A just heat transition

Assessing the future of heat supply in Amsterdam using an energy justice framework

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Preface

This thesis started with the quest for a research subject. I wondered where my interest truly lies. Justice in a broad sense has always been close at heart ever since I was young. During my master I developed an interest in the energy field, and the merging of these two topics became the starting point of this research. Personally, I strongly feel the need to reduce CO2-emissions, to take climate action and to reduce the use of natural gas. I recently moved to the Hague and my new apartment is connected to a district heating network. Although I was excited about this at first, my enthusiasm quickly disappeared when I found out that the estimated monthly costs are 110 euros per month for a 50 square meter apartment. To compare, a gas-fired boiler would result in 50-60 euros in gas use per month. The fact that I didn't have a choice in the source of the heat or the supplier, made the sense of *injustice* even stronger. On top of this, the connection to this district heating network reduces CO2-emissions, but does not ban them, and still relies largely on a gas-fired plant (that I can actually see looking out my window). I am convinced that for broad societal support, the heat market needs to transform. This strengthened my interest in energy justice as a research topic related to the heat transition.

There are many people who have supported me in this process, that I would like to thank. First of all, thank you to my two supervisors Margot Weijnen and Maurice Harteveld for their enthusiasm about the subject and their feedback during our meetings. I value that both of you have given me so much freedom to explore this topic yet provided me with valuable input in every meeting. Throughout the process I have received a great amount of trust, which has been very encouraging.

Then, I would like to thank all the interview respondents: Bastiaan van Perlo, Emiel Reiding, Jannis van Zanten, Pallas Agterberg, Ellen van der Heijden, Marjolein Groen, Ben Hendriks and Eef Meijerman. It has been truly inspiring to hear about your perspectives of energy justice in practice. I also would like to thank Aad Correljé and Bert van Wee who have helped me in finding and applying the right methods and validating my conceptual framework, which has smoothened the process from an academic perspective.

Lastly, I am always grateful to all my partner, family, friends and previous teachers who have supported me in life and shaped me as a person. Relating this thesis, a special thank you for everyone who has spent time with me at the TU Delft library or at AMS-institute, and to those who have helped me in sometimes distracting my mind from my graduation year.

Since the energy transition will affect everyone in one way or another and because justice entails everyone, I hope this read will inspire you.

Martijn

Summary

Heat services are essential for all households in the Netherlands, because warmth is a basic need (Halse, 2008). Currently, this service is delivered to 95% of households in the Netherlands in the form of natural gas. The earthquakes in Groningen as a result of natural gas extraction have resulted in the fact that this exploitation will stop (S. E. Raad, 2018). For the reason of security of supply, the Netherlands prefers not to rely on foreign countries for the supply of gas. Therefore, the transition from natural gas to alternative sources of heat has been started. The Paris Agreement has set goals for carbon dioxide reduction to prevent global temperatures from rising more than 2 degrees Celsius. On top of this, the Dutch Climate agreement has formulated the ambition to reduce CO2-emissions with 49% in 2030, compared to 1990 (S. E. Raad, 2018). These ambitions support the transition from the fossil fuel, CO2-emitting natural gas, to alternative, sustainable and renewable sources of heat.

Because of the importance of heat services to secure a basic human need (warmth), it is undesirable to accept large differences in the affordability or access to these services between different groups of society. Currently, the trends of decentralization, increased citizen responsibility, the focus on CO2-emission reduction targets and the previous decades of liberalization, all lead to concerns about the effects of the heat transition (Goldthau, 2014; Szulecki, 2018). These effects are largely unknown to date and will depend on political choices that are made, underpinned by public values. Currently, these values are overshadowed by the urgency of a rapid transition. In order to address these values, the academic field of studying energy justice has emerged, in which justice principles are applied to the field of energy production, consumption, policy, activism and security (Jenkins, McCauley, Heffron, Stephan, Rehner, 2015). Energy justice aims: "to provide all individuals, across all areas, with safe, affordable and sustainable energy" (McCauley, Jenkins, & Forman, 2013).

The emergence of the concept energy justice offers an interesting framework to assess the decisions related to the heat transition. Therefore, the following research question is formulated: *What is the impact of the transition from the natural gas heat supply to sustainable heat provision on energy justice in the metropolitan area of Amsterdam?*

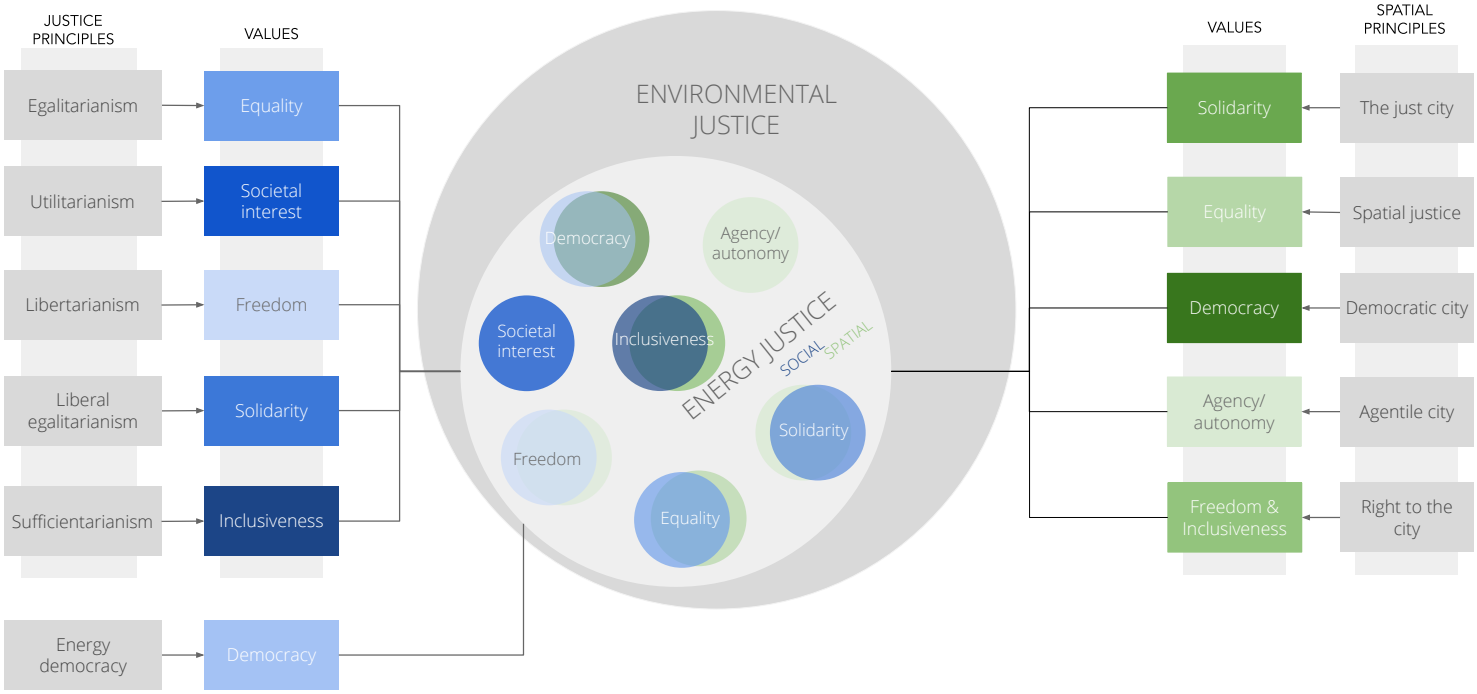

Figure 01. Conceptualization of energy justice.

A conceptualization of energy justice is developed by comparing justice principles, spatial justice principles and energy justice. The following values are derived from justice principles: equality, solidarity, freedom, societal interest and inclusiveness (Vergeer, Rooijers, Davidson, 2017; Dworkin, 1981; Lucas, van Wee, & Maat, 2016). The spatial justice principles lead to the values: solidarity, equality, democracy, agency/autonomy, freedom and inclusiveness (Bouzarovski & Simcock, 2017; Harteveld, 2017; David Harvey, 2008; Fainstein, 2010). It is reasoned that all these values find their place in the concept of energy justice. Besides these values, energy justice includes the principle of energy democracy, which is based on the value democracy. The way these different values are integrated in energy justice, is visualized in figure 01.

Until this point, energy justice remains an abstract concept. For this reason, it is developed into a practical conceptual framework, that can be used for real-life application. Three sources of energy justice literature are selected: Sovacool, Burke, Baker, Kotikalapudi, & Wlokas (2017), Jenkins, McCauley, Heffron, Stephan & Rehner (2015) and Hernandez (2015). Comparing and integrating these three conceptualizations of energy justice, leads to the breakdown of energy justice in: distributional justice, procedural justice and recognition justice. The first, distributional justice, addresses the distribution of costs and benefits in society. Secondly, procedural justice calls for fair procedures in which everyone is involved in a non-discriminatory way. And finally, recognition justice secures differences that may lead to injustice are observed and recognized. Each of these three types of justice are further operationalized into indicators. The indicators are supported by justice principles and have been developed by integrating concepts that are found in the literature data. This leads to the proposed conceptual framework, visualized in figure 02. A larger version is found in Appendix D, figure 16, on the last page of this document, page 93.

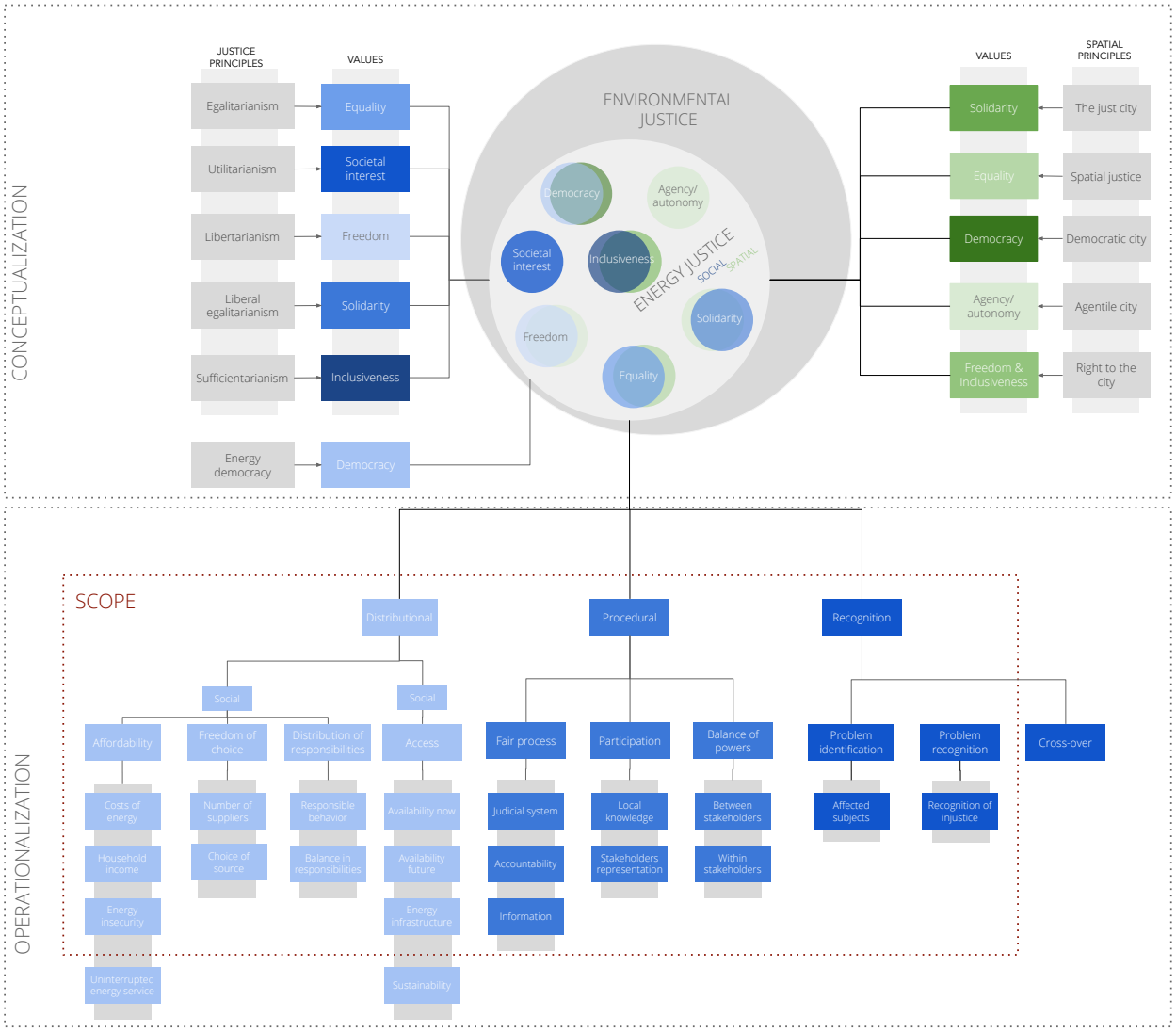

Figure 02. Conceptual framework.

In order to test the conceptual framework in practice, interviews were conducted with policy-makers and decision-makers in the energy field. The outcomes are described for each of the three types of justice; distributional, procedural and recognition. To start with recognition justice, it is identified that low-come households, and households with other non-financial obstructions such as language barriers or illness are a group that needs to be monitored closely in the heat transition regarding a just outcome. In Amsterdam, this is recognized, but these households have not been identified yet (Hendriks, personal communication, 09-04-2019).

For distributional energy justice in Amsterdam, it was found that the affordability is the most important indicator that raises concerns (Van Zanten, Agterberg, Van der Heijden, Groen, Hendriks, Meijerman, personal communication, 2019). Low-income households and a large share of middle-income households do not have the financial room to spend more money on heating (Meijerman & Ligthert, 2019). This is even more concerning since the freedom of choice is expected to decrease when more households will be connected to district heating, because this is the main alternative to natural gas in Amsterdam at the moment. In district heating networks the way they exist to date, consumers do not have any choice of their heat supplier or source of heat. This contradicts the value and principle of freedom. There are many possible ways to improve this and build in choice, even when the heat market is not unbundled, e.g. choice of temperature, choice of heat source, large-scale networks vs. collective networks, and ownership structures (Agterberg, personal communication, 02-04-2019). Furthermore, it is concluded that the current policy approach does not distribute costs according to the principle that the strongest shoulders should carry the largest burden (CPB, 2019). This contradicts equality and solidarity principles, which can potentially lead to injustices.

In relation to procedural energy justice in Amsterdam, far-reaching collaboration between industry and government is desired, with a high degree of influence for users (Van Zanten, Meijerman, personal communication, 2019). This is important to value equality between these main actors. Furthermore, the neighborhood-approach should include democracy in order to lead to 'just' outcomes (Agterberg, personal communication, 02-04-2019). Also, information ought to be shared transparently, which most stakeholders claim to do as best as possible, but there is room for improvement. Lastly, a high level of citizen participation is desired, which is not passive information provision, but active involvement and decision-power (Van Perlo, personal communication, 21-03-2019). This means citizens all have to be represented (inclusive) and have to have decision power (democracy).

The ambition of the city of Amsterdam, is to expand district heating networks in the coming years, potentially connecting up to 70% of all households in 2040 (MRA, 2016). For this reason, the monthly expenditures for natural gas are compared to monthly costs of district heating for 16 socio-economic groups. This reveals that the costs of heating in the case of connection to a district heating network (DHN) would increase with 32-48% compared to natural gas for all 16 groups. As a result, two of the socio-economic groups exceed the 6,5% threshold of heat poverty. In a situation where all households are connected to district heating, assuming no changes to the building or prices of heat are made 5/16 groups would spend more than 6,5% of their household income on heating. Four groups even spend more than 10% of household income on heating, and the worst-off group tops just above 13%. The low-income groups witness a stronger increase of costs, due to the fact that it is assumed they live in houses with a low energy label. It can be concluded that, if no measures are taken, the transition from natural gas to district heating would be extremely problematic for at least 5 out of the 16 socio-economic groups in Amsterdam.

Regarding the main research question, it is concluded that the transition from natural gas to sustainable heat provision will mostly impact the affordability and freedom of choice, both in a negative way, thereby posing the risk of degrading the just outcome of the transition in Amsterdam.

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Definitions

Energy transition – In this thesis the term energy transition will be used to describe the process currently taking place in the shift from finite and fossil sources of energy to clean and renewable sources, including the accompanied societal changes in policy, regulations and behavior.

Heat transition – The term heat transition refers to the transition that is currently taking place in the Netherlands from the use of natural gas to renewable and sustainable sources of heat.

Energy poverty– Threshold that is reached when a household spends more than 10% of income on energy services.

Heat poverty – Threshold derived from energy poverty. Since on average 65% of household income is spent on heating, heat poverty is assumed to occur when over 6,5% of household income is spent on heating services.

Energy services – Functions performed using energy which are means to obtain or facilitate desired end services or states (Fell, 2017).

Household equivalent – A unit to measure heat that is equal to 35 GJ of heat. Used to express the heat demand for households, but also larger consumers.

Abbreviations

RES – Renewable Energy Sources
VvE – Association of Owners (Dutch: Vereniging van Eigenaren)
DH – District heating
DHN – District heating network
NOVI – National Environmental Vision (Dutch: Nationale Omgevings Visie)
BW – Civil Code (Dutch: Burgerlijk Wetboek)
NMDA – Not More Than Otherwise (Dutch: Niet Meer Dan Anders)
SEG – Socio-economic group
ACM – Authority Consumer and Market (Dutch: Autoriteit Consument en Markt)
MRA – Metropolitan Region of Amsterdam
NAM – Dutch Natural Gas Company (Dutch: Nederlandse Aardolie Maatschappij)
CPB – Netherlands Bureau for Economic Policy Analysis (Dutch: Centraal Plan Bureau)
WPW – Westpoort Warmte
AEB – Waste energy company (Dutch: Amsterdam Energie Bedrijf)

1

Introduction

This first chapter introduces the subject of this thesis: the transition from natural infrastructure to sustainable heat provision. Furthermore, it briefly describes the history of heat provision in the Netherlands and the present-day trends and challenges that are observed. The concept energy justice is introduced which serves as the framework of this research. Finally, a problem statement is formulated.

1.1 Heat services and the heat transition

The importance of heat services

Energy has become an essential service for every household, which includes heating. Natural gas has been the standard infrastructure for heating homes in the past few decades in the Netherlands, which has resulted in high standards of comfort and reliability, and affordable prices. Warmth is a basic need at the lowest level of the Pyramid of Maslow (Halse, 2008). This indicates that it is amongst the most primary types of human needs, the physiological needs. Energy services and more specifically heat services, can provide for this need. Different authors have come up with various terms for emphasizing the importance of heat and energy. Justice theorists reason that, if physical security is a basic right, the conditions that create this are a basic right too, which includes; employment, food, shelter and a healthy living environment (Benjamin K. Sovacool, Raphael J. Heffron, Darren McCauley, & Andreas Goldthau, 2016). Therefore, people are entitled to a minimal amount of energy services, that enable people to attain a basic minimum of wellbeing. In this line of reasoning energy services are a primary social good. This term was introduced by John Rawls (1973) and is a category of goods that includes (civil and political) rights, liberties, income and wealth, and the social bases of self-respect (Rawls, 1973).

Because warmth is provided by energy, and because energy provides the possibility for taking part in economic practices and secures basic needs, all parts of society must have access to energy and energy itself should be recognized as a necessary commodity for human life (Jenkins, Sovacool, & McCauley, 2018). This need is translated into policy ambitions. The European Pilar of Social Rights has formulated 20 principles that serve as a compass towards better working and living conditions for EU-citizens. Included is: 'the right to essential services of good quality, including […] energy' (European Commission, 2018). In the Netherlands, this right to energy services, is operationalized by a right to affordable, reliable and sustainable energy.

Change is coming

Currently, there is a large amount of attention in the public debate for the 'energy transition' (Verbong & Geels, 2007). It is important to realize that energy transitions are constantly taking place. The history of energy shows there is always an ongoing transition (Weijnen, 2019); from the use of peat a few centuries ago, to using coal after which our society transitioned to natural gas, when this was discovered in Groningen. The term energy transition refers to a change in an energy system, usually to a particular fuel of source, technology or prime mover (Sovacool, 2016). Besides this technological change, energy transitions cause social change as well, because the energy sector is intertwined with the sociopolitical and economic contexts of institutions and practices (Szulecki, 2018). Thereby making the energy system a socio-technical system, which means the energy transition affects society, and political processes shape the energy transition. At this moment the term energy transition is used to describe the process of replacing fossil fuels with renewable and sustainable sources of energy. This transition is taking place in the electricity sector, but also in the heat sector, which is called the *heat transition*. In the Netherlands, the heat transition describes the process of decreasing and eventually ruling out the use of natural

gas and replacing this energy carrier by renewable and sustainable heat sources. This will be the focus area of this research.

Impact

There seems to be consensus about the fact the heat transition needs to be accelerated in order to decrease dependency on fossil fuels, safeguard our energy supply in the future and reduce emissions of harmful compounds. Moreover, in the Netherlands, the natural gas production should be decreased as quickly as possible to reduce the risk of earthquakes in Groningen. Alternative sources of heat need to be explored to reduce dependency on foreign countries for gas (and thus heat) supply. With regard to the transition from gas to renewable sources, it will be a challenge to reduce the use of natural gas. Currently, still 95% of households is connected to gas infrastructure (Idenburg & Weijnen, 2018). However, it has not been mapped what the impact on society will be of overcoming the barriers. Many Dutch citizens are concerned about this transition and a variety of numbers about the costs of the heat transition are mentioned by politicians, industry experts and scientists (Ekker, 2019). Due to the high importance of heat services, the transition will have a large impact on households, even physically entering their house when the gas connection is removed and a new source of heat installed. Questions arise about the distribution of costs and benefits, about the spatial implementation of new energy systems and about the relationship between citizens, government and private corporations.

The heat transition and justice

The heat transition is largely dependent on political choices, that are underpinned by values. Currently, these values are overshadowed by the urgency of a rapid transition (Jenkins, McCauley & Forman, 2017). In order to address these values, the academic field of studying energy justice has emerged, in which justice principles are applied to the field of energy production, consumption, policy, activism and security (Jenkins, McCauley, Heffron, Stephan, Rehner, 2015). Energy justice aims: “to provide all individuals, across all areas, with safe, affordable and sustainable energy” (McCauley et al., 2013). It addresses the distribution of costs and benefits (distributional justice), a fair process (procedural justice and recognizes those who are affected (recognition justice). This is important because justice in this respect relates to the accessibility and affordability of essential infrastructural services in society, that everyone needs to function well and therefore interferes with ethical values (Idenburg & Weijnen, 2018). *Justice* in itself, ensures and recognizes the basic equal worth of all human beings and aims to distribute good and inequality. Recently the traditional debate on justice has been expanded with topics such as environmental justice. Because we live at a time of resource depletion and fuel poverty, energy justice is a part of these debates that needs greater attention from researchers (Szulecki, 2018). It serves as an analytical tool for people researching energy, to create understanding of how values are represented in energy systems and to solve common energy problems (Sovacool & Dworkin, 2015).

1.2 History of heat supply in the Netherlands – an ongoing transition

The introduction of natural gas

Constructing a sewage system, drinking water supply, electricity, telecom and gas infrastructures, was seen as a condition for a healthy and prosperous society in the late 1900s and first 70 years of the twentieth century (Idenburg & Weijnen, 2018). This universal access to a variety of infrastructural services was arranged by law, shaped by the right of consumers to be connected, along with obligations for suppliers to connect users to drinking water infrastructure, sewage, electricity and - until recently - natural gas (Idenburg & Weijnen, 2018). One specific law arranging a certain standard in heating in buildings was the first Housing Act, in 1901 (Soer, 2009). This act was the first in requiring sufficient quality of housing, which included sufficient heating.

The first discovery of natural gas in the Netherlands was in 1948 (Smits & Gales, 2000). After the discovery it took some time until large-scale introduction followed. During this time, technological challenges were solved and agreements between the government and the NAM (Dutch Natural Gas Company) about exploitation were made. In the introduction phase, the electricity sector was excluded from buying natural gas until 1968, and the gas was mainly used for space heating for households and private buildings (Verbong & Geels, 2007). After 1968, gas-fired electricity plants increased the share of natural gas in the electricity sector to about 80% in the mid1970s. Advantages of the gas turbines were a short start-up time, the short time to construct a new gas turbine and low upfront investment costs, which lead to utilities adopting gas turbines for peak-load generation (Verbong & Geels, 2007). The advantages overpowered the fact that gas turbines had a lower fuel efficiency rate and smaller capacity than steam turbine plants.

Until 1960 the dominant actors in the energy regime were regional (and municipal) utilities. This changed when natural gas was introduced (Verbong & Geels, 2007), which led to the national government taking a more leading role in the energy regime. The reason for the government dominating the energy sector was that energy services were believed to serve the public interest. For this reason, natural gas became a public service quickly after its discovery. The introduction of natural gas was a transition process, rapidly replacing the use of coal and oil for heating purposes, with natural gas. The result was not only technological change in the way of heating, but also change in relations between dominant industry actors. Gasunie was founded to secure the quality of natural gas and held a monopoly position on natural gas transmission and distribution. During this period, the supply of natural gas and electricity, in the form of heating services, was the task of utility companies (De Jong, Weeda, Westerwoudt & Correljé, 2005). These companies were largely owned by municipalities and their strategy was largely determined by politics and the ministry of Economic Affairs. The third white paper on energy in 1995 set a different direction, towards the introduction of free market forces. This is the process of liberalization, which was driven by increasing efficiency and lowering prices of heat (and energy) services (De Jong et al, 2005).

Liberalization and privatization

Until the mid 1990's, the production, transmission, distribution and supply of heat services was a public monopoly. Liberalization deconstructed the current energy sector, to create a new market-oriented system. This was done with the belief that liberalization would stimulate innovation and efficiency and reduce unnecessary costs. The main way to do this was by unbundling, which means that the existing companies were divided into an energy production company and an energy supplier. This made market competition possible because new players were allowed on the market (De Jong et al, 2005). Consequently, this led to new ownership-structures, where certain companies were completely privatized, and others ended up with a public-private mix. The production became a competitive part of the chain, where apart from the NAM, also foreign companies were allowed to take part. Similarly, the market for the supply of heat services also opened up, allowing new players and stimulating competition. Different actors were allowed access to the grid, but the transmission and national distribution remained a monopoly of Gasunie. To ensure fair prices on this monopoly market, a new regulatory authority was founded to ensure efficiency (De Jong et al, 2005).

Another trend, occurring to some extent as a result of liberalization was privatization. The regional and municipal distribution companies were unbundled in a network part and a supply part. As a result, the newly existing supply companies were privatized (Van Damme, 2006), since market-competition increased the financial risks for municipalities and provinces.

1.3 Current trends

Changing technologies: decentralization

Now, the heat sector faces another transition, enabled by present-day trends in the infrastructure systems. The most dominant change in the system is decentralization both technologically and in terms of governance (Walker, 2009; Goldthau, 2014). Technological advancements increasingly allow microgeneration. For electricity this is well-known in the case of solar-PV panels. Also, for heat supply, there is a trend from centralized generation in a coal or gas-fired plant, to using different, more decentralized sources of heat. Many of these sources are yet to become mainstream such as geothermal, thermal energy from surface water and residual heat from data centers. It is argued that this decentralized character of the system is required to achieve carbon-emission reduction goals (Koirala et al., 2018). Since the heat system is a socio-technical system (Kern & Smith, 2008), these technological changes are accompanied by societal change. The transition from natural gas to alternative sources of heat is not just a technological transition, but also a transition from a collective service on a national level, to a new scale that is more individual on the level of a street, neighborhood or city. This increasingly complicates the governance of the system and calls for a context-specific approach on different scale levels (national, regional and local) (Goldthau, 2014).

Citizens more involved

The technological changes are accompanied by social change. One result of the decentralization is citizens becoming more involved in the heat transition. Where the current natural gas infrastructure supplies most households with gas, in the future district heating networks and heat pumps will be more common. These solutions have a more local character, which means some citizens will be forced to be more involved in the process of heat generation and distribution, sometimes becoming part of a local heat cooperative (Koirala et al., 2018).

Another way in which citizens will have to take action is home improvements, mostly insulation. This involves citizens financially. In this way, citizens are becoming more involved politically – sometimes without them realizing – both directly (when engaged in political action) and indirectly (by becoming part of the heat system) (Szulecki, 2018). The result is that citizens become a vital component in the system, which without the system would not work. A far-reaching level of involvement is when citizens become owner of (a part of) a heating network or system. In this case, the user gains power through ownership of production means.

CO2 reduction

Despite the large amount of attention that the current energy transition receives, the implementation of renewable energy is low in The Netherlands, compared to other European countries (Szulecki, 2018; Verbong & Geels, 2007). Therefore, the reduction of CO2-emissions is a main ambition of policy-making in the Netherlands, as well as internationally. This shows from the Paris Agreement and the Dutch Climate Agreement. The Paris Agreement was signed by 185 countries in 2016, in which they agreed to mitigate climate change, decrease global warming and increase the adaptability to adverse impacts of climate change (UNFCCC, 2015). The main ambition is to keep global warming under 2 degrees Celsius. In addition to the Paris Agreement, the Netherlands is working on the Dutch Climate Agreement, of which the concept version was published in 2018. The central goal of this national agreement is to reduce CO2-emissions with 49% by 2030, compared to the emissions of 1990 (S. E. Raad, 2018). The heat transition is one means of reducing CO2 emissions and reaching the Climate Agreement targets.

Changing policies

Grid operators used to have the obligation to connect every household to the gas and electricity infrastructures. For the connection to gas this changed after the 'Law Progress Energy transition' (In Dutch: Wet Voortgang Energietransitie) got enforced on July 1st 2018, meaning houses built after this date will not be connected to gas infrastructure anymore (Koirala et al., 2018). Mayors and Alderman have the power to make exceptions, since the municipal governments hold the mandate over the way in which heat is supplied, without the use of natural gas. For the price of alternative heating by district heating (DH), the NMDA-principle, meaning Not-More-Than-Otherwise (In Dutch: Niet-Meer-Dan-Anders), applies. This principle states that current costs of heat supply should not be higher than the costs as they are in case of traditional gas supply. It is currently enforced by the Heat Act and aims to protect citizens against unreasonably high heating costs. The Heat Act is currently being reviewed and the updated version is expected to be enforced in 2020. Another large change in policy is the New Environmental Act, expected to be enforced in 2021 (Ministerie van Infrastructuur en Milieu, 2017). This act aims to create more integrated spatial planning practices and will emphasize the responsibilities of the different governmental levels; national, regional (provinces) and local (municipalities). Both the Heat Act and New Environmental Act are expected to affect the heat supply, creating more integrated systems and emphasizing the local levels and decentralized solutions.

