How can digital tools be used to engage citizens in the energy transition?

A case study of the simulation tool ESSIM within the H2020 Making City Project

Capstone project in collaboration with TNO

University of Groningen

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Global Responsibility and Leadership

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Abstract

Considering the importance of a citizen-centric energy transition approach, this paper aims to answer the question of how digital tools can be used to engage citizens in the energy transition and specifically concentrates on the energy system simulation tool ESSIM. This research is a collaboration within TNO, the Dutch Organisation for Applied Scientific Research, and is situated within the European H2020 Making City Project in Groningen. Overall, interviews with homeowners suggest that Groningen has neither established a strong culture of engagement outside of citizens' homes, nor engages citizens digitally. Additionally, the challenges of offline and online participation in the energy transition on an individual, community and municipal level are discussed. Based on these findings, this paper presents two scenarios for potential engagement tools based on ESSIM. The first applies ESSIM in an individual use case, while the second concentrates on ESSIM's use in collective contexts, such as participatory energy planning. Subsequently, recommendations to the municipality, developers and context of citizen engagement tools are given.

Keywords: energy transition, citizen engagement, digital participation, ESSIM, H2020 Making City

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1. Introduction

The traditional fossil-fuel industry has created an energy system based on the central paradigm that energy provision is unidirectional: large energy suppliers provide consumers with energy from a central grid. Hence, the current energy system enforces a passive role of energy consumers. Based on the assumption that citizens lack awareness, knowledge and interest, energy measures and technologies are designed for minimal engagement. However, current trends, such as climate change and negative impacts of fossil fuel energy, have initiated a transition towards a more sustainable energy system which fundamentally challenges the centralisation paradigm (Devine-Wright, 2007). Increasing possibilities to organize energy systems within a community and produce one's own energy puts more responsibility on citizens, increasing their agency and engagement in the energy transition (Devine-Wright, 2007). Scholars agree that future energy systems must be based on three core principles: decarbonisation, decentralisation and digitalisation (Andoni et al., 2019; Teufel et al., 2019).

Nevertheless, participation in the energy transition faces many challenges, as governments and citizens themselves are still locked into a system of limited agency (Lennon et al., 2019). Although citizen engagement is often used as an instrument aiming to increase public acceptance of existing policies, this approach involves no shared power, leaving the citizens with participation opportunities without actually influencing decision-making (Alcaide Muñoz & Rodríguez Bolívar, 2019; Castelnovo, 2019; Hartmann, 2019). Instead, researchers call for a more bottom-up approach to citizen participation in the energy transition (Castelnovo, 2019). Similar developments can be witnessed in Smart Cities (SCs), which are often used as study sites for citizen engagement. Although there is no commonly agreed definition of SCs, scholars agree that SCs aim to empower citizens to solve their own problems with the means of smart technology. This involves e-government practices as well as technology co-produced with the citizens (Alcaide Muñoz & Rodríguez Bolívar, 2019). Although SCs are assumed to be citizen-centric, initiatives are often based on a top-down approach that puts technologies at its core. Hence, the smart city literature calls for a shift from initiatives *designed for citizens* to initiatives *designed with substantial engagement from citizens* (Castelnovo, 2019). Also the European Union (EU) acknowledges the central role citizens should play in the energy transition: the 'Clean Energy for all Europeans' policy package dedicates a whole chapter to "consumers at the heart of the energy transition" (European Union, 2019). According to this package, technological developments, from digitalisation to smart appliances, enable citizens to participate more actively in the energy transition (European Union, 2019). The need for participation to be extended to a virtual environment is exacerbated by the current COVID-19 crisis as it

forces interactions to take place in a digital realm (Chen et al., 2020).

1.1. Defining citizen engagement and participation

Although citizen engagement is crucial for a successful energy transition (Lennon et al., 2019), the concept of citizen engagement and citizen participation is poorly conceptualised. The notions of civic participation, civic engagement and citizen participation are used interchangeably in most literature (Hartmann, 2019). Some have differentiated between participation and engagement using the concept of shared power: participation can be any activity, whereas engagement is the process by which citizens influence decision making (Aslin & Brown, 2004). In the context of the energy transition, Barrios-O'Neill and Schuitema (2016) define participation as "active engagement with energy transitions" happening on three different levels: (1) technological, such as interacting with energy control devices, (2) products (installing solar panels), or (3) developments, by for example engaging in an energy initiative. Given the fact that municipalities play a crucial role in energy transitions (Olivadese et al., 2021), I suggest summarising the technology and product level into one, called individual engagement. Thus, this paper defines participation in the energy transition as active engagement with the energy transition on three levels, namely a) individual, b) community, c) municipality. Furthermore, this paper uses the term 'citizen' rather than 'consumer' in order to imply a more active role than being 'just' a consumer.

1.2. Context of this project

This research project is a collaboration with TNO, the Dutch Organisation for Applied Scientific Research, and belongs to the focus of TNO Energy Transition Studies. It is situated in Groningen as the example city of the H2020 Making City Project, one of the efforts of the EU to address urban energy challenges (Olivadese et al., 2021). In order to become a carbon neutral city by 2035, the municipality of Groningen developed a district energy approach that conceptualises the planning process for the districts. As can be seen in figure 1, this approach includes four steps: the development of 1) a district energy vision, 2) a district energy plan, 3) a concrete district action plan and 4) implementation (Gemeente Groningen, n.d.).

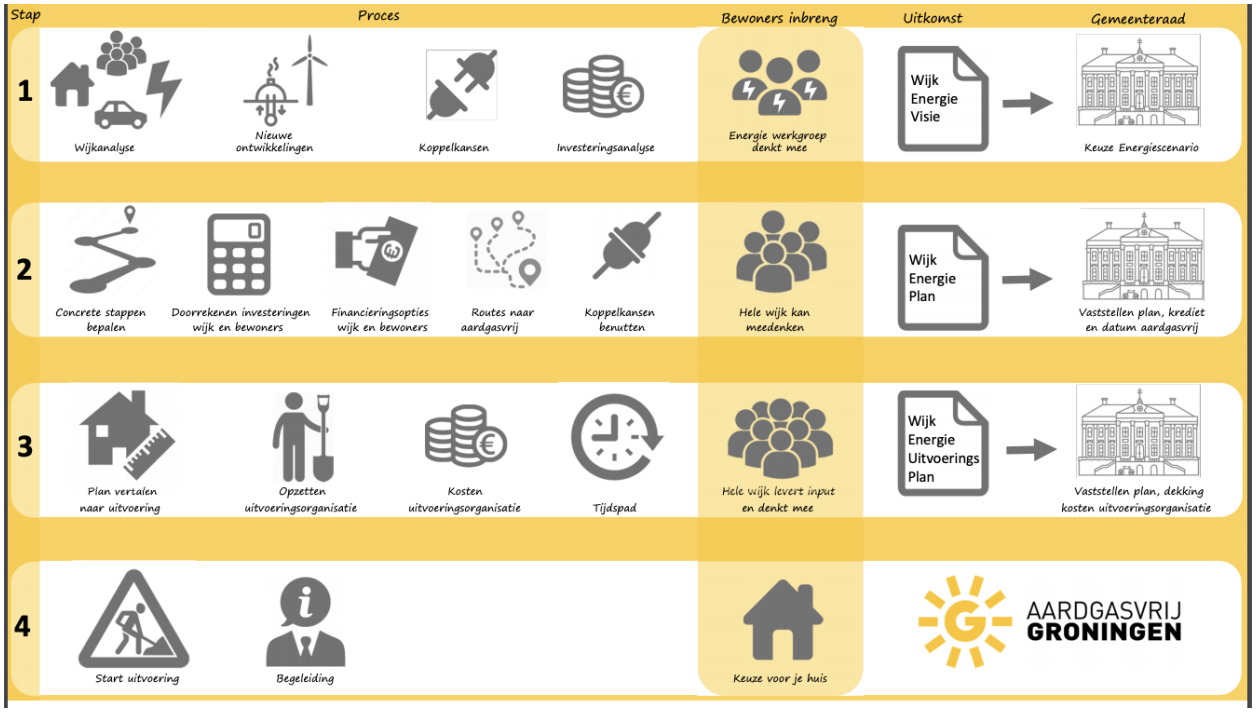

Figure 1: District Energy Plan (Gemeente Groningen, n.d.)

