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Climbing up the ladder to a sustainable heat transition Working Paper

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1. INTRODUCTION

The Netherlands has a long history of natural gas use and extraction, in 2018 it was the most important energy source of the country. In 2018, natural gas accounted for about 51 percent of electricity generation, 90 percent of residential heating demand and about 76 percent of domestic energy production (IEA, 2020). This may be attributed to the fact that the Groningen gas field is one of the largest gas fields globally. However, earthquakes in 2018 and 2019 damaged more than 10,000 buildings in Groningen and has been linked to gas extraction activities in the region. As a result strong public and political pressure has led the Dutch cabinet to issued a decision to end gas extraction in Groningen to mid-2022 which has since been amended to 2035 (IEA, 2020) (Ministerie van Economische Zaken, 2019). At the national level, the heating transition is outlined in the Dutch 2019 Climate Agreement goal to reduce carbon dioxide emissions in the built environment by 3.4 Mt by 2030. These national goals are realized through the Regional Energy Strategies (RES) which outlines the regional transition approach and the Municipal Visions (MV) which outlines the local transition approach. Given the national heating transition entails the commitment of residents and building owners to sustainability improvements, a neighbourhood and participatory approach has been adopted to achieve these targets (Ministerie van Economische Zaken, 2019). This follows increasing recognition of the importance of citizen participation in energy transitions, in which the public are viewed as active participants in the energy system with the potential for action rather than passive stakeholders (P. Devine-Wright, 2007) (Beauchampet & Walsh, 2021). This may be attributed to the numerous normative and pragmatic advantages of participation, the most prominent being:

- Increased public trust in decision making (T. C. Beierle, 1998; Cornwall, 2008; Reed, 2008; Richards et al., 2004; Stringer et al., 2006)
- Empowerment of local citizens through co-generated knowledge(Greenwood et al., 1993; Macnaghten & Jacobs, 1997; Okali et al., 1994; Reed, 2008)
- Heightened perception of fairness and legitimacy(Cornwall, 2008; Martin & Sherington, 1997; Reed, 2008; Richards et al., 2004; Wallerstein, 1999)
- Higher transparency and accountability(Cornwall, 2008; Hurlbert & Gupta, 2015)
- Enhancing equitable policy making and implementation(Martin & Sherington, 1997)(Reed, 2008)
- More informed project design, technological adaption and decision making which better serves local needs(T. C. Beierle, 2002; T. Beierle & Cayford, 2002; Blackstock et al., 2007; Fischer, 2020; Fritsch & Newig, 2012; Habron, 2003; Irvin & Stansbury, 2004; Konisky & Beierle, 2011; Koontz & Thomas, 2006; Martin & Sherington, 1997; Newig, 2007; Reed, 2008; Stringer et al., 2006)
- Greater adoption and diffusion rates of technologies, and acceptance of decisions (Junker et al., 2007; Martin & Sherington, 1997; Reed, 2008)
- Better adapted technologies and projects to serve local needs(Dougill et al., 2006b; Martin & Sherington, 1997; Reed, 2008)

The benefits and approach to increased citizen participation is also outlined in the national transition. regional transition and local transition policy. The Dutch Climate Agreement states that “it is crucial that residents contribute to and participate in the transition process to achieve natural gas-free districts” (Ministerie van Economische Zaken, 2019). Good participation processes are linked to better decision-making processes and increased acceptance of measures in the Agreement. The importance of participation is further ingrained in the related Environment and Planning Act (Omgevingswet) which is comprised of several acts that form the basis for the environmental legislation. The Act includes guidelines on the implementation of obligations regarding public access to information,

access to justice and public participation in the built environment, housing, infrastructure, environment, nature and wate (RVO, 2022). The plan stresses that "early participation of the public and stakeholders, resulting in a broadly supported preferred direction and coordinated execution, are of major importance" (RVO, 2022). The working method outlined in the Act includes an area-specific approach with broad participation from stakeholders including citizens, companies, and organisations at an early stage in projects. At the national level, both the Climate Agreement and Environment and Planning Act does not specify a specific approach for participation processes since participation can unfold differently in different context. Consequently, the area specific and interpretation of local ownership and participatory approach is therefore passed down to the regional level through the RES, which outlines the participatory approach and contribution to the national transition. The Groningen RES defines ownership as "risk-bearing (co-) development and exploitation of energy projects by local parties, with a view to re-invest the proceeds locally for CO_2 reduction, tax relief and quality of life"(de Graaff et al., 2021). The adopted definition of ownership in Groningen is very broad, intentionally so, to leave room for interpretation of what local is and what this ownership looks like in practice. However, the RES does note that while ownership and participation is often used interchangeably, they are not considered to be the same thing. The RES notes that participation may be expressed during the process or in the financial sense (de Graaff et al., 2021). The RES defines process participation as the involvement of the local environment (stakeholders) in the development of new policies or energy project, the initiator along with local stakeholders undergo a process in which agreements are made in relation to the spatial planning integration, extra-statutory consumption, financial participation, and the design of the project among other things. On the other hand, financial participation entails investing and/or benefiting from the revenue of an energy project in the form of co-ownership, financial participation, environmental funds and local resident schemes(de Graaff et al., 2021). Co-ownership is defined as local residents jointly owning a project through an association or energy cooperative; financial participation includes local residents in risk-bearing through shares, bonds, or certificates; environmental funds means that part of the proceeds of the energy project benefits social goals in a neighbourhood; and local residents' schemes is defined as providing immediate advantage to local residents in the form of sustainability of their home or green discounts. Given that the heating transition at both the national and regional level takes on a neighbourhood heating approach due to the centrality of local residents and building owners to the targets, the RES Groningen does not provide an exact outline of the heating transition, and instead leaves it to the competent local authorities to outline the local transition approach that will contribute to national and regional district heating targets and the participatory approach that will be adopted. This is to be outlined in Municipal Visions for the Heat Transition. As a starting point the Natural Gas Free Test Beds Programme is a testing grounds for municipalities to pilot district heating projects with a participatory approach and to determine the feasibility, opportunities, and challenges with different approaches. In the Groningen province, 6 test beds were initiated in 2018 and an additional 5 were initiated in 2020 (Programma Aardgasvrije Wijken, 2018a).

Community energy initiatives in the Netherlands are expected to be an integral part of the 'local ownership' goals and neighbourhood approach to heating listed in the Climate Agreement and Groningen RES. There are about 46 community energy initiatives active in Groningen province, of which 4 are involved in a district heating project. However, the role and impact of these initiatives will be hard to analyse, or measure given the issues around defining and measuring 'participation 'and 'ownership'. The conundrum that arises is that a narrow definition and approach misses the nuance of local contextual differences in participation processes, but a very broad definition is also problematic because achieving the target for a neighbourhood approach to the heat transition and 'local ownership' will need to be worked out on an ad-hoc basis and can lead to inefficiencies in reaching the set-out targets. In order to understand the impact and role of these community energy initiatives (which is not universal) is dependent on the degree of community engagement, ambitions

or motivations for participation and the business model design of the cooperative (Berka & Creamer, 2018; Patrick Devine-Wright, 2019). In addition, the diversity of local needs and motivation, level of citizen engagement, scale, technology, social dynamics, and ownership models disqualifies generalizations on participation as well. Similar issues are prevalent in mainstream academic literature, while participation is considered an important factor of energy transitions in the literature, 'participation' is not clearly defined. Moreover, while transitions literature often covers 'local ownership' and community energy initiatives in energy transitions, the literature does not provide deep contextualization of 'participation' and 'ownership', and it frequently lacks detailed analysis of the levels of 'participation 'or 'ownership' in community energy initiatives. This may be attributed to the fact that participatory literature which supports the conceptualization of these terms and participation levels have largely been disconnected transitions literature and energy policy. Consequently, there is a need for a robust transitions framework for understanding the role and degree of citizen participation in community energy initiatives and which captures the diversity found in these initiatives. It is precisely the conundrum of defining and measuring participation while avoiding superficial generalizations that this report seeks to address. The report is focused on the gap between participatory literature and transitional frameworks, and the lack of literature on participation levels and outcomes in energy transitions. Subsequently, this report has three key objectives: to conceptualize 'participation' and 'ownership' levels in a transitional framework; to understand the levels of 'participation' and 'ownership' in Groningen's community heat initiatives; and to identify the barriers and opportunities for participation in community heating initiatives. In order to do so the paper develops a new conceptual framework for participation and applies this frame to two cases to test the robustness, flexibility, and comparability of the framework. The section 2 of the paper outlines the methods used and the case studies that the paper will cover, namely, the Buurtwarmte and Warmtenet Loppersum cases. Section 3 then introduces a robust theoretical framework consisting of the Socio-ecological Systems Framework (SESF) and participatory literature. Thereafter, the results of applying the new framework to the case selection will be outlined in section 4. The results are divided into the participatory environment and the level of participation. Lastly, section 5 discusses the key findings and conclusions.

2. METHODOLOGY

2.1. Conceptualization and operationalization of participatory literature and Socio-ecological systems Framework

This report uses participatory literature and the Socio-Ecological Systems Framework (SESF) to develop a framework for understanding participation in community heating initiatives. Therefore, it is important that we elaborate how these two conceptual frameworks can be operationalized to answer our research questions. We conducted 3 separate literature reviews in order to develop our framework. The starting point was a review of the benefits of participation in order to identify the key elements our frame required, this is briefly summarized in section 1 and more thoroughly listed in section 3.3. We use the SESF developed and popularized by Elinor Ostrom given its multi-tiered nature and rootedness in collective action theory which makes it a good fit for understanding the complexity of participation. Desk research was used to identify literature in which SESF has been operationalized in order to identify the key mechanics of the framework in practice that needed to form the basis of our own framework. The overview of this literature is further elaborated in section 3.1. We then conducted a literature review to identify the key conceptual frameworks used in participatory studies. We identified Arnstein's ladder as a key conceptual framework given that it forms the basis for a large some of participatory frameworks. The key findings of the participatory review are further elaborated in section 3.2. Based on the 3 literature reviews and our research question we developed our conceptual framework in section 3.3.

2.2. Case study design

In order to test our conceptual framework and to gain insights into how "local ownership" and "local ownership" is operationalized in local heating initiatives we have used 2 case studies: Buurtwarmte and Warmtenet Loppersum (see table 1 for overview). The case study design allowed us to conduct an in-depth analysis of local level participation processes and how they have unfolded in different context in the sense that the projects are geographically different and the in that one project was a bottom-up initiated projected while the other was a top-down approach. In addition, the case studies are of different scales which allowed us to identify potential challenges in the scaling up process of energy projects. The two cases present 2 of 5 local heating initiatives listed in the Local Energy Monitor, these were selected based on the following criteria:

- Initiative is partially or fully owned by local residents
- Sufficient primary and secondary information is available
- Geographic location (Groningen province, Netherlands)
- Part of the natural gas free test beds
- Listed as local heat initiative in the Local Energy Monitor
- Grassroot social innovation/ dissemination of niche innovation locally
- Project has started (a heating network has been identified as feasible and steps are being taken to begin rolling out)
- Selected case 1: Paddepoel, Buurtwarmte (meets all the criteria)
- Selected case 2: Loppersum, Warmtenet Loppersum-Noord (meets all the criteria)
- Selected case 3 Het Hogeland/ Bedum, EC Durabel (meets the criteria but did not participate in time to be included in the study)
- Not selected: Boven Pekela, Duurzaam Pekela (focused on green gas rather than a heating network)
- Not selected: Duurzaamheidscoöperatie Reitdiep (listed as still in the process of considering whether a heating network is feasible)

Paddepoel	Loppersum
Initiated by local residents in 2012	Initiated by the Municipality of Loppersum (now municipality of Eemsdelta) in 2015
Formation of a foundation in 2016	Formation of project partnership in 2019
Initially targeted 450 residential connections	Initially targeted 10 residential and 4 non-residential connections> Moved to 60 residential
Now focused on 3000 residential connections	Now focused on 210 residential and 4 non-residential connections
Key decision makers: Grunneger Power & The Municipality of Groningen	Key decision makers: LOPEC, the Municipality of Loppersum, Enpuls
Other Stakeholders: Co-Create, Paddepoel Energiek, Shell	Other Stakeholders: Green Vis, Village Association
Granted government grant (€) 5,260,000.	Granted government grant (€) 3,056,000
Government grant per housing equivalent (€) 1,503	Government grant per housing equivalent (€) 5,556

Table 1: Case study overview

2.3. Data collection and analysis

The data for the case studies consist of project websites, project reports (internal and external party reports), newsletters, meeting notes, presentations, door to door surveys conducted by Hanze University and the Horizon 2020 project and online interviews that were carried out with the main project planners in both case studies. In total, four semi-structured interviews were carried out for the Buurtwarmte case and two semi-structured interviews for the Warmtenet Loppersum case. The reason that the Buurtwarmte case required more interviews was the fact that there are more project stakeholders (Grunneger Power, the Municipality of Groningen, Paddepoel Energiek) than in the Loppersum case, and not all involved persons of Paddepoel Energiek continued to be involved with the phase 2. In Loppersum, the project is rather small (60 residential connections and 4 commercial), and consequently only the Municipality and LOPEC were project planners.