Values in the supply of heat

The values in the supply of heat align with the values dominant in the energy system. The acknowledged importance of heat (and energy) services has led to the fact that reliability is one of the three main pillars, and values, in energy policy. The other two are affordability and sustainability. These three are often positioned in a triangle where they compete, e.g. the more sustainable or reliable, the most expensive and thus less affordable. In policy and regulations, the emphasis on one of these three goals of energy policy changes over time. Between 1974 and 1986 reliability was the determining factor (De Jong et al, 2005). In 1986 the nuclear disaster in Chernobyl took place, leading to a shift in emphasis on sustainable (i.e. clean) energy policy. A decade later, affordability becomes dominant as a leading thought, which results in the market-oriented approach and liberalization. The way this dominance shifts over time demonstrates how different values are important at certain times, and how these values lead to different types of regulation and policies.

Besides the fact that different values can lead to different policy strategies, the outcome of energy policy and energy transitions also has an effect on society, sometimes even without being anticipated. The introduction of natural gas had such an effect. One way in which natural gas has served the public interest is by the large amount of income it has generated for the national government. The price of natural gas was linked to the international oil-price (Smits & Gales, 2000). In 1973 the oil-prices increased, leading to an exponential growth in gas-related income for the Dutch national government (Verbong, 2000). This 'extra' money was used by the government to contribute to social security and lower labor costs, this way contributing to wider society. So, during the years when natural gas has been the dominant source of heating, public values have been safeguarding

the collective interest, where the costs were socialized, and the benefits of reliable and affordable energy were shared by society as a whole.

This collective character of infrastructural services is nowadays no longer a given fact, for which two main reasons are observed. First of all, the past decades of energy policy were characterized by liberalization, which led to the unbundling of the energy market and market-oriented approach of policy. The second reason lies in the distributed character of the technology. It is becoming increasingly easy to generate your own electricity using solar panels, to produce your own hot tap water by using a solar thermal collector, or to generate your own heat using a heat pump. This undermines the collective character of the infrastructure that is based on the assumption that everyone is connected.

Related to the values reliable, affordable and sustainable, in the current policy approach there is an emphasis on the latter, which is demonstrated by the Paris Climate Agreement and the national Dutch Climate Agreement. However, the role of the three pillars have changed. Sustainability is now the ambition level or goal that the system aims to transition to. Reliable and affordable are two of the conditions that the system will need to fulfill.

1.4 Problem statement

In order to reduce CO2-emissions, reduce the risk of earthquakes in Groningen and reduce dependency of foreign countries, the heat transition is taking place. Given the large number of households connected to the gas infrastructure, it is an enormous undertaking, accompanied by a number of challenges and concerns. The first concern relating the heat transition are costs and benefits, and moreover how they will be distributed. There are signs that benefits of the advancing technology end up at high-income groups, because this group of people is easily acquainted with new technologies and furthermore relatively aware of the consequences of their behavior on their heat consumption. Improvements in the quality of buildings and houses requires large investments that lower income groups often cannot make. Meanwhile, high income groups reap the benefits of subsidies for sustainable energy and electrical mobility, also because land and house owners have the opportunity to exploit their properties, and people who rent don't (Idenburg & Weijnen, 2018). This is concerning from an ethical justice perspective. Furthermore, the unequal distribution of costs also undermines the support of the infrastructural investments that have to be made for a more sustainable heat provision and climate adaptation (Idenburg & Weijnen, 2018). This calls for more attention and focus on lower-income groups about being more aware of their heat consumption and the various options they have in relation to the heat transition (ECN, 2017).

An example of poor distribution of costs and benefits is energy poverty. What indicates energy poverty is a high share of energy expenses as a percentage of the overall monthly expenditures. The European Commission uses the following definition: "Households that spend more than a predefined threshold share of their overall consumption expenditure on energy products" (European Commission, 2010). A share that exceeds 10% is a commonly used threshold (ECN, 2017). In the Netherlands, among other countries, the energy quote (the amount of income spent on energy in percentages of the entire spendable income) has risen in the past few years. There is a group of about 2,6 million household that have a low income and have an energy quote of about 9%. For middle- and high-income households this is about 3 to 4% (PBL, 2014). More concerning is that the number of people exceeding the 10% threshold grew with 40 percent between 2006 and 2009. This is a problem because physical access and the affordability of infrastructural services are essential for each citizen to participate in society; economically and socially (ECN, 2017).

The second concern is the fact that new sources of heat will be increasingly dependent on geographical characteristics, posing the risk of increasing inequality between regions, areas and neighborhoods. There are currently already differences in terms of the access to and affordability of infrastructural services (ECN, 2017). This inequality takes place between citizens, between regions and between urbanized areas and the periphery. The spatial effects of the heat transition will affect these exciting differences. For example, the supply and investment costs of heat will be largely geographically dependent. Certain areas will have abundant heat sources available in surface water or geothermal heat, while others will not. In agricultural areas, there might be opportunities for biogas, when wastewater treatment plants are in proximity. In industrial areas, residual heat might be available to heat buildings (Idenburg & Weijnen, 2018). Another large difference is condition of buildings, and its quality relating the heating-efficiency. While newly built neighborhoods are nearing being energy neutral, old districts and buildings will use more energy to heat their house to the same temperature. Two thirds of the housing stock in The Netherlands dates from before 1984. Updating these buildings to the current standards will require large investments that not all house owners can make (PBL, 2014; Van Hoek & Koning, 2018).

Furthermore, when investments have to be made in rural areas, there might not be a positive business case, posing the risk of these places being left out.

The third issue is the fact that differences between groups of society such as income and education level will influence their chances to participate in the heat transition. Besides the lack of money, some groups of people lack knowledge, space, time and 'do-power'(Bovens, Keizer, & Tiemeijer, 2017). Especially low-educated people, and people who lack digital skills struggle to understand the system of sales of heat suppliers. For this group it will become increasingly complicated if they are expected to participate in active response systems, which is more likely to be expected since the trend is that citizens become more involved. Also, it will not be easy for this group to make wise decisions about the variety of options in the supply of heat without natural gas in their neighborhood (Idenburg & Weijnen, 2018).

The final concern identified that relates the heat transition is the dominance of the neo-liberal regime in the energy market in the Netherlands the past three decades, and the accompanied underlying values. The fact that since July 1st there is no more obligation to be connected to the natural gas, hands over power to the already powerful private sector. In many developing countries, infrastructural connections to rural areas are not being established, because they are not profitable (ECN, 2017). The Netherlands faces the same risk with new sources of heat. The decentralized technology and liberalization of the past years results in the fact that collective values no longer underpin the heat infrastructure and heat services with certainty. The rapid transition and importance of CO2-reduction emissions overshadow the debate about public values and conditions under which the heat transition should take place.

1.5 Conclusion

Because of the importance of heat services to secure a basic human need, it is undesirable to accept large differences in the affordability or access to these services between different groups of society. Currently, the trends of decentralization, increased citizen responsibility, the focus on CO2-emission reduction targets and the previous decades of liberalization, all lead to concerns relating the effects of the heat transition. The distribution of costs and benefits, geographical conditions and citizen participation in the heat transition question what the effect of the heat transition will be on energy justice, in order to provide all individuals, in all areas with safe and affordable heat. The effect of the heat transition on energy justice will be further investigated in this thesis.

1.6 Reading guide

In this thesis, the social effects of the heat transition will be investigated by using an energy justice framework. This aims to create understanding of the implications that it will have on our society of the future. It requires exploration of morals and values that underpin the heat transition, alongside an analysis of the current heat transition and perspective of the future. For this reason, background information about the history of energy policy is explained and a problem statement developed, stressing the importance of this research. Next, the research design, aim and questions are elaborated, after which an expected outcome is projected. In chapter 3, the values and rights under which the transition is desired to take place are explored by the introduction of spatial justice. Chapter 4 builds a conceptual framework that is fitting for this research by reviewing energy justice literature. This framework is brought to practice in chapter 5, in which findings from policy, reports and interviews are stated that relate to energy justice in the Netherlands. Chapter 6 zooms in on this even farther, by exploring the spatial component of energy justice in the metropolitan area of Amsterdam and comparing the affordability of the current natural gas to district heating. In chapter 7 all the findings are discussed after which the main conclusions are presented in chapter 8.

2

Research design

This chapter explains the methodological approach that is taken in this research. First, a research aim is developed that is supported by a research question. In order to answer the main research question, four sub research questions have been formulated. The cohesion of the research questions and activities is shown in the research design flowchart. Then, this chapter will describe the different methods that are used in order to obtain data, analyze the data and draw conclusions to answer the research questions.

2.1 Research aim

In the problem statement it is identified that the heat transition raises justice concerns, which is the focus of this research. The research will investigate a challenge and does not focus on providing solutions to solving it, however it will formulate recommendations. Moreover, it aims to create more understanding of the implications of the heat transition on energy justice. The research aim is defined as:

Contribute to increase the understanding of the effects of the transition from gas to sustainable sources of heat on energy justice.

In order to achieve this outcome, four main steps are taken. First, an exploration of values and rights are explained based on justice theories and principles, and the notion of spatial justice, then linked to the heat transition. Next, a conceptual framework is constructed to translate the theoretical findings into practical indicators to analyze. This will be followed by a descriptive analysis of the current state of energy justice and perspective of the future heat provision, focused on Amsterdam.

2.2 Scope

This research only investigates heat services, leaving electricity services aside. The focus on heat has two reasons, the first being that the heat demand takes up a larger share of the energy bill of about 60 to 70%. Secondly, the energy transition will affect the heat supply on a household level much more than electricity. Electricity, even though it will come from different, renewable and sustainable sources, will still be delivered to the consumer. Natural gas, however, is a finite resource that will become much less available because the extraction in Groningen is decreased after recent Earthquakes. Entirely new heat infrastructures will have an invasive spatial and financial impact on households and their private living spaces. Furthermore, the research will focus on the implications of the heat transition on a household level, because this is the most interesting scale-level in relation to energy justice. For this reason, the industrial sector and mobility will not be discussed, even though they account for a large share of the energy consumption. Lastly, the scope of this research is limited to the geographical area of the Metropolitan Region of Amsterdam (MRA).

2.3 Research questions

The research question is formulated in such a way, that answering it will lead to a positive outcome of the research aim and follows:

What is the impact of the transition from the natural gas heat supply to sustainable heat provision on energy justice in the metropolitan area of Amsterdam?

In order to answer the main research question, sub-questions are formulated. Each of the chapters that follow in this thesis will answer one of the sub research questions. Table 01 shows an overview of the sub research questions, activities that are undertaken to answer it, and the main method associated.

	Research question	Activity	Method
Main RQ	What is the impact of the transition from the natural gas heat supply to a sustainable heat provision on energy justice in the Metropolitan Area of Amsterdam?	Find the impact of the heat transition on energy justice in Amsterdam	Mixed methods used in all sub RQs
SRQ 1	What is energy justice and how is it related to classical justice principles and spatial justice principles?	Comparing energy justice to general justice principles and spatial justice concepts	Literature study
SRQ 2	What does the conceptual framework of energy justice look like and how can this concept be operationalized to measure energy justice?	Construction conceptual framework	Literature review
SRQ 3	What is the current state of Energy Justice in (the policy approach of) Amsterdam?	Map the current state of energy justice in Amsterdam	Policy analysis and interviews
SRQ 4	What are the implications of the heat transition from natural gas to district on 1) the affordability on a household level in Amsterdam and 2) the spatial component of energy justice?	Link the heat transition to energy justice in neighborhood of Amsterdam	Case study (interviews and quantitative data analysis)

Table 01. Overview of research questions.

2.4 Research design flowchart

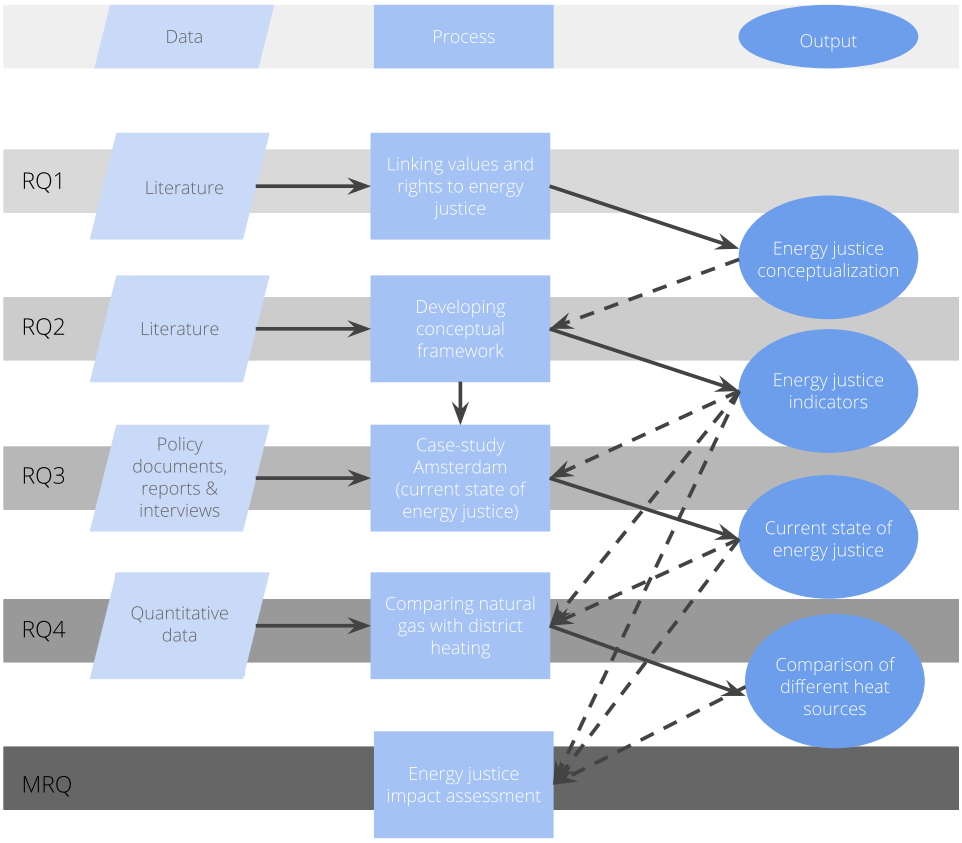

Figure 03. Research design.

The research design flowchart (figure 03) shows how the research questions are related, and how the sub-questions subsequently lead to answering the research question. The first box of each row represents data input, that is processed in the second 'box' which describes an activity. The last circle resembles the output of the activity. All solid arrows represent direct data input. The dotted arrows also represent data input; however, this is data that has is a result of previous steps of this research.

The research question aims to describe energy justice in Amsterdam, which means first, energy justice needs to be defined. Therefore, the first research question leads to the conceptualization of energy justice. As shown in figure 03, first, literature review will give a theoretical and conceptual background. This explores values, rights, and how these are interrelated with the heat transition, especially in a spatial manner and policy context. The literature will describe all the relevant concepts after which they will be used to construct a conceptualization of energy justice. Second, a framework needs to be developed that operationalizes the concept of energy justice to practice, which is done by answering research question two. The leads to the output of energy justice indicators. These indicators are validated by expert consultation. Next, a descriptive analysis of the current energy policy in the Netherlands is constructed, that will be based on literature and policy data as well as interview data to validate these documents, revealing the barriers that the transition faces today. This will result in the level of energy justice now and after the transition, influenced by technical aspects, such as availability of heating systems, but also spatial aspects, since different locations have different sources of heat available (think of geothermal, tidal, or solar). Furthermore, it will be defined by policy, since local policy has a strong influence on the energy policy, this again leads to spatially different levels of energy justice. It will also look into the fairness of the process taking place, defined by factors such as financial restrains, lack of knowledge, lack of willingness to participate and the level playing field in which civil society might or might not have enough power to influence the heat transition. After this, district heating is compared to natural gas as an alternative for heat supply. Central will be the affordability indicator, to assess the future of heating through an energy justice framework. Eventually, the main research question can be answered based on the results and conclusions of the sub research questions.

2.5 Expected outcomes

The outcome of the thesis will be a new approach to operationalize the concept of energy justice. So far there is no assessment of the current state of energy justice or injustice in Amsterdam. By operationalizing this concept, an overview of the energy (in)justice in Amsterdam can be produced. This new method will be documented and open-access, so application of the conceptual framework in different contexts will be possible for future researchers.

2.6 Societal relevance

This thesis is relevant to society, because even though not everyone realizes it; "in some sense we are all energy decision-makers" (Sovacool & Dworkin, 2015). This means that energy justice is a societal wide topic that deserves a societal wide debate. The threats to energy justice are starting to be unraveled in academia but are yet to reach the public, because energy justice can affect which technologies we select as part of our energy mix, by framing energy decision-making as ethical issues (Jenkins et al., 2018). This thesis aims to contribute to this societal debate by further investigating the problem and also aims to safeguard the values and principles by which the heat transition takes place, securing energy justice.

2.7 Academic relevance

Energy justice is a field of research, that recently has emerged. Until now the research conducted remains on an abstract level. The term 'energy justice' has been defined but remains abstract and practical application is lacking. This means the state of energy justice as it is today, is still largely unknown. An attempt to quantify energy justice has been made by (Heffron, McCauley, & Sovacool, 2015) in 'Resolving society's energy trilemma through the Energy Justice Metric. Although this tool achieves to show energy justice on a large scale (between countries) and different energy sources, it is not very specific. Therefore, this thesis attempts to take the energy justice concept, make it operational, and apply it to an Amsterdam case study. This approach will contribute to the energy justice domain by operationalizing the concept of energy justice into a practical framework that can be applied to case studies and serve as input for decision-making and policy-making processes.

2.8 Used methods

In order to answer the main research question and sub research question, different methods were used. A short explanation for each method is given.

2.8.1 Literature review

Literature review was used to construct a conceptual and theoretical framework. Different justice theories and principles are the foundation of energy justice, which were explored. To construct a conceptual framework, multiple energy justice literature sources have been reviewed, which led to new conclusions and a new operationalization of the concept of energy justice. Furthermore, review of policy documents and research reports were used to describe the current state of energy justice in the Netherlands, especially in Amsterdam.

2.8.2 Interviews

Semi-structured interviews were held with experts from industry and policy makers in the energy field. The interviews were used to validate the conceptual framework and test the indicators that were defined for the operationalization. Besides the validation purpose, the interviews were the main data input for the descriptive analysis of the current state of energy justice in Amsterdam. The interviewees have been selected based on two main criteria. First, they need to have a high degree of influence, either by being in a position with decision-power in the field of policy or by a leading role within the private sector. Besides this, there had to be an even representation of interviewees that work on a local, regional and national scale. Table 02 shows an overview of the interview respondents, their expertise and the reason for selection.

The interviews were conducted, recorded and transcribed resulting in a large amount of data. This data was structured in an excel document, after which it has been used to construct the text, quotes and tables in this thesis. To make sure the conclusions and quotes are interpreted well, they have been sent to all interview respondents for a feedback and validation round, after which small adjustments were made.

Number	Date	Name	Job description	Reason for selection	Duration (mins)
1	21-03-2019	Bastiaan van Perlo	Woonbond	Represents large group of people who rent a house	56:37
2	28-03-2019	Emiel Reiding	Director National Environmental Vision	Decision power on a national level regarding policy that influences the heat transition	51:13
3	01-04-2019	Jannis van Zanten	Program manager Amsterdam Energie Bedrijf	AEB is one of the leading stakeholders in the development of district heating networks in Amsterdam	56:45
4	02-04-2019	Pallas Agterberg	Director strategy Alliander	Alliander is the grid operator in Amsterdam which is responsible for the reliability of energy services and a main local stakeholder	44:55
5	05-04-2019	Ellen van der Heijden and Marjolein Groen	Province of Noord-Holland	The province of North-Holland plays a role in climate and sustainability policy on a regional level	34:43
6	09-04-2019	Ben Hendriks	Project management bureau municipality of Amsterdam	The municipality is the main level at which the heat transition is being shaped by the government	45:12
7	11-04-2019	Eef Meijerman	!WOON	!WOON is an initiative by the municipality of Amsterdam that supports all residents of the city with issues related to housing	50:56

Table 02. Overview of interview respondents.

2.8.3 Case study

Case study is a research method that allows for in-depth and holistic research within a specific context (Zainal, 2007). In this research has been used to put the conceptual framework of energy justice that is developed in practice. In this case study the context is the heat transition currently taking place in a neighborhood in Amsterdam. The case study was used to 1) test the conceptual framework in practice (chapter 5), 2) illustrate the state of play of energy justice in Amsterdam (chapter 5) and 3) compare how different sources of heat perform on energy justice (chapter 6).

The local government (municipality) plays an important role in the distribution of resources. Therefore, it is interesting and relevant to describe a case on a local scale, using the perspective of households. The research took place within the metropolitan region of Amsterdam, which was the case-study area. The energy justice indicators have been explained for Amsterdam, based on the interviews and support with reports and policy documents. Furthermore, energy justice in Amsterdam was described by a quantitative analysis of the affordability of district heating compared to natural gas. For this analysis, different socio-economic groups were selected and compared to each other.

2.8.4 GINI-coefficient

Lucas, van Wee and Maat (2016) have developed a method to quantify socially relevant accessibility impacts of policies (Lucas et al., 2016). The main reason for this is the lack of a method that effectively evaluates the social impact of the policy. The current methods - Cost-Benefit Analysis and Multi Criteria Analysis - do not identify the social and spatial distribution of impacts across different population groups (Lucas et al., 2016). It is stated that regarding accessibility, it is important to include these social and spatial factors, if one wants to protect or enhance the accessibility of an 'at risk' group. This is the bridge to the heat transition, since there are 'at risk' groups here as well. This means it would be beneficial to apply the methodology that includes the social and spatial impact factors to the heat transition. Even though this method is developed for transport and accessibility it can apply to energy, since the underlying theories apply. According to Islar (2017) the energy justice framework is based on principles that allow us to weigh and rank the normative considerations that impact our decisions, including sufficientarianism and egalitarianism (Islar, Brogaard, & Lemberg-Pedersen, 2017).These two theories are used to support the use of the GINI-coefficient.

A GINI index is a scale to show distribution through a Lorenz curve, for example income distribution. In this case the Lorenz curve shows the cumulative distribution of income over the cumulative population ordered by increasing share of income (Lucas et al., 2016). This method has been the inspiration for the comparative analysis that will done for Amsterdam. This has been done based on the GINI index, that is supported by the theory of egalitarianism. This theory states that all people are equal, that focuses on providing social goods and that aims to maximize the greatest benefit of the least advantaged members of society. This index shows how the costs of heat (energy) as a percentage of the household income are distributed amongst 16 socio-economic groups. The GINI index itself has been calculated and indicates an even or uneven distribution. Furthermore, for all groups, the annual and monthly costs in case of connection to a DHN were calculated. The current GINI index is compared to the GINI index in the new situation.

2.9 Data handling

The main source of data in this research is qualitative data. A characteristic of qualitative data, especially related to case-studies is that the data is voluminous and produces a large amount of documentation (Yin, 1984), which is why proper handling of the data is key when doing a qualitative study (Creswell, 2013). For this reason, this research follows the steps as described by Creswell (2013). The first step of data handling is collecting the data, in this case interview data. The interviews were recorded as an audio file and stored in a folder on a hard drive and on a cloud service. To be able to analyze the data the interviews were transcribed completely. This resulted in seven large text documents that contain unstructured data, for this reason the next step was to organize the data. This was done at first by reading the entire transcript several times while memoing and highlighting important sections. It is important to read the transcripts carefully to start understanding the data and see patterns, which helps in the next step; describing, classifying and interpreting data. This was done using codes that followed from the theoretical framework. Concepts, topics and indicators that were identified previously, were used first for developing the interview questions. After the interview they were used for categorizing the data that was generated from the interviews. Categorizing the data forms the heart of qualitative data analysis (Creswell, 2013). In this process, the concepts, topics and indicators are used as codes. By reading and memoing the interviews, concepts and topics came up that were not represented in the conceptual framework, so these were added to the list. In an excel table, the codes were used to classify pieces of text document, derived from the interviews. When the data was categorized and structured, the next step was the interpretation. In qualitative research, interpretation is about extracting information beyond the codes and themes to find the larger meaning of the data (Creswell, 2013). The final step in the data handling in a qualitative study was to represent and visualize the data. In this research, this was done by describing the phenomena that are observed and by comparing different point of views in tables. After the data collection and data analysis, the writing phase starts. In a qualitative study, researchers need to position themselves in their writings, which is the concept of reflexivity. By doing this the writer is conscious of the biases, values, and experiences that he or she brings to a qualitative research study (Creswell, 2013).

Apart from the qualitative data, some quantitate data was used in the case-study. The source of this data is Meijerman and Lighthert (2019). It has proven difficult to collect data that reflects the household level in Amsterdam, due to privacy concerns. Therefore, the 16 socio-economic groups were used that represent a large share of the population of Amsterdam. Another challenge was to find geo-data to identify the locations at which these groups live in the city. The required data was not available at the municipality.

3

Values, rights and energy justice

This chapter starts with a theoretical exploration of a variety of concepts that are used in justice literature. It describes how values and rights are interrelated and how they influence the city. Then, it links these concepts to an energy context and explores how the notion of the just city can help by shaping the conditions for the heat transition in terms of values and rights. By doing so, this chapter will answer the first sub research question: *"What is energy justice and how is it related to classical justice principles and spatial justice principles?"*

3.1 Justice principles

Justice is a subjective concept. Everyone has a *sense* of what is just and what is not. To analyze justice and discuss this concept based on arguments, a common, rationale and substantiated conception of justice needs to be formulated. Therefore, a selection of justice theories and their relevance to the heat transition are discussed. Translating broad, universally accepted values into real life to the household and individual level can lead to just decision-making (Sovacool, 2016). For this reason, the values that have a central role in the justice principles are extracted.

Egalitarianism (equality)

Egalitarianism is the most simple justice principle that states everyone should receive an equal share, since morally, all humans are equal (Vergeer, R., Rooijers, F., Davidson, 2017). According to egalitarianism, everyone is equal and should therefor receive the same costs and benefits. The theory of egalitarianism is used to support the GINI-coefficient, which is an indicator for the even or uneven distribution of money, usually the household income. The main value that is central in egalitarianism is equality. In relation to affordability of heat, this value can be operationalized in different ways, e.g. each household spends the same percentage of income on heating or every household pays an equal amount of money to heating services, regardless of their income.

Liberal egalitarianism (solidarity)

Liberal egalitarianists are in favor of redistributive policies by the government, to safeguard the needs of the weakest. This is based on the notion that life comes with a certain amount of luck (Vergeer, R., Rooijers, F., Davidson, 2017). Based on the most important value in liberal egalitarianism, solidarity, the less-fortunate should be compensated for being 'unlucky' (Dworkin, 1981). For energy decisions, this would mean the costs and benefits are redistributed according to people's capacity to pay. Those able to afford it, pay more than those who cannot contribute.

Libertarianism (freedom)

The most important value of libertarianism is freedom. It is based on the moral principle that people should be free from obligations and should have the power to make independent life-decisions (Vergeer, R., Rooijers, F., Davidson, 2017). For this reason, libertarianism is not in favor of high taxes (on energy), but when a sense of urgency is involved it is not ruled out. In relation to energy, this would mean that libertarianism would only accept taxes based on a 'the polluter pays-principle.' The operationalization of this principle could be that pollution, such as CO2-emissions and other emissions of harmful compounds, are taxed.

Utilitarianism (societal interest)

Utilitarianism assesses wealth by investigating the total societal amount of happiness, utility and prosperity (Vergeer, R., Rooijers, F., Davidson, 2017). According to this belief, good policy maximizes the total share of wealth and happiness, and thereby safeguards the societal interest and public goods. This requires efficiency, and for this reason utilitarianism is also in favor of the 'the polluter pays-principle.' In energy policy, this results in the fact that costs end up with the well-off, and are minimized for the less fortunate, all to safeguard the societal interest.

Sufficientarianism (inclusiveness)

Sufficientarianism aims to improve the well-being of those below a minimum threshold and gives absolute policy priority to doing so (Lucas et al., 2016). It dictates that a minimum amount of goods should be available to everyone and calls for distribution to be fair, so everyone receives a sufficient amount of social goods to meet their basic needs (Islar et al., 2017).This is based on the central value of inclusiveness, that secures no-one ends up below a pre-defined threshold. In relation to energy, this means, everyone should have access to energy (and thus heat) services for a reasonable price.

Extraction of values

For all justice principles it is reasoned that there is a dominant value that takes a central role. This does not mean that no other values support each of the principles. Figure 04 shows how each justice principle leads to the extraction of a dominant value.

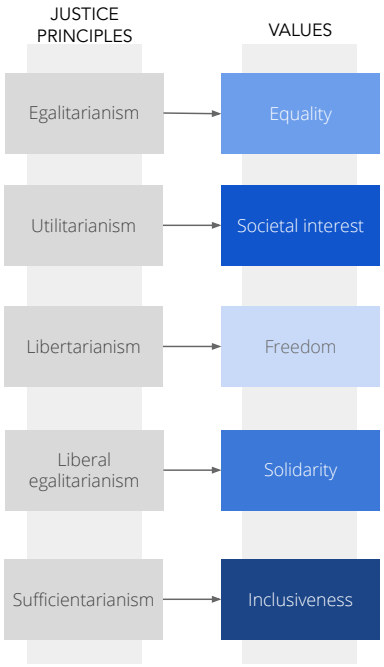

Figure 04. Extraction of values from justice principles.

Synergies

These different justice principles may seem conflicting in the situation where they are adopted in their most pure (and extreme) form. For example, libertarianism dictates that a liberal heat market would create the most efficient prices and thus lead to affordable heat services, whereas liberal egalitarianism would reason for more government interferences regarding heat prices. However, the different principles can also form synergies, supporting each other by complementing the central values. This happens when the different values are applied to different aspects of justice. For example, libertarianism can inspire to safeguard freedom of choice in the source or supplier of heat, and liberal egalitarianism can influence the price structure regulations. In this way the central values of all theories can co-exist and even supplement one another. From the different justice principles, the values equality, solidarity, freedom, social interest and inclusiveness are extracted and reasoned to be important in order to lead to justice. All values apply in different ways to the heat transition and are found in the concept of energy justice that will be explored next.

