Msc Thesis in Engineering and Policy Analysis

Delft University of Technology

Investigating whether the engagement of citizens in energy communities could lead to a rise in energy justice

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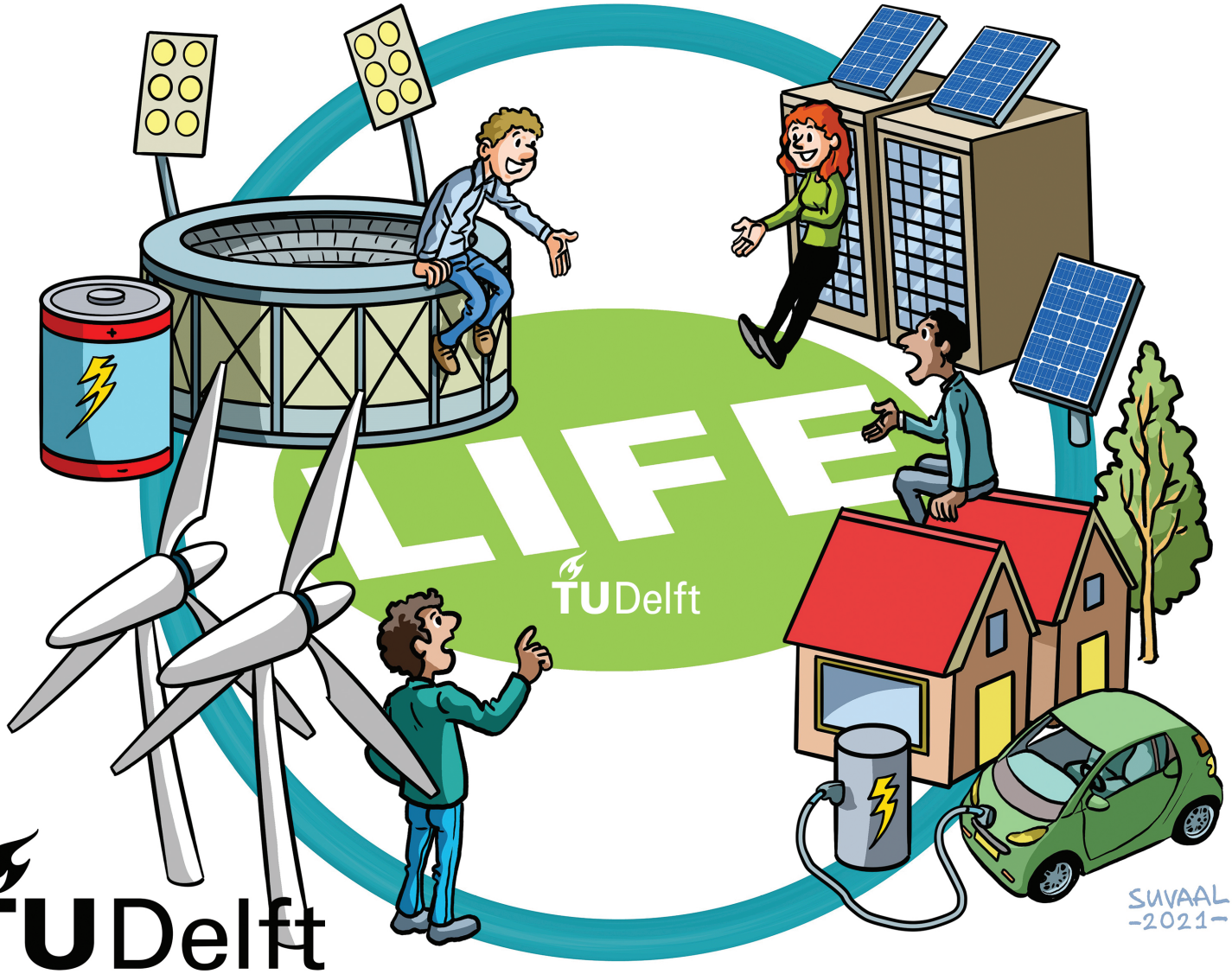
August 2022



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INVESTIGATING WHETHER THE ENGAGEMENT OF CITIZENS IN ENERGY COMMUNITIES COULD LEAD TO A RISE IN ENERGY JUSTICE

A thesis submitted to the Delft University of Technology in partial fulfillment of the requirements for the degree of

Master of Science in Engineering and Policy Analysis

by

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August 2022

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Cover Image: (SUVAAL 2021)

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ABSTRACT

Energy Communities (ECs) are initiatives ran by members of the same or different communities with the aim of producing, distributing and consuming cleaner energy. The potential of these initiatives, as identified from this clean energy production, to play a key role in the energy transition is assumed to be vital as recognized by the European Commission's Clean Energy for All package and the provision of a legislative framework for their operation in European countries (Caramizaru and Uihlein, 2019). In the light of this, European policy makers assume that promoting the engagement of more citizens in such initiatives will lead to a rise in energy justice and a fairer energy transition. However, several researches show that this assumption maybe flawed as the relation between the two is not explicitly verified. Through the acknowledgement of minority groups, this research aims to investigate whether an increased citizen engagement in ECs could lead to a rise in Energy justice. For this, the research is broken down into three key steps involving: 1) investigating what factors could affect the willingness of citizens to engage in ECs by conducting a literature review and then evaluating potential influence of the identified factors for the city of The Hague as case study area, 2) investigating the distribution of the identified factors around areas with ECs to find out whether there are any social groups favoured by the distribution of these factors around neighbourhoods with 24 ECs. This is done by conducting spatial data analysis to investigate whether the engagements of any particular social groups or classes of people might be favoured by the spatial locations of ECs in specific areas of The Hague 3) finally by conducting one on one interviews with 8 board members of ECs in The Hague, the research seeks to investigate the relation between the identified factors potentially affecting citizens' desires to engage and the three tenets of energy justice. The results show that in the city of The Hague, although a majority of neighbourhoods in which ECs are located are characterized by a high number of minority groups, a high majority of the ECs interviewed (7 out of 8) acknowledge that minority groups are generally less involved. However for the classes of people engaging in such initiatives, a majority seeks to raise their powers and that of other community members in the decision making process. Hence, this allows to conclude that for the case study area, ECs might only lead to a limited rise in Energy justice due to the partial or non-acknowledgement of minority groups. These results align with those of (Hanke et al., 2021), who after studying the presence of energy justice in 71 European ECs concludes that care must be taken when referring to such initiatives as initiatives promoting energy justice due to the limited extent to which they promote energy justice. Similarly, the results also align to that of (Mundaca et al., 2018), who finds out from two case studies in Denmark and Germany that only certain classes of people usually benefit from the opportunities provided by ECs.

ACKNOWLEDGEMENTS

I deeply believe the most significant changes in life occur when citizens decide to take leadership of their destinies!

It is with this belief that I decided to conduct this Master's thesis research on the topic of energy communities, as I believe the actions lead by the members of these initiatives have the potential to generate more rapid impact on the society than those coming from the top !

As I finalize this thesis report, I would like to extend my special gratitude to my third thesis supervisor Dr. ir . Ö. Özge Okur for introducing me to this research topic and for following my work on weekly basis under the supervision of the committee Chair Prof.dr. M.E. Martijn Warnier, whose straightforward, easy to understand, quick and detailed feed-backs highly contributed to the finalization of this report. Words cannot express my gratitude for my second committee member Dr. J. Jenny Lieu for her very insightful feed-backs, kindness and generous availability for sessions requested even with short notice.

I would also like to thank my family whose belief in me has always kept my spirit and motivation high during this process. Finally, I would like to thank my bachelors degree supervisor Asst. Prof. SALTUK BUĞRA SELÇUKLU for whom I have the greatest respect for his constant support though out the duration of my Masters degree.

Elie Christian Azeufack
August 2022

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ACRONYMS

1 INTRODUCTION

1.1 ENERGY COMMUNITIES

The term "Energy Communities (ECs)", as discussed by different authors owes its origin to various social and environmental movements that rose across Europe in the 1960s and to the "oil shocks" that happened in the early 1970s (Hewitt et al., 2019). With time, ECs have been used to denote a diverse range of energy actions undertaken collectively by citizens to participate in different areas of the energy system with diverse levels of involvement, motivations and in different geographical areas (Caramizaru and Uihlein, 2019). According to (Moroni et al., 2019), these diversities make the definition of the term problematic as different authors have used different conflicting definitions in different areas. (Brummer, 2018) on the other hand emphasizes that all definitions for ECs must incorporate the aspects of ; 1) more sustainable systems in their technological sides and 2) systems allowing more democratic management and participation. In the light of these, the definition used in this research is that acknowledged by the European Union (EU) in its "European Clean Energy for All Package", where it defines energy communities as: «a way to 'organise' collective energy actions around open, democratic participation and governance and the provision of benefits for the members or the local community» (Caramizaru and Uihlein, 2019).

1.2 TYPES OF ENERGY COMMUNITIES

(Moroni et al., 2019) identifies four types of energy communities; the first type being 1) "place–based communities" which are communities made of members coming together based on the closeness of their spatial locations and sharing common objectives and cohabitation rules. Place-based communities will be explored in this research to examine how citizen engagement in such communities could affect energy justice in a selected case study area. The second type, which is the 2) "non place–based community" is formed by members having no common spatial connection to a specific area. A good example can be a group of people from different cities in the Netherlands buying a share of an energy project in Rotterdam. The third type identified is the 3) single purpose community, which is one whose members involve just for the purpose of producing and consuming or purchasing energy. The final type, the 4) multi–purpose community on the other hand has members who, in addition to sharing the same energy objectives, also share various types of goods and services.

1.3 ENERGY JUSTICE

According to (van Bommel and Höffken, 2021), "Energy Justice" exists in a community if there is an equitable share of the costs and benefits of the global energy system and an equal representation of different groups in the decision making process. In the same line, (Lacey-Barnacle, 2020) identifies the following four tenets of energy justice;

1. **Procedural justice**: This involves the taking part of citizens in energy related decision making processes. This form of energy justice is the most important reason why citizens engage in energy community initiatives. Similarly, in a research to study citizen perception of the energy transition, (Lennon et al., 2019) determined that citizens not taking part in energy community initiatives often feel restricted in their number of choices as simple "Energy Consumers" and do not often get a sense of having power in the decisions made regarding their energy consumption.

2. **Distributional justice**: This form of energy justice occurs when there is an equal sharing of burdens and benefits of energy systems between all community members. The lack of procedural justice often leads to inequitable energy configurations in the society with different groups not having the same share of the benefits and burdens of the energy system.

3. **Recognition justice**: This tenet of energy justice aims at ensuring the acknowledgement of marginal groups in energy systems. Marginal groups refer to groups of people of a particular culture facing high risks of discrimination in a given context based on characteristics such as age, ethnicity, gender, religion or belief, education, income, sexual orientation, gender identity, health status or due to the geographical areas in which they reside (EIGE, 2022). In general, minority groups, who are groups representing national or ethnic, religious or linguistic groups and who are generally fewer in number than the rest of the population group sharing a common identity are the most marginalized groups together with indigenous people in different societies, facing exclusion from involvement in the socio-economic life, and have rare access to political power (UNHCR, 2022). According to (van Bommel and Höffken, 2021), in Europe, ECs seem to be dominated by rich or middle class, white and retired men. Similarly, (Lazoroska et al., 2021) and (Allen et al., 2019) argue from a gender based perspective that ECs, despite having more men than women in their memberships, still have the power to raise issues in terms of women's voices when included.

4. **Restorative justice**: This is a form of energy justice which involves the improvement of perceived injustices

1.4 PROBLEM DEFINITION AND KNOWLEDGE GAP

Energy communities have an enormous potential to promote the energy transition due to their decentralized and citizen-led nature. On the 22nd of May 2019, the EU commission recognized this potential by adopting the "Clean Energy Package for all Europeans", in which it provides a legal framework to promote the creation of renewable energy communities in its member states (Caramizaru and Uihlein, 2019). This package was created with the assumption that a higher number of such initiatives will provide a wide range of benefits to resolve energy justice issues. However in the literature, although several attempts were made by (Hanke et al., 2021), (Forman, 2017), (Mundaca et al., 2018) and (van Bommel and Höffken, 2021), no explicit link between such initiatives and their ability to resolve energy justice issues has been identified. Rather, the attempts from (Hanke et al., 2021) and (Forman, 2017) suggest to further investigate the existence of context specific ties between energy communities and energy justice in different European countries due to the crucial role played by contexts in determining the strategies used to achieve energy justice. On the other hand, in their research to critically analyze successful low carbon energy transitions from an energy justice perspective, (Mundaca et al., 2018) fail to acknowledge minority groups whose inclusion in the view of (Lacey-Barnacle, 2020) is foundational for the achievement of all instances of energy justice.

In the light of the aforementioned points, it becomes clear that there is a lack of knowledge about the ability of ECs to lead to an increase in energy justice. Thus, it follows that a bottom-up approach investigating a context specific case while integrating the inclusion of minority groups and then relating the findings to the general global situation might provide more clarity to the existing gaps. Further, to supplement the investigations made by (Hanke et al., 2021),(Forman, 2017),(Mundaca et al., 2018) and (van Bommel and Höffken, 2021), a more quantitative approach might provide a significant contribution to the existing qualitative findings.

1.5 RESEARCH QUESTION AND SUB – RESEARCH QUESTIONS

The Research Question (RQ) and SRQs provided in this section are developed to facilitate the investigation of a context specific link between energy communities and their ability to lead to a potential rise in energy justice through the inclusion of minority groups. Moreover, the questions also aim to integrate a quantitative approach at a given stage of the research as described in section 1.4:

RQ: What is the relation between citizen engagement in Energy communities and Energy Justice?

SRQ1: *Which factors could influence the willingness of citizens to engage in energy communities?*

SRQ2: *What is the distribution of factors potentially affecting citizen willingness to engage around areas with energy communities?*

SRQ3: *What effects could citizen engagement in energy communities have on energy justice?*

1.6 RESEARCH APPROACH

This section provides a brief summary of the methods used in this research; at the start of each chapter, a more detailed description of the different research methods used is provided with justifications for their selection.

First, in order to answer SRQ1, a literature review is conducted to identify the different factors that affect the willingness of citizens to engage in ECs in different parts of the world. Then, a case study approach is used to identify an area of interest (the city of The Hague) to serve as the context specific area as discussed in section 1.4. Later, an online survey is conducted in the province of South Holland due to its closeness to the case study area to evaluate how the factors identified from the literature review could affect (provide insights) citizens' motivations to engage in the city of interest. It is important to emphasize that while the case study area is the city of The Hague, the survey is conducted for the province of South Holland rather than the city itself due to time constraints and for technical reasons. Moreover, as the research seeks to contextualize the findings to the case study area as much as possible, it assumed that evaluating the situation for the province in which the case study area is located might provide insights which are closest to its real situation due to the closeness of the locations of respondents. In the second phase, SRQ2 is investigated by performing spatial data analysis around neighbourhoods with 24 ECs in the case study area. This allows for the determination of the distribution of the factors identified from SRQ1 around the areas with energy communities. Then using the results from the second SRQ,

interviews are conducted with 8 board members of different energy communities in the case study area to find out whether there is a presence of the recognition justice and the other energy justice tenets in their initiatives as a result of their engagement. Following this section, a section dedicated to the interpretation of the results and how each SRQ contributes to answering the main research question is elaborated. Finally, a discussion section is provided followed by the research conclusion.

1.7 SOCIETAL RELEVANCE

Across the 28 EU Member states, there is an intense situation of energy poverty faced by about 82.3 million people (Bouzarovski et al., 2020). These people, often constituting energy vulnerable groups are usually left aside from the energy transition process as they are not able to benefit from its opportunities such as lower energy fairs and higher efficiency (Hanke et al., 2021). However, in the EU 2018 Directive on the promotion of the use of energy from renewable sources, it is clearly mentioned that the participation in Renewable energy communities must be accessible to all energy consumers including those from vulnerable households with low income (EU, 2018). So, establishing the link between engagement in energy communities and energy justice is vital to ensure that the measures and investments put in place by different institutions will lead to a more equal and inclusive energy transition.

1.8 SCIENTIFIC RELEVANCE

This research contributes to the scientific knowledge in several ways; first, it makes use of an online survey whose results are analyzed qualitatively to determine the factors potentially affecting citizen willingness to engage in ECs in the province of South Holland in which the case study area is located. Although (Koirala et al., 2018) previously conducted a survey covering the whole country, the aim of their research was different and less contextualized to the case study area due to the broadness of the area covered. Moreover, focus was on different factors than those of this research. Further, this research makes use of spatial data analysis to investigate the distribution of identified factors potentially affecting the motivations of citizens to engage in ECs and subsequently determines whether energy communities are representative of the areas in which they are found. From the literature, no previous studies involving the use of spatial data analysis to investigate the potential presence of energy justice in ECs was found. Likewise, while previous research has focused on procedural and distributive justice, this research has a particular focus on recognition justice which is assumed to be foundational for the first two as discussed in section 1.3. Finally, the research contributes to filling the gaps identified by (Forman, 2017) and (Hanke et al., 2021) where they suggest to investigate energy justice in a context specific situation and further relating it to the existing general situation.

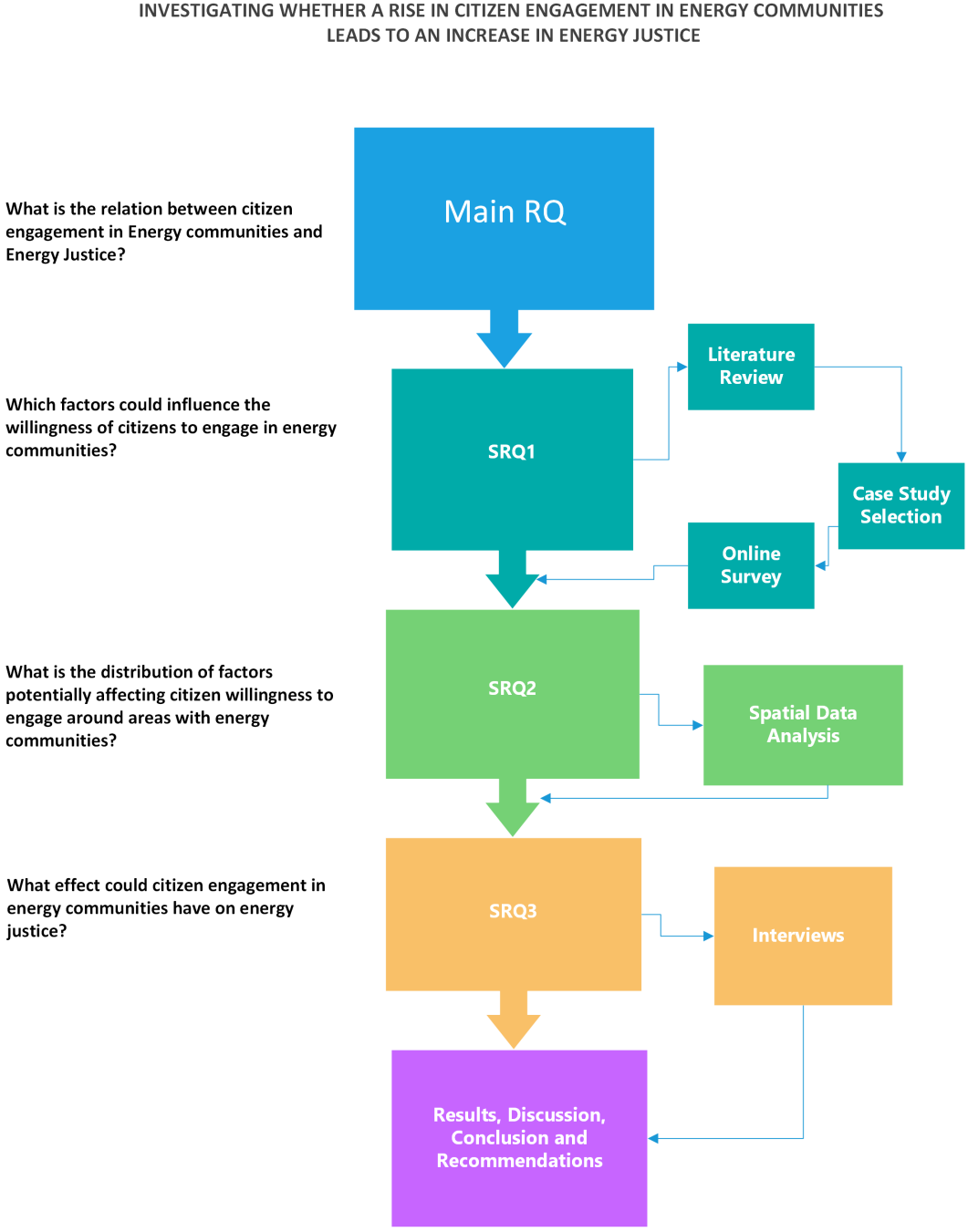

Figure 1.1: Research Flow Diagram

2 FACTORS AFFECTING WILLINGNESS TO ENGAGE

This section describes the different methods used to answer SRQ1 and the results obtained from these. In order to investigate this SRQ, three different methods are used. In a first instance, a literature review is conducted to identify the factors affecting citizens' desires to engage in ECs in different areas of the world. This is followed by the use of a case study approach to identify an area to scope down the research. Then, since place-based energy community members come together based on the closeness of their spatial locations as discussed in section 1.2, a survey is conducted in the region surrounding the case study area to evaluate the factors that may potentially affect citizen willingness to engage in the selected case study area. At the end of each method, justifications for choosing them are provided.

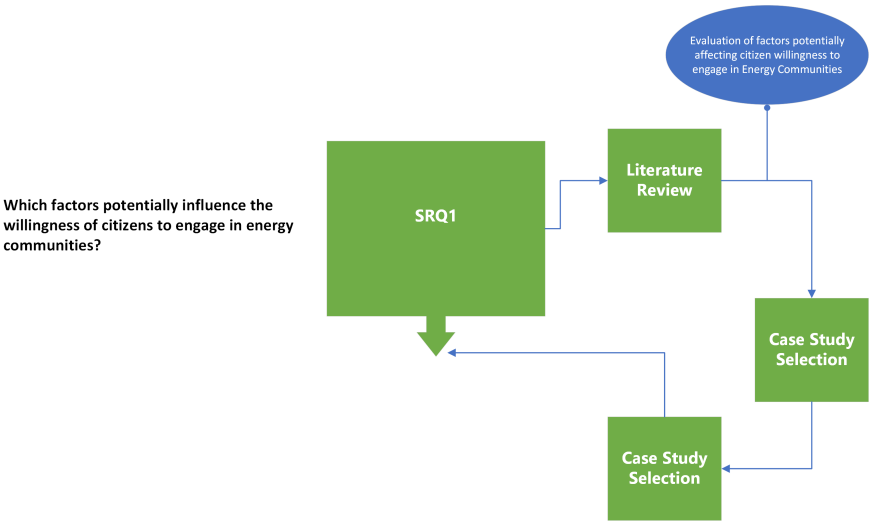

Figure 2.1: Research Flow Diagram

2.1 LITERATURE REVIEW

In order to investigate the factors potentially affecting the willingness of citizens to engage in ECs, a review of the literature was deemed most appropriate as a first step. At the onset of this research, a literature review was conducted and the factors affecting the willingness of citizens to engage in ECs were identified. Literature review was thus deemed most relevant as the findings were known from the onset. The advantages of using this technique are thus the fact that it informs about the factors on which more focus should be placed for the subsequent phases of the research and it also allows to mitigate most flaws arising from the re-writing of a literature review such

as 1) feeling overloaded by the amount of information, 2)starting everything from scratch which is often quite tough or 3)having to re-read articles for verification or validation purposes (Silyn-Roberts, 2013).

2.1.1 Literature Review Process

This section describes the methodology used for the literature review. In the initial phase of the process, the keywords "citizen engagement/ participation", and "Energy communities/ cooperatives" were developed. Then, these keywords were primarily associated to the terms "socioeconomic / sociodemographic" and "factors" to make different search queries based on the topic of interest as indicated in Appendix A.1. Using these, a search targeting primary materials such as reviews, articles, conference materials and scientific papers was made on the platforms Scopus and Google scholar. From a first search on Scopus, due to the high level of specificity of the keywords in the query, only three search results were found. From these, 1 scientific paper was identified as highly relevant with 68 citations. Then, the snowball method was performed on this paper, modifying the initial keywords and finding other papers that cited the initial one on both platforms. Later, with search queries associating less keywords, 132 search results were found. Materials found were deemed relevant when they included terms related to factors influencing citizen engagement in energy communities. At the end, 15 papers were deemed relevant and appropriate for use to carry out this research.

