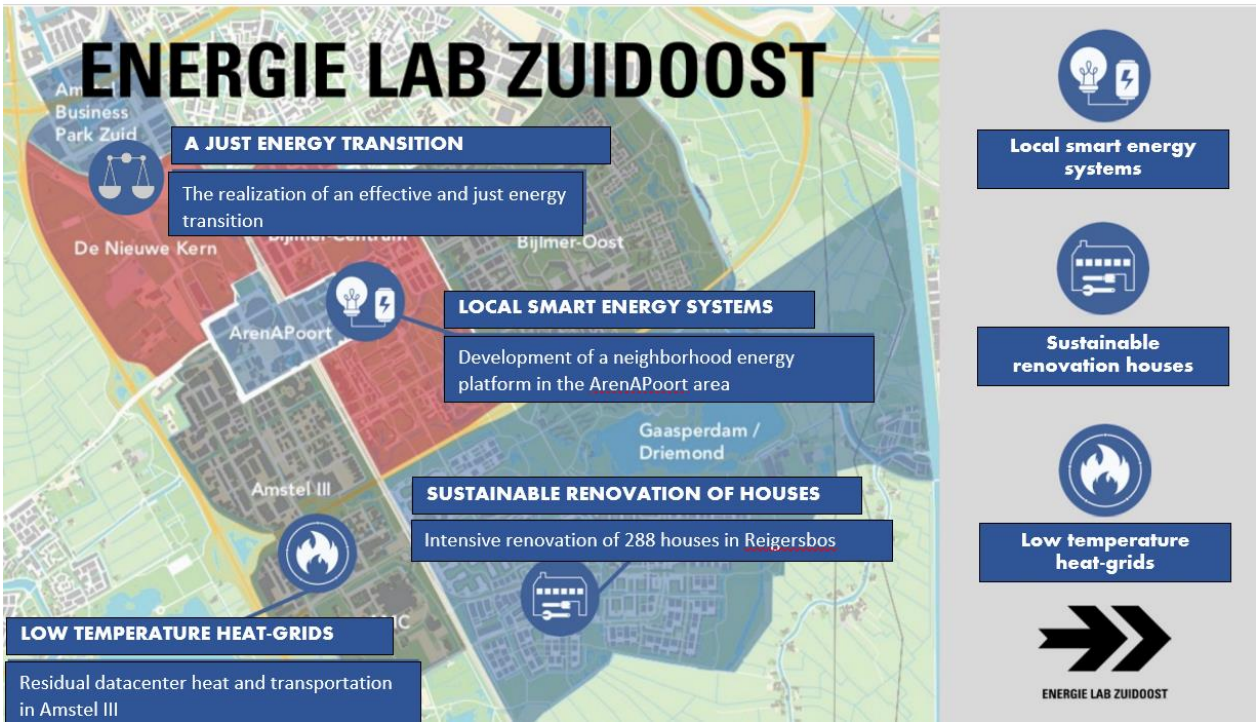

Figure 2. Overview of projects Energy Lab Southeast. Source: presentation seminar energy lab southeast. Translation by author

5.2. Digital Heat in the MRA

The project 'Digital Heat in the MRA' is spearheaded by Firan, in collaboration with the TU Delft, AMS, and the municipality of Amsterdam. Firan is part of the Alliander group and an energy distribution company that focuses on the development, implementation and exploitation of heating networks.

The goal of the project is to alleviate current barriers and market failures, and to serve as a showcase project to generate and disseminate knowledge on the challenges and opportunities encountered whilst developing, realizing and exploiting a low temperature heat network based on residual datacenter heat (Firan B.V., 2021).

The intended heating grid is based on residual heat from a datacenter of Equinix, an exploitation company of datacenters, called AM5. The grid aims to serve the redeveloped area of Paasheuvelweggebied and two large building blocks in Holendrecht called Senso 1 & 2, as shown in figure 3. To realize the grid, agreements have to be made with the developers or owners of the buildings that have to be connected. In Paasheuvelweggebied these are yet to be realized buildings where the developers have to reach an agreement with Firan. The buildings in Holendrecht are in possession of a consortium of owners in which EigenHaard, a housing association, holds around 75% ownership, and with that the majority of voting. The connection of Senso 1 & 2 is especially interesting as these are existing buildings that are to be taken of the natural gas grid.

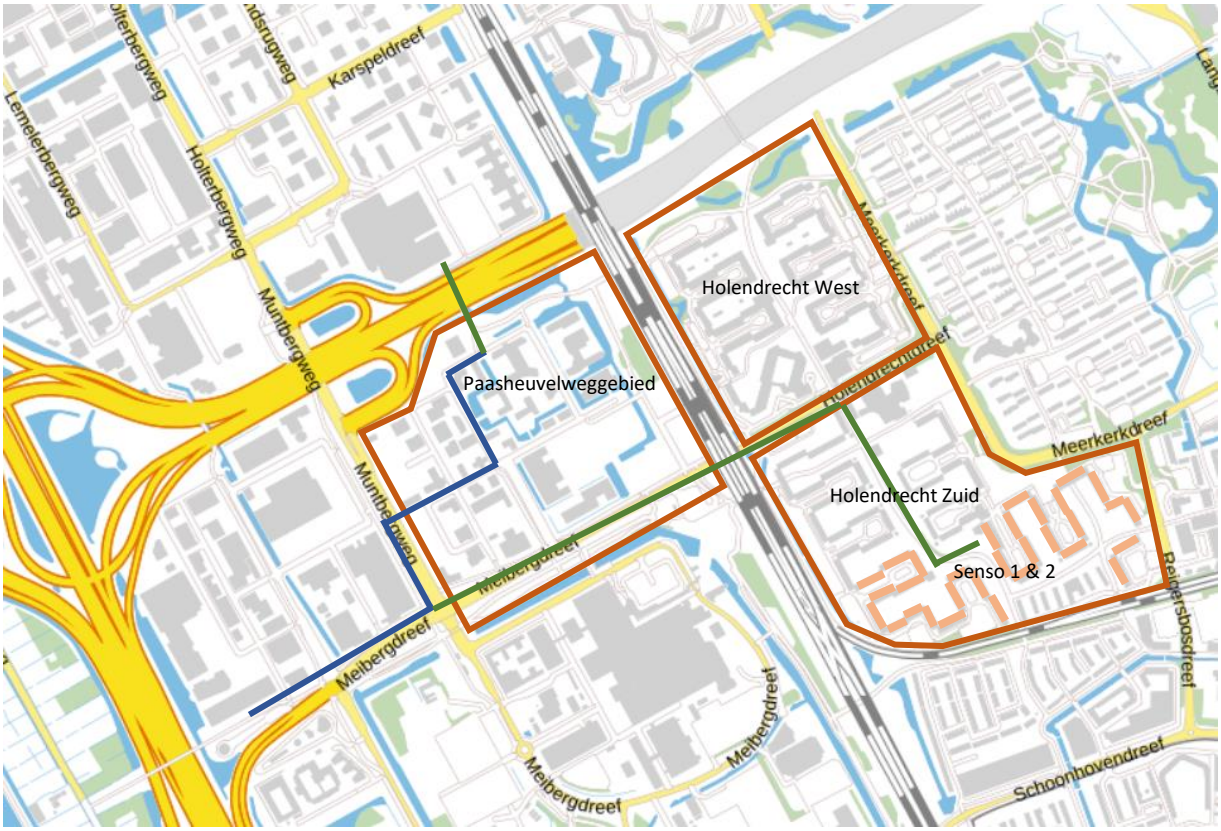

Figure 3. Trajectory of the proposed heating network in the project 'Digital heat in the MRA' and overview of affected areas. Source Firan B.V. adapted by author

5.3. Paasheuvelweggebied & Holendrecht

In this section the area where the proposed heating grid is situated is discussed. First Paasheuvelweggebied is introduced and second the Holendrecht area is discussed.

Paasheuvelweggebied

Paasheuvelweggebied is located at the Southwest corner of Amstel III and enclosed by the highway A9 in the North, the railway tracks in the East, the Paasheuvelweg in the South, and the Muntbergweg in the West, as shown in figure 4 in blue. The area of Amstel III, including Paasheuvelweggebied is being redeveloped from a monofunctional office and business district to an area with a mix of functions such as housing, education, and recreation facilities (Gemeente Amsterdam, 2013).

For the showcase project of 'Digital heat in the MRA' it is proposed to connect a number of the to be developed buildings in Paasheuvelweggebied to the heating grid, as well as two building blocks in Holendrecht (Firan B.V., 2021).