3.2 Energy justice

The concept of energy justice was founded in environmental justice literature (McCauley et al., 2013). It focuses on energy policy and energy systems, and since heat makes up a significant share of energy for households, energy justice strongly applies to heat provisioning. A definition of energy justice by McCauley et al (2013) is: "a global energy system that fairly disseminates both the benefits and costs of energy services, and one that has representative and impartial energy decision-making". The field of energy justice enables us to assess whether developments in the energy systems are 'fair' or ethically responsible (Correljé, 2018). The justice, that is assessed is about the distribution of primary goods and public goods (Sovacool & Dworkin, 2015). Examples are rights and liberties, power and opportunities, and income and wealth. But it also deals with public bad, such as pollution and poverty. Therefore, it is argued that energy justice addresses the unequal distribution of ills, resulting from policy decisions on infrastructure placement (e.g. wind farms, nuclear power plants), subsidies (e.g. solar pv-panels, offshore wind), pricing (e.g. energy poverty) and consumption indicators (e.g. smart meters). Three core themes, called tenets have been formulated in energy justice literature: distributional, procedural and recognition justice (McCauley et al., 2013). All three are interlinked and show overlapping issues. They are described next.

3.2.1 Distributional justice

The first tenet of energy justice is distributional justice (Heffron et al., 2015; McCauley et al., 2013). This type of justice follows from the implementation of the traditional concept of social justice, which is about the distribution of benefits and ills in society (Elster, 1992). Distributive justice deals with three questions: 1) What goods are to be distributed? 2) Between what entities do they have to be distributed? and 3) What is the proper mode of distribution? (Sovacool et al., 2016). Environmental benefits and ills are physically unequally distributed as well as their associated responsibilities, making energy justice an inherently spatial concept (Walker, 2009). This comes with the notion that some resources are inevitably unequally distributed, such as wind, hydropower or geothermal energy. But distributional justice, does not only concern the siting of infrastructure, it also concerns the access to energy services (Jenkins, McCauley,Heffron, Stephan, Rehner, 2015). This means distributional justice entails both physical access to heating and cooling as well as the extent of individual freedoms (e.g. freedom of choice over energy supplier).

An example of a highly influential justice theory, that uses the aforementioned justice principles is the theory of urban justice, constructed by John Rawls (1973). He developed his theory in the 1970's, which is a quest to answering what principles we would agree to in an initial state of equality (Schlör, Fischer, & Hake, 2013). His theory is of distributive nature since it aims to formulate principles for the fair distribution of all cooperatively produced social goods alongside developing justification for these principles. The first principle Rawl states is that each person has equal right to the most extensive basic liberty that is also compatible with that of others. The second principle dictates that social and economic inequalities must be arranged so they can be expected to benefit everyone and are attached to positions and open to all (Rawls, 1973; Schlör et al., 2013). These principles are targeted to institutions because they have distribution powers. Their main goal is to enable social justice by just distribution which in the end leads to social stability. Rawls believes everyone is entitled to basic social goods and his principles specify the rules for distribution of these goods (Rawls, 1973).

Distributional justice and the heat transition

The consequences of the heat transition can either be positive or negative for citizens and businesses. Among the potential positive effects are improvements in someone's living environment, housing, employment and business activities (Correljé, 2018). Besides these direct impacts, there are general advantages such as slowing down the greenhouse gas effect and other benefits to nature and the environment, which will be stronger is some regions compared to others. Counter to these positive effects, are the negative consequences in terms of financial and societal costs of new technology, discarding old technology, adapting to new habits and routines and possible adaptation of the living environment (Correljé, 2018). These different positive and negative effects – or costs and benefits – have to be distributed. This raises an ethical question about the degree to which citizens will experiences these costs and benefits, since an equal distribution is impossible.

3.2.2 Procedural justice

Secondly, procedural justice calls for equitable procedures that treat all stakeholders in a non-discriminatory way (McCauley et al., 2013; Walker, 2009). This requires all groups to be able to participate in decision making, along with these decisions being taken seriously. Furthermore, it requires access to information, meaningful

participation, access to legal processes for achieving redress (Sovacool & Dworkin, 2015), transparent and impartial information provision by government and industry, and the right engagement mechanisms (Heffron et al., 2015; McCauley et al., 2013). Jenkins et al. (2015) argue there are three mechanisms of inclusion designed to achieve just outcomes in the procedural energy justice field: local knowledge mobilization, greater information disclosure and better institutional representation.

Procedural justice and the heat transition

The heat transition is a complex process that affects citizens in different ways. The trends of decentralization and increased citizen engagement result in the fact that all citizens have to make heat related decisions, since everyone has to disconnect from natural gas sooner or later. Procedural justice addresses the way in which this process is shaped by describing the relationships and responsibilities between the dominant actors.

3.2.3 Recognition justice

The third tenet of energy justice is recognition justice. A definition of recognition (in)justice by Walker (2009) is formulated as: "the process of disrespect, insult and degradation that devalue some people and some places identities in comparison to others" (Walker, 2009). This type of justice stems from critical theorists of recognition, who reason that obstacles for attaining a healthy sense of self should be overcome in the name of everyone's legitimate claim to an equal opportunity for realizing an undistorted identity (Zurn, 2003). Translating this from theory to practice, the recognition tenet states that individuals must be represented fairly, free from physical threats and offered complete and equal political rights (Schlosberg, 2003). Furthermore, it requires acknowledgement of the divergent perspectives rooted in social, cultural, ethnic, racial and gender differences (Jenkins et al., 2015). Recognition justice is important to secure energy justice. At a policy level, non-recognition towards an injustice such as energy poverty can influence if and in what form alleviation policies take place (Bouzarovski & Simcock, 2017). In areas where recognition is not in place (also called non-recognition) in relation to energy poverty, fewer effective policies are likely to be enacted to solve the challenges, which potentially leads to distributive injustice.

Recognition justice and the heat transition

The heat transition will inevitably have an enormous impact on households, their private living space and financial autonomy. Recognition is intertwined with the process, since it is the way of alerting differences (that may lead to injustice) that come into existence.

3.2.4 Integration of general justice principles

The aforementioned justice principles apply in various ways to distributional justice, procedural justice and recognition justice. First, this is demonstrated by the integration of the values in distributional justice. Even though *equal* can be operationalized in different ways, distributional justice addresses equal or unequal distribution of goods. Furthermore, freedom is mentioned as a key component of distributional justice. Also, societal interest applies, since it is found in Rawls' second principle that is of distributive nature, where the 'just' distribution of goods benefits the entire societal interest.

The value inclusiveness that is extracted from the justice principles applies directly to procedural justice. This is reasoned to be an essential part to achieve procedural justice and entails inclusion of different actors as well as inclusion within the same actor-group. Furthermore, it is reasoned that the process should be democratic.

The recognition justice tenet mostly reflects the value solidarity. Recognizing differences and how differences may lead to unjust situations looks out for vulnerable groups of society that may be hit disproportionately by energy decisions or policy. Furthermore, recognition justice is based on equality, given that everyone should receive the same rights.

Figure 05 shows how the values that are extracted from the justice principles are integrated into energy justice. In energy justice no division between distributional, procedural and recognition justice has been made, because all values apply to all three energy justice tenets, even though the extent in which they apply varies.

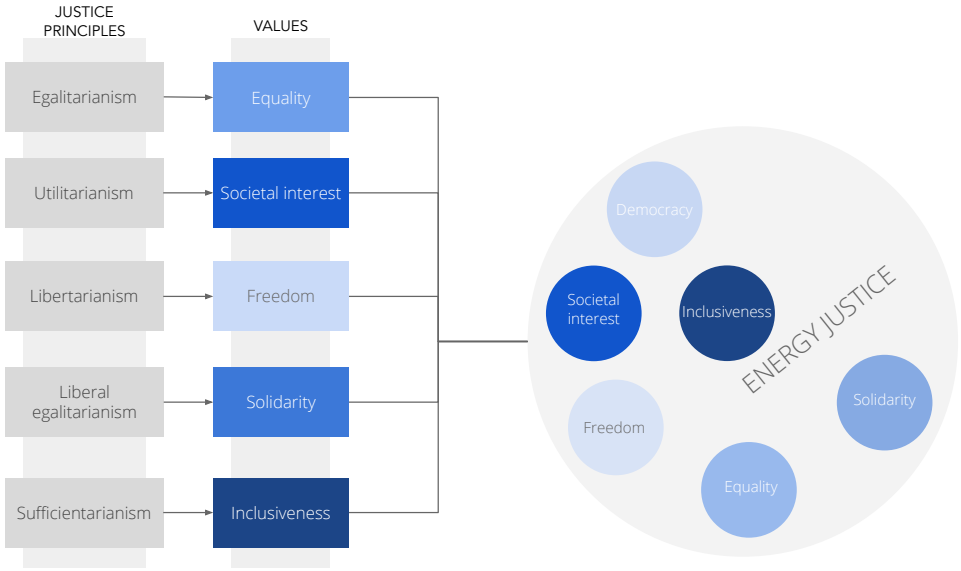

Figure 05. Integration of justice principles in energy justice.

3.3 The spatial component of energy justice

Energy justice knows a significant spatial component, mostly in relation to the distributional justice tenet. To analyze the heat transition in Amsterdam, this spatial component is of great interest. Numerous authors have written about justice in relation to its spatial component, of which a selection is described in this section. From these different spatial principles, values can be extracted.

Spatial justice (equality)

The just city implements social justice, which traditionally refers to the distribution of benefits and burdens is society (Elster, 1992), into a spatial concept; and becomes spatial justice. It aims to translate political philosophy (i.e. the debate about values, rights and justice) into spatial principles of justice, which is complex (Israel & Frenkel, 2018). The concept of spatial justice, provides an interesting framework for analyzing energy decisions and their spatial implications on justice (Yenneti, Day, & Golubchikov, 2016). A spatial justice approach does not only involve revealing and describing geographical patterns of inequalities, but also critically evaluates these in terms of wider forms of (in)justice and the accompanied effect on human well-being (Bouzarovski & Simcock, 2017). The starting point in doing this is fair and equitable distribution in space of resources that are socially valued, alongside the opportunities to use them (Soja, 2016). Walker (2009) claims that all distributional inequalities have a demonstrable spatial manifestation. Spatial justice does not call for complete socio-spatial equality. Perfectly even development and absolute distributional justice are not achievable (Soja, 2016). Some degree of inequality is even embedded in the geography we live in. So, within spatial justice, a degree of inequality is accepted and can still lead to a 'just' outcome. Even though equality can be operationalized in different ways, it is the most important value that is addressed in spatial justice.

The city as a strategic place

Cities are a key place where new norms are developed (Sassen, 2017). The conditions in cities can create new power structures and openings for political actors who have been invisible or without a voice until now. This is a form of localization and can lead to the disadvantaged contesting globalized power (Sassen, 2017). According to Fainstein (2010) there are two conditions that make cities strategic sites: 1) the re-scaling of strategic territories that articulate the new politico-economic system and thereby at least some features of power, and 2) the partial unbundling or weakening the national as container of social process due to the variety of dynamics encompassed by globalization and digitization. The result is that cities emerge as strategic sites for (economic) transition processes (Fainstein, 2010), one of these is the heat transition.

So, these strategic places are a concentration of global, national and local dynamics, that force the need to respond and innovate in new ways, taking into account both the most powerful and the most disadvantaged (Fainstein, 2010). Cities are also nodes of infrastructures. They have historically been able to develop and still owe their existence to these infrastructural systems (Idenburg & Weijnen, 2018). Since cities are places with a high

density of infrastructure, they are more vulnerable for the heat transition, because this transition relies largely on infrastructure. Yet at the same time there is an advantage for higher density areas, since access to energy (and especially heat through a DHN) depends on the infrastructure for distribution (Leach, 1992). This infrastructure thrives well by higher density areas, dividing the infrastructural costs over a greater number of households.

The just city (solidarity)

The model of the *just* city originates from critiques of scholars in urban politics in the beginning of the 1960s (Fainstein, 2010). They argued to increase the focus on protecting the rights of minorities and lower-class citizens, as well as on focusing on neighborhoods and neighborhood facilities, rather than downtown areas. According to American political and urban theorist Susan Fainstein, the just city is: "a city in which public investment and regulation would produce equitable outcomes rather than support those already well off" (Fainstein, 2010). This is underpinned by the value solidarity. This concept is relevant again to date, as the heat transition threatens the rights of low-income groups of society, of people living in remote areas and of tenants in the commercial sector. In a capitalist economy, which we live in, the normal workings of an urban system accompanied by the everyday activities, is a primary source of inequality and injustice, because it leads to the redistribution of real income in favor of the rich over the poor (Soja, 2016).

The right to the city (freedom & inclusiveness)

Besides this collective right to energy services, according to Harvey (2008), we also have the right to the city. "The right to the city is far more than a right of individual access to the resources that the city embodies: it is a right to change ourselves by changing the city more after our heart's desire" (Harvey, 2008). With this quote, he demonstrates that the city influences its residents as much, as the city is shaped by the people who live in it. This highlights a procedural issue. If people, citizens, residents have the right to shape the city, they have the right to participate, to decide and have a certain level of power. This is based on the values freedom and inclusiveness. Citizens should have freedom to make decisions and to participate. According to urban theorist Toni L. Griffin (2015), a just city has to include everyone (Griffin, Cohen, & Maddox, 2015). Inclusiveness ensures nobody is left out (Harteveld, 2017).

If citizens have the right to shape the city, and if the energy system is a part of the city, then citizens also have the right to shape the energy system. This is especially true since citizens are increasingly expected to participate in decision-making in relation to heating systems. If not all citizens can participate and get a share of the benefits of the transition in infrastructures, situations can emerge that are perceived as unjust or make groups of citizens feel left out (Idenburg & Weijnen, 2018). Degradation of social justice and inclusivity can break down the support for societally desired infrastructure transitions that require large investments.

The democratic city (democracy)

The concept of the democratic city builds on the notion of the right to the city. If we all are entitled to the city, or at least a share of it, this requires a structure for decision-making, which is provided by the value democracy. Democratic values ensure that everyone is represented in the power (Harteveld, 2017). In relation to the heat transition this is of importance, because of the expected effect on the living environment of the consumer. Democracy is sometimes limited, when the government makes autonomous (spatial) planning decisions. Occasionally the government formalizes a participatory planning process (Harteveld, 2017).

The reason democracy is of high importance in the energy sector is because the decision-making in this domain is usually dominated by experts, where engineers construct the energy infrastructure and scientists design the hardware (Szulecki, 2018). This technocratic approach leaves little influence for participation of non-experts, which does not reflect the values that are reasoned to be important to create a just city. One compelling argument to include society as a whole in energy decision-making is that energy decisions impact the entire society e.g. on issues as energy poverty, air pollutions and climate change. Another reason to include non-experts in decision-making in energy policy is that broadening the stakeholder group increases the chance that policies indeed are for the common good (Szulecki, 2018). This reasoning emphasizes the values inclusiveness and democracy.

The agential city (agency and autonomy)

One last value that can be derived from spatial justice principles is autonomy. This is the central value of the agential city, where citizens have a sense of agency. The agential city allows for differences in behavior and keeps systems open to everyone (Harteveld, 2017). This can be interpreted as an answer to the individualization of society, in which currently individuals are perceived equally, if not more important than the common interest

(CBS, 2017). Thereby, the citizens receive the right to make autonomous decisions (Wong, 2016) and act freely and independently, which does not have to influence the societal interest in a negative way.

The heat transition in the just city

The fact that the heat transition will have spatial consequences makes the spatial justice principles relevant to analyze it. There are indications for clear geographic patterns, that are associated with energy justice concerns, the most prominent example being energy poverty (Bouzarovski & Simcock, 2017). The factors that lead to this, are of geographical nature as well. Despite this fact, most literature and research has focused on injustices between social groups, without much attention to the spatial injustices present among the energy system. This can be overcome by introducing the spatial justice theory into the energy justice debate. For this reason, the heat transition is brought into the context of the just city.

Extraction of values

Similar to extracting values from justice principles, values can be extracted from the spatial justice principles. This is shown in figure 06. Again, this does not mean that all the spatial justice principles are only supported by one value. The values that are shown in figure 06 are reasoned to be the most dominant values found in the principles, amongst other values.

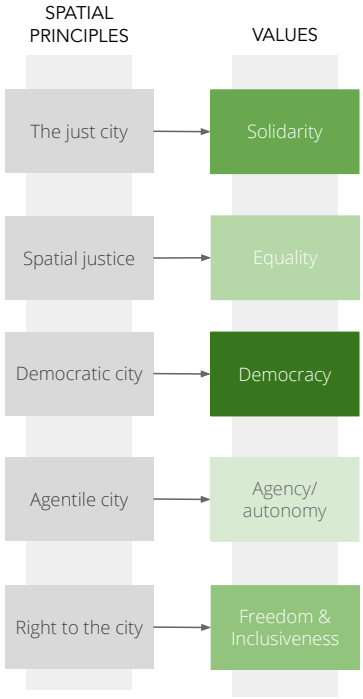

Figure 06. Extraction of values from spatial principles.

3.4 Governance (of the just city and the heat transition)

The just city

Governance and policy making, plays an important role in keeping a city just. Higher levels of government along with autonomous decisions of private investments largely determine the availability of resources in a city (Fainstein, 2010). However, local policy making largely defines the distribution of these resources and decides who gets what. These local governments make important decisions on the choice of investments. Generally, governing regimes aim to create growth by investing in infrastructure, subsidies and regulatory relief of property developers, and city-making (Fainstein, 2010). This desired growth is usually assumed, while the consequences for social equity are rarely mentioned. However, people challenge these policies and the need for growth on environmental grounds. Furthermore, they contest the distribution of benefits from using public money to benefit

private investments and they resist the outcomes of neighborhood transformation resulting from private investments (Fainstein, 2010).

The heat transition

Governance is important, if not essential for a just heat transition. Even a low-carbon transition could distribute the costs and benefits just as unequally as fossil-based transitions. Without a governance strategy that keeps in mind distributional justice and without attention to a fair process, a just outcome is at risk (Fainstein, 2010). One example being, that if the affordability of heat provisioning is not addressed in policy-making, the societal support for the transition can be undermined. It is a concern that explicit involvement of energy justice frameworks is often missing in transition strategies (Jenkins et al., 2018).

One example of decisive governance that has brought forwards a rapid energy transition is in the Netherlands itself. The natural gas field in Groningen was discovered, which started the transition away from coal and oil towards natural gas. By 1971, natural gas supplied over 50 per cent of the Netherland's primary energy (Sovacool, 2016). The reason for this successful transition was the approach of the government as it implemented measures such as subsidies for new businesses, the relocation of government industries, offering shares in Groningen to the State Mining Company (Dutch: Staatsmijnen). This example demonstrates how governance can accelerate and facilitate a rapid and smooth energy transition. The current heat transition in the Netherlands is moving away from this natural gas, but in 2010 the total share of primary energy from natural gas was still 45 per cent, which demonstrates that this transition is in an early stage and in need of good governance.

Energy democracy

Energy governance is a part of governance in the city. At the moment, energy governance is facing constraints in energy choices (Szulecki, 2018; Sovacool, 2016) . Different externalities in the energy production such as climate change, public health and water safety are all major challenges, along with aging energy infrastructure and limited energy resources. The result is a shift from a centralized fossil fuel-based energy sector, towards a distributed energy system including an increasing number of small and medium-sized producers (Szulecki, 2018). This trend is not only occurring in the electricity sector but is also observed in the provision of heat services, where there is a shift from the centralized natural gas infrastructure to district heating networks and individual households switching to all-electric heat solutions. The increasing involvement of societal actors, such as prosumers, energy cooperatives and non-profit organizations, has led to the introduction of 'energy democracy' (Szulecki, 2018). This concept is a reaction to the neoliberal, approach of most modern democracies and aims to democratize energy governance.

The question of what energy democracy entails is answered by Szulecki (2018). First, there is an obvious participatory aspect, requiring meaningful participation and accountability to make collective energy decisions. The second aspect is less recognized, but equally significant; the equality of political subjects, their agency and empowerment (Szulecki, 2018). Where energy democracy focusses on political implications, the concept of energy justice looks at the broader moral implications of our collective energy decisions. In this way energy democracy can even be considered as a part of energy justice, because the democratic values influence the political process that shapes the heat transition.

To conclude, it is argued that energy democracy states the values that form conditions for energy governance. Energy democracy entails (meaningful) participation, accountability of stakeholders, and inclusion and equality of political subjects. It is important to stress that democracy here does not equal consensus but leaves room for disagreement. In order to increase engagement and political participation, alternative perspectives from excluded or ignored voices should be heard (Szulecki, 2018). This is more likely to happen in a democracy that acknowledges the inevitability of conflict (Parallax & Change, 2013).

The influence of politics

When analyzing socio-technical systems such as the energy system, it is important to be aware of the influence of politics. Political support is essential for implementing a socially just and sustainable energy policy (Jenkins et al., 2018). The distributional issue is above all a topic for political decision-making. Without the government, stakeholders are not to be expected to solve this on their own. They rely on the government administration to make clear political choices, regarding a just distribution of costs and benefits (Sociaal-Economische Raad, 2018). This should be done in respect to distribution between citizens and industry, but also between different governmental levels.

3.5 Conclusion

In this chapter it is argued that classical justice principles lead to the extraction of the values equality, solidarity, freedom, social interest and inclusiveness. These values are all integrated in the concept of energy justice, in different ways, since it aims to provide all individuals (*inclusive and equality*), in all areas (*spatial justice*) with clean and safe energy (*societal interest*). It has a spatial and a social component and it supported by a variety of justice principles that can all be integrated in the energy justice concept.

All values apply to all three types of justice, but there is a focus to be observed. Equality and freedom apply mostly to distributional justice, inclusiveness applies mostly to procedural justice, solidarity applies mostly to recognition justice, and societal interest is a main objective in all three tenets.

Furthermore, values have been extracted from spatial justice principles. It is reasoned that democracy and inclusiveness are relevant to procedural justice, since everyone should have decision-making power to secure a just outcome. Freedom and agency also apply mostly to the procedural aspect of energy justice, since it states that citizens have autonomy to make their own decisions. The values solidarity and equality relate more to distributional justice, asking for an operationalization of these values for 'just' spatial distribution. Concerns about the distribution of costs exist, potentially leading to energy poverty based on spatial characteristics.

The integration of different values into the concept of energy justice has been visualized in figure 07 to answer the first sub research question: "*What is energy justice and how is it related to classical justice principles and spatial justice principles?*" Energy justice is depicted as a grey circle in which the blue circles represent the underlying justice principles. Furthermore, energy justice has a spatial component that is derived from the principle of spatial justice. This leads to the conclusions that energy justice has a social and a spatial part, which is shown in figure 07. The social aspects are shown in blue, while the spatial justice aspect is green. Lastly, energy democracy is argued to be included in the concept of energy justice, also shown in a blue circle in figure 07. Energy democracy mostly relates to procedural justice. Altogether, this leads to a conceptualization that shows which justice principles and values are supported by energy justice. In this respect energy justice is the most complete framework.

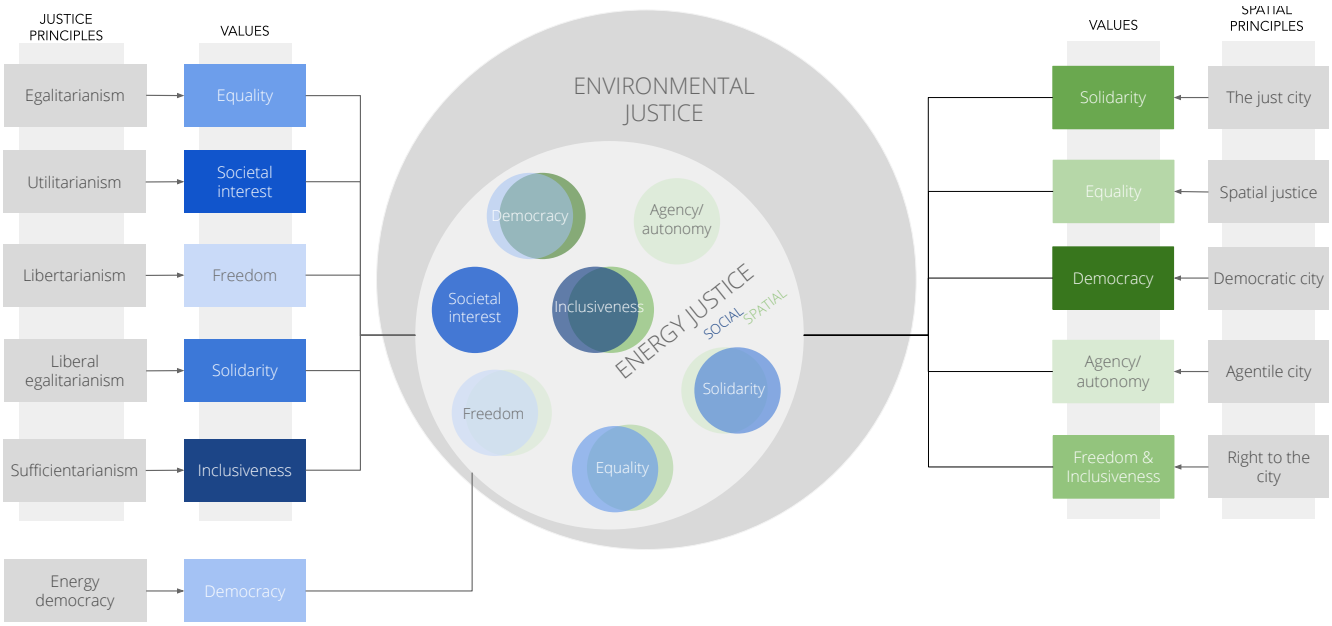

Figure 07. Conceptualization of energy justice with underlying values and justice principles.

Figure 07 shows how values are extracted from justice principles and spatial justice principles and integrated into the energy justice concept, shown as the light grey circle. Most extracted values show overlap between the social and spatial part. Furthermore, it is shown that energy justice is part of the broader concept environmental justice. The conceptualization of energy justice still leaves room for operationalization based on political choice. All the values can be interpreted differently, based on moral choices. Therefore, this conceptualization only shows which values need to be addressed. Doing this can still take different forms. The next chapter will further explore this, taking the conceptualization of energy justice as a start and build a framework that can be applied in a practical way.

4

From the energy justice concept towards a practical framework

Energy justice is a relatively new concept that is increasingly used in academic literature. Even though authors as Sovacool and Jenkins have conceptualized energy justice, up to this date there has not been a conceptual framework developed fitting to answer the research questions in this thesis. Therefore, this chapter builds a conceptual framework using the methodology as described by (Jabareen, 2017). He has defined eight phases that sequentially construct a conceptual framework. The steps will not be explicitly described but are used as the guiding principle for constructing a conceptual framework of energy justice. By constructing a conceptual framework, this chapter answers the first sub-research question: *"What does the conceptual framework of energy justice look like and how can this concept be operationalized to measure energy justice?"*

4.1 Data input

The data input for the conceptual framework is academic literature. Three sources have been selected, written by leading authors in the field of energy justice. One important selection criterium was that the source has to be recent (less than 5 years old). This ensures that the latest insights on energy justice are processed in the conceptual framework. The input sources are: Sovacool, Burke, Baker, Kotikalapudi, & Wlokas (2017), Jenkins, McCauley, Heffron, Stephan & Rehner (2015) and Hernandez (2015). Table 03 shows the way different authors have conceptualized energy justice. Thus far, energy justice remains a concept described mainly on a global level and even though it is being supported by numerous examples in literature – mostly of injustices – the translation to real life application is yet to be made.

4.2 Identifying the concepts

In the selected literature, concepts related to energy justice have been identified and are listed in table 03. First, all authors give a breakdown of the concept energy justice answering which components lead to ensuring energy justice. Sovacool's breakdown of energy justice into distributional, procedural and recognition justice is widely adopted. He furthermore proposed a fourth notion of energy justice that he calls cosmopolitan justice. Jenkins uses the same tenets of energy justice but changes the order. She reasons that first distributional justice identifies where injustices occur. Then recognition justice considers which parts of society are ignored or misrepresented. Finally, procedural justice deals with the process in which to restore the justice. Hernandez describes four rights, that are in line with the conceptualization of energy justice of Sovacool.

Author	Sovacool (Sovacool et al., 2017)	Jenkins (Jenkins et al., 2015)	Hernandez (Hernandez, 2015)
Energy Justice breakdown	1. Distributional justice 2. Procedural justice 3. Recognition justice 4. (Cosmopolitan justice)	1. Distributional justice 2. Recognition justice 3. Procedural justice	1. Right to healthy, sustainable energy production 2. Right to best available energy infrastructure 3. Right to affordable energy 4. Right to uninterrupted energy service

Principles	1. Availability 2. Affordability 3. Due process 4. Transparency and accountability 5. Sustainability 6. Intragenerational equity 7. Intergenerational equity 8. Responsibility 9. Resistance 10. Intersectionality	1. Physical distribution 2. Distribution of responsibilities 3. Access to energy services 4. Affordable access 5. Freedom of choice 6. Local knowledge mobilization 7. Meaningful participation 8. Information disclosure 9. Institutional representation 10. Non-recognition 11. Disrespect	

Table 03. Overview of concepts in energy justice literature.

4.3 Deconstructing and categorizing the concepts

After reading, re-reading and identifying concepts, the next phase of building a conceptual framework is to deconstruct each concept; to identify its main attributes, characteristics, assumptions, and role (Hernandez, 2015). Therefore, the concepts identified in the literature are positioned in table 04, followed by two columns; the description of the meaning of the concept and the data source.