2.1.2 Literature Review Findings

According to (Koirala et al., 2018), the most important determinants of citizens' desire to engage in Energy communities are; energy related education and awareness about the presence of local energy initiatives, renewable energy acceptance , environmental concern, education, community resistance, energy independence and community trust. The perceived drawbacks on the other hand are lack of time, trust issues, lack of financial resources and technical know-how. Likewise, in addition to trust and environmental concern, (Bauwens and Eyre, 2017), in his research to explore the links between community based governance and the use of sustainable energy realizes that most cooperative members are from the upper middle socio - economic class. Similarly, (Kalkbrenner and Roosen, 2016) perceives environmental concern, social norms and income as the main factors affecting citizen willingness to engage in energy communities. In the same line, (Fleiss et al., 2017), after investigating the effect of desires and beliefs on private investment in solar energy citizen engagement initiatives identifies financial beliefs as the main drawback to participation in such initiatives. To strengthen the previous findings, (Radtke, 2014), in his research to investigate citizen participation in energy communities identifies income, education and knowledge about such initiatives as the main motivators for citizen engagement. (Network, 2021) similarly identifies the main barriers to citizen participation as economic, technical and institutional. Finally, while (Lazoroska et al., 2021)

realizes that most energy community board members are males, (Kracher and Mundaca, 2021) highlights in his findings that there might be a need for different strategies in order to recruit citizens to such initiatives based on their genders and incomes.

2.1.2.1 Literature Review Knowledge gaps

In the literature, several factors were identified as key contributors to the drawbacks for citizen participation in energy communities; 1) previously, (Koirala et al., 2018) made a multi–variate regression analysis with survey data from 599 Dutch citizens to study the influence of socioeconomic, demographic and environmental factors affecting citizen's desire to take part in energy community initiatives. At the end, he concludes that there is still a limited understanding of factors that influence the citizens' desire to participate in such initiatives. Similarly, 2) (Kalkbrenner and Roosen, 2016), after conducting a survey with household members in charge of energy related financial decisions in Germany suggests for future research to include indicators related to community trust and readiness to take risk. Likewise, other survey research from 3) (Radtke, 2014) and (Fleiss et al., 2017) suggest that factors such as education and income may affect citizens' willingness to engage. Other qualitative research from 4) (Lazoroska et al., 2021), (Magnusson and Palm, 2019) and (Koirala et al., 2016) recommend for future research to investigate socioeconomic factors affecting engagement in energy communities such as age, ethnicity and class.

2.1.2.2 Summary of Findings

The literature review results are summarized on the table 2.1 below:

Factors affecting willingness to engage:	Energy education, awareness about existing local energy initiatives, renewable energy acceptance , environmental concern, age, education, community resistance, energy independence, trust, time, ethnicity,income ,technical know-how, social norms, gender
Knowledge Gaps:	General limitation in understanding about the factors affecting willingness to engage, Trust, readiness to take risk, education, income, age, social class and ethnicity

Table 2.1: Literature Review findings and Knowledge Gaps

One of the main observations from the literature review is that there is still a general limitation in the understanding of the factors that influence citizens' desires to engage in energy communities. Moreover, a majority of the key identified factors also constitute existing knowledge gaps.

2.2 CASE STUDY APPROACH

In order to scope this research, a case study approach was deemed most relevant. According to (Crowe et al., 2011), a case study approach is used to obtain a deep appreciation of a complex multi–faceted phenomenon or issue in its real life context. For the study to be suitable, the case study area must have relevant boundaries identifying the relevant social group(s), geographical area or organization to allow for in-depth study of the phenomenon of interest. In the context of this research, the selected case study area is the city of The Hague and the focus is on all its energy communities whose information is provided by its Municipality and its partner ECs for this research. On the other hand, it is important to note that although the case study area is the city of The Hague, the online survey in section 2.3 is conducted for the province of South Holland. Similarly, while an ideal situation would be the conduction of this survey only within the case study area, this was not possible within the frame of this research due to technical reasons and time constraint. The survey was thus disseminated in the province in which the case study area is located to contextualize the findings as much as possible to the city of interest as the inhabitants of its surrounding regions were assumed to have the most similar habits to those of the case study area due to the closeness of their locations.

- ***Justification***

The city of The Hague is also known as "The legal capital of the world" with over 160 International Organizations including the International criminal court having their offices in the city (TheHague, 2021). In light of this, it is argued in this research that identifying any issues of energy justice in a city with this significance for the world can provide a strong basis for any quest for changes in the field of energy justice or promoting a fair energy transition at the energy community level. However, although the selection of this city might seem very appealing, flaws might arise leading to lots of theoretical generalizations if the city is not fit for purpose. To mitigate this, a prior search was made to verify the presence of a fair number ECs in the city and a total number of 24 identifiable ones were found. Moreover, to supplement this, the municipality regularly updates datasets containing information about different socio-economic factors for the city on its website. This information can be used to further investigate the results obtained from table 2.1.

2.3 MIXED METHOD APPROACH

A mixed method approach involves a collection and analysis of both qualitative and quantitative data within the same research (Shorten and Smith, 2017). Generally, this method is used to answer research questions which can neither be answered only by using qualitative or quantitative methods. In the light of this, the decision is made to answer SRQ1 by using a mixed method approach involving in a first instance conducting a qualitative online survey to which weighted questions are added for ranking purposes.

Moreover, as discussed in section 2.2, this online survey is conducted for the province of South Holland as it was not possible to confine the study just to the city of The Hague within the frame of this research due to time constraints and for technical reasons.

- ***Justification***

After obtaining information about the socio-economic factors affecting citizens' desire to engage in ECs in different parts of the world as summarized in table 2.1, it was deemed most relevant to conduct an online survey in and around the case study area. The aim was to use these results to evaluate how these identified factors could potentially affect citizens' desires to engage in ECs in the case study area as required by the SRQ. According to (Ponto, 2015), one of the most recurring flaws occurring with surveys is having people who are not part of the target population filling the questionnaires. This issue was mitigated by asking questions requiring the respondents to indicate whether they live in the region of interest as shown in appendix A.2. Responses from people not living in the province of South Holland were discarded.

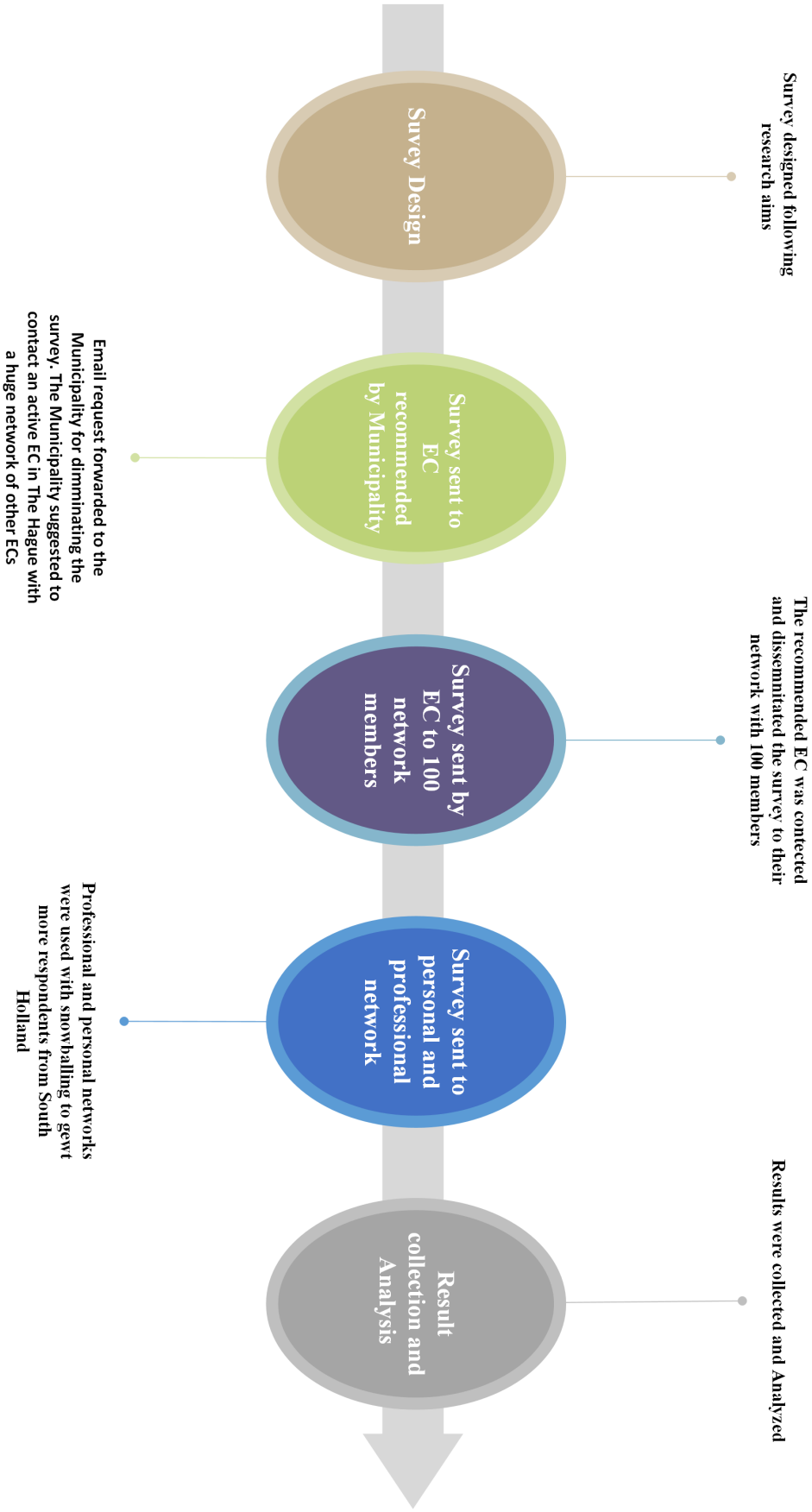

Figure 2.2: Mix - Method Approach Process Overview

2.3.1 Research design and Data Collection

The first step used in the data collection process was to determine the relevant factors to be investigated from those identified from the literature review (table 2.1). For this, it is important to recall that the research aims to find out the relation between citizen engagement in ECs and energy justice by integrating the recognition justice lens due to its foundational nature for other energy justice tenets. As defined in section 1.3, recognition justice ensures an acknowledgement of marginal groups in the energy system. These marginal groups by definition are groups of people facing high risks of discrimination on the basis of their ages, genders, education levels, incomes, sexual orientations or due to the areas in which they live. Similarly, minorities are often among the most marginalized groups in the world (UNHCR, 2022). On the basis of this, the factors listed on table 2.2 were selected for further investigation through the online survey. A major advantage of using these factors is that information about them is available on the Municipality of The Hague's website and this will allow for the evaluation of SRQ2 through spatial data analysis. Moreover, this choice ensures the same indicators used to conduct the survey are also utilized for the spatial data analysis. A point to note is that the employment status factor was included due to its close link to the income level, its influence on peoples' availability to get involved in initiatives during their free times and also based on (Bauwens and Eyre, 2017)'s finding stipulating that most ECs members are from the upper-middle socio-economic class.

Factors Investigated through the survey	Age Gender Income Ethnicity Employment status Education

Table 2.2: Factors Investigated though the survey

2.3.1.1 Survey Design

The survey used for this research was designed using the sample from (Kalkbrenner and Roosen, 2016). Using the software called "Qualtrics" provided by the Delft University of Technology , the survey was designed with a series of multiple choice questions where respondents were asked to choose their age ranges, income, genders, ethnicity, employment status and levels of education. Moreover, the respondents were asked to indicate their likelihoods to engage voluntarily in renewable energy communities during their leisure times by choosing between the options very likely, somewhat likely, neither likely nor unlikely, somewhat unlikely and very unlikely. To ensure all responses came from people living in the region of interest, the respondents were asked to choose the province in which they reside. The online survey questions are found in appendix A.2

2.3.1.2 Data collection

The survey was disseminated online to a mailing list containing 100 Energy community members in The Hague with support from the Municipality and an energy community having a huge network in the city, through professional and personal networks in the province of South Holland throughout the months of May and June 2022. The data was collected and saved as a CSV file downloaded from an online platform designed for the survey software. At the end, a total number of 104 responses were received from people living in the province of South Holland through the online survey. Table 2.3 shows the nature of the data collected.

Variables	Category	Total	Percentage
Gender	Males	64	61.5
	Females	40	38.5
Age	Under 18	1	0.09
	18 - 24	50	48
	25 - 34	39	37.5
	35 - 44	4	3.8
	45 - 54	4	3.8
	55 - 64	3	2.9
	65+	4	3.8
Ethnicity	White	48	46.1
	Black or African descent	24	23.1
	Asian	11	10.6
	Hispanic	8	7.7
	Other	14	13.5
Level of Education	University	92	88.5
	High School	9	8.7
	Secondary School	2	1.9
	Higher Vocational Education	2	1.9
Employment Status	Unemployed	42	40.4
	Part time worker	39	37.5
	Full time worker	19	18.3
	Retired	4	3.8
	Prefer not to say	1	1
Average Annual Income	Unemployed	37	35.6
	< 28800 Euros	35	33.7
	28800 Euros	2	1.9
	Between 28800 and 57000 Euros	18	17.3
	> 57000	7	6.7
	Do not want to disclose	6	5.8
Likelihood to volunteer in Renewable Energy initiative	Somewhat likely	27	26
	Somewhat Unlikely	20	19.2
	Very Likely	20	19.2
	Very Unlikely	20	19.2
	Neither Likely nor Unlikely	15	14.4

Table 2.3: Demographic and socio-economic characteristics of respondents

2.3.1.3 Demographic Representation and Validity of Survey Results

Table 2.3 shows the full overview of the information collected from the different survey respondents. Table 2.4 on the other hand shows the age groups (18 -24 and 25 -34) and employment groups(part-time workers and unemployed people) whose number of respondents would be deemed significant for a statistical analysis due to the availability of a fairly equal or high number of respondents for all groups. Regarding the level of education, there is an extremely higher number of respondents from the university, which could negatively affect a statistical analysis for university level students and render the results insignificant. However because SRQ1 seeks to investigate the factors that could potentially affect the willingness of citizens to engage in ECs, the insights generated by using all the survey results are considered very relevant and insightful for formulating hypothesis used for the investigation of SRQ2. It is thus important to point out to the fact that the survey results are not used to measure significant relationships between the different indicators but to rather provide more qualitative data to allow for the exploration of the potential for some factors to influence citizens' desires to engage in ECs in the region of interest.

Variables	**Category**	**Total**	Percentage
Age	Under 18	1	0.09
	18 - 24	**50**	48
	25 - 34	**39**	37.5
	35 - 44	4	3.8
	45 - 54	4	3.8
	55 - 64	3	2.9
	65+	4	3.8
Level of Education	**University**	**92**	88.5
	High School	9	8.7
	Secondary School	9	1.9
	Higher Vocational Education	2	1.9
Employment Status	**Unemployed**	42	40.4
	Part time worker	39	37.5
	Full time worker	19	18.3
	Retired	4	3.8
	Prefer not to say	1	1

Table 2.4: Indication of the significant survey results

2.3.1.4 Analysis

Initially, the downloaded data was cleaned and analyzed using the software "Python". Then later, in order to find the factors potentially having the most influence on the willingness to engage, it was necessary to rank the variables obtained for each category. For this, the likelihoods for citizens to volunteer

in a renewable energy initiative during their free time were assigned weights as indicated on table 2.5. Then for each group of indicator, the sum of all weights was calculated and divided by the total number of respondents in the group to obtain the mean values per category. Using these, each category was ranked based on the magnitude of the average value obtained from the calculation. All calculations made in this section are described in Appendix A.3

$$Formula = \frac{\sum weights}{(Number\ of\ respondents)}$$

Variable	Category	Weight
Likelihood to volunteer in a Renewable energy initiative during free time	Very likely	5
	Somewhat likely	4
	Neither Likely nor Unlikely	3
	Somewhat Unlikely	2
	Very Unlikely	1

Table 2.5: Weights Assigned to likelihoods to engage

2.4 RESULTS

NB: Although a quantitative method was used to rank the results obtained for different indicators, the results are analyzed only qualitatively to provide insights about the nature of the real situation which can be verified quantitatively in future research. The insights generated in turn are used to generate different hypothesis to investigate SRQ2.

2.4.0.1 Age

The results on figure 2.3 show that the likelihood to engage in ECs in the South Holland province and in The Hague might increase with a rise in age and might be highest for citizens between the ages of 55-64. These insights align with those of (van Bommel and Höffken, 2021) where he determines that ECs in Europe are usually dominated by people of higher age groups.

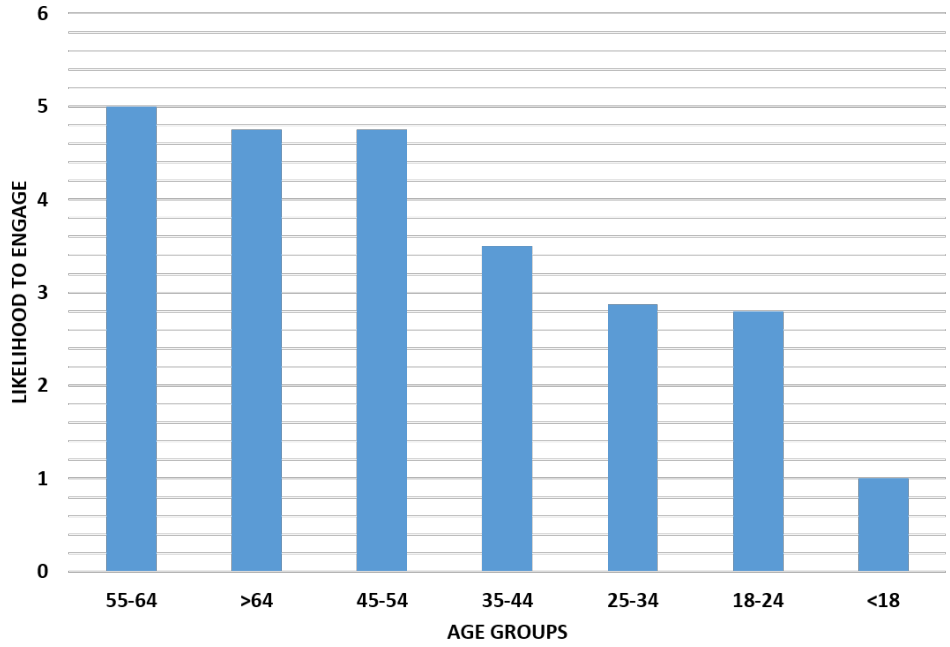

Figure 2.3: Likelihood to engage for different Age groups

2.4.1 Ethnicity

In qualitative terms, the results illustrated in figure 2.4 show that in general, people with Asian and Black or African origins might be more likely to engage in ECs during their free times than the natives.

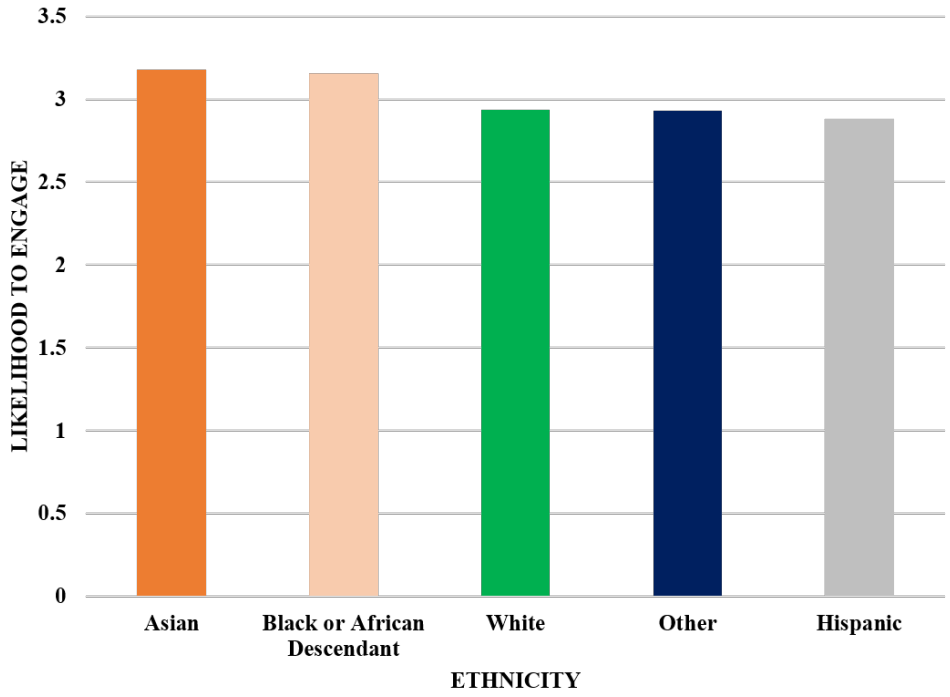

Figure 2.4: Likelihood to engage based on Ethnicity

As this result could potentially contradict the findings of (van Bommel and Höffken, 2021), which suggest that a higher proportion of energy community members are whites, a further investigation is conducted to find out what might be the possible explanation for this. In the survey, a question was asked to participants to indicate whether they have ever heard about the word "Energy Communities". In the analysis, for respondents who indicated they were aware about the existence of Energy communities, the results shown in figure 2.5 were obtained, suggesting that white people might be more likely to engage when they become aware about the existence of ECs or that other groups may be changing their minds.

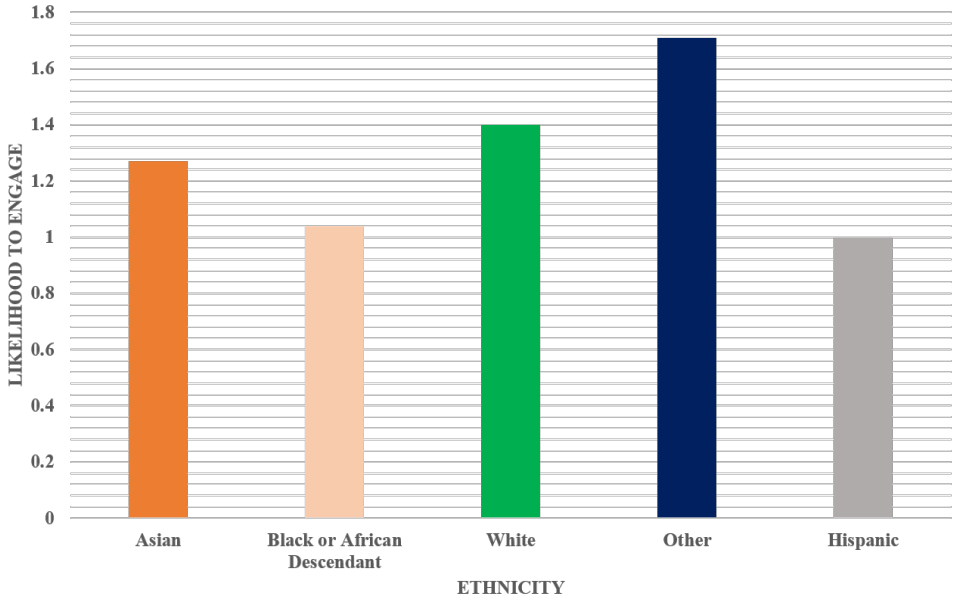

Figure 2.5: Likelihood to engage for respondents aware about the existence of energy communities

The procedure was then repeated for respondents who have never heard about the existence of Energy communities and the results illustrated in figure 2.6 were obtained, leading to the same suggestion that minority groups might be changing their minds ones they become aware about the existence of ECs. Moreover. this could also be an issue related to lack of information or communication.

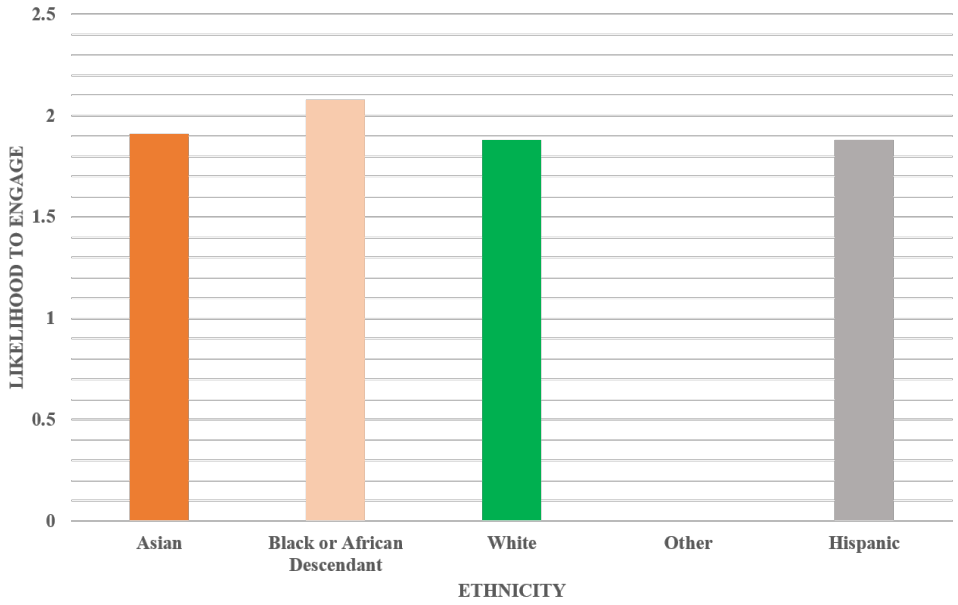

Figure 2.6: Likelihood to engage for respondents unaware about the existence energy communities

2.4.2 Employment Status

The results illustrated in figure 2.7 reveal that in South Holland, likelihood to engage in ECs might be higher with increase in the number of working hours. However, retired people might be the most likely people to engage in ECs in the region of interest. This result aligns with observations made by (van Bommel and Höffken, 2021), where he indicates that most ECs members in Europe are usually old or retired.