For energy transition planning, TNO developed an Energy System Simulation tool ESSIM (figure 2). This tool runs different energy simulations and can thus be a testbed for future energy pathways. It can interpret any energy system, be it neighbourhood level or nationwide, if described in the Energy System Description Language (ESDL). Additionally, time periods, control strategies or consumption patterns can be specified as inputs to the simulation. ESSIM then creates network models and calculates energy flows. Resulting from this, modellers can interpret the results from simulations using the primary and secondary Key Performance Indicators (KPIs) seen in the figure below.

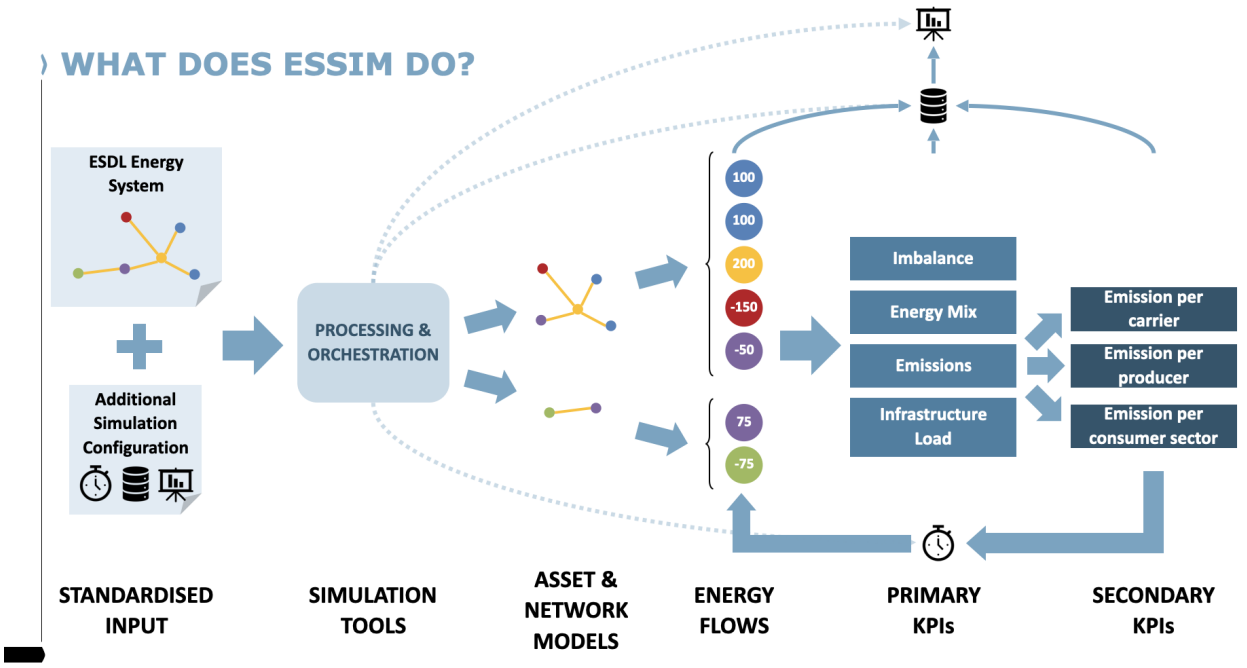

Figure 2: What does ESSIM do? (A. Subramanian, personal communication, March 18, 2021)

Initially, TNO posed the question of whether and how ESSIM can be used for citizen engagement. However, asking a question such as "How can we apply ESSIM in a participatory context?" and thus taking ESSIM as a starting point could very easily be categorised as "putting technologies at the core" (Castelnovo, 2019). Instead, this paper focuses on citizen's experiences and ideas, which can later form the basis of a potential digital energy tool. Therefore, the research question this paper aims to answer is **"How can digital tools be used to engage citizens in the energy transition?"**. Particular focus is then given to the city of Groningen and results are later applied to the ESSIM context.

This paper is structured as follows. In section 2, literature is reviewed concerning citizen engagement in the energy transition on the three conceptual levels (individual, community, municipality). Additionally, literature on digital participation within these levels is included in the review. After discussing the study approach in section 3, section 4 presents the interview results. These are then discussed in light of earlier findings from literature. This discussion can be found in section 5. In section 6, all previous literature, interview and consultation findings come together and are applied to potential citizen

engagement tools based on ESSIM. This report ends with recommendations in section 7, followed by conclusions, limitations and suggestions for further research in section 8.

2. Literature review and theoretical framework

In this section, literature concerning traditional citizen engagement (2.1.), as well as digital participation in the energy transition (2.2.) is reviewed. This is analysed according to the three levels of citizen engagement in the energy transition, a) individual, b) community and c) municipality.

2.1. Drivers and barriers to citizen engagement in the energy transition

Individual engagement in the energy transition

TNO and associated organisations within the H2020 Making City project (Broekhuis et al., 2019) conducted several behavioural studies, yielding an overview of drivers and barriers of citizens to engage in the transition in Groningen. Here engagement was defined as implementing sustainable measures in their own houses. The study found that in order for citizens to start engaging in the transition process, they either need to already be intrinsically motivated or be triggered externally. In Groningen, gas extraction is likely to function as an external trigger. Two related barriers for citizens to decide on sustainable alternatives were effort and time, as they reported not being able to easily access information specific to their situation and about the municipality's plans for their neighbourhood. Relating to this information deficit, citizens also commonly felt like they were lacking knowledge about financial and investment aspects, as well as technical knowledge about their houses. To bridge this knowledge gap, Broekhuis and colleagues (2019) suggest that citizens can be incorporated in the knowledge production by exchanging knowledge and best practices within the community. Another important barrier to investing in sustainable energy measures were high investment costs, as several fossil free alternatives are only profitable after some amount of time. Uncertainty about future policies and technological development also influenced citizens to wait for better solutions and more certainty.

Interestingly, Broekhuis and colleagues (2019) also found that social factors are a key influence on whether and how people engage. Habitual behaviour can be a barrier to getting involved in new processes. Deciding on alternatives and installing new technologies can be perceived as "lots of hassle and adjustments" (Broekhuis et al., 2019). Collaborations can help take some of this burden away from citizens. Next to habitual processes, social influence plays a crucial role too: citizens are often influenced

by other people's actions. Additionally, enhancing social status can also be a motivation for citizens to purchase sustainable products. Lastly, Broekhuis and colleagues (2019) point to the fact that not all people feel addressed when the energy transition is framed in terms of environmental sustainability. Some citizens find values other than sustainability more important, such as family or health.

Community engagement

In the context of individual engagement, researchers have pointed to the challenge that this "material-based" engagement can lead to excluding less economically fortunate citizens (Ryghaug et al., 2018). Therefore, other studies have conducted research into barriers to join community-focused energy projects or initiatives (Koirala et al., 2018; Lennon et al., 2019). Lennon and colleagues (2019) report that citizens describe a lack of clear information about community-focused energy projects. A study by Koirala and colleagues (2018) found that participants experienced a lack of time, financial resources, and technical expertise as reasons to not participate in energy initiatives. For some, even owning a PV installation was seen as a barrier to join community projects. However, the most significant predictor of willingness to participate was found to be community trust: 24% described having no trust in their community, 29% were neutral and 47% indicated trusting their community. The ones that experienced strong community trust were also more likely to participate in local energy projects (Koirala et al., 2018).