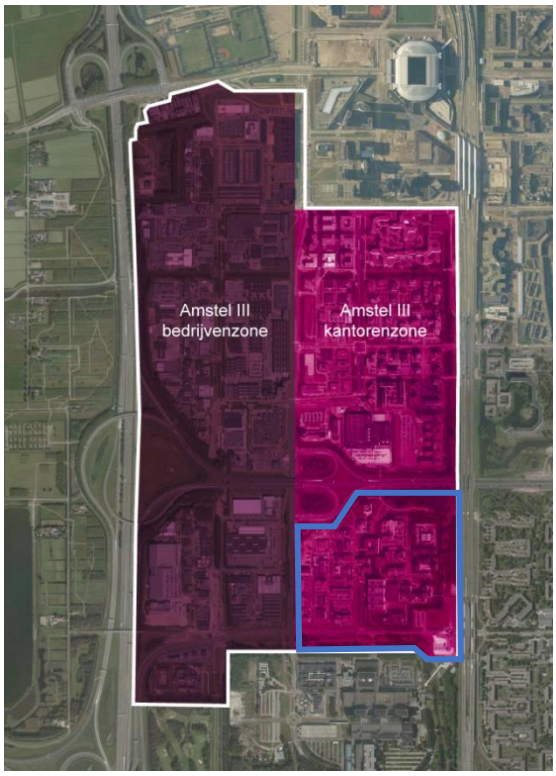

Figure 4. Amstel III separated in business and office zone with Paasheuvelweggebied in blue. Source: Planviewer: Amstel III Oost. Adapted by author.

Holendrecht

Holendrecht is a neighborhood located in the Southeast of Amsterdam (see figure 3). It lies between the Gaasperdammerweg in the North, the Metroline in the East and South, and the Langbroekdreef and Reigersbosdreef in the West. Holendrecht can be seperated into three neighborhoods. Holendrecht West, Holendrecht East, and Holendrecht South, seperated by the Meerkeerdreef and Holendrechtdreef.

It is the areas of Holendrecht West and Holendrecht South that are of interest for this study as it is these neighborhoods that the proposed heating grid, connecting Senso 1 & 2, will cross.

Holendrecht West and Holendrecht South have been build in the 1970s. The buildings are four stories high and build in a meandering shape of connected apartment blocks. The apartments in Holendrecht West are owned by housing association Stadsgenoot and in Holendrecht South for the majority by housing association EigenHaard (Gemeente Amsterdam, 2022).

In general, the Southeast of Amsterdam has a bad image regarding the livability and safety (Gemeente Amsterdam, 2022). Furthermore, the percentage of households living below the social minimum in Holendrecht West and Holendrecht South are respectively 30% and 19%. This is significantly higher than the national avarage of 7% (AlleCijfers, 2022).

However, there is also a high potential in this area due to the high amount of social cohesion and because of many citizen organizations.

5.4. The heating network in detail

Technical aspects

To decouple build-up areas from natural gas as their source of heating, heating networks based on renewable heating sources are identified as the main approach to do so (Lund et. al., 2018; Buffa et. al., 2019). Currently, there are a number of large and small heat networks in the Netherlands, which supply around 400.000 households with heating. The larger networks, or district heating, cover a specific area with multiple connections to the network. The smaller networks, or block-heating, cover a single building or a single block of buildings. Most of the current networks are third generation networks. Meaning that they run on supply temperatures between 70 °C and 100 °C (Lund et. al., 2018). Moreover, these types of heating networks are often vertically integrated, meaning that the heating source, the distribution and the delivery are all owned by the same organization. This means that these organizations have a monopoly on the network, limiting the possibility of third-party access to connect an additional heat source and leaving consumers vulnerable to lock-in of heat supplier (Lavrijssen & Vitéz, 2021).

But, with the need to decouple neighborhoods from natural gas to mitigate climate change, municipalities and the industry are now looking into the implementation of fourth and fifth generation heat networks. These networks run respectively on temperatures around 60 °C and 25 °C for the heat supply, with fifth generation networks also able to provide cooling. Because these temperatures are lower than those of the third generation, more heat sources are able to be connected for heat provision. With both the fourth and fifth generation, the sources of heat to be connected are renewable. However, due to the lower temperature, the buildings are required to be well insulated in order to be suitable for low temperature heating. Fifth generation heat networks also require heat pumps to be installed in order to meet the higher temperatures required for showering and hot tap water. Yet, the fifth-generation networks are very efficient in terms of minimizing energy losses as the temperature differences with the surrounding area are small (Lund et. al., 2018; Buffa et. al, 2019). Furthermore, due to the lower temperatures needed, more heat sources can be added to the network and more attention is given to the role of prosumers and third-party access for heat suppliers. To enable the connection of prosumers and third-party access, the governance structure of 4th and 5th GDHC networks recommended to be unbundled. Meaning that the heat production, distribution and delivery are managed by different organizations (Lavrijssen & Vitéz, 2021).

Through the Digital Heat in the MRA project the development of a fifth-generation district heating and cooling network (5th GDHC) is being realized on a large scale. The development of 5th GDHC network envisioned in the project is innovative in the Netherlands. Currently, no such a network is put in place in a real-life context in the Netherlands. The use of a LT heating network (25C° – 15C°) with bidirectional flow providing heating and cooling simultaneously in the same system is yet to be implemented.

Governance aspects

Furthermore, the envisioned governance structure is also innovative in comparison to current district heating networks in the Netherlands. Most of the contemporary networks are vertically integrated, meaning that the heat production, distribution/transport, and the delivery to the customers are all done by the same company. However, this new project aims to unbundle the activities and give access to third parties. This means that multiple sources can be connected to the network and costumers will have freedom of choice regarding heating source and supplier. This would be the case after the first 15 years where Equinix will be the provider (Firan B.V., 2021).

To extend the heating network to Senso 1 and 2 a consortium of partners has made a proposal to connect the Senso's to the 5th GDHC network. EScom, a company that delivers modular sustainable heating systems for stacked apartment blocks, is the leading party for the offer. Inwarmte will take on the role of heat supplier and will manage the ESCo. The ESCo is the proposed energy cooperation consisting of Inwarmte, EigenHaard and the residents. Lastly, Firan will deliver residual datacenter heat to the installation of EScom (EScom, n.d.).

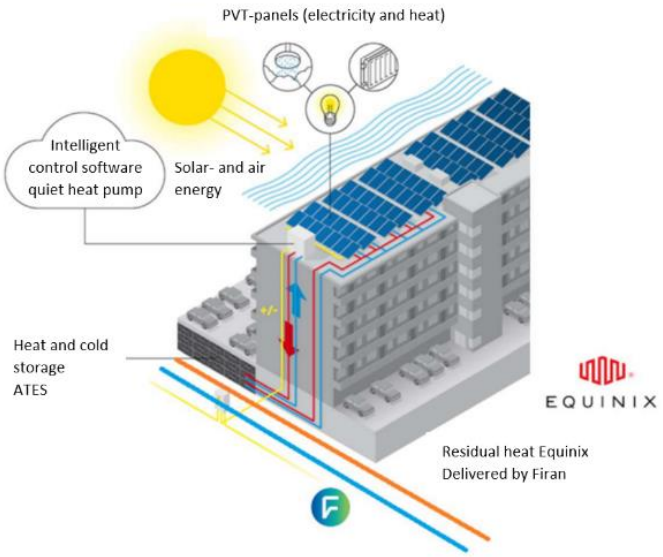

Figure 5. Schematic overview heating infrastructure at building level. Source: presentation EScom. Translation by author

Division of technical responsibilities per actor

The technical aspect of the proposal from EScom involves the installation of PV-TE panels on the roof, providing electricity and heating to the building, as shown in figure 5. The heat and cold is stored in an aqua thermal energy storage (ATES) below ground. To match the heating demand, the warm water will be upgraded with a collective heatpump mounted on the roof of the building. In addition a connection will be made between the ATES and the transportation pipes of Firan, delivering residual datacenterheat and retrieving the cooled down water to cool the datacenter of Equinix. In this way the Senso's will be connected to the 5th GDHC pilot network that is to be roled out in Paasheuvelweggebied (EScom, n.d.).

6. Analysis: The three tenets of energy justice in digital heat in Holendrecht and the insights from visuals

In this chapter the sub question two and three are answered based on the interviews, observations and documents used in this study. The sub questions are restated below:

SQ2 – Which injustices are identified by organized stakeholders in the process of decoupling the Senso's from the gas grid?

SQ3 – What visuals are used to communicate about energy injustices regarding the process of decoupling the Senso's from the gas grid?

To find an answer to these questions the findings are structured per tenet of energy justice. Meaning that first the distributional injustices and the visuals used to gain insights into this type of injustice are presented. Hereafter recognition and procedural justice are presented in a similar vein. The chapter will close with a conclusion on both sub questions.

6.1. Distributive justice

Distributive justice: textual

Here the 'what' of the proposed system is analyzed on its relation to distributive justice. First, the physical infrastructure will be discussed. Second, the service infrastructure will be analyzed. Third, the intergenerational implications of the proposed network will be discussed.

Net congestion

With regards to the physical infrastructure to connect the Senso's to a heating grid there are two main challenges. First, net congestion is identified as a critical aspect concerning the decoupling of the Senso's from the gas grid. Due to the switch to induction cooking and the heat pumps required for sustainable heating, a large strain is put on the electricity infrastructure. This additional strain is seen as a challenge because currently the net is not able to facilitate the additional strain. As shown in box 1 below, there is a concern within the housing association EigenHaard whether or not the electrical network needed to facilitate the decoupling from the gas grid will be in place in time (personal communication 19th of July, 2022).