3.THEORETICAL FRAMEWORK

Energy transitions are complex developments and requires a framework which can capture the complexity of various interacting dynamics. In order to shift from the current energy system to a more sustainable one is not a re-orientation of the current trajectory, it is a shift to a new trajectory through changing the society-ecology-energy relationships (Byrne et al., 2009) (Hielscher, Seyfang, & Smith, 2013). Energy transitions include more than just a technological shift, it includes power struggles between incumbent actors and emerging actors, external shocks, changing behaviour and beliefs and the disruption of existing energy systems. Moreover, embedded processes (cognitive, institutional, technological, social, economic) lock in trajectories while also locking out sustainable replacements (Seyfang & Smith, 2007). Science Technology Studies or Science, Technology and Society (STS) emerged as a distinct intradisplinary field in the 1970s and 1980s which emphasizes the inseparability of science and technology from social structures (Bijker, Hughes, Pinch, & Douglas, 2012) (Jasanoff, 2010) (O'Riordan, 1996) (Raskin, 2002).. Since its inception, STS has also linked public participation and democratic engagement to the social dimensions of science and innovation (Nelkin, 1977) (Lezaun, Marres, & Tironi, 2017). Consequently, numerous frameworks have been developed which focusess on the relationship between science and society (Joss & Durant, 1995); (Nowotny, Scott, & Gibbons, 2001); (Callon, Lascoumes, & Barthe, 2009) (Renn, Webler, & Wiedemann, 1995) (Lövbrand, Pielke, & Beck, 2011) (Chilvers & Longhurst, 2016).

The most prominent framework is the heuristic framework, the Multi-level Perspective (MLP, which includes aspects of technical, social, economic and political systems across space and time (Geels & Kemp, 2000) (van den Bergh & Gowdy, 2000) (Rip & Kemp, 1998). From this perspective transitions are the result on interplay of actions at the niche level where disruptive innovations occur, socio-technical regimes which is made up of rules and practices of existing systems and the socio-technical landscape which consists of slow-changing developments and external (Elzen, Geels, & Green, 2004) (Geels & Schot, 2007) (Schot & Geels, 2008) (Smith, Vob, & Grin, 2010). (Seyfang, Haxeltine, Hargreaves, & Longhurst, 2010) (Markard , Raven , & Truffer, 2012) (Klitkou, Bolwig, Hansen, & Wessberg, 2015). (Roberts & Geels, 2018). The broadness MLP is often criticized but the co-evolutionary dynamics of transitions may be better explained by a heuristic framework rather than precise models, which is exactly why the MLP is often used to explore the complexities of energy transitions (Porter, 1991) (Genus & Coles, 2008). Geels, 2011). However, the MLP does not address socio-ecological systems and distribution systems. It is focused on "provisioning systems whose main function is to transform energy and resources and render them useful for final consumption" whereas it does not give enough focus on "distribution systems whose main function is to determine the types of goods and services to be provided as well as the population groups getting access to these". Consequently, MLP does not sufficiently cover social sustainability (such as inequality or empowerment for example) despite emerging research on justice and distribution in the MLP approach. In addition, while the MLP framework can explain sustainable innovation trajectories within an energy transition, sustainability is not implicitly dealt with in the model. Lastly, actors are implicit in the MLP framework there is not enough conceptualization of concepts such as 'ownership' and 'participation'.

Contrariwise, the Socio-ecological Systems Framework (SESF) covers the ways in which nature and society interact (pollution, deforestation, land use etc.), provision systems (transforming natural resources and energy for consumption), distribution systems (provision of goods and services) and geographical systems (governance and economic jurisdictions). The framework is not necessarily superior to MLP, but it may be more useful to explain participation in local heating initiatives. The framework is as broad and flexible enough to address the panacea problem analysing participation in energy transitions; to represent social and ecological systems equally; and it has a more nuanced focus on self-organisation and cooperation between actors due to its historic rootedness in collective

action theory (Ostrom & Cox, 2010) (Partelow, 2018). Consequently, the report has opted to use SESF as a starting point to analyze participation in community heat iniatives in the Netherlands. On the otherhand, SESF is a diagnostic tool not a theory which is what allows it to be adaptable and flexible. However, this also means that the framework can be used to collect and capture complex data but the are no causal links between variables and no normative claims inherint in the frame. Subsequently, in the operationalization of SESF in the literature, variables are selected and adjusted to the research question being asked since this allows the researcher to delineate the system's boundaries (Hinkel et al., 2015). In order to connect variables or measure action situations according to a normative claim, SESF needs to be supported by complimentary theory suited to the research question being asked. In fact, SESF is a theory building tool and can be used to test theory on the role of system interactions, outcomes and dynamics (Partelow, 2016). Since the key research questions of this report is focused on participation and ownership levels in community heating initiatives, there is a normative assumption that 'citizen empowerment', 'ownership' or 'citizen control' are 'good' and 'important'goals for a community heating iniative to have. Thus, we enrich the SESF with participatory theory to delineate the system's boundaries and to be able to measure the levels of participation in these initiatives. The following section will outline the SESF, participatory literature and our operationalization of the framework and theory.

3.1. Socio-Ecological Systems Framework

Markets and private property rights are considered to be sufficient in managing private goods. However, public goods and common pool resources are not as optimally managed by markets or private property rights due to the governance challenges that arise from collective action challenges such as provision or produce appropriation issues(Hinkel et al., 2015). Ostrom and colleagues attempted to provide a framework to analyze Social-ecological systems (SES), called the Socio-Ecological Systems Framework (SESF) that goes beyond substractability and excludability of goods which provides a deeper understanding of the governance challenges and good practice in preserving SES (Hinkel et al., 2015) (Ostrom 2007, 2009, McGinnis and Ostrom 2014). A SES can be defined as systems of critical resources that are dynamic and complex, and that are structured by interrelated ecological and social systems that interact (Redman, Grove, & Kuby, 2004) (Machlis, Force, & Burch, 1997) (Gunderson & Holling, 2002). Another way of looking at it is that SESs are created when humans interact with the environment (Anderies, Janssen, & Ostrom, 2004). The properties which emerge from the interaction between social and ecological systems cannot be fully understood or explained by either system on its own (Goldstein, 1999). In addition, feedbacks that may hinder or promote change result from these interactions which may take place across temporal and spatial scales (Gunderson & Holling, 2002). Consequently, transformations in one part of a social-ecological system may lead to a reorganization of the system or result in non-linear responses in another part of the system (Scheffer, Carpenter, Foley, Folke, & Walker, 2001)

The SESF is robust and flexible which makes it particularly useful in avoiding the panacea problem with analysing and understanding participation and sustainable energy in terms of community heating initiatives (Hayek 1945; Scott 1998 (Korten 1980). (Ostrom & Cox, 2010). Identifying and understanding social-ecological systems in space and its interaction with regimes can relay critical insights into self-organization and natural resource use patterns impact on sustainability and transitions. The SESF also provides insights into a core challenge of identifying why some SESs are more sustainable than others since it analyses relationships not only at various levels but also at different spatial and temporal scales (Ostrom, 2007b). Moreover, it represents social and ecological systems equally (Binder, Hinkel, Bots, & Pahl-Wostl, 2013). While STS has generally lacked literature on common goods system governance, the SESF provides a systematic way to analyse self-organization and "the governance of common technological resources in STS"(Acosta et al., 2018).

Given the fact that sustainable energy transitions are instances in which humans interact with nature through provision and distribution systems, we can conceive of community energy as a SES. Recent (albeit limited) research in STS has applied the SESF model to the 'energy commons' in which energy is the common resource that requires governing to ensure that the cost and benefits of the energy transition is fairly distributed among community energy members (Acosta et al., 2018). This entails co-management arrangements across varying geographical scales, context and diverse actors with multiple sources of governances or commonly referred to as polycentricity (Ostrom & Cox, 2010). Using SESF we can systematically assess the system conditions which lead to different degrees of participation that accompany self-organization in common pool energy resources and technologies, and test the application of participatory theory to community heating initiatives while also taking into account the contextual differences between cases and the polycentric governance arrangements across geographic scales (Ostrom 1990)(Agrawal 2001) (Ostrom 2007; Basurto and Ostrom 2009) (Partelow, 2016)(Acosta et al., 2018) (Ostrom & Cox, 2010). This section outlines the SESF variables and concepts in relation to community heating initiatives, and the limitations of the framework.

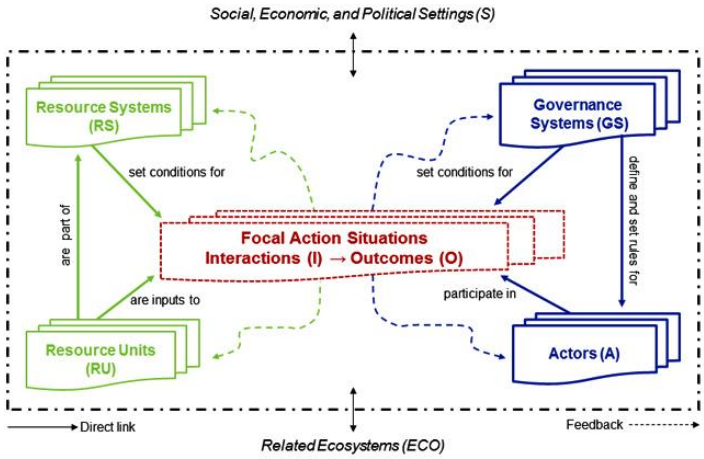


Figure 1: Socio-ecological Systems Framework First Tier Variables (Ostrom, 2009; Ostrom & Cox, 2010)

The SESF is a multi-tier framework of variables and concepts applied to common-pool resource management in which resource units in a resource system are extracted by resource users (Ostrom, 2007) (Ostrom, 2007b) (Ostrom, 2009). The first tier of the framework conceptualizes SES as being made up by several subsystems, namely, resource systems (RS), resource units (RU), actors (A) and governance systems (GS) which contribute or partake in "focal action situations" comprised of interactions (I) and outcomes (O) (see figure 1). The "focal action situations" are comprised of interactions (I) between systems and the outcomes (O) of these interactions (Binder, Hinkel, Bots, & Pahl-Wostl, 2013) (Ostrom, 2007). The "focal action situations" may be viewed as the key variables which "affect the preferences, information, strategies and actions of participants" (see figure 2) (Ostrom & Cox, 2010). The ecological system is represented by the (RS) and (RU) which set the conditions for and are inputs to "focal action situations" respectively (McGinnis and Ostrom 2014). (Hinkel et al., 2015). The (RS) and (RU) variables may be divided into "biophysical resources systems and technical resource systems" (Bauwens, 2017). The biophysical resource system includes the proposed (RS1)- (RS3), (RS5)-(RS7) and (RS9) second tier variables in figure 2, which is focused on the type and availability of energy resources, location etc (Hinkel et al., 2015). The technical resource system may be comprised of the proposed (RS4), (RS8) and (RU1)- (RU7) second tier variables in figure 2, which is focused on the distance from the grid, storage capacity, size and type of technology etc. (Hinkel et al., 2015). The (RS) and (RU) variables characterize governance challenges in provisioning action situations and appropriation action situations (Hinkel et al., 2015). Provisioning

action situations are characterized as instances where (A) faces collective problems in creating, improving and/or maintaining a collective good and an appropriation action situation is instances when (A) is challenged with overuse of a collective good (Hinkel et al., 2015). With regards to community heating initiatives, provisioning action situations are more suitable since community members (A) are challenged with initiating, improving, and maintaining a district heating network which may be viewed as a collective good. Appropriation action situations are not as suitable to sustainable energy initiatives since the issue is not the overuse of a collective good but rather the overuse of something that is detrimental to the collective good (health, environment etc.). The (GS) and (A) first tier variables make up the social system. The (GS) is made up of the second-tier variables (GS1)- (GS8) and (A) is comprised of second tier variables (A1)-(A9). The (GS) defines the rules and enforcement mechanisms for (A) and sets the conditions for "focal action situations" that (A) participates in (McGinnis and Ostrom 2014). The (RS), (RU), (GS) and (A) interact in economic, political and social settings (S) and related ecosystems (E) which are the external factors that create the context of the cases (Ostrom & Cox, 2010) (Ostrom 2007, 2009, McGinnis and Ostrom 2014).

Figure 2: Second tier SESF variables (Hinkel et al., 2015)

The proposed framework is extremely robust and able to capture complex dynamics in community heating initiatives such as the polycentricity of the heating transition, the activities related to self-organization and participation, and technological and economic factors in relation to sustainability. However, there are issues with operationalizing SESF. While the framework highlights that interaction (I) lead to outcomes (O), the relationship to other variables is not clear cut. This may be attributed to the fact that SESF does not posit specific causal relationships among variables (McGinnis and Ostrom 2014). The SESF is a decomposable tier system, which means that all the proposed variables can be adapted or decomposed into smaller variables (Mitchell, Clark, Cash, & Dickson, 2006). It is intentionally broad and adaptable to different cases to avoid the panacea problem, but the result is that the tiers may seemingly lack meaning and it is not clear where or how new variables should be included in the framework without an additional theoretical lens (McGinnis and Ostrom 2014). In fact, a key aim of SESF is to build knowledge and theory in diverse cases that otherwise would be hard to draw conclusions from because of the diversity of the cases (Hinkel et al., 2015). This is particularly

useful in analysing community heating initiatives which operate in different political, social, economic, and geographical settings as well as related ecosystems, thus, making general conclusions across cases particularly challenging. By using SESF our report can specify the elements and interconnections that are relevant to the research questions on citizen participation in community heating initiatives which makes the framework 'fit for purpose' and by enriching the framework with participatory theory we are then able to connect variables to outcomes based on participation levels.