Citizen engagement in the municipality

Whereas participation in the energy transition on individual and community level is a well studied phenomenon, citizen engagement in municipalities is mostly studied within the framework of smart cities (Rodríguez Bolívar & Alcaide Muñoz, 2019). Similar to community engagement, trust also plays a role in participation on municipal level. Since trust in governments is decreasing, it might inhibit participation (Hartmann, 2019). At the same time, Hartmann (2019) stresses that increased participation could enhance trust, which highlights the importance of participation in municipal contexts. Lowndes and colleagues (2006) introduced the CLEAR framework for citizen participation in local governmental decision-making. According to this framework, citizens participate when they *can (C)*, meaning when they have the capacity to. Citizens should identify with the city, which makes them *like (L)* to participate. Thirdly, citizens need to be *enabled (E)* by effective channels for participation. Furthermore, the government needs to *ask* and motivate citizens to engage. Lastly, citizens must be *responded (R) to*, meaning the government has to consider the citizens' input in decision making.

2.2. Digital citizen participation

After having reviewed the drivers and barriers to engage in the energy transition, literature is reviewed in the context of digital tools used for engaging citizens in the energy transition levels.

Individual engagement

Literature on digital participation on the individual level is sparse. Existing studies are mostly descriptive about the tools used rather than investigating which factors influence the usage of digital tools in households. Naus and colleagues (2015) point out that (digital) tools are used for energy monitoring. Examples of such tools are annual energy bills, meter readings, and energy consumption tests or performance advice. Although it is noted that people initially hold positive attitudes towards feedback, advisory practices and information sharing with other households, Naus and colleagues (2015) highlight that upon further consideration citizens might have reservations regarding privacy or social judgements. Therefore, they suggest that information sharing should always be a voluntary practice. Related to energy monitoring, a comparative study on energy conservation games and dashboards (Fijnheer et al., 2019) indicates that feedback given through dashboards does not lead to long-term change in behaviour and knowledge. Instead, games representing reality were proven to impact long-term energy consumption and knowledge (Fijnheer et al., 2019). Other than this scarce literature, no study has specifically concentrated on digital tools used on an individual level. Kloppenburg and Boekel (2019) summarise the research gap by calling for further research on how digital means influence how people decide on “the best next action”.

Community level

To date, there has not been much conceptual research about the use of digital tools in the energy transition. Barrios-O’Neill and Schuitema (2016) aim to fill this gap and conceptualized the literature on online engagement for sustainable energy projects into the Socially Dynamic Communications Framework (SDCF). Firstly, they point out that online tools may help to collect information about the citizens more effectively in order to design more targeted engagement strategies. To overcome trust barriers, online engagement should foster frequent interaction making use of direct responsiveness (real-time communication) and indirect responsiveness (FAQ or feedback forms). Furthermore, SDCF states that trust can be enhanced through accurate representation and information, suggesting that online tools must find a balance between accuracy and complexity. Another major factor playing into strong relationships and trust is credibility. Here, Barrios-O’Neill and Schuitema (2016) refers to Sundar

(2008) who argues that credibility depends on the following four aspects: modality (type of message, e.g. text or audio), agency (source of information), interactivity, and navigability. In order to meet the needs of diverse audiences, information should be presented in various ways, where visualisations, vividness and interactivity play a crucial role. Barrios-O'Neill and Schuitema (2016) also suggest incorporating online tools into offline interaction to provide continuous knowledge building and bridge the digital divide that arises from differences in tech savviness due to age, income and geographic factors. Lastly, since social and emotional processes play a critical role in engaging citizens, SDCF calls for a greater proactivity from users. Proactivity can be induced through interactive functionalities, such as social sharing, simulation of real-world processes and interactive visualisations (Barrios-O'Neill & Schuitema, 2016).

Municipality level

On the municipality level, digital participation is often studied within the context of smart city literature. In general, literature suggests that SC projects do favour citizen participation through the use of ICT tools (Alcaide Muñoz & Rodríguez Bolívar, 2019; Hartmann, 2019). Alcaide Muñoz and Rodríguez Bolívar (2019) indicate that social media is often used as a means of communication and to share opinions and ideas with citizens. Fewer governments implement e-participation applications that enable more active engagement. These apps are mainly used for public transport, tourist information, events, reporting incidents and giving input on city projects (Alcaide Muñoz & Rodríguez Bolívar, 2019). However, Varela-Álvares and colleagues (2019) confirm that citizen centricity, i.e. how citizens personalise services, and engagement are improved mostly by more sophisticated participation mechanisms, such as blogs, debate forums, open data platforms, social networks or transparency information. To a lesser degree, centricity and engagement are also increased by basic participation tools (chats, virtual assistant, email or virtual mailboxes).

Hartmann (2019) suggests that citizen engagement should be carried out on different platforms with the same functions. This way users can choose their preferred channel and more diverse audiences can be reached. In this case, several researchers point to the challenge of the digital divide. E-participation has been found to decrease with age (Novo Vázquez & Vicente, 2019) and lack of internet access might inhibit participation in low-income communities (Hartmann, 2019). Literature suggests political efficacy to be another crucial factor: engagement increases when citizens believe they can influence governmental decision-making (Novo Vázquez & Vicente, 2019). Royo and colleagues (2020) confirm that

making citizens' inputs binding for the municipality gives citizens the feeling of being taken seriously. They highlight that citizens should also be updated on the progress to show their effect of contributions. Hartmann (2019, p.65) adds that feedback can "humanize the face of the government". Furthermore, it has been shown that time does not only play a role in offline participation (Novo Vázquez & Vicente, 2019): digital tools should be designed to be a quick and easy way to engage, which includes keeping clicks on platforms to a minimum (Hartmann, 2019). As previously mentioned, privacy concerns also play a part in citizen participation platforms. Hartmann (2019) states that only essential information should be asked and users should be able to decide what kind of information to publish. Lastly, Royo and colleagues (2020) underline the importance of embedding digital tools in traditional ways of participation to increase acceptability among citizens.

Digital tools for planning purposes

Besides engagement that can be classified into the three levels of citizen participation in the energy transition, digital tools have also been studied in the context of planning. Fiukowski and colleagues (n.d.) for example have submitted an article studying impacts of simulation tools used for stakeholder empowerment. To note is that this article is neither peer reviewed nor published yet, but raises some interesting points that can contribute to this research. They have suggested that using simulation tools for participatory planning purposes can help increase transparency of energy planning and lead to high levels of participation and stakeholder empowerment, if citizens are included in all steps. This process of participatory modelling, Fiukowski and colleagues (n.d.) outline in figure 3.