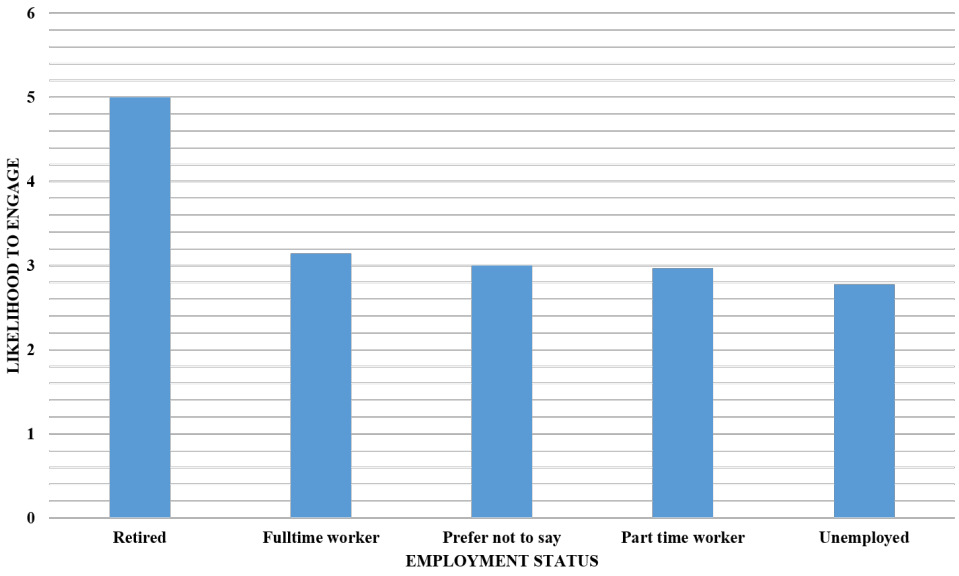

Figure 2.7: Likelihood to engage based on employment Status

2.4.3 Level of Income

The findings reveal that citizens' likelihood to engage might increase with a rise in income for the selected population as illustrated on figure 2.8. This finding aligns with those of (van Bommel and Höffken, 2021), (Kalkbrenner and Roosen, 2016) and (Radtke, 2014) and (Bauwens and Eyre, 2017).

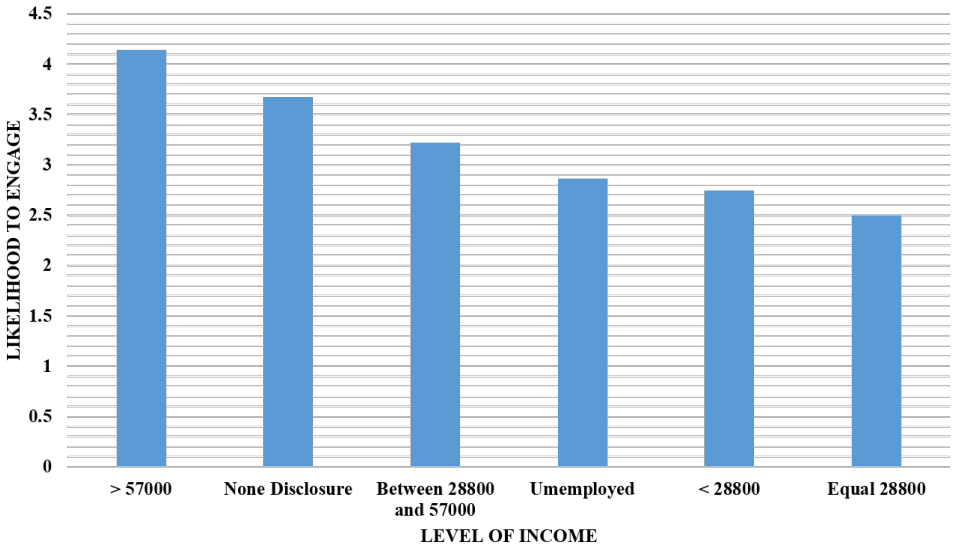

Figure 2.8: Likelihood to engage based on Level of Incomê

2.4.4 Gender

Regarding the gender, the results, as shown in figure 2.9 suggest that females might be more willing to engage in ECs than males in general. As they could potentially contradict the findings of (van Bommel and Höffken, 2021), the procedure used in section 2.4.1 with the ethnicity was repeated to explore whether there could be a potential difference in behaviour between those aware and those who are not. The result as shown on figures 2.9 and **??** show that the likelihood of females is always higher than that of males. This finding is thus not line with that made in section 2.4.1, suggesting that females might be present in ECs in the case study area.

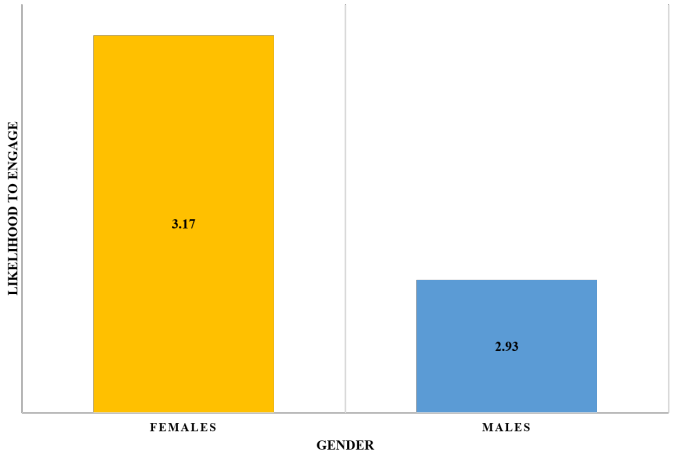

Figure 2.9: Likelihood to engage based on gender

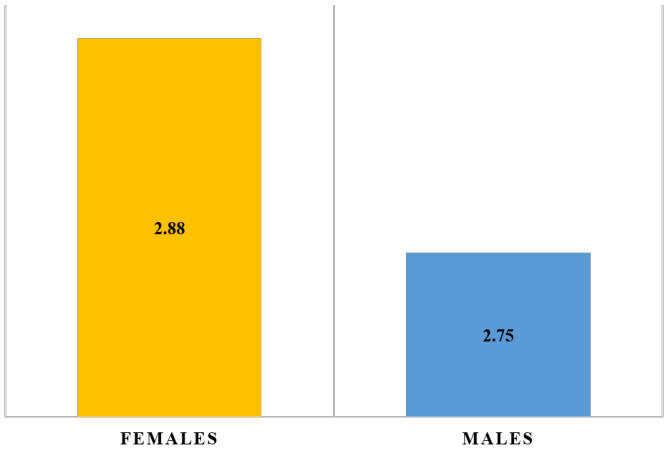

Figure 2.10: Likelihood to engage based on gender groups unaware about the existence of energy communities

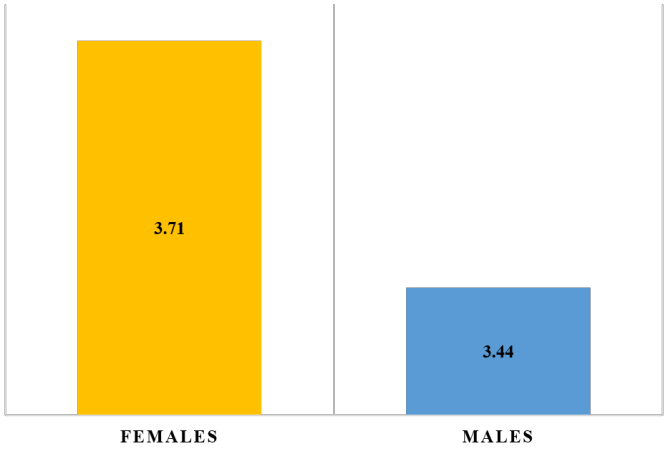

Figure 2.11: Likelihood to engage based on gender groups aware about the existence of energy communities

2.4.4.1 Education

Figure 2.12 shows that in South Holland, the likelihoods of citizens to engage in ECs might increase with a rise in the level of education with people attending vocational education having the highest probability to engage followed by university level students, high school and secondary school pupils respectively.

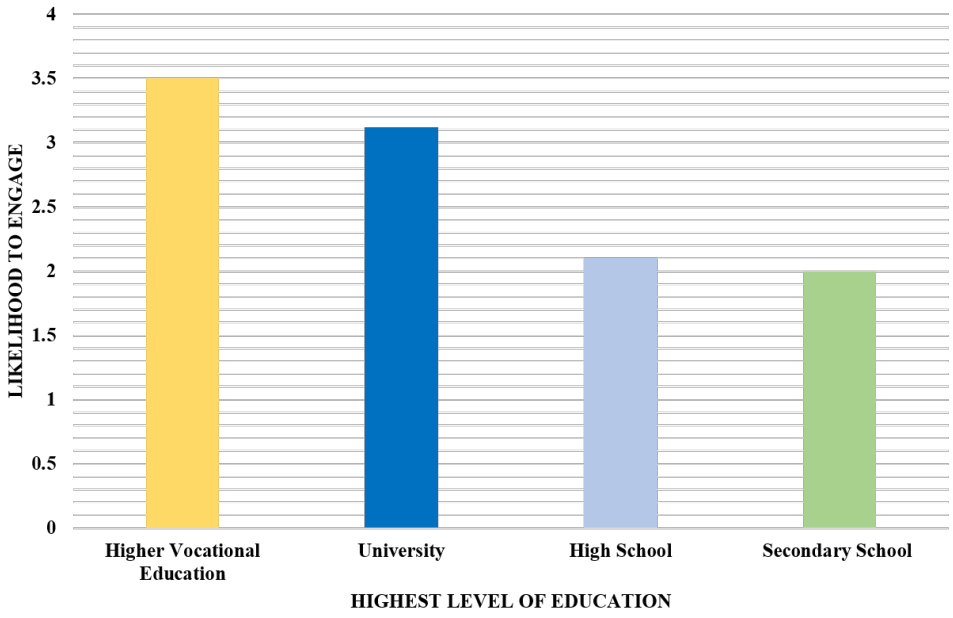

Figure 2.12: Likelihood to engage based on level of education

2.4.4.2 Summary of Results

Table 2.6 below summarizes the results from this section:

Indicator	Potential effect on citizen willingness to engage in ECs
Age	Willingness might increase with increase in age
Number of Minorities (Ethnicity)	Higher willingness than natives for those aware and unaware about the existence of ECs Lower willingness than natives for those aware about the existence of ECs Higher willingness than natives for those unaware about the existence of ECs
Level of Income	Willingness might increase with an income rise
Number of Employed persons	Willingness might rise with increased working hours
Gender	Females might be more willing to engage than males in all situations
Education	Might be highest respectively for people attending vocations schools, university, high school and secondary education

Table 2.6: Summary of Survey Results

2.4.4.3 Conclusion of section on SRQ1

In qualitative terms, the results from SRQ1 show that in the province of South Holland and potentially in The Hague, citizen engagement in ECs might be influenced by the ethnicity (with minority Africans, African descendants and Asians more willing to engage in general and for those unaware about the existence of energy communities), employment status(with willingness to engage more likely to increase with rise in level of income), and gender(with females potentially more willing to engage than males both when they are aware and unaware about the existence of energy communities). The situation observed with a potential higher likelihood for natives to engage when aware about the existence of ECs suggests that minorities might be changing their minds after becoming aware about the existence of ECs or that there might be communication issues between the ECs and the people living in their neighbourhoods. Regarding the age groups, the results suggest that citizens of higher age groups might be more willing to engage in ECs than the younger ones. A similar situation is observed with employment status, where more citizens might be willing to engage when their number of working hours are higher, with the exception of retired people potentially having the highest willingness. The desire to engage based on the highest level of education might however be highest for those having attended vocational schools, and respectively for university students, high school and secondary school pupils. These results provide great insights about how those factors might affect citizen desire to engage in ECs in the case study area. These

insights are very relevant and will be used to generate several hypothesis for investigating SRQ2.

3 DISTRIBUTION OF FACTORS AROUND ENERGY COMMUNITIES

This section describes the steps used to investigate the distribution of factors potentially affecting citizens' desire to engage in ECs around areas with energy communities. The aim is on the one hand to determine whether any social groups might be favoured by the distribution of such factors and on the other hand to set the stage for SRQ3, where the presence of energy justice tenets is investigated by conducting one on one interviews with specific board members of ECs in The Hague. For this, different hypothesis are formulated using the survey results obtained for each indicator identified in SRQ2 (age, gender, income, employment, ethnicity and education). By testing these hypothesis, the distributions of these indicators around the 24 energy community neighbourhoods of interest are identified. Finally, a research is also made to determine whether the presence of the ECs in those neighbourhoods might be exclusively due to a result of the unexpected presence of those factors in their neighbourhoods. Justifications for choosing these methods are also provided in this section.

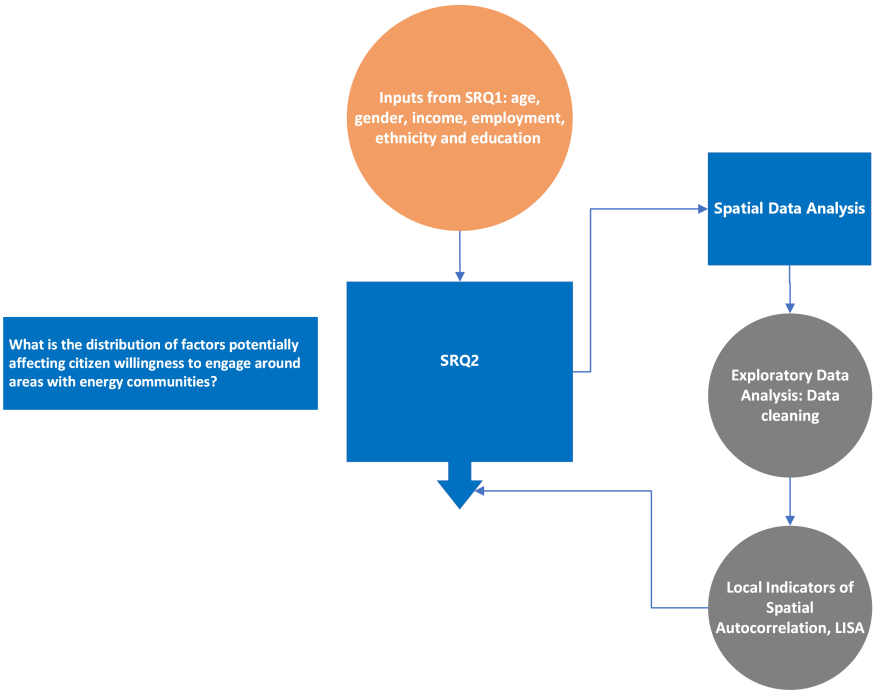

Figure 3.1: Research Flow Diagram

3.1 THE USE OF SPATIAL DATA ANALYSIS

In order to successfully investigate this SRQ, spatial data analysis methods were deemed most relevant. Spatial data analysis involves using a combination of methods in search for data irregularities, specific patterns or verifying theories and hypothesis based on a set of available spatial data (Anselin, 1999). The two major spatial data analysis techniques used in this chapter are Exploratory Data Analysis (EDA) and Exploratory Spatial Data Analysis (ESDA).

3.1.1 Exploratory Data Analysis

EDA involves analyzing dataset to derive valuable insights for building models (Rao et al., 2021). Performing an EDA allows for the discovery of anomalies in datasets such as missing data, irregular patterns or other irregularities. Using this method, data can be cleaned and made fit for use for visualizations using different statistical graphs. The most important advantage of EDA is that it allows the modeler to gain confidence about the datasets being used to make an analysis. Conversely, the major pitfall is that the nature of the dataset may require deleting valuable information about the areas of interest or neighborhoods during the data cleaning process. This pitfall can however be mitigated by replacing data showing irregularities with average values or converting to zero in order not to lose valuable information. At the end of an EDA process, the dataset ideally gets fit for use in further analytical processes.

3.1.2 Exploratory Spatial Data Analysis

ESDA refers to a collection of methods used to visualize and describe spatial distributions, identify outliers and patterns of close similarity (Anselin, 1999). Its main importance is that it enables the modeler to identify and visualize highly influential pairs of locations and unusual patterns to obtain more robust estimates of variations.

3.1.3 Data Collection

Three major datasets are used in this section:

- **The shape file of the map of The Hague**: This file is used to visualize the locations of the neighborhoods with ECs. This data was obtained from a course called "Introduction to Urban Data Science" at the faculty of Technology, policy and management of the Delft University of Technology.

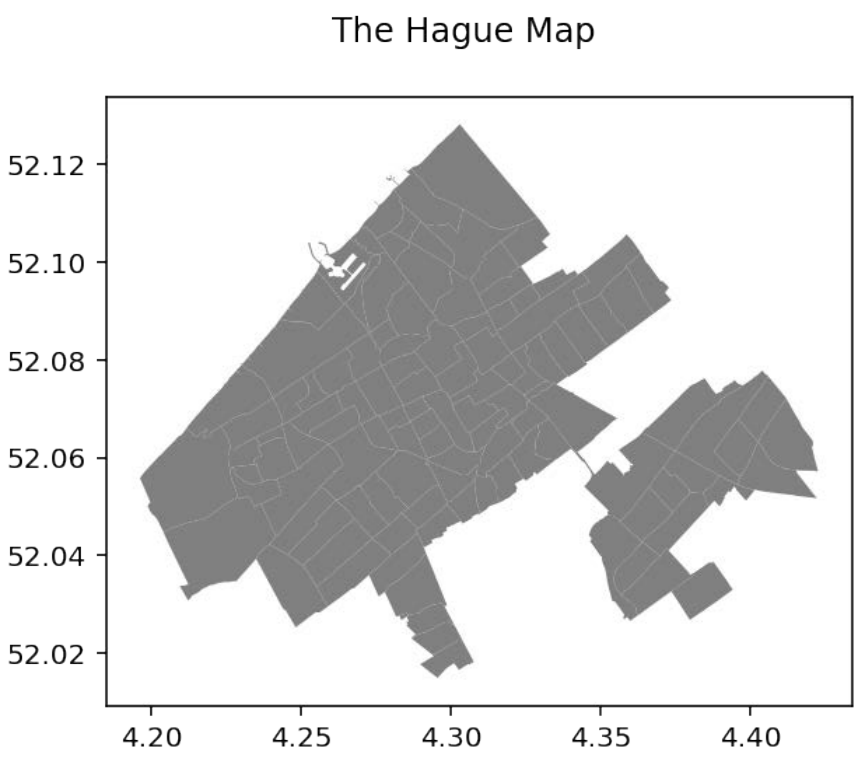

Figure 3.2: Map derived from the shape file of The Hague

- **The dataset containing the locations of ECs in The Hague**: In a first instance, an open source dataset suggesting the existence of a total number of 11 ECs in The Hague was found from the website of the energy cooperative called Opgewekt (Opgewekt, 2021). Later, after contacting the municipality for more information, the municipality provided the contact details of an Energy community in The Hague with a huge network of other members. This energy community provided another list containing a total number of 24 ECs in the city. In order to be able to display those ECs on the map, the exact locations of the neighborhoods in which they are located labeled in the same way as they are on the map itself was needed. To match these, the locations of each one of those ECs was entered on the website drimble.nl to get the exact names of the neighborhoods in which they are located. These names were then matched with those on the shape file of the city's map.

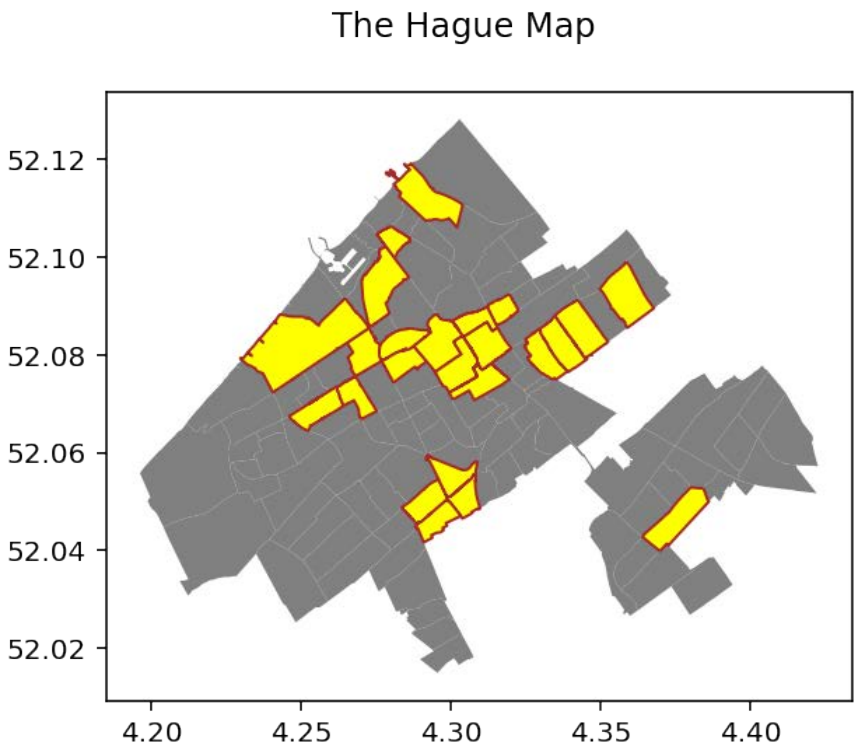

Figure 3.3: Map showing the locations of 24 Energy Communities in The Hague

- **Dataset containing information about Age, income, gender, ethnicity and education**: Except for education, fit for this research datasets related to all other indicators are made available and regularly updated on the website of the Municipality of The Hague (gemeentedenhaag, 2022). Desciptions of the available datasets are provided on table 3.1.

Indicator as of 2021	Description
Western Minorities	The Municipality of The Hague defines minority groups as ethnic groups who are socio - economically disadvantaged relative to native Dutch people. This group is usually subject to the minority policy. The Western minorities are thus people from industrialized countries such as Northwestern Europe, North America, Australia, New Zealand, Japan and former Dutch East indies (denhaag, 2020)
Other Non - Western Minorities	This refers to minority groups with Surinamese, Antilleans, Turks, Moroccans, Southern European origins and persons from 'other non-industrialized countries'
Average Personal Income	This dataset contains information about the wealth of a single person in a household (Iiv, 2019)
Number of Employed Persons	This dataset provides information about the number of employed persons. An employed person refers to one working for a number of hours ranging from 1 - 40 per week and can be permanently employed or might be on temporal contract.
Average Age	This dataset provides information about the average ages of people living in different neighborhoods
Male to Female	This represents the dataset with the number of males per neighborhood as a ratio of the number of females

Table 3.1: Table of Indicators used for the Spatial Data Analysis

3.1.4 Data Analysis

The analysis was performed using EDA and ESDA. The different codes and libraries used are listed in appendix A.4

3.1.4.1 Exploratory data analysis(EDA)

All datasets containing different indicators were downloaded as separate excel files from the Municipality's website. The files were later loaded on the software python and merged to obtain a single file with all indicators. Later, a check for inconsistencies was made and where data was missing, averages of other values from the same indicator were used to fill those gaps. Filling those gaps with average values ensured that there was no loss of information about some neighborhoods on the map. After cleaning up the data, the file was merged to that of the shape file of the map of The Hague for the ESDA and further analysis.

3.1.4.2 Exploratory Spatial Data Analysis (ESDA)

In this section, the distribution of the identified socio-economic factors outlined in table 3.1 around neighborhoods with the 24 Energy communities was investigated. For this, the use of 1) choropleth maps, with the concepts of 2) Local Spatial Autocorrelation and the 3) Local Moran I indicators were made to provide more accuracy to the results.