3.2. Participatory Literature

The notion of polycentricity is implicit in the SESF which views co-management as complex arrangements with multiple actors and sources of governance, and addressing environmental issues such as climate change, natural gas extraction and the related earthquakes requires polycentric governance arrangements across geographic scales (Ostrom & Cox, 2010). The inclusion of polycentricity in SESF makes it highly compatible with participatory theories and frameworks which are focused on co-ownership, participation, and the related governance structures of such arrangements. While the SESF is considered to be a systematic diagnostic checklist to analyse system complexity and interaction, the components are theory neutral which allows the framework to facilitate testing of theory or generating new theory (McGinnis and Ostrom 2014). Consequently, SESF can be enriched by participatory theory and literature by isolating key system components necessary for analysing participation levels and by providing a normative measure of the system interactions observed in case studies (Partelow, 2016). This section outlines the participatory theories and literature that was used to enrich our SESF across the political, technical, and economic dimensions.

Participatory democracy has been at the center of decision-making processes since the 1960s. Most prominently, the dominant theories on citizens' participation arose in the 1950s, 1960s and 1970s (Marzouki et al., 2017). The participatory turn is linked to the academic discourse on the need to radicalize democratic practices and rethink the public sphere, and the critique of representative and liberal democracy (Habermas, 1989)(Barber, 1984)(Fraser, 1990). Initially, participation was seen as a means to allow citizens to have an influence on decision making processes that were otherwise political. Moreover, participatory mechanisms were to be tools to not only empower citizens but also to hold government leaders accountable for decisions (Fung & Wright, 2016). Globally, collaborative governance emerged as a response to complex problems that were hard to solve due to incomplete/ inconsistent information, complicated interdependencies and shifting environments (Rittel & Webber, 1973). Collaborative governance focus on participation is centered on collaboration and power-sharing. As a result the public provision of goods and services has shifted from national governments to provincial governments to local governments (Kettl, 2006)(Ran & Qi, 2017). However, the shift included a shift to complexed arrangements that made way for conflict and disagreement. Consequently, the conflict management and dispute resolution model came about in the 1980s, which was largely driven by workplace disputes focused on labor rights (Godard, 2014). While literature on participation has evolved since the 1960s to address various emerging issues surrounding participation, Arnstein's ladder of participation remains highly cited and has formed the conceptual basis of many of the existing participatory classification frameworks and research (see Baum, 2015; Bizjak et al., 2017; Davidson, 1988; Kindon et al., 2007; Lawrence, 2006; Luyet et al., 2012; Nelson & Wright, 1995; Pretty et al., 1995; Puskas et al., 2021; Soma et al., 2018; Tippett et al., 2007; Wiedemann & Femers, 1993). Consequently, Arnstein is the starting point for our literature review. Arnstein outlines 8 rungs of the ladder on participation and non-participation(Arnstein, 1969) (see figure 3). Manipulation and Therapy are at the lower levels of the ladder and are levels of "non-

participation" that is often used in place of genuine participation. The second rung, therapy, in which powerholders fool citizens by 'involving' them in planning when in actuality they are subjected to clinical group therapy. The Informing and Consideration rungs are levels of "tokenism" that allows the marginalized to be heard. However, citizens do not have the power to ensure that their interests and inputs will be given serious consideration by those who hold power. Placation is also a level of higher tokenism since it allows the marginalized to advise but this does not necessarily translate to change since the decision still resides with the powerholders. The last three levels in the ladder, Partnership, Delegated Power and Citizen Control are actual civic participation. Partnership enables citizens to negotiate and manage trade-off collaboratively with powerholders. With Delegated Power and Citizen Control, the citizens are the key decision makers, either by holding a majority of decision-making seats or by having full managerial power. While there is no logical progression on Arnstein's ladder it remains popular due to its simplicity and robustness in that between the rungs there may be a spectrum.

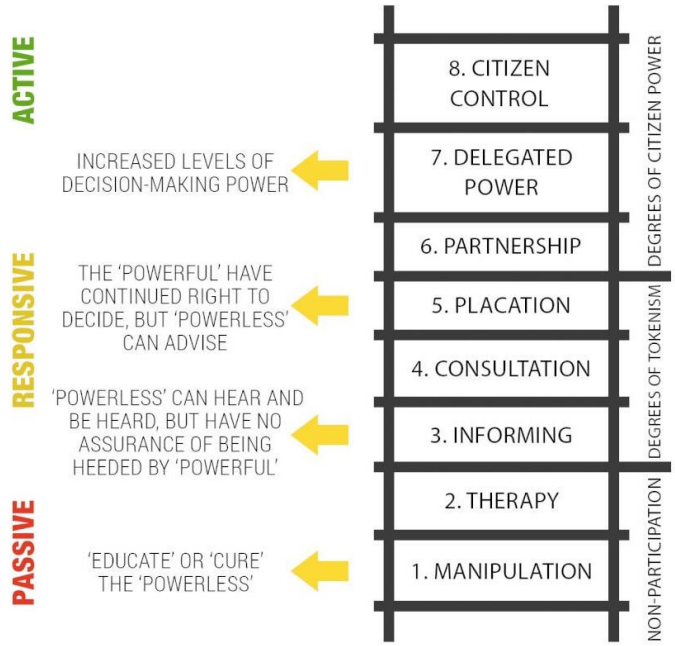


Figure 3: Arnstein's ladder of participation

Connor introduced "a new ladder of participation" built on Arnstein's work which sought to create a logical progression from one step to the next (Connor, 1988). The first three steps coincide with steps identified in Arnstein's ladder: 1) education (tokenism) 2) information feedback (tokenism) 3) consultation (placation). However, instead of full citizen power or ownership at the top of the ladder, Connor's ladder focuses on conflict resolution with resolution and prevention being at the top rung and joint planning, mediation, and litigation in the middle rungs. While Arnstein's ladder is focused solely on the citizens in the ladder, Connor's ladder distinguishes the first three rungs as areas in which the general public may be involved whereas joint planning to resolution or prevention does not need to include the general public but may include 'leaders' or 'representatives' of the public. Davidson proposed a "wheel of participation" instead of a ladder, and the wheel measures participation on four scales: information, consultation, participation and empowerment(Davidson, 1988). Each scale has three sub-categories which are meant to identify the participatory techniques used. The wheel of participation aimed to capture the fact that different levels and types of engagement may be different in different context due to varying objectives and capacities. Potapchuk focused on how participation related to the level of decision making (Potapchuk, 1991). Consultation may be done at two levels of decision making: either government consults with individuals and decides or government consults representative groups and decides. The levels of decision making also relates to Arnstein's ladder. In the levels of decision making in which the government consults individuals or representative groups and decides, this falls in the rungs of manipulation and therapy which is "non-participation" that is often used in place of genuine participation. This also falls into Arnstein's informing, consideration and placation rungs which allows the marginalized to be heard and to advise but powerholders do not give power to citizens to ensure their interest and inputs are considered. However, when government works with representative

groups and jointly decide it falls into the partnership rung in which citizens can negotiate and manage trade-offs with powerholders through techniques of negotiation and mediation. When government delegates decisions to others through privatization of public decision making or community development corporations, it falls into the rungs of delegated power and citizen control. Lawrence proposed a ladder across four levels: consultative, functional, collaborative and transformative at the top rung of the ladder (Lawrence, 2006). At the bottom rung of the ladder is consultation, which is equated to Arnstein's placation level, at this level centralized decision makers ask for information and citizens contribute to it, making it extractive and passive. The functional rung is also top down in which decision makers make decisions and citizens provide decisions and/or act on decisions that have already been made. The collaborative rung is equated to partnership or delegated power on Arnstein's ladder, and in this instance central decision makers work with citizens to jointly make decisions. The transformative rung may be equated with Arnstein's citizen control rung, at the top of the ladder citizens make decisions, implement them, and seek expert advice only when needed whereas central decision makers only provide information and support.

Participation in science and technology has also adopted the conceptual basis of the ladder of participation. Haklay has used the basis to form a ladder of citizen science to determine the level of involvement and power citizens have ranging from level 1 to 4 (Haklay, 2013). The lowest level is crowdsourcing in which citizens are sensors and voluntarily compute information. Level 2 is distributive intelligence in which citizens voluntarily think and are basic interpreters of information. The third level is participatory science in which citizens define the problem and participate in data collection. At the highest level is extreme citizen science or collaborative science in which citizens are involved in the problem definition, data collection and analysis. Follett and Strezov categorize the level of citizen involvement in science as contributory, collaborative or co-created (Follett & Strezov, 2015). The contributory method is when citizens are not involved in the design of research, instead scientist or companies design the research and the members of the public contribute (usually through data collection). The contributory method is a top-down approach with lower levels of citizen participation. However, the collaborative project goes beyond data collection to analysis, interpretation, and dissemination. The public usually does not design the project, but they are included more throughout the project and are able to give inputs into the design. Co-created projects are partnerships between scientist/companies and the public. The public participates from the design to the end of the project. Collegiate citizen science projects are citizen run with no professional scientist or business involvement. Harris et. al proposed a ladder of participation for co-production which consists of 6 rungs that are grouped in sets of (Harris et al., 2019). At the bottom rungs educating (6^{th} rung) and informing (5^{th} rung) are grouped as market management/ control in which things are done to or for citizens without involving them in the process. The middle rungs, consultation (4^{th} rung) and engagement (3^{rd} rung) are grouped as commissioning co-production in which citizens are engaged by asking and gaining their views and perspectives. At the top rungs co-design (2^{nd} rung) and co-production (1^{st} rung) which are grouped as co-producing, citizens are equal partners in production. Similarly, the Business Lab collaborated with numerous organizations to also develop a ladder of co-production with 7 rungs (Business Lab, 2020). At the bottom rungs are coercion and educating which is the equivalent of Arnstein's "non- participation "rungs; citizens are expected to use a product or service, or they are educated on the benefits and rationale of services but are not asked to provide input or help make decisions. In both these rungs citizens are not asked to provide input nor do they have any decision-making power. The informing, consulting and engaging rungs are the equivalent of Arnstein's "tokenism" rungs in which citizens are informed about a service or product, citizens are invited to express their thoughts and preferences or there are regular opportunities for citizens to express their views which can influence some decisions. At the top rungs are co-designing and co-producing which are the equivalent to Arnstein's "citizen power" rung.

While the ladder is robust and has been used to understand various types of engagement across disciplines, it has not been used to understand levels or types of financial participation in the literature even though it is possible to develop such a ladder. This may be attributed to the fact that "ownership" implicitly implies some form of financial participation as well. However, since the Groningen's RES definition of process participation entails financial participation and financial participation is defined as investing or benefiting from an energy project, it is useful to understand the key avenues for citizen financial participation. Crowdfunding is a key financial mechanism which allows the general public to invest in initiatives or efforts by other people by pooling money together (Ordanini, Miceli, Pizzetti, & Parasuraman, 2011). There are four models of crowdfunding, namely, reward-based, lending-based, donation-based, or equity-based. Reward-based is a model commonly used by entrepreneurs to raise finances for a specific project in return for non-fiscal rewards. The rewards are not a legally binding obligation, and it is not a sale either (Gajda & Walton, 2013). Lending-based crowdfunding is when an individual or company lends from a group of people rather than a bank (Kirby & Worner, 2014). Lenders are rewarded with financial returns and higher interest payments than on saving accounts (or similar bank products) whereas the business may get a loan with a lower interest rate than commercial banks. Donation-based crowdfunding is generally used by NGO's and is ear-marked for a specific project. There is no financial or significant material return, instead there is social return on investment (Gajda & Walton, 2013). Equity-based crowdfunding is like traditional investment and lending schemes for development, this is usually when a business or entrepreneur attracts investment from a group of people rather than private investors or business angels. The ownership model employed by an initiative determines who invests and how benefits are distributed in the community, it also determines the level of citizen engagement and decision-making power they have in energy projects. There are three legal vehicles which define the ownership model, the ownership model may be one of the three vehicles or a combination of them (Roberts, Bodman, & Rybski, 2014). Cooperatives are member driven and are primarily designed for the benefit of members through profits, community upliftment and energy savings. Membership is open and voluntary; members have a say in the governance of the cooperative and the distribution of profits. A legal partnership is comprised of individuals who aim to provide energy to the community. Generally, voting power is determined by size of investment in the company. These partnerships generate profits but may also benefit the community in which it operates. A charitable organization is another legal vehicle focused on social benefits for a community rather than profits. These may widely differ in structure. Unlike partnerships or cooperatives, it allows communities to benefit (energy supply and other co-benefits) even when individuals in the community cannot afford to participate. However, a cooperative may partner with a charitable organization creating a hybrid model.