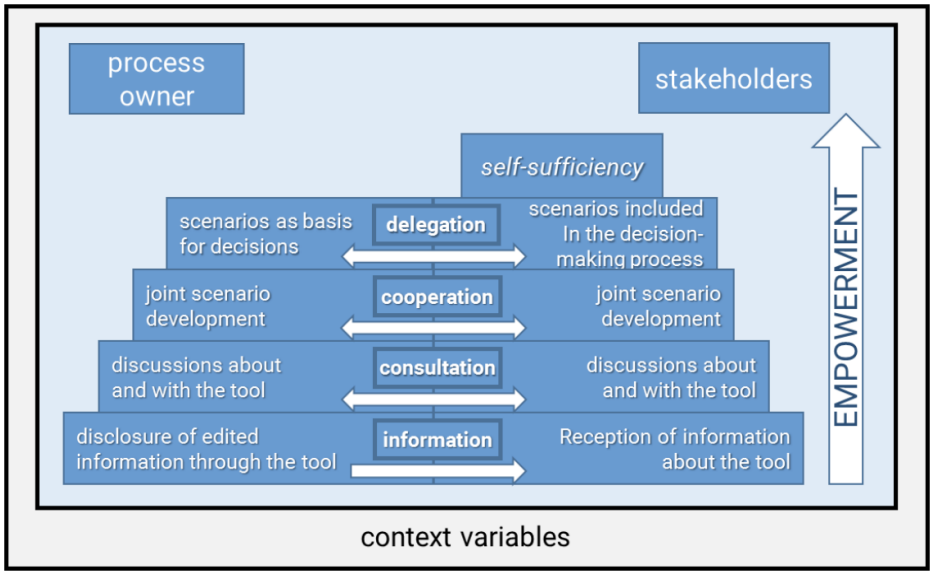

Figure 3: Stakeholder empowerment through participatory simulation (Fiukowski et al., n.d.)

While simulation tools serve as a framework for what is feasible, stakeholders bring in new perspectives and input concerning social feasibility. Fiukowski and colleagues (n.d.) highlight the challenge of representing the complexity of the energy system whilst keeping the interface simple for citizens to understand. The more specific and flexible the input parameters of simulation tools, the more difficult it tends to be for non-specialist users to grasp. Therefore, Fiukowski and colleagues (n.d.) recommend comprehensive user guidelines and a workshop leader as an intermediate between the citizens and the tool.

3. Methodology

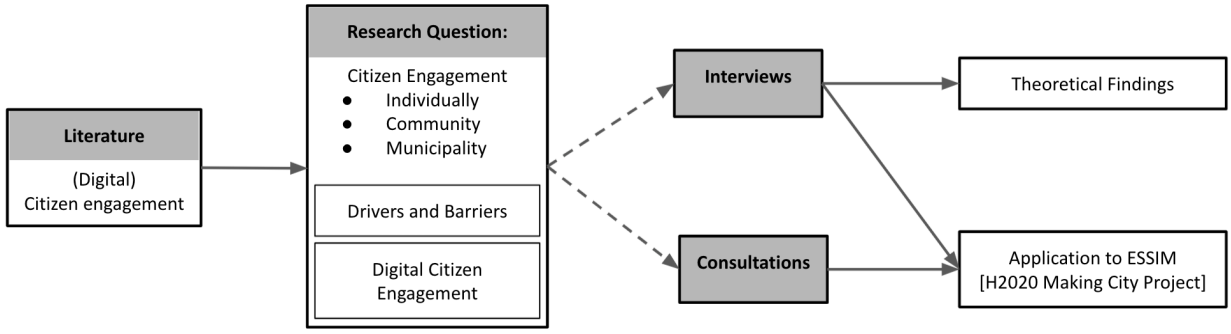

Figure 4: Study approach

3.1. Consultation with ESSIM

Throughout this project, I was in close contact with my supervisors, George Huitema and Joke Kort, who continuously gave input and feedback. Regarding ESSIM, TNO researchers Arun Subramanian and Selma Causevic, who are familiar with the ESSIM tool, were included in this study through a continuous feedback loop:

- ESSIM: Firstly, both familiarised me with the ESSIM tooling, providing me with background knowledge and leaving opportunities to ask questions.
- Brainstorm: The next step included a brainstorming session about potential scenarios of what kind of information from ESSIM could be useful for people and to understand the realm of possibilities.
- Interview Guide: Before conducting the interviews, Subramanian and Causevic gave input for and feedback on my interview guide.

- Results & Discussion: After finishing the interviews, the results were discussed in a joint session, which are important inputs for section 6.

3.2. Interviews

This study is based on a phenomenological research approach (Moustakas, 1994), investigating the phenomenon of citizen engagement and specifically citizens' ideas about digital participation in the energy transition. In order to get an understanding of citizens' lived experiences, I conducted four in-depth interviews. The interviews were semi-structured based on the framework presented in the literature review. Topics included traditional citizen engagement on three levels: a) individual, b) community, c) municipality. Additionally, in the second part of the interview, interviewees were asked about their experience with and ideas regarding digital tools in the energy transition. In the end, they were also presented with ESSIM and our ideas on potential citizen engagement tools in order to receive some citizen input and feedback.

Participants and procedure

The selection criteria for participants was to be homeowners in the city of Groningen. Homeowners were chosen as they have more power over their energy measures compared to citizens that rent their home. Restricting participants to nothing but the homeowner criteria ensured that my results were as representative as possible for the city of Groningen within the scope of this research. Participants benefited directly and indirectly from this study: they received a 25€ Bol.com voucher from TNO for participating in this research. Additionally, interviewees had the opportunity to take part in shaping a potential digital tool.

The four interviewees were recruited through various routes. Firstly, a request was sent out in the newsletter of Grunneger Power (GPO) as well as directly to some of its members. GPO is the biggest energy cooperation in Groningen for and run by citizens (Grunneger Power, n.d.). As members of GPO are familiar with the challenges related to the energy transition, their experiences, opinions and beliefs were expected to be of great value for the topics studied in this research. However, due to the little responses, participants were also recruited through personal outreach to Groningen-based Campus Fryslân's professors and their contacts. Finally, the snowball tactic resulted in one more participant.

Ethical considerations and drawbacks

This research was reviewed for ethical considerations and approved by the Campus Fryslân ethics committee. Prior to conducting the interviews, the participants were informed about the research project via email and asked to sign a consent form including ethical considerations, such as transcripts and recordings. Due to the Covid pandemic, the interviews had to be conducted online via Google Meet or the interviewees' preferred method of calling (e.g. phone). After having obtained signed and verbal consent, the interviews were audio-recorded. Subsequently, the recordings were transcribed and anonymised. All data was analysed by me only and is stored on my personal and TNO laptop, as well as on the University Y- and Google Drive. Upon completion of the transcripts, the audio recordings were deleted to safeguard the participants' privacy. Their names were known only to me and the supervisor for the purpose of sending the voucher. To keep their identity confidential, the results section refers to any participant using 'they' regardless of gender. To ensure that participants felt comfortable in the interview setting, the interviews were conducted in English or Dutch depending on the participant's preference.

Data analysis

As common in the phenomenological research approach, the transcripts were analysed using a thematic approach with a mixture of inductive and deductive methods. Firstly, the interviews were analysed according to the pre-existing themes engagement on a) individual, b) community and c) municipality level, and digital tools. Within these themes, new codes emerged, which I kept track of using a codebook.

4. Results: citizen engagement in the energy transition in Groningen

The citizens who participated in this study were between the ages of 31 and 69 and lived in Helpman, Oosterparkwijk and Indische Buurt. Due to the different recruiting procedures, the participants were in different stages regarding the energy transition. The participant that was recruited via the GPO route was most familiar with the energy transition on all levels, whereas interviewees who were contacted through other routes were not necessarily actively engaging on community or municipality level. This section presents the interviewees' experiences in the energy transition in Groningen.

4.1. Engagement on individual level

Starting with engagement on the individual level, three out of four interviewees reported getting their energy from sustainable sources, including a green electricity contract, own solar panels, or investment into wind turbines. Only one participant stated that they use “normal” (conventional) electricity, because they did not “believe in the difference between green and grey energy”. As can be seen from table 1, two interviewees used natural gas systems for heating and cooking. The other two had heating systems based on electricity or green gas and already cooked on induction or planned on changing to induction. From the three natural gas users, two participants expressed some level of dissatisfaction with their gas systems due to sustainability concerns. Concerning insulation, two participants (1 and 4) stated that their house was poorly insulated due to its construction years. Contrastingly, the other two participants either had quite a new house or insulated their house themselves.