Concept	Description	Source
Availability	People deserve sufficient energy resources of high quality (suitable to meet their end uses)	(Jabareen, 2017)
Affordability	All people, including the poor, should pay no more than 10% of their income for energy services	(Sovacool et al., 2017)
Due process	Countries should respect due process and human rights in their production and use of energy	(Sovacool et al., 2017)
Transparency and accountability	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 et al., 2017)
Sustainability	Energy resources should be depleted with consideration for savings, community development, and precaution	(Sovacool et al., 2017)
Intragenerational equity	All people have a right to fairly access energy services	(Sovacool et al., 2017)
Intergenerational equity	Future generations have a right to enjoy a good life undisturbed by the damage our energy systems inflict on the world today	(Sovacool et al., 2017)
Responsibility	All actors have a responsibility to protect the natural environment and minimize energy-related environmental threats	(Sovacool et al., 2017)
Resistance	Energy injustices must be actively, deliberately opposed	(Sovacool et al., 2017)
Intersectionality	Expanding the idea of recognitional justice to encapsulate new and evolving identities in modern societies, as well as acknowledging how the realization of energy justice is linked to other forms of justice e.g. socio-economic, political and environmental	(Sovacool et al., 2017)
Physical distribution	Distribution of benefits and ills on all members of society regardless of income, race, etc.	(Sovacool et al., 2017)
Distribution of responsibilities	Distribution of responsibilities related to environmental benefits and ills	(Jenkins et al., 2015)
Access to energy services	Physical access to heating and electricity, and to what extent an individual has freedom, i.e. the extent of choice a person has over his/her life	(Jenkins et al., 2015)
Affordable access	The (un)even spread of financial burdens (e.g. energy poverty)	(Jenkins et al., 2015)
Freedom of choice	The extent of choice a person has over his/her life	(Jenkins et al., 2015)

Local knowledge mobilization	Attracting and including the knowledge of indigenous and other local stakeholders	(Jenkins et al., 2015)
Meaningful participation	Engaging all stakeholders in a non-discriminatory way	(Jenkins et al., 2015)
Information disclosure	Impartial and full information disclosure by government and industry	(Jenkins et al., 2015)
Institutional representation	Representation in a wide range of institutions including; business, local, national and international governmental bodies, as well as non-state actors	(Jenkins et al., 2015)
Non-recognition	To not recognize the specific needs of particular social groups	(Jenkins et al., 2015)
Disrespect	Individuals are disrespected by investors and developers by the top-down provision of information (on e.g. economic benefits, climate mitigation and moderate noise levels)	(Jenkins et al., 2015)
Right to healthy, sustainable production	Energy production should be held to the highest standard of protection of the environment and human health	(Hernandez, 2015)
Right to best available infrastructure	Existing infrastructure warrants periodic upgrades, also in areas lacking service and in need of modernization	(Hernandez, 2015)
Right to affordable energy	Affordable energy constitutes to a basic entitlement that should be accessible to all regardless of socioeconomic status	(Hernandez, 2015)
Right to uninterrupted energy service	Ensures that provisions are in place to prevent utility service interruptions due to non-payment and arrearages	(Hernandez, 2015)

Table 04. Concepts found in literature related to energy justice.

4.4 Integrating concepts

Taken into account the semantic meaning of each concept, they are integrated. The first step is to group them as shown in table 05. The concepts are grouped into the three types of justice; distributional, procedural and recognition. These are widely adopted in academic literature. Then, the concepts that have the same semantic features and the same role are grouped together and are given a name. This name sometimes matches the leading concept, and sometimes summarizes the meaning of the grouped concepts. Furthermore, in the distributional justice column, a distinction is made between social aspects and spatial aspects of distributional justice.

	Distributional Justice	Procedural Justice	Recognition Justice
Social	**Affordability** - Affordability[1] - Affordable access[2] - Right to affordable access[3] - Right to uninterrupted energy service[3] **Freedom of choice** - Freedom of choice[2] **Distribution of responsibilities** - Responsibility[1] - Distribution of responsibilities[2]	**Fair process** - Due process[1] • Transparency and accountability[1] • Information disclosure[2] **Participation** - Local knowledge mobilization[2] - Meaningful participation[2] **Balance of powers** - Institutional representation[2]	**Problem identification** - Resistance[1] **Recognition** - Non-recognition[2] - Disrespect[2] **Crossover** - Intersectionality[1]
Spatial	**Access (to heat services)** - Intragenerational equity[1] (= right to fairly access energy service) - Physical distribution[2] - Access to energy services[2] • Availability[1] (now) • Intergenerational equity[1] (=availability in the future)		

[1] Sovacool (Sovacool et al., 2017)
[2] Jenkins (Jenkins et al., 2015)
[3] Hernandez (Hernandez, 2015)

- Sustainability[1] - Right to healthy, sustainable energy production[3] - Right to available energy infrastructure[3]		

Table 05. Integration of concepts from literature.

4.4.1 Distributional justice indicators

In the next section, the concepts are integrated and described. All the indicators reflect a certain value and are based on a certain justice theory, that are described in chapter 3.

Grouping the concepts has resulted in four indicators for distributional justice. The affordability is most clear as it is reasoned to be of high importance regarding distributional justice by all authors. Freedom of choice is only explicitly mentioned by Jenkins but believed to be an important determining factor for just outcomes. Furthermore, responsibilities also have to be distributed. The access is the concept including most terms from literature, which makes it a broad (spatial) concept. The distributional indicators are supported by values such as equality, freedom, solidarity and inclusiveness.

Affordability (Value: equality, Theory: egalitarianism) – Affordability is the name of the first group of concepts, that is found in all three literature sources. In general, it states that everyone, no matter what socio-economic background, should have access to energy services. It is widely adopted that it is undesired if anyone spends more than then percent of their income on energy services. This is referred to as energy poverty.

Also, the right to uninterrupted energy service is an affordability issue. This aspect relates to those who experience energy poverty, that may not have been able to pay the energy bills, meaning they face the risk of be shut-off from electricity and/or gas (Hernandez, 2015). Even though this topic is highly interesting, it is outside the scope of this research. Mainly because energy poverty is an indicator, which identifies the group that faces disconnection from energy services. The debate of how to deal with this is a different subject.

Freedom of choice (Value: freedom, Theory: libertarianism) – Even though this concept is only explicitly described in one of the sources, it is an important aspect of distributional justice and not covered by any of the other concepts. Freedom of choice explains the extent of individual freedom. In relation to the consumption of energy services it is about the freedom to choose your own supplier, energy source and cost structure. It is of high interest to this research since various solutions to the heat transition will reduce the freedom of choice. The most important example is connections to district heating networks.

Distribution of responsibilities (Value: solidarity, Theory: Liberal egalitarianism) – This concept combines two different types of responsibilities. First is the responsibility of each stakeholder to protect the natural environment and minimize environmental threats. Secondly, it is about how this responsibility distributed between the stakeholders.

Access (to heat services) (Value: inclusiveness, Theory: Sufficientarianism) – The access to energy services, more specifically heat services, is defined by a number of components. First, in order to access the heat (energy), it has to be available today, which is also called intragenerational equity. It takes into account the physical distribution. This availability entails providing sufficient supply with a low(er) degree of dependency on foreign imports of fossil-fuels (Islar et al., 2017). This increases the relevance for application to the Dutch situation. Where the heat transition is mainly driven by reducing the amount of natural gas use from Groningen, it is a risk that this demand is met by importing gas from abroad. But the heat (energy) also has to be available in the future, safeguarding intergenerational equity. Looking at the description of the word sustainability, as described by Sovacool et al. (2017), the meaning of this concept is very similar to the concept intergenerational equity. Therefore, it is grouped under access, and specifically close to intergenerational equity. It also states that energy resources should not be depleted too quickly (Sovacool et al., 2016). The only difference to intergenerational equity is that sustainability is broader and does not only entail to ensure energy for future generations, but also for maintaining the planet. Safeguarding this is extremely complex and entails many different industries, scale-levels and uncertain factors. For this reason, sustainability is left outside the scope of this research. Lastly, to access the energy, it has to be available, but it is also essential to have access to energy infrastructure as well, which is why the right to available

energy infrastructure is positioned here. So, in this research the definition of access entails a broad range of factors that in the end together determine if a household has physical access to energy services.

4.4.2 Procedural Justice indicators

After integrating the different concepts found in the energy justice literature, procedural justice has three indicators. When comparing the term 'energy democracy' to the procedural justice indicators this shows great similarities to the conceptualization of procedural justice. Meaningful participation is named explicitly in both concepts. Furthermore, what is called inclusive in the concept energy democracy is safeguarded in procedural justice by the balance of powers and institutional representation. Therefore, it is argued that the procedural justice indicators are also representative of energy democracy indicators. The values that underpin these indicators for both energy democracy and for procedural justice are equality, inclusiveness, democracy and transparency. These values are directly linked to the indicators.

Fair process (Values: transparency & democracy, Theory: utilitarianism) – A fair process includes a due process, which requires fair legal treatment. Further requirements for the process being fair are accountability of all stakeholders and sharing information (in a transparent way) between stakeholders. Accountability is fundamental for democratic practices and ensures the public controls the experts, giving them the right to question their decisions and policy choices (Szulecki, 2018).

Participation (Value: inclusiveness, Theory: Sufficientarianism) – Local knowledge mobilization is one way of participation, where local stakeholders are engaged and used as an asset in a process, because of their valuable information about the site. Meaningful participation states that all stakeholders should be engaged in a non-discriminatory way. This is supported by Fuller who highlights the significance of not just ensuring different types of representation and involvement of citizens in decision-making, but the cultural and political recognition of vulnerable and marginalized social groups (Fuller & Mccauley, 2016).

Balance of powers (Value: equality & democracy, Theory: egalitarianism) – Balance of powers between the stakeholders is important, which is stressed by the concept of institutional representation. This states that different groups of society have to be represented within institutions, but also states that in a process stakeholders have to be involved including; businesses, local stakeholders, governmental and non-state actors.

4.4.3 Recognition justice indicators

The recognition justice indicators are slightly different compared to the distributional and procedural justice indicators. Recognition justice is more about recognizing who is affected whereas distributional and procedural justice focus on how these people are affected. Therefore, the recognition justice aspect can be used to identify vulnerabilities in the distribution and in the process. Recognition justice both identifies the problem and recognizes the people it affects, based on the value solidarity.

Problem identification (Value: solidarity, Theory: liberal egalitarianism) – In order to recognize (in)justice, first the problem has to be identified, and in case a problem is observed, deliberately opposed. For this reason, resistance is grouped here. Resistance takes place only in case of injustices, and therefore the name problem identification is proposed, which entails sharp observation and leaves room for different kinds of actions. Problem identification identifies *who* is affected by energy.

Recognition (Value: solidarity, Theory: liberal egalitarianism) – After the identification of the problem and especially who is affected, recognition is required for justice. Non-recognition and disrespect are examples of injustices, and both call for recognition. Without this step, distributional justice and procedural justice are not likely to be secured.

Cross-over – Cross-over covers a broad range of concepts that energy is related to. The word cross-over has been chosen to symbolize that the concept of energy justice is closely related to other fields of research, such as energy democracy as explained by Szulecki (2018) and stems from environmental justice. Furthermore, practical energy solutions cannot be seen separately from solutions in water or even mobility infrastructure, which leads to synergies. Cross-over will not be within the scope of this research, since it does not provide enough analytical ground to the problem, nor does it assist the framework in exploring solutions.

4.5 Validating the conceptual framework

In section 4.4 a conceptual framework has been proposed. In order to bring this framework to practice, it has to be validated first, which is done by expert consultation. For this reason, the process of constructing the conceptual framework has been iterative and has consisted of three rounds. First, a framework was constructed and proposed, following the method described by Jabareen (2017). This framework was reviewed by Aad Correljé, who is an energy justice expert in the academic field (Delft University of Technology). The originally proposed conceptual framework is added in Appendix A1, figure 14. The main change that was made after this first review was in the recognition justice part. According to Correljé, the essence of this aspect of energy justice is to recognize that different people are affected differently by energy policies and the heat transition. For example, people in different geographic areas, people in houses constructed in different time periods and people who rent versus people owning a house. Changes to the conceptualization of recognition justice have been made according to this view. This has led to the creation of the new indicator 'problem recognition', which is according to Correljé in line with authors such as Sovacool and the essence of recognition justice.

The second iteration took place after conducting the interviews. In the interviews the conceptual framework is proposed to the interviewees after which they had the chance to comment. This was a simplified version and translated to Dutch, which can be found in Appendix A2, figure 15. The comments from the interview respondents are processed and have led to small changes in the conceptual framework. Most respondents commented that the conceptual framework was well thought-through and complete. Some topics were highlighted to be missing:

- Bastiaan van Perlo mentioned that participation does not go far enough, he would rather see that citizens actually have a say in the heat transition. For this reason, the concept participation is adjusted to participation and control. Which demonstrates that control and having a say ensures that the participation is meaningful.
- Emiel Reiding is convinced that the debate should not only be about the costs, but also about the benefits, both financially and in terms of societal issues. This is part of the affordability and distributional justice, but this notion will be taken into account and the benefits will be highlighted in the analysis. Furthermore, he stated that there should not be a transfer of the problem and costs to 1) other times, such as future generations, this is classified under the availability in the future (intergenerational equity), 2) different geographical areas, which is classified as access (spatial), and 3) different groups of society, which is classified under the distribution of responsibilities.
- Ben Hendriks also stated that benefits should be distributed evenly amongst all citizens. This includes the financial benefits, but also distribution of employment opportunities. In the conceptual framework, this will be taken into account under the affordability in the distributional justice tenet.
- Eef Meijerman would add autonomy and ownership as an indicator. This includes decision-power of citizens to make their own considerations. This is a procedural issue and is represented by the 'balance of power' and 'participation and control' in the conceptual framework. When citizens are involved in the process, and the power is in balance, this would ensure that they have the opportunity to make autonomous decisions.

4.6 Operationalizing the conceptual framework

After the conceptual framework has been constructed and validated, the next step is to further operationalize it, so it can be measured both in a quantitative and qualitative manner. Table 06 shows the concepts the way they are grouped in the previous step. Then indicators are listed to measure the concept, followed by the data sources that will be used for this measurement.

Affordability

- The costs (and benefits) of energy determine the affordability.
- Household income plays a large factor in the affordability of energy services.
- The affordability of energy services is typically measured in energy poverty. There is a widely adopted threshold that no more than 10% of the household income should be spend on energy. In order to find this indicator, the costs of energy and the household income need to be known.
- Uninterrupted energy service is secured by affordability. However, if the costs and household incomes are assessed, the uninterrupted service does not add to the analysis and is therefore outside the scope of this thesis.

Freedom of choice

- Freedom of choice is relevant for the number of suppliers. For example, a DHN is a monopoly, meaning there is only one supplier to choose from, whereas for energy there are many options.

- The choice of energy source is important to consumers, for example in terms of sustainability. When consumers want to contribute to a sustainable world, they choose a source with low CO2-emissions and a small climatological impact.

Distribution of responsibilities

- Responsibility has to be distributed between different stakeholders, which leads to a balance in responsibilities.
- Every stakeholder has to act responsibly on an independent level as well, which is called responsible behavior.

Access

- The first main indicator to have access, is availability now. If energy (heat) is not available, one cannot access it.
- Furthermore, to secure long-term access it has to be available in the future as well.
- To access the available energy (heat), energy infrastructure needs to be in place, which therefore is the third access indicator.
- One of the indicators under the concept access, is sustainability. Because this aspect of energy is already widely researched and more importantly is already one of the three main drivers of the Dutch energy policy approach, it is outside the scope of this research.

Fair process

- A fair process includes a judicial system that people can count on.
- Accountability in practice means the control exercised by the public over experts and the responsiveness of experts to public demand (Szulecki, 2018).
- The information provision is believed to be vital for a fair process. Transparency is the main value that should be monitored in relation to information.

Participation and control

- The local knowledge mobilization is reasoned by Jenkins to be important in ensuring participation. This participation focusses locally, because this group is the user.
- Stakeholders all have to be represented and actively participate.

Balance of powers

- Balance has to be present between different stakeholders, mainly the three large groups; government, industry and civil society.
- Also, within organizational structures of stakeholders there should be a distributed power-structure to ensure misuse of powers of individuals. This is important because the heat transition keeps in mind the societal interest.

Problem identification

- In order to analyze any problem, the first step is to identify who is affected.

Recognition

- Identification of affected subjects is not enough; it has to be recognized that differences that are observed may lead to injustices.

	Indicator	Unit	Data source
DISTRIBU	Affordability	• Energy poverty (%) • Cost of energy (€) • Household Income (€) • Uninterrupted energy services	TNO, ECN, PBL, Interviews Energy supplier (Nuon) CBS, Nibud
	Freedom of choice	• Number of suppliers (#) • Choice of source (#)	Data & Interviews Data & Interviews

TIONAL	Distribution of responsibilities	• Responsible behavior • Balance in responsibilities	Interviews Interviews
	Access	• Availability now (GJ)(#) • Availability future (GJ)(#) • Energy infrastructure • Sustainability	Amsterdam open data Unknown Amsterdam open data & Interviews
PROCEDURAL	Fair process	• Judicial system • Accountability - Control exercised by the public over experts - Responsiveness of experts to public demands • Information	Documents & Interviews Documents & Interviews Documents & Interviews
	Participation and control	• Local knowledge • Stakeholders representation	Documents & Interviews Documents & Interviews
	Balance of powers	• Between stakeholders • Within stakeholder organizations	Documents & Interviews Documents & Interviews
RECOGNITION	Problem identification	• Subjects that are affected	Documents & Interviews
	Recognition	• Recognition received by subjects	Interviews

Table 06. Indicators of distributional, procedural and recognition justice.

4.7 Visualizing conceptual framework

In figure 09, the conceptual framework has been visualized. The top half of the picture shows the conceptualization of energy justice and the relations with justice principles and spatial principles, which was constructed in chapter 3. Added is the operationalization that is shown in the bottom half of figure 09. First, energy justice breaks down in distributional, procedural and recognition justice. These three energy justice tenets all break down into the energy justice indicators that have been derived from literature and grouped together. Finally, for each of the indicators the units that have been developed for operationalization are listed under the indicator. Altogether, the conceptual framework gives a complete overview of energy justice, how it is embedded in theory and how it is operationalized into a framework that can be applied in a real-life context. The scope of this research is highlighted by a dotted red line. The indicators and units that are selected will be further investigated in the next chapters for the metropolitan region of Amsterdam.

Because the visualization of the conceptual framework produces a large image, for readability purposes, a larger version can be found in Appendix D1, figure 16, page 93.

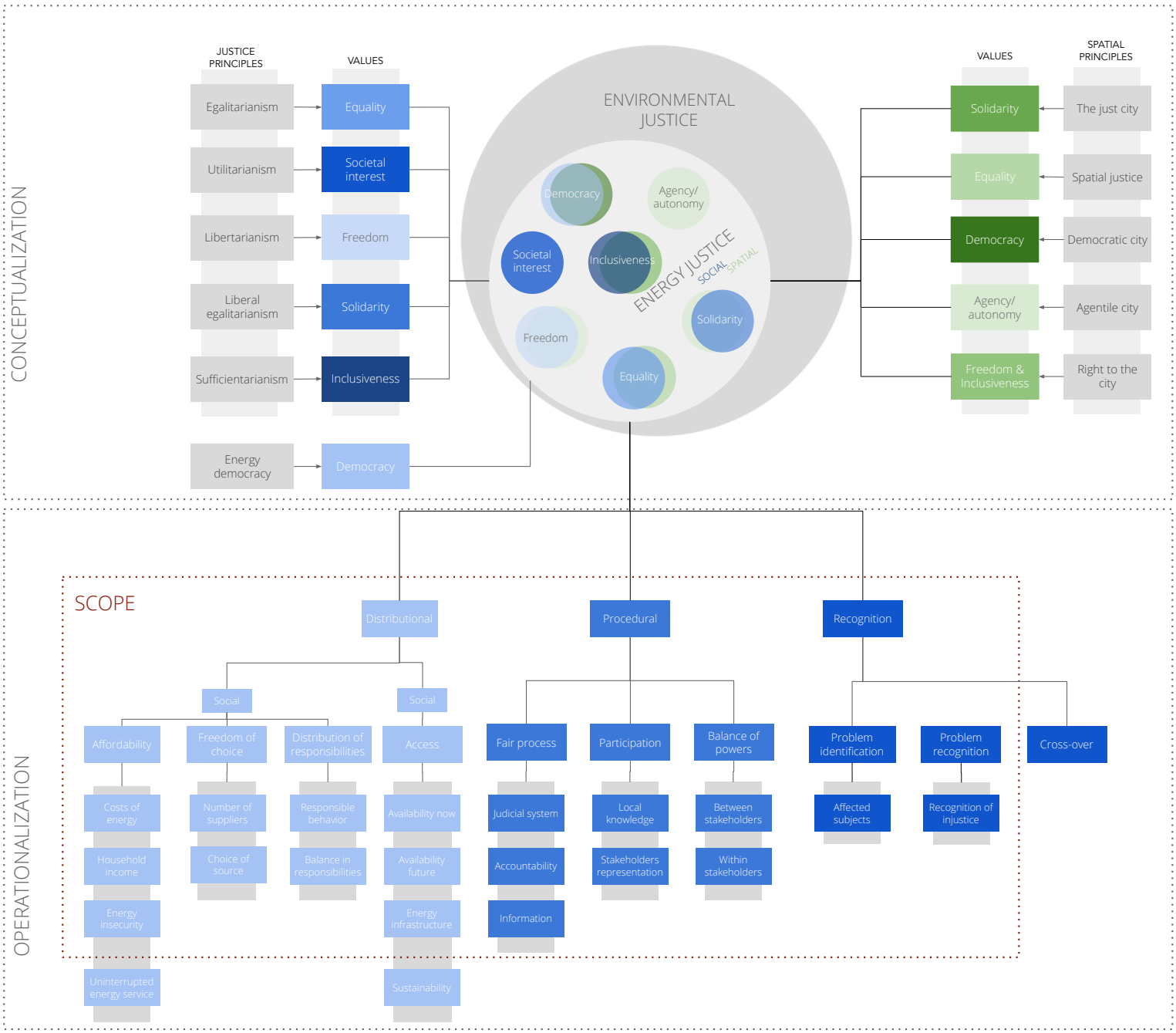

Figure 09. Conceptual framework.

4.8 Conclusion

This chapter answered the research question: "*What does the conceptual framework of energy justice look like and how can this concept be operationalized to measure energy justice?"* The conceptual framework is shown in figure 09. It shows that values that are extracted from principles are supported by energy justice. These values are influenced by political choices. The values safeguard justice (e.g. spatial justice, urban justice and energy justice). These types of justices are based on different theories, e.g. egalitarianism, libertarianism and utilitarianism. Energy justice is made up of; distributional, procedural and recognition justice. Analysis of energy justice literature has led to the identification of energy justice indicators, that are visualized in figure 09, within the dotted box *operationalization*. The conceptual framework that is presented aims to translate academic theories into more concrete (and measurable) indicators. Application of the framework to a real-life context follows in the next two chapters.

5

Case study: Energy Justice in Amsterdam

In chapter 4, a conceptual framework of energy justice has been constructed and validated. This chapter takes the conceptual framework and uses it to measure the current state of energy justice in Amsterdam in a descriptive way, by analyzing policy documents and conducting interviews with policy makers and people with decision power. By doing this, the second sub-question of this thesis will be answered: *"What is the current state of energy justice in (the policy approach of) Amsterdam?"* In order to answer the research question of this chapter, seven interviews are conducted with policy-makers on different institutional scale-levels as well as with experts from the energy-field, and governmental and non-governmental institutions. The interviews lead to a description of the state of energy justice, by using the indicators that have been extracted in the conceptual framework, constructed in chapter 4. Furthermore, the interviews validate this conceptual framework once more.

5.1 Values in practice

In order to validate the values that are extracted from (spatial) justice principles, these are discussed during the interviews. The general observation is that all values that are found are relevant for the heat transition. First of all, it is stated that a certain level of inequality is inevitable. Even when inequality is present, something can still be 'just' (Reiding, personal communication, 28-03-2019). This raises an operationalization question; what is an acceptable amount of inequality? The importance of addressing equality is supported by the interview respondents.

Similarly, democracy is an operationalization issue. What level of support is required to give a certain decision a democratic label? (Van Zanten, personal communication, 01-04-2019). The current administration in Amsterdam highly prioritizes democracy and finds it to be important that everyone has a say in what is happening, including the heat transition (Hendriks, personal communication, 09-04-2019). This stresses that the value democracy is highly respected in practice, closely related to inclusiveness. According to Agterberg, freedom of choice should be supported by democracy and inclusiveness is crucial for a good process.

Also, autonomy and a sense of agency is addressed, which should lead to decision-power for citizens and the right to make their own considerations (Meijerman, personal communication, 11-04-2019). This indicates the level of participation; a high level, in which citizens have a say in decision-making and planning (Van Perlo, personal communication, 21-03-2019).

5.2 Recognition justice

Recognition justice is indicated by the identification of affected subjects, which explains who is affected. Furthermore, the recognition that differences might lead to injustice is important. The two indicators are described below based on the interview data.

Identification of affected subjects

As dictated by the conceptual framework, the use of energy justice starts with the identification and recognition of the problem and the subjects affected. One major issue that various interviewees identified is that there are groups in society that have low incomes, who will be hit disproportionately hard by the heat transition. A large share of policy-making is based on calculations that in their turn are based on average households. There are concerns about all below-average income households. (Van Perlo, personal communication, 21-03-2019). Various

reasons that make households extra vulnerable are mentioned: 1) the size of a household. Bigger households with more children consume more energy. 2) The building typology. Apartments are relatively well insulated, compared to single family homes (Van Perlo, personal communication, 21-03-2019). 3) Regional climatological differences. In the North of the Netherlands it is significantly colder in winter than at the coast in the West. 4) Commercial landlords focus mostly on profit and are less inclined to invest in home improvement, even though for a large part, their building stock is in worse condition compared to the building stock of housing corporations. These landlords only adjust their real estate to the minimum lawful standards (Agterberg, 02-04-2019). When these homes are remodeled for energy saving purposes, the rent is expected to increase significantly (PBL, 2014). This group makes up about ten per cent of all citizens. 5)There is a group of people who bought apartments from social housing corporations, because this would decrease their housing costs. However, this group does not earn enough money to finance home improvements. 6) Another group of vulnerable people are the ones who don't speak Dutch very well. They often have received low levels of education and as a result they have lower-paying jobs, which means less money to spend. They don't have the time and capacity to think about the heat transition. 95% Of these people live in social housing which makes them dependent on housing corporations to invest, which often leads to increased rents (Hendriks, personal communication, 09-04-2019). These people have other things on their minds and are essentially 'surviving'. Dragging their kids to school, making sure they do not end up in the criminal circuit, applying for jobs and looking for support when they have problems. They are forced to spend time on this, without it being their decision and they do not welcome another challenge to think about; the heat transition. 7) According to Meijerman, it is not just the lower incomes, but also middle-class households who will have no money to spend on the heat (and energy) transition. As soon as a tactic would be in place that raises the gas prices or increases the energy tax, they will have a problem. This is strengthened by the problem of housing costs in Amsterdam. The rents and selling prices have drastically gone up over the past years.

Even though there are groups that are identified, these are still based on gut feelings and observations of the interview respondents. The municipality of Amsterdam is currently working on identifying the groups who will be in trouble, because they have not been formally identified (Hendriks, personal communication, 09-04-2019). In order to do this, there is a sufficient amount of data at the municipality of Amsterdam available for example about the amount of people living in poverty or dealing with energy poverty.

Besides the fact that there are differences between households to be recognized, there are also differences between businesses and citizens that can lead to a disturbed perception of justice (Reiding, personal communication, 28-03-2019). Furthermore, various respondents stated that there is substantial recognition amongst citizens that the people in Groningen were treated dishonestly (Van Perlo, Reiding, van Zanten, Meijerman, van der Heijden, Groen, personal communication, 2019). This results in willingness amongst citizens to disconnect from natural gas.

Recognition of possible injustice

Besides the identification of who will be affected negatively by the heat transition, it is important to recognize differences and how these differences lead to injustice. Van Perlo says that the transition to renewable sources of heat threaten to be unjust for lower income groups.

> "I don't think the transition will strike the tenants more than house owners, it will be similar for equivalent income groups." - Van Perlo, personal communication, 21-03-2019

However, what is known is people who rent usually have lower incomes compared to house owners. Van Zanten explains something similar referring to research that was done in Amsterdam that show, with minor exceptions, that households have a problem if they are asked to contribute more to energy than they do now. According to him, this problem is recognized, but there is no solution yet. This observation is strengthened by Hendriks who states that the recognition of the problem is in place within the municipality of Amsterdam, but the affected subjects are not formally identified yet. Meijerman states the importance of good recognition and stresses that it influences how things are distributed.

Conclusion

Interview respondent	Identification of affected subjects	Recognition of injustice
Bastiaan van Perlo	Above-average user with below average income	To lower income groups
Emiel Reiding	Residents in Groningen	
Jannis van Zanten		Most households (especially low to middle incomes)
Pallas Agterberg	Tenants in the commercial sector	
Ben Hendriks	People with low education and income and poor Dutch sufficiency	The municipality recognizes the problem
Eef Meijerman	Most lower to middle-class households & Vulnerable people who have other than financial problems	Recognition matters for the distribution

Table 07. Overview of interview respondents on recognition justice.

Table 07 gives a summary of the identified affected subjects and recognition of difference, that together make up the recognition justice tenet. Looking at the answers of different interview respondents it can be concluded that especially low-income groups will be affected by the heat transition whether they are house owners or whether they rent. Of the tenants, people renting from a private commercial landlord will be worse-off according to the interview respondents, because of their higher profit margins and lack of willingness to invest in their real estate. The recognition of the problem is largely in place. Both the national governmental and municipality monitor the groups to be affected closely. In respect of recognition, it seems that the municipality of Amsterdam is ahead of other municipalities in the Netherlands. According to Hendriks and Meijerman there is a large amount of data within Amsterdam on household income and energy poverty. Money and initiatives to tackle these problems are available.

5.3 Distributional justice

First, it is interesting to mention that the interview respondents stress the importance of distributional justice. Van Perlo states that it (distributional justice) should be more precisely taken into account in policy making (Van Perlo, personal communication, 21-03-2019). Also, the municipality of Amsterdam recognizes this importance and works on a fair distribution of costs and benefits. The question that is put forward is: 'What is a fair?' The conceptual framework assists in answering this question. This section will elaborate on the indicators of distributional justice that are extracted in the conceptual framework.

First the social indicators of distributional justice will be investigated; affordability, freedom of choice and distribution of responsibilities.

5.3.1 Affordability

The affordability is made up by the cost of energy and the household income and is the most obvious indicator of distributional justice when looking at the household level. According to Van Zanten, justice is the affordability (of energy prices). He explains that there is always a competing force between the affordability, reliability and sustainability of energy (Van Zanten, personal communication, 01-04-2019). When the energy source is more sustainable, the price goas up and becomes less affordable. Similarly, a high degree of reliability is expensive and decreases the affordability. The question is; what is affordable?

Also, Van Perlo and Hendriks agree that affordability is the most important indicator to keep a sense of justice amongst citizens. One way to safeguard this sense of justice is to make sure energy prices do not increase because of the heat transition.