3.3 Enriched Multi-tier Conceptual Framework

In order to enrich SESF with participatory conceptual frames we first apply the SESF first tier variables to our existing case and then use the participatory literature review to determine the second, third and fourth tier variables that need to be adapted to the research question, and it is used to develop the measurement of the SESF variables in terms of participation. With regards to applying SESF to community heating initiatives the first-tier variables may be outlined as the (RS) being the heating system and the (RU) as the energy units which are a part of the (RS). The (GS) is made up of the provincial government and municipalities of Groningen and Loppersum who shape the rules and procedures for (A) involved in heating systems. The (A) involved include energy cooperatives, end-users, utilities, government officials, banks, and civil society groups. The (RS) and (GS) sets conditions for (I) and (O), (A) participate in these focal action situations and (RU) are inputs into it. The (I) variables are further developed with participatory literature and the (O) are the outcomes of the reviewed cases. The Social, Economic and Political Settings (S) are exogenous factors that impact community heating initiatives in our case study. The related (E) includes water systems, food systems, forestry, and other systems. Ultimately, these elements are either directly linked to each other or included in a feedback loop. However, our research questions on participation narrows down the variables which are important for our study to the interactions (I) between (GS) and (A) and the (O) of such interactions. While these relate to (RS), (RU) as well as (E) and (S) it is not necessary to breakdown these variables to tiers 2, 3 or 4 to understand how participation occurs in the cases or the degree of participation in the cases. There are other publications that have focused on these additional elements of SESF given the research question being asked, however our conceptual framework does not dig deeper into these variables(see these publications for examples operationalizing these additional variables: Acosta et al., 2018; Delgado-Serrano & Ramos, 2015; Hinkel et al., 2015; Partelow, 2016). Based on the review of the participatory literature we can conclude what elements need to be considered in the framework and how it can be integrated into the SESF existing variable listed in figure 1. Table 2 illustrates the participatory elements, which variables in the existing SESF and added variables from the participatory literature can be integrated as well as the sources or justification for inclusion.

Participatory element	Integration into SESF	Sources/ Justification
Integration of all stakeholders	• **(A1) No. of relevant actors** includes diverse stakeholder mapping in the third tier. • **(A4) Location: (A4.1.) population characteristics** reviews the targeted stakeholder diversity. • **(GS2) Government organizations** and **(GS3) Nongovernment organizations** include third tier variables to account for a diverse set of stakeholders. • **(GS4) Network structure: (GS4.2.) the roles of actors** in the project can determine how actors are integrated in the project design. • **(I5) Self organising activities**: **(I5.4) Local staff recruited for the project**; **(I5.5)** local **residents engaged in organization of project activities** can determine how local residents are integrated into the project.	(Duram & Brown, 1999; Korfmacher, 2001)
Citizen involvement in the establishment of rules-in-use	• **(GS5) Rules in use** defines constitutional, operational, and collective choice rules. • **(GS4)- Network structure: (GS4.2.) the roles of actors** also relate to how actors are involved in rulemaking. • **(I2) Deliberation processes** can determine citizen involvement in establishing rules. • **(I5) Self-organizing activities** looks at the established rules citizens have created to organize themselves.	(Sharpley, 2006)(Renn et al., 1995)
Integrating local and scientific knowledge	• **(A1) No. of relevant actors: (A1.5) # of citizen scientist**. • **(I1) Information sharing activities: (I1.4) community capacity to collect and analyse data; (I1.5) dissemination strategy to share scientific results and (I1.6) citizen scientists participating in publications** can determine if and how local scientific knowledge is integrated into the project.	(Follett & Strezov, 2015; Greenwood et al., 1993; Haklay, 2013; Macnaghten & Jacobs, 1997; Okali et al., 1994; Reed, 2008;

	• **(I5) Self-organizing activities: I5.2. Barriers to participation** have been explored addresses whether or not research on participatory barriers have been done and if the results are integrated into the project.	Tippett et al., 2007)
Involvement in planning	• **(GS4) Network structure: (GS4.2.) the roles of actors** in the project can determine if citizens are involved in the planning aspect of the project. • **(I5) Self-organizing activities: (I5.6) distribution of responsibilities in the planning process** can determine how citizens are organized in planning processes.	(Arnstein, 1969) (Harris et al., 2019) (Business Lab, 2020)
Informing citizens bidirectionally	**(I1) Information sharing activities** outlines how information is shared and whether there are feedback systems and if residents are satisfied with the type and method of information sharing.	(Arnstein, 1969) (Connor, 1988)(Davidson, 1988) (Potapchuk, 1991)(Lawrence, 2006)
Consulting citizens on decisions and/or allowing them to advise on aspects of the project	• **(GS4) Network structure: (GS4.2.) the roles of actors** in the project can underscore if citizens play a role in consulting or advising on the project. • **(I1) Information sharing activities** includes methods such as consulting and advising.	(Arnstein, 1969) (Connor, 1988)(Davidson, 1988) (Potapchuk, 1991)(Lawrence, 2006)
Allowing citizens to voice opposition and providing platforms to resolve conflicts and tension	**(I3.1) Conflict resolution process** outlines how conflicts are dealt with and whether the methods used to resolve conflicts are effective and how satisfied citizens are with the process.	(Connor, 1988)(Lawrence, 2006)
Empowering citizens to make decisions and by giving them decision making power	• **(GS5) Rules in use** show how decisions are made. • **(GS4) Network structure: (GS4.2.) the roles of actors** in the project can determine if citizens have decision making power. • **(I2) Deliberation processes** highlights if citizens can make decisions and how they included in making decisions. • **(I5) Self organizing activities: I5.1. the ownership structure** highlights how local residents make decisions.	(Arnstein, 1969)(Davidson, 1988) (Potapchuk, 1991)(Lawrence, 2006)
Co-creation/production of projects	• **(GS4) Network structure: (GS4.2.) the roles of actors** in the project can determine if citizens roles are equal to other stakeholders. • **(I5) Self organizing activities** shows if and how co-creation occurs.	(Harris et al., 2019) (Business Lab, 2020; Greenwood et al., 1993; Harris et al., 2019; Macnaghten & Jacobs, 1997; Okali et al., 1994; Reed, 2008)
Providing avenues for citizens to financially participate in the project through investment or benefiting from the project	• **(A1) No. of relevant actors: (A1.1) # of investors**. • **(I4) Investment/ Financing activities** provide an overview of how finances are raised, who finances the project and if investment and participation cost are affordable to citizens.	(Ordanini, Miceli, Pizzetti, & Parasuraman, 2011) (Gajda & Walton, 2013). (Kirby & Worner, 2014). (Roberts, Bodman, & Rybski, 2014).
Alignment to local resources	• **(A2)- Socioeconomic attributes** of the community the project is operating in. • **(A4)- Location: (A4.1.) population characteristics; (A4.2.) availability of RE sources; (A4.3.) existing energy infrastructure; and (A4.4) energy consumption.** • **(A3) History or past experience: (A3.2) expertise related to sustainable energy** can determine if there are sufficient local expertise to engage the project at a higher level. • **(A6-) Importance of energy source (dependence): (A.6.1.) Citizens prefer to move away from natural gas.** • **(A7) Sustainable energy technologies are available.** • **(I5) Self organizing activities: (I5.7.) sufficient local capacity to self-organize.**	(T. Beierle & Cayford, 2002; Blackstock et al., 2007; Davies et al., 2004; Dougill et al., 2006a; Fischer, 2020; Fritsch & Newig, 2012; Habron, 2003; Irvin & Stansbury, 2004; Kenney et al., n.d.; Konisky & Beierle, 2011; Koontz & Thomas, 2006; Leach & Pelkey, 2001; Martin & Sherington, 1997; Newig, 2007)
An environment that promotes trust and respect among stakeholders through transparency, accountability, and equal processes	• **(GS5) Rules in use** can determine if the process is transparent and equal. • **(A3)- History or past experiences: (A3.1) There are decentralized energy projects in the area** which can determine if citizens have trust based on previous engagements. • **(A5) Knowledge of SES/ Mental models** can be used as indicators for willingness to participate and to understand perceptions related to trust and respect. • **(I2) Deliberation processes** can underscore if the process is fair, if there is accountability and transparency in the deliberation process.	(T. C. Beierle, 1998; Cornwall, 2008; Dougill et al., 2006a; Hurlbert & Gupta, 2015; Moote et al., 1997; Reed, 2008; Richards et al., 2004; Stringer et al., 2006; Webler et al., 2001; Webler & Tuler, 2000)

Table 2: Integration of participatory literature and SESF

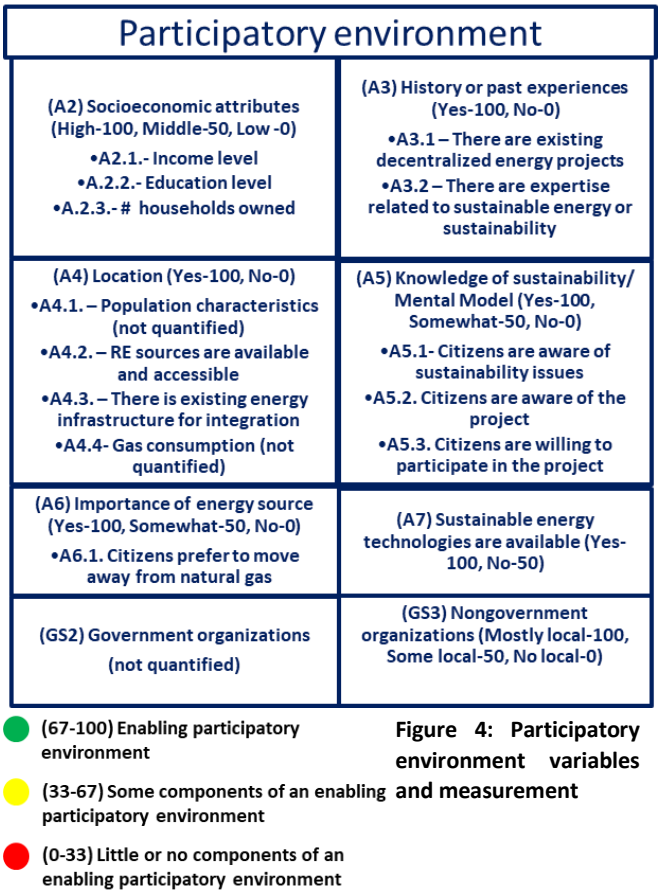


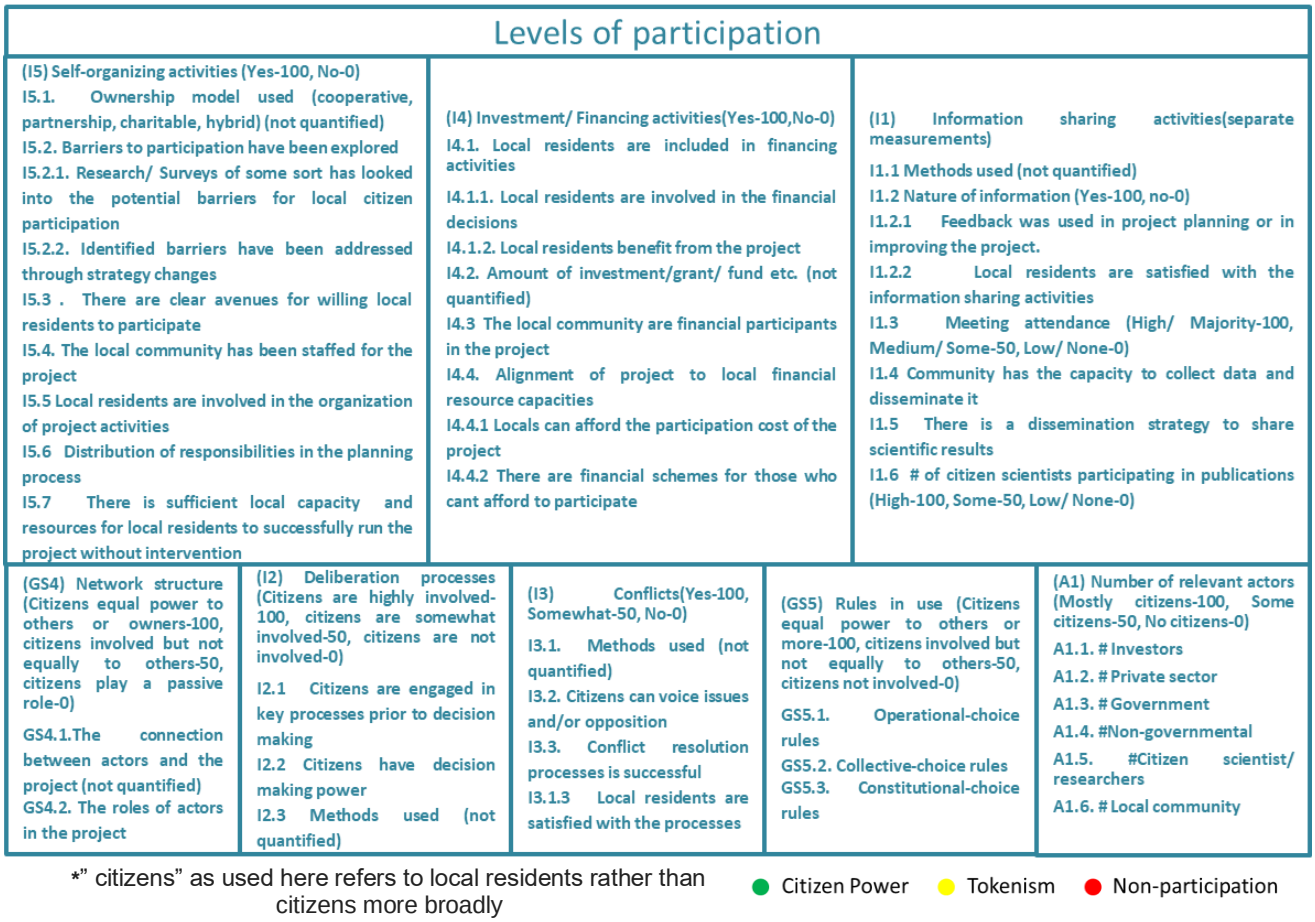
Figure 4: Participatory environment variables and measurement