- ***Choropleth Maps***:

  Choropleth maps show the spatial distribution patterns of different natural and social phenomena (Ciurlionio, 2022). These graphical visualizations facilitate the interpretation of statistical table data which often require the intervention of specialists. A major advantage of choropleths is that they make it easy to distinguish spatial similarities and differences and hence ease decision and policy making. For this reason, choropleth maps are used in a first instance to get a first impression about the spatial distribution of the factors of interest around the neighborhoods with the 24 ECs. A major flaw of choropleth maps is that they make use of colors to show the distribution of similar or dissimilar values. While similar colors represent areas of positive correlation, they do not inform the viewer about whether these values are high or low. Different methods thus need to be used to distinguish between these values. Moreover, the representation of information on choropleths might lead to misinterpretation of the facts by the user due to an over-generalization of the indicators on the map.

- ***Local Spatial Autocorrelation (LSA)*:**

  LSA provides information about the areas where specific clusters or outliers are located on a map. In contrary to choropleths, LSA focuses on the relationships between specific observations and their surroundings rather than just summaries of these relationships across a map (Sergio J. Rey, 2020). These local measures of spatial autocorrelation allow for the identification of areas of unusual clustering of values. Moreover, these clusters represent values of a given type that are unlikely to occur under the assumption of spatial randomness. The local Moran I concept is used to identify these areas.

- ***Local Moran I (LMI)***:

  One of the core concepts used to identify these areas of unusually high or low concentration of given values in a certain location of the map is the Local value of the Moran I. The main idea behind the LMI is to find out areas of the map where the values of observations is either more similar to those of their surroundings (Areas with high values surrounded by areas with high values for a given indicator (HH) or Areas with Low values surrounded by areas with low values for a given indicator (LL)) or dissimilar (Areas with high values surrounded by areas with low values for a given indicator (HL) orAreas with low values surrounded by areas with low values for a given indicator (LH)) than it could be expected from pure chance (**?**). The LMI uses the Local Indicators of Spatial Autocorrelation (LISA) to do this. The software python uses an inbuilt package algorithm to evaluate the LISA and so for each of the results obtained, detailed explanations of the meanings or implications shall be provided.

3.2 HYPOTHESIS

Table 3.2 shows the different hypothesis formulated based on the literature review findings from (Bauwens and Eyre, 2017) and (van Bommel and Höffken, 2021) and the qualitative survey results obtained from SRQ2. Although the hypothesis from the literature are not the main focus of this research, they are placed on the table to provide a comparative analysis with the case study area. From the literature review results, it can be hypothesized that a majority of residents of areas with ECs might be rich, white retired males. Following the survey results, the hypothesis is made that most residents of The Hague are employed female minorities with of younger ages with high average personal incomes.

Indicator	Hypothesis formulated based literature review findings	Hypothesis formulated based survey results analysis
Age	Residents will be of higher age groups	Residents will be of higher age groups
Gender	More males will be present than females	More females will be present than males (based on general survey findings)
Ethnicity	More residents will be natives (whites)	More residents will be minorities (Based on general survey results)
Employment Status	More residents will be employed	More residents will be employed
Average annual Income	Residents will have high average personal incomes	Residents will have high average personal incomes

Table 3.2: Hypothesis made based on existing literature and survey results

3.2.1 Minorities

3.2.1.1 Western Minorities

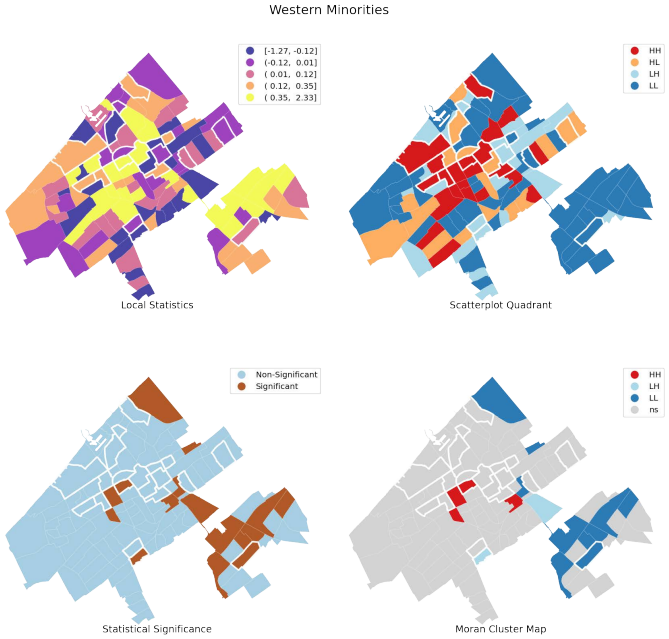

Figure 3.4: Map of Western Minorities Distribution in The Hague

1. **Local Statistics Map**: On the map of local statistics at the top left corner, the yellow and purple locations represent the largest positive or negative values for the local statistics. These magnitudes represent positive or negative spatial autocorrelation which can be of high or low values. However, this shows that for the western minorities, similar distributions which can either be HH or LL are located close to each other around the city center(yellow color). Although this first map cannot be used to differentiate between areas with low or high number of western minorities, it provides an overview about the distribution of minority groups in the city.

2. **Scatterplot Quadrant**: The scatterplot quadrant map at the top right on the other hand shows the locations of the different Moran I statistics on a scatter plot. The HH as found on the legend represents areas with high number of minority groups surrounded by areas with other high minority groups. The HL represents areas with high number of minorities surrounded by areas with low number of minority groups. LH conversely represents areas with low number of minorities surrounded by areas with high numbers of western minorities. The LL on the other hand represents areas with low number of minorities surrounded by areas with low minority groups.

   Interpretation of top two Maps: From the 24 ECs of interest, 3 are located in the neighborhood called Zuidwal, 2 in Koningsplein and 2 others in Burgen en Horsten. Hence while interpreting the results, Zuidwal accounts for 3 out of the 24 Energy community areas while Koningsplein and Burgen en Horsten account respectively for two. In order to count these communities and their quadrant locations, an algorithm is used on python. The scatterplot quadrant map thus reveals that 16 out of the 24 Energy communities are located in areas with high number of western minorities compared to 8 which are located in areas with low western minority areas. Further interpretation is provided in section 3.2.1.2

Indicator	**Western Minorities**
Total Number of ECs	24
Number of ECs neighborhoods with high number of Western Minorities	16
Number of ECs neighborhoods with low number of Western Minorities	8

Table 3.3: Local Statistics map and Scatterplot Quadrant for Western Minorities

3. **Statistical Significance map**: In the interpretation of the first two maps, care must be taken as the they do not consider the statistical significance of the LISA values. Only the raw LISA values have been mapped with the quadrant in which they are located. However for each LISA, python automatically computes a p - value. Since it is not every observation that represents a statistically significant one, the aim is to identify those with p - values small enough that it eliminates all possibilities that those values might have occured out of pure chance. In

other words, through this map, the research seeks to find out whether the energy communities are located in hot spot areas(HH) of outliers or cold spots(LL).

Significant	Highly unlikely to have occurred due to pure chance
Non - Significant	Could have occurred from pure chance

Table 3.4: Interpretation of statistical Significance

4. **Moran cluster Map**: The Moran cluster map on the bottom right extracts the significant information (Unlikely to have occurred from pure chance) and plots them with specific colours depending on the region association modes. Regarding the neighbourhoods of interest, only 4 out of the 24 Energy communities are found in locations that allow to reject the possibilities that they might have occurred out of pure chance in minority regions.

   Interpretation of bottom two Maps: The bottom two maps show that only 4 out of the 24 ECs are found in hot or cold spot areas of western minorities. This allows to conclude that the presence of ECs in those 4 neighborhoods is not exclusively due to the unexpected presence of those high or low numbers of western minorities.

Indicator	**Western Minorities**
Total Number of ECs	24
Number of ECs found in neighborhoods highly unlikely to have occurred due to pure chance	4(Significant)
Number of ECsfound in neighborhoods with likelihood to have occurred as a result of chance	20(Non - Significant)
Number of ECs with neighbors found in Significant areas	6

Table 3.5: Statistical Significance and Moran Cluster Map for Number of Western Minorities

3.2.1.2 *Non Western Minorities*

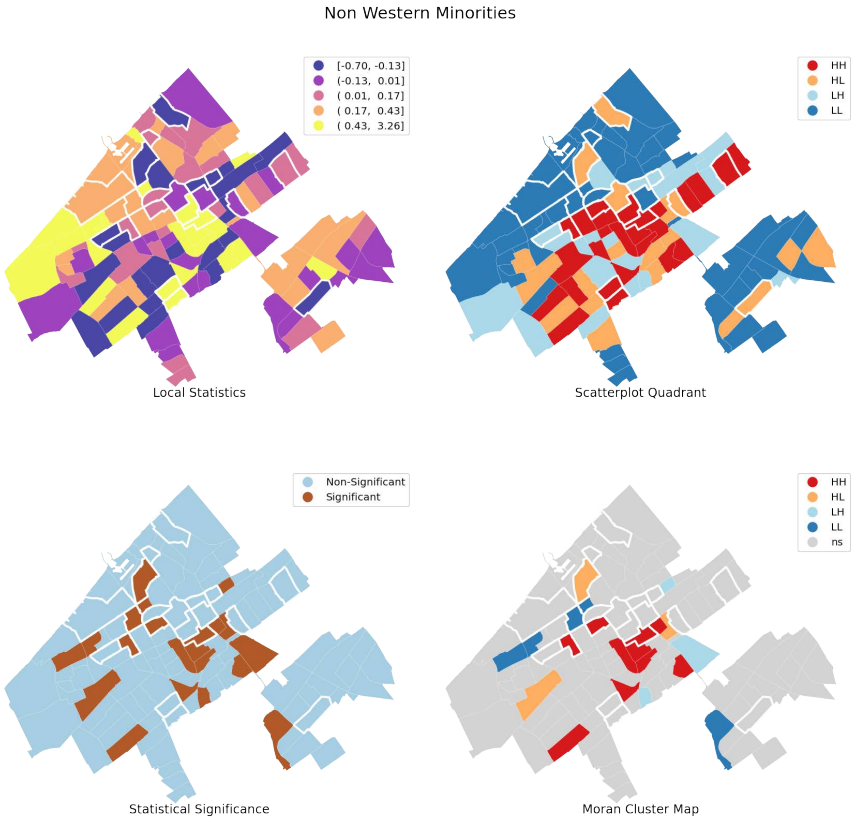

Figure 3.5: Map of Non - Western Minorities Distribution in The Hague

In this section and subsequent ones, interpretations of the map results are provided directly to avoid repetition of explanations:

1. **Interpretation of top two Maps**: The scatterplot quadrant map reveals that 16 out of the 24 Energy communities are located in areas with high number of non western minorities compared to 8 which are located in low western minority areas. This result is the same as that obtained with the western minorities and thus allows to conclude that energy communities in The Hague are in majority located in areas characterized by a high number of minority groups. This result confirms the hypothesis formulated based on the survey results for non western minority groups.

Indicator	**Non Western Minorities**
Total Number of ECs	24
Number of ECs neighborhoods with high number of Non Western Minorities	16
Number of ECs neighborhoods with low number of Non Western Minorities	8

Table 3.6: Local Statistics map and Scatterplot Quadrant for Non Western Minorities

Indicator	Non Western Minorities
Total Number of ECs	24
Number of ECs found in neighborhoods highly unlikely to have occurred due to pure chance	4(Significant)
Number of ECsfound in neighborhoods with likelihood to have occurred as a result of chance	20(Non - Significant)
Number of ECs with neighbors found in Significant areas	9

Table 3.7: Interpretation of statistical Significance and Moran Cluster Map for Non Western Minorities

2. **Interpretation of bottom two Maps**: The bottom two maps show that only 4 out of the 24 ECs are found in a significant area of non western minorities(hot or cold spot areas). This also allows us to conclude that the presence of ECs in those 4 neighborhoods is not exclusively due to the unexpected presence of those high or low number of non - western minorities.

3.2.2 Average Personal Income

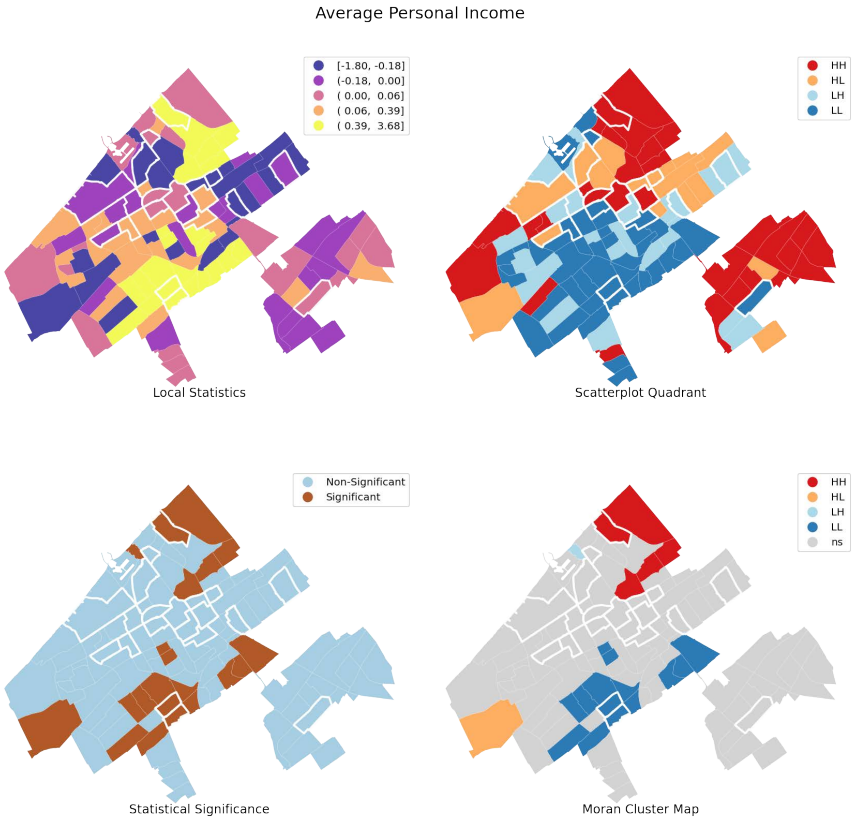

Figure 3.6: Map of Average Personal Income in The Hague

1. **Interpretation of top two Maps**: The scatterplot quadrant map reveals that 8 out of the 24 Energy communities are located in areas where people have relatively high average incomes compared to 16 which are

located in areas with low average incomes. This result does not allow for a confirmation of the hypothesis formulated based on the existing literature knowledge or th survey finding as it suggests that the most likely people to engage in ECs have relatively low average personal incomes.

Indicator	Average Personal Income
Total Number of ECs	24
Number of ECs neighborhoods with high average personal income	8
Number of ECs neighborhoods with with low average personal income	16

Table 3.8: Local Statistics map and Scatterplot Quadrant for Average Personal Income

2. **Interpretation of bottom two Maps**: The bottom two maps show that only 3 out of the 24 ECs are found in a significant area of average personal income (hot or cold spot areas). This also allows to conclude that the presence of ECs in those 3 neighborhoods is not exclusively due to the presence of the peoples' unexpected high or low average personal incomes.

Indicator	Average Personal Income
Total Number of ECs	24
Number of ECs found in neighborhoods highly unlikely to have occurred due to pure chance	3(Significant)
Number of ECsfound in neighborhoods with likelihood to have occurred as a result of chance	21(Non - Significant)
Number of ECs with neighbors found in Significant areas	9

Table 3.9: Statistical Significance and Moran Cluster Map for Average Personal Income

3.2.3 Number of Employed Persons

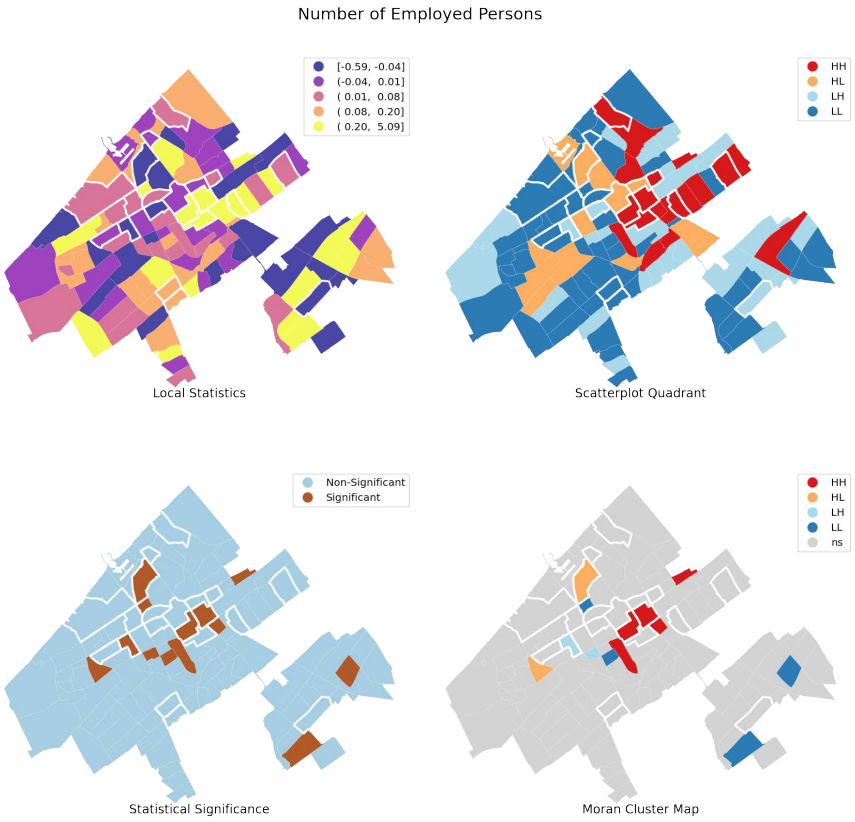

Figure 3.7: Map of Number of Employed Persons Distribution in The Hague

1. **Interpretation of top two Maps**: The scatterplot quadrant map reveals that 13 out of the 24 Energy communities are located in areas with high levels of employment compared to 11 which are located in areas with levels. This result suggests that people in neighborhoods with high levels of employment are more likely to engage in Energy communities in The Hague, confirming the hypothesis formulated based on the literature findings and survey results.

Indicator	Number of Employed Persons
Total Number of ECs	24
Number of ECs neighborhoods with high number of employed persons	13
Number of ECs neighborhoods with with low number of employed persons	11

Table 3.10: Local Statistics map and Scatterplot Quadrant for Number of Employed Persons

2. **Interpretation of bottom two Maps**: The bottom two maps show that only 4 out of the 24 ECs are found in a significant area for number of employed persons(hot or cold spot areas). This allows to conclude that the presence of ECs in those 4 neighborhoods is not exclusively

due to the presence of the peoples' unexpected high or low levels of employment.

Indicator	Number of Employed Persons
Total Number of ECs	24
Number of ECs found in neighborhoods highly unlikely to have occurred due to pure chance	4(Significant)
Number of ECsfound in neighborhoods with likelihood to have occurred as a result of chance	20(Non - Significant)
Number of ECs with neighbors found in Significant areas	9

Table 3.11: Statistical Significance and Moran Cluster Map for Number of Employed Persons

3.2.4 Average Age

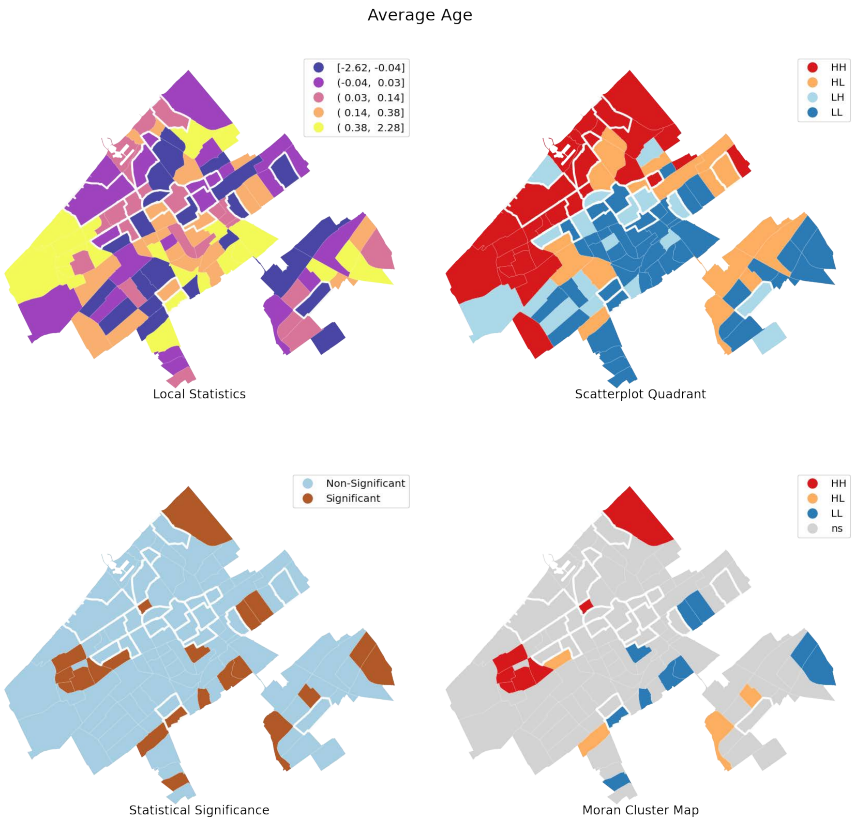

Figure 3.8: Map Average Age in The Hague

1. **Interpretation of top two Maps**: The scatterplot quadrant map reveals that 9 out of the 24 Energy communities are located in areas with high average age compared to 15 which are located in areas with low levels. This result suggests that people in neighborhoods with lower average ages are more likely to engage in Energy communities in The Hague. This result contradicts the hypothesis formulated based both on the literature and survey findings.

Indicator	Average Age
Total Number of ECs	24
Number of ECs neighborhoods with high average age	9
Number of ECs neighborhoods with with low average age	15

Table 3.12: Local Statistics map and Scatterplot Quadrant for Average Age

2. **Interpretation of bottom two Maps**: The bottom two maps show that only 1 out of the 24 ECs are found in a significant area for average age(hot spot or cold spot areas). This also allows to conclude that the presence of ECs in that neighborhood is not exclusively due to the presence of the peoples' unexpected high or low levels average ages.

Indicator	Average Age
Total Number of ECs	24
Number of ECs found in neighborhoods highly unlikely to have occurred due to pure chance	1(Significant)
Number of ECsfound in neighborhoods with likelihood to have occurred as a result of chance	23(Non - Significant)
Number of ECs with neighbors found in Significant areas	10

Table 3.13: Statistical Significance and Moran Cluster Map for Average Age

3.2.5 Male to Female Ratio

Originally, the dataset was obtained respectively for males and females in the different neighborhoods. In order to be able to compare with the gender results obtained from 2, the male - female ratio was evaluated by dividing the dataset for the number of males per neighborhood by those for the number of females.

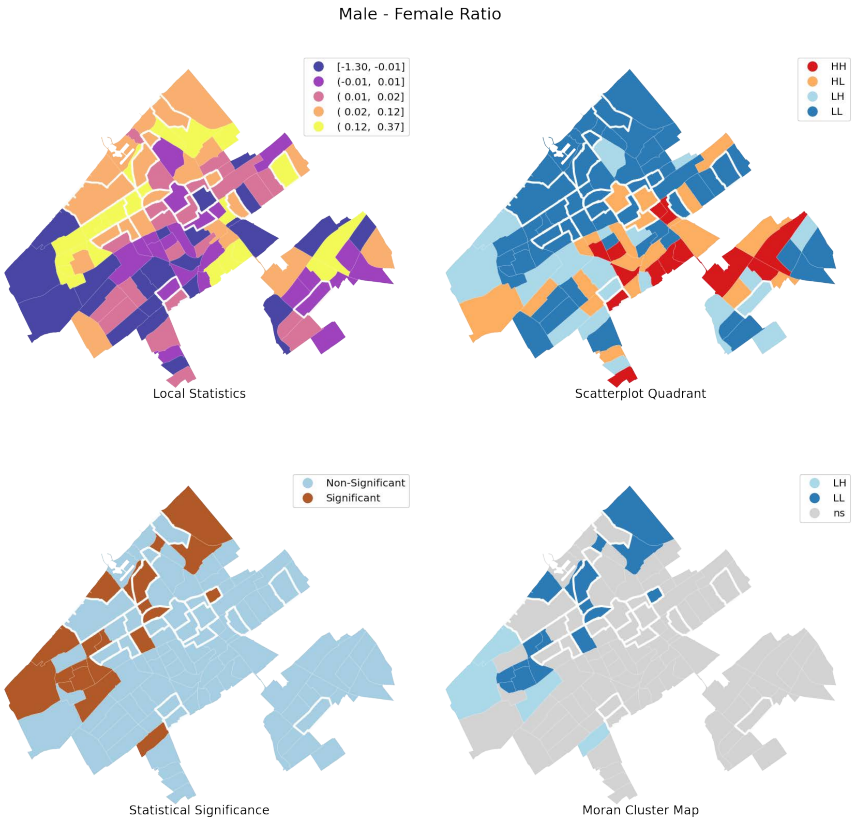

Figure 3.9: Map of Male to Female in The Hague

1. **Interpretation of top two Maps**: The scatterplot quadrant map reveals that 6 out of the 24 Energy communities are located in areas with high male - female ratio suggesting a higher number of females in these regions compared to 18 which are located in areas with low levels. This result suggests that ECs are located in neighbourhoods with higher number of females. While this result confirms the survey hypothesis, it is in contradiction with the hypothesis formulated on the basis of the literature results.