"If you make sure a housing corporation does not increase the rent, or at least keeps it in line with the decrease of the energy bill, people will be okay with it." - Hendriks, personal communication, 09-04-2019

One reason citizens will accept a slight increase in heat costs, is because they will be living in a renovated home. However, the energy prices are already increasing because of higher energy taxes for consumer households while

the industry is dismissed. This feeds into the unjust sentiment amongst citizens. Currently, every household is charged the same amount of tax on energy, which was a conscious choice of the government, and the reason for the energy bill increase this much at the start of the year (2019) (Agterberg, personal communication, 02-04-2019).

Then, there is the issue of investments that have to be made for home improvement. As an owner-resident you can invest in your home without it leading to a lower energy bill. You can decide to take a loss, since a loss is also a way to 'cover' investments. Most people avert to this, but if people are convinced of the importance ruling out natural gas, they might be willing to do this (Meijerman, personal communication, 11-04-2019).

Cost of energy

The price of heat(energy) is made up of three components (Van Zanten, personal communication, 01-4-2019). First, a fixed fee is charged to get connected to the grid (which is also the case for electricity and gas). In the field of heat, this fixed fee is less regulated than in the electricity and gas market. Secondly, consumers pay an annual fixed charge with a regulated price by the Heat Act. Lastly, there is a price per GJ of heat (energy) used, which is restricted as well by the NMDA-principle. This principle states that the price of heat cannot exceed the price consumers would pay if they were using natural gas. This price structure is a result of the heat transition and the nature of the DH technology. The situation we come from is one where centrally producing energy is the cheapest way of production, because of advantages due to scale. Current technology has opened up possibilities for decentralized production, e.g. solar panels. This new production from is slowly becoming the cheaper way of production (Agterberg, personal communication, 02-04-2019). For these new sustainable sources, the return on investment times are longer compared to fossil fuels, due to high initial investments. Another difference between renewables and fossil fuels is exploitation costs are relatively high for gas and coal and. Furthermore, the costs of the grid infrastructure is increasing. The three differences in the nature of the technology mentioned here all result in the fact that fossil fuels have low fixed charges and high variable charges depending on the consumption and renewables have high fixed charges and low(er) variable charges that depend on the consumption.

A result of this new distribution of fixed and variable charges is that consumers have less impact on their energy bills, because of the inability to save money by consuming less (Meijerman, personal communication, 11-04-2019). Once an investment is made, the depreciation costs remain. Furthermore, there is a trade-off between insulating a house and other home improvements costs versus costs to heating a building. If a building is heated by high temperature, landlords and home owners are not constrained to the same investment's costs, since the requirements for insulation are not as high in order to heat the building. This debate relates to the energy label of a building, that is required to disconnect from natural gas. Furthermore, disconnection from natural gas and insulating a building until almost energy neutral is not the same (Kraniotis, 2019). EIB has demonstrated the costs to improve homes to a certain energy label, alongside the savings this would mean in terms of the energy bills. Up to energy label B the savings exceed the costs, which is shown in figure 09.

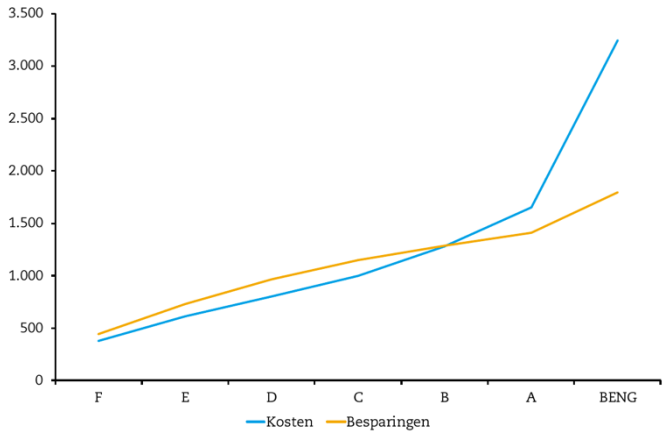

Figure 09. Annual costs (at an interest rate of 6% and duration of 25 years) and savings (benefits) to reach a higher energy performance (label) in euros per year, per home. (Van Hoek, T. & Koning, 2018).

In order to keep the costs of energy low, it is important to minimize the cost of construction, the cost of maintenance and the costs of production. Van Zanten thinks this is possible by further reducing investment and exploitation costs to bring the energy costs down.

The current policy approach does not distribute the costs of energy according to just values such as equality and solidarity. CPB concludes that the current climate policy (note this includes more than just heat) leads to a decline of household income of 1,8% for the lowest income groups, while the highest income groups are set back 0,8% (CPB, 2019). This means a different approach in policy and regulations is required. To stimulate justice, it is desirable that people who live in social housing would benefit from the heat transition when energy bills decrease more than the rents increase (Hendriks, personal communication, 09-04-2019). The main challenge to overcome this is the fact housing corporations do not have to funds to make these large investments.

Lastly, it is important to note that the discussion about the costs of energy, are currently about the costs only. Reiding urges that this discussion should include the benefits as well. For example, the CPB was instructed to perform a cost analysis on the Dutch Climate agreement, which should have been a cost-benefit analysis for a more realistic image of the transition. Politicians now talk about how much citizens will have to spend on measures such as installing a heat pump, which costs money. There has to be an increased realization about the generated revenue in return (Reiding, personal communication, 28-03-2019). This is the reason people have installed solar panels.

Household income

In order to ensure that households can afford energy, they need to generate sufficient income. In these household incomes, differences are observed, for example in building typology and ownership structure. People who rent spent a relatively large share of income on energy services (Van Perlo, personal communication 21-03-2019). These differences lead to a sense of injustice among citizens.

For above-average users with low incomes, the risk of energy poverty and non-payment is increasing. In Amsterdam there is an abundance of this group, especially in areas in which district heating has already been realized (Van Zanten, personal communication, 01-04-2019). Research shows that 50 to 70 per cent of households cannot contribute a larger share towards the energy bill than in the current situation (Meijerman & Ligthert, 2019). This is partly due to the fact that the income spread in Amsterdam has two peaks. There is a large representation of low-incomes and one of high-incomes, the middle section is quite small (Meijerman, personal communication, 11-04-2019).

Large government expenditures ask for a fair distribution of costs and benefits, which also regards employment and influences household incomes. For employers who lose their job, or businesses that struggle as a result of the heat transition, fitting social arrangements and trust increasing measures should be taken (CPB, 2019). This is done keeping in mind that citizens should be spared or compensated if they do not profit (in the short term) of the chances and benefits that the heat transition offers long-term.

In order to stimulate justice regarding the household income, the municipality of Amsterdam is working on a strategy to employ people in the energy field and ensure the employment benefits end up amongst all groups of society (Hendriks, personal communication, 09-04-2019). For example, by making deals with energy companies about educating citizens that are unemployed. The costs of the education would be split between the municipality and energy company. After completion of the education this person can be employed for minimum a year and e.g. install solar panels.

Energy poverty

Energy poverty is a result of high energy prices and a low household income, as it reflects the percentage of a household income spent on energy. This indicator is high on the policy agenda in Amsterdam. Despite the recognition of this problem there is still one major concern, which is a hidden group of energy insecure citizens. This group can organize themselves well and survive in poor conditions, which keeps them off the radar (Van Perlo, personal communication, 21-03-2019). Currently, the way energy poverty is tackled is mostly by energy coaches that assist households in reducing their energy consumption by simple measures.

5.3.2 Freedom of choice

The fact that the heat transition will limit the freedom of choice is widely recognized by the interview respondents. This is true especially for district heating networks. Reasons that are stated are; the technology that is being used, living in a housing complex (e.g. where there is a VvE) and people renting a house or apartment. Once connected to district heating there is a lock-in effect, meaning that the consumer will be connected for a long amount of time, depending on the heat service of a single supplier.

If a neighborhood is appointed to disconnect from gas and a heat plan is made, a citizen cannot decide to keep the natural gas connection. The decision has been made for them and the only choice they have is *how* they will be disconnected from natural gas, not *if* they will be (Hendriks, personal communication, 09-04-2019).

In respect to energy justice, there can be concerns about becoming connected to a DHN. The underlying reason is the perception of being forced into this decision and having no choice (Van der Heijden, personal communication, 05-04-2019). Hendriks states that being forced to a DHN degrades justice, but yet some limitation in the freedom of choice should be accepted, because the municipality can overlook the bigger picture. On the contrary, there is also a group of people choosing to get connected to DHN because of the ease and comfort of it (Meijerman, personal communication, 11-04-2019).

To partly resolve the restriction regarding freedom of choice, various options are put forward. It can be interesting to explore dividing the production and supply in district heating systems (Van Perlo, personal communication, 21-03-2019). Reiding agrees that electricity should be examined as an example, which is an unbundled market. Even if the heat market would not be formally unbundled, Agterberg believes there are still enough options on the table, especially in low temperature district heating networks, for example in the source, the temperature or connecting it to other energy systems such as solar panels, to lower costs even further (Ageterberg, personal communication, 02-04-2019).

Number of suppliers

The number of suppliers of a DHN, largely depends on the question whether the heat market will be unbundled into the production and distribution of the heat. Table 08 gives an overview of how the interview respondents think about unbundling the heat market. The main finding that becomes visible is that all respondents are in favor of allowing different sources of heat onto the same network. By doing this, a certain amount of choice is created. However, Van Zanten is the only respondent against unbundling, because of financial feasibility. This concern is shared by Van der Heijden.

Interview respondent	Unbundling yes or no
Bastiaan van Perlo	Interesting to explore the option of unbundling
Emiel Reiding	Not sure if possible, but preference for opening up the market
Jannis van Zanten	Unbundling is not a good idea, because most costs are fixed infrastructure
Pallas Agterberg	Not clear, but choice of source can be built in regardless of unbundling yes or no
Marjolein Groen & Ellen van der Heijden	Start with one source and let more sources on, to create competition
Eef Meijerman	No exact statement, but argues for public ownership of district heating networks

Table 08. Overview of interview respondents on unbundling the heat market.

The interview respondents express hesitation towards unbundling the DHN market, however most are in favor of at least exploring this option. According to Tieben and Van Benthem (2019), the disadvantages of unbundling outweigh the advantages (Tieben & Van Benthem, 2019). They conclude the societal costs exceed the benefits, which is in line with the reasoning of Van Zanten. The technical characteristics of DHN lead to a different cost structure when compared to natural gas. This is due to the fact that a DHN has a supply and drain pipe, which increase infrastructure costs. Secondly, DHNs have a relatively high energy loss (of temperature) which dictates the local and distributed character and complicates competition on one network.

If the production and distribution is not separated, a DHN will have one supplier by definition. This is stated as a restricting factor for expending DHNs further. Citizens resist to being connected, because it is one large privatized supplier that they do not want to depend on (Meijerman, personal communication, 11-04-2019).

Choice of source

Similar to the number of suppliers, the choice of source partly depends on whether a district heating network will be unbundled. However, for sources there are more options. Even if the distribution and production are not separated, different sources of heat can be allowed on the same network. If a source is cheaper and more

sustainable, it already is allowed to enter the current DHN in Amsterdam (Van Zanten, personal communication, 01-04-2019). Furthermore, households have the choice not to connect to the DHN and provide their own solution, e.g. by going all-electric and installing a heat pump. When safeguarding choices relating the source, there are more options abundant for low temperature heating, such as geothermal, surface water, heat from air or residual heat from a datacenter (Agterberg, personal communication, 02-04-2019). For this reason, low temperature systems are preferred over high temperature systems.

Affordability vs. Freedom of choice

Many respondents argue that there is a tradeoff between affordability of heat and the freedom of choice (Van Perlo, Van Zanten, Hendriks & Meijerman, personal communication, 2019). If the heat remains affordable, households may accept a lack of choice. One way to organize freedom of choice is by realizing competition in the heat market, which costs money, according to Van Zanten approximately 200 euros per household. An average household spends 1000 euros on heat annually, of which only 20 per cent can be competed over, since the majority of costs are fixed (e.g. infrastructure and network costs). By his reasoning, realizing this market competition would cost too much, so the limited freedom of choice should be accepted. Some quotes that illustrate the trade-off:

"Freedom of choice often comes with a price tag." - Van Perlo, personal communication, 21-03-2019

"There is a trade-off between the freedom of choice and affordability, yes." - Hendriks, personal communication, 09-04-2019

"Yes, district heating is a monopoly, but it is more comfortable and easier and maybe more affordable for landlords, which means they don't have to invest as much." - Meijerman, personal communication, 11-04-2019

5.3.3 Distribution of responsibilities

As far as distribution of responsibilities in relation to the heat transition, currently there are more questions than answers. First the responsibilities have to be distributed between citizens, government and industry. But for each group there will be a sub-division. What government level has most responsibility? And do all citizens have the same amount of responsibility? The following section will explain a number of responsibility challenges.

On a policy level relating heat infrastructure and networks, there is a large responsibility for the municipality. One policy instrument is the Heat plan (in Dutch: Warmteplan). This plan is constructed for an area of the city, for example Amsterdam, that will either be redeveloped or newly built. In this area there is the obligation to connect households to a district heating network, until the intended number of households is connected (Akerboom, S., Linden, F., Otte, F., Pront, S., Beijen, B., Buijze, A., Korsse, D., Rijswick, 2016). A developer or house owner can only withdraw from this obligation if a different source of heat is exploited that has the same, ore more CO2-reduction as the DHN.

In order to realize a collective DHN, the best societal cost-benefit ratio has to be in place, which is unlikely to be case when this responsibility lies with a commercial party only. This means it is desirable to have government influence, e.g. by using shares, by law and policy or other steering mechanisms (Van Zanten, personal communication, 01-04-2019). For this reason, Van Zanten advocates for a public-private partnership. Businesses are specialized in constructing the networks and infrastructure, something that the government (municipality) does not have the knowledge to do at this point. Instead, the government should take a directing role in convincing citizens that disconnection from natural gas is important. In Amsterdam there are ongoing preparations for these partnerships, where stakeholders come together to agree on a common vision for the heat transition and talk about their personal role in this process.

Citizens have their own responsibility in the heat transition and especially disconnection from natural gas and by definition the responsibility to mind justice is all of ours (Van Perlo, personal communication, 21-03-2019). In the end, property and real-estate owners decide whether they disconnect from the gas infrastructure. Currently, no rules or regulations are in place that can command owners to do this, and the strategy is based on seducing and convincing citizens into disconnecting. Eventually this leads to a large responsibility for the real estate owner.

Tenants are a special case, because they inhabit a home, but they do not own it. There is an initiative right (in Dutch: initiatief recht) that dictates tenants can demand home improvements, based on article 2:43, book 7 BW, such as improved insulation or replacing boilers. In the end, citizens need to trust that the government serves their interest and that moments of inattentiveness and weakness will not have direct radical consequences (Bovens et al., 2017). This will benefit self-reliance of citizens, but also the government earnings and the legitimacy of the government and its policy.

Within the government there has been a shift in the distribution of responsibilities in the past decade, regarding spatial planning. There used to be a strong hierarchical relationship, where the national government enacted a certain policy, the provinces and municipalities had to follow in the same line. Decentralization and deregulation took place, which shifted responsibilities regarding the heat transition mostly to the municipal level. Currently, municipalities carry the most responsibility for regional tuning of energy and heat plans (Ministry of Economic Affairs and Climate Policy, 2016).

The NOVI and new Environmental Act are being developed. These policies will not change the distribution of responsibilities as they are today. However, the relationship between the national, regional and local government will change from a hierarchical to a more horizontal structure, as a result of judicial changes. Within the same set of responsibilities, there is more room for interpretation on each level and there are less constraints (Reiding, personal communication, 28-03-2019). This might lead to an inequality issue, namely of the differences between municipalities. Since the national government has handed over responsibilities to the provincial and municipal level and also provides more freedom, this can lead to differences between municipalities since some large municipalities have a sufficient amount of knowledge and resources to tackle the challenges and some do not.

Even though the relationship between the different governmental levels will not be hierarchical anymore, information can still be passed on. This might not be formally enacted, but there is still the possibility for a high degree of influence (Reiding, personal communication, 28-03-2019). The national government has a the most amount of knowledge that it aims to share with the other governmental levels. The province takes the same approach. The role and responsibility it takes is a knowledge and education one, where they assist and support the municipalities by organizing masterclasses, knowledge sessions and workshops, to get as many different stakeholders as possible on board (Van der Heijden, personal communication, 05-04-2019). Furthermore, they facilitate and fund research, for example in the field of geothermal heat sources, and they accelerate the transition by connection stakeholders. The success of switching between national and regional strategies for energy is crucial for a successful heat transition.

This is stressed by the dependence the city of Amsterdam has on its surrounding regions, because the city demands large amounts of energy, while there is little space to generate energy using solar pv-panels or wind turbines. The ambitions of the Amsterdam municipality are higher than those of the national government, e.g. Amsterdam aims to disconnect from natural gas earlier. To reach the ambitions, Amsterdam needs both the national government as well as the region to work together (Hendriks, personal communication, 09-04-2019).

Responsible behavior

All interviewers state that the stakeholder they represent takes their responsibility. This means that both the governmental bodies; national government, provinces and municipality, and the industry recognize the importance of the heat transition and aim to respond to this process in a responsible way.

Balance in responsibilities

Balancing responsibilities is of high importance for a smooth transition process. Table 09 shows who the interview respondents have indicated to carry the most responsibility in the heat transition process and keeping justice concerns in mind. It is clear that the government is expected to take a role, especially on the level of the municipality. This is in collaboration with the industry, since there is awareness that all actors have their own strengths that are needed in the process.

Interview respondent	Responsibility
Bastiaan van Perlo	Mainly with the government; the national administration, the Second Chamber and the municipality.
Jannis van Zanten	Public-private partnership; use the strengths of each stakeholder. At the same time a major role lies with the government.

Pallas Agterberg	Municipality should be responsible for neighborhood-based approach.
Marjolein Groen & Ellen van der Heijden	The government starts (and boosts) the transition.
Ben Hendriks	Large role for government, especially municipality. Businesses have to accelerate the heat transition.

Table 09. Overview of interview respondents on distribution of responsibilities.

5.3.4 Access

The next indicator of distributional justice is access, which is a socio-spatial concept. Some people reason access in the Netherlands is about affordability. When you can afford it, you have access. But access related to energy justice also takes into account if the access is distributed according to just principles. It includes all factors that eventually lead to access of energy services, except for the price which is described under the affordability indicator. Therefore, access includes the equitable spatial distribution; preventing the transfer of problems to other geographical areas. Not one area should only benefit, while another area bears the costs (Reiding, personal communication, 28-03-2019). One example of this, is that Groningen currently carries the burden of the natural gas extraction, while other areas in the Netherlands benefit from cheap gas and thus heat supply. According to the interview respondents, there is understanding and support for the residents of Groningen, which is the main driver for people to disconnect from natural gas infrastructure. If the supply of natural gas stops, in a situation where we do not arrange an alternative, the Netherlands will depend on countries such as Russia and Iran. Many people agree this is undesirable, which is the main argument to arrange things locally.

Availability now

Gas has been abundantly available. At the time of discovery, it was not expected to be used for decades and was believed to be a temporary energy source, which is why prices were low (De Jong et al, 2005). Renewable and sustainable heat sources that are available today are mostly heat pumps, which generate heat from water, soil or air, and district heating networks. DHNs to date are largely dependent on fossil fuels, such as natural gas. In North-Holland research to find alternative and sustainable sources of heat that can feed into the DHN is ongoing (Groen, Van der Heijden, Van Zanten, personal communication, 2019). There is still uncertainty about the availability of sources, especially of high temperature heat. For heat on lower temperatures, there are many more sources, such as residual heat from datacenters, heat from surface water and geothermal heat (Agterberg, personal communication, 02-04-2019).

Availability future

In order to prevent the problem to be transferred to the future, now is the time to act (Reiding, personal communication, 28-03-2019). Intergenerational distribution is a motive for people in society to reduce CO2-emissions, because they want to leave the earth in a good condition for their children (Meijerman, personal communication, 11-04-2019). This demonstrates that the availability in the future is on the radar. But there are many uncertainties relating the availability of heat sources in the future. For this reason, research to the availability of geothermal energy in the south part of North-Holland is conducted. It is stressed that research to the long-term effect of energy sources is important, since we do not want to make the same mistake we made in Groningen (Van der Heijden & Groen, personal communication, 05-04-2019). Furthermore, since the DHNs are largely dependent on natural gas and the incineration of waste, new sources have to be found in the future, because natural gas is phased out and less waste will be available as the economy becomes more circular.

Energy infrastructures

The infrastructure of heat energy shows large differences compared to gas infrastructure. Fossil energy did not require much space. The technology for renewable energy is more distributed in nature, which increases the spatial complexity (Reiding, personal communication, 28-03-2019). This does not only include above-ground, but also underground infrastructure, such as geothermal.

The infrastructure for DHN, drives up the price of the heat service. Even more costly is to upkeep two infrastructures at the same time; natural gas and district heating, which is the case during the transition period. This is expensive because the fixed infrastructural costs have to be paid by a smaller amount of people connected at this time. For this reason, the transition period should be minimized to ten years (Van Zanten, personal communication, 01-04-2019). Especially since there is the risk of people leaving the grid. There is a certain group

of people (high incomes and concerned with the environment) that could leave the grid, increasing the costs for everyone who remains connected. Another price effect of energy, but more related to electricity, is that when electricity demand rises, the grid needs to be strengthened. This could increase the price of all-electric heating solutions.

Peak supply of heat is an infrastructural challenge. Renewable heat sources do not react as much and as quickly on changes in heat demand (CBS, 2012), which results in a problem when there is an unexpected peak demand. It is reasoned that two infrastructures exciting at the same time is undesirable because of high costs. But in terms of reliability, it is uncertain if DHN and all-electric options can provide in peak demand in January and February when temperatures are low. Natural gas could still be used for peak supply. Another infrastructural challenge is capacity (Van der Heijden & Groen, personal communication, 05-04-2019). Between 2025 and 2030 the maximum number of new connections to DH is limited to 80.000 housing equivalents per year, because the sector believes that is the maximum capacity in the construction of DHN (Planbureau & Leefomgeving, 2019). Furthermore, the capacity of available sources can be a limiting factor. In the Amsterdam DHN, there is enough high-temperature heat available for 170.000 households. The ambition is to expand to 500.000 household equivalents, for which new heat sources need to be explored (MRA, 2016).

The spatial component of infrastructures is further complicated by the current policy approach. Regional Energy Strategies are developed in regions within a year after signing the climate agreement (Planbureau & Leefomgeving, 2019). This fast pace is a risk for the public support of the measures. Infrastructural adjustments of energy grids take time, to ensure an approach that secures environmental concerns. The RES and new Environmental Act are still under development, which is why there is still uncertainty regarding the rights and responsibilities of those involved. This is confirmed by Van der Heijden and Groen (personal communication, 05-04-2019).

Energy services

It is essential to classify the supply of heat as an energy services. This opens up possibilities for innovative ways of financing home improvement such as insulation (Agterberg, personal communication, 02-04-2019). If renovation is financed separately from the house itself (mortgage), it is a service that can be paid off in a different timespan. An example of this is building bound finance (Dutch: gebouw gebonden financiering), which is explored in the Netherlands at this moment.

Conclusion

Table 10 summarizes the distributional justice indicators and states the most important conclusions of each interview respondents. Affordability for everyone is found essential by all interview respondents. Furthermore, freedom of choice is closely linked to energy justice, where it is stated that a reduction of choice, leads to a less just outcome. Comparing the statements about the distribution of responsibilities it becomes clear that all actors have their own type of responsibilities, which calls for good collaboration to use the strength of each actor and come to partnerships. Regarding access, the main uncertainties are in the availability of heat sources and the costs of infrastructure to deliver this service to the consumers. This links access to affordability, where it can be stated that access can be arranged, but will lead to higher costs, making the heat service less affordable, potentially leading to injustices.

Interview respondent	Affordability	Freedom of choice	Distribution of responsibilities	Access
Bastiaan van Perlo	Tenants spend a larger share of their income on energy. People with above-average use and below-average income should be monitored.	A limit on freedom of choice is inevitable. It is interesting to explore where choice can be built in.	By definition everyone has a share of the responsibility, but mainly the government (national and municipal level) are responsible for the heat transition process.	
Emiel Reiding	Affordability includes costs, but also	Freedom of choice should be explored.	Within the same responsibilities,	Renewable energy sources come with

	benefits. The latter should be emphasized in the current discussion.		different governmental bodies have more room for interpretation as a result of the New Environmental Policy and NOVI.	complex spatial problems. Prevent transfer of problems to other geographical areas.
Jannis van Zanten	Justice is closely linked to affordability, because this is the most important indicator for households. There is a tradeoff between affordability, reliability and sustainability.	Organizing freedom of choice in a situation of DH costs money. This leaves too little room for competition of multiple suppliers on one DHN.	Public-private collaboration. Government responsible for process and engaging citizens. Industry responsible for executing plans.	The transition period where two infrastructures co-exist should be minimized, to reduce costs.
Pallas Agterberg	The trend of distributed energy generation affects the cost structure. Avoid generation income via energy taxes.	Choice can and should be built in. Low-temperature DH provides opportunities to do this.	Municipality responsible for neighborhood-approach.	In the Netherlands, this is affordability. When you can afford it, you have access. Classifying as access to energy service is essential.
Marjolein Groen & Ellen van der Heijden	Energy should be affordable for everyone.	Tenants do not have much choice, which reduced the sense of justice. Similarly, being forced to connect to DH has the same effect.	The province has a facilitating and knowledge responsibility.	There are uncertainties about the availability of sustainable heat sources in the future (e.g. geothermal).
Ben Hendriks	Affordability is the most important aspect to safeguard energy justice. It is desired to provide benefits (also in terms of employment) with vulnerable groups of society.	Being forced to connect to a DHN degrades justice. The decision to disconnect is already made. Freedom of choice should include the choice for the alternative heat source.	Everyone responsible in their own expertise.	
Eef Meijerman	Affordability is an issue for low-income groups, but also middle-income groups. The cost structure of DH leaves little room to save money by consuming less.	Forcing people into anything is undesirable. Ownership can improve the freedom of choice.	The real-estate owner has the responsibility to make the final decision.	For some citizens availability in the future (intergenerational equity) is important.

Table 10. Overview of interview respondents on distributional justice.

5.4 Procedural justice

Procedural justice dictates the conditions under which the heat transition should take place. For the heat transition in Amsterdam, there is still a high degree of uncertainty (Van Zanten, personal communication, 01-04-

2019). Amsterdam consists of 480 neighborhoods and when these are disconnected from natural gas, whether one at a time or twenty or thirty at a time, the impact on the city will be tremendous. Thus, this requires a smooth transition process.

5.4.1 Fair process

Agterberg explains the process needs to be directed strictly, which involves good planning. In advance the location and agenda of meetings has to be available, to ensure that at each step of the process it is known what information is available. The municipality of Amsterdam strives for democratization already, by ensuring all citizens are involved in energy decisions. Crucial success factors to reach a democratic process are transparency and information provision throughout the entire heat transition.

A fair process is directly linked to the value democracy, which should be included as a part of the process. This democracy should take shape in a really practical way, according to various interview respondents. In a neighborhood approach, that is preferred by the respondents, at the end of the process there should be an election about the way forward (Agterberg, personal communication, 02-04-2019). In this election, the power to vote should be handed to neighborhood residents only. Elections as a form of democracy also could be conducted within an apartment complex and VvE. Current legislation states that if 70% of tenants approved of a proposed renovation, it is presumed reasonable (Winters, Otte, Slot, & Koch-Mathian, 2016). Tenants who do not approve, need to take it to court within 8 weeks to prove the proposal is unreasonable. With elections, it is of high importance to have a large majority in favor of a certain measure (Meijerman, personal communication, 11-04-2019). If it is close to 50/50, still near half the people opposes the plan.

Information provision

Within the information provision, respondents stress the importance of transparency. An example of transparency is that heat suppliers should share information in a transparent way about the sustainability and financial aspects of the DHN (Van Perlo, personal communication, 21-03-2019). For DHN this is of high importance, since the heat supplier is a monopoly on the market. Furthermore, transparent and open information provision will engage citizens in the process, which results in more support. One measure to increase the transparency is ownership of DHNs by citizens. If users become owners, they receive full insight into the underlying economic models.

The current culture of sharing information openly and transparently between government, industry and citizens is sufficient to good, according to the respondents. Table 11 shows how respondents feel the information is shared now. The heat transition still finds itself in a starting phase, that focusses on involving those who want to join in. The Amsterdam municipality organizes participation meetings as a part of the Roadmap Amsterdam climate neutral, which is a working plan that receives improvement continuously. Furthermore, it is an open invitation to the citizens of Amsterdam; think along, work with us, please tell us what you want.

Even though the table shows the respondents are hopeful and try to give the right example themselves, there are concerns. Agterberg explains that all knowledge is available somewhere, but sometimes difficult to locate. Furthermore, there is the struggle of contradicting policy reports that complicates the quest for the 'truth.' She reasons that transparency is therefore dependent on ordination of information, which carries a subjective component. This is a complex playing field, where the involved stakeholders, industry and government, are trying to improve their practices.

Another concern expressed by Reiding is that more information on the benefits of the heat transition should be available. This is not the result of the way information is shared or its underlying transparency, but simply a lack of available information.

Lastly, even though government and industry claim to be sharing information openly and transparently, this does not mean citizens share the same perception. One example of this is the NMDA-principle, that lack transparency mainly on the actual costs of heat. Currently, the price is based on gas and not on actual costs. Transparency of the costs for generation and distribution of heat has to be increased (Huygen, Annelies; Lavrijssen, Saskia; De Vos, Coen; De Wit, 2011).

Interview respondent	Current culture of information sharing
Bastiaan van Perlo	Positive because the process is at the start, but room for improvement in terms of transparency
Emiel Reiding	Information is shared openly

Jannis van Zanten	Hope that information is shared honestly and openly
Pallas Agterberg	Transparency and locating information should be improved
Marjolein Groen & Ellen van der Heijden	Unclear, because the province is not responsible. Information from province level to municipality is good
Ben Hendriks	Provision of information is very transparent from government to citizens
Eef Meijerman	The Amsterdam municipality is making steps in in the transparency and information provision

Table 11. Overview of interview respondents about the current culture of information sharing between government, industry and citizens.

5.4.2 Participation and control

Participation by citizens is seen a crucial component of a just heat transition. All seven interview respondents once again stress this importance. The question that remains is not *if* citizens should participate in plan and decision making related to the heat transition but rather *how* they participation takes form in practice.