	Interviewee 1	**Interviewee 2**	**Interviewee 3**	**Interviewee 4**
Electricity	Conventional	Electricity not specified Solar panels	Green electricity	Green electricity Solar panels Wind turbines
Heating	Natural gas	Natural gas (HR CV)	Electrified (CV)	Green gas
Cooking	Natural gas	Natural gas	Gas, but plan to switch to induction	Induction
Insulation	Not well insulated Mostly double glass	New wall and roof insulation Double glass (HR++)	Well insulated	Not well insulated Mostly double glass

Overwhelmed by information

When it comes to how participants informed themselves about the energy transition and their experience with this process, the code that came up the most was the feeling of being lost. Two participants referred to the saying “ik zie door de bomen het bos niet meer” which translates to “I cannot see the wood for the trees”. Hereby, they suggested that it is easy to become overwhelmed by

the amount of information and products that can be found online. This was supported by another interviewee sharing that despite existing motivation, citizens often struggle with where to begin.

External factors

When interviewees were asked about the reason for not choosing a sustainable energy alternative, several external factors were brought up. Interviewee 2 stated that when they renovated, heat pumps were not yet used for old houses and their home connection to the gas infrastructure was just recently renewed. Similarly, interviewee 1 said that these decisions lay with the homeowner association without leaving much room for individual action. Additionally, the belief that the current energy supplier was already "doing well" with energy sustainability was given as a reason not to explicitly invest in sustainable energy.

Financial influence

One key objective of the interviews was to find out what kind of information citizens find important when deciding to invest in sustainable measures. All interviewees agreed that money is an important factor in decision making. Some mentioned that higher energy prices can be an incentive to use less energy, while others brought up financial struggles as a barrier to implementing sustainable measures. Yet, all participants recognised that money is not the most important factor: it is "more or less" important (4) or "I am not really concerned about the prize" (1).

Sustainability

The motivation to invest into sustainable energy measures was mostly based on sustainability: three out of four respondents were willing to pay more for a sustainable option. Other interviewees compared the sustainability of energy suppliers and said "we are pretty green people".

Social context

Two participants also said that their motivation depends on social factors: social comparison is "how you benchmark if you're doing a good job or not". Interviewee 2 confirms that citizens are often influenced by their neighbours who renovated their house ("My neighbour did it too, so I'll also do it"). On the contrary, the social comparison in the monthly energy report was also mentioned as an inhibiting factor: "the energy report [...] shows me that I am a low user and that also tells me that there is not that much that I can do right now. [...] In that way I also don't feel pushed to do something about it, about getting

better energy". In this social context, participants also highlighted the importance of the experience of others. Asking for experiences, tips and tricks influenced their opinions about websites, products and companies.

4.2. Community participation

When interviewees were asked about their community participation, two interviewees mentioned being actively involved in their community. One participant was the administrator of a homeowner association, through which an investigation was initiated into how the apartment complex can be made more sustainable. This ongoing investigation was also referred to as a restrictive factor to their engagement in the energy transition, to quote: "It mostly depends on the inquiry with the housing association, because there is not that much that I can do myself". The other participant reported a generally high sense of community in their neighbourhood: it is "almost a village". They were chair of the sustainability working group as well as a member of Grunneger Power. The main role of the working group was to connect citizens to the right contact points: sharing experiences within the community or connecting them to experts and companies. They criticised that a lot of work is left in the hands of these neighbourhood initiatives, although these often lack knowledge and expertise. On the other hand, they brought up that the initiative is in the process of sourcing existing knowledge from the community. In this context, Covid-19 was brought up, since physical meetings were inhibiting especially the older parts of the community from participating.

The other two interviewees stated that they were not very involved in the community regarding the energy transition. One expressed that to them it feels "us for the environment" rather than "feel[ing] connected to other people doing this". Despite not being part of any energy-related initiative or alike, they reported participation through other ways, for example in sustainable groups on social media or in a community center. Reasons for not participating more on community level were related to a lack of time, not wanting to put too much responsibility on themselves or just not having thought about it.

4.3. Engagement on municipality level

Regarding the energy transition in Groningen, three interviewees were not well aware of energy transition developments in the municipality. Some projects or developments they did mention were related to more electric loading points for cars, the Warmtestad project, and potential subsidies for sustainable energy measures. One interviewee was very well informed about the municipality's

involvement in the energy transition including the plans for their neighbourhood. They highlighted having a good connection with the municipality through the sustainability working group. Other sources of information were the municipality's newsletters or news stemming from other sources.

Concerning engagement, interviewees felt that citizens were not included in the planning process of the municipality's plans for the energy transition and that they could not influence the decision making in the municipality. One participant thought that influencing the municipality happens more indirectly: "it's [...] more who you vote for". The chair of the sustainability group merely mentioned that the group is "one of the signals" the municipality hears. In this context, they also raised that it is challenging to get people to participate in sustainability-related matters, especially on neighbourhood or municipality level. Barriers to participation within the municipality were diverse: one participant said: "I don't really feel that it's really a big thing here". They stressed that it could be an incentive to become more involved if the municipality put more emphasis on the energy transition. Furthermore, the participant highlighted that the municipality should clearly communicate what they expect from the citizens and emphasized that for them engagement should be much more practical and on the individual level. Other restraining factors that were brought up were a lack of skills and the assumption the municipality was already "doing fine".

4.4. Digital tools

Throughout the interviews, participants described their experiences with digital tools in the energy transition. The different tools interviewees used are summarized below (figure 4). The most common functions of tools were information provisioning, sharing of experiences and getting in contact with companies in order to invest in sustainable energy measures. In the context of social media, one interviewee highlighted that it is an anonymous and easy way to ask for experiences and tips or to be referred to companies or other contact points. This participant also pointed to critical and judgemental voices in groups on social media, but did not see this as a big issue. This digital participation is often connected to offline interactions, since one participant stated they were often referred to websites by friends. Another interviewee also noted that digital tools only provide value when citizens are already familiar with the topic and are actively searching for information or engagement. They attributed the responsibility of spreading awareness rather to the traditional media, such as TV or newspapers. Furthermore, they suggested that giving feedback on websites is not very common yet.

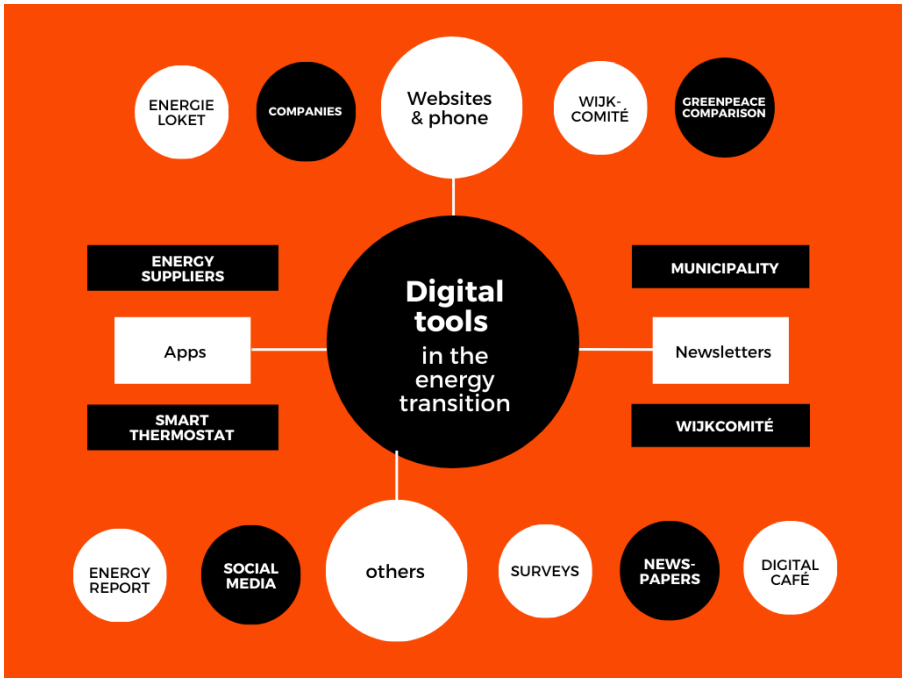

Figure 4: Digital tools in the energy transition (Interviews).