Indicator	**Male to Female Ratio**
Total Number of ECs	24
Number of ECs neighborhoods with high Male to Female Ratio	6
Number of ECs neighborhoods with with low Male to Female Ratio	18

Table 3.14: Local Statistics map and Scatterplot Quadrant for Male to Female Ratio

2. **Interpretation of bottom two Maps**: The bottom two maps show that only 3 out of the 24 ECs are found in a hot spot or cold spot area. This also allows to conclude that the presence of ECs in those neighborhoods is not exclusively due to the presence of the peoples' unexpected high or low number of males or females.

Indicator	Male to Female Ratio
Total Number of ECs	24
Number of ECs found in neighborhoods highly unlikely to have occurred due to pure chance	3(Significant)
Number of ECsfound in neighborhoods with likelihood to have occurred as a result of chance	7(Non - Significant)
Number of ECs with neighbors found in Significant areas	7

Table 3.15: Statistical Significance and Moran Cluster Map for Male to Female Ratio

3.3 SUMMARY OF RESULTS AND CONCLUSION

To investigate SRQ2, this section made use of spatial data analysis with Moran I's component of spatial auto-correlation to find out the distribution of the factors identified from SRQ1 around neighbourhoods with 24 energy communities in The Hague to determine whether any social groups are favoured by their distribution around areas with 24 ECs. Table **??** summarizes the results obtained from this analysis.

Indicator	Hypothesis formulated based on literature review findings	Hypothesis formulated based on survey results analysis	Data Analysis Results (Distribution of factors ECs neighbourhoods)
Age	Residents will be of higher age groups	Residents will be of higher age groups	The number of residents in/around the majority of EC neighborhoods have low average personal incomes
Gender	More males will be present than females	More females will be present than males	The number of residents in/around the majority of EC neighborhoods are females
Ethnicity	More residents will be natives (whites)	More residents will be minorities (Based on general survey results)	The number of residents in/around the majority of EC neighborhoods are minorities
Employment Status	More residents will be employed	More residents will be employed	The number of residents in/around the majority of EC neighborhoods have high levels of employment
Average annual Income	Residents will have high average personal incomes	Residents will have high average personal incomes	The number of residents in/around the majority of EC neighborhoods have low average personal incomes

Figure 3.10: Comparison of hypothesis formulated based on literature findings, survey results and spatial data analysis results

The results from table 3.10 show that a higher proportion of the 24 ECs in The Hague are found in neighbourhoods where inhabitants have relatively low average ages, where the number of females is higher than that of males, a higher number of residents are minorities, employed and where residents have relatively low average personal incomes. Following the hypothesis set from the survey results, the results obtained for factors such as gender, ethnicity and number of employed persons came out as predicted by the hypothesis, suggesting that in the city of The Hague, the distribution of females, minorities and highly employed persons around a majority of areas with ECs favours their engagements in such initiatives.

On the other hand, while the average ages and incomes were hypothesized to be high in areas with ECs, the results obtained indicate a higher presence of people with lower average ages and personal average incomes around

these areas, suggesting that they might be more likely to engage in ECs in the case study area. While the results from 3(gender, ethnicity and employment status) out of the 5 indicators match with those of the survey results hypothesis, only 1 (average annual income) matches with that made based on existing literature knowledge. This shows that for the case study area, there might be a deviation in the observations made from the membership compositions and representations of different groups of people in ECs, suggesting that people of lower average ages, more females and minorities and more people with lower average personal incomes might be present in ECs. Table 3.16 provides a summary of the findings, indicating the expected and unexpected results based on literature and survey results hypothesis. These results are used to investigate the actual representations in ECs through one on one interviews with 8 ECs board members in The Hague in SRQ3.

Indicator	**Charactics of people more likely to engage based on their distributions around areas with 24 ECs**	**Compared to literature hypothesis**	**Compared to survey hypothesis**
Age	The distributions of people with lower average ages favour their engagement in ECs	Unexpected result	Unexpected result
Gender	The distributions of females favour their engagement in ECs	Unexpected result	**Expected result**
Ethnicity	The distributions of minority groups favour their engagement in ECs	Unexpected result	**Expected result**
Employment Status	The distributions of employed people favour their engagement in ECs	**Expected result**	**Expected result**
Average Annual income	The distributions of people with lower average personal incomes favour their engagement in ECs	Unexpected result	Unexpected result

Table 3.16: Summary of SDA results Showing expected and unexpected results based on survey and literature review hypothesis

4 ENERGY JUSTICE AND CITIZEN ENGAGEMENT

This chapter describes the different steps used to investigate whether increased citizen engagement in energy communities could lead to a rise in energy justice using the inclusion of minority groups (recognition justice tenet) as a foundation. For this, interviews are conducted with 8 board members of energy communities in The Hague using the results obtained from SRQ2. The results are then analyzed and discussed to determine to what extent they address this SRQ.

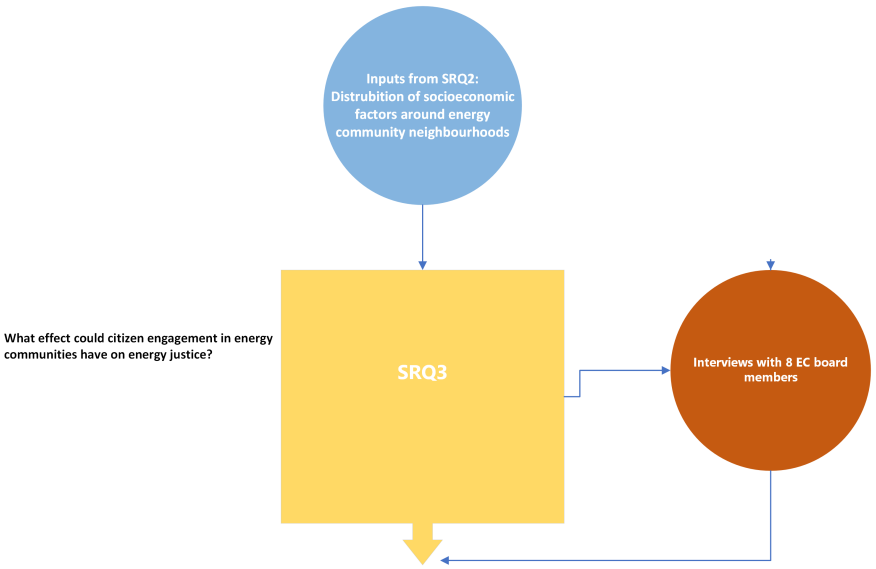

Figure 4.1: Research Flow Diagram

4.1 INTERVIEWS

In the data collection process, semi-structured interviews were used. According to (Feel, 2014), semi-structured interviews contain a set of structured questions organized in a predetermined order with a set of open ended questions to allow for the exploration of new topics or issues about the questions being investigated. Moreover, these types of interviews often come along with an interview guide containing the objectives of the interview, the different topics and set of questions to be asked.

- ***Justification***

Semi-structured interviews are used to complement pre-existing knowledge about a topic under investigation (Feel, 2014). After coming up with the results of the second SRQ, it became evident that more clarity about the topic could be brought by directly interacting with members of energy communities. Moreover, in order to investigate the potential presence of the different tenets of energy justice as discussed in section 1.3, this research argues that having an interaction with energy community members is the most direct way to cover the remaining knowledge gaps.

4.1.1 Stakeholder engagement and Interview Questions

4.1.1.1 Stakeholder Engagement and Participant Observation

The stakeholder engagement process started at the onset of the research. After clarifying the objectives of the research and knowing the different methods to be used, a list containing the contact details of the ECs in The Hague was made. Then, an invitation to a 45minutes masters thesis interview email containing the research objectives, what would be expected from the participants and also the specific dates and times when the interviews were required was drafted (appendix A.5) and sent out to 9 members of ECs. This first email was sent two months before the planned dates of the interviews. A day after the first emails were sent out, a board member of one of the ECs replied saying he would not be available for any interview as he was unhappy with meeting the municipality several times in the previous year without being able to receive enough funding for his roof top project. Later, when asked for suggested ECs for the interviews, the board member recommended another energy community. After numerous follow-up emails to receive a reply from this recommended community, non of its members could be available for the interview. To get more responses from the 9 ECs initially contacted, follow-up emails were sent on weekly basis for three weeks with 3 out of the 9 initiatives finally accepting the invitation. On the other hand, an email was drafted and sent to the municipality of The Hague to request for recommendations about possible interview participants. The Municipality provided the name and contact details of an energy community with which it regularly collaborates to provide support to other ECs in the city. After contacting the initiative, they replied with an invitation to one of their events about "engaging more youths in the energy transition". At the event, a request for few minutes was made to the presenter to explain this research objectives and also to request for possible participants for the interviews. At the end, two more participants volunteered for the interviews. Later, a list of other ECs in The Hague was provided by the initiative whose name was provided by the municipality. Then, a Microsoft form requesting people to choose their preferred times for a 45minute interview in the month of May 2022 was designed and sent out with an email to 19 new ECs, requesting these new potential participants to indicate their potential availabilities for a 45 minutes interview (appendix A.6). Two out of the 19 initiatives contacted provided positive responses. The name and contact details of the 8th mem-

ber were provided to during an interview with one of the members who said the 8th person should absolutely be contacted for the interview due to her activism in the field. This made a total of 8 participants for the interviews.

4.1.1.2 *Interview Questions*

Appendix A.7 shows the interview questions sent to the participants in preparation for the interviews. The first three questions require information about their backgrounds, motivations to engage and experiences working as members of their respective communities. The aims of these questions were to find out whether resolving any energy justice issue was part of their motivations to engage or whether they experience any such issues working in their respective ECs. The third question, which is fundamental to investigate recognition justice on the other hand presents the results obtained from SRQ2 and asks for their personal experience working in their respective ECs. While question 5 seeks to investigate the barriers to citizen engagement and suggestions for improvements, questions 6 and 7 are rather more directed towards researching the presence of distributive and procedural justice. All questions were made open ended to avoid influencing the participants responses.

4.1.2 Interview process and lessons learned

Out of the 8 board members interviewed, 3 of the participants were interviewed face to face while the remaining 5 participated remotely following their preferred settings. During the interviews, due to the difficulty getting the more elderly participants to answer the exact questions asked, the precaution taken to save time was to pick up some of the responses and redirecting them to the original questions. Another major observation which was quite helpful was that the second participant took time to comment his experience regarding each one of the factors stemming from table developed from SRQ2 about representation in his energy community. This was very relevant for the data collection process. In the subsequent interviews, all participants were requested to comment their experiences in terms of representation for each one of those factors.

Full summaries of the interview responses are found in appendix B. The legend on figure 4.2 on the other hand can be used to interpret the results on figures 4.3 and 4.4

LEGEND	
	Presence of instances of procedural Justice
	Observed instances of recognition justice (No minorities, Old, white, employed or retired males with high income)

Figure 4.2: Interview Results Legend

4.2 INTERVIEW RESULTS

Initiative	Work Area	Motivations to engage	Experience / Definition of success	Representation observed	Barriers to Citizen Engagement	Ways to improve barriers	Benefit Sharing (distributive Justice)	Decision Making
A	To support place based ECs in The Hague working on sustainability, greening and cooling.	To raise awareness about climate change and play a connecting role between citizens and the municipality	Defines success as being part of a larger movement for sustainability and climate movement and being able to mobilize people to get climate policies on the agenda	ECs are not representative of the areas in which they are found in general. The general observation is white people starting the initiatives. Members are usually employed males with high incomes	Lack of time and communication. Lack of proper roofs for projects. Several policies favor the use of fossil fuels and hence citizens are reluctant to engage . Other barriers include lack of technical, legal and policy knowledge and cheaper cost of fossil energy	Connecting people, building trust, raising awareness of people to clarify doubts and democratizing the decision making process	Main benefit: Allow members to work for sustainable society and get to know their neighborhood members Burdens: Requires much efforts to run activities	Democratic Management
B	The initiative aims to reduce CO_2 emissions by promoting less use of fossil energy	To bring house owners together around the topic of community and work to reduce CO_2 emissions by promoting less use of fossil energy	The city plans to make the district green by 2030 by replacing all its gas pipes which are old. However, the board member does not believe this goal will be achieved due to delayed activities	Non Dutch members are hardly present. Members are mainly males above average age although there is a current huge interest from younger generations	There is a problem of communication as people are unaware about the sustainability challenges faced by the district. Activities are moving too slowly	There needs to be a way to make all community members to get advantages for being members	Less bills will be paid if they achieve their efficiency goals	/
C	To connect residents to a sustainable heat network to replace non - sustainable energy sources use	To make the neighborhood more sustainable by working with people.	Easy to get people involved and funding from the Municipality	No minorities are present . Members have high incomes, level of employment is high and the age groups are high. No comment on male – female	Lack of time. Government not involving citizens. Experience halting of activities at times because the government funds different projects in same area	More funding should be provided to people from poorer communities and understand that all projects have risk of failure	The main benefit of being member is that it helps members to know people from their neighborhoods	/
D	To generate sustainable local electricity through collective solar roofs	To make a greater contribution to the society	The initiatives currently operates two roofs on buildings with approximately 520 solar panels.	About 90 percent of members are males, white, retired and of older ages	The biggest hardship is to find enough roofs as most roofs in the city are owned by the municipality	The municipality could find ways to make roofs available for their projects	/	/

Figure 4.3: Interview Results for first 4 interviewed EC members

Initiative	Motivations to engage	Experience / Definition of success	Representation observed	Barriers to Citizen Engagement	Ways to improve barriers	Benefit Sharing (distributive Justice)	Decision Making
E	To help the neighborhood citizens to have access to information and become free by having access to sustainable energy	Perceives as success the recent organization of a festival to promote democracy and the development of the area.	No non Dutch descent is involved. Moreover, members are mostly males above average age although there is a rising interest from the younger generations	Lack of awareness and action perspective	/	The main benefit observed is an increased cooperation of social entrepreneurs. Initiative takers perceive money as compensation. The main issue on the other hand is a lack of resources to reward all volunteers	Democratically
F	To get inhabitant perspectives into heat transition plans	The interviewee's biggest success has been an observation of a higher number of people engaging	Energy communities are not usually representative of the neighborhoods in which they are located. Minority groups are low as they have not particularly focused on engaging them. Age groups are usually higher with medium – high incomes and the Ecs are usually located in areas where number of employed people are high	Lack of trust as the state does not respect some promises made	/	The perceived long term benefit is the satisfaction of having a sustainable neighborhood	/
G	To learn the practical part of her master's degree programme course work by engaging in the initiative	The biggest accomplishment of the participant as a youth is that she interacts with different people and is able to gain by discussing with people with different perspectives	Minorities are low, members are of higher age groups with medium to high incomes and the level of employment in the community areas is usually high	Lack of time, trust, intellectual and social capital. Raising awareness about the existence of their energy community is difficult	A good communication strategy is needed. minorities could be paid for participating in their activities	/	Decentralized
H	She was called on board to write and submit proposals to receive funding from the municipality	Cooperation with other members is perceived as being very positive	/	The government says much and does little	/	/	/

Figure 4.4: Interview Results for last 4 interviewed EC members

4.3 ANSWERING SRQ3 BASED ON INTERVIEW RESULTS

SRQ3 seeked to determine the effects citizen engagement in ECs could potentially have on energy justice. As this research had a high focus on the recognition justice aspect, the results are discussed starting from the insights obtained for this tenet and subsequently moving to others.

4.3.1 Recognition justice

Looking at the column for the representation observed, figures 4.3 and 4.4 show that with the exception of participant H, all other 7 members acknowledged a total or partial absence (fewer presence) of minority groups in their respective ECs, suggesting a limited presence of recognition justice. Based on the SDA results, this situation was unexpected as a majority of the ECs are surrounded by a high number of minority groups. This raises the question as to why this observation was made. From the interviews, a possible explanation might be those provided by participants A and F, where they acknowledged that energy communities in The Hague are not usually representative of the areas in which they are found as only people interested in such initiatives tend to engage. This however raises an important question for future research. Table 4.1 shows the results obtained from interviews and how they relate to the SDA results.

Indicator	**Charactics of people more likely to engage based on their distributions around areas with 24 ECs**	**Interview Results for the 8 ECs interviewed**	**Result obtained**
Age	The distributions of people with lower average ages favour their engagement in ECs	A majority of members are of older age groups (7 out of 8) 2 Members mention a growing interest from the youths who are still to engage	Unexpected result
Gender	The distributions of females favour their engagement in ECs	5 out of 8 acknowledge that a majority of their members are males	Unexpected result
Ethnicity	The distributions of minority groups favour their engagement in ECs	7 out of 8 members acknowledge that a majority of their members are natives	Unexpected result
Employment Status	The distributions of employed people favour their engagement in ECs	7 members acknowledge that their EC members are employed	**Expected result**
Average Annual income	The distributions of people with lower average personal incomes favour their engagement in ECs	7 members acknowledge that members usually have high average personal incomes	Unexpected result

Table 4.1: Comparison of SDA results and Interview results

Following the unexpected results on table 4.1, this research raises important questions that could be investigated in future research as to why people with younger ages, females, minority groups and those with lower average annual incomes do not engage in the majority of the interviewed ECs irrespective of their high presence in a majority of neighbourhoods in which the ECs are located. When asked during the interviews, participant G mentioned that minorities could be paid as motivation to engage in such initiatives and that many people are unaware about the existence of their respective ECs.

4.3.2 Procedural justice

Looking at the column for the motivations to engage and experience, tables 4.3 and 4.4 show that 5 out of the 8 members aim to raise their voices and those of their community members in the decision making process. In relation to SRQ3, this shows that an increased citizen engagement in ECs in the selected case study area might lead to a slight increase in procedural justice.

4.3.3 Distributive justice

While the aim of the column "Benefit sharing" was to investigate the presence of distributive justice, interview respondents did not provide responses that could be explicitly aligned with the definition of this energy justice tenet, which acknowledges an equal sharing of burdens and benefits of the energy system between members. However, some of the perceived benefits derived from participating in such initiatives were the payment of less energy bills if efficiency goals are achieved, having the chance to get to know other community members by participating in activities and finally achieving sustainable neighbourhoods through organizing activities with ECs. Some of the perceived burdens on the other hand are the lack of resources to reward volunteers and too much efforts required to run activities.

4.4 OTHER INSIGHTS GENERATED FROM INTERVIEWS

4.4.1 Barriers to citizen engagement and improvement strategies

The main barriers to citizen engagement are lack of time, citizens not trusting the state as they believe the state says many things and does others; for example, the state claims to strive for the promotion of greener societies but however, several policies still favour the use of fossil fuels. Other barriers include lack of technical, legal and policy knowledge. Similarly, participants A, B, E and G mentioned an issue of communication between their initiatives and community members and also an issue with the state not properly communicating citizens. Another issue mentioned by participants A and D was that of delayed activities as most roofs in the city are owned by the state who does not want to offer them for their projects although all their activities are based on promoting the energy transition by installing solar panels on roof tops.

Regarding the improvement strategies, proper ways of communication could be developed to engage ECs minorities and other community citizens. Moreover, people could be provided with little amounts of money or other benefits to get involved in their activities.

4.4.1.1 Conclusion

Based on the results obtained for the 8 interviewed participants, it can be concluded that in the city of The Hague, citizen engagement in ECs could

lead to a limited rise in energy justice due to a non inclusion of minority groups. However, the engagement of citizens could lead to a rise in procedural justice, since 5 out of the 8 interview participants claimed to have engaged to raise their voices and those of their community members in the decision making process.

5 DISCUSSION

This section discusses the research findings in six major steps; first, a brief summary of the key findings are provided with the main takeaways from the research. Then, these key findings are placed in the current global context by backing up and discussing them with reference to the current researches and pre-existing literature. In a third instance, the major unexpected results are discussed with interpretations in relation to the main research question. This is followed by a discussion of the weaknesses or limitations of the research. Later, suggestions for future research are made. Finally, the implications of these key research findings in the field are discussed.

5.1 SUMMARY OF KEY FINDINGS

Following the first SRQ, it is found out that in the province of South Holland in which the case study area is located, the main factors that might affect citizens' willingness to engage in ECs are ethnicity (with minorities potentially more willing to engage in general and for those unaware about the existence of energy communities), gender, age, employment and level of income(with more citizens potentially willing to engage when they are females, their age groups, incomes are higher and when they have higher number of working hours). Similarly, more citizens might be likely to engage with an increase in the level of education and technical know-how. In relation to the main RQ, the insight provided by these results is that for the case study area, a majority of ECs might have a high number of native females of higher age groups with high average incomes and high number of working hours. The relatively lower potential inclusion non natives however may imply a low presence or an absence of recognition justice. Nevertheless, to get a better understanding of these factors in the city of The Hague, several hypothesis were formulated using the different insights obtained from the results of SRQ1 to investigate SRQ2. Turning to SRQ2, it follows as summarized in table 3.16 that around a majority of neighbourhoods with the 24 ECs, the distribution of citizens in terms of age groups, gender, ethnicity, employment status and average annual income favour the engagement of citizens with lower average ages, females, minority groups, people with higher number of working hours and lower average annual incomes. If a conclusion was to be drawn at this point, the result would slightly contradict that from SRQ1 as these suggest a potential higher engagement likelihood of minority groups and hence a potential rise in recognition justice with citizen engagement. However, the results obtained from SRQ2 were used to investigate the situation on the field by interviewing board members of 8 ECs in the case study area through one on one interviews. From SRQ3 and its results summarized

in 4.1, it follows that for the 8 ECs whose board members were interviewed, a majority of their members were native employed males with relatively high average ages and incomes. This allows to conclude for the 8 ECs studied that a rise in citizen engagement only leads to a limited increase in energy justice due to the partial or non acknowledgement of recognition justice and a limited rise in procedural justice. Regarding the main RQ, these results allow to conclude that in the city of The Hague, a rise in citizen engagement in ECs might lead to a very limited increase in energy justice due to the partial or non - inclusion of minorities whose involvement is foundational for the presence of other tenets of energy justice.

5.2 RELATION OF RESEARCH FINDINGS TO GLOBAL CONTEXT

The findings from this research agree with and take further the work of (Hanke et al., 2021), where they conclude that much care must be taken while referring to energy communities as equity enhancing actors as is currently the case in many European countries. Further, this research highlights the fact that energy leaders must be more cautious when making legislations based on unverified assumptions as was the case with that made by the EU in 2019 to promote the creation of energy communities without verifying whether their rise in number could lead to a rise in energy justice (Caramizaru and Uihlein, 2019). Moreover, proper research must be made to ensure that the opportunities created by all formulated policies and laws are equally benefited by all members of the societies in which they are implemented. Similarly during the interviews, when asked about the barriers to citizen engagement, some of the participants mentioned factors such as lack of time, lack of trust between the state and citizens, poor communication with lack of intellectual and social capital. These issues, which constituted some of the key findings from (Koirala et al., 2018), (Radtke, 2014) and (Network, 2021) are indications of existing problems between energy community issues and local development as described by (Forman, 2017). Finally, this research brings a perspective different from that of (Mundaca et al., 2018), where they discuss their findings without explicitly mentioning the role or presence of recognition justice, which according to (Lacey-Barnacle, 2020) is foundational for the other two tenets. This research brings that new perspective to the light and shows that considering the foundational nature of recognition justice for the other two tenets bring new insights about the relation between citizen engagement and energy justice to the actual debates.