The importance of participation lies in the acceptance and support of the public (Van Zanten, personal communication, 01-04-2019). According to Agterberg, getting people onboard is done by a good process, not just by good content only. A good process can improve the sense of justice experienced by citizens (Groen, personal communication, 05-04-2019). People have to be engaged in the process, where they are explained how they benefit from a certain measure, in this case the transition moving away from natural gas. The risk faced is that this story will be overshadowed by subsidies, money and policy ambitions. For example, when there is an ambition to be disconnected from natural gas by a certain year and citizens receive the message; You can either participate by connecting to a DHN now or have a problem to fix yourself in ten years.

According to most respondents, participation does not reach far enough, as this can exist in a form that is rather passive. Participation should at least be in the form where citizens have a say (i.e. decision-power), control or ownership in order to be meaningful (Van Perlo, Meijerman, Reiding, personal communication, 2019). Furthermore, it is important to involve residents from the start of the process, which requires large investments in informing, collecting demands etc. (Meijerman, personal communication, 11-04-2019). This is a shift in the current way of working, where for new construction the only stakeholders involved are project developers.

Reiding adds that participation, and decision-power/ having a say often happens in the early stage (development) of a process, where control lasts in the exploitation phase. When a person has control, they are more accepting of nuisance, and when citizens are engaged, they experience benefits from a certain measure, which increases acceptance even more. For this reason, direct influence of the user in the use of a product or solution in the exploitation phase is desirable.

In Amsterdam, participation and decision-power, only relates to *how* solution relating the heat transition will be shaped. The question how much power and control citizens will have, is still open (Hendriks, personal communication, 09-04-2019). Some people within the municipality believe the right to vote and elect the city administration is enough power and enough democracy. Especially in making complex strategic decisions regarding the heat transition, the municipality overlooks the bigger picture, whereas citizens reason from their own individual perspective. For this reason, some decisions should be made by the municipality weighing off societal interest over individual interests.

One issue, pointed out by Van Perlo, is that tenants have a relatively small amount of control over the environment in which they live. According to the Woonbond, tenants should be empowered by regulatory tools that command home improvements, executed by the real estate owner.

Local knowledge

Local knowledge is stressed by the respondents and calls for a neighborhood approach. This is reflected by the current Dutch policy approach. By 2021, every municipality is obliged to have a heat transition vision in place, that states how and when every neighborhood will be disconnected from natural gas (Van Zanten, personal communication, 01-04-2019). Also, the NOVI dictates that large wind turbine parks can only be developed by including participation and ownership for local stakeholders. The benefits of a neighborhood approach should be to prevent double investments, to make renovation achievable, and to ensure collective projects are (financially) more beneficial compared to individual ones (Meijerman, personal communication, 11-04-2019).

The success of the neighborhood approach will depend on the process shaped by the municipality. Currently, critiques expressed indicate that municipalities have a long history pretending to listen to citizens, instead of taking them seriously and giving them decision power (Agterberg, personal communication, 02-04-2019). The pitfall is to let experts design neighborhood plans and in one way or another impose these on citizens. This may result in resistance. Therefore, a condition for this neighborhood approach should be democracy and transparency. Residents of the area should be able to check all the solutions they are presented to disconnect from natural gas, have the ability to add options, and finally vote for the best option (Agterberg, personal communication, 02-04-2019). This keeps industry stakeholders sharp, because it means they have to deliver a reasonable plan not just to secure their own benefits, but also those of the residents.

Stakeholder representation

Within a 'fair' process that includes participation, all stakeholders should be represented. This representation mostly focusses on citizens. They can represent themselves, but there are many organized group of citizens, such as residents' committees (Dutch: bewoners organisaties) and local tenant organizations. All of these have their own role. Van Perlo argues to use these existing organizational structures for participation, focusing on decision-power. He identifies a challenge; the municipality does not realize tenants are organized in this way, which means they struggle to deal with them.

Citizens are not just representing themselves, but in Amsterdam, !WOON stands for all citizens and residents and their accompanied interest. This is unique in the Netherlands, and ensures that all stakeholders are represented, since the citizens are usually the group that is left out. !WOON has been dealing with the topic of disconnection from natural gas for a while, since energy is a significant share of housing expanses and comfort (Meijerman, personal communication, 11-04-2019).

5.4.3 Balance of powers

Between stakeholders

The conceptual framework argues for an even distribution of power between all the stakeholders involved, mainly; government, industry and citizens. Who holds the most amount of power, seems to be subjective, since the respondents answer this question differently, but most of them position the greatest power with the government. Van Zanten states that power is about '*who decides?*' For the heat transition in the end, this is the national government, provinces, but mostly the municipality, where these decisions need to be democratically legitimized. The power handed to the government lies in law and policy, rules and regulations, subsidies and taxes. One important topic that the government is in charge of the energy prices (Hendriks, personal communication, 09-04-2019), which is a key aspect to get the entire heat transition done.

Currently, Reiding observes a shift in the distribution of power. He reasons this power used to be mostly with the industry, but the government interferes more now, which transfers power from the industry to the government. In the future he expects citizens to become more concerned with this topic, which will inevitably lead to the empowerment of citizens.

Respondents call for a public-private collaboration (Van Zanten, van der Heijden, Groen, personal communication, 2019). It is expected that the government initiates the transition, because it safeguards the societal interest. But the industry has to execute the plans, which leads to acceleration. So, both government and industry are mutually dependent on each other. Meijerman pleads for a farther-reaching collaboration: co-production between all three major stakeholder groups. Essentially the real estate owner has the final decision-power to what measures are taken in that certain building, which is the investment decision. Also, the heat supplier has to make an investment decision relating the service he is able to deliver for a certain price. The municipality is needed to ensure the construction process is public space is coordinated. All these tasks together leads to coproduction, where every stakeholder group has their own type of power.

> "Everyone has their own role, which is why I think it is inevitable, and I already tell people: it's going to be co-production." - Meijerman, personal communication, 11-04-2019

The citizens are not brought forward in the answers of respondents. It is mentioned that they might be well off, since things are taken care off by others. But it could also be a threat for injustice, when citizens are surpassed.

One possibility to keep power amongst the users and citizens is to keep the natural gas connection, even though this costs money. By doing this, is creates leverage from the consumer to the heat supplier, since the consumer can say: "Either keep your prices affordable, or I will have a central heat boiler installed again" - Van Perlo, personal communication, 21-03-2019

Table 12 gives an overview of the distribution of power according to the interview respondents. It is stated that the government has a significant amount of power and may be gaining even more. This power lies in regulatory and legal mechanisms.

Interview respondent	Distribution of power
Emiel Reiding	Moving from industry to governance. In turn the governance involves more citizens
Jannis van Zanten	Government, mostly on a municipal level, legitimizes decisions
Marjolein Groen & Ellen van der Heijden	Government and industry have an equal amount of power, just in different ways
Ben Hendriks	Power lies with government, mostly municipality
Eef Meijerman	Everyone has their own type of power

Table 12. Overview of interview respondents about the distribution of power.

Conclusion

Table 13 summarizes the three indicators of procedural justice. For a fair process it becomes visible that transparency is essential, also relating to the provisioning of information. Democracy is stated as essential to secure procedural justice and should be operationalized by elections and decision-power for citizens. This decision-power is stressed again by participation and control. All respondents call for a high level of participation in all stages of the process. The local scale of solutions asks for a neighborhood approach. When executed well (in a transparent and democratic manner), this approach can lead to an improved sense of justice amongst citizens. In order to balance the powers between government, industry and citizens, there should be more focus on the latter. It is mentioned that a partnership and co-production will lead to the most just outcomes, where every actor takes a role according to their strengths.

Interview respondent	Fair process	Participation and control	Balance of powers
Bastiaan van Perlo	More transparency in the process (in terms of contracts and pricing) is desired to reach a more just outcome.	A high level of participation is crucial; this should include 'a say', decision power or control for citizens.	Citizens can be empowered by more ownership. Another option is to keep natural gas infrastructure, to pressure heat suppliers.
Emiel Reiding	There should be more information and emphasis on the benefits of the transition for a better debate.	A level of control over citizens increases the acceptance, and just be included during exploitation phase as well (not only during planning phase).	The power has moved from industry more towards the government. The government empowers citizens more and more.
Jannis van Zanten	Communication to citizens can be improved to increase sense of justice.	Neighborhood-focused approach is important, in which explaining to citizens is crucial for the acceptance.	Energy is a public task that is best served by public-private partnership, where each stakeholders fulfill the role they have.
Pallas Agterberg	A fair process needs to be orchestrated really tightly, where democracy is a key value. Communication from industry and citizen	A neighborhood-focused process is crucial with a high level of participation and control by citizens. Democracy is important	

	leaves room for improvement.	and can include an election; this is true decision-power.	
Marjolein Groen & Ellen van der Heijden		If citizens are more involved in the process, the sense of justice can be improved.	Government and industry have equal amount of power. Government in policy, taxes and subsidies. Industry in has to execute the plans.
Ben Hendriks	Democracy, transparency and information are crucial for a fair process.	Decision-power and control for citizens is important but should not diminish the larger societal interest that the municipality can oversee.	Government in general has power; especially the municipality. Citizens and businesses have the power to accelerate.
Eef Meijerman	A fair process includes democracy, where 70% should at least be in favor. Democracy legitimizes certain measures	Citizens and residents have to be involved from the start of the process, they can be represented and group themselves around a certain topic	Coproduction is the best power-relationship, in which every stakeholder group, citizens, government, industry, have an equal amount of power.

Table 13. Overview of interview respondents on Procedural justice.

5.5 Towards a just heat transition

Besides identifying many challenges, the interview respondents have put forward various solutions, that aim to stimulate justice in one way or another. These are discussed in this section. Because not finding solutions: "is a lack of fantasy. If you really want to solve a problem, it is possible" – Agterberg, personal communication, 02-04-2019

The first solution lies in the financial construction of the energy prices. A shift in energy pricing is stated as a means to shape the heat transition. If the NMDA-principle is abandoned, there is the option of increasing the gas prices while stabilizing the prices of heat through DHNs. This would stimulate the expansion of DHNs while providing a sense of justice for those who get connected. However, this would require a grounded compensation structure for low-income households who do not have the opportunity to disconnect from gas infrastructure. In the end it is important not to collect taxes via the energy bill (Agteberg, personal communication, 02-04-2019). Furthermore, the energy tariffs have to represent real average prices. The NMDA-principle does not offer enough protection for consumers. The price of heat is connected to the price of natural gas and does not reflect the actual costs for the supply of heat, which is at odds with the competition law (Dutch: mededingingsrecht) (Huygen, Lavrijssen, De Vos, De Wit, 2011). The respondents agree that the NMDA-principle has to be reviewed (Van Perlo, Reiding, Hendriks, Meijerman, personal communication, 2019). Van Perlo observes that 'not more than otherwise' sometimes results in 'a little more than otherwise.' This degrades the societal support and acceptance of being connected to DHNs (Wiebes, 2018).

SiRM has investigated different regulatory structures, instead of the NMDA-principle which is the gas reference. They identify three ways of regulation: 1) tariffs established by the heat company in combination with rules for transparency, 2) national reference tariffs established by the 'supervisor' Authority Consumer and Market (ACM), and 3) tariffs established by the ACM, specified for each heat company or DHN (Heida & de Haas, 2019). There is not one way of regulating that seems to score best on the three goals of network regulation (preventing excess profit margins, efficient business operations and necessary investments), nor does one option score best on goals for DHNs (account for local situation, sustainability, investment climate). Therefore, it is concluded that neither one is the best option and tailoring of regulation is desired (Heida & de Haas, 2019).

Another solution that comes forward is financial in nature too, which is changing the ownership structure of DHNs. Van Perlo states: "All the connection fees should be directly converted into stocks in a district heating network, which would make the user also owner." This reasoning would increase the sense of justice. Agterberg supports the same reasoning. She imagines a system where the consumer leases the infrastructure, so

the investments do not have to be made beforehand. Another option is to establish a heat company as a neighborhood cooperation that own the DHN. When this company supplies to a certain consumer, this consumer becomes partial owner. This leads to a sense of decision power and ownership, which again stimulates the sense of justice.

The current approach focusses on housing corporations to disconnect from natural gas first. Because they own approximately 30 per cent of all housing, they can significantly contribute to energy reduction. These large-scale renovations are supposed to accelerate cost reduction, build market capacity, be a learning process, produce required innovations and secure quality (Bouwagenda, 2019). The interview respondents underpin the value of this approach (Van Perlo, Hendriks, Meijerman, personal communication, 2019). Not just the scale advantage and cost reduction are mentioned, but moreover corporations are a special type of owners. They provide housing to a group who cannot do this themselves (Meijerman, personal communication, 11-04-2019). For this reason, it is desired they are unburdened in the heat transition.

Furthermore, to allow a more flexible transition, new regulations are required in which consumers (users) will play a crucial role. The starting point for new policies should be 'technology neutral,' which means that not a given technology or energy carrier is dominant in regulations, but the function of energy is concerned; the energy services (Lavrijssen, 2018). The public incentives, such as taxes and subsidies should be used taking the long term into account, and shaped in such a way that large consumers (thus polluters) are encouraged to participate in reshaping the energy market (Roelofsen, de Pee, & Speelman, 2016). This is in line with the 'polluter pays' principle, supported by the utilitarianism's view.

It is concluded previously, that a neighborhood-approach offers advantages in disconnecting citizens from natural gas infrastructure. Furthermore, it is explained that municipalities have the responsibility to lead this process. This will be a challenge since municipalities barely have instruments to orchestrate owners of existing homes and buildings to connect to DH, and to force heat producers to switch to CO2-emission free heat (PBL, 2017).

Costs should be socialized (PBL, 2017) to ensure the heat transition is affordable for everyone. Money can be reserved for changing the system (Van Perlo, personal communication, 21-03-2019), because a socializing tax is the fairest way to distribute the costs; it is what society is for. Everyone pays, which can be collected via income tax, property tax, corporation tax and this way will be carried by the strongest shoulders. This results in the fact that everyone benefits, some more, others less, but everyone benefits. This is nothing new, 40 years ago, the sewage system was installed in the inner city of Amsterdam, mostly paid with public money. Meijerman states that the current government spends a disappointing amount of money on the heat transition. Furthermore, with the number of fixed tariffs that exist today, there is no income dependency; everyone pays the same price. This disproportionally affects the people with the lowest budgets and degrades a just distribution of costs.

> "So, you look for a balance in the benefit of collectivity, while still taking into account people's personal situation. […] When you talk about distributive justice, in my opinion, collecting tax in the Netherlands receives the broadest support." - Meijerman, personal communication, 11-04-2019

5.6 Conclusion

In order to answer the research question of this chapter: *"What is the current state of energy justice in (the policy approach of) Amsterdam?",* the main conclusions are stated. First, it is identified that low-incomes (both home-owners and tenants) are hit disproportionately hard by the transition from natural gas to district heating, raising justice concerns. This is also true for certain middle-income groups, tenants in the commercial sector and people who have other than financial problems. However, identifying large groups would diminish the complexity of the situation. Thought has to be given to the identification of households on a neighborhood and individual level.

In terms of distributional justice, it can be concluded that in Amsterdam, affordability is the most important indicator. Affordability after the transition from natural gas to alternative heat provisioning justifies the measure and can even make up for a lack of choice. This means if the transition leads to an increase of prices, without an increase of household income, it can threaten a just outcome, especially for the aforementioned low-income households. Furthermore, it is concluded that the current policy approach does not distribute costs according to the principle that the strongest shoulders should carry the largest burden. This goes against equality and solidarity principles, which leads to injustices. Then, a lack of choice is another distributional issue that is at odds with the

principle of freedom. A reduction of choice can be compensated by lower costs, but since this is not the case, the reduction is the choice of the energy supplier when connecting to DH, is a justice problem.

Regarding the unbundling of the heat market into production and distribution, it is concluded that this is not desired at this point in time. However, to increase the amount of choice and value the freedom-principle, as many sources as possible should be connected to the grid, so consumers have a choice. There are many possible ways to build in this choice, even in an unbundled market, e.g. choice of temperature, choice of heat source, large-scale networks vs. collective networks, and ownership structures.

To ensure procedural justice a number of factors is important. First, coproduction between industry and government, with influence of users is required to safeguard equality between actors. Furthermore, the neighborhood-approach should include democracy in order to lead to 'just' outcomes. Also, information ought to be shared transparently, which most stakeholders claim to do as best as possible, but there is room for improvement. Lastly, a high level of citizen participation is desired, which is not passive information provision, but active involvement and decision-power.

To get back to the research question of this chapter, it can be concluded that energy justice is at stake in Amsterdam, due to rising housing prices, heating costs and reduced freedom of choice. This is recognized by many stakeholders, which is promising in looking at solutions. Regarding the process of the transition from natural gas to alternative heating provision, there are still a great amount of uncertainties, but justice will be at stake if the government does not take full responsibility to lead a process in which inclusiveness and democracy are highly present. This means citizens all have to be represented (inclusive) and have to have decision power (democracy).

6

From natural gas to district heating

In Amsterdam district heating is currently the most common way of heating as an alternative for natural gas. Currently, 170.000 household equivalents (1 household equivalent is 35 GJ of heat) are connected to a DHN and the aim is to increase this number to 500.000 by the year 2040 (MRA, 2016). Since there will not be enough (high temperature) heat it is recognized in Amsterdam that a mixed solution is desirable, of all-electric, smaller scale collective district heating, and larger scale DHN (Van Zoelen, 2019). However the total sum of household equivalents in Amsterdam is currently calculated to be 689.800 (MRA, 2016), which means the ambition is connect over 70% of all heat consumers in Amsterdam to district heating by 2040.

District heating is known to reduce the freedom of choice, by limiting the choice of heat supplier and source of heat, which is at odds with energy justice principles. Secondly, there are signs that district heating leads to an increase of heating costs. These justice concerns, combined with the ambition to expand district heating networks in Amsterdam in the coming years, make this alternative the natural gas the most interesting to evaluate. By doing this, chapter 6 will answer the sub-research question: *"What are the implications of the heat transition from natural gas to district on 1) the affordability on a household level in Amsterdam and 2) the spatial component of energy justice?"*

6.1 Affordability of gas compared to district heating

The affordability of heating is defined by the monthly costs for gas and district heating for households. This is based on the assumption that the household income does not change when the household disconnects from natural gas and gets connected to district heating. First, the monthly costs for heating will be calculated for both natural gas (reference) and district heating (alternative). After this, a Lorenz curve is plotted to graphically display inequality in heating prices and a GINI-coefficient is calculated. Finally, natural gas and district heating prices and their effect on heat poverty will be calculated and discussed. In order to calculate these prices, assumptions have to be made.

6.1.1 Samples and socio-economic groups

Data provided by Meijerman & Ligthert (2019), has defined 16 socio economic groups (SEGs) (Meijerman & Ligthert, 2019). An overview of the groups accompanied by some assumptions are found in table 14. The groups are defined based on their income, household size, housing typology and the associated energy label. Even though, these groups do not represent the entire population in Amsterdam, it is reasoned they represent the majority of people. Moreover, vulnerable groups are included that depend on social allowances and live in homes with a poor energy label.

Group	Income group	Annual household income (estimate)	Household size	Housing type	Housing typology	Energy label
1	Social security payment	17.328	1	Social housing	Flat 1966-1975	G
2	Old-age pension	19.042	1	Social housing	Flat 1966-1975	G
3	Top of social housing allowance	20.810	1	Social housing	Gallery entrance flat 1976-1980	E
4	Exceeds social housing	28.862	1	Rent commercial	Apartment 1990-2000	C
5	Exceeds social housing	27.692	1	Owner-occupied	Apartment 1990-2000	C
6	Social security payment	38.135	4	Social housing	Gallery entrance flat 1976-1980	E
7	Top of social housing allowance	56.997	4	Social housing	Gallery entrance flat 1976-1980	E
8	Exceeds social housing	58.685	4	Rent commercial	Apartment 1990-2000	C
9	Exceeds social housing	60.522	4	Owner-occupied	Apartment 1990-2000	C
10	Middle-high	66.218	4	Owner-occupied	Apartment 1990-2000	B
11	Social security payment	22.509	2	Social housing	Flat 1966-1975	G
12	Old-age pension	26.443	2	Social housing	Flat 1966-1975	G
13	Top of social housing allowance	29.093	2	Social housing	Gallery entrance flat 1976-1980	E
14	Exceeds social housing	29.093	2	Rent commercial	Apartment 1990-2000	B
15	Exceeds social housing	29.093	2	Owner-occupied	Apartment 1990-2000	B
16	Middle-high	48.307	2	Owner-occupied	Apartment 1990-2000	B

Table 14. Overview of socio economic groups and building typology. (Meijerman & Ligthert, 2019).

6.1.2 Assumptions

In order to calculate the costs of heating in the case of natural gas and district heating, the following assumptions are made:

1. The calculations are based on 16 socio-economic groups that are representative of a large share of the population of Amsterdam.
2. Traditionally, heat takes up 65 per cent of the energy bill. Since this research focusses on comparing heat prices, electricity is left aside. Therefore, in line with the energy poverty threshold of 10 per cent, it is assumed that a household experiences heat poverty when the costs of heating exceed 6,5 per cent of the spendable household income.
3. The average price per GJ of natural gas is assumed to be €23,143 (CBS, 2019). This is based on the assumption that households consume 20-200 GJ per year.
4. The calculations assumes that households are connected to a DHN, exploited by Nuon, which is the case in Amsterdam. For this reason, the heat prices of Nuon are used to calculate the costs. The price per GJ is €26,15, the fixed fees are €752,90 per year for households consuming 50-100 GJ and €475,61 per year for households consuming 0-49 GJ (Nuon, 2019).

5. In the samples of the socio-economic groups, the households in a single-family home are outside the scope, since 88% of all housing in Amsterdam is multi-family homes.
6. It is assumed that the housing typology and energy labels are representative for each of the socio-economic groups.
7. For each group the size is estimated based on data about the number of people of a certain household. In Amsterdam there are 246.378 1-person households, 95.647 2-person households and 40.651 4-person households (OIS Amsterdam, 2018). Since more detailed data about the household size combined with household income is not available. It is assumed that each of the socio-economic groups represent an even number of households (e.g. there are 5 groups 1-person households, so each group consists of: 240.800/5= 48160 persons). In total these household types make up 82% of all households in Amsterdam.

6.1.3 Prices of heating for natural gas compared to district heating

To compare the household costs for heating in the case of natural gas with district heating, the prices are compared. The gas price per GJ is based on the average price of 23,143 for households that consume between 20 and 200 GJ per year (CBS, 2019). All of the households in the 16 socio-economic groups consume within this range. To compare this with prices for district heating, the current tariffs used by Nuon in Amsterdam have been used. This price is based on the assumption that both central heating as well as heating hot water uses the DHN. It clearly shows that both the price per GJ, as well as the total sum of fixed fees is much higher for district heating than it is for natural gas.

	Natural gas		District heating Nuon
Price per GJ (€) for consumption 20-200 GJ[4]	23,143	Prices per GJ (€)[5]	26,15
Fixed connection fee and network costs (€/month)[6]	15,93	Fixed connection fee[6] (independent of consumption) (€/year)	318,95
		Measurement fee[6] (€/year)	25,89
		Delivery set (€/year)[6]	181,09
		Discount NUON[6]	-50,32
Total sum of fixed fees (€/year)	191,16	Total sum of fixed fees (€/year)	475,61

Table 15. Overview of gas price and price for district heating (Nuon).

Based on the assumptions, for each group the average income has been calculated, accompanied by their monthly gas costs. These costs are based on the assumed building typology and energy label, which results in a certain gas consumption. In order to compare the costs for gas to the costs for heat, the gas prices are first converted into GJ, by dividing the costs by 23,141, which is the average gas price per GJ (CBS, 2019). This results in the average heat consumption per month, which is multiplied by 12 to have the consumption per year. This is of relevance, since fixed fees depend on the average heat consumption. Using this annual consumption, the fixed fees and consumption fees for heat, when connected to the Nuon DHN, can be calculated. Table 17 shows an overview of the outcomes of these calculation. As expected, based on the gas and heat prices shown in table 16, for each of the socio-economic groups the costs for heating per month increase in the case of district heating instead of natural gas. It is demonstrated that the groups with the highest gas consumption per year in GJ, see the share of their income spent on heating increase the most. These groups are also the groups that live in homes with the poorest energy labels.

[4] Data: CBS (2019)
[5] Data: Nuon (2019)
[6] Average fixed fees in Amsterdam. Data: (Hernandez, 2015)

Socio-economic groups	Gas consumption per year (GJ)	Gas consumption per month (€)	Gas consumption as share of household income (%)	Heat consumption per month (€)	Heat consumption as share of household income (%)
1	57,59	111,07	8,8	188,24	13,0
2	57,59	111,07	8,0	188,24	11,9
3	57,59	111,07	7,3	188,24	10,9
4	30,11	58,07	3,1	105,25	4,4
5	30,11	58,07	3,2	105,25	4,6
6	45,15	87,07	3,2	138,02	4,3
7	45,15	87,07	2,2	138,02	2,9
8	27,00	52,07	1,4	98,47	2,0
9	28,04	54,07	1,4	100,73	2,0
10	28,04	54,07	1,3	100,73	1,8
11	48,26	93,07	5,8	144,80	7,7
12	57,59	111,07	5,8	188,24	8,5
13	36,33	70,07	3,5	118,81	4,9
14	30,11	58,07	3,1	105,25	4,3
15	30,11	58,07	3,1	105,25	4,3
16	27,00	52,07	1,7	98,47	2,4

Table 16. Overview of gas consumption and associated monthly costs for gas (reference) and district heating (alternative).

Figure 10 displays the percental change in monthly costs for heating when switching from natural gas (current) to DHN (alternative). It is striking that for all socio-economic groups that are included in this calculation, the price of heating increases with 32-48 per cent, even though the NMDA-principle applies, that states heating by DHN should not be more expensive compared to natural gas.

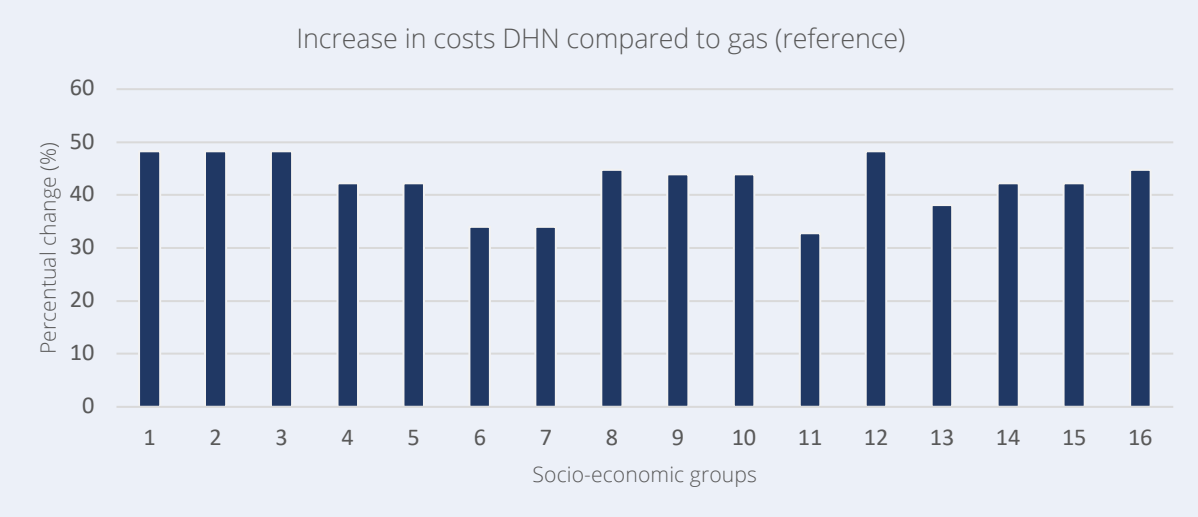

Figure 10. Increase in heating costs, DHN compared to gas (reference).

The reason the costs for being connected to DH are higher is, because the NMDA-principle is not applied strictly by law. Not all components of the supply of heat are taken into account (Huygen, Annelies; Lavrijssen, Saskia; De Vos, Coen; De Wit, 2011). The costs for heating supply is made up of a connection fee, a fixed annual fee and variable price per GJ. The NMDA-principle applies only to the latter two components of the price, which results in the fact that the total costs for the consumer are higher. Huygen et al observe two more reasons for the increase in energy prices when connected to DH, that in nature have to do with the calculation of heat prices based on the NMDA-principle (Huygen, Lavrijssen, De Vos, De Wit, 2011). In this calculation, houses that use natural gas are assumed to have energy-losses in the gas pipes, whereas houses on a DHN do not. Furthermore,

the efficiency of boilers that is assumed, applies to 15 to 20-year-old technology. Since the average boiler is 7,5 years old, higher efficiency rates should be used. The current approach increases the price at connection to DH.

6.1.4 Lorenz curve and GINI index

The GINI index, supported by a Lorenz curve, is a worldwide adopted method to calculate the distribution of a certain unit. Traditionally it displays the distribution of income over a population. In this research, it aims to demonstrate the distribution of energy costs, measures by the energy prices in percentages of the spendable household income.

Analysis based on theory of egalitarianism

Using the GINI index to analyze distribution is done based on the theory of egalitarianism. According to this theory all people are equal, which means public goods should be distributed equally to maximize the societal interest. It therefore focusses on increasing the benefit of the least advantaged members of society (Lucas et al., 2016). The introduction of the egalitarianism theory to the energy justice framework is done by Islar who reasons egalitarianism dictates fair distribution, everyone must have an equal share of goods (Islar et al., 2017). In line of this reasoning, this notion translates to the hypothesis that for equal distribution, all households should spend roughly the same share of their income on energy.

First, the cumulative percentage of gas costs as a share of household income is calculated. This is based on the percentages found in table 17. The socio-economic groups are ranked from the group who spends the largest share on gas, group 1 (8,8%), to the group who spends the smallest share on gas, group 10 (1,3%). Then, all the groups are weighted for their size, based on data found in OIS Amsterdam (2018). If the share of household income spend on gas would be plotted, the curve would appear above the trendline, because the low-income households (on the left of the graph) spend more than the high-income households (on the right of the graph). To correct this, the graph displays the percentage of household income that remains after the gas bill has been paid (=100 – percentage of household income spent on gas). After all cost are calculated as a percentage of the household incomes these numbers are all added together, to find the total costs of heating over all groups. Then, the cumulative share is calculated for each household group. Then, the Lorenz curve is plotted and graphically displayed in figure 11. Furthermore, a trendline is plotted that resembles perfectly even distribution. The data input for figure 11 can be found in Appendix D1, D2 and D3.