When interviewees were asked about a tool they would like to use, several ideas came up. This ranged from informing people via email or newsletter to survey-like ideas in order to get an idea what people are already doing and what their experiences are. Furthermore, two participants had ideas for a website. The first brought up a website where citizens are guided to FAQs and experiences of others. Another interviewee said they would like a website where they can fill in their basic information of their house and be provided with options for making the house more sustainable. Generally, some factors were mentioned that should be considered in a digital tool, such as interactivity, objectivity, ease of use and practicality (tailored to individual situations).

5. Discussion

The main aim of this research is to shed light on how citizens experience traditional as well as digital citizen engagement in the Groninger energy transition. This section interprets and discusses the interview findings.

5.1. Citizen engagement in Groningen

Most participants in this study cared about sustainability and the energy transition, and were already active or in the process of transitioning to more sustainable energy sources. Besides these internal

motivations, triggers to implement sustainable energy measures were attributed to two external factors: renovating the house and the desire to become gas-free. This is in line with Broekhuis and colleagues (2020) who indicated citizens either need to be intrinsically motivated or triggered externally. Most other findings on individual engagement are also confirmed by Broekhuis and colleagues (2020), which makes sense considering that both studies were conducted in Groningen. This includes specific information not being easily accessible, being influenced by social surroundings and highlighting the importance of sharing experiences with others. Contrary to Broekhuis and colleagues' (2020) suggestion that cost of sustainable alternatives are experienced as too high, participants were willing to pay more for sustainable options, even the one that mentioned money as a barrier. This could either be explained by the fact that interviewees found sustainability to be an important part of their lives, or by the fact that participants did not live in low-income neighbourhoods, suggesting a certain socioeconomic status.

Although most of the interviewees seemed to find sustainable energy important, there was little engagement in the community and even less on the municipality level. The only participant that did engage in a sustainability working group talked about the initiative as a place to share experiences, and to act as intermediate between citizens and the municipality. This participant was also the only one to mention good social cohesion in the neighbourhood, which is in line with Koirala and colleagues (2018) indicating that community trust is the most important predictor of community engagement. Other participants reasoned not having thought about joining an initiative yet, which might be related to the lack of information about community initiatives (Lennon et al., 2019). Additionally, not wanting to put too much responsibility on themselves could be related to the time component that was found to be an inhibitor both by this study as well as by Koirala and colleagues (2018).

On the municipality level, there seemed to be little communication between citizens and the municipality, except for the interviewee involved in the sustainability working group. This indicates that community initiatives are the main point of contact between citizens and the municipality. None of the participants were involved in the development of the energy transition plans nor knew about anyone that was. At first glance, this is surprising given that the municipality of Groningen is the lighthouse city for the H2020 Making City project (*Making City – Energy Efficient Pathway for the City Transformation*, n.d.) and has already developed the district energy approach (Gemeente Groningen, n.d.). Yet, none of the interviewees lived in neighbourhoods with existing energy visions or plans. According to the district

energy approach, most engagement with citizens and initiatives happens only once the development of energy visions is started (Gemeente Groningen, n.d.).

The reasons citizens gave for not participating were diverse, but all confirmed previous findings. Although participants felt like they could not influence governmental decisions, supporting Novo Vázquez & Vicente (2019) argument of political efficacy, interviewees did not complain but rather justified this lack of efficacy. This in combination with the suggestion that "it's not a big thing here" (participant 1) indicates that involvement is not yet a standard practice. While literature found lack of technical expertise to be a barrier to community engagement (Koirala et al., 2018), these findings suggest that the perception of a lack of skills also inhibits participation in municipal processes. This is in line with Devine-Wright (2007) who argues that the centrality paradigm creates a distance between "experts" and the passive "users". Simultaneously, some participants did not feel the need to participate (Hartmann, 2019) because they thought the municipality was transitioning well in terms of sustainable development. These results can be summarised by Hartmann's (2019) quote: "citizens not only have to feel a **need for participation**, but governments also have to **encourage** their participation and show some **reaction and meaning** to it" (Hartmann, 2019, p.62).

This study has also highlighted how interlinked the three dimensions of citizen engagement are. The feeling that the energy transition is not a major concern in Groningen can decrease individuals' motivation to implement sustainable energy measures at home. To sum up, I can hypothesise that there is not yet a culture of engagement on community and municipality level in Groningen.

5.2. Digital tools

Unfortunately, participants did not have extensive experience with digital tools, which confirms the research gap of digital tools in the energy sector. Most tools were used for information purposes on an individual level, such as websites, energy reports, or newspapers. The few interactive tools, such as social media and a digital café with the mayor, were also used for information and sharing of experiences. This confirms that mere online presence and communication on social media is not enough to engage citizens and especially not enough to include them in decision making processes (Hartmann, 2019).

When it comes to what is important to citizens in a digital tool, special attention should be given to the factors that were found to be important in the previous section: practical information, money,

sustainability, emissions, social comparisons, experiences and best practices. Asking citizens explicitly about digital tools yielded several points to keep in mind when designing a citizen engagement tool. Participants mentioned that digital tools should be interactive, which was also found to be an important factor in literature. Two way communication and feedback were found to increase trust and make citizens feel like their inputs are taken into account (Barrios-O'Neill & Schuitema, 2016; Hartmann, 2019). Barrios-O'Neill & Schuitema (2016) also suggest that interactivity ties in well with tailoring information and tools to individual situations, which this research found to be of special importance for interviewees. In line with Naus and colleagues (2015), objective information was important to participants and advice from sources without profit orientation were preferred. Furthermore, interviewees raised that a digital tool should be easy to use, a factor that came up in all of digital engagement literature (Barrios-O'Neill & Schuitema, 2016; Fiukowski et al., n.d.; Hartmann, 2019; Novo Vázquez & Vicente, 2019). This includes an easy representation of information (Fiukowski et al., n.d.), minimising the number of clicks needed to complete a certain action (Hartmann, 2019) and adhering to some design principles, such as the 16 guidelines de Paula and colleagues propose to develop successful interactive applications (2014).

In the interview process, a few challenges to digital participation came up. The most crucial one that scientific literature also emphasises is the digital divide. While literature pointed to barriers due to skills and internet access (Hartmann, 2019), this study found skills to be more important. Obviously, this can be attributed to the fact that my interview sample was part of a certain socioeconomic group that all had access to the internet. Nevertheless, Covid-19 was mentioned as the trigger, since meetings suddenly had to be held online, which excluded large parts of the older population. This could especially become a problem in citizen engagement because older people are known to have more time and thus are more likely to participate in the energy transition (Novo Vázquez & Vicente, 2019). Another critical remark that was made by one of the participants is that digital tools in the energy transition are "supplementary" materials for engagement. A prerequisite for a citizen engagement tool is that the public wants to be involved. This stresses that this digital participation requires a good basis of citizen engagement in the offline or traditional citizen engagement realm. Royo and colleagues (2020) also highlight that traditional forms of participation should be included in new digital participation channels. In line with this, one participant stressed the importance of including community initiatives in digital engagement tools.