5.3 UNEXPECTED RESULTS

While reviewing the literature, papers from (Bauwens and Eyre, 2017) and (van Bommel and Höffken, 2021) suggested that most energy community members are either old rich or middle class retired white men. Similar results were thus expected from each of the SRQs. However in SRQ1 whose

results are summarized on table 2.6, the insights provided by the survey analysis of the ethnicity was the most surprising. For the general cases (those aware and unaware about the existence of ECs) and for those unaware about the existence of ECs, the results suggest minority groups might be more willing to engage in ECs than non minorities. However when aware about their existence, natives appear to be more willing to engage. These results suggest that minorities might be changing their minds about engaging in such initiatives after becoming aware about their existence. Further at the interviews in SRQ3, several participants acknowledged the existence of communication issues between their initiatives and citizens living in their neighbourhoods, which might explain this lack of engagement from minority groups. Conversely, while results from SRQ1 and SRQ2 suggest that females might be more likely to engage and that their distributions around a majority of neighbourhoods with the 24 ECs investigated favours their engagements, the result from SRQ3 demonstrate for the 8 ECs involved that less females might involve in reality. These could however serve as topic for further research. From SRQ2, the results obtained for the distribution of age groups (which was low) and average annual income (which was low) around a majority of neighbourhoods with ECs did not match the hypothesis formulated based on the survey results, highlighting the need for further investigation in SRQ3. Finally in SRQ3, the results obtained in relation to the actual representation of energy community members as shown on table 4.1, contradict the expectations generated from the SDA results except for the employment status. Rather, these findings align with those mentioned by (van Bommel and Höffken, 2021) and (Bauwens and Eyre, 2017) in the literature, where they mention that most EC members are old white males with high incomes. This suggests that while SDA might be efficient in providing statistical results allowing for the generation of insights about existing phenomenons and situations, interactions with individuals directly involved might be more efficient in generating more direct responses based on life experience. However, it is also important to consider that board member opinions might be biased in certain situations and that observations might vary based on the nature of datasets used for the investigations.

5.4 RESEARCH LIMITATIONS

The biggest limitation of this research was at the demographic level in getting enough survey respondents. In the literature, most papers suggest that energy community board members are old, rich, retired and educated. However, although the surveys were disseminated to people from all groups, fewer responses were obtained from people of higher age groups and those having higher number of working hours. Similarly, most of the respondents' highest level of education was at the university level leading to an oversampling for this category. However since the aim of SRQ1 was to generate insights, the results of the analysis were deemed very relevant for the research as they helped to achieve its aims. For a more statistical research, more time should be allowed for the generation of more demographically significant results. On the other hand, another issue stemmed from the inter-

views as some of the participants were old and at times provided answers that were not very useful. A proper way used to address this was to constantly redirect the conversations with follow-up questions leading to the initial questions when needed. Finally, the responses obtained from interview participants when asked about distributive justice were not very well structured as their perceived benefits were very diverse and their responses were not pointing to the way they shared the benefits and burdens of their memberships as asked during the interviews. This tenet was left aside and the conclusion was made principally based on the foundational tenet of recognition justice with additions based on the responses obtained for procedural justice.

5.5 FURTHER RESEARCH RECOMMENDATIONS

Regarding future research recommendations, as this research concludes that citizen engagement only leads to an increase in energy justice upto a limited extent due to the partial or non-acknowledgement of minority groups for the 8 ECs interviewed and might have the same effect for the whole city of The Hague, future research could further investigate this in different areas to generate more knowledge about the the topic. Likewise, based on the results obtained for the 8 interviewed ECs, other research could focus on ways to make ECs more inclusive for different groups of people. Moreover, as interview participants A and F mention that ECs are not usually representative of the neighbourhoods in which they are located, more research could be made to investigate in a first instance whether it is true and why it might be the case. Further, respondent F (appendix B.8) mentioned that no particular focus was previously placed on trying to engage minorities in ECs. This could potentially raise questions as to why this is not the case and how this situation could be improved. Moreover, following the survey results from SRQ1, minorities might be willing to engage in ECs for those unaware about their existence. However, the opposite is observed for those aware, meaning there might be a loss of interest or a communication issue. During the interviews, participants A, B, G and E mentioned the existence of a communication issue which could be interesting to investigate. Finally, 7 interview participants mentioned barriers between citizens and the government such as lack of trust and the non provision of enough support such as roofs owned in majority by the municipality (Participants A and D) to run their projects. These issues highlight existing problems between the ECs and the state at the local development level on which further research could focus.

5.6 IMPLICATIONS OF RESEARCH FINDINGS

To sum up, this research reveals that globally for the 8 ECs interviewed, an increased engagement of citizens in ECs leads to a limited rise in recognition justice which is foundational for the other two tenets of energy justice. Moreover, 5 out of the 8 members who are natives of the Netherlands en-

gage to raise their voices, powers and those of their community peers in the decision making process, leading to a limited rise in energy justice overall with citizen engagement. These findings allow to conclude that in the city of The Hague, an increased citizen engagement in ECs might lead to a limited rise in energy justice. These findings reveal that in the absence of proper measures to promote an equal engagement of all social groups, the same groups or classes of people might keep benefiting from the opportunities offered by the energy transition and the level of inequality might keep rising. Further, before coming up with legislations to promote the creation of such initiatives, proper research should be made to ensure all groups will equally benefit from the opportunities generated by the new policies. Finally, following the EU 2018 Directive on the promotion of the use of energy from renewable sources(EU, 2018) which mentions that the participation in Renewable energy communities must be accessible to all energy consumers including those from vulnerable households with low income, one may argue that ECs are already accessible to all and that it is the responsibility of each social group to decide whether to engage or not based on their interests and priorities. However from the interviews, while participant F mentioned that vulnerable groups have not been the particular focus of their initiative, participants B, and G mentioned that people should be paid to dedicated time working for ECs. It is for this reason that proper support in terms of policies, funding or other measures could be provided to such groups to raise their interests in the energy transition and promote energy justice.

6 CONCLUSION

Through the acknowledgement of minority groups, this research aimed to investigate the relation between citizen engagement in energy communities and energy justice. For this, the case study area selected was the city of The Hague due to its significance in the world in terms of justice and the availability of organized and regularly updated dataset on the Municipality's website that could be used to investigate the presence of instances of the recognition justice tenet. The results allow to conclude that for the selected area, a rise in citizen engagement in the current setting might only lead to a limited increase in energy justice principally due to a limited presence of instances of the recognition justice tenet(partial or non-inclusion of minority groups) in the 7 out of the 8 ECs whose board members were interviewed. The sections that follow discuss how each SRQ contributes to answering the main RQ:

6.1 SUB – RESEARCH QUESTION 1

SRQ1: *Which factors could influence the willingness of citizens to engage in energy communities?*

To investigate SRQ1, this section made use of a literature review, a case study approach and an online survey through a mix method approach. The literature review reveals that the following factors in table 6.1 affect the willingness of citizens to engage in energy communities in general.

Factors affecting willingness to engage:	Energy education, awareness about existing local energy initiatives, renewable energy acceptance , environmental concern, age, education, community resistance, energy Independence, trust, time, ethnicity,income ,technical know-how, social norms, gender

Table 6.1: Literature Review findings and Knowledge Gaps

The purpose of the online survey carried out in the province of South Holland was to evaluate whether and / or how the literature review findings of interest (factors of age, ethnicity, gender, income, education and employment status) could affect the willingness of citizens to participate voluntarily in energy communities during their leisure times to contextualize the findings around the case study area. It is important to note that these specific factors were selected based on the research aim which is to investigate the

recognition justice tenet that in turn acknowledges an inclusion of marginal groups which are characterized by these indicators as described in 1.3 and defined by (EIGE, 2022) and (UNHCR, 2022) and also due to their availability on the Municipality's website for the investigation of SRQ2.

6.1.0.1 Contribution of SRQ1 results to answering the main RQ

The results obtained from SRQ1 show that in the province of South Holland and potentially in the case study area, the likelihood to engage in an energy community might increase with an increase in age, income, number of working hours, level of education and might be higher for females. Similarly, natives aware about the existence of ECs might be more likely to engage than minority groups (Asians, Africans and African descendants). Looking at these results, it appeared as if the minority groups, males and people from lower age groups might be less likely to engage, suggesting that recognition justice and potentially other energy justice tenets might be absent. However, the aim of the survey was to provide insights about the factors that could potentially affect citizen willingness to engage in the ECs to be used in SRQ2 for hypothesis generation. The findings from this SRQ thus contributed by producing insights used to generate several hypothesis used to investigate SRQ2.

6.2 SUB – RESEARCH QUESTION 2

SRQ2: *What is the distribution of factors potentially affecting citizen willingness to engage around areas with energy communities?*

To investigate SRQ2, this section made use of the survey results to formulate different hypothesis for each indicator, which were later used to investigate their distributions around the neighbourhoods with 24 ECs in The Hague. This allowed to determine whether any particular social groups were favoured by their distributions around the ECs.

The results (table 3.16) show that the locations of people with lower ages, females, minority groups, majority of employed people and people with lower average incomes around the majority of neighbourhoods with ECs favour their engagements in such initiatives. Following the survey hypothesis, the results obtained for the distribution of females, minorities and people with higher number of working hours was expected.

6.2.0.1 Contribution of SRQ2 results towards answering the main RQ

The results obtained from SRQ2 allowed to further contextualize the findings to the case study area, since the study performed with SRQ1 was made for the whole province of South Holland. Moreover in relation to the main RQ, these findings provide information used at the interview phase in SRQ3

to investigate the fundamental part of the research which is to determine whether the recognition justice tenet might be present in ECs as a result of citizen engagement using the interview questions (appendix A.7). Finally, the results obtained from this section provide an idea about the potential membership representation of ECs

6.3 SUB – RESEARCH QUESTION 3

SRQ3: *What effect could citizen engagement in energy communities have on energy justice?*

As the final sub-research question, this question used the results obtained from SRQ2 to investigate the effects citizen engagement in ECs could have on energy justice through the inclusion of the recognition justice tenet. Moreover, the results obtained from this also allow to determine whether there is a potential relation between citizen engagement and ECs as required by the RQ. For this, 8 board members of ECs in The Hague were interviewed. The relevant interview responses are shown on tables 4.3 and 4.4

6.3.0.1 Contribution of SRQ3 results to answering the main RQ

Following the interview results (figure 4.3), 7 out of 8 board members of the energy communities acknowledged that most members of their initiatives are usually old, white, rich employed or retired. Moreover, 5 members acknowledge that a majority of their members are males. This shows that with a rise in citizen engagement, inequalities in terms of people with higher ages, the same ethnicity, high income and employment status might keep rising for the 8 ECs whose board members were interviewed. These results provide important insights about what might be the general situation in the whole city and an important starting point for further research. Moreover, the results obtained for the majority of initiatives interviewed shows that a majority of ECs in The Hague might not be representative of the neighbourhoods in which they are located as confirmed by two interview participants (neighbourhoods having high number of minority groups, relatively low average income, age and higher number of females with fewer participants from those groups). However, 5 out of the 8 participants acknowledged to have engaged in order to have higher influence on the decisions affecting the energy they consume, suggesting that their engagement might lead to a rise in procedural justice. No direct response was obtained in relation to distributive justice as participants all perceive different and non quantitative benefits in engaging in such initiatives.

6.4 ANSWERING THE MAIN RESEARCH QUESTION

RQ: What is the relation between citizen engagement in Energy communities and Energy Justice?

This research question aimed to investigate whether an increased citizen engagement in ECs might lead to a rise in energy justice by integrating the inclusion of recognition justice in the research. Following the findings from the three SRQs, it follows that for the case study area, a rise in citizen engagement in ECs might only lead to a limited increase in energy justice due to the non or partial inclusion of minority groups irrespective of their high presence in the majority of neighbourhoods ECs. For the 8 initiatives interviewed, the absence or lower number of these minority groups in their memberships shows there is no equal distribution of the benefits and burdens of the energy systems(distributive justice) or equal rise in decision making power in their settings. However, the fact that 5 out of the 8 interview participants said they had engaged in their respective ECs to raise their powers and those of their community members in the decision making process shows that although there is a limited presence of recognition justice whose nature is foundational for the other two tenets, the participating members are still willing to raise their voices in the decision making process. These results show that in the whole city of The Hague in general, citizen engagement in ECs might lead to a rise in energy justice upto a limited extent due to the non or limited acknowledgement of minority groups and the motivations for members to raise their voices in the decision making process.

6.5 REFLECTION

The findings from this research align with that of (Hanke et al., 2021), where they conclude that care must be taken while referring to energy communities as initiatives promoting energy justice. Thus, this research shows that the assumption that ECs lead to a rise in energy justice as made by the EU by coming up with a legislation to promote the creation of such initiatives (Caramizaru and Uihlein, 2019) should had been verified in the first place as this tie is not explicit. Further, the results show that energy community issues highlight problems of local development as discussed by (Forman, 2017) as the majority of the interview participants mention issues encountered with the state while working on their objectives. On the other hand, although (Mundaca et al., 2018), find out that only certain classes of people usually benefit from the opportunities provided by ECs, this research argues based on its hypothesis and findings that any research seeking to investigate the link between such initiatives and energy justice must explicitly consider the recognition justice tenet due to its foundational nature as highlighted by (Lacey-Barnacle, 2020). Finally, the existing barriers to citizen engagement found in the case study area(communication, lack of technical know-how and social capital, mistrust and time issues) also align with those identified by (Koirala et al., 2018), (Radtke, 2014) and (Network, 2021) which might be good topics for further research.

To complement the interesting findings and potential further research areas discussed in section 5, the survey results revealed that for those unaware about the existence of energy communities, minority groups are more will-

ing to engage in such initiatives. Moreover, an even more interesting observation between SRQ1, SRQ2 and SRQ3 according to the interviewed board members was that the majority of energy community members in The Hague are native males irrespective of a high presence of minority groups and females in the areas with those initiatives. These findings also highlight the importance of using both qualitative and quantitative techniques in performing such research helping to detect the potential advantages of one method over the other. In this particular case, while the survey and interview results allow to strengthen the already existing literature findings, the findings from the SDA highlight a possible unequal share or benefiting of opportunities between different classes of people as those with higher distributions around ECs neighbourhoods seem to be the less involved. Further research could thus focus on investigating why this phenomenon was observed and what could be done to achieve a more equal level of engagement. Similarly, following the main research finding, further research could focus on investigating how to make energy communities more appealing for minority groups.

All in all, this research shows that for the 8 ECs whose board members participated in the interviews, an increased engagement of citizens only leads to a limited rise in energy justice. This result allows to conclude that a similar situation might potentially be observed in the whole case study area. However, before making any significant conclusion, more research covering a larger number of energy communities and involving a more demographically equal number of survey respondents from diverse contexts might be needed.

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A APPENDIX

A.1 LITERATURE REVIEW

Query	Keywords	Results
1	"Socioeconomic factors" OR "Sociodemographic" OR "demographic"	
2	"Citizen engagement*" OR "Energy Consum* engag* " OR " Citizen participation" OR "Energy Consum*"	
3	"Statistic* analysis " OR "Data* analysis" OR "Numeric* analysis"	
4	"Netherland*" OR "Dutch"	
5	[Search Query 1] AND [Search Query 2] AND [Search Query 3] AND [Search Query 4] AND [Search Query 5]	0
6	[Search Query 1] AND [Search Query 2] AND [Search Query 3] AND [Search Query 4]	4
7	[Search Query 1] AND [Search Query 2] AND [Search Query 3]	3
8	[Search Query 1] AND [Search Query 2]	132

Table A.1: Literature Review Search Queries

A.2 ONLINE SURVEY QUESTIONS

You are being invited to participate in a research study titled " **Investigating the socioeconomic factors affecting the willingness of citizens to engage in Energy Community Initiatives**". This study is being conducted by Elie Christian Azeufack from the TU Delft.

The purpose of this research study is to determine the socioeconomic factors that affect the willingness of citizens to engage in Energy community initiatives, and will take you approximately **2 minutes to complete**. The data will be used for a statistical analysis and will be made publicly available as part of my Master's thesis study after publication. We will be asking you to answer the questions in the online survey below as part of this research.

As with any online activity, the risk of a breach is always possible. To the best of our ability, your answers in this study will remain confidential. We will minimize any risks by an institutional tool managed by the Delft University of Technology and the data will remain on the Delft University of Technology Infrastructure accessible only to the research team. We will not ask for any information that could lead to your identification. The data collected will be publicly shared with the results of the Master's Thesis after publication

Your participation in this study is **entirely voluntary and you can withdraw at any time**. You are free to omit any questions.

You can reach me at eazeufack@tudelft.nl for any question

Do you Currently Reside in The Netherlands?

Yes

No

If the answer to the previous question is "Yes", please indicate the province in which you reside

- Drenthe
- Flevoland
- Friesland
- Gelderland
- Groningen
- Limburg
- Noord-Brabant
- Noord-Holland
- Overijssel
- Zuid-Holland
- Utrecht
- Zeeland

up do you belong to?

Non - Binary

Prefer not to say

Which gender group do you belong to?

- Male
- Female
- Non - Binary
- Prefer not to say

How old are you?

- Under 18
- 18-24 years old
- 25-34 years old
- 35-44 years old
- 45-54 years old
- 55-64 years old
- 65+ years old

Which social Group do you feel closest to?

- White
- Black or African descendant
- Asian
- Hispanic
- Other

→

What is your highest level of Education?

- Basic Education
- Secondary School
- High School
- Higher Vocational Education
- University

What is your current employment Status ?

- Unemployed
- Fulltime Worker
- Retired
- Part time Worker
- Prefer not to say

Please Select your Annual Income Level in Euros.

- Unemployed
- Less than 28800
- 28800
- Between 28800 and 57000 Euros
- Greater than 57000 Euros
- Do not want to disclose

← →

The Following Questions Concern Energy Community Initiatives

Definition: An Energy Community Initiative is a joint Action ran by citizens to produce their own renewable(Green) Energy to share the benefits and burdens of the energy system.

Have you ever head about the word "**Energy Community**" or "**Energy Cooperative**?"

- Yes
- No

How likely are you to volunteer during your leisure time in a regional energy cooperative that undertakes projects related to renewable energies ?

- Very likely
- Somewhat likely
- Neither likely nor unlikely
- Somewhat unlikely
- Very unlikely

How likely are you to participate financially by making an investment in a regional energy cooperative focused on renewable energies ?

Very likely

Somewhat likely

Neither likely nor unlikely

Somewhat unlikely

Very unlikely

← →

A.3 ANALYSIS OF SURVEY RESULTS NOTEBOOK

In [1]:
```
%matplotlib inline
import matplotlib
from matplotlib import pyplot as plt
import os             # This provides several system utilities
import pandas as pd    # This is the workhorse of data munging in Python
import seaborn as sns
```

The following code loads the online survey results file named "surveyresults.csv" into Python, elliminates the gaps between the words in column names and displays the top 5 rows of the file

In [2]:
```
data =pd.read_csv('data/surveyresults.csv') #Loads the survey results file
data.columns = data.columns.str.replace(' ', '_') #Removes gap between words in column names
data.head()  #display top 5 rows of dataset
```

Out[2]:

	StartDate	EndDate	Status	IPAddress	Progress	Duration_(in_seconds)	Finished	
0	Start Date	End Date	Response Type	IP Address	Progress	Duration (in seconds)	Finished	
1	{"ImportId":"startDate","timeZone":"America/De...	{"ImportId":"endDate","timeZone":"America/Denv...	{"ImportId":"status"}	{"ImportId":"ipAddress"}	{"ImportId":"progress"}	{"ImportId":"duration"}	{"ImportId":"finished"}	{"ImportId":"recordedDate","timeZ
2	2022-05-02 11:48:49	2022-05-02 11:50:11	IP Address	213.127.29.113	100	81	True	202
3	2022-05-03 01:49:25	2022-05-03 01:52:37	IP Address	86.95.10.124	100	191	True	202
4	2022-05-03 02:09:11	2022-05-03 02:11:17	IP Address	139.63.45.124	100	125	True	202

5 rows × 28 columns

The code below drops the row with index number 1 to allow for easier examination of the data

In [3]:
```
new_data = data.drop(1)  #drop row with index number 0
new_data.head(2)
```

Out[3]:

	StartDate	EndDate	Status	IPAddress	Progress	Duration_(in_seconds)	Finished	RecordedDate	ResponseId	RecipientLastName	...	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	
0	Start Date	End Date	Response Type	IP Address	Progress	Duration (in seconds)	Finished	Recorded Date	Response ID	Recipient Last Name	...	If the answer to the previous question is "Yes...	Which gender group do you belong to?	How old are you?	Which social Group do you feel closest to?	Why did you choose to take the question tour?	What is your current employment Status ?	Please Select your Annual Income Level in Euros.	Have you ever head about the word "Energy Comm...	like y volu d yo
2	2022-05-02 11:48:49	2022-05-02 11:50:11	IP Address	213.127.29.113	100	81	True	2022-05-02 11:50:11	R_1n3AyAABbScxOQ6	NaN	...	NaN	Male	35-44 years old	Asian	High School	Fulltime Worker	28800	Yes	

2 rows × 28 columns

On the survey results file, columns with information such as the start date of the survey, status, progress, recipients last name are created. For the sake of the analysis, all columns not relevant for the analysis are dropped so as to allow only columns with containing interview questions and responses

In [4]:
```
new_data_c = new_data.drop(['StartDate', "EndDate","Status","Progress","Duration_(in_seconds)",
                            "Finished","RecordedDate","ResponseId","RecipientLastName"
                           ,"IPAddress","RecipientFirstName","RecipientEmail","ExternalReference",
                            "LocationLatitude","LocationLongitude","DistributionChannel",
                            "UserLanguage","Q1_Single_choice",], axis = 1)  #drop columns not useful for the analysis

new_data_c.head()
```

Out[4]:

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
0	If the answer to the previous question is "Yes...	Which gender group do you belong to?	How old are you?	Which social Group do you feel closest to?	Why did you choose to take the question tour?	What is your current employment Status ?	Please Select your Annual Income Level in Euros.	Have you ever head about the word "Energy Comm...	How likely are you to volunteer during your le...	How likely are you to participate financially ...
2	NaN	Male	35-44 years old	Asian	High School	Fulltime Worker	28800	Yes	Very likely	Very likely
3	Zuid-Holland	Male	45-54 years old	Other	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely
4	Zuid-Holland	Male	55-64 years old	White	University	Part time Worker	Greater than 57000 Euros	Yes	Very likely	Somewhat likely
5	Zuid-Holland	Female	35-44 years old	White	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely

The code below counts the number of null / zero values per column

In [5]:
```
new_data_c.isna().sum() # counts the number of null / zero values per column
```

Out[5]:
```
Q2      13
Q2.1     7
Q3       7
Q4       7
Q5       8
Q6       8
Q7       8
Q8      12
Q9      12
Q10     12
dtype: int64
```

Because the survey responses were collected for participants from all provinces of The Netherlands, responses received from other regions are dropped so as to remain only with those from South Holland

In [6]:
```
zuidholland = new_data_c[new_data_c.Q2 == 'Zuid-Holland'] # create a subset so as to remain only with data from residents of South Holland
zuidholland.head()
```

Out[6]:

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
3	Zuid-Holland	Male	45-54 years old	Other	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely
4	Zuid-Holland	Male	55-64 years old	White	University	Part time Worker	Greater than 57000 Euros	Yes	Very likely	Somewhat likely
5	Zuid-Holland	Female	35-44 years old	White	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely
6	Zuid-Holland	Female	65+ years old	White	University	Retired	Greater than 57000 Euros	Yes	Very likely	Somewhat likely
7	Zuid-Holland	Male	65+ years old	White	University	Retired	Greater than 57000 Euros	Yes	Very likely	Very unlikely

In [7]:
```
zuidholland.describe() #provides description of the dataset
```

Out[7]:

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
count	105	105	105	105	105	105	105	102	102	102

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
unique	1	3	7	5	4	5	6	2	5	5
top	Zuid-Holland	Male	18-24 years old	White	University	Unemployed	Unemployed	No	Somewhat likely	Very unlikely

The code below counts and displays the number of respondents per catergory for Q2.1 which is: Which gender group do you belong to?

In [8]:
```
l = zuidholland['Q2.1'].value_counts() #count and display number of respondents for the question
                                       # Which gender group do you belong to?
l
```

Out[8]:
```
Male            64
Female          40
Non - Binary     1
Name: Q2.1, dtype: int64
```

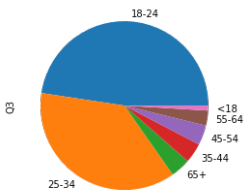
The code below counts and displays the number of respondents per catergory for Q3 which is: How old are you?

In [9]:
```
a = zuidholland['Q3'].value_counts() #count and group based on age groups
a
```

Out[9]:
```
18-24 years old    50
25-34 years old    39
35-44 years old     4
45-54 years old     4
65+ years old       4
55-64 years old     3
Under 18            1
Name: Q3, dtype: int64
```

In [10]:
```
a.plot(kind='pie', labels=['18-24','25-34','65+', "35-44","45-54", "55-64", "<18"]) #display pie chart for different age groups
```

Out[10]:
```
<AxesSubplot:ylabel='Q3'>
```



The code below counts and displays the number of respondents per catergory for Q4 which is: Which social Group do you feel closest to?