Based on the key dimensions of participation and the literature we can further separate these elements in two parts: the participatory environment and the degree of participation (see figure 4 and 5).The participatory environment contains the contextual variables of the community in which the project occurs such as the demographics, existing stakeholders, available technologies, local resources and mental models which can influence or impact the degree of participation, how participation occurs and the barriers to participation. The degree of participation are the measurement variables which provides an understanding of the level of participation across the technical, economic, and social dimensions of the heating project. Measuring the participatory environment and the degree of participation is challenging given the diverse set of qualitative variables, and as noted in the participatory review, various means and types of participation are important in their own right. Given that the research is primarily aimed at identifying how "participation" and "ownership" is operationalized in community heating initiatives and to identify the key participatory challenges and opportunities in local heating initiatives we employ a multi-tier traffic light system with equal weighted variables. This allows the degree of participation to be decomposed into the various streams of participation (technical, political, economic) individually. It also supports the analysis of how participation in these streams is collectively operationalized without assuming any one type of participation on its own is more superior to the other, which is beyond the scope of this report. In addition, this makes the framework very robust since at a granular level one can identify the specific components of participation that are currently not operationalized in the chosen cases and at a higher level one can note how these granular variables relate to other variables in the framework. Moreover, adopting this framework has 2 additional benefits beyond our research: it allows others to decompose the framework and apply the same logic to focus on specific forms of participation and it can support energy cooperatives in benchmarking their level of participation with other energy cooperatives to identify good practice and areas for improvement.

In order to operationalize our traffic light system, we work on a scale of 0-100, the highest third (67-100) is categorized as green, yellow is the middle range (33-67), and red is lowest third (0-33). Despite a scoring scale, the framework does not compare the case scores but rather this is used to identify the current status of participation; the things that have worked well in some cases and the challenges in each context. For the participatory environment we base our scores on what is deemed good principles for participation as listed in table 2. Based on these good principles of participation, green indicates that there is a relatively enabling participatory environment which provides a good foundation for participation to occur ; yellow indicates that there are some positive participatory environmental factors but there is room for improvement and potential barriers to participation that needs to be addressed; and red indicates that there is little or no positive participatory environmental elements which means there is a poor foundation for participation to occur and potentially more barriers in achieving high levels of citizen participation (see figure 3). For the degree of participation,

we use the participatory ladder conceptual basis and literature in which green (67-100) indicates degrees of "citizen power", in this instance citizens have increased level of decision-making power either by being in complete control of the project, through delegated power or partnerships (see figure 5). In other words, citizens are actively engaged and involved in the project. Yellow (33-67) indicates degrees of "tokenism" in which citizens are informed and can give their inputs through consultation or advising but they do not have the right to decide. The yellow indicates a responsive rather than active approach to participation. Lastly, red (0-33) indicates levels of "non-participation" in which participation is passive, citizens are educated and informed on decisions, but they have little or no avenues to make decisions.

Figure 5: Levels of participation variables and measurement



4. RESULTS

In this section of the report, we outline the results of our research in the Buurtwarmte project and the Loppersum Warmtenet project. In the Buurtwarmte project we divide our results into phase 1 and phase 2 due to the significant changes in the two phases, thus making the first case study comparatively longer than the second. The results and conclusions are further discussed in section 5.

4.1 Buurtwarmte

4.1.1. Participatory environment

Participatory environment 76.1	
50 (A2) Socioeconomic attributes	0 (A3) History or past experiences
100 (A4) Location	83.3 (A5) Knowledge of sustainability/ Mental Model
100 (A6) Importance of energy source	100 (A7) Sustainable energy technologies are available
GS2) Government organizations (not quantified)	100 (GS3) Nongovernment organizations)

Figure 6: Buurtwarmte Participatory Environment Phase 1

Participatory environment 57.1	
50 (A2) Socioeconomic attributes	50 (A3) History or past experiences
100 (A4) Location	50 (A5) Knowledge of sustainability/ Mental Model
50 (A6) Importance of energy source	100 (A7) Sustainable energy technologies are available
GS2) Government organizations (not quantified)	0 (GS3) Nongovernment organizations)

Figure 7: Buurtwarmte Participatory Environment phase 2

The Buurtwarmte project was initiated by local residents of Paddepoel in 2012. In 2016 residents formed Paddepoel Energiek, a foundation. The project has two phases, the first targeted 450 connections in Paddepoel and the second that started in 2018 targets about +-3000 connections in Paddepoel, Selwerd and Vinkhuizen(Programma Aardgasvrije Wijken, 2018b). The overall participatory environment score decreased from 76.1 (green: enabling participatory environment) in the first phase to 57.1 (yellow: some components of an enabling participatory environment) in the second phase (see figure 6 and 7 for the scores in the two phases). Based on the recent developments in the project, should neighbourhood energy cooperatives be developed, **(GS3)** can then be scored 100 making the overall second phase score 74.4. This section outlines the tiered variables which contributed to the score change in phase 1 and 2.

(A4) Location:

(A4.1) Population characteristics (not quantified):

In Paddepoel North and South has a total population of about 10,110 which makes up 5965 households(Central Bureau of Statistics, 2017). There are 2129 residents are above 65 years old and 1326 are below 15 years old, indicating that there is roughly 66 percent of the population above 15 years old and below 65 years old (Ibid.). About 35 percent of residents have a migrant background (3524 residents), of which 1277 residents are from a Western migration background and 2253 are from a non-Western migration background (Ibid.). In Selwerd the total population is 6230 making up 3271 households (Central Bureau of Statistics, 2018b).

About 997 residents are above 65 years old and 810 are under 15 years old, indicating that about 72 percent of the population is above 15 years old and below 65 years old (Ibid). Residents with a migrant background make up 29 percent of the population (1807 residents), of which 13 percent have a Western migration background and 26 percent have a non-Western migration background (Ibid). In Vinkhuizen, there are 10,980 residents with 5071 households. The population is made up of 2145 residents above 65 years old and 1390 are below 15 years old(Central Bureau of Statistics, 2018c). There is 75 percent of the population below 65 years old and above 15 years old, and 32 percent of the population have a migrant background (3501 residents), of which 1392 are from Western migrant backgrounds and 2109 are from non-Western migrant backgrounds (Ibid.).

(A4.2) RE sources are available and accessible

The variable was given 100 score in both phase 1 and 2, this is evident from the *Wijkenergievisie Aardgasvrij Paddepoel* and the *Stap voor Stap naar Aardgasvrije Wijken en Dorpen* reports developed by the Municipality of Groningen(Gemeente Groningen, 2019a, 2019b). Ultimately (A4) overall was scored 100 in both phases putting it in the green zone. This Zernike geothermal energy was considered a potential energy source but due to the ambiguities around earthquake risks the state has decided to not consider this source at this time. However, residual heat from the companies and power plants in Delfzijl and Eemshaven have the potential to heat 50,000 houses with low-temperature heating (Gemeente Groningen, 2019a). The neighborhood vision also explores three approaches: all-electric, heating network and hybrid solutions, the feasibility studies have concluded that a heating network or an all-electric option is more suitable than hybrid solutions but given that large parts of the neighborhoods have homes that are not well insulated (see A4.3.). a preference is given to a heating network(Gemeente Groningen, 2019a, 2019b). The source of energy closely relates to the sustainable heating technologies that are available. Consequently, the related variable **(A7) sustainable energy technologies are available** also received 100 points in both phase 1 and 2.

(A4.3.) Homes are new (after 2000 construction) (not quantified)

In Paddepoel 77 percent of homes have been constructed before 2000. In Selwerd 98 percent of homes were constructed before 2000 and in Vinkhuizen 88 percent of homes were constructed before 2000 respectively (Central Bureau of Statistics, 2018b, 2018c).

(A4.4)- Gas consumption (not quantified)

Gas consumption in Paddepoel South is 1 080 m3 across all housing types and 1,260 m3 in Paddepoel North respectively(Central Bureau of Statistics, 2017). In Selwerd gas consumption was 1 210 m3, in Vinkhuizen the gas consumption in the North was 1 170 m3 and 1,000 m3 in the South across all housing types (Central Bureau of Statistics, 2018b, 2018c).

(A2) Socio-economic attributes:

In Paddepoel 77 percent of the population are income recipients, more than half of which are low income earners(Central Bureau of Statistics, 2017). In Selwerd, 74 percent are income earners and 60 percent are low income earners (Central Bureau of Statistics, 2018b). In Vinkhuizen, 78 percent are income earners and 59 percent are low income earners.(Central Bureau of Statistics, 2018c). Consequently, indicator **(A2.1.) income level** received 0 points in both phase 1 and 2. (**A.2.2.) Education level:** educational level data is not captured at the neighbourhood level in Groningen, however, based on the municipal level data we found that 76 percent of Groningen's population at least a secondary education, and of which 33 percent has a higher education level (Central Bureau of Statistics, 2011). In 2019, a survey was conducted by Communication Works in Paddepoel, 95 percent of 86 residents responded to the survey of which more than 80 percent had an MBO or higher(Communication Works, 2019). Another survey was conducted in 2021 with 324 respondents of Paddepoel which indicated that 52.8 percent had a HBO or university qualification and at least 21.1

percent had completed an MBO education(Elbert & Bouw, 2021). Similarly, the interview participants from the Municipality of Groningen and Grunneger Power noted that the neighbourhoods of Vinkhuizen and Selwerd generally have residents with at least a secondary education(Huizinga, 2020; Venema, 2020). We have therefore allocated a score of 100 to the variable (A2.1.). (A.2.3.) in both phase 1 and 2. (A2.3.) Number of households are owned: in Paddepoel about a quarter of homes in the neighbourhood are occupied by owners, while the rest are rental properties with privately owned rentals making roughly 20 percent of the rental markets(Central Bureau of Statistics, 2017). In Selwerd, 21 percent of homes are occupied by owners and 25 percent of rental houses are privately owned(Central Bureau of Statistics, 2018b). In Vinkhuizen about 24 percent of homes are occupied by owners and 11 percent of rentals are privately owned (Central Bureau of Statistics, 2018c). Given that the number of owned houses is neither high nor low comparative to the total number of houses in both phase 1 and phase 2, we scored the variable (A2.3.) with 50. The cumulative average of variables (A2.1.), (A2.2.) and (A2.3.) resulted in a score of 50 for socio-economic attributes, thus putting the indicator in the yellow zone.

(A3) History or past experiences

(A3.1) There are existing decentralized energy projects

In phase 1 of the project a 0 was scored due to the fact that were no other or previous experience with decentralized energy projects in the area (Schwencke et al., 2021). However, in phase 2 this was scored as 100 given that phase 1 basis including experience with solar, wind and energy auditing had been gained. Consequently, this made difference in the overall score for (A3) in the two phases: phase 1 was scored as zero and (A3.2.) was absent as well making the overall score 0 and in the red; phase 2 was scored 100 while (A3.2.) was scored zero making the overall score 50 and in the yellow.

(A3.2) There are expertise related to sustainable energy or sustainability

In both phase 1 and 2, (A3.2.) was scored zero. The 2021 survey conducted in Paddepoel tested the level of knowledge in the field of renewable energy in 3 ways. The first was checking if respondents had a good idea of the energy sources in the Dutch energy supply, the second question checked if respondents knew how much renewable energy part of the energy supply was currently and the third checked familiarity with heat grids, solar panels, heat pumps and biomass boilers. Across these questions, it was evident that there was not a significant amount of knowledge about sustainable energy(Elbert & Bouw, 2021). This is contrary to the earlier survey conducted in 2019, in which 40 percent of the 85 respondents said they knew what a heat network is (Communication Works, 2019). However, the sample size of the 2021 survey was much larger and the framing of the questions tested the actual knowledge rather than a yes-no format. Consequently, we have used the latest survey insights in the scoring. In addition, the project planners interviewed (Grunneger Power and the Municipality of Groningen) stated that while the survey indicates low levels of knowledge on sustainable energy, the level of knowledge in Paddepoel is anticipated to be higher than that of Selwerd and Vinkhuizen based on the neighborhood meetings and engagement to date (Huizinga, 2020; Venema, 2020)

(A5) Knowledge of sustainability/ Mental Models

In phase 1 (A5) was scored 83.3 but this decreased to 50 in phase 2, which may be attributed to the decreased score of (A5.1) and (A5.3).