> The only disadvantage is, there is Vattenfall who is involved and EScom. However, both are dependent on Liander. Because Liander is of course for the connection to the electricity grid. If you decouple from the gas, then you have to switch to induction cooking. Well, that. Induction cooking is a main point. The net has to be able to cope with it. And Liander is currently busy with maintenance but to actually, it is still unclear if that net of Liander will be realized. Will it be there or not. And when would it be there, the maintenance. Can we actually decouple from the gas. That is also a big question. Can we decouple from the gas?

Box 1. Concern voiced by the sustainability representative of EigenHaard regarding the ability to decouple from the natural gas grid

The concern by the representative from EigenHaard highlights a possible injustice regarding the distribution of electricity. Even if the housing association wants to decouple from the gas, they might be prohibited due to insufficient capacity on the electrical grid in the area. Furthermore, the need for a greater capacity of the electricity grid has also been recognized and discussed in several of the

meetings that have been attended for this thesis (personal communication 18th of May, 2022; personal communication 24th of May, 2022).

Because it will take time to upgrade the electricity grid to be able to facilitate the heating transition, some households will not be able to transition towards sustainable heating during this enhancement. This leads to a temporal distributive injustice for those seeking to transition towards sustainable heating (Sovacool et. al., 2019). Injustice caused by the physical siting of expanded electricity networks is also recognized by Jenkins et. al. (2016), who mention not only the need to supply an area is important but also where the electricity comes from and how it would get there. However, this study only focuses on the facilitation of the heating infrastructure.

Available space in the subsurface

Second, the limited space in the underground presents a challenge for both the implementation of the cables needed for the electrical grid and the piping needed for the heating network. As shown below in box 2 (personal communication 19th of May, 2022).

> Here those planning the public space are in charge of the developments in the underground as well which is a unique position. This gives an insight into where can fit what. With regards to space in the underground there are two things that determine the available space. Underground trashcans and trees. Below both, no pipes or cables can be laid down. Another constraining factor that is more upcoming is the amount of cables and pipes already in the ground and those that have to be put in place to facilitate the heating and cooling transition.

Box 2. Concern raised by the spatial planning representative of the Municipality of Amsterdam indicating the limited space in the subsurface

The limited amount of space in the underground to place the cables and pipes means that the trajectory of the main pipelines is dependent on the availability of space in the subsurface and that the implementation of the pipelines is timely. As mentioned by one of the representatives of the Municipality of Amsterdam "one has to keep in mind it is implemented 15 meters per day" (personal communication 25th of May, 2022). Meaning that to connect all those who want heating and cooling to the network is a timely matter, leading to the possibility of individuals that want to be connected to the grid not being able to do so in a short time period.

The time it will take to construct a heating grid is also recognized as a distributive injustice by Sovacool et. al. (2019), who mention that during the construction of the heating grid it is not yet possible to switch to sustainable heating. Therefore, some households will not be able to connect during the roll out of the heating grid. As shown, this is especially important to the context of Amsterdam where the crowded subsurface means that the grid can be implemented at a slow pace.

Ability to supply heating

Besides the two main points described above that affect both networks there are also differences in the physical infrastructure of EScom and Vattenfall related to aspects of distributional justice.

With regards to the availability of heat, both the representative of EigenHaard as the representative of a local community center express their doubts about the long-term supply of heating from the datacenter (personal communication 9th of June, 2022; personal communication 18th of July, 2022). With regard to the ability of Vattenfall to supply heat the representative from EigenHaard mentions "I do believe Vattenfall can supply heat for the next 30 years. That won't just stop" (personal communication 18th of July, 2022).

Here, there is an uncertainty regarding the ability of the network of EScom to supply heat on the long term within the housing association and the community center. However, the project plan of Firan highlights the datacenters as a long-term sustainable source due to the increasing number of datacenters build and their constant supply of heat (Firan B.V., 2021). This is in line with Lund et. al. (2018) and Buffa et. al. (2019) who mention residual data center heat as a future potential reliable source of waste heat.

The described uncertainty might originate from the fact that the risks from the network of EScom are not yet fully known. As mentioned by the representative from the community center: "the answer from EigenHaard was: we know Vattenfall and we don't know EScom. Thus Vattenfall is a known risk and EScom is an unknown risk" (personal communication, 9th of June, 2022). This is also mentioned by the sustainability representative from EigenHaard who says "For Vattenfall we know the risks. We know exactly what we need to think about, what is the problem. (…) At EScom it is unknown. EigenHaard was also thinking, EScom never heard of it. (…). Can we demand the same requirements as from Vattenfall" (personal communication 18th of July, 2022).

However, regardless of where the uncertainties come from, it is important to recognize that they are there and have to be critically examined.

Financial differences between tenants and homeowners

One of the key points mentioned with regards to the service infrastructure is that tenants should not have to pay more that they are currently spending on their energy bills, making sure the transition towards sustainable heating does not come with excessive financial costs. For those who are owners of their house the calculation will be different as they will have to make the investments for isolation and induction cooking themselves. As mentioned by the sustainability representative from EigenHaard, shown in box 3.

> We do not want the tenants to pay extra for [district heating], but that it is equal to the price they would be spending on gas. Thus, anything that comes on top of that. How do they call it again. The standard costs. We will pay that for our tenants. For the owners it is a whole different calculation.

Box 3. Financial difference between tenants and homeowners highlighted by the sustainability representative of EigenHaard.

This difference in calculation regarding the heating transition between homeowners and tenants is also mentioned by Sovacool et. al. (2019). Investments such as isolation or heating pumps require a certain amount of capital. For those who do not have this there is a risk of being left out of the transition. Furthermore, the increase of property value due to the investments are only profitable for the homeowners. This does not affect the tenants or might even cause them to have to pay higher rents.

Long-term impacts

With regards to possible intergenerational injustices within the decision-making process the representative of EigenHaard concerned with sustainability mentions "That is also an option, that we will replace the flue gas extraction and say to Vattenfall and EScom, we will not decouple from the gas. We will stay on the gas for another 15 years. That is also possible" (personal communication 18th of July, 2022). Here the long-term impacts and risks of staying on the gas grid do not seem to be taken into account. The decisions made by EigenHaard today might severely impact the socioeconomic position of inhabitants and the sustainability of the build environment tomorrow. It is

possible that in the future extra, and possibly more steps, are necessary, leading to generational inequity (Jenkins et al., 2016).

Distributive justice: visual

To discuss the increasing electricity demand and the needed infrastructure for the supply, mostly maps were used. Figure 6a shows a map indicating the potential locations for substations of TenneT and Liander needed to facilitate new developments and the heating transition in the Southeast of Amsterdam. Figure 6b shows two locations identified by a developer in the Southeast for a substation on their plot, indicated by the red arrows (personal communication 24th of May, 2022).

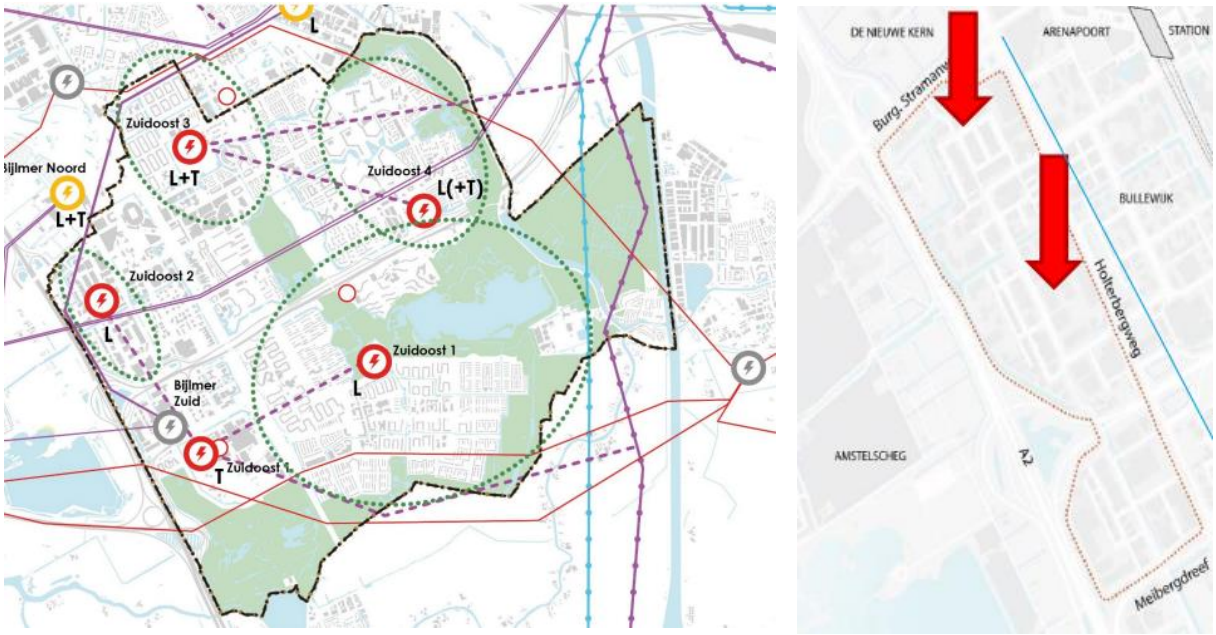

Figure 6. a) shows a map of the Southeast of Amsterdam indicating research locations for a new substation by Tennet, Alliander and the Municipality of Amsterdam. b) shows a map of the business park Amstel III indicating research locations for a new substation by WoodenCity. Source: personal communication 24th of May, 2022.