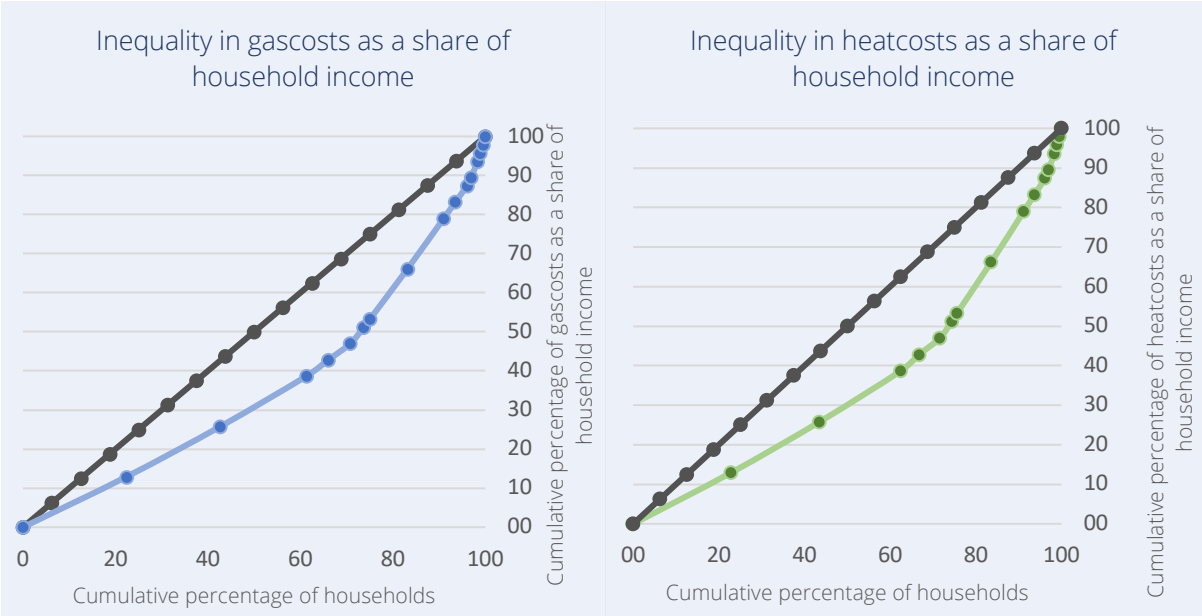

Figure 11. Lorenz curve of gas price inequality next to Lorenz curve of heat price inequality.

Then, the GINI index is calculated. The GINI index is found by dividing the area in between the Lorenz curve and the trend line by the entire area under the trendline (=100*100/2 = 5000). First the area under the Lorenz curve is calculated. Then 5000 is subtracted, which is the area under the trendline, which results in the area between

the Lorenz curve and the trend line. The GINI index can be seen as the ratio between the area just calculated (in between the trend line and Lorenz curve) to the area under the trend line, resembling equal distribution. To calculate the GINI index, the area found between the two lines, is divided by 5000. The GINI index found for this curve is 0,28. A value of 0,28 does not indicate an extremely unequal distribution of cots. This process is repeated for heating when connected to a district heating network, based on the prices shown in table 16. The Lorenz curves are plotted next to each other to be compared. It becomes clear that the Lorenz curve does not change significantly, which is also true for the GINI index.

Looking closely at the Lorenz curves, roughly three groups can be distinguished. The first five groups show a line that is more or less straight, indicating that these groups pay a similar percentage of their household income on gas. Then the slope of the line increases, indicating this another group that spends similar percentages of their household income on gas. Lastly, there are five groups for which the slope of the trendline is very steep. Taking a closer look at the groups a conclusion can be drawn relating the energy label of the house. Table 18 shows the three groups that are observed in the trendline of the Lorenz curve. For each observed group, it shows which socio-economic groups are attributed to the group, and which energy label their house is. This clearly shows that the uneven distribution of gas costs as a percentage of household income is related to the energy label of the house. The lowest label (G) is only found in the worst performing group, whereas the higher energy labels are found in groups 2 and 3. The most surprising outcome is to find socio-economic group 7, with energy label E in the last section of households spending a relatively small share of income on energy. This is due to the high household income, because of child allowances.

Observed pattern in Lorenz curve	Associated socio-economic groups and energy label	
Group 1	Group 1	G
	Group 2	G
	Group 3	E
	Group 11	G
	Group 12	G
Group 2	Group 4	C
	Group 5	C
	Group 6	E
	Group 13	E
	Group 14	B
	Group 15	B
Group 3	Group 7	E
	Group 8	C
	Group 9	C
	Group 10	B
	Group 16	B

Table 17. Observed trend in Lorenz curve related to socio-economic groups.

6.1.5 Heat poverty in the situation of natural gas compared to district heating

Figure 12 compares the energy prices of natural gas to the ones in a situation where the household is connected to the DHN. Since this aspect of distributional justice is about the affordability, the energy costs for heat only are shown in percentages of the total spendable household income. The threshold line of 6,5 per cent is plotted, above which it is assumed that households struggle to pay for heating. Out of the 16 groups, 3 are classified as heat insecure in the reference situation. This number increases to 5 out of 16, if households switch from natural gas to DH. When looking into the characteristics of these groups, it is striking that all of them live in a social housing situation, and with the exception of one group, they all depend on social security payments as their main source of income. Furthermore, they are assumed to live in housing with energy label G or E.

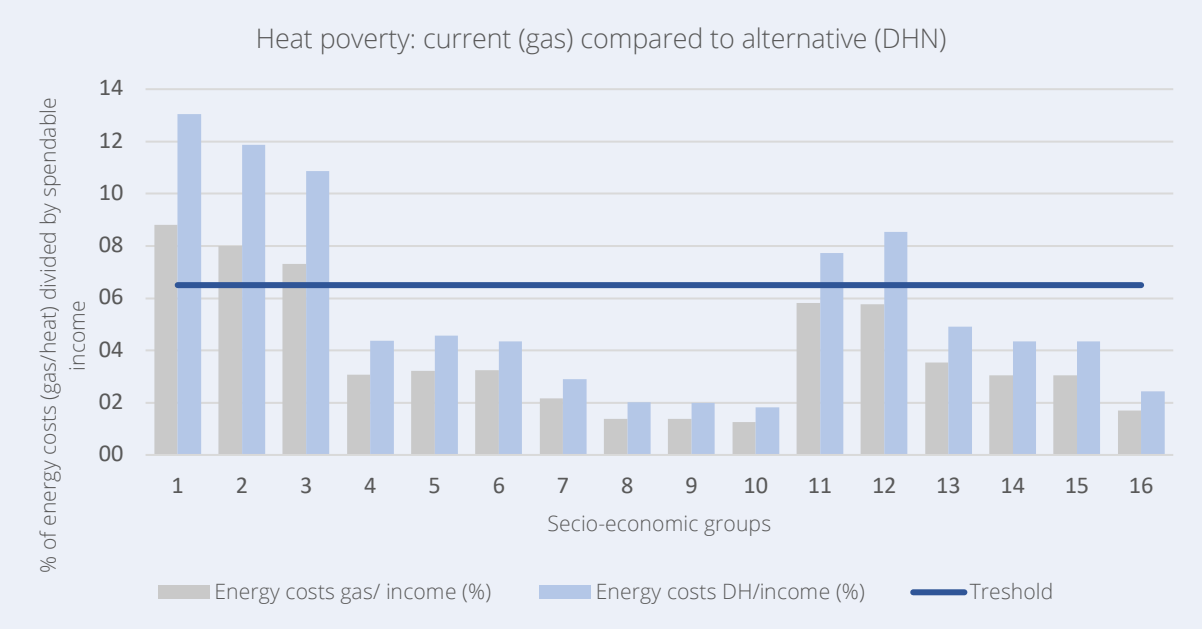

Figure 12. Heat poverty: current (gas) compared to alternative (DNH).

6.1.6 Conclusion

First, it can be concluded that the absolute number of heat insecure households will increase if they transition from natural gas to DHN. This is mostly due to the fact that these households have low incomes (social security allowances) and based on the assumption that they live in flats build between 1966 and 1975, which results in a poor energy label G. Furthermore, figures 10 and 12 shows that all households, no matter the size or energy consumption, will see an increase in their costs for heating as a result of switching to DH. Most alarming is the fact that households in energy inefficient homes see higher increases in their costs, of up to 7 percent. Households in energy efficient homes, that also have higher incomes only see the share of their income spend on heating increase with 0,6%.

Secondly, when investigating the Lorenz curve, the 16 socio-economic groups can be divided into three larger groups. These groups are characterized by the energy labels, where the worst performing group scores much worse compared to groups 2 and 3. This leads to the conclusion that the energy label of a home largely defines the percentage of income a household spends on gas or heat.

6.2 The spatial challenge of district heating

Since there is no geo-data is available on household income, gas consumption or energy labels of buildings, it is not possible to locate energy poverty spatially in the scope of this research. Instead, some concerns of spatial nature in relation to justice will be discussed, that are a result of the transition from natural gas provision to heat provision through district heating.

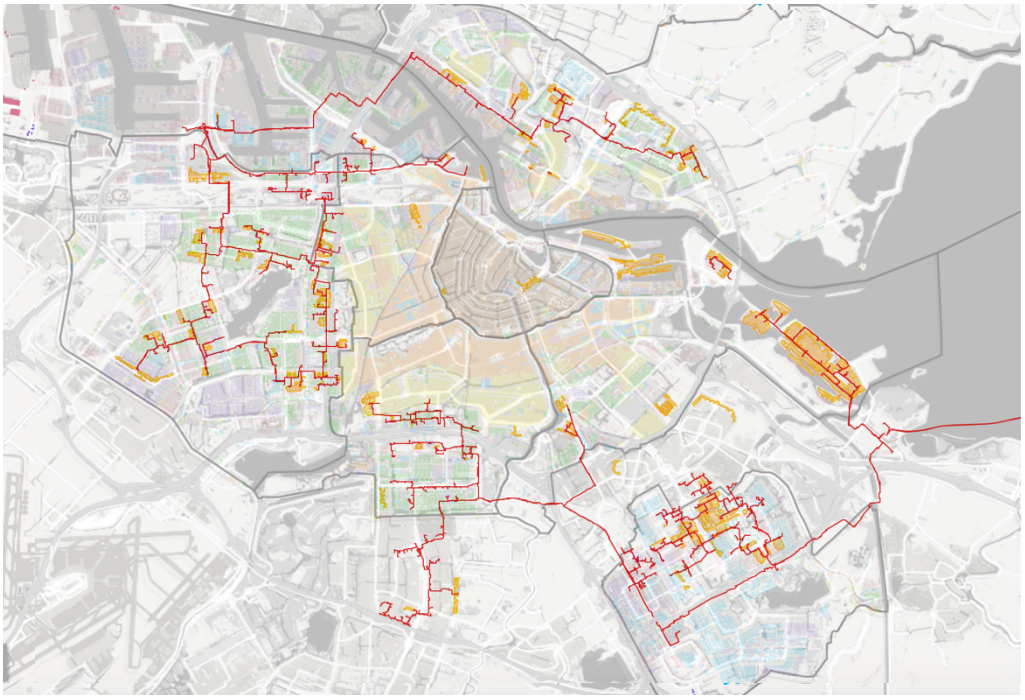

Figure 13. District heating networks in Amsterdam displayed on top of building age. Data: Gemeente Amsterdam (2019a, 2019b), retrieved from: maps.amsterdam.nl

Figure 13 illustrates where the current district heating networks exist (Gemeente Amsterdam, 2019a; Gemeente Amsterdam, 2019b). The infrastructure is shown in red and the connected building blocks are orange. The image is displayed on top of a map that shows the construction years of buildings. When analyzing the map, it becomes clear that there are roughly four different parts of the city connected to DH. First, in the west of the city, the underlying color of buildings is green, which means they are built between 1940 and 1969. Then, in the northern part of the city, where the DHN is currently expanded a smaller number of households is connected where it mostly supplies buildings constructed after 2000. These connections from one network together, exploited by Westpoort Warmte (WPW). This is a joint venture of Nuon (Vattenfall) and the municipality of Amsterdam. The main source of heat is the AEB, the waste energy company, that incinerates waste and generates heat (Rekenkamer Amsterdam, 2018). Secondly, in the eastern part, IJburg is connected to district heating. It is clearly visible there is a dense network of connections. The buildings connected were constructed after 2000. Furthermore, in the south-east part of the city the network supplies heat to buildings constructed between 1970 and 1985. These connections make up the second DHN in Amsterdam, operated by Nuon. The primary source of heat on this network comes from the gas-fired electricity plant in Diemen (Innoforte, 2018).

Sustainable or not?

The first spatial issue that comes forward is the issue of sustainability. In order to reduce CO2-emissions, first, energy consumption is reduced, and the remaining consumption is generated from (more) sustainable sources. This is in line with the proposed approach of the Dutch Climate Agreement (S. E. Raad, 2018). The energy consumption is linked to the energy performance of a building, whether indicated as an energy label, or energy index. The year of construction largely defines how well buildings are insulated. Currently the question is how well buildings have to be insulated in order to disconnect from natural gas, and connect to district heating (Agterberg, personal communication, 02-04-2019). This is depending on the year of construction and partly defines the temperature of the heat that will be supplied. DHNs can be grouped in to low-temperature(< 70 degrees Celsius), medium-temperature (70-90 degrees Celsius) and high-temperature (90-120 degrees Celsius)

networks (MRA, 2016). When a building is insulated to a high standard, it can be sufficiently heated by lower temperatures.

Spatially this is visible in figure 13, where mostly (relatively) newer buildings are currently connected to district heating. The first reason is because these buildings are insulated well-enough to be heated with heat from DHNs. Moreover, when new construction is planned and infrastructure is built, it is easy to construct a DHN instead of natural gas infrastructure. Since Amsterdam shows large differences between the year of construction for different neighborhoods, this leads to spatial differences. In the inner city, where constructing DH is challenging because of the old poorly insulated buildings and historic value, there are questions about whether this part of the city should use green gas, through the existing gas pipes. Green gas is much more expensive than natural gas, which means the inner city will become even more expensive to live in (Meijerman, personal communication, 11-04-2019). This puts the value equality under pressure, if it is not formally defined and operationalized what level of inequality of heat prices, rents and income is accepted.

Furthermore, the sense of agency is under pressure in the situation in which citizens are forced to disconnected from natural gas infrastructure by a certain year. Consumers have the right to make autonomous investment decision about their property and living environment (Agerterberg, Meijerman, personal communication, 2019). Theoretically, improving the insulation in old buildings leads to high energy-savings. But the true consumption of old and poorly insulated homes is lower than theoretically assumed, which means there is less potential to save money when investments in insulation are made (Rekenkamer Amsterdam, 2016). This results in the fact that a return on investment cannot always be generated. According to the value autonomy, home-owners should make the final decision on whether or not to invest. This investment does not only relate to insulation, but also a gas-fired boiler. When someone has just installed a new one and the municipality announces their neighborhood will be disconnected from gas infrastructure within 2 years, this person will not be happy (Van Zanten, personal communication, 01-04-2019). Timely and transparent information provisioning can be a way to prevent such problems.

Apart from reducing CO2-emissions by lowering consumption, the source of heat can become more sustainable. In the current DHN in Amsterdam, for 1 GJ of heat supplied, still 0,562 GJ of fossil fuel has been used for production (Innoforte, 2018). This is the average over both the two separately exploited district heating networks in Amsterdam. In the case of this DHN, this is mostly natural gas. This requires DHNs to find alternative sources of heat to replace the natural gas completely by 2040. This is currently happening, by investigating geothermal heat, surface water heat and residual heat from datacenters (MRA, 2016). Besides the reduction of fossil fuels, a main policy ambition is to reduce CO2-emissions. Currently, the WPW district heating network depends on incinerating waste, which emits CO2 into the atmosphere.

The spatial justice comes into the picture, in the case of the planned biomass incineration plant in Diemen, that will feed into the Nuon DHN. The municipality and citizens resist this plan, since they believe it is not sustainable enough and it pollutes the surroundings with harmful emissions (Meijerman, personal communication, 11-04-2019). The national government approves of building the facility, since it is the only way CO2-reduction targets can be achieved nation-wide (Claus & Straver, 2019). It is reasoned that incinerating wood (which will be used type of biomass) is CO2-neutral, since new trees are planted that capture the CO2 again. Besides the fact that this reasoning is questioned by scientists (Claus & Straver, 2019), the biomass plant is a threat to spatial justice principles, since no matter what, the biomass station will emit CO2 in its direct environment. This threatens the living environment and ignores the value solidarity, that should be respected in making just decisions relating the heat transition.

How many systems?

The feasibility of a DHN depends on the amount of connections that can be realized, which is related to the population density of the areas. Since cities, and especially Amsterdam, are densely populated, DHNs are a suitable alternative to natural gas. It has been mentioned that for financial reasons, it is preferred to install district heating and remove gas connections (Van Zanten, personal communication, 01-04-2019), but the questions of how many systems can co-exist is yet to be answered.

There are advantages of maintaining more than one system. For example, having two systems is more reliable, which is currently the case with electricity and natural gas. When you're only running on electricity and there is a blackout it is both cold and dark (Van Zanten, personal communication, 01-04-2019). This is a call for at least a separate system for electricity and heat. When the natural gas infrastructure is also maintained, even though it might be expensive, the system becomes more flexible. Natural gas can be used as peak-supply in cold months, it can be used as leverage to keep heat prices of alternatives low (Van Perlo, personal communication,

21-03-2019) and in the future it can possibly be used to transport other types of gas, e.g. green gas or hydrogen gas. The question how many systems are maintained and where they are exploited poses a risk for a just outcome of the heat transition, based on the values equality and inclusiveness. If the system configuration will be different for various areas, the costs will vary as well, which may be in opposition with the operationalization of equality (e.g. energy poverty). Furthermore, it poses the risk of certain areas not being connected to a certain system, reducing their (freedom of) choices.

Nuisance

Apart from the costs and benefits of financial nature, there are costs and benefits in a broader sense, that can spatially be poorly distributed in contradiction with inclusiveness, equality and solidarity. Negative effects are interrelated with the geographical positioning of the heat source, such as a waste incineration plant or biomass station. Also, the choice of system can have an impact. If the inner city of Amsterdam will receive green gas through the existing gas pipes, these citizens will not experience nuisance due to construction of DHN. People that are located in an unlucky geographical position, might face a situation in which their whole street under construction for years when the neighborhood is disconnected from natural gas (Van Zanten, 01-04-2019). Currently, 2,5% of all streets in Amsterdam are closed some time for construction every year. If the whole city has to be gas-free by 2040, this has to be increased to 10% of the streets, which is four times more than the current situation (Van Zanten, personal communication, 01-04-2019).

Conclusion

The discussion of spatial effects of the expansion of DHN in Amsterdam reveals threats to energy justice. First of all, DHNs do reduce the use of fossil-fuel (natural gas), but not completely. It remains uncertain when enough new sources can be exploited to become gas-free. Furthermore, the generation of 'sustainable' heat, by using biomass or incinerating waste is a risk for spatial justice principles. CO2 is emitted and reduces the quality of the living environment of people who live close to the biomass station.

There is a possible risk of spatial differences between the inner city and other parts of Amsterdam, due to the year of construction of buildings and the historical value of the city-center. These differences can include; the source of heat and the infrastructure for heat that lead to different energy prices. Furthermore, different investments in insulation might be required and benefits or costs other than financial ones may affect the city-center differently than the outskirts. All of these differences may potentially lead to injustices as a result of the transition from heat provision through natural gas to heat provisioning through DH, if the values solidarity, inclusiveness and equality are not considered and operationalized.

7

Discussion

This chapter will start with an interpretation and discussion of the main findings. By doing so the limitations of the research will be revealed and explained. Lastly a reflection of the research process is formulated.

7.1 Interpretation of Findings

The first main finding of this research is the conceptualization of energy justice. A list of values was extracted from justice principles and spatial justice principles and reasoned to apply to energy justice. This conceptual approach should be interpreted as a method to create understanding of how values are related to justice. It is important to mention that the list of values is not limited to these values and that the justice principles are supported by more values than only the ones that are mentioned. This means the conceptualization used in this research only shows the most essential values and could be enriched by further research.

The results relating recognition justice show that especially low-income groups are identified, and energy poverty is recognized as a risk to a just heat transition. This is a general observation that extends beyond the heat transition and applies to the larger context of the transition from fossil fuels to renewables in the Netherlands and other parts of the world.

Regarding distributional justice, it is found that the affordability is the indicator that receives most concerns from interview respondents and policy reports. Furthermore, when constructing district heating systems, the freedom of choice is at stake, since this results in only one supplier and no choice in source for the consumer. These findings apply to areas where DHN are the main alternative to natural gas, which are mostly urban areas. It is important to realize the temporal aspect of these findings, since the heat market may face changes in the near future, e.g. unbundling, allowing different sources onto the network and expansion may lead to cost-effectiveness and lower prices. When the heat market changes, this would influence this costs for heating, thereby changing the affordability and leading to different justice outcomes.

For procedural justice it was found that democracy and inclusiveness are essential for a just process, according to literature and interview respondents. Little can be said at this point about whether the process will be just or not, since it is in an early stage of development.

Then, it was found that heat prices would drastically go up (32-48%) for all 16 socio-economic groups, when they connected to district heating instead of the natural gas supply. This is one of the most surprising findings of this research, since the NMDA-principle exists in Dutch legislation, which states that heat prices should not exceed gas prices. Even though the ACM regulates these prices and this market, it turns out that the price structure of heat still has a structure in which the total price ends up high above the gas price. It could have been expected that the heat price was slightly higher for some groups, but is it striking that it is significantly higher for all groups.

7.2 Limitations

Personal limitations

Alongside practical limitations, it has to be considered that in a qualitative study, interpretation of the researcher is of key importance. There are always biases present that exist because of previous experiences with the topic. In this research this previous experience exist because of personal experience as a consumer of heat, through natural gas, but also by being connected to a district heating system. This shapes the perception of the consumer-supplier relationship, it brings along biases about energy pricing, freedom of choice and balance of powers. Furthermore, there is personal experience on a more professional and research level, because of previous

experience and involvement in a research project about collectivity in district heating. In this project past experiences with stakeholders that were involved, such as the municipality of Amsterdam shape the researcher's perception of the distribution of responsibilities and the balance of powers.

Aside from personal experiences that are a limitation to the research, lack of knowledge and skills can also be considered as a limiting factor. In this thesis that mostly relates to applying research methods, that I was unfamiliar with. The use of the GINI index was new to me, which resulted in a long time to investigate the method compared to the time actually calculating based on the data for this research.

Conceptual limitations

Something to keep in mind is one of the most important conclusions in the work of Islar. In using the justice framework principles there is the risk that the pursuit of the principle may undermine the pursuit of more general justice concerns (Islar et al., 2017). Therefore, the energy justice principles are an ethical limitation. More generally, the formulation of values and linking them to justice is a moral undertaking. Essentially this moral component is based on personal values and political choice. It should be stated that all researchers, have biases that we may be unaware of. The ethical and moral aspects of this research increase the vulnerability to these biases. In relation to this research it could have influenced the selection of the subject, the selection of literature sources and the selection of interview respondents.

Validation

Even though the conceptual framework has been validated by expert consultation and by the interview respondents, validation is a main weakness of this research. Since the research has an ethical and moral character, the best way to validate the conceptualization is by conducting a survey over a large and representative sample. This would validate that the values that are extracted from the justice principles are supported by wider society.

Limitations based on scope and time

Another limitation of this research is that is focuses only on the metropolitan area of Amsterdam. Energy justice is not just a metropolitan problem, but also threatens rural areas and it would be interesting to compare areas with a different population density. However, this is outside the geographical scope of this research. Furthermore, it is a limitation that some indicators of the conceptual framework are left outside the scope of the research. Another significant limitation is the availability of data in Amsterdam on a household level, which means there can only be conclusions on the scale of the larger city.

Besides the scope, also the time is considered a limitation. In case of abundant time, more interviews could have been held, a survey could have been conducted and further quantitative analysis could have been executed. Since the concept energy justice was not found to be operational at the start of this research, a large share of time has gone into the conceptualization and operationalization of energy justice. This also is one of the main outcomes of the research but has led to the fact that the application of the framework got restricted by time-constrains.

Lastly, regarding the interviews, the validity of the answers can be discussed. Every interview respondent represents a stakeholder in the heat transition. It can be expected that the answers given are limited to their own perspective and contain biases. For example, in answering the question whether their stakeholder group takes responsibility for a just heat transition, it is tempting for a respondent to answer positively and optimistic. Therefore, answers have been critically reviewed and cross-checked if possible.

Limitations in Case-study

Besides the case study method having many advantages, such as being able to provide in-depth information on complex social situations, there are a number of things to keep in mind. First, the fact that a case study often lacks rigor, which results in equivocal evidence or biased views (Zainal, 2007). This is a realistic pitfall for the case study of this research. This will be managed by validation of the data by experts as well as all the interview respondents.

Secondly, case studies provide little ground of generalization, because it uses only one subject (Zainal, 2007). Again, this is true for the case study in this research. Only one case will be executed that might not be representative, since there is already a good amount of citizen participation in this neighborhood. However, the nature of the case study is explorative and should prove the point that energy justice is something that should be taken into account in the heat transition. Since the heat transition will take place everywhere in a different form, it will have different implications on energy justice everywhere. This does not take away the fact that the case study is of value in bringing the concept energy justice into the real-life world.

Data limitations

One of the biggest limitations is the lack of available data, especially geo-data. This type of data would be highly relevant to locate energy justice on a map in Amsterdam. This data on a household level is not available due to privacy regulations. Even though datasets on gas-use and energy labels is available, this is no geo-data, which makes it more difficult to spatialize it. Also, the limited availability of interview respondents is a limitation in data. Lastly, it is considered a limitation that only a selection of justice principles have been selected and represented in the conceptualization. Energy justice covers these values, but it is like to extract more values from different justice principles that also apply to energy justice.

Limitations of quantitative analysis

First of all, using the GINI index is a choice that can be debated. It was chosen because it is a widely adopted measure of inequality that is scale-independent. However, many more ways to measure inequality exist. Extensive research into these methods can be done to evaluate which one is best to apply to energy justice. The choice for the GINI index may also be the reason that no significant change is observed for the situation of district heating compared to the situation of natural gas. Even though, table 12 shows that the low-income groups see a higher increase in heating costs compared to higher income groups, this is not reflected in the Lorenz curve or change in the GINI index. Apparently, the relative changes are not large enough to demonstrate a change in the curve and index. Since all households increase, relative to one another, the unequal spread of costs remains the same. This might be different if another method for analyzing inequality was chosen.

In order to calculate the GINI index and the costs of heat when connected to district heating, a number of assumptions was made. These assumptions result in the fact that the outcome is less precise. Since there is no data available on the amount of people in every socio-economic group, a rough estimation has been made. In an optimal situation, more data would be available that combines household income with the type of housing and its associated energy label. In case this data would be available the analysis would be more precise.

Another limitation of the quantitative analysis is the assumption that energy labels would remain unchanged after the heat transition. Currently, the approach focusses on insulating houses to reduce energy demand. This means that even though the costs per GJ of heat would increase, the total sum of heat costs would remain unchanged, due to the savings in heat use. This was not taken into account, since there are too many uncertainties about the cost of renovation and the options to finance this.

For the Lorenz curve, the first derivative of each point has to increase, meaning the slope of the curve only increases. When closely investigating the trendlines of the Lorenz curves, it appears that some data points, this is not the case. Two reasons can be found for this. First of all, it can be due to the visualization of the data and the fact that the line is not smooth but comprised of segments. Furthermore, it can be attributed to the fact that the data is not very precise. In total there are four layers of precision for which the Lorenz curve can be constructed. First, unweighted groups. This would be the case if the curve was plotted for the 16 socio-economic groups, assuming that each group is the same size. Then, the curve can be plotted for roughly weighted groups, which is the case in this research. The weighing is rough because data on household income combined with household size and energy label is lacking. Next, the curve could be plotted for ideally weighted groups and finally for individuals. With each of these steps the precision increases, resulting in a Lorenz curve that represents the real situation better.

7.3 Reflection on the process

Conducting this research and writing this thesis has been the most challenging learning-experience for me to date. First of all, since the scope of MSc MADE is broad and interdisciplinary, the abundance of research topics to choose from led to a long phase of finding and specifying the research subject. Even though, this was not easy at times, it has ensured that the subject reflects a high level of personal interest. Besides this, it has also been a great learning experience of exploring research topics independently and formulating my own research design.

The main change of approach in this research occurred when I found that the concept of energy justice remains very abstract to date. At the start, I expected the conceptualization of energy justice to be a framework that could be directly applied in a real-life environment, such as the city of Amsterdam. However, I struggled to find indicators to test, whether in a qualitative or quantitative way. Therefore, a large share of the total time available has been spent on developing a conceptual framework that is fitting for this research. This framework had to be applicable to the Dutch context and scale-level of the metropolitan region of Amsterdam and fitting to the current

heat transition. The fact that this took more time than expected, has resulted in less time to actually apply the framework, test it, review it and maybe improve it.

Furthermore, finding data and interview respondents proved to be time-consuming as well. I have contacted many people who never respondent. Luckily, I found eight inspiring interview respondents that were all highly relevant and enthusiastic. The lack of open-source data resulted in a significant amount of time spent contacting people and looking for data online. This is a point for improvement, not just in the energy field, but in wider research and academia.

One point of reflection is that I could have arranged more supervision apart from the two day-to-day supervisors. This thesis marks the final phase of five years of academic studying, in which a student is expected to orchestrate his/her own research. Since I like to solve problems myself, I am sometimes hesitant to ask for help. Even though I have tried to improve this over the last year, it could have accelerated the process if I would have attracted more supervision mostly in the exploration phase of this research, which would have created more focus from the start.

Altogether, conducting this research has taught me more than knowledge on energy justice and district heating. After years of soaking up knowledge, this is the first time I was in charge of my own research, from start to end, with an assignment that leaves room for personal interpretation. This has resulted in a process that forced me to plan ahead and stick to the planning, that took me outside my comfort-zone in contacting and interviewing people I look up to, and that tested my endurance and perseverance.