6. Application to ESSIM

After having discussed and situated the findings within the current state of research, this section brings together knowledge from literature, consultations from ESSIM and findings from interviews to apply to ESSIM. Two different scenarios for potential citizen engagement tools based on ESSIM are presented and discussed here.

6.1. ESSIM applied to an individual use case

What is modelled?

Firstly, this tool would enable the citizens to model **their own house**. Users would be asked to fill in their basic home situation in terms of electricity, heating, cooking, and insulation. While this would be based on ESDL, the application needs a user-friendly interface on top. To reduce time and complexity, citizens should be able to choose from predefined lists for input fields (Hartmann, 2019). Additionally, the app should include default options based on an average in case the user is not sure about an input field.

This digital representation of the user's home represents the status quo and gives the citizen an impression of their energy performance at the moment. Next to the user's own home, their **district** should also be modelled to expose the user to developments in the neighbourhood. Besides taking advantage of social influence (Broekhuis et al., 2019), this would also make otherwise hidden energy infrastructures visible (Devine-Wright, 2007). Although citizens have expressed positive feelings towards information-sharing, it is questionable how much privacy they are willing to give up (Naus et al., 2015). This privacy issue could either be solved by abstraction of data, i.e. aggregating data into numbers and showing only in relative proportions, or by making data sharing voluntary and having users agree to share data with the community.

What information is included?

The KPIs that are relevant for citizens are slightly different from the ones that are relevant for energy

planning. The following list summarises the findings of important information citizens value when evaluating energy measures.

- **Money**: Although currently not included as a KPI in ESSIM, the application could use *ESSIM financial*, another ESSIM-related system that calculates cash-flows.
- **Emissions**: Besides the already included emissions per carrier, producer and sector, individuals could be interested in emissions for their own house as well as the entire neighbourhood.
- **Sustainability**: To make environmental consequences and community implications more tangible, the application could provide information on how the measures contribute to the city's goal of being carbon neutral in 2035.

As Royo and colleagues (2020) suggest, the **community** aspect could be included by providing information or links to initiatives. **Experiences** of others can be included in the form of best practices or by giving the users the opportunity to get in contact with one another.

Simulations

After having modelled the status quo and having evaluated the system's current status of KPIs, the user should be provided with options for their own houses. Because the tool has been provided with the state of sustainability measures in the citizen's house, it can give **specific and practical options for improvements**. To stay objective, the application should not refer to companies, but rather show general scenarios. The range of possibilities is determined by the municipalities' plans for the district. This enables the user to evaluate different options in an **interactive** way, while being able to see how the options impact the KPIs.

Actors and context

To ensure objectivity of this application, an important question to consider is what kind of actors are included and what role they play.

- **Community:** The community could play several roles in this scenario.
  (a) Initiatives could be a mediator between the tool and citizens, promoting its use to the general public and providing training.
  (b) Existing initiatives could help with data collection for modelling the district.

- **Energy suppliers:** Companies supplying energy in the district could be another contact point for data collection.
- **Municipality:** In this scenario the municipality would play a rather passive role as they determine the framework under which citizens can operate.
- **TNO:** TNO would serve as the IT provider of the tool.
- **Energy advisor:** These could play a role in development of the tool, as they are closer to the citizens and bring expertise with user-friendly design.

6.2. ESSIM applied to a collective use case

What is modelled?

Rather than focussing on individual use, this application would model a bigger picture. As the municipality plans the energy transition on district levels (Gemeente Groningen, n.d.), a district modelling approach seems most plausible. In this case, describing the district energy system in ESDL could mainly be done by an expert. However, in order to engage citizens more actively with this tool, it is still vital to have an easy interface for citizens to understand (Fiukowski et al., n.d.).

What information is included?

The KPIs presented in the first scenario (money, emissions and sustainability) remain crucial in this application to make the outcomes more relevant to citizens. However, along with the broader approach to this scenario, all traditional KPIs from ESSIM become crucial again, namely energy imbalances, energy mix, and infrastructure loads.

Simulations

This application could be used by the municipality in two ways. Either **(1) to communicate existing energy plans** to citizens in information evenings or **(2) to integrate citizens in the planning process**. The latter is more favoured by citizen engagement literature given its active involvement of citizens and the increasing importance of bottom-up energy planning (Castelnovo, 2019; Fiukowski et al., n.d.;

Gray et al., 2017). In both cases, the simulations are an interactive way of engaging with potential future energy developments for the district.

Actors and context

Similar to the individual scenario, a multitude of actors are of importance here with slightly different roles.

- **Municipality:** In this scenario, the municipality plays a central role. In the case of option **(1)**, this can be applied on information evenings at any time throughout the energy transition process, whereas option **(2)** requires a long-term modelling process with all stakeholders. To situate this tool within the district energy approach of the city of Groningen, such participatory modelling processes would be applied either in developing the energy vision (step 1) or energy plan (step 2) (Gemeente Groningen, n.d.).
- **Modellers:** Modellers are also a key part of this process, and are especially involved in the participatory modelling option **(2)**.
- **Community:** Similarly to the first scenario, the community could play several roles.
  (a) Especially in the participatory modelling option, initiatives are key mediators, as this process can take place within a subgroup of community initiatives. Here, citizens should be included in all steps of participatory modelling.
  (b) Existing initiatives could help with data collection for modelling the district.
- **Energy suppliers:** Like in the individual scenario, energy suppliers in the district can be another contact point for data collection.
- **Energy advisor: Just like in the individual scenario,** advisors can play a role in development of the tool, but also be part of the participatory modelling process in option **(2)**.
- **TNO:** TNO would serve as the IT provider of the tool.

On which level and how ESSIM is finally implemented depends on how the municipality of Groningen wants citizen engagement to look like. As discussed previously, on an individual level the awareness and engagement seems to be existent and the challenges are related to being overwhelmed by information and wishing for more tailored, practical information. When citizens were asked for feedback on these two ideas, they were very enthusiastic about the individual use scenario. Therefore, the first scenario might be more easily adopted by the citizens. On the other hand, building such an application requires

more research and changes to the existing tool, since it applies energy system modelling in a context completely different from its original purpose. Applying ESSIM in energy planning processes in community or municipality contexts however suits its original purpose much more and thus requires less adjustments to the tool itself. Nevertheless, this scenario also needs careful planning and must be well integrated in the engagement process to overcome a multitude of challenges, especially balancing the complexity of the energy system and the simplicity of use for the participating citizens. In an ideal scenario, both versions would be implemented as part of a larger citizen engagement platform and strategy within the municipality of Groningen. Combining this into an overall platform would leave the citizens less overwhelmed by different information sources and increase engagement on all three levels of the energy transition.

7. Recommendations

This study brings to light the several opportunities and challenges of offline and online citizen engagement in the energy transition in Groningen. A range of recommendations directed to the municipality as well as developers of digital tools follow from these findings.

Municipality

The municipality is a crucial actor in the energy transition not only for engagement on the municipal level but also because the municipality's actions can have repercussions for both the individual and community engagement.

1. *Improve communication*

The municipality should clearly communicate to the citizens that the energy transition is a priority. When citizens recognize that the municipality is truly concerned about a topic and engages with it thoroughly, citizens are more likely to participate themselves.