The map on the left has been created by Tenent, Liander and the municipality of Amsterdam in a search for the location of a substation. With TenneT and Liander providing the expertise and the municipality providing information about the local context. The red circles are identified as research locations for possible substations. The decision on where the substation can be located has to be made together with the municipality and those surrounding the identified space. The image on the right shows a map made by one of the developers in the area, indicating where they would be able to facilitate one of the substations. The map made by the developer was not met with enthusiasm by the representative from TenneT. During the meeting on the 24th of May the representative of TenneT expressed his displeasure with the scan made by WoodenCity (figure 6b) and mentioned that “this is the job of TenneT and Liander”. However, having the two maps available during the conversation allowed for a comparison between the two and showed the lower red arrow to be on the same spot as the Bijlmer Oost 3 station as shown in the scan of TenneT. The maps then acted as a tool for communication and understanding between the two parties with regards to the physical distribution of the substations (personal communication 24th of May, 2022).

In this meeting stakeholders from the municipality, utility companies and businesses, together discussed the physical placement of the substations and cabling needed for the electricity infrastructure. The remark made by the representative from TenneT indicating that "it is the job of TenneT and Liander to identify possible locations for the substations” indicates a possible distributive injustice as the ground for the research locations is not owned by the municipality but by

WoodenCity. The physical placement of the substation then directly affects the developer who therefore made a scan themselves as well.

To highlight the limited space in the underground photos are used that depict the current situation of the amount of cables and piping in the ground. Figure 7 is an example which had been used during the meeting on the 24th of May (2022) to give insight into the challenge of fitting the cables needed for the electricity and the piping for the heating infrastructure. Here the cables and piping that were laid down first get precedence over those to come as now the subsurface of certain roads is already full and cannot be used as routing for the new infrastructure. This causes some to be delayed in their connection to a heating grid and some to be unable to connect. The picture shows a snapshot of a type of distributional injustice on a temporal scale. With those who want or have to connect later not being able to do so because of the limited space in the underground.

Figure 7. A photo shown during the presentation on the 24th of May indicating the limited space in the subsurface. Source: personal communication 24th of May, 2022

Distributive justice: conclusion

As shown in this section, three main issues are identified with regards to distributive justice. First, net congestion in the Southeast of Amsterdam is identified by the participants in the interviews and during the observations as an important prerequisite for the heating transition. It is therefore crucial that enough capacity on the net is available to support the heating transition, allowing all that want to disconnect from the gas grid to do so. Second, the available space in the underground is mentioned as a limiting factor with regards to if and in what time frame building blocks can be connected to the heating grid. Also, meaning that placing multiple pipelines from multiple heat suppliers is not an option, necessitating a choice to be made between providers that want to implement a pipeline. This is also the case for the Senso's where a decision has to be made between Vattenfall and EScom. Third, the availability of supply is discussed as a potential issue where doubts are raised by participants of the interviews on the guarantee of supply of datacenter heating. It is important to look into this issue further or improve communication surrounding it.

With regards to the visuals that have been used it is shown these are mostly maps and photographs as an aid in the communication to provide a visual frame to the story. The maps have been used to highlight the spatial context regarding the physical infrastructure. Photographs were used to give insights into otherwise overt things such as an opened-up piece of road, showing the crowded sub surface in Amsterdam. The maps and photographs are both used to discuss the distribution of the physical infrastructure. Here, these visuals allowed for the identification of distributional injustices in the physical infrastructure.

6.2. Recognition justice

Two types of recognition injustices have been identified. First, it is the possibility of prejudice to argue that tenants only care about money and disturbance in their home. This can be seen misrecognition. As mentioned, “most have limited money and time to be involved in this [the transition towards sustainable heating]” (personal communication 9th of June, 2022), “In the end it is about money and disturbance” (personal communication 5th of July, 2022). Crediting certain interests of residents to them could lead to misrecognition as some might have legitimate concerns that are not about money or disturbance could be dismissed (Jenkins et al., 2016). One such claim is the distrust towards Vattenfall of local residents that could be overlooked (personal communication 9th of June, 2022). If only looking into the cheapest and least unintrusive option, this might be neglected.

Second, is the absence of those affected by the decision of EigenHaard in the rest of the neighborhood, which can be seen as non-recognition. As mentioned by the two representatives from EigenHaard, the choice they make regarding how to heat their buildings impacts the whole neighborhood (personal communication 5th of July, 2022; personal communication 18th of July, 2022). Because the party they choose to provide heating to their buildings will be the one that in the future serves those that are alongside its trajectory. This is due to a law in the Netherlands that states that buildings within a 40-meter radius of a district heating pipe have to be connected to that pipeline (Bouwbesluit, 2012). However, for the choice of heat supplier only the Senso’s are taken into account. Meaning that whilst the other parts of the neighborhood are recognized as those affected by the decision, they are not recognized in the decision-making process.

Recognition justice: visual

The element of non-recognition is mostly explained by means of a map. Figure 8a&b show the different routings for both Vattenfall (figure 8a) and EScom (figure 8b). On both maps it can be seen that the routing of the heating infrastructure crosses other housing blocks to get to the Senso’s. Once the Senso’s are connected by either of the two parties, it means that the housing blocks surrounding the trajectory also have to be connected to that particular heating grid in the future. Yet, those living there are not included in the decision-making process, whilst the decision will directly affect them.

The maps allowed for the identification of those who are missing in the process by showing the routing of the proposed heating-grids in the local context.

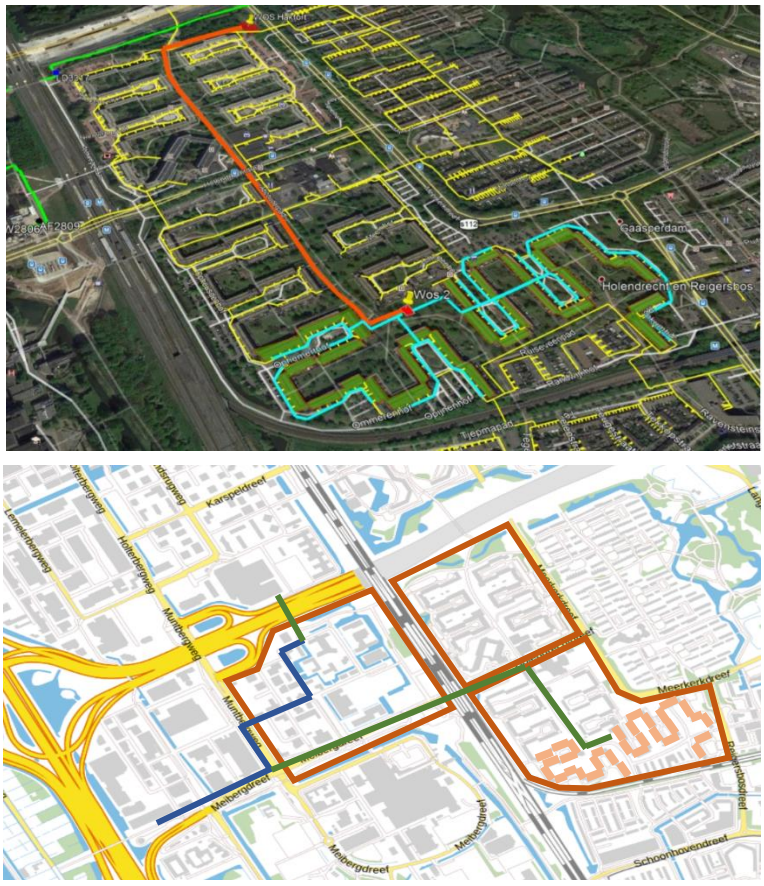

Figure 108. a) Trajectory of the proposed heating grid of Vattenfall (above). b) Trajectory of the proposed heating grid by Firan (below). Source: a) personal communication 7th of February, 2022; b) made by author, based on Firan B.V., 2021

During the interviews, the participants often referred to the location of the Senso's, the routing of the pipes as expressed in the images, and the area it affected (personal communication 9th of June; personal communication 5th of July, 2022; personal communication 19th of July, 2022). Both the representative from the community center and the representative from EigenHaard responsible for participation mentioned the location of the Senso's as an important element to their concerns about the impact on the whole area. They referred to the apartment blocks that would not (yet) be connected to the heating grid but are surrounding the grids trajectory (personal communication 5th of July, 2022; personal communication 19th of July, 2022).

Recognition justice: conclusion

As shown, there are two types of possible injustices found regarding the tenet of recognition justice. The first is the possibility of misrecognition as residents are described as only caring about the intrusiveness and the costs of the intervention. The second is non-recognition of the residents that live surrounding the proposed pipeline but not in the Senso's. They are not taken up in the discussion by organized stakeholders.