(A5.1) Citizens are aware of sustainability issues

In phase 1 (A5.1) scored 100 whereas in phase 2 this was decreased to 50. In phase 1, the 2019 survey respondents of Paddepoel found it important to stop gas extraction because of the earthquakes in the region and thought that the climate plans of the Municipality were

important(Communication Works, 2019). The 2021 survey in Paddepoel asked respondents about their plans to make their homes more sustainable themselves, it found that 62 percent of respondents have already taken sustainability measures (Elbert & Bouw, 2021). In addition, respondents thought sustainable energy and moving away from gas was important (Ibid.). Both these survey findings indicate that residents in Paddepoel take note of sustainability issues and climate change hence in phase 1 (A5.1) has been scored 100. However, in all four of the interviews conducted noted that in the new districts Selwerd and Vinkhuizen there is less awareness of sustainability issues (this is more prevalent in Vinkhuizen) (Huizinga, 2020; Struiving, 2020; van der Gaast, 2020; Venema, 2020). Consequently, given that phase 2 includes these two neighborhoods the score was adjusted to somewhat.

(A5.2) Citizens are aware of the project

In both phase 1 and 2 (A5.2) scored 50. The 2021 Paddepoel survey indicated that 31.5 percent of respondents did not know anything about the Buurtwarmte project, 34.9 percent knew the initiative by name and only 30.9 percent were aware of the initiatives activities(Elbert & Bouw, 2021). Out of this percentages, there were differences between homeowners and those who rented. In rentals 49.3 percent of respondents were not aware of the project compared to the 18.6 percent of homeowners who were not aware of the project (Ibid). The interviews conducted also confirmed that the awareness levels in Selwerd and Vinkhuizen was lower than Paddepoel, given that the project had originally started in Paddepoel (Huizinga, 2020; Venema, 2020).

(A5.3) Citizens are willing to participate in the project

In phase 1 , the majority of the survey respondents in Paddepoel indicated that they were interested in a heating network(Communication Works, 2019). A similar notion is reflected in the 2021 survey in that only 32 percent of respondents said that they would not be willing to contribute to the sustainability of their neighborhood(Elbert & Bouw, 2021). The interviews further confirmed this with all 4 interviewees noting that there was a lot of enthusiasm and willingness to participate in the project (Huizinga, 2020; Struiving, 2020; van der Gaast, 2020; Venema, 2020). Consequently, phase 1 was allocated 100 points. On the other hand, all interviewees noted that in Vinkhuizen people were less willing to participate in the project, and in both Vinkhuizen and Selwerd those who were willing to participate were only willing to do so if it was not more expensive than their current gas price. Consequently, for phase two scored (A5.3) at 50 indicating that there was some willingness to participate but not very high willingness due to the inclusion of the two new neighborhoods.

(A6) Importance of energy source

The 2021 survey in Paddepoel indicated that more than half of the respondents thought that promoting renewable energy and using less gas was important (Elbert & Bouw, 2021). This was also the case in the earlier 2019 survey of Paddepoel (Communication Works, 2019). However, the interview with the Municipality indicated that there were more people that were sceptical about new sources of energy in the district of Vinkhuizen and overall residents were only willing to switch in Vinkhuizen if it would be cheaper or the same as their current gas bill (Venema, 2020)

(GS3) Non-government organizations

The score decreased from 100 in phase 1 to 0 in phase 2. This is due to the fact that in phase 1, Paddepoel Energiek was made up of local residents and jointly oversaw the project with Grunneger Power which is a more professionalized energy cooperative at a larger scale (Huizinga, 2020; Struiving, 2020; van der Gaast, 2020; Venema, 2020). Initially phase 2 was only coordinated between the Municipality and Grunneger Power which is why the score was zero. However, a recent development of neighbourhood cooperatives in the project can be viewed as a positive change to 100, changing the overall score for the participatory environment.

4.1.2. Degree of participation

Levels of participation-71		
58.3 (I5) Self-organizing activities	50 (I4) Investment / Financing activities	60 (I1) Information sharing activities
100 (GS4) Network structure	100 (GS5) Rules in use	100 (I3) Conflicts
50 (A1) Number of relevant actors	50 (I2) Deliberation processes	

Figure 8: Levels of participation Buurtwarmte phase 1 (past period)

Levels of participation-25.8		
8.3 (I5) Self-organizing activities	33.3 (I4) Investment / Financing activities	40 (I1) Information sharing activities
0 (GS4) Network structure	0 (GS5) Rules in use	50 (I3) Conflicts
50 (A1) Number of relevant actors	25 (I2) Deliberation processes	

Figure 9: Levels of participation Buurtwarmte Phase 2 (interim/current period)

Levels of participation-85.4		
83.3 (I5) Self-organizing activities	100 (I4) Investment / Financing activities	50 (I1) Information sharing activities
100 (GS4) Network structure	50 (GS5) Rules in use	100 (I3) Conflicts
100 (A1) Number of relevant actors	100 (I2) Deliberation processes	

Figure 10: Levels of participation Buurtwarmte Phase 2 (potential/future period)[2]

As noted in the previous section, the second phase of the Buurtwarmte project significantly scaled up. In phase 1 of the project, the overall score was 71 indicating degrees of citizen power (see figure 8). However, between moving from phase 1 to phase 2, there are higher degrees of non-participation (see figure 9). However, recent discussions and potential future changes may increase the level of participation well above the phase 1 to 85.4, indicating a significant degree of participation (see figure 10). This section outlines the changes through the three periods of the project.

(A1) Number of relevant actors

The number of relevant actor's variable was scored 50 in both phase 1 and the current phase, indicating a degree of tokenism. The key actors in phase 1 was Shell (the financer), Paddepoel Energiek (a foundation with a handful of local residents) and Grunneger Power (a larger city level energy cooperative) [1] (Communication Works, 2019; Paddepoel Energiek, 2018a; van der Windt, 2020). While local residents were involved in phase 1, there were about 6-8 genuinely active in the project planning (Communication Works, 2019; Huizinga, 2020; Paddepoel Energiek, 2018a; van der Gaast, 2020; van der Windt, 2020). In phase 2 currently, the Municipality of Groningen became the key financer and Paddepoel Energiek and Shell were not actively involved in the planning (050 Buurtwarmte, 2021a; Huizinga, 2020; Struiving, 2020; van der Gaast, 2020; Venema, 2020). In the future period, there is potential for relevant actors to be scored 100 due to the formation of an energy cooperative in which residents are owners of the project as well (050 Buurtwarmte, 2021a; Grunneger Power, 2021b).

(GS4) Network structure

In phase 1, Paddepoel Energiek had equal power to Grunneger Power which is why the indicator was scored 100 (Struiving, 2020; van der Gaast, 2020; Venema, 2020). However, during the current interim period citizens play a passive role in the project which is why 0 was given. In the potential

[1] While Grunneger Power is marketed as a 'local'cooperative in that it operates at the Groningen Municipal level, the report identifies 'local' as the neighbourhood/district level. Consequently, while Grunneger Power is a municipal level energy cooperative, it is not necessarily representative of citizen participation at the 'local' level which is defined as the neighbourhood/district level.

[2] The project planners were contacted to confirm if the potential/future period changes are already in effect, but none responded. An additional interview was conducted with a former member of Paddepoel Energiek who an active citizen in the project is now. However, since the information about the current status of the project could not be verified by multiple stakeholders involved, the phase is referred to as "potential" or "future". In other words, it reflects what the project status could be if these changes are already inacted or if the plans to do so come to fruition.

stage the score 100 may be given due to the fact the local residents each have a vote (050 Buurtwarmte, 2021a). However, in terms of the (GS5) rules in use score across the stages of the project, phase 1 was higher since Paddepoel Energiek could set the rules for the project whereas in the current phase the Municipality dictates the (GS5.3) constitutional choice rules and together with Grunneger power dictates the (GS5.2) collective choice rules. Grunneger Power is also the rule maker for (GS5.1) operational choice rules. Even if local residents become decision makers through an energy cooperative, the rules-in-use will still lie with Grunneger Power and/or the Municipality.

(I5) Self-organizing activities

Self-governing activities were in the tokenism bracket in phase 1 and steeply decreased to non-participation in the current interim period but has the potential to increase to a high degree of citizen power.

(I5.1.) Ownership model used (not quantified)

The ownership model of the project is different across the stages of the project but has generally been a hybrid model (see section 3.2). In phase 1, Paddepoel Energiek (a foundation) was in partnership with Grunneger Power (a municipal energy cooperative). In the current interim period, Grunneger Power and the Municipality of Groningen entered into a form of partnership and in the potential phase Grunneger Power, the Municipality and the neighborhood cooperative/s will jointly own the project.

(I5.2) Barriers to participation have been explored

In phase 1, the indicator was scored 50 since (I5.2.1.) research was conducted into the barriers of participation which scored 100, however, a key barrier being the untransparent governance structure of Paddepoel Energiek was not addressed in phase 1 and therefore scored 0 (I5.2.2.) (Struiving, 2020). During the current period Paddepoel Energiek was completely out of the planning and how to address the barriers to participation was unclear which is why the indicator also scored 50 in this instance (Venema, 2020). In the future stage of the project the indicator has the potential to score 100 since an additional survey was conducted in January 2021 and several meetings have already been conducted in Selwerd, Paddepoel and Vinkhuizen, and based on the identified issues in the current phase, strategy changes have been suggested. For example, as noted in the participatory environment due to the scale up to two new neighbourhoods, not all the included areas had high levels of knowledge of sustainable energy or awareness of the project, and there were some residents in the two new neighbourhoods who were sceptical about switching to gas. In order to address this, several thematic workshops, catch up sessions, webinars and excursions were set up in 2021 (Grunneger Power, 2021a, 2021c, 2021d). However, an updated interview suggests that these workshops etc. have very few local residents involved or participating (3-4) which would need to be addressed for the overall score to increase (Struiving, 2021).

(I5.3) There are clear avenues for willing local residents to participate

In phase 1 and the current period of phase 2 (I5.3) received 0. In phase 1, while local residents were part of the Paddepoel Energiek group there weren't clear pathways for other local residents to be active participants of the project (Struiving, 2020).In the current phase, the role that local residents will play in the project is not solidified or clear (Struiving, 2021; Venema, 2020). However, in the future stage the development of neighbourhood cooperatives would make it clear to residents how they can be involved in decision making processes, and therefore would be scored 100 (050 Buurtwarmte, 2021a). Residents would also be able to choose how much they are willing to participate in the project through new proposed membership structures, thus, leaving it up to residents to decide what level of participation best suits them.

(I5.4) The local community has been staffed for the project

In phase 1 members of Paddepoel Energiek were salaried by Shell which is why a score of 100 was allocated (Struiving, 2020). In the current phase and future phase, no local residents are staffed for the project (Huizinga, 2020; Venema, 2020).

(I5.5) Local residents are involved in the organization of project activities

In phase 1, local residents were involved in the organization of project activities under Paddepoel Energiek scoring 100 for the indicator (Els, Anne, Anne, Wytze). In the current interim phase no residents were involved in the project activities which scored 0 but this may change to 100 in the future phase since residents would be involved in activities through the neighbourhood energy cooperative(050 Buurtwarmte, 2021a). This is the same reasons for the same scoring across the phases in (I5.6) distribution of responsibilities in the planning process.

(I5.7) There is sufficient local capacity and resources for local residents to successfully run the project without intervention

In phase 1 and the current phase the indicator scored 0, this is due to the fact that there was no official local cooperative to govern the collective action and the original team of local residents were only a hand full of persons, thus making it hard to manage a project of 3000 households with local residents. This can change in the future phase to 100 through the formation of a local energy cooperative/s which would solve the governance issues from the previous 2 phases and would allow for local capacity and resources to be pulled together efficiently.

(I1) Information sharing activities

(I1.1) Methods used (not quantified)

In all stages of the project residents have been informed through newsletters, the project websites, the neighborhood magazine, local newspapers, workshops, surveys and face to face meetings (050 Buurtwarmte, 2019, 2021b; Buurtwarmte 050, 2020, 2021; Communication Works, 2019; Elbert & Bouw, 2021; Grunneger Power, 2021a, 2021e, 2021f, 2021g; Paddepoel Energiek, 2018b). In phase 1, coffee tables were arranged for casual gatherings and discussion, in phase 2 catch up sessions are the equivalent (Grunneger Power, 2021a; Paddepoel Energiek, 2018b). Several co-creation presentations were also conducted. Due to COVID-19 some meetings have moved to online platforms. In phase 2, a webinar and excursion was also held for residents of the targeted neighborhoods(Grunneger Power, 2021c, 2021d).