In [11]:
```
zuidholland['Q4'].value_counts() #counts and displays the number of respondents per catergory for Q4 which is:
                                 #Which social Group do you feel closest to?
```

Out[11]:
```
White                          48
Black or African descendant    24
Other                          14
Asian                          11
Hispanic                        8
Name: Q4, dtype: int64
```

The code below counts and displays the number of respondents per catergory for Q5 which is: What is your highest level of Education?

In [12]:
```
zuidholland['Q5'].value_counts() #counts and displays the number of respondents per
                                 #catergory for Q5 which is: What is your highest Level of Education?
```

Out[12]:
```
University                    92
High School                    9
Higher Vocational Education    2
Secondary School               2
Name: Q5, dtype: int64
```

The code below counts and displays the number of respondents per catergory for Q6 which is: What is your current employment Status ?

In [13]:
```
zuidholland['Q6'].value_counts()
```

Out[13]:
```
Unemployed           42
Part time Worker     39
Fulltime Worker      19
Retired               4
Prefer not to say     1
Name: Q6, dtype: int64
```

The code below counts and displays the number of respondents per catergory for Q7 which is: Please Select your Annual Income Level in Euros

In [14]:
```
zuidholland['Q7'].value_counts()
```

Out[14]:
```
Unemployed                   37
Less than 28800              35
Between 28800 and 57000 Euros    18
Greater than 57000 Euros      7
Do not want to disclose       6
28800                         2
Name: Q7, dtype: int64
```

The code below counts and displays the number of respondents per catergory for Q7 which is: Have you ever head about the word "Energy Community" or "Energy Cooperative?"

In [15]:
```
zuidholland['Q8'].value_counts()
```

Out[15]:
```
No     63
Yes    39
Name: Q8, dtype: int64
```

The code below counts and displays the number of respondents per catergory for Q7 which is: How likely are you to volunteer during your leisure time in a regional energy cooperative that undertakes projects related to renewable energies ?

In [16]:
```
zuidholland['Q9'].value_counts()
```

Out[16]:
```
Somewhat likely               27
Very unlikely                 20
Somewhat unlikely             20
Very likely                   20
Neither likely nor unlikely   15
Name: Q9, dtype: int64
```

In [17]:
```
province_data = zuidholland  #rename dataset with survey results for the province of south holland
province_data.head(2)
```

Out[17]:

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
3	Zuid-Holland	Male	45-54 years old	Other	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely
4	Zuid-Holland	Male	55-64 years old	White	University	Part time Worker	Greater than 57000 Euros	Yes	Very likely	Somewhat likely

The code below creates a new column called "Q11" by assigning weights based on participant's likelihoods to engage with 5 assigned to people very likely to engage and 0 very unlikely to engage respectively

In [18]:
```
def categorise(row):
    if row['Q9'] ==  "Very likely":
        return 5
    elif row['Q9'] == "Somewhat likely":
        return 4
    elif row['Q9'] == "Neither likely nor unlikely":
        return 3
    elif row['Q9'] == "Somewhat unlikely":
        return 2
    else:
        return 1
province_data['Q11'] = province_data.apply(lambda row: categorise(row), axis=1)
province_data.head()
```

```
C:\Anaconda3\envs\gds\lib\site-packages\ipykernel_launcher.py:12: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/user_guide/indexing.html#returning-a-view-versus-a-copy
  if sys.path[0] == '':
```

Out[18]:

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
3	Zuid-Holland	Male	45-54 years old	Other	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely	4
4	Zuid-Holland	Male	55-64 years old	White	University	Part time Worker	Greater than 57000 Euros	Yes	Very likely	Somewhat likely	5
5	Zuid-Holland	Female	35-44 years old	White	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely	4
6	Zuid-Holland	Female	65+ years old	White	University	Retired	Greater than 57000 Euros	Yes	Very likely	Somewhat likely	5
7	Zuid-Holland	Male	65+ years old	White	University	Retired	Greater than 57000 Euros	Yes	Very likely	Very unlikely	5

For the age groups, the code below computes the sum of all weights within the same age group and divides by the sum of values per group

In [19]:
```
age_rank = province_data.groupby('Q3')['Q11'].sum() / province_data.groupby('Q3').size()
age_rank.sort_values(ascending=False)          #Rank values in descending order
```

Out[19]:
```
Q3
55-64 years old    5.000000
65+ years old      4.750000
45-54 years old    3.750000
35-44 years old    3.500000
25-34 years old    2.871795
18-24 years old    2.800000
Under 18           1.000000
dtype: float64
```

In [20]:
```
#ax = age_rank.plot.bar(x='Q11', y='val', rot=1110). Verify plots
```

For the ethnicity groups, the code below computes the sum of all weights within the same age group and divides by the sum of values per group

In [21]:
```
ethnic_rank = province_data.groupby('Q4')['Q11'].sum() / province_data.groupby('Q4').size()
ethnic_rank.sort_values(ascending=False)          #Rank values in descending order
```

Out[21]:
```
Q4
Asian                          3.181818
Black or African descendant    3.166667
White                          2.937500
Other                          2.928571
Hispanic                       2.875000
dtype: float64
```

For the education level groups, the code below computes the sum of all weights within the same age group and divides by the sum of values per group

In [22]:
```
education_rank = province_data.groupby('Q5')['Q11'].sum() / province_data.groupby('Q5').size()
education_rank.sort_values(ascending=False)              #Rank values in descending order
```

Out[22]:
```
Q5
Higher Vocational Education    3.500000
University                     3.108696
High School                    2.111111
Secondary School               2.000000
dtype: float64
```

For the employment type groups, the code below computes the sum of all weights within the same age group and divides by the sum of values per group

In [23]:
```
employment_status_rank = province_data.groupby('Q6')['Q11'].sum() / province_data.groupby('Q6').size()
employment_status_rank.sort_values(ascending=False)              #Rank values in descending order
```

Out[23]:
```
Q6
Retired              5.000000
Fulltime Worker      3.157895
Prefer not to say    3.000000
Part time Worker     2.974359
Unemployed           2.785714
dtype: float64
```

For the income level groups, the code below computes the sum of all weights within the same age group and divides by the sum of values per group

In [24]:
```
income_rank = province_data.groupby('Q7')['Q11'].sum() / province_data.groupby('Q7').size()
income_rank.sort_values(ascending=False)           #Rank values in descending order
```

Out[24]:
```
Q7
Greater than 57000 Euros         4.142857
Do not want to disclose          3.666667
Between 28800 and 57000 Euros    3.222222
Unemployed                       2.864865
Less than 28800                  2.742857
28800                            2.500000
dtype: float64
```

For the gender groups, the code below computes the sum of all weights within the same age group and divides by the sum of values per group

In [25]:
```
gender_rank = province_data.groupby('Q2.1')['Q11'].sum() / province_data.groupby('Q2.1').size()
gender_rank.sort_values(ascending=False)              #Rank values in descending order
```

Out[25]:
```
Q2.1
Female          3.1750
Male            2.9375
Non - Binary    1.0000
dtype: float64
```

Evaluations below are for respondents who indicated they were aware about the existence on ECs

The code below creates a subset of the dataset only for respondents who indicated they had previouly heard about the existence of ECs

In [26]:
```
have_heard=province_data[province_data["Q8"].isin(["Yes" ])]
have_heard.head()
```

Out[26]:

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
3	Zuid-Holland	Male	45-54 years old	Other	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely	4
4	Zuid-Holland	Male	55-64 years old	White	University	Part time Worker	Greater than 57000 Euros	Yes	Very likely	Somewhat likely	5
5	Zuid-Holland	Female	35-44 years old	White	University	Fulltime Worker	Between 28800 and 57000 Euros	Yes	Somewhat likely	Very likely	4
6	Zuid-Holland	Female	65+ years old	White	University	Retired	Greater than 57000 Euros	Yes	Very likely	Somewhat likely	5
7	Zuid-Holland	Male	65+ years old	White	University	Retired	Greater than 57000 Euros	Yes	Very likely	Very unlikely	5

The Code below ranks based on ethnic groups aware about existing ECs

In [27]:
```
heard_ethnic_rank = have_heard.groupby('Q4')['Q11'].sum() / have_heard.groupby('Q4').size()
heard_ethnic_rank.sort_values(ascending=False)
```

Out[27]:
```
Q4
White                           4.187500
Black or African descendant     3.571429
Other                           3.000000
Asian                           2.800000
Hispanic                        2.666667
dtype: float64
```

The Code below ranks based on gender groups having heard about existing ECs

In [28]:
```
heard_gender_rank = have_heard.groupby('Q2.1')['Q11'].sum() / have_heard.groupby('Q2.1').size()
heard_gender_rank.sort_values(ascending=False)
```

Out[28]:
```
Q2.1
Female    3.714286
Male      3.440000
dtype: float64
```

Evaluations below are for respondents who indicated they were unaware about the existence on ECs

The code below creates a subset of the dataset only for respondents who indicated they had never heard about the existence of ECs

In [29]:
```
have_not_heard=province_data[province_data["Q8"].isin(["No" ])]
have_not_heard.head()
```

Out[29]:

	Q2	Q2.1	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11
9	Zuid-Holland	Male	25-34 years old	Black or African descendant	University	Fulltime Worker	Between 28800 and 57000 Euros	No	Somewhat likely	Somewhat likely	4
17	Zuid-Holland	Male	18-24 years old	Black or African descendant	High School	Part time Worker	Less than 28800	No	Very unlikely	Very unlikely	1
18	Zuid-Holland	Male	18-24 years old	White	High School	Part time Worker	Less than 28800	No	Very unlikely	Very unlikely	1
19	Zuid-Holland	Male	18-24 years old	White	University	Unemployed	Unemployed	No	Somewhat unlikely	Somewhat likely	2
20	Zuid-Holland	Female	18-24 years old	White	University	Part time Worker	Less than 28800	No	Somewhat unlikely	Neither likely nor unlikely	2

The Code below ranks based on ethnic groups unaware about existing ECs

In [30]:
```
not_heard_ethnic_rank = have_not_heard.groupby('Q4')['Q11'].sum() / have_not_heard.groupby('Q4').size()
not_heard_ethnic_rank.sort_values(ascending=False)
```

Out[30]:
```
Q4
Asian                           3.500000
Black or African descendant     3.125000
Hispanic                        3.000000
Other                           2.833333
White                           2.400000
dtype: float64
```

The Code below ranks based on gender groups unaware about existing ECs

In [31]:
```
not_heard_gender_rank = have_not_heard.groupby('Q2.1')['Q11'].sum() / have_not_heard.groupby('Q2.1').size()
not_heard_gender_rank.sort_values(ascending=False)
```

Out[31]:
```
Q2.1
Female          2.884615
Male            2.750000
Non - Binary    1.000000
dtype: float64
```

In [ ]:

A.4 SPATIAL DATA ANALYSIS NOTEBOOK

NB: All guidelines used to perform evaluations on this notebook are available the course called Introduction to Urban Data Science taught at the Delft by Trivik Verma, Assistant Professor of Urban Science and Policy at TU Delft available from laboratory exercise 4 at Course Materials and also on the online resources available at Online resources

In [1]:
```
%matplotlib inline

import matplotlib.pyplot as plt
import geopandas as gpd
import palettable as pltt
from seaborn import palplot
import numpy as np
import scipy as sp
import matplotlib as mpl
import matplotlib.cm as cm
import pandas as pd
from IPython.core.display import HTML
import seaborn as sns
#from sklearn.linear_model import LinearRegression
#from sklearn.model_selection import train_test_split
#from sklearn.metrics import mean_squared_error
from pysal.lib import weights
from pysal.explore import esda
import warnings
from splot.esda import moran_scatterplot, lisa_cluster, plot_local_autocorrelation
import contextily as ctx
warnings.filterwarnings('ignore')
%config InlineBackend.figure_format ='retina'
```

The Code line below imports the shape file of the map of The Hague

In [2]:
```
#pd.set_option("display.max_rows", None)
#pd.set_option('display.max_rows', None)
hague_shape=gpd.read_file("data/neighborhoods.shp") #Imports shape file with geometric data
hague_shape.head() #displays the top 5 rows
```

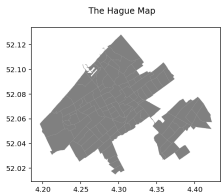
Out[2]:

	neighb_cbs	neigb_cijf	geometry
0	Oostduinen	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...
1	Belgisch Park	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...
2	Westbroekpark	73 Westbroekpark	POLYGON ((4.29171 52.10745, 4.29181 52.10739, ...
3	Duttendel	74 Duttendel	POLYGON ((4.32252 52.10768, 4.32252 52.10766, ...
4	Nassaubuurt	48 Nassaubuurt	POLYGON ((4.31943 52.09247, 4.31943 52.09247, ...

The lines below uses the shape file imported to plot the map of The Hague

In [3]:
```
f, ax = plt.subplots(1) # Sets up figure and axis
hague_shape.plot(ax=ax, facecolor='grey', figsize=(100, 100)) #Plots layer of polygons on the axis
f.suptitle("The Hague Map") #Adds title
```

Out[3]:
```
Text(0.5, 0.98, 'The Hague Map')
```



The code below imports the csv files containing information about the average ages, genders, employment level, average personal incomes and minorities

In [4]:
```
age=pd.read_excel("data/age.xlsx", index_col=0) #reads the csv file containing our dataset
gender=pd.read_excel("data/gender.xlsx", index_col=0) #reads the csv file containing our dataset
employment=pd.read_excel("data/employment.xlsx", index_col=0) #reads the csv file containing our dataset
average_income=pd.read_excel("data/average_income.xlsx", index_col=0) #reads the csv file containing our dataset
minorities=pd.read_excel("data/minorities.xlsx", index_col=0)
```

In [5]:
```
age.head(2) #display average age dataset
```

Out[5]:

	Age
neigb_cijf	

neigb_cijf	Age

In [6]:
```
gender.head(2) #display gender dataset
```

Out[6]:

neigb_cijf	male	female
01 Oud Scheveningen	0.503	0.497
02 Vissershaven	0.486	0.514

In [7]:
```
employment.head(2) #display no. of employed persons dataset
```

Out[7]:

neigb_cijf	No_of_employed_persons
01 Oud Scheveningen	856
02 Vissershaven	3102

In [8]:
```
average_income.head(2) #display average income dataset
```

Out[8]:

neigb_cijf	average_personal_income
01 Oud Scheveningen	32600
02 Vissershaven	37000

In [9]:
```
minorities.head(2) #display minorities dataset
```

Out[9]:

neigb_cijf	non_western_minorities	western_minorities
15 Schildersbuurt-West	2226.0	1711.0
25 Laakkwartier-Oost	1903.0	4161.0

The code below creates a list from the age, gender, employment, average_income, minorities datasets

In [10]:
```
data_frames = [age, gender, employment, average_income, minorities]
type(data_frames)   #display data type
```

Out[10]:
```
list
```

In [11]:
```
from functools import reduce
```

The code line below merges the data from the different list sets on the column called "neigb_cijf". This column contains the names of different neighbourhoods in The Hague

In [12]:
```
df_merged = reduce(lambda  left,right: pd.merge(left,right,on=['neigb_cijf'],
                                            how='outer'), data_frames)
```

The code below converts the merged list data to a dataframe in table form

In [13]:
```
pd.DataFrame.to_csv(df_merged, 'merged.txt', sep=',', na_rep='.', index=False)
```

In [14]:
```
df_merged.head() # display data
```

Out[14]:

neigb_cijf	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities
01 Oud Scheveningen	42.5	0.503	0.497	856	32600	173.0	436.0
02 Vissershaven	42.8	0.486	0.514	3102	37000	256.0	797.0
03 Scheveningen Badplaats	41.6	0.49	0.510	2567	39000	508.0	1298.0
04 Visserijbuurt	42.6	0.469	0.531	1638	34800	360.0	911.0
05 v Stolkpark/Schev Bosjes	46.6	0.487	0.513	741	85000	75.0	260.0

The code below merges the dataset from the shape file of the map of The Hague to the merged indicators dataframe on the "neigb_cijf" column with names of neighbourhoods

In [15]:
```
merged_data = hague_shape.join(df_merged, on='neigb_cijf')  #Merges datasets at the neigb_cijf column
merged_data.head()
```

Out[15]:

neighb_cbs	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities

	neighb_cbs	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities
0	Oostduinen	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...	NaN	NaN	NaN	1148	NaN	NaN	NaN
1	Belgisch Park	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...	42.3	0.491	0.509	3888	46600	781.0	1978.0
2	Westbroekpark	73 Westbroekpark	POLYGON ((4.29171 52.10745, 4.29181 52.10739, ...	57.7	0.449	0.551	364	69800	58.0	279.0
3	Duttendel	74 Duttendel	POLYGON ((4.32252 52.10768, 4.32252 52.10766, ...	50.2	0.447	0.553	2789	71400	74.0	274.0

In [16]:
```
merged_data.isnull().sum()   # check null values in dataset
```

Out[16]:
```
neighb_cbs                0
neigb_cijf                0
geometry                  0
Age                       3
male                      3
female                    3
No_of_employed_persons    0
average_personal_income   7
non_western_minorities    3
western_minorities        3
dtype: int64
```

For all rows without indicator values, the code below replaces the 0 and NAN values with the mean indicator values for those columns

In [17]:
```
for_maps = merged_data.fillna(merged_data.mean())#Fill NANs with Column means
for_maps.head(2)
```

Out[17]:

	neighb_cbs	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities
0	Oostduinen	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...	40.840541	0.500883	0.499117	1148	39417.757009	607.837838	965.927928
1	Belgisch Park	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...	42.300000	0.491000	0.509000	3888	46600.000000	781.000000	1978.000000

In [18]:
```
for_maps.isnull().sum()  # counts null values
```

Out[18]:
```
neighb_cbs                0
neigb_cijf                0
geometry                  0
Age                       0
male                      0
female                    0
No_of_employed_persons    0
average_personal_income   0
non_western_minorities    0
western_minorities        0
dtype: int64
```

The code below subsets the containing the column names "neighb_cbs and neigb_cijf". While the labellings under neighb_cbs are those for neighbourhoods as labelled by the Centraal Bureau voor de Statistiek, only those labelled by the municipality of The Hague under the column "neigb_cijf" are used in the later parts of the research.

In [19]:
```
targeted_hoods=for_maps.loc[:, ['neigb_cijf', 'geometry', 'Age', 'male', 'female', 'No_of_employed_persons',
                'average_personal_income', 'non_western_minorities', 'western_minorities']]
targeted_hoods.head(2)
```

Out[19]:

	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities
0	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...	40.840541	0.500883	0.499117	1148	39417.757009	607.837838	965.927928
1	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...	42.300000	0.491000	0.509000	3888	46600.000000	781.000000	1978.000000

NB: Based on the information provided by the Municipality of The Hague and the Energy community it recommended for this research, the names of the exact locations of these energy communities as labelled under the "neigb_cijf" column were found by using the website https://www.drimble.nl/. The code below subsets the shapefile of the map of The Hague so as to remain only with information about the 24 ECs of interest

In [20]:
```
Nine_ECs_map=hague_shape[hague_shape["neigb_cijf"].isin(["14 Zuidwal","44 Koningsplein eo", "07 Statenkwartier", "09 Vogelwijk","112 Morgenweide",
                                                         "53 Vruchtenbuurt", "48 Nassaubuurt", "45 Zeeheldenkwartier","04 Visserijbuurt","47 Willemspark","69 Burgen en Horsten","71 Belgisch Park",
                                                         "12 Voorhout","52 Bomenbuurt","11 Kortenbos","43 Sweelinckplein eo","37 Moerwijk-West",
                                                         "20 Moerwijk-Oost", "38 Moerwijk-Noord", "39 Moerwijk-Zuid", "54 Heesterbuurt", "64 Bezuidenhout-West", "65 Bezuidenhout-Midden", "66 Bezuidenhout-Oost" ])]

Nine_ECs_map.head(2)
```

Out[20]:

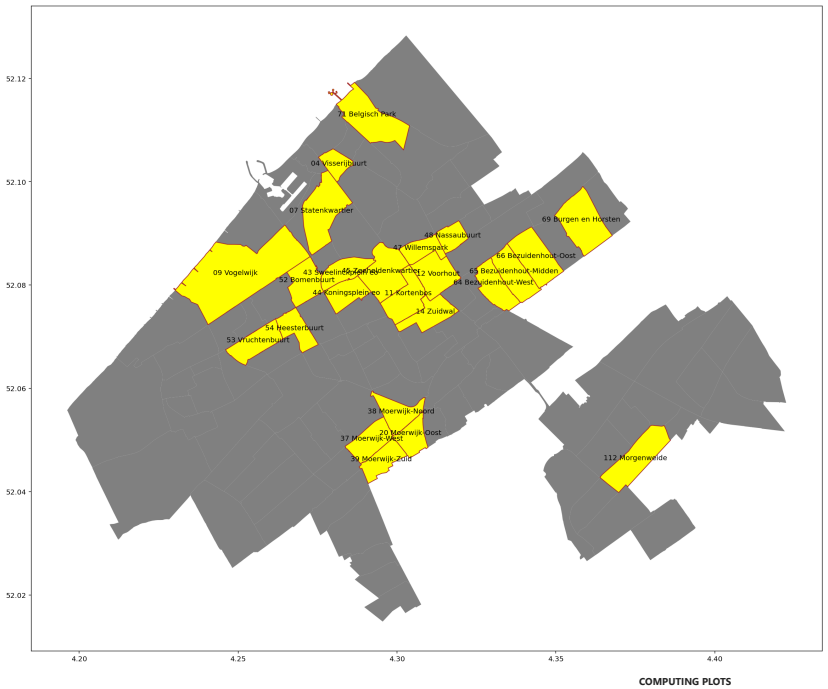
	neighb_cbs	neigb_cijf	geometry
1	Belgisch Park	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...
4	Nassaubuurt	48 Nassaubuurt	POLYGON ((4.31943 52.09247, 4.31943 52.09247, ...