With regards to the visuals used, maps were used the most as a tool to place the physical infrastructure into context and to identify who was affected along the trajectory and who was or was not included.

6.3. Procedural justice

Limited involvement of those directly affected

With regards to the decision-making process surrounding the decoupling of the Senso's from the natural gas grid, there is a limited involvement of those who will be affected by the decision. Box 4 below shows that those affected in the senso's can only vote on the preferred option as presented by EigenHaard.

> I actually don't want to present two choices to the VVE. We have analyzed the two choices and this is our preference to vote on. I notice, the more choice you give to the owners or residents (…) the more that impacts the process. If I go to the VVE with a proposal, I actually already want to have a package of 'this is my preference, and these are the choices I have made'. And for the tenants it will be a more dressed down package. They only have to know 'what do I pay, and how do I cook, and do I have 24/7 warm water'. Well than you actually have to, per target group, need another approach.

Box 4. Involvement of residents in the Senso's as explained by the sustainability representative from EigenHaard

This limited involvement of those who are affected by the decision to decouple from the natural gas-grid leads to procedural injustices (Jenkins et al, 2016). Moreover, as mentioned in the section on recognition justice, the decision made will also affect those who are living around the trajectory of the proposed heating grids. However, the representative from EigenHaard concerned with sustainability mentioned that the research carried out by an independent consultancy firm on what would be the best option, would only focus on the Senso's (personal communication 18th of July, 2022). Here, the others affected by the decision are left out. This concern is also shared with the representative from the community center and participation manager of EigenHaard (personal communication 9th of June, 2022; personal communication 5th of July, 2022). The inclusion of those affected in the decision-making process is however key in facilitating a just procedure (Sovacool & Dworkin, 2015; Jenkins et al., 2016; McCauley et al., 2019).

Limited share of information

The comment in box 4 also shows the different levels of information sharing between those affected. Giving those in the VVE a proposal of one supplier with a detailed substantiation of why this choice has been made, whilst giving the other residents only information on the price, usage and comfortability of the system. With regards to the proposal to the VVE, this can be seen as limited share of information. Whilst there will be a detailed substantiation of the choice of supplier, they are not supplied with information of both suppliers. Regarding the tenants, they receive only a limited amount of information regarding the choice of supplier. Here, the detailed substantiation is not given. Yet, both the homeowners and tenants have to make a yes or no decision on their choice of supplier, based on the information they have been given. This makes the process vulnerable to the question if they are given enough information to make an informed decision. Because the free sharing of information is an important part of a just process, the limitation in this case can be seen as injustice (Sovacool & Dworkin, 2015; Jenkins et al., 2016; McCauley et al., 2019).

Power imbalance

A noticeable remark regarding the decision-making process was made by a representative from EigenHaard who mentioned to feel a hidden agenda of someone within the municipality to choose Vattenfall (personal communication 5th of July, 2022). Whilst this is his interpretation of the situation, the document of the meeting with the municipal actor does give the advice to add Holendrecht Zuid, where the Senso's are located, to the second tranche of the Amsterdam Heat Motor (AWM) (personal communication 5th of July, 2022). This is a co-operation between housing associations, Vattenfall and the municipality to connect 10.000 houses to the heating grid (AFWC, 2021).

The conflicting support of both EScom and Vattenfall within the municipality is likely due to the area being a gray area in the TVW. As the sustainability representative of EigenHaard mentions "this never happens because the municipality has designated an area as city heating [and the other as] that will be an electric CV kettle. They have made arrangements with Vattenfall in advance. This area is still a gray area, thus not a specific choice" (personal communication 18th of July, 2022). However, whilst Vattenfall is an important party within the realization of the TVW, the TVW does not specifically designate an area to be connected to the heating grid of Vattenfall (Gemeente Amsterdam, 2020).

The possibility for both EScom and Vattenfall to connect the Senso's to a heating grid leads to market forces, incentivizing both to sharpen their offer. Although it is the first time in Amsterdam there is a choice between two providers of heating grids the decision-making process remains inaccessible for those affected.

That both representatives from EigenHaard mention to feel a certain pressure with regards to the decision to take the Senso's off the natural gas grid indicates possible power imbalances within the decision-making process (personal communication 5th of July, 2022; personal communication 18th of July). This imbalance in power might cause issues with a fair and equitable process of decision-making as the participation manager from EigenHaard indicates to feel this is being used to influence a decision.

Procedural justice: visuals

When looking into visuals that are used in the decision-making process mostly online maps where used. During the meeting on 17th of May 2022 there was a decision to be made on the cabling of the electricity cables and the effect on the underground with respect to leaving room for the piping of the heating grids. Figure 9 shows the proposed routing of the cables (red line) and the places where the cables come to the service to be able to facilitate maintenance (red squares). The routing and places for maintenance have been decided upon by means of moving the hands across the screen

showing the map and locations for the cables and maintenance areas. The decision to drill the cabes was based on keeping space in the subsurface for the datacenter heat pipelines and to minimize the disturbance for the residents.

Whilst the residents are recognized and taken into consideration during the decision-making process they are not included. However, during the conversation it is mentioned that one of the maintenance squares is close by the residence of one of the employees of the community center. Thereafter, it is mentioned to get in touch with the employee to the community center to discuss the plans (personal communication 17th of May, 2022). This shows how the locations of the maintenance squares offer insights into who will be affected by the decision but are not jet included in the process. This allows for the inclusion in a later stage.

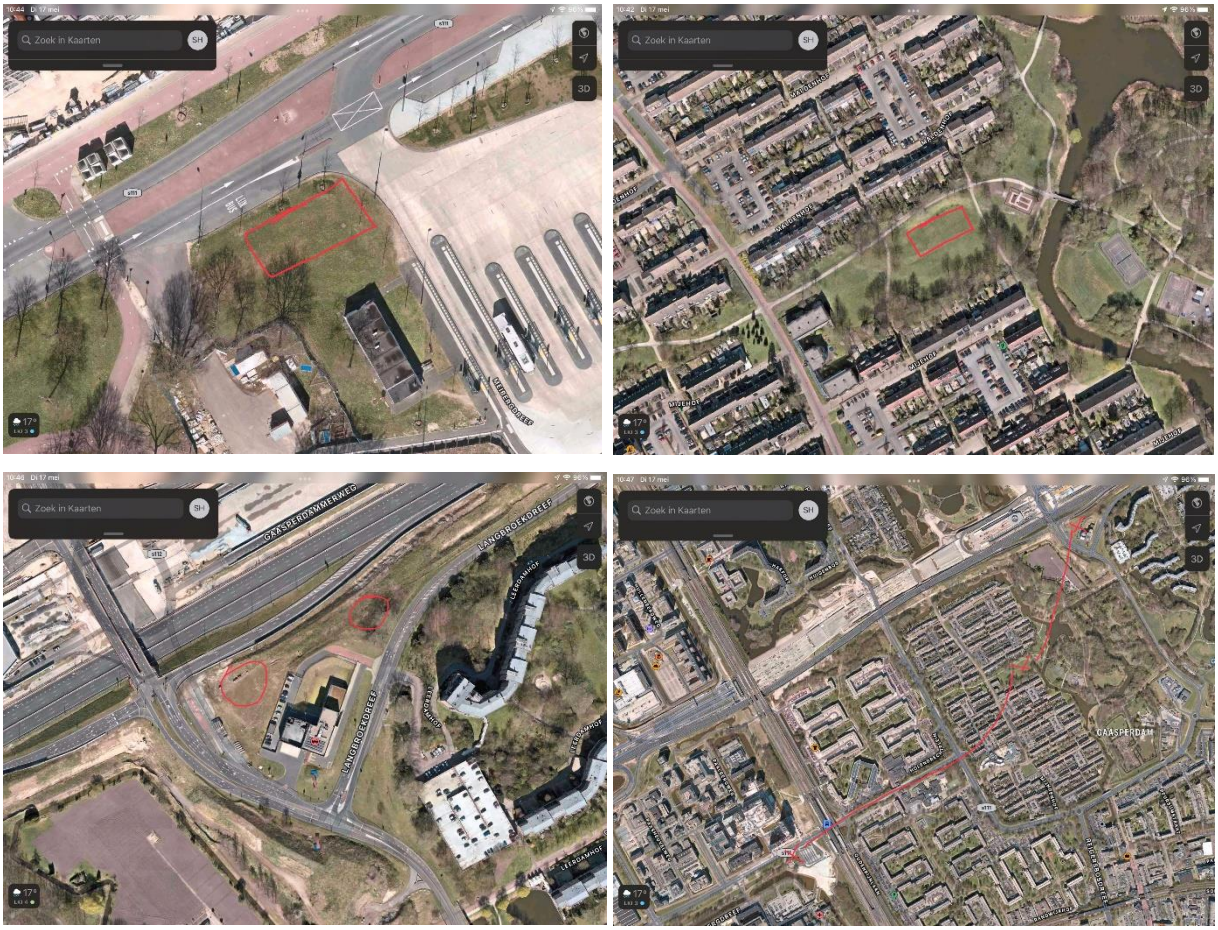

Figure 119. Images showing the siting of maintenance squares and the trajectory used during the meeting on the 17th of May. Source: personal communication 17th of May, 2022.