(I1.2) Nature of information

In all three stages feedback from information sharing is integrated into the project planning (I1.2.1) scoring 100 points. However, local residents satisfaction with the information sharing dropped to 0 in the current phase because residents were not happy with the 6 month gap in communication between phase 1 and 2 (I1.2.2)(Huizinga, 2020; Venema, 2020).Consequently, the overall score for (I1.2) is 100 in the first phase but only 50 in the current period but has the potential to revert back to 100 if the matter is resolved. In all stages meeting attendance is scored at 50, since in none of the phases were the majority of targeted citizens present although there have been meetings with higher attendance than others (Huizinga, 2020; Struiving, 2020). In all instances (I1.4) community has the capacity to collect data and disseminate it scored 100 given that the project had contributed to the development of good practice case studies, presented at numerous workshops, and have organized

several surveys or supported research of the project. However, in all instances there is no actual dissemination strategy (knowledge management strategy) in place thus (I1.5) has been scored 0 in all stages. (I1.6) In both the current and future stage, no citizen scientist of the neighbourhoods are participating (or expected to participate) in publications and therefore a 0 was awarded but the interview with Paddepoel Energiek noted that there were 2-3 local students who collected data and research with the project members in phase 1, which is scored 100 (Struiving, 2020)

(I2) Deliberation processes

In phase 1 the scoring for the deliberation process was 50 because Paddepoel Energiek and Grunneger Power had decision making power on the board, meaning some local residents had decision making power and were engaged before key decisions were made (Huizinga, 2020; Struiving, 2020; van der Gaast, 2020). There were groupings for technique, stakeholder management and communication and members of these groupings formed the governing of the project (Struiving, 2020).Not all decisions were made with broader local residents. For example, residents were asked to provide feedback and opinion on some technical aspects but were given a limited selection of options, therefore, a key decision on the technical side was made without local residents outside of the Paddepoel Energiek circle. Residents of phase 1 were also not included in the decision to scale up to phase 2 (Huizinga, 2020; Struiving, 2020; Venema, 2020). It was also not easy for local residents outside of Paddepoel Energiek to engage the project planners because it was a foundation rather than a cooperative with member voting (Struiving, 2020). In the current period decisions are made by Grunneger Power and the Municipality of Groningen , while Grunneger Power has been leading the project, the Municipality is consulted on all key decisions and they collectively decide on a way forward (Huizinga, 2020; Venema, 2020). Generally, monthly meetings are held by the two parties to decide on key things. Since no local residents are involved in this period of the projects key decisions a 0 has been allocated. However, if new local energy cooperatives are formed, residents who are members will each have 1 vote in the decision-making process and therefore can be scored 100.

(I3) Conflicts

A key conflict that arose during the project was in the scale up from phase 1 to 2 which is why the current period scored 50. There was no involvement of local residents of Paddepoel in the decision to scale up and this decision was not communicated to the residents for about 6 months (Huizinga, 2020; Struiving, 2020; Venema, 2020). Since the project was initially started by local residents of Paddepoel, there was some backlash on the decision and lack of communication. Residents felt that the project was no longer a local initiative and felt that their decision-making power had been stripped (Ibid.). While there were many avenues for citizens to voice their concerns and opposition to decisions at meetings and coffee tables in phase 1, given the lack of communication and clear plan of ownership citizens felt that they were not heard (I3.2.). Grunneger Power took responsibility for the lack of communication and hosted meetings with local residents to explain the scaling up (Ibid.). However, trust needed to rebuilt and not all residents were satisfied with the conflict resolution process (Ibid.). However, as noted in previous sections a lot has been done to engage local residents and to give them a sense of ownership again which may fully resolve the conflicts, therefore scoring 100 in the future phase.

(I4) Investing/Financing activities

The Municipality of has made a grant of (€) 5,260,000 available, of which (€) 4 million will be used to attract additional capital and to set up a revolving fund of (€) 40 million(050 Buurtwarmte, 2021a; Programma Aardgasvrije Wijken, 2018b). Part of the required funds will be sourced through a bank loan, but this had not been confirmed as yet. In phase 1 **(I4) local residents are included in financial activities** was scored 100 because local residents were involved in the financial decision making, at least through Paddepoel Energiek and the targeted residents benefitted from the project in terms of the project not costing more their current gas prices and improving the homes in terms of sustainability (050 Buurtwarmte, 2021a; van der Gaast, 2020; Venema, 2020). In the current stage this was reduced to 50 since financial decisions were made by the Municipality of Groningen and Grunneger Power (Ibid.). However, in the future stage has the potential to be scored 100 because members of the cooperatives would receive 1 vote which would allow them to vote on budgeting and how to spend any proceeds of the project (050 Buurtwarmte, 2021a). In both phase 1 and the current phase 2 (**I4.3) the local community are financial participants in the project** is scored 0 because there were no options for co-investing and no membership but in the future phase co-investing may be a possibility and members contribute membership fees, therefore it can be scored 100 (050 Buurtwarmte, 2021a; Struiving, 2020; Venema, 2020). In all stages of the project (**I4.4.) alignment of project to local financial resource capacities** is scored at 50 since the project is income neutral affordability is scored at 100 **(I4.4.1)** but there are no schemes for those who want to participate but can't afford to do so (membership fees/co-investing) therefore **(I4.4.2)** is scored at 0.

4.2 Loppersum Warmtenet

4.2.1. Participatory environment

Participatory environment 95.8	
66.6 (A2) Socioeconomic attributes	100 (A3) History or past experiences
100 (A4) Location	100 (A5) Knowledge of sustainability/ Mental Model
100 (A6) Importance of energy source	100 (A7) Sustainable energy technologies are available
GS2) Government organizations (not quantified)	100 (GS3) Nongovernment organizations)

Figure 11: Participatory environment Warmtenet Loppersum Noord

The Warmtenet Loppersum-Noord project was initiated by the Municipality of Eemsdelta in 2018 and the local energy cooperative LOPEC officially joined the project in 2019 (Ettema & Scholten, 2020). The project started with 10 residential connections and 4 non-residential connections, this was changed to 60 residential connection and most recently to 210 residential connections and 4 non-residential connections (Jansen, 2020; Programma Aardgasvrije Wijken, 2018a). The participatory environment has not changed from the start of the project to date hence only one calculation was done. Overall, the participatory environment scored extremely high at 95.8 percent (see figure 11). This section outlines the participatory environment in Loppersum.

(A4) Location:

(A4.1) Population characteristics (not quantified):

Loppersum district has a total population of about 3430 which makes up 1545 households(Central Bureau of Statistics, 2018a). There are 926 residents are above 65 years old and 480 are below 15 years old, indicating that there is roughly 59 percent of the population above 15 years old and below 65 years old (Ibid.). About 6 percent of residents have a migrant background (206 residents), of which 103 residents are from a Western migration background and 103 are from a non-Western migration background (Ibid.).

(A4.2) RE sources are available and accessible

Loppersum is a frontrunner in solar roofs and in rural areas wind turbines are very common (Gemeente Loppersum et al., 2020; LOPEC, 2020c). Indicating potential for solar and wind which is why (A4.2) has been scored 100. Based on this (A7) sustainable energy technologies are available also received 100 points. Originally, biomass had been considered for the heating network but due to opposition the plans have turned to solar and wind as potential sources(Ettema & Scholten, 2020; LOPEC, 2020c). Wind generation has been the key avenue explored since the cost associated with it was on par with biomass but due to the landscape aesthetic this is being reconsidered as well(Jansen, 2020).

(A4.3.) Homes are new (after 2000 construction) (not quantified)

In Loppersum district only 11 percent of homes have been constructed after 2000(Central Bureau of Statistics, 2018a).

(A4.4)- Gas consumption (not quantified)

Gas consumption is 1,550 m3 across all housing types (Ibid.)

(A2) Socio-economic attributes:

In Loppersum district 81.6 percent of the population are income recipients, 43 percent are low income earners(Central Bureau of Statistics, 2018a). (A2.1.) income level was therefore scored as 50. (A.2.2.) Education level: educational level data is not captured at the neighbourhood or district level in Loppersum, however, based on the municipal level data we found that 40 percent of Loppersum's population has at least a secondary education, and 20 percent has a higher education level(Central Bureau of Statistics, 2018a). We have therefore based the scoring on the available data as 50. (A2.3.) Number of households are owned: in Loppersum district about 62 percent of homes are owned and 38 percent are rented with 6 percent of the rentals being privately owned (Ibid.)

(A3) History or past experiences

(A3.1) There are existing decentralized energy projects

The project was scored 100 project since the cooperative LOPEC completed its first project, a Postcode Rose scheme in 2017 and has since been working on several other decentralized energy projects (LOPEC, 2017; Schwencke et al., 2021).

(A3.2) There are expertise related to sustainable energy or sustainability

Due to the experience of LOPEC in other energy projects in solar and wind, the cooperative LOPEC has expertise related to sustainable energy and its 150 members are also well informed about various aspects of the energy transition(Ettema & Scholten, 2020; LOPEC, 2017, 2021a, 2021b). Consequently, (A3.2.) was also scored 100 thus making (A3) accumulatively 100 as well.

(A5) Knowledge of sustainability/ Mental Models

(A5.1) Citizens are aware of sustainability issues

A survey with 271 respondents was conducted which measured the attitude towards the sustainable energy transition (Elbert & Wiekens, 2020). Only 6.6 percent of the respondents did not think that fossil fuels contributed to climate change, 74. 9 percent of respondents thought that energy consumption was an issue, and 55.7 percent regularly kept track of their consumption levels and 38.7 percent kept track of their consumption but not regularly (Ibid.). Subsequently, (A5.1) scored 100.

(A5.2) Citizens are aware of the project

In the first instance Willy Jansen of the Municipality had engaged the targeted 60 houses door to door so the targeted group was aware of the project (Jansen, 2020). In addition, the 150 members of LOPEC were made aware of the project through various meetings, presentations and minutes throughout the project cycle (Jansen, 2020; LOPEC, 2020a, 2020b, 2020d, 2020e, 2020f, 2021c). Generally, the turn out to the LOPEC meetings has been high (LOPEC, n.d.). We have therefore scored the awareness of the project as 100.

(A5.3) Citizens are willing to participate in the project

In the initial door to door visit about 90 percent of the engaged households were willing to participate in the project (Jansen, 2020). In the 2020 survey respondents were questioned about their willingness to participate, only 31 percent did not want to participate in a local energy project(Elbert & Wiekens, 2020). Similarly, only 21.7 percent of respondents did not want to participate in a gas free project in their neighborhood (Ibid.). In addition, 40.4 percent of respondents wanted to participate in discussions if a local project is initiated and only 20.7 were not interested at all (Ibid.).

(A6) Importance of energy source

As noted in (A5.1) residents generally agreed that fossil fuels contributed to climate change and were concerned about their energy consumption(Elbert & Wiekens, 2020). The project planners indicated that there was big motivation and support to move away from natural gas among residents (Ettema & Scholten, 2020; Jansen, 2020). Residents were also strongly against the use of biomass due to reports of deforestation (Ettema & Scholten, 2020; Jansen, 2020; LOPEC, 2020a). Consequently, (A6) was scored as 100.

(GS3) Non-government organizations

The score was 100 since LOPEC is an energy cooperative with 150 + members each with 1 vote in decisions regarding the heating network(Ettema & Scholten, 2020). While the Municipality and Enpuls are partners of the project, decisions have strongly been based on the inputs of LOPEC members(Jansen, 2020).

4.2.2. Degree of participation

Levels of participation-**88.8**		
100 (I5) Self-organizing activities	100 (I4) Investment / Financing activities	60 (I1) Information sharing activities
100 (GS4) Network structure	50 (GS5) Rules in use	100 (I3) Conflicts
100 (A1) Number of relevant actors	100 (I2) Deliberation processes	

Figure 12: Levels of participation in the Warmtenet Loppersum

Given the structure of the Loppersum Warmtenet project, the overall level of participation is scored 88.8 which indicates strong degrees of citizen power. This section will outline the results of the levels of participation analysis in the project.

(A1) Number of relevant actors

The number of relevant actor's variable was scored 100. The project is a joint effort between the Municipality, the Enexis sister company Enpuls and LOPEC. While the project was initiated by the Municipality and is funded by the Municipality citizens are still key actors through LOPEC and can therefore be involved in various aspects of the project (Jansen, 2020).

(GS4) Network structure

The Municipality initiated the project in 2018 and asked LOPEC to join in 2019. Together with Enpuls they form the project team. Enpuls is responsible for the network, while the Municipality is responsible for financing the project and LOPEC brings local residents into the decision making process (Ettema & Scholten, 2020; Jansen, 2019, 2020). Enpuls will also finance a part of the heating network. Consequently, the network structure has been awarded 100 points given that citizens play a significant role in the project. However, while the Municipality has willingly engaged citizens on decisions and have jointly made decisions, the power to change the rules remains with the Municipality which is why (GS5) rules in use is scored 50(Ettema & Scholten, 2020).

(I5) Self-organizing activities

(I5.1.) Ownership model used (not quantified)

The ownership model of the project is a hybrid model in which ownership is equally shared between the Municipality of Loppersum, LOPEC and Enpuls (see section 3.2).

(I5.2) Barriers to participation have been explored

The indicator was scored 100 because **(I5.2.1.)** research was conducted into the barriers of participation with the initial door to door engagement and the 2020 survey, consequently the indicator was scored 100. In addition, the survey results have been used in subsequent planning on the project so **(I5.2.2.)** also scored 100 (Elbert & Wiekens, 2020; Ettema & Scholten, 2020; Jansen, 2020).

(I5.3) There are clear avenues for willing local residents to participate

Since LOPEC is an energy cooperative with members who each receive 1 vote the avenue for participation is clear: become a member of LOPEC and vote on decisions (Ettema & Scholten, 2020). Local residents are also able to participate in the project through village meetings organised by the village association (Ibid.). All of the targeted residents have also been given the Municipal lead Willy Jansen's personal phone number and are able to directly engage with the Municipality (Jansen, 2020). Therefore, **(I5.3)** has been scored as 100.

(I5.4) The local community has been staffed for the project

The board of LOPEC are working on the project, in a sense they are considered to be local residents staffed for the project(Jansen, 2020). In addition, there are number of volunteers of the cooperative who will be engaged with the project(Ettema & Scholten, 2020). We have therefore allocated 100 points.