8

Conclusions and recommendations

This chapter concludes the research by stating the answers to the main research question and sub research questions and by formulating recommendations for future research and decision-makers in the energy field. The research aim was defined as: *Contribute to increase the understanding of the effects of the transition from gas to sustainable sources of heat on energy justice.* In order to reach this aim, the follow research question was formulated: "What is the impact of the transition from the natural gas heat supply to a sustainable heat provision on energy justice in the Metropolitan Area of Amsterdam?" In order to answer the main research question, sub research questions were formulated, for which answers are formulated. Finally, the main research question is answered.

8.1 Conclusions

The conclusions will be answered sequentially for the sub-research questions, leading to the answer of the main research question.

Sub-question 1

"What is energy justice and how is it related to classical justice principles and spatial justice principles?"

To answer the first sub-question, it is concluded that energy justice is a concept that aims to implement justice principles into the energy field. It aims to provide individuals, across all areas with safe and affordable energy. Thereby safeguarding a set of values. These values overlap with the values that were extracted from justice principles; equality, solidarity, freedom, societal interest and inclusiveness. Furthermore, energy justice reflects values that are extracted from spatial justice principles; solidarity, equality, democracy, agency/autonomy and freedom. Lastly, energy justice is closely linked to energy democracy, from which the value democracy is extracted. These values can all be operationalized in different ways, but energy justice safeguards these values. By doing this the concept of energy justice can contribute to stimulating a just heat transition. The extraction of these values and integrating them into energy justice, a conceptualization of energy justice is generated, shown in figure 07 on page 34. It is reasoned that political choices define how certain values are operationalized, but the conceptualization shows which values need to be addressed. Sub research question two takes this conceptualization and operationalizes it into a practical framework for application in a real-life context.

Sub-question 2

"What does the conceptual framework of energy justice look like and how can this concept be operationalized to measure energy justice?"

Answering sub-question two shows the operationalization of energy justice, which is visualized in figure 09 on page 43. Energy justice consist of distributional, procedural and recognition justice. By integrating the concepts found in three sources of energy justice literature the following energy justice indicators are developed. Distributional justice: affordability, freedom of choice, distribution of responsibilities, access. Procedural justice: Fair process, participation, balance of powers. Recognition justice: problem identification, problem recognition and cross-over. These indicators are operationalized further, as shown in figure 09, page 43 and can be used to describe energy justice in a real-life setting. This conceptual framework is applied in a case-study of Amsterdam in sub research question three.

Sub-question 3

"What is the current state of energy justice in (the policy approach of) Amsterdam?"

The third sub-question is answered by investigating recognition, distributional and procedural justice, based on the indicators of the conceptual framework and the values that underpin the indicators. For recognition justice it is found that the challenge of a just transition from natural gas to alternative heat provisioning is recognized in Amsterdam, by the municipality and local stakeholders. Furthermore, the national government also recognizes that energy justice should be taken into account for the heat transition. Although the problem is recognized, the identification of affected subjects has yet to take place. It is essential for this to happen in order to respect the value of solidarity.

Regarding distributional justice it is found that the affordability is the most concerning indicator in Amsterdam, but also on a national level. When looking into the affordability, the value equality should be considered and can still be operationalized in different ways. Furthermore, the construction and expansion of district heating networks reduces the freedom of choice of consumers, which decreases the just outcome, because it contradicts the freedom-principle. The responsibility of a just transition mostly lies with the government. The infrastructure is found to be crucial for a just outcome, mostly because it largely defines the costs, thereby it is closely linked to the affordability indicator. Lastly, there is great uncertainty regarding the availability of sustainable sources of heat now and in the future, that potentially will have a large impact of the just outcomes of the heat transition.

Procedural justice is safeguarded by transparent information provision. Currently, most actors aim to do this, but there is room for improvement in the availability of information on the benefits of the heat transition and information about the costs of heat production. Secondly, a high level of local citizen participation is desired to secure procedural justice. This requires far-reaching levels of engagement, which promotes inclusiveness, and decision-power, which promotes democracy.

Sub-question 4

"What are the implications of the heat transition from natural gas to district on 1) the affordability on a household level in Amsterdam and 2) the spatial component of energy justice?"

To assess the affordability on household levels, based on assumptions, the monthly costs for heating is calculated for 16 socio-economic groups. This reveals that the costs of heating in the case of connection to a DHN would increase with 32-48% compared to natural gas for all 16 groups. As a result, two of the groups break through the 6,5% threshold of heat poverty. In a situation where all households are connected to district heating, assuming no changes to the building or prices of heat are made 5/16 groups would spend more than 6,5% of their household income on heating. Four groups even spend more than 10% of household income on heating, and the worst-off group tops just above 13%. The low-income groups witness a stronger increase of costs, due to the fact that it is assumed they live in houses with a low energy label. Even though the low-income groups see a stronger increase in costs, the GINI index does not significantly change comparing natural gas to district heating. It can be concluded that, if no measures are taken, the transition from natural gas to district heating would be extremely problematic for at least 5 out of the 16 socio-economic groups in Amsterdam.

Investigating the spatial effects of the expansion of DHNs in Amsterdam reveal possible risks for energy justice. It is concluded that district heating networks in the way the exist to date, they are not gas-free and furthermore, still emit CO2 locally, reducing the direct living environment of some people more than others. Furthermore, spatial differences between the city-center and the surrounding neighborhoods are found, based on the construction year and historical value, which may result in a different future heating system accompanied by different costs and heating prices. These differences may potentially lead to injustices as a result of the transition from heat provision through natural gas to heat provisioning through DH, if the values solidarity, inclusiveness and equality are not considered and operationalized.

Main research question

"What is the impact of the transition from the natural gas heat supply to a sustainable heat provision on energy justice in the Metropolitan Area of Amsterdam?"

Regarding the main research question, it can be concluded that the transition from natural gas to sustainable heat provision will mostly impact the affordability and freedom of choice, both in a negative way, thereby posing the risk of degrading the just outcome of the transition. Furthermore, if citizens are not included and given decision-power in a democratic plan and decision-making process, a just heat transition is at risk.

8.2 Recommendations

The conclusions brought forward by this research lead to recommendations that built on the knowledge that has been generated. First, recommendations for further research will be stated after which recommendations are formulated for policy makers on the different scale-levels; national, regional (province) and local (municipality).

Research

Future research should focus on further operationalizing the energy justice concept into measurable indicators. The importance of justice in this transition is supported by the interview respondents, but also the lack of practical applicable tools to check whether justice is served. This research makes a first attempt in translating an abstract concept into practice. Future research can focus on ways to quantify different aspects and indicators of energy justice and prioritizing some over others. Furthermore, one case illustrates the issue, but for more detailed conclusions a comparative analysis between neighborhoods within the city of Amsterdam, between cities and regions within the Netherlands, and between countries within Europe are interesting to make.

Regarding the quantification of affordability, it would be interesting to further develop the use of the GINI index. Now it is used based on 16 socio-economic groups, but when time and data are available, it is a valuable method to compare different neighborhoods and effects of policy measures such as CO2-taxation. The GINI index can basically be performed on four different levels: unweighted (which is the case for the 16 socio-economic groups), roughly weighted (which is done in this research), ideally weighted and on the level of individuals. The latter providing most insight, since the heat costs are very personal as it depends on many factors such as; energy use, energy label of the home, household size, etc. In future research it would be highly interesting to use the GINI index to quantify the affordability of heat on an individual level.

Given the moral and ethical nature of this research, it would be good to further investigate how values are linked to justice in an energy-context and related to the heat transition. This could be done by more literature research, but also testing the assumptions based on a large sample is recommended, for example by conducting a questionnaire to find out which values are supported by a large and representative group of society.

Policy-makers National Government

The national government defines the policy that regulates the heat market. Based on the conclusions that shows the costs of energy for DH are extremely high and based on the interview respondents, I would recommend reviewing the NMDA-principle and changing the cost structure of heat provisioning. A number of reasons lead to the perceived sense of injustice; the price structure is not transparent, it does not reflect the real costs of production and it is connected to the gas price.

Furthermore, I would recommend not to further increase the tax on heat (services). Energy and heat services are an essential service. Even though taxation is reasoned to decrease the use of energy, this is mostly true for electricity. For heat services, lowering demand is more challenging, since warmth is more essential (especially in winter) and can therefore only be reduced so much. Keeping in mind the value of solidarity, to lead to a just outcome of the heat transition, it is recommended to use a socializing tax structure, that unburdens the low-income groups and places the costs at the strongest shoulders.

Policy-makers province North-Holland

Given the fact that the role of the province is to finance research, to bring stakeholders together, and to provide knowledge, there is the opportunity of accelerating the energy transition based on action on the level of the province. Since large differences exist between geographical areas (e.g. population density, availability of heat sources and knowledge within the municipality) the province should take a coordinating role in the heat transition. Currently in North-Holland this takes the shape of the steering group Heat-Cold, focused on the MRA, in a very practical way. The focus seems to be on practicalities of heat provisioning such as the availability, affordability and access. Given the fact that justice values are at stake, I recommend including these principles in policy-making on a regional level and consider them when making decisions.

Policy-makers Municipality Amsterdam

The municipality is the main governmental level to be leading the heat transition. First, I recommend to closely identify the people who are at risk of this transition. This includes being at risk in terms of affordability (increasing heat prices as a result of the transition), but is further includes identifying who is at risk of a reduction of choice and moreover of people who will struggle to participate in the process, because of lack of resources, knowledge, language barriers etc.

The Amsterdam municipality has the opportunity to increase the sense of justice in the transition by shaping a process that gives a central role to inclusiveness and democracy. Since, these values are supported by theory and found important by the interview respondents, I recommend addressing them in policy regarding the heat transition. Safeguarding these values can increase the societal-wide support for the transition away from natural gas. This practically means to invest in involving everyone, informing them in the most transparent way possible, handing decision-power to citizens possibly by elections, and giving them freedom to choose. All of this should have local character, because the complexity of the system does not provide generic solutions.

9

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Appendix A: Development of conceptual framework

A1 Conceptual framework before expert validation

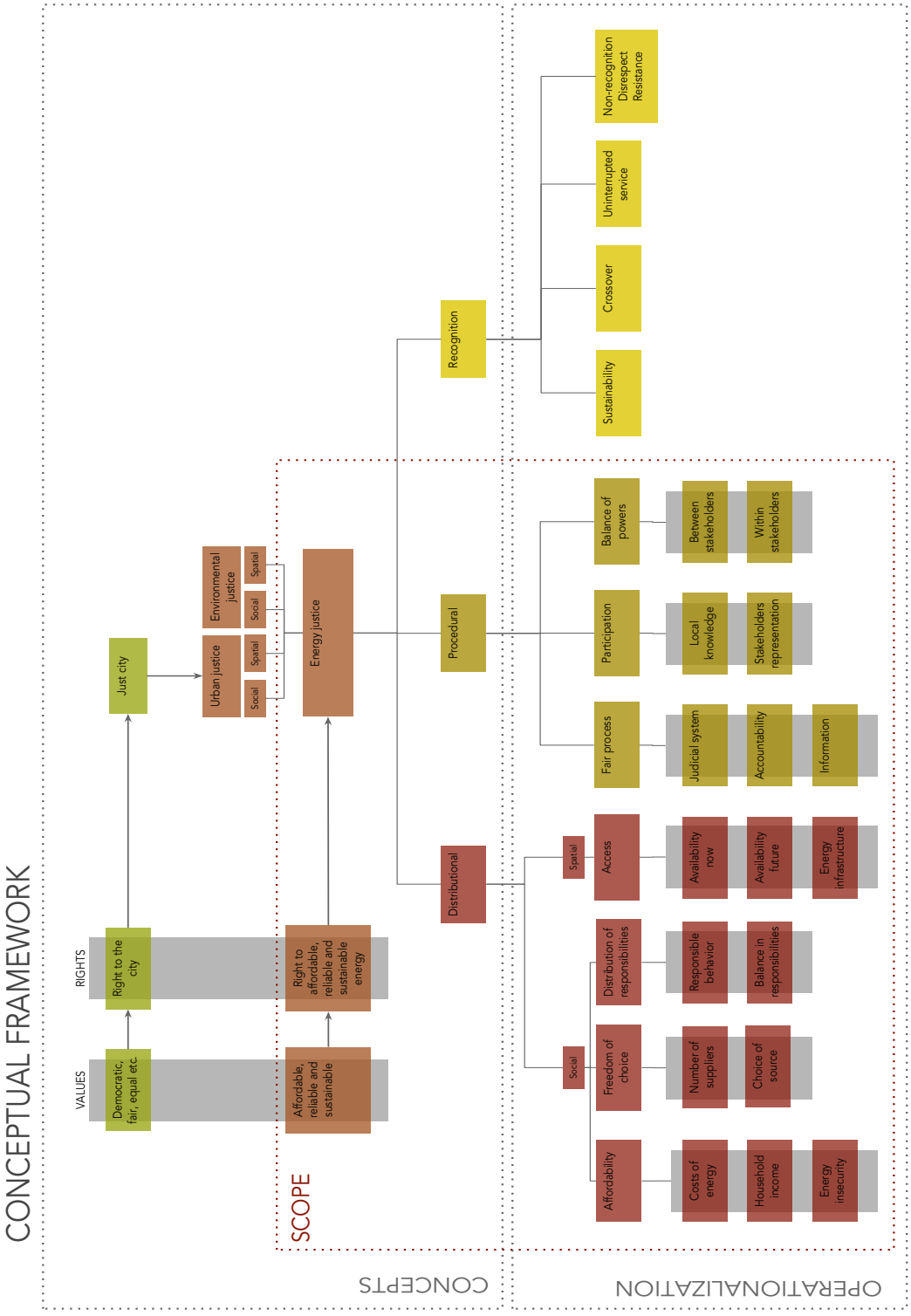

Figure 14. Conceptual framework before expert validation.

A2 Simplified conceptual framework in Dutch as used in interviews

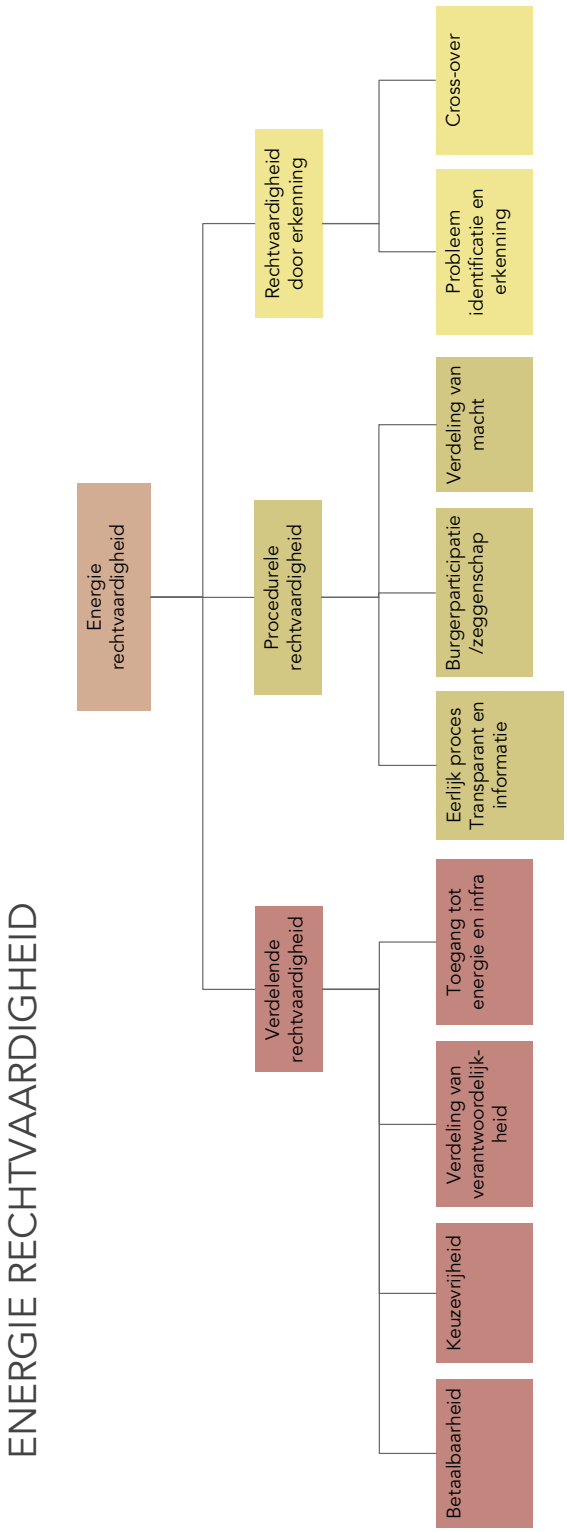

Figure 15. Conceptual framework in Dutch (simplified) for interviews.

Appendix B: Interview design and analysis

B1 Interview Framework Thesis (example)

Naam:
Organisatie/bedrijf:
Functie:
Interview nummer:

Introductie:
Allereerst bedankt dat u wilt meewerken aan dit interview dat energie rechtvaardigheid in kaart brengt. Energie rechtvaardigheid is een concept uit de academische literatuur. Doel van dit interview is om dit concept concreet te maken en toe te passen op de context van de warmtetransitie in Nederland.

Organisatorisch:

- Vindt u het goed als het interview wordt opgenomen?
- Vindt u het oké als uw naam wordt gekoppeld aan het interview of wilt u liever anoniem deelnemen?
- Als er quotes worden gebruikt uit tekst die voortkomt uit dit interview zal ik deze eerst voorleggen, voordat de scriptie wordt gepubliceerd.

Doel:

- Het conceptueel raamwerk valideren
- Een beeld krijgen van energie rechtvaardigheid in Nederland op lokaal, regionaal en nationaal niveau
- Inzicht genereren in het effect dat de warmtetransitie heeft op energie rechtvaardigheid.

- (WA) Waarden
- (RE) Rechten

Indicatoren energie rechtvaardigheid:

- (BE) Betaalbaarheid
- (KV) Keuzevrijheid
- (VV) Verdeling van verantwoordelijkheden
- (TO) Toegang tot warmte en koude
- (EP) Eerlijk proces
- (PA) Participatie
- (BA) Balans in macht

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1. Kunt u kort uw functie bij […] beschrijven en uitleggen hoe uw werkzaamheden betrekking hebben tot het thema energie?

Stap 1: Identificeren hoe waarden gelinkt zijn aan energie rechtvaardigheid en welke waarden hieraan ten grondslag zouden moeten liggen.

2. (WA) Op dit moment staan vooral de waarden betaalbaarheid, betrouwbaarheid en duurzaamheid centraal binnen het energiebeleid in Nederland. Denkt u dat deze waarden toereikend zijn? Zoja, beargumenteer dit. Zo nee, welke zou u toevoegen.

3. Bent u als directeur Strategie bezig met (energie)rechtvaardigheid? Zo ja, hoe?
4. Heeft u een definitie van (energie)rechtvaardigheid? Zo ja, wat is deze?

5. Binnen het begrip rechtvaardigheid is een bepaalde mate van ongelijkheid acceptabel. Hoe wordt in de NOVI vorm gegeven aan deze verschillen tussen groepen mensen in de samenleving?

Stap 2: Rechtvaardigheids indicatoren en conceptueel raamwerk. Is de lijst compleet?
7. Welke aspecten denkt u dat invloed hebben op energie rechtvaardigheid?

Conceptueel raamwerk laten zien en uitleggen.

8. Zijn alle indicatoren in het conceptueel raamwerk relevant?
9. Moeten er nog indicatoren bij die er nu niet op staan?

Stap 3: Hoe is het met energie rechtvaardigheid nu en hoe wordt dit beïnvloed door de warmtetransitie?

10. Door de warmtetransitie zullen er verschillen ontstaan tussen bepaalde groepen (bijvoorbeeld ruimtelijk: stad vs. platteland). Voorziet u dat deze verschillen voor ongelijkheid of onrechtvaardigheid zullen leiden? Zo ja, kunt u de groepen nader toelichten?

- Verschil koop/huur
- Verschil sociale huur/private huur
- Verschil bouwjaar woning

11. Op welke aspecten (die zijn te zien in het conceptueel raamwerk) voorziet u dat verschillen tussen bepaalde groepen toenemen?

12. (BE) Als energiearmoede is gedefinieerd dat meer dan 10% van het inkomen wordt uitgegeven aan de energierekening. Is energiearmoede een fenomeen dat u herkent als probleem in de praktijk?

13. (KV) Denkt u dat keuzevrijheid (met betrekking tot energiebron, leverancier etc) in het geding is als gevolg van de warmtetransitie?

14. Warmtenetten zijn een natuurlijk monopolie, waardoor veel burgers niet de keus van warmteleverancier en bron zullen hebben. Doet dit afbreuk aan rechtvaardigheid? Is het hebben van keus een 'must' volgens u?

15. (VV) Wie zou volgens u verantwoordelijk moeten zijn voor de verdeling van kosten en baten van de energietransitie?

16. (EP) Op basis van uw ervaring en observaties, is de huidige energietransitie een proces waarin informatie eerlijk en openlijk wordt gedeeld tussen de overheid, de markt en de burgers?

17. (BA) Hoe is op dit moment de verdeling van macht tussen actoren die invloed hebben op de warmtetransitie (overheid, markt, burger)?

18. (PA) Een van de trends in het energiebeleid is decentralisering. Hierbij worden lokale stakeholders en burgers steeds belangrijker. Hoe is op dit moment de vertegenwoordiging van lokale stakeholders in de warmtetransitie?

Stap 4: Wat doet […] aan rechtvaardigheid?

Er komen een aantal nieuwe beleidsmaatregelen aan die gevolgen zullen hebben voor mensen en hun energielevering. Veranderingen: (oplossingsrichtingen)

- NOVI
- Klimaatakkoord (Woonbond zat aan klimaattafel(s)?)
- Nieuwe warmtewet
- Decentralisering

19. Wat zullen de gevolgen zijn van de decentralisering voor de groepen die worden benadeeld door de energietransitie die we besproken hebben? (denk aan beleid etc)

20. Wie is er volgens u verantwoordelijk voor/ aan zet om de vraagstukken die aan bod zijn gekomen op te lossen? Op welk schaalniveau?

B2 Interview analysis framework

This table shows the concept, topics and indicators that were used to analyze the interview transcript. The last column is left empty here, which is where the answers are inserted for every respondent.

Concept	Concept	Topic	Indicators	Answers Interview Respondent
Energy Justice	Recognition Justice	Problem identification Problem recognition Cross-over	 Affected subjects Recognition of differences	
	Distributional justice	Affordability Freedom of choice Distribution of responsibilities Access	 Cost of energy Household income Energy insecurity Number of suppliers Choice of source Responsible behavior Balance in responsibilities Availability now Availability future Energy infrastructure Energy services	
	Procedural justice	Fair process Participation/control	 Judicial system Accountability Information Local knowledge Stakeholder representation	

		Balance of powers	Between stakeholders Within stakeholders	
	Sustainability			
	Values	Freedom of choice vs affordability Democratic Equal Inclusive Say (control)		
	Rights to	Affordable, sustainable, reliable energy		
	Solutions	Shift in expenses Income convergence Socialization of costs Housing corporations first Start with high consuming homes Nuisance	Gas price	
	Heat act	NMDA		
	NOVI/ Environmental Act	Spatial		
	Political debate	Responsibility Fairness		
	Policy	Historical trends Rents/ price development Liberalization		
	(Freedom of choice)	ownership		
	Technology	CV/ afleverset Security of supply District heating		
Quotes	Affordability/justice			

Table 18. Interview analysis framework.

Appendix C: Data input Lorenz curve and GINI-coefficient

C1 Estimation of group size and cumulative number of households

Group	Number of people in group (#)	Cumulative households (#)	Cumulative Percentage of households (%)
	0	0	0,0
1	49275	49275	12,9
2	49275	98550	25,8
3	49275	147825	38,6
4	15941	163766	42,8
5	15941	179707	47,0
6	15941	195648	51,1
7	8130	203778	53,3
8	49275	253053	66,1
9	49275	302328	79,0
10	15941	318269	83,2
11	15941	334210	87,3
12	8130	342340	89,5
13	15941	358281	93,6
14	8130	366411	95,8
15	8130	374541	97,9
16	8130	382671	100,0

Table 19. Estimated size of each socio-economic group and cumulative percentage of households.

C2 Input Lorenz curve gas costs as a share of income (%)

Group	Gas/income (%)	Share of gas	Cumulative share of gas	Percentage cumulative share of gas (%)
	0	0	0	0,0
1	8,79495294	4333,713063	4333,713063	22,3
2	8,00347868	3943,714118	8277,427181	42,7
3	7,3233459	3608,578694	11886,00588	61,3
4	5,81103991	926,337872	12812,34375	66,0
5	5,76337489	918,7395908	13731,08334	70,8
6	3,54729869	565,4748843	14296,55822	73,7
7	3,24114428	263,5050301	14560,06325	75,0
8	3,20666987	1580,08658	16140,14983	83,2
9	3,0766928	1516,04038	17656,19021	91,0
10	3,05232678	486,5714121	18142,76162	93,5
11	3,05232678	486,5714121	18629,33304	96,0
12	2,16855345	176,3033954	18805,63643	96,9
13	1,68918499	269,2729797	19074,90941	98,3
14	1,39048215	113,0461988	19187,95561	98,9
15	1,3879278	112,8385305	19300,79414	99,5
16	1,26853649	103,1320166	19403,92616	100,0

Table 20. Gas a share of income, cumulative for households in socio-economic groups.

C3 Input Lorenz curve heat costs as a share of income (%)

Group	Heat/income (%)	Share of heat	Cumulative share of heat	Percentage cumulative share of gas (%)
	0	0	0	0,0
1	13,03613796	6423,556981	6423,556981	22,8
2	11,86299152	5845,489073	12269,04605	43,5
3	10,85487872	5348,741489	17617,78754	62,4
4	7,719453253	1230,558043	18848,34559	66,8
5	8,542643791	1361,782847	20210,12843	71,6
6	4,900570564	781,1999535	20991,32839	74,4
7	4,343047893	353,0897937	21344,41818	75,6
8	4,560806567	2247,337436	23591,75562	83,6
9	4,375941803	2156,245324	25748,00094	91,2
10	4,341286311	692,0444508	26440,04539	93,7
11	4,341286311	692,0444508	27132,08984	96,1
12	2,905804453	236,241902	27368,33174	96,9
13	2,446081197	389,9298037	27758,26155	98,3
14	2,013534489	163,7003539	27921,9619	98,9
15	1,997219225	162,373923	28084,33582	99,5
16	1,825415888	148,4063117	28232,74214	100,0

Table 21. Heat a share of income, cumulative for households in socio-economic groups.

Appendix D Full conceptual framework

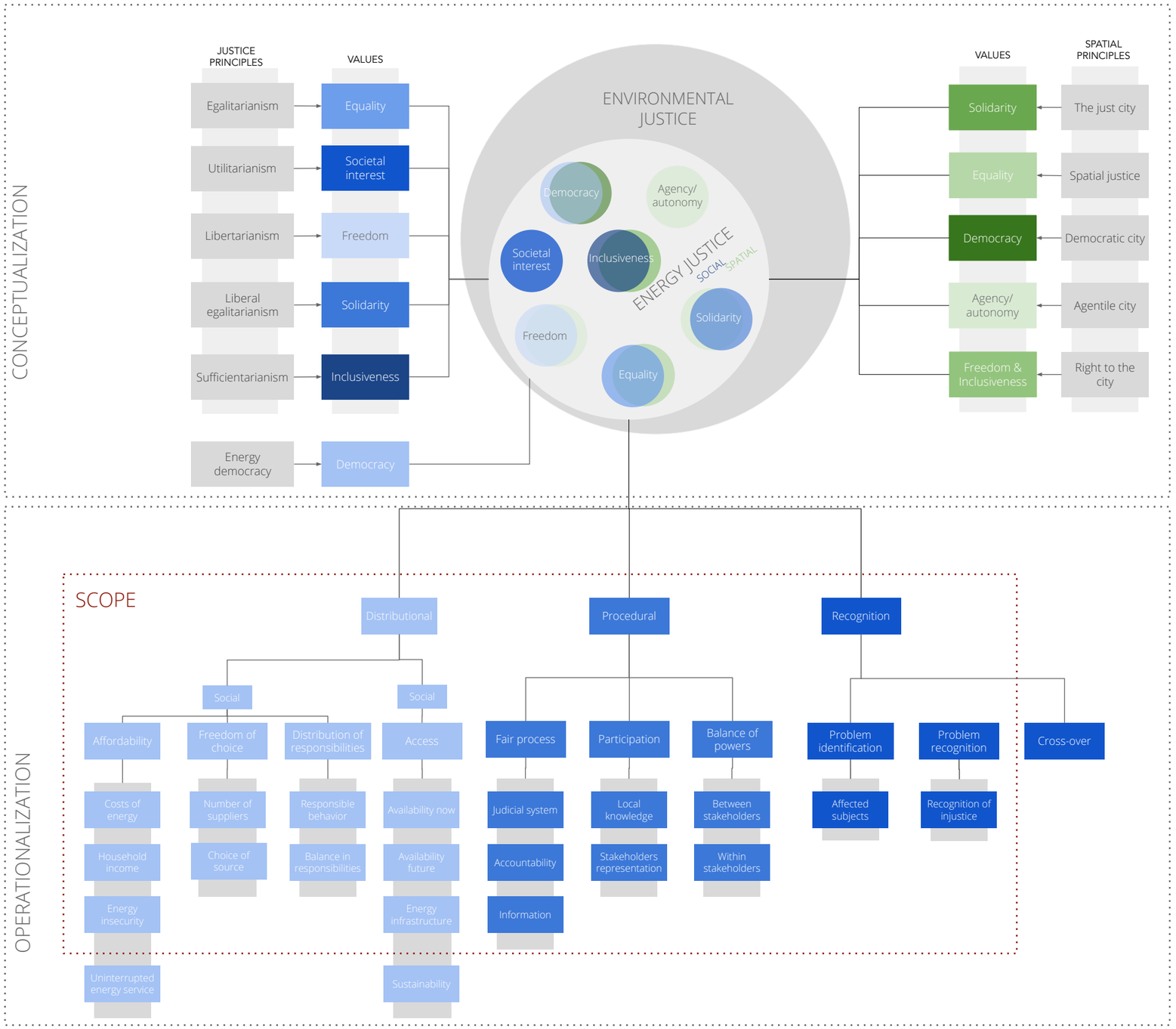

Figure 16. Full conceptual framework