6.4. Conclusion: answer to sub questions

In sum there are several injustices identified for all three of the tenets of energy justice. First, net congestion, the limited space underground, the ability to supply heating, differences between tenants and homeowners, and long-term impacts are mentioned as critical aspects to be aware of when decoupling existing buildings from the gas grid in Holendrecht as identified by the respondents. Moreover, maps and photographs have been used throughout the attended meetings to identify distributional injustices especially regarding the physical infrastructure.

Second, it is important to look out for misrecognition and non-recognition when discussing the tenants of EigenHaard. These forms of injustice have been identified by the respondents and those present during the participatory observations though the identification of those directly affected who are not part of the decision-making process, and by citing tenants are mostly concerned about money and disturbance. Furthermore, maps and photographs are also key for this tenet of energy justice in identifying possible injustices. Here the visuals aided in the identification of those affected by the physical infrastructure but not part of the discussion.

Third, the involvement of those affected by the transition towards sustainable heating, the limited share of information, and the power imbalances are critical aspects to be aware of. Also, regarding the use of visuals in decision-making, online maps were used most frequently in the process. This allowed for the identification of the location of the physical infrastructure and who would be affected by it.

Table 5 gives an overview of the energy injustices identified per tenet and how visuals were used to identify these injustices.

Table 5. Summary of identified injustices and communication surrounding visuals

Tenets	**Distributive justice**	**Recognition justice**	**Procedural justice**
	Net congestion causing an inability to decouple from the gas grid.	Exclusion of tenants surrounding apartment complexes	Limited involvement of those directly affected
	Limited space in the subsurface causing long waiting times to implement heating infrastructure.	Possible misrecognition of tenants EigenHaard	Limited share of information
	Financial differences between tenants and home owners		Power imbalance
	Overlooking long-term impacts		
Visuals used to identify injustices	Maps and photographs – mostly related to the physical distribution of the infrastructure	Maps and photographs – mostly related to who is affected by the physical infrastructure	Online maps

7. Discussion

In this chapter first, a reflection is given on the interpretation of the results. Second, the implications of the findings are discussed. Third, the limitations of the research are set out.

7.1. Interpretations

Here, five interpretations important to this research are given. The chosen theoretical grounding is discussed. Second, the significance of the identified injustices is set out. Third, a reflection is given on the interpretation of use of visuals for communication. Fourth, the effect of the scope of the research is considered. Fifth, the influence of the selected meetings and interviewees of this study is discussed.

First, to guide and set up the process of co-creating a heating grid, this research has used the literature on energy justice to analyze where organized stakeholders identify current injustices in the process. In this research a selection of aspects of energy justice for inquiry has been made by comparing their expectations in the literature and grouping those with overlap together. A different grouping or the use of other papers might have resulted in other aspects of inquiry, leading to different results. However, the papers used to identify these aspects are from leading scholars in the field of energy justice, conceptualizing energy justice through literature reviews. The chance of significantly different aspects for inquiry is therefore limited.

Moreover, this research has looked into the visuals that have been used during meetings with multiple organized stakeholders and analyzed how the organized stakeholders have used them during the meeting to discuss issues related to the aspects of energy justice. Here the visuals have been placed under a certain tenet of energy justice on the basis of their use in the context of the conversation. Analyzing the visuals separately, without context or by means of inquiry into the visuals themselves might produce different results in the grouping of the visuals within a certain tenet. However, as it is their use to communicate energy injustices during the process of implementing a heating grid that is of importance to understand the value of these visuals in the communication process, this study has provided an initial research into how this is done in the case of Holendrecht.

Second, the identification of net congestion and limited space in the subsurface as two main issues with regards to connecting the Senso's to a heating grid is striking. This because these are not identified in other research on and energy just the implementation of energy infrastructure, or only get a small mention (Sovacool et. al., 2019). These two types of distributional injustice then seem to be location specific.

With regards to the identified recognition injustices, the exclusion of tenants who live in the buildings surrounding the Senso's is important as these are affected by the decision to connect the Senso's due to the Dutch law to connect all buildings within 40 meters of an existing heating pipeline (Bouwbesluit 2012). Yet, these are not included in the decision-making process. Furthermore, the identification of possible misrecognition of tenants of EigenHaard that live in the Senso's is significant as this can lead to exclusion from the decision-making process.

These identified recognition injustices tie in with the identified procedural injustices of limited involvement of those directly affected and the limited share of information. As shown the tenants of EigenHaard in the other building blocks are not included in the decision-making process whilst they are directly affected by the decision. Furthermore, the tenants of the Senso's are involved to a limited extend by only giving them the price, usage and conformability of the system and asking

them if they want it or not. This might be the result of misrecognizing the tenants as only caring about money and disturbance. The observed overlap between recognition and procedural justice is in line with previous studies that mention the two types of injustice often intertwine (Savocool & Dworkin, 2015; Jenkins et. al., 2016). Noticeable is the identified power imbalance. This is twofold. First, it is recognized that EigenHaard has a significant decision power in the choice of heating grid, which in turn affects a considerable number of buildings surrounding the chosen heating grid. Second, powerful actors such as departments of the municipality of Amsterdam, Vattenfall, and Firan recognize the strategic location of the Senso's and seem to put pressure on those responsible for the decision within EigenHaard. The powerful actors then seem to use their advantaged position making a procedural just process difficult.

Third, the visuals that have been used during the meetings attended for this study where mostly maps and photographs related to the physical infrastructure of the heating system. Distributional injustices were identified by the physical placement of the infrastructure and recognition injustices by who were affected by the placement of the physical infrastructure. Online maps were used to communicate about procedural injustices. That mostly maps where used to communicate about energy justice shows similarities with findings on environmental justice where often maps are used to communicate about environmental injustices (Metze, 2020). Furthermore, it should be noted that the collected visuals have mostly come from the meetings facilitated by the municipality of Amsterdam. This means that visuals used in meetings hosted by other organized stakeholders have not been included which could have led to different results. However, as the municipality is in the lead for the heating transition they facilitate most of the meetings. Limiting the chance of a significantly different collection of visuals.

Fourth, it should be noted that this research has explicitly focused on identifying emerging injustices. This means that current processes that are aiding energy justice have not been discussed in this study. That mostly injustices are identified in this study should not be mistaken for the process to connect Holendrecht to a sustainable heating grid is unjust. It is merely a critical examination of injustices that are present and should be mitigated to reach a more energy just transition. As mentioned by Jenkins et al. (2016) it is important to identify injustices from the start so they can be mitigated during the process of implementing the new technologies.

Fifth, this study has focused on the identification of energy injustices by organized stakeholders in the transition towards sustainable heating in Holendrecht and how they make use of visuals to communicate about these injustices. First, it should be noted that this study does not claim to have included all organized stakeholders on this topic as each research is dependent upon the willingness of parties to participate in the research. Second, this study has only taken the energy injustices into account as identified by the interviewees and those precent at the participatory observations. Other injustices might be present. These have however not been taken up in this study.

7.2. Implications

This research has set out to contribute to closing the research gap in seeking what energy injustices are identified by organized stakeholders in the transition towards sustainable heating in Holendrecht and looked into how visuals are used to communicate about injustices. In this way it adds to the societal question to gain insights into the area specific energy injustices in Holendrecht and gives attention to the scientific gap of how visuals are used to communicate about energy injustices during multi-stakeholder processes.

The identified injustices as shown in table 5 are the result of this case study research into the connection of specific buildings in Holendrecht, namely the Senso's. This means that these injustices should be seen in light of this specific case. However, three of the identified distributional injustices can be extrapolated to a larger area, namely net congestion, limited space in the subsurface, and financial differences between tenants and homeowners.

Net congestion and the limited space in the subsurface are challenges that are recognized in multiple areas in Amsterdam. It is important to note that these injustices have a strong temporal element, as mentioned in the results section. The injustice stems from the fact that it takes time to enhance the energy grid and, due to the limited space in the subsurface, it takes time to lay down the piping needed for the heating infrastructure (Sovacool et. al., 2019). This means that in about 10 years this might not be an issue anymore as the infrastructure needed to facilitate sustainable heating has been put in place. However, amidst the transition towards sustainable heating it is important to look at those who are able to make the transition and those who are left out, although temporary. Moreover, the reverse could also be true when more pressure is being put on the space in the subsurface due to increased demand for internet, water, and sewage systems.

Furthermore, the notion of financial differences between tenants and homeowners with regards to the benefits or ability of investments is a type of injustice that is recognized in other studies as well (Sovacool et. al., 2019). This then is not exclusive to this case study. However, the approach to have the tenants not paying more than they currently do for their energy bill does make sure they do not suffer financial ills due to the installation of the new heating system. Yet, they also do not gain the financial benefits of the new heating system as the increase in property value due to better isolation and investments in the heating of the building does not reach the tenants. Meaning that there is still a difference between the financial benefits and ills with regards to tenants and homeowners.