(I5.5) Local residents are involved in the organization of project activities

Local residents have been involved in the project since LOPEC joined as partner, residents are invited to meetings to consider planning, the next steps and setbacks in the project and are able to volunteer to participate in project activities (Ettema & Scholten, 2020; Jansen, 2020; LOPEC, n.d., 2020a, 2020b). Based on this both **(I5.5)** and **(I5.6) distribution of responsibilities in the planning process.** have been scored 100.

(I5.7) There is sufficient local capacity and resources for local residents to successfully run the project without intervention

Given that LOPEC has conducted a successful solar project among other local initiatives, and there are numerous active associations that are involved in local projects, the local capacity and resources available are suited to successfully run projects self-sufficiently(Ettema & Scholten, 2020; LOPEC, 2017, 2021a, 2021b). Therefore, 100 points has been awarded to this variable.

(I1) Information sharing activities

(I1.1) Methods used (not quantified)

Local residents have been informed through newsletters, the project websites, surveys, face to face meetings, presentations, village meetings and meeting notes (Ettema & Scholten, 2020; Jansen, 2019, 2020; LOPEC, n.d., 2020b, 2020e).

(I1.2) Nature of information

In all three stages feedback from information sharing was integrated into the project planning (**I1.2.1)** scoring 100 points. However, local residents satisfaction with the information sharing dropped to 0 in the current interim phase because residents were not happy with the 6 month gap in communication between phase 1 and 2 **(I1.2.2)**(Huizinga, 2020; Venema, 2020).Consequently, the overall score for **(I1.2)** is 100 in the first and future phase but only 50 in the current interim period. In all stages meeting attendance is scored at 50, since in none of the phases were the majority of targeted citizens present although there have been meetings with higher attendance than others (Huizinga, 2020; Struiving, 2020). In all instances (**I1.4) community has the capacity to collect data and disseminate it** scored 100 given that the project had contributed to the development of good practice case studies, presented at numerous workshops, and have organized several surveys or supported research of the project. However, in all instances there was no actual dissemination strategy (knowledge management strategy) in place thus **(I1.5)** has been scored 0 in all stages. **(I1.6)** While in both the current interim and future stage there were no citizen scientist of the neighbourhoods participating in publications and therefore a 0 was awarded but the interview with Paddepoel Energiek noted that there were 2-3 local students who collected data and research with the project members in phase 1, which is scored 100 (Struiving, 2020)

(I2) Deliberation processes and (I3) Conflicts

Decisions are jointly made with the Municipality of Loppersum and LOPEC (Jansen, 2020). Local residents are engaged in the processes before a decision is made through village and cooperative meetings. Based on the outcome of the meetings and the majorities opinion a decision is made by the Municipality and LOPEC(Ettema & Scholten, 2020; Jansen, 2020). LOPEC also has its annual general meeting in which members of the cooperative can vote on matters (LOPEC, 2020e). The level of decision making power of local residents is evident by the **(I3) conflict** on the use of biomass, in which 40 or so citizens lobbied against the use of biomass and inevitably the decision to use biomass was overturned (Ettema & Scholten, 2020; Jansen, 2020; LOPEC, 2020a, 2020c). Consequently, both (I2) and (I3) were scored 100.

(I4) Investing/Financing activities

The Municipality of Groningen has made a grant of (€) 3,056,000 available, an additional (€) 1,170,000 has been contributed through the national gas free living fund and Enpuls is expected to contribute (€) 1,500,000 to finance the network (Jansen, 2020; LOPEC, 2021c). **(I4) local residents are included in financial activities** was scored 100 because local residents were involved in the financial decision making in terms of membership voting on LOPEC's financial decisions and since 2 percent of

the proceeds of the project will be given to local residents through the energy cooperative(Jansen, 2020). The decision was made that LOPEC, the Municipality and Enpuls would all receive equal profits. (I4.3) **the local community are financial participants in the project** is scored 100 because local residents contribute (€) 15 membership fees to LOPEC to vote on decisions and to benefit from the 2 percent profit of the project and can make use of the natural gas free living scheme (Ettema & Scholten, 2020; Jansen, 2020; LOPEC, 2021c). In addition, (I4.4.) **alignment of project to local financial resource capacities** is scored 100 since the project offers a 5 percent guaranteed reduction in the energy cost the affordability is scored at 100 **(I4.4.1)** and the natural gas free living scheme is available scoring **(I4.4.2)** 100 as well (Jansen, 2019, 2020).

5. DISCUSSION & CONCLUSIONS

Participatory environment

In the Buurtwarmte project the participatory environment changed over the course of the project, which was largely due to the scaling up process. In the phase 1 of the project the overall score of 76.1 indicated that there was an enabling environment for participation. However, during the current phase the participatory environment decreased to 57.1. A key change in the participatory environment was the decrease in sustainability knowledge and mental models which may be attributed to the inclusion of the districts Selwerd and Vinkhuizen. While the socio-economic attribute scoring has remained relatively the same in all phases, the inclusion of the two districts may exacerbate difficulties of participation linked to socio-economic characteristics. Several studies suggest a positive relationship between higher income levels and education and willingness to invest in sustainable energy technologies, and lower incomes and education with less willingness to participate (Frey, 1971; Lancee & Van de Werfhorst, 2012; Long, 1993; Mahapatra & Gustavsson, 2008; Michelsen & Madlener, 2012; B. F. Mills & Schleich, 2010; B. Mills & Schleich, 2012; Philippsen et al., 2017; Wilkinson et al., 2010). In Buurtwarmte Paddepoel was already a low-income neighbourhood is a barrier to participation but generally residents were highly educated making it more likely for them to participate in local initiatives. However, the scaling up process added more low-income households into the project exacerbating the challenge of getting lower income households to participate in sustainability initiatives. In addition, the education level in these two districts were also lower which presents a different challenge to engaging higher educated low-income households in Paddepoel. In the Loppersum case, the participatory environment was enabling, meaning that participation in this context is easier to achieve. While there were few low-income residents and while the education levels were a lower than that of Paddepoel residents were still willing to participate in the project. In addition, studies suggest that residents who own buildings are more likely to partake in energy efficiency upgrades than those who rent (Michelsen & Madlener, 2012; B. F. Mills & Schleich, 2009). This difference in homeowners and renters is also shown in the Paddepoel 2021 survey. In Loppersum, most of the homes were owned not rented whereas in all three districts of the Buurtwarmte project there were more renters than homeowners, making it a harder participatory environment.

In both phases of the Buurtwarmte project awareness of sustainability issues and the project itself was the same (yellow). However, the engaged residents of Paddepoel had a greater awareness of sustainability issues due to the close social network of Paddepoel Energiek in the targeted area and higher overall educational levels and the success of the first phase (Di Maria et al., 2010; Olli et al., 2016). Though, when scaling up to the two additional neighbourhoods the education levels are lower, incomes are slightly lower and there are no pre-existing community energy initiatives to build on which relates to the lower awareness of sustainability issues and the project itself in engaged residents. This can be seen in the difference between Paddepoel residents and those in the other two districts when it comes to the preference to move away from natural gas. In Paddepoel, moving away from natural gas was important due to climate considerations whereas in the other two districts there was some scepticism and conditions with moving away from natural gas. The latest developments in the project are positively addressing these challenges through increased engagement and awareness raising. In Loppersum, there were higher degrees of awareness of both the project and sustainability issues and the more preference to move away from natural gas which positively correlated with the

willingness to participate in the project. There are two drivers for this positive participatory environment component. The first is that unlike the Buurtwarmte project, Loppersum engaged a local energy cooperative in the early stages. LOPEC had already run a successful project and was known by residents of Loppersum. The second factor is the small network of Loppersum versus the larger network in the Buurtwarmte phase 2. Due to the smaller size of the Loppersum project residents had door to door engagements and information sharing, and residents had the personal number of the Municipal official, who is well known, if they had any concerns or wanted more information. Thus, residents in Loppersum were able to get individualized attention compared to the larger scale of the Buurtwarmte project. However, frequent thematic workshops and catch ups for the different districts are underway and proving to have a positive effect on the awareness of residents in the two new neighbourhoods.

Levels of Participation

The levels of participation in the Buurtwarmte project differed greatly between phase 1, the current phase 2 and future phase 2. The higher-level score of phase 1 of the project does not relate that much to higher levels of self-organizing activities. The lack of conflicts in phase 1 is one of the factors that has increased the overall score, this strongly relates to the greater sense of ownership and decision-making power perceptions of local residents in Paddepoel in phase 1. Paddepoel Energiek was comprised of local residents who had strong personal connections in the neighbourhood, therefore, the project was seen in a more positive light despite it not actually having that many residents directly involved in decision making indicated by the lower score on the number of actual residents actively involved. Given that Paddepoel Energiek was comprised of local residents who were involved in the board of the project, positive scores were given for the rules in use, financing, and network structure of phase 1 because local residents, albeit a select few, had equal decision-making power to Grunneger Power. However, there were transparency and governance issues related to Paddepoel Energiek being incorporated as a foundation. For one there were no clear avenues for local residents outside of Paddepoel Energiek to be active participants of the project and when it came to decision making this was done with Grunneger Power and Paddepoel Energiek in a board setting. There was no local resident voting process although information about the project was shared with local residents. Some of the decisions given to local residents were limited decisions, for example, deciding on which type of system would best fit. Despite these clear barriers for local residents beyond Paddepoel Energiek to participate that was also highlighted in engagements with residents, there were no strategy changes to address in phase 1. On the other hand, there wasn't sufficient local capacity and resources for local residents to run the project without external support. While the information sharing in phase 1 was relatively good the score was generally lower on this indicator in all three phases due to medium meeting attendance and the capacity to collect and disseminate data. In the current phase, the overall project scored as degrees of non-participation. In this stage of the project Grunneger Power and the Municipality were the sole decision makers in the project which decreased several indicators into the red because there was no local resident component. In addition, the decision to scale up was taken without involving local residents of Paddepoel and they were only informed 6 months later which negatively affected the sense of ownership and trust in the project.

However, the future stage of the project is promising with a score of 85.4 percent it has the potential to display a high degree of citizen power. This is largely due to the fact that the formation of local energy cooperatives would allow local residents to be equal stakeholders with a form of genuine

ownership in the project. Since members in energy cooperatives each would have 1 vote and would be more included in the decision making and planning of the project the number of local community actors involved in the project would go up and the self-organizing activities would drastically increase as well. In addition, the deliberation process would also be improved. The rules in use decreased since phase 1 though, this is based on the fact that Paddepoel Energiek made up of residents had some control overrule making whereas the Municipality and Grunneger Power still has more rule making power than local citizens even in the potential future phase. There is potential for significant improvement in the investment and/or financing aspects of the project. Based on the proposed local energy cooperative membership in the future phase residents would be able to actively engage in financial decision making. This was equally scored in phase 1, however, it was only Paddepoel Energiek involved in the key decisions so in the current phase more local residents are involved in this aspect. In addition, each member of the cooperative can vote on the annual budget and how to spend proceeds of the project which was not the case in the phase 1 and the interim phase. Options are also being explored for co-investing which will further integrate citizens in the financial participation side of the project. The Loppersum case has similar dynamics to the current phase of the Buurtwarmte project. The level of participation displayed was a high degree of citizen power scored at 88.8. However, unlike the Buurtwarmte case there has been no negative fluctuations in participation. While the Buurtwarmte project was initiated by local residents and the Loppersum case was initiated by the Municipality, the Municipality included citizens to a higher degree much earlier than in the Buurtwarmte case. LOPEC was engaged very early on in the project therefore positively affecting the self-organizing activities, deliberation processes and number of actors scores. The equal partnership is also reflected in the way that profits of the project is evenly distributed between LOPEC, the Municipality and Enpuls. Thus, not only allowing local residents to equally make decisions in the project but to also benefit from the project fairly. Unlike the Buurtwarmte case, there has been no significant conflicts in the Loppersum case which may be attributed to the fact that local residents had equal decision-making power and the Municipality went along with the decisions of citizens because it would increase acceptance of new technologies. However, the rules in use in Loppersum scored low due to the fact that rule making power remained with the Municipality.

Conceptual Framework

Combining the SESF and participatory ladder conceptual frameworks provided a very granular analysis of participation across the political, technical, and economic dimensions. The framework was able to identify gaps in the participatory environment and the degree of participation and then narrow down the areas in which there are issues. In addition, the framework proved to be extremely adaptable and flexible in spatial and temporal terms. The indicators allowed the analysis to be conducted with specific contextual variables related to the spatial dynamics of the project areas in Loppersum and Groningen. At the same time, as can be noted by the Buurtwarmte case, the framework can also be applied to specific periods of a project to detect changing patterns of participation across time. While the framework is context specific it could be used to compare the two cases participatory outcomes and key processes. Given the interactions between various variables, aspects of the framework can be streamlined by combining similar variables into one or under the same tier. While the framework integrated variables related to the integration of scientific knowledge into local energy projects, in all instances of the analysis the variable was missing which resulted in lower scores in information sharing. It is unclear whether or not there are any cases in which this variable makes a significant difference to the process of participation and the related levels. More empirical work is needed to fully test the frameworks adaptability and usefulness.

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