The lines below uses the shape file imported to plot the map of The Hague

In [21]:

```
f, ax = plt.subplots() # Sets up figure and axis
hague_shape.plot(ax=ax, facecolor='grey', figsize=(50, 30))
f.suptitle("The Hague Map") #Adds title#Plots layer of polygons on the axis
Nine_ECs_map["coords"] = Nine_ECs_map["geometry"].apply(lambda x: x.representative_point().coords[:])
Nine_ECs_map["coords"] = [coords[0] for coords in Nine_ECs_map["coords"]]
Nine_ECs_map.plot(ax=ax, color="yellow", edgecolor="brown")
for idx, row in Nine_ECs_map.iterrows():
    plt.annotate(s=row["neigb_cijf"], xy=row["coords"], horizontalalignment="center", color="black", fontsize =10)
f.set_figheight(20)
f.set_figwidth(20)
```

The Hague Map



COMPUTING PLOTS

In [22]:
```
targeted_hoods.head(2)  #display map's top two rows
```

Out[22]:

	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities
0	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...	40.840541	0.500883	0.499117	1148	39417.757009	607.837838	965.927928
1	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...	42.300000	0.491000	0.509000	3888	46600.000000	781.000000	1978.000000

The code line below generates spatial creates the spatial weights matrix from the dataframe using the neigb_cijf column

In [23]:
```
%time w = weights.Queen.from_dataframe(targeted_hoods, idVariable='neigb_cijf')
```

```
Wall time: 495 ms
```

In [24]:
```
w['70 Oostduinen']   #display all neighbours of the neighbourthood called "70 Oostduinen" based on spatial weights
```

Out[24]:
```
{'76 Duinzigt': 1.0, '74 Duttendel': 1.0, '71 Belgisch Park': 1.0}
```

The code line below standardizes the rows so that the sum of all neighbour weights equals 1

In [25]:
```
w.transform = 'R'
```

In [26]:
```
w['70 Oostduinen'] #display all neighbours of the neighbourthood called "70 Oostduinen" based on spatial weights
```

Out[26]:
```
{'76 Duinzigt': 0.3333333333333333,
 '74 Duttendel': 0.3333333333333333,
 '71 Belgisch Park': 0.3333333333333333}
```

In [27]:
```
targeted_hoods.set_index('neigb_cijf') #set index column to neigb_cijf
targeted_hoods.head(2)
```

Out[27]:

	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities
0	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...	40.840541	0.500883	0.499117	1148	39417.757009	607.837838	965.927928
1	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...	42.300000	0.491000	0.509000	3888	46600.000000	781.000000	1978.000000

The code below computes and adds a male - female ratio column to the dataset

In [28]:
```
targeted_hoods['male/female'] = targeted_hoods['male']/targeted_hoods['female']
targeted_hoods.head(2)
```

Out[28]:

	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities	male/female
0	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...	40.840541	0.500883	0.499117	1148	39417.757009	607.837838	965.927928	1.003538
1	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...	42.300000	0.491000	0.509000	3888	46600.000000	781.000000	1978.000000	0.964637

COMPUTING PLOTS FOR THE AVERAGE PERSONAL INCOME
NB: THE SAME PROCEDURE IS USED TO MAKE EVALUATIONS FOR ALL OTHER INDICATORS

The code line below computes the stardization of the average personal income values

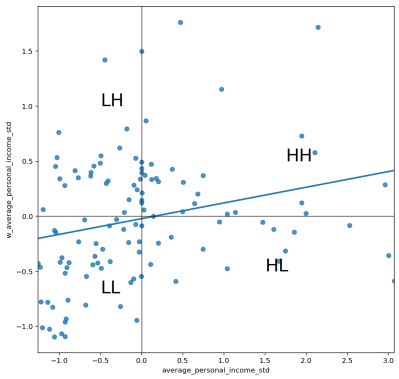
In [29]:
```
targeted_hoods['average_personal_income_std'] = (targeted_hoods['average_personal_income'] - targeted_hoods['average_personal_income'].mean()) /targeted_hoods['average_personal_income'].std()
```

The code line below computes the spatial lag of the average personal income to allow for the visualization of its spatial patterns

In [30]:
```
targeted_hoods['w_average_personal_income_std'] = weights.lag_spatial(w, targeted_hoods['average_personal_income_std'])
```

The code line below displays the distribution of the average personal income values in different quadrants

In [31]:
```
# Setup the figure and axis
f, ax = plt.subplots(1, figsize=(9, 9))
# Plot values
sns.regplot(x='average_personal_income_std', y='w_average_personal_income_std', data=targeted_hoods, ci=None)
# Add vertical and horizontal lines
plt.axvline(0, c='k', alpha=0.5)
plt.axhline(0, c='k', alpha=0.5)
plt.text(1.75, 0.5, "HH", fontsize=25)
plt.text(1.5, -0.5, "HL", fontsize=25)
plt.text(-0.5, 1, "LH", fontsize=25)
plt.text(-0.5, -0.7, "LL", fontsize=25)
# Display
plt.show()
```



The code below computes the local indicators of spatial autocorrelation

In [32]:
```
lisa = esda.Moran_Local(targeted_hoods['average_personal_income'], w)
```

In [33]:
```
# Break observations into significant or not
targeted_hoods['significant'] = lisa.p_sim < 0.05
# Store the quadrant they belong to
targeted_hoods['quadrant'] = lisa.q
```

In [34]:
```
targeted_hoods['significant'].head()
```

Out[34]:
```
0     True
1     True
2    False
3    False
4    False
Name: significant, dtype: bool
```

The block below used the spatial weights, lags

In [35]:
```
from splot import esda as esdaplot
```

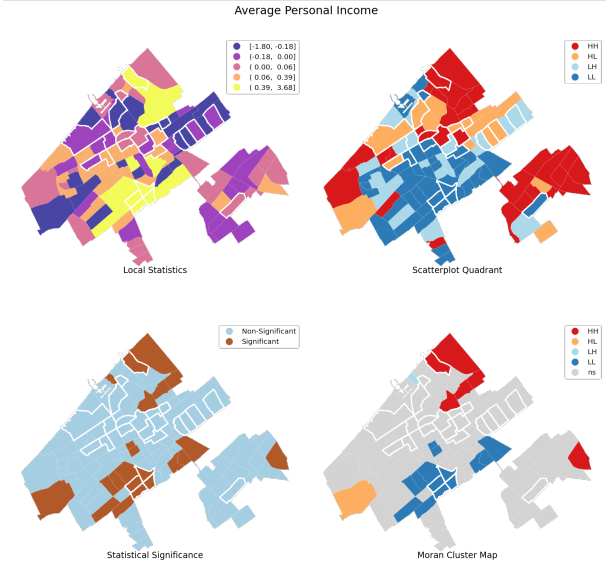
In [36]:

```
f, axs = plt.subplots(nrows=2, ncols=2, figsize=(12, 12))
# Make the axes accessible with single indexing
axs = axs.flatten()
                    # Subplot 1 #
          # Choropleth of local statistics
# Grab first axis in the figure
ax = axs[0]
# Assign new column with local statistics on-the-fly
targeted_hoods.assign(
    Is=lisa.Is
# Plot choropleth of local statistics
).plot(
    column='Is',
    cmap='plasma',
    scheme='quantiles',
    k=5,
    edgecolor='white',
    linewidth=0.1,
    alpha=0.75,
    legend=True,
    ax=ax
)
Nine_ECs_map.plot(ax=ax, linewidth=2, edgecolor='w',facecolor='None')
                    # Subplot 2 #
                # Quadrant categories
# Grab second axis of local statistics
ax = axs[1]
# Plot Quandrant colors (note to ensure all polygons are assigned a
# quadrant, we "trick" the function by setting significance level to
# 1 so all observations are treated as "significant" and thus assigned
# a quadrant color
esdaplot.lisa_cluster(lisa, targeted_hoods, p=1, ax=ax);
Nine_ECs_map.plot(ax=ax, linewidth=2, edgecolor='w',facecolor='None')
                    # Subplot 3 #
                # Significance map
# Grab third axis of local statistics
ax = axs[2]
#
# Find out significant observations
labels = pd.Series(
    1 * (lisa.p_sim < 0.05), # Assign 1 if significant, 0 otherwise
    index=targeted_hoods.index          # Use the index in the original data
# Recode 1 to "Significant and 0 to "Non-significant"
).map({1: 'Significant', 0: 'Non-Significant'})
# Assign labels to `db` on the fly
targeted_hoods.assign(
    cl=labels
# Plot choropleth of (non-)significant areas
).plot(
    column='cl',
    categorical=True,
    k=2,
    cmap='Paired',
    linewidth=0.1,
    edgecolor='white',
    legend=True,
    ax=ax
)
Nine_ECs_map.plot(ax=ax, linewidth=2, edgecolor='w',facecolor='None')

                    # Subplot 4 #
                    # Cluster map
# Grab second axis of local statistics
ax = axs[3]
# Plot Quandrant colors In this case, we use a 5% significance
# level to select polygons as part of statistically significant
# clusters
esdaplot.lisa_cluster(lisa, targeted_hoods, p=0.05, ax=ax);
Nine_ECs_map.plot(ax=ax, linewidth=2, edgecolor='w',facecolor='None')
                    # figure styling #
# Set title to each subplot
for i, ax in enumerate(axs.flatten()):
    ax.set_axis_off()
    ax.set_title(
        [
            'Local Statistics',
            'Scatterplot Quadrant',
            'Statistical Significance',
            'Moran Cluster Map'
        ][i], y=0
    )
# Tight layout to minimise in-betwee white space
f.tight_layout()

# Display the figure
plt.suptitle('Average Personal Income', size=16)
```

```
plt.show()
```



The code line below displays the total number of observations per quandrant with HH = 1, LH = 2, LL = 3 and HL = 4

In [37]:
```
counts = pd.value_counts(lisa.q)
counts
```

Out[37]:
```
3    43
1    30
2    24
4    17
dtype: int64
```

In [38]:
```
targeted_hoods.tail(2)
```

Out[38]:

	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities	male/female	average_personal_income_std	w_average_personal_income_std	significant	quadrant
112	120 De Vissen	POLYGON ((4.41188 52.07213, 4.41192 52.07210, ...	40.0	0.494	0.506	1274	40200.0	852.0	910.0	0.976285	0.051477	0.869121	True	1
113	121 Rietbuurt	POLYGON ((4.41539 52.05744, 4.41538 52.05707, ...	31.5	0.500	0.500	762	45100.0	358.0	293.0	1.000000	0.373928	0.428123	False	1

In [39]:
```
df = targeted_hoods.reset_index()
df.head(2)
```

Out[39]:

	index	neigb_cijf	geometry	Age	male	female	No_of_employed_persons	average_personal_income	non_western_minorities	western_minorities	male/female	average_personal_income_std	w_average_personal_income_std	significant	quadrant
0	0	70 Oostduinen	POLYGON ((4.30290 52.12832, 4.30298 52.12827, ...	40.840541	0.500883	0.499117	1148	39417.757009	607.837838	965.927928	1.003538	4.788043e-16	1.499217	True	1
1	1	71 Belgisch Park	POLYGON ((4.28056 52.11706, 4.28053 52.11706, ...	42.300000	0.491000	0.509000	3888	46600.000000	781.000000	1978.000000	0.964637	4.726373e-01	1.762734	True	1

NB: The code below counts the number of observations made per quadrant for each one of the 24 ECs, bearing in mind that 3 ECs are located in "14 Zuidwal", two in "44 Koningsplein eo" and the last two in "69 Burgen en Horsten". Considering this fact, and that the result rendered by the code below sums to 24, the quadrant locations of the said neighbourhoods was verified in from the scatterplot quandrant in each case to adjust the counts on the Thesis report

In [40]:
```
cnts=df[df["neigb_cijf"].isin(["14 Zuidwal","44 Koningsplein eo", "07 Statenkwartier", "09 Vogelwijk","112 Morgenweide",
                               "53 Vruchtenbuurt", "48 Nassaubuurt", "45 Zeeheldenkwartier","04 Visserijbuurt","47 Willemspark","69 Burgen en Horsten","71 Belgisch Park",
                               "12 Voorhout","52 Bomenbuurt","11 Kortenbos","43 Sweelinckplein eo",
                               "20 Moerwijk-Oost", "54 Heesterbuurt", "64 Bezuidenhout-West", "65 Bezuidenhout-Midden", "66 Bezuidenhout-Oost" ])]
cnts['quadrant'].value_counts()
```

Out[40]:
```
4    7
3    6
2    4
1    4
Name: quadrant, dtype: int64
```

In [ ]:

A.5 INITIAL INTERVIEW REQUEST DRAFT EMAIL

Subject: Masters Thesis Interview Request

Dear Board Members of the energy community (**Initiative name**),

My name is Elie Christian Azeufack, I am a MSc student in Engineering and Policy Analysis at TU Delft. I am currently doing a research study to find out how the Municipality of The Hague can improve energy justice by promoting the engagement of more citizens in Energy community initiatives. With this letter, I would like to invite you for a 45 minutes interview on the subject.

Subject

My research goal is to find out which socioeconomic factors the Municipality of The Hague should improve to promote the engagement of more citizens in Energy communities for an improved energy justice. More precisely, the interview questions will revolve around what were your motivations to engage in your energy community initiative and what have been your experiences so far. The aim is to know what can be done to ease the engagement of more citizens in such energy community initiatives as we believe it can lead to a more rapid energy transition.

Requested Interview day and time:

(**Day**), (**Month**) (**date and year**) from (**start time**) – (**end time**)

Venue

Either online using Microsoft Teams/Zoom or at your premises

Please feel free to suggest another day and time when you could be available.

More information will follow as soon as i receive your response.

While hoping to hear from you soon,

I wish you a great day,

With kind regards,

A.6 DRAFT OF EMAIL SENT TO 19 ECs TO REQUEST FOR INTERVIEW PARTICIPANTS

Subject: Masters Thesis Interview Request

Dear Dear members of the Energy Community (**name of initiative**),

I hope you are fine. I am Elie, a final year Masters student in Engineering and Policy Analysis at TU Delft. Well, the cooperative called (Name of initiative) recommended me to contact you for my Masters thesis research interview. For my Masters Thesis, I would please like to conduct an interview with a member of your energy community to investigate the motivations of citizens to engage in Energy community initiatives in The Hague. Your experience on this topic will constitute a very valuable part of my Thesis.

Desired interview period: The week starting from (**day, time, year**) until **day, time, year**).

Interview duration: 45 minutes

Availability: If you or any of your members can be available for an interview, please kindly confirm so by replying to this email and indicating your availabilities on the link: **AVAILABILITIES FORM HERE**

Venue: Online via zoom or Physically based on your preference Please find attached some background information about the Thesis research and aims of the interview.

Thanks much in advance for your time

Wishing you a great day with kind regards,

A.7 INTERVIEW QUESTIONS

INSTRUCTIONS

Good Morning. My name is Elie Christian AZEUFACK. Thank you for accepting my invitation. The aim of this interview is to investigate what are the motivations of citizens of The Hague to engage in Energy Communities. This study is made within the frame of my Master's Thesis at TU Delft. For this interview, I would like you to feel comfortable with saying what you really think and how you really feel.

TAPE RECORDER INSTRUCTIONS

If it is okay with you, I will be audio-recording our conversation. The purpose of this is so that I can get all the details but at the same time be able to carry on an attentive conversation with you. I assure you that all your comments will remain confidential. I will be compiling a for my Master's Thesis which will contain your comments without any reference to you as a participant of this interview. Summaries of your answers will be made and written in my Master's Thesis. Before publishing the summaries, i will seek for approval from you to ensure that they reflect your comments.

PREAMBLE/CONSENT FORM INSTRUCTIONS

Before we get started, please take a few minutes to read this preamble (read and sign this consent form). (Hand R consent form/preamble.) (After R returns preamble/consent form, turn tape recorder on.)

Investigating whether the engagement of more citizens in Energy Community Initiatives leads to a more just Energy Transition

Interview

Planned Duration: 45 minutes

Table to be filled by Interviewee

Name of Organisation	Position/occupation in Organization	Types of community projects

Interview Questions

Salutations

1. Could you please provide some background information about yourself?
2. What motivated you and the community(other members) to engage in your energy community?
3. How can you describe your experience so far and what do you define as successes?
4. Based on the locations of Energy Communities in The Hague, our primary analysis shows that areas where people have higher chances to participate in an Energy Community have the following characteristics:

High number of Minority groups	Low Average Personal Income	High Number of Employed Persons	Low Average Age	Areas having more females than males

Question: What is your experience on this? How is the representation in your Energy community?

5. Do you perceive any barriers or challenges for citizens to participate in Energy Communities? If so, how do you think these can be improved?
6. Can you describe if/how your energy community shares the benefits and burdens of the different energy processes?
7. How is the decision-making process managed in your Energy Community?

B INTERVIEW RESPONSE SUMMARIES

B.1 INITIATIVE A

Interview Date	11 May 2022
Initiative	A
Field of Work	The initiative supports place based ECs in The Hague working on sustainability, greening and cooling the city with the aim of promoting the energy transition. Initiative A provides direct support to initiatives in vulnerable neighbourhoods and also organizes networking events to share knowledge on how to start new inbitiatives. Moreover, initiative brings different initiatives together through a platform and also through organizing events with the municipality to share knowledge, experience and to work towards solving their existing issues
Role in Energy Community	Board Member
Motivation to engage in initiative A	The interviewee became very environmentally aware at a certain stage of his life. His interest in environmental issues further rose after reading the IPCC report. He aims to raise awareness about climate change and the energy transition. Moreover, he also aims to play a connecting role between citizens and the municipality
Experience	The respondent defines success as being part of a larger movement for sustainability and climate movement which leads to a rise in policy ambitions and awareness rise of citizens. Moreover, the respondent defines success as being able to mobilize people and getting polities placed on the agenda irrespective of how little the impact might be. Further, the respondent has observed successes from some of the initiatives they have supported in their various fields.
Representation	Energy Communities are not representative of the areas in which they are found in general. The general observation is usually white people starting the initiatives as they have more time. Moreover, members are usually employed males with high incomes.
Barriers for citizens to engage	- One of the major barriers to citizen engagement is usually time. Moreover, communication is an issue as the ECs are smaller compared to the neighborhood size. Similarly, it is sometimes difficult to and very demanding to realize sustainable energy activities as for example installing rooftop solar panels on roofs of citizens without proper roofs. - People only invest in such initiatives if the policies favouring renewable energy use are implemented. However, several policies still favour the use of fossil fuels. - Other barriers to citizen engagement are lack of technical, legal and policy knowledge - Finally, community members are scheptical about engaging in such initiatives as they do not know whether engaging in sustainability is realistic. They believe gas is less expensive than renewable energies and also believe it is easier to heat their houses with gas than with fossil fuels during the winter
How barriers could be improved	Barriers can be improved by connecting to the people, building trust, take away doubts by raising awareness about the ability of ECs to resolve energy issues. Making the decision making process more democratic
How benefits and burdens are shared	The main benefit perceived by the respondent is that ECs enable its members to contribute positively for the development of a sustainable society. Moreover, it allows them to get to know their neighbourhoods and share their concerns and experiences with other members. Likewise, ECs provide financial benefits to members who are get back on their energy bills. The main burdens on the other hand are that lots of efforts are required as an energy community member to run the activities leading to frequent draw - backs that need to be caught up in later stages.
Decision making Process management	Decision making processes are managed democratically through votes by all members.

Table B.1: Interview Summary: Initiative A

B.2 INITIATIVE B

Interview Date	9 May 2022
Initiative	B
Field of Work	The initiative aims to bring house owners together around the topic of community. Moreover, the initiative aims to reduce CO_2 emissions by promoting less use of fossil energy
Role in Energy Community	Board Member (Founder)
Motivation to engage in initiative B	The respondent aims to bring house owners together around the topic of community. Moreover, he aims to reduce CO_2 emissions by promoting less use of fossil energy
Experience	The district in which the energy community is located belongs to the 10 greenest in The Hague. Moreover the city plans to make it green by 2030 by replacing all its gas pipes. However, the board member does not believe this goal will be achieved due to delayed activities.
Representation	Non Dutch members are hardly present. Moreover, members are mainly males above average age although the is a current huge interest from the younger generations
Barriers for citizens to engage	Citizens are not interested and it is very hard to get them involved. Moreover there is a huge communication issue as people are not aware of the sustainability challenges faced by the city and planet. Finally, the interviewee believes activities are going too slowly
How barriers could be improved	There needs to be a way for all energy community members to get advantages for being members.
How benefits and burdens are shared	The perceived benefits if they achieve their efficiency goals will be less payment for gas bills
Decision making Process management	/

Table B.2: Interview Summary: Initiative B

B.3 INITIATIVE C

Interview Date	6 May 2022
Initiative	C
Field of Work	The initiative seeks to connect 500 neighbourhood residents to a sustainable heat network within few years to replace non - sustainable energy sources use
Role in Energy Community	Board Member (chair)
Motivation to engage in initiative C	The main motivation to engage was to make the neighbourhood more sustainable, supporting the country to reach its long term sustainability goals.
Experience	The interviewee's experience has been overall positive. The initiative received funding from the municipality, organized an activity in April with the aim of reaching 500 people but had a turnout of 630 participants
Representation	No minortities are present in the initiative. Moreover, members have higher income and the level of emplyment is high in the area. The age groups of members used to be very high . No information provided about the male - female ratio
Barriers for citizens to engage	The main barrier to citizen engagement is lack of time as people work and have other responsibilities. The Dutch government has had an individualistic approach where it perceives citizens only as consumers The state creates confusion at times by organizing different projects in the same neighbourhood at the same time, leading to a halt in the initiative's activities
How barriers could be improved	The municipality should entrust citizens of poorer communities with more funding to realize their projects as they can also be supportive to their long term goals. Civil servants should understand that all projects have probabilities of failure and start searching for solutions first rather than focusing ¨ only on the risks involved
How benefits and burdens are shared	The main benefit of being member is that it helps members to know people from their neighbourhoods to develop the area together. Moreover, it allows people to have a say in the cost of the energy consumed The main disadvantage is that engaging as an energy community member takes a lot of time and is unpaid
Decision making Process management	/

Table B.3: Interview Summary: Initiative C

B.4 INITIATIVE D

Interview Date	4 May 2022
Initiative	D
Field of Work	To generate sustainable local electricity through collective solar roofs in which people and businesses in the area can invest
Role in Energy Community	Board Member (Treasurer)
Motivation to engage in initiative D	The interviewee wanted to make a greater contribution to the society than to keep making money and coding at his previous company
Experience	The initiatives currently operates two roofs on buildings with approximately 520 solar panels.
Representation	About 90 percent of members are males, white, retired and of older ages
Barriers for citizens to engage	Finding people to engage is easy. The biggest hardship is to find enough roofs as most roofs in the city are owned by the municipality. Currently, the municipality uses the roofs to achieve its own sustainability goals.
How barriers could be improved	Private roof owners are not willing to offer their roofs for their projects. So, the municipality could find ways to make roofs available for their projects The municipality should centralize responsibilities to speed up processes; at times they discuss with nice civil servants who are not able to pass their message due to too much bureaucracy.
How benefits and burdens are shared	Electricity production gains are divided with participants based on the number of solar panels bought and the gains made from paying less taxes.
Decision making Process management	/

Table B.4: Interview Summary: Initiative D

B.5 INITIATIVE E

Interview Date	18 May 2022
Initiative	E
Field of Work	To stimulate, develop and realize green economic activities that benefit the neighbourhood's development
Role in Energy Community	Board Member
Motivation to engage in initiative E	The energy transition became a reality in The Netherlands and her nbeighbourhood became a focus area. She would like to help the neighbourhood citizens to have access to information and become free by having access to sustainable energy. Moreover, she is motivated to enable citizens to obtain a power rise in decision making
Experience	Codesigned a new sustainable energy system which is social and participatory by design.
Representation	No Dutch descent is involved. Moreover, members are mostly males above average age although there is a rising interest from the younger generations
Barriers for citizens to engage	The main barriers are lack of awareness and action perspective even after becoming aware about the energy challenges
How barriers could be improved	/
How benefits and burdens are shared	The main benefit observed is an increased cooperation of social entrepreneurs. Moreover, initiative taker receive money as compensation. The initiative also teaches members to work together as individuals. The main issue on the other hand is a lack of resources to reward all volunteers
Decision making Process management	Democratic with each member having the right for a single vote

Table B.5: Interview Summary: Initiative E

B.6 INITIATIVE F

Interview Date	11 May 2022
Initiative	G
Field of Work	To work with neighbourhood residents to make them greener and more sustainable
Role in Energy Community	Board Member
Motivation to engage in initiative G	The interviewee wants sustainability to be viewed from a broader perspective. For this, he is working to bring the sustainability perspective into the Energy Transition debates. He also works to get inhabitant perspectives into heat transition plans.
Experience	The interviewee's biggest success has been an observation of a higher number of people engaging. Moreover, two of their projects were received indirect funding from the municipality.
Representation	Energy communities are not usually representative of the neighbourhoods in which they are located. Moreover, minority groups are low as they have not particularly focused on engaging them. Moreover, energy community members usually of higher age groups with medium - high incomes and are found in areas with high number of employed people.
Barriers for citizens to engage	Lack of trust as the state does not respect some promises made. Some citizens perceive ECs as government agents
How barriers could be improved	/
How benefits and burdens are shared	The perceived long term benefit is the satisfaction of having a sustainable neighbourhood
Decision making Process management	/

Table B.6: Interview Summary: Initiative F

B.7 INITIATIVE G

Interview Date	11 May 2022
Initiative	G
Field of Work	To work with neighbourhood residents to make them greener and more sustainable
Role in Energy Community	Board Member
Motivation to engage in initiative G	The interviewee is interested to learn the practical part of her master's degree programme course work by engaging in the initiative
Experience	The biggest accomplishment of the participant as a youth is that she interacts with different people and is able to gain by discussing with people with different perspectives. Likely, she was able to connect the initiative to her university for collaboration
Representation	Minority groups are low as they have not particularly focused on engaging them. Moreover, energy community members usually of higher age groups with medium - high incomes and are found in areas with high number of employed people.
Barriers for citizens to engage	The main barriers are lack of time, intellectual and social capital. Moreover, citizens do not trust that the government will undertake any action in their favour. Finally, raising awareness about the existence of their energy community is difficult.
How barriers could be improved	To resolve the issues, a good communication strategy is needed. Moreover, minorities could be paid for participating in their activities
How benefits and burdens are shared	/
Decision making Process management	Decentralized: A meeting is organized every five weeks and decisions are made in smaller groups for discussion in the larger ones.

Table B.7: Interview Summary: Initiative F

B.8 INITIATIVE H

Interview Date	4 May 2022
Initiative	H
Field of Work	To provide residents free help from an energy coach, who advises on measures in the home and the financing options. Residents can also receive advice on purchasing solar panels and applying for a subsidy
Role in Energy Community	Former board member (Chair)
Motivation to engage in initiative H	She was called on board to make and submit proposals to receive funding from the municipality
Experience	Cooperation with other members is perceived as being very positive
Representation	/
Barriers for citizens to engage	The government says much and does little
How barriers could be improved	/
How benefits and burdens are shared	/
Decision making Process management	/

Table B.8: Interview Summary: Initiative H

COLOPHON

This document was typeset using LaTeX. The document layout was generated using the `arsclassica` package by Lorenzo Pantieri, which is an adaption of the original `classicthesis` package from André Miede.