The identified recognition and procedural injustices, as well as one of the distributive injustices, namely overlooking long-term impacts, are specific to this case. This is not surprising as those affected by the decision-making process, and those included in the process are determined by the spatial context of the proposed heat network in the project 'Digital heat in the MRA'. Yet, with the ambition to scale up the project and use more datacenters as a heat source for residential heating there could be somewhat similar cases in the future.

That maps and photographs have been identified as commonly used tools during the participatory observations to communicate about injustices related to the physical infrastructure shows their instrumental usefulness in the communication surrounding these injustices in the transition towards connecting the Senso's to a sustainable heating grid. When aiming to communicate about energy justice in light of the physical infrastructure in the larger area of Holendrecht, these types of visuals then seem suitable.

Going back to the introduction, this research has identified issues with fairness and equity early on in the process of co-creation by means identifying issues with energy justice as seen by the organized stakeholders. Moving away from gaining community acceptance for certain sustainable heating initiatives but using energy justice as a way for organized stakeholders to analyze and set-up their process from the start in a fair and equitable way to reach community acceptance. That the focus here is on organized stakeholders is, as argued in the introduction, because it is these organized stakeholders that set-up the co-creation process, set the initial agenda, and should safeguard a fair and equitable process. The identified injustices by these stakeholders, and the way visuals can support the communication surrounding parts of these injustices as shown in this study, provide

these stakeholders with insights into how using energy justice can identify current issues within the fair and equitable process needed for community acceptance.

7.3. Limitations

Research design

One limitation of this research is the generalizability of the findings. This is an inherent restraint of case study research (Bryman, 2016). As an intensive investigation has been conducted into the process of connecting the Senso's in Holendrecht a heating grid it is likely that results have been produced that are only applicable to the specific case chosen. However, as argued in the section on the implication of the research, some of the identified injustices can be extrapolated to a larger context.

Methodological choices

This study has made use of a variety of methods to gather and analyze qualitative data by means of participatory observations, semi-structured interviews, going through relevant documents, and analyzing them through a thematic analysis. For all of these methods it is important to note that the interpretation of the researcher plays a substantial part.

First, the participatory observations attended for this study have been dependent upon the access to those meetings (Bryman, 2016). By means of an internship at the municipality of Amsterdam access has been gained to multiple meetings on the implementation of the heating grid to connect the Senso's, facilitated by the municipality. Whilst this has meant a substantial number of meetings could be attended, there might be a bias regarding visualizations used and energy injustices discussed towards the meetings facilitated by the municipality. Meaning that if meetings facilitated by other organized stakeholders would have been attended, this might lead to different results. However, as it is municipalities that are in the lead for the heating transition (Nationaal programma RES, 2021), it are the meetings facilitated by the municipality that are crucial to achieving a just energy transition.

Another point of attention is the researcher his memory and values. For the participatory observations accounts have been written on the basis of field notes or by writing out key evens down as soon as possible after they happened. This means that some information might have been lost that could have influenced the results. Furthermore, the accounts that have been written down and visuals collected are dependent on the researcher his interpretation of their importance to the study. This means another researcher might have written different accounts and chosen other visuals. However, by means of a framework for observation the chances of selecting significantly different visuals or writing different accounts have been limited (appendix C).

Second, the semi-structured interviews have been used to gain insights into the energy injustices as identified by the interviewees. This means the selection of the interviewees influences the results presented in this paper. Besides the organized stakeholders that have been interviewed two other important organized stakeholders have not been included namely the homeowner association of the Senso's and Vattenfall. This has been due to either time constraints for this research or access. Interviewing these parties also might lead to different results. However, it must be noted that during the interviews these parties have been brought into presence by the other organized stakeholders which gives some insights in their position but not enough to make definitive conclusions.

Also, the nature of semi-structured interviews is that there is a guide for the interviews which to some extent might constrain the interviewee to speak freely, possibly missing useful data (Bryman, 2016). Yet, the semi-structured interview allowed for a more direct and shorter interview,

putting less strain on the interviewees and heightening the chance cooperation, leading a larger number of interviews.

Third, the analysis of the data by means of a thematic analysis is based on the researcher his interpretation of the data. The themes have been found by the relations identified by the researcher in the data. Therefore, another researcher might identify different themes. However, in this research the aspects of energy justice as identified in the chapter on the Theoretical Framework and operationalized in chapter on the Methodology provided a springboard for the selection of themes for the analysis. In this way the selection of themes has been guided by previous research limiting to some extent the interpretations of the researcher (Yin, 2014).

Furthermore, the nature of a thematic analysis means that the data from the participatory observations and semi-structured interviews is separated into fragments based on their relevance to a certain theme. Meaning that the context of these fragments might be lost. This could lead to misinterpretation from the researcher as to under what theme a certain fragment fits. To limit the chance of misinterpretation triangulation has been used through interviews, participatory observations, and documents, and a presentation has been given at the municipality to validate these findings.

8. Conclusion & Recommendations

In this chapter first the sub questions are restated and answered, and second an answer is given to the main question. This research aimed **to gain insights into the energy injustices identified by organized stakeholders within the transition towards sustainable heating in Holendrecht and how visuals are used by those stakeholders to communicate about energy injustices.**

Following this research aim, the main research question is: *What energy injustices are identified by organized stakeholders in the transition towards sustainable heating in Holendrecht and how are visuals used to communicate about energy injustices?*

To answer this question, first the answers to the three sub questions are given.

SQ1 – What indicators for energy justice are found in the literature?

To find an answer to this question a literature review has been conducted into the literature on energy justice. Three papers of leading scholars in the field of energy justice have been analyzed on their conceptualization of energy justice and the aspects it consists of. By means of comparing the descriptions of each aspect a synthesis has been made by coupling those that overlap. This has led to the understanding that the literature on energy justice divides the concept into three tenets. Distributional justice, recognition justice, and procedural justice. Each of these elements have their separate indicators. Firstly, distributional justice is concerned with the spread of the physical infrastructure, its service infrastructure and its impact on the future generations. Secondly, recognition justice is aimed to alleviate non-recognition, misrecognition, and disrespect. Lastly, procedural justice can be divided into two parts namely formal and informal inclusion (Sovacool & Dworkin, 2015; Jenkins et. al., 2016; McCauley et. al., 2019). The identified indicators have been used as a basis for the participatory observations and semi-structured interviews, and formed a springboard for the themes of the thematic analysis to identify the injustices in sub-research question two.

SQ2 – Which injustices are identified by organized stakeholders in the process of decoupling the Senso's from the gas grid?

Through the thematic analysis several types of energy injustice have been identified with regards to decoupling the Senso's from the natural-gas grid. It is shown that net congestion, the crowded subsurface, and the ability of the system to provide heating, financial differences between tenants and homeowners, and long-term impacts are identified by the interviewees as the main elements that could lead distributional injustices. Furthermore, instances of misrecognition and non-recognition are identified with respectively labeling residents as only worried about money and disturbance, and not including the implications and residents of the other parts of Holendrecht that will be affected. Lastly, injustices can be found in the decision-making process where the inclusion of those who are affected, the free share of information, and power imbalances are identified as elements where a more just procedure can be implemented. It is these identified elements of energy injustice that should be alleviated as much as possible to reach a more just transition.

SQ3 – What visuals are used to communicate about energy injustices regarding the process of decoupling the Senso's from the gas grid?

The results show that maps and photographs are useful tools to identify distributional injustices regarding the physical infrastructure of the proposed heating networks or to facilitate those networks. Maps and photographs are also useful tools to identify who are directly affected by the physical infrastructure but not included in the decision-making process. These visuals give insights into possible injustices whit regards to who are being recognized. Regarding the tenet of procedural justice, it has been found that online maps were used to make decisions on infrastructure sightings. These decisions were made without including those affected by the placement of the infrastructure, leading to procedural injustice. Regarding the communication about energy injustice the visuals are mainly used to communicate about injustices regarding the physical infrastructure of the proposed heating network by means of maps, online maps and photographs.

RQ - *What energy injustices are identified by organized stakeholders in the transition towards sustainable heating in Holendrecht and how are visuals used to communicate about energy injustices?*

For this research a case study has been done into the energy injustices and visuals used by organized stakeholders in the proces of connecting two building blocks in Holendrecht to a district heating grid. By means of a review of academic studies on energy justice, a set of indicators has been identified to guide the paticipatory observations and the interviews, and to serve as a springboard for the thematic analysis. This has led to the identification of ten energy injustices that could be subdivided among the three tenets of energy justice. The distributional injustices identified are the congestion on the electricity network, the limited space in the underground, the ability of the system to provide heating, financial differences between tenants and homeowners, and long-term impacts. With regards to recognition injustices, those directly affected by the siting of the heating infrastructure are not included in the decision-making process, leading to non-recognition. Furthermore, recognizing the tenants as only caring about money and disturbance could lead to misrecognition and overlooking legitimate claims by some of the residents. Procedural injustices have been identified as the limited involvement of those affected, the limited sharing of information and a power imbalance.

Visuals that have been used to gain insights into injustices are maps, photographs and online maps. With the first two being used to identify distributional injustices with regards to the physical distribution of the infrastructure, and to identify recognition injustices by highlighting who are directly affected by the physical infrastructure but not involved in the decision-making process. The online maps were used during the decision-making process itself as tools for decision-making. Here, these maps also allowed for the identification of those affected by the decision, yet not included in the process.