2. *Foster a culture of engagement*

The municipality should aim at making engagement in the energy transition a norm. First of all, the municipality has to create routes for citizens to participate. Although already included in the district energy approach, these engagement routes need to be expanded and citizens should be at the heart of energy planning, being actively included at every step of the process. Yet, it is most important, to not

only create opportunities for engagement, but to really take citizens' inputs into consideration in decision making. These routes for participation need to be clearly communicated to the citizens to create awareness and motivation to engage.

Developers of ESSIM digital engagement tool

These findings are also relevant for developers when designing an engagement tool based on ESSIM, as design decisions shape the functionalities and thus impact the effectiveness of participation.

1. *Include information important to citizens*

Based on this study, information that is important to citizens include information tailored to their situation, costs, sustainability, emissions, social comparison and experiences of others. Developers should ensure these are represented in a digital tool.

2. *Keep the tool user friendly*

To keep the citizens engaged, the tool should be interactive and easy to use. Developers should aim to minimise the time it takes to perform any action. To reduce confusion, input fields should be a predefined list and always include a default option.

3. *Include citizens in the development*

Irrespective of the scenario ESSIM is developed for, it is crucial to include citizens in the development process. Citizen technologists can for example be included through hackathons (Hartmann, 2019). Including citizens also ensures a user-friendly design.

Context of the engagement platform

1. *Embed the tool in offline participation*

For a variety of reasons, any tool should be embedded in offline participation. Because energy initiatives are central in the energy transition in Groningen, it is critical to include these. For the different use cases, community initiatives play slightly different roles, which can be found in section 6.

8. Conclusion

This research aimed to answer the question "How can digital tools be used to engage citizens in the energy transition?" and later apply the gained knowledge to answer how ESSIM, the Energy System Simulator tool developed by TNO, can be applied in participatory contexts within the H2020 Making City project in Groningen. Considering the importance of approaching engagement from a citizen-centric perspective, this study focused on homeowners' experiences and ideas about online and offline citizen engagement in the energy transition, rather than putting ESSIM at the core.

8.1. Main findings

Throughout this study, citizen engagement was analysed on three conceptual levels, namely individual, community and municipality. Citizens were found to be engaged on the individual level, while being less active in community and municipal contexts. Nevertheless, important conclusions can be drawn on drivers and barriers for all levels of engagement. Individually, the most important barrier was rooted in the large amount of information available, leading to citizens being overwhelmed and not knowing where to start. Based on the findings from community and municipality engagement, it becomes clear that community involvement is a strong indicator for municipality engagement. Nevertheless, overall, Groningen has not yet managed to establish a strong culture of engagement outside of citizens' own homes. The three levels of engagement are highly interrelated and citizen engagement on all levels is especially influenced by how the municipality approaches the energy transition. Concerning digital engagement, citizens were not very experienced with digital tools that went above information provisioning or sharing of experiences. Regardless, this study yielded essential considerations for the development and implementation of digital citizen engagement, outlined in the recommendations section.

8.2. Implications for ESSIM

Based on interviews, consultations, and literature, two scenarios for potential citizen engagement tools were presented. Firstly, ESSIM could be used in an individual use case, where citizens are able to model their house and district. The simulations based on ESSIM would give citizens tailored options for their houses and display the effects these measures have on the factors that were found to be important when evaluating potential energy measures. This application of ESSIM to citizen engagement requires more fundamental changes to the original tool, but is likely to be easily adopted by citizens. Secondly,

ESSIM could be used in community and municipality contexts either as a channel for the municipality to communicate existing energy pathways, or in participatory energy planning. The latter is a more citizen centric approach, as it requires active involvement of citizens. This use case is closer to ESSIM's original purpose and would thus need less modifications to the tool itself.

8.2. Limitations & further research

Because the sample size of 4 interviews was relatively small, findings from this study cannot be generalized and should be seen as an indication for further exploration. Furthermore, the homeowners that were interviewed could be seen as a certain socioeconomic group, since none of the participants lived in low-income neighbourhoods. Considering that the interviewees also did not live in any of the three districts with existing energy visions, it can be assumed that this impacted the opportunities citizens had to participate. Therefore, conducting the same study in other municipalities or even neighbourhoods would likely result in very different experiences. Nevertheless, the strong point of this study is its practical orientation towards ESSIM, whilst keeping a citizen-centred approach to this research. As such, this study serves as a foundation for further research, but also contributes to effective action for sustainability in Groningen.

Should TNO continue with the planning and development of an engagement tool based on ESSIM, further research suggestions depend on the type of application TNO decides for. In case the individual use case application is favoured, further research and development should continue to be citizen-centric to find out how information can be represented and designed in order for a general public to understand. If the participatory modelling idea is further taken up, research should further concentrate solely on the steps and considerations important for participatory modelling. Furthermore, the neighbourhoods with existing energy visions could be examined to study how this modelling could fit in the existing planning process.

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10. Appendix

10.1. Interview Guide

Opening Question

Name

Age

What's your current occupation/job?

In which neighborhood or district do you live in Groningen?

How is your housing situation? (With whom? How many?)

Background

How do you implement sustainability in your house? Concerning energy?

What kind of energy do you use at home? Why?

How do you heat your house? Why?

Do you have any further plans regarding sustainability? (energy, heating, electric car?)

Participation

If we talk about participating in the energy transition, what do you understand under participation and how would you say you are involved in the transition?

How has Covid impacted this?

What do you think are the main barriers or challenges for citizens not to get involved in the energy transition? How about yourself?

Own house

How do you inform yourself about different options? From whom? Where?

Which digital tools do you use to inform yourself?

What kind of information is important to you? // How did you select which measure fits best? Money? Sustainability?

How do you feel about the information that is out there? Is it sufficient, are you missing anything?

How did you experience this process? Did you experience any problems? Is there anything that could have been done differently?

Community

How important is it to you what your neighbours/district is doing in terms of energy?

Are you involved in any neighbourhood activities or initiatives or energy corporations?

How does the community/initiative help you?

Do you already use digital tools within your community or initiative? Which ones?

→ What do you think about these?

→ What can be done better?

Municipality

How well informed are you about the plans the municipality has for your district?

What are the municipality's plans for your neighbourhood/district?

How did you hear about those plans?

[Do you initiate?, Information evenings (from municipality), Local initiatives]

To what extent were you/was the public involved in the development of the plans?

→ do you feel like you could influence the decisions that were being made?

→ how would you want to be (more) involved?

Which means or tools did the municipality use to get you as a citizen involved …

- in the planning process?
- in communicating existing plans?

  → What do you think about these?

  → What can be done better?

Digital participation

In general, what is your experience with digital tools? Do you find them useful?

Which platform do you prefer to use digital tools on? Phone or web?

What kind of tool would be most beneficial to you?

ESSIM

At TNO, they developed an energy simulation tool, so basically you can put any kind of energy system in there and then go through different 'what-if' scenarios. This is mostly used in testing out different plans and finding potential problems.

Present different scenarios/options:

Individual: model your own house

- Show the consumer the neighbourhood and what is already happening
- Give the consumer different options for their own house
- Information about how much the consumer contributes to the goal of being carbon neutral by 2030

Municipality: show plans & get feedback

- Potential plans can be pre-programmed and tested out by the user
- user/citizen can give feedback on which strategy they like best

What does this tool need to be able to do?

What information would be helpful to you on such a tool?

Can you think of other situations where such a tool, or a variation could be useful?

Closing questions

What's the most important thing for a digital tool to have for you?

Do you have anything else to discuss?

10.2. Transcripts

See following document:

https://docs.google.com/document/d/1J8ScLOaO3rSjSb7wbGxD7xlMDiWznscLn4M4nNFHdvM/edit?usp=sharing