This study has indicated that the framework of energy justice allowed for the identification of issues regarding fairness and equity by organized stakeholders at the start of the process, exposing current areas of improvement to reach a more just heating transition in Holendrecht. Furthermore, the analysis of the use of visuals in the communication about energy justice allowed for the identification of their usefulness in communicating about the injustices surrounding the physical infrastructure of the heating network.

Extrapolating these findings to the larger context of Amsterdam in the light of executing the TVW this case study has provided an approach to analyze similar cases on their merits of energy justice and ways visuals are used to communicate those and highlighted three distributional injustices that are applicable to the context of Amsterdam namely, net congestion, limited space in the subsurface, and differences in the spread of financial benefits and ills between tenants and homeowners.

8.1. Recommendations

As mentioned, one of the limitations of this study is that it did not include all organized stakeholders in the process of connecting the Senso's to a district heating grid. Further inquiry is therefore suggested into energy injustices identified and visuals used by other organized stakeholders such as the homeowner association of the Senso's and Vattenfall to create a more holistic overview of these injustices and visuals used.

Second, as mentioned in the results regarding recognition injustice and procedural injustice, those living in the buildings surrounding the Senso's and those living in the Senso's are respectively not included or limitedly included in the process of connecting the Senso's to a district heating grid whilst they are directly affected. A complementary study can be done into energy injustices and visuals used for communication identified by those living in the buildings surrounding the Senso's and in the Senso's.

Third, as described in the section on interpretations of the findings, this research has analyzed and subdivided the visuals used between the three tenets of energy justice on the basis of how they were used during the communication on energy injustices. An interesting field of inquiry would be to see not only how visuals are used for the communication of energy justice, but also how effective they are and what the experience is of the stakeholders presented with the visuals. In this line it could be analyzed if visuals could be made more effective for communication by means of co-creating these visuals.

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Appendix A: Code book for indicators energy justice

Table A.1. Aspects of energy justice identified in the literature

Sovacool and Dworkin (2015)	Jenkins et. al. (2016)	McCauley et. al. (2019)
Tenets: Procedural justice Distributional justice Recognition justice Cosmopolitan justice	Tenets: Distributional justice Recognition justice Procedural justice	Tenets: Distributional justice Recognition justice Procedural justice Cosmopolitan justice
Aspects: - Availability - Affordability - Due process - Good governance - Sustainability - Intergenerational equity - Intragenerational equity - Responsibility	Aspects: - Distribution of physical infrastructure - Distribution of responsibilities - Affordable access to energy services - Freedom of choice - Non-recognition - Misrecognition - Disrespect - Mobilizing local knowledge - Disclosing information - Representation in institutions	Aspects: - Distribution of physical infrastructure - Temporal variations - Risk on future generations - Misrecognition - Cultural domination - Non-recognition - Disrespect - Access to formal involvement - Informal involvement through culture, norms and values - Negative externalities

Table A.2. Descriptions given per aspect identified in the literature on energy justice

Aspects	Description	Source
Availability	People deserve sufficient energy resources of high quality	Sovacool & Dworkin, 2015. p440
Affordability	All people, including the poor, should pay no more that 10 percent of their income for energy services	Sovacool & Dworkin, 2015. p440
Due process	Countries should respect due process and human rights in their production and use of energy	Sovacool & Dworkin, 2015. p440
Good governance	All people should have access to high quality information about energy and the environment and fair, transparent, and accountable forms of energy decision-making.	Sovacool & Dworkin, 2015. p440
Sustainability	Energy resources should not be depleted too quickly	Sovacool & Dworkin, 2015. p440
Intergenerational equity	All people have a right to fairly access energy services	Sovacool & Dworkin, 2015. p440
Intragenerational equity	Future generations have a right to enjoy a good life undisturbed by the damage our energy systems inflict on the world today	Sovacool & Dworkin, 2015. p440
Responsibility	All nations have a responsibility to protect the natural environment and minimize energy-related environmental threats	Sovacool & Dworkin, 2015. p440
Distribution of physical infrastructure	Recognition of the physically unequal allocation of environmental benefits and ills	Jenkins et. al. 2016
Distribution of responsibilities	Recognition of the uneven distribution of responsibilities regarding the physical infrastructure	Jenkins et. al. 2016
Affordable access to energy services	Individuals should have access to affordable energy services	Jenkins et. al. 2016
Freedom of choice	Individuals have the right to have the freedom of choice regarding energy services	Jenkins et. al. 2016
Non-recognition	Failure to recognize the needs specific affected groups	Jenkins et. al. 2016
Misrecognition	Failure to recognize legitimate concerns due to prejudice	Jenkins et. al. 2016
Disrespect	Interpreting local knowledge as wrong	Jenkins et. al. 2016
Mobilizing local	Seeking inclusion and engagement of those affected	Jenkins et. al. 2016

knowledge		
Disclosing information	Free share of information of governmental, business and public knowledge	Jenkins et. al. 2016
Representation in institutions	Recognizing the impact of unequal representation in a wide range of institutions has on the decision-making	Jenkins et. al. 2016
Distribution of physical infrastructure	Assessment of where the key impacts are located	McCauley et. al. 2019
Temporal variations	Benefits and ills shift overtime	McCauley et. al. 2019
Misrecognition	Overlooking the true impact on neglected sections of society	McCauley et. al. 2019
Cultural domination	Overlooking non-dominant cultures	McCauley et. al. 2019
Non-recognition	Not taking into account the needs of specific groups affected	McCauley et. al. 2019
Disrespect	Not taking voiced concerns seriously	McCauley et. al. 2019
Access to formal involvement	Right to a fair process both in free share of knowledge as in costs	McCauley et. al. 2019
Informal involvement through culture, norms and values	Taking into account and understanding differences in cultures, values and norms	McCauley et. al. 2019
Negative externalities	Taking into account negative effects on third parties	McCauley et. al. 2019

Appendix B: Interview set-up

Interview guide (+/- 1 hour)	
Introduction: Thank you for taking about an hour of your time to answer a few questions of mine and giving your input for my research. As mentioned in the email I am conducting research into integrating energy justice principles within the transition towards sustainable heating and the visuals used for communication. Therefore I am working on the case of implementing a heat-network in Holendrecht as part of an assignment of the municipality of Amsterdam. In this interview I would like to get your perspective on the *[participant expertise]* of the heat-grid. **Would you mind if I record this interview?**	
Questions	**Alterations for next interview**
- **Interview information** Date: Location: Setting:	
- **Participant information** Name: Age: Gender: Organization: Department: Contact info:	
Can you introduce yourself?	
What is it you do in your daily life?	
Distributive justice	
Do you see challenges in the implementation of the physical infrastructure? [e.g. piping, inhouse infrastructure, heat sources]	
Are you looking into the differences in service infrastructure between the parties?	
Recognition justice	
What do residents of the senso's think of the transition towards sustainable heating? How are they taken into account?	
Are the residents of the other building block who are directly affected by the decision taken into account?	
Procedural justice	
Which parties are involved in the decision-making process to decouple the Senso's from the natural gas grid? And how?	
Who ultimately makes the decision on if and by what party the Senso's are supplied with sustainable heating?	
How do you think the decision-making process should look like?	
Closing question	
Is there anything you would like to add that we haven't talked about and you feel should be included?	
Closing:	

Thank you for the interview. In the coming months I will transcribe and analyze this and the other interviews in order to draw conclusions for my research. Please let me know if you have any further questions. You can always email me via robert.vanberkel@wur.nl. If you which for me not to include this interview, feel free to let me know. Than I will leave it out. I hope you enjoyed this as much as I did and have a lovely day.

Appendix C: Participatory observation structure

Title of the meeting:

Day and Time:

Who is present:

What is the setting:

Key insights:

General description of activities:

Reflection on methods and tools used:

Next steps:

Analytical reflection:

- Distributive justice
    - Physical infrastructure:
    - Service infrastructure:
- Recognition justice
    - Misrecognition:
    - Non-recognition:
    - Disrespect:
- Procedural justice
    - Informal involvement:
    - Formal involvement:

Appendix D: Analysis framework

Table D.1. Analysis framework participatory observations

Meeting/acitvity	Pressent	Setting	Goal/main point	Type of visual	Distributional justice	Recogniton justice	Procedural justice	Use of visual	reflection
Observation 1									
Observation 2									
Etc.									

Table D.2. Initial framework for analysis interviews

(1/3)	Interviewee	Participation	Scaling	Visual	Choice	Ability to supply those who need heating	A diversified heating value chain	A robust system that can withstand disruption	➔
Interview 1									
Interview 2									
Etc.									

(2/3)	Low volatility in pricing	Equitable percentage of income spend	Impacts on future generations	Risks on future generations	Non-recognition	Misrecognition	Disrespect	Norms	➔
Interview 1									
Interview 2									
Etc.									

(3/3)	Values	Cultures	Inclusion of those affected	Minimized corruption	Free share of information	Representation in institutions
Interview 1						
Interview 2						
Etc.						