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Published in:
Renewable & Sustainable Energy Reviews

DOI:
10.1016/j.rser.2023.113975

Renewable and Sustainable Energy Reviews 189 (2024) 113975

Contents lists available at ScienceDirect

Renewable and Sustainable Energy Reviews

journal homepage: www.elsevier.com/locate/rser

Citizen participation gaps and challenges in the heating transition: Learning from Dutch community initiatives

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ARTICLE INFO

Keywords:
Local participation
District heating
Community energy initiatives
Citizen inclusion
Self-organization
Socio-ecological systems framework
Participation literature

ABSTRACT

The European Union has recognized the significance of community energy initiatives in the energy transition and introduced legislation to promote active consumer participation and renewable energy communities. The Netherlands, with its transition away from natural gas, serves as a valuable case study for understanding the challenges and processes of local ownership and participation in community energy initiatives. The research aims to address the dual challenge of defining local ownership and participation and exploring case-specific applications of these concepts. To achieve this, the study employs the Socio-Ecological Systems Framework and literature on participation, providing a theoretical foundation for analyzing citizen engagement. A mixed-methods approach, including interviews and data collection, is used to examine five Dutch community heating initiatives. The analysis highlights the importance of an enabling participatory environment, inclusive participation, information sharing, and the presence of energy cooperatives for successful citizen engagement. The findings have practical implications for EU energy policy, emphasizing the need for clear definitions, inclusive decision-making processes, and tailored engagement strategies.

1. Introduction

Community energy initiatives (CEIs) have gained momentum in the field of transition studies, and their importance in terms of local ownership and citizen participation has been widely recognized in policy and academic literature [1,2]. Extensive academic literature has highlighted the numerous benefits of citizen participation in energy transitions, including enhanced decision-making processes, greater acceptance and adoption of renewable energy projects, positive behavioral change, and increased investment in community-led initiatives [3]. The significance of CEIs in policy is highlighted in the European Union (EU) Clean Energy for all Europeans package, adopted in 2019, which brought the concept of citizen energy communities into EU legislation [4]. Specifically, the Directive on common rules for the internal market for electricity (EU/2019/944), the Regulation on the internal market for electricity (EU/2019/943), and the revised Renewable energy directive (2018/2001/EU) emphasize the value of active consumer participation, renewable energy self-consumption, and the integration of renewable energy communities. These developments are of great significance for the future of CEIs, as they establish a supportive framework that fosters and advances community-driven energy initiatives throughout the EU. The EU experience can serve as a trailblazing example and a roadmap for other countries to involve citizens in their own energy transitions.

As countries work toward global climate goals and transition to cleaner energy sources, addressing heating challenges becomes crucial. Heating in residential and commercial buildings accounts for a significant portion of energy consumption, and approximately 60% of heating demand is supplied by fossil fuels [5]. CEIs can play a key role in a neighborhood approach to the heating transition. They can provide a context-specific approach that enables tailored solutions that are better aligned with end-user preferences and needs. However, the impact and role of CEIs can vary due to various factors, such as project design, local needs, technology, scale, social settings, levels of engagement, types of ownership, and motivations for participation [6,7]. While the benefits of citizen and local participation in heating transitions are apparent, the diverse nature of these factors makes it challenging to draw generalizable conclusions about how CEIs engage local residents in energy projects.

In the Netherlands, the transition from natural gas is of particular importance in the broader energy transition, as it constitutes a major energy source for electricity generation and residential heating [8]. This may be attributed to gas extraction activities in the Groningen province, which houses one of the world's largest gas fields. The country's overall

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https://doi.org/10.1016/j.rser.2023.113975
Received 26 September 2022; Received in revised form 19 October 2023; Accepted 20 October 2023
Available online 2 November 2023

Abbreviations

CEI	Community Energy Initiative/s
PAW	Natural Gas Free Test Beds Program
SESF	Socio-Ecological Systems Framework
A	Actors
GS	Governance Systems
I	Interactions
O	Outcomes
m3	Cubic Meter
PE	Participatory Environment
LoP	Levels of Participation
EU	European Union

energy transition requires ending gas extraction in the province by mid-2035 [9], and this ambitious transition entails active participation and commitment from residents and building owners to adopt sustainable heating alternatives. Consequently, and in line with the EU directives, the Dutch heating transition emphasizes a neighborhood approach to sustainable heating, with an increasingly important role for CEIs [9]. However, the Dutch Climate Agreement and national-level planning do not specify a rigid approach to the participation process, due to the fact that participation may unfold differently in different local contexts, which has led to varying interpretations and variations in the implementation of the targets [9,10].

As a front-runner in the EU in terms of engaging CEIs in community heating projects, the Netherlands can provide great insights into the underlying processes of participation in community heating projects and the challenges of practically applying the EU directives to the energy transition. In particular, there are two contrasting challenges encountered in the application of local ownership and citizen participation in heating transitions. The first challenge lies in the need for a comprehensive definition of local ownership and participation that effectively accommodates the diverse nature of CEIs and addresses local differences. The second challenge involves exploring case-by-case applications of these concepts to ensure efficient implementation and overcome potential inefficiencies. However, there is still a need to evaluate the varying degrees of citizen participation in community heating initiatives in order to identify inefficiencies, barriers, and gaps related to citizen participation in these initiatives. To bridge this gap, the present study aims to investigate the lessons learned and good practices for addressing the dual challenge in the application of local ownership and participation in energy transitions.

The paper addresses the overarching research question by investigating various aspects related to the application of local ownership and participation in local energy transitions. It explores the unfolding dynamics of participation processes at the local level within CEIs, examining how these initiatives facilitate active participation among local communities. Furthermore, the study identifies and explores the barriers and challenges associated with integrating local participation into CEIs, offering insights and strategies to overcome these obstacles and foster active local involvement in energy projects. To analyze our case studies, we employ an existing framework that combines the Socio-Ecological Systems Framework (SESF) and literature on participation, providing a robust theoretical foundation for understanding the complexity of local citizen participation, as outlined in Section 2. Section 3 of this paper outlines our comprehensive methodology, including a coding guide, which not only serves as a valuable tool for our research but also offers a guide for future studies on local participation in energy transitions. The coding guide is used for a comparative analysis of five Dutch community heating initiatives from the province of Groningen, Amsterdam, and Wageningen in Section 4. By employing a comparative case study approach, we strive to broaden the applicability of our findings to other regional and local settings. The specific challenges, strategies, and dynamics observed in the Dutch context can serve as valuable lessons and inform similar initiatives worldwide. This research endeavors to contribute to the field by providing valuable insights into participation processes in community heating initiatives. The findings, outlined in Section 5, are expected to enable policymakers, practitioners, and researchers to gain a better understanding of citizen participation, facilitating the development of robust frameworks and strategies for community energy transitions.

2. Theoretical framework

The Socio-Ecological Systems Framework (SESF) is a recognized and valuable framework for comprehending the intricate dynamics of human-nature systems, including decision-making processes. Its suitability for analyzing participation in CEIs stems from its capacity to capture the complex interactions among multiple actors operating independently or collectively at different jurisdictional levels [11]. Rooted in collective action theory, the SESF provides a historical perspective that elucidates the cooperation and coordination within the complex techno-ecosystem of CEIs, bridging social and ecological dimensions found in energy transitions [12–14]. Moreover, its multi-tiered and adaptable nature enables researchers and practitioners to examine participation dynamics and the factors influencing citizen engagement in diverse CEIs, contributing to a holistic understanding of energy transitions [15,16]. In the SESF, the first-tier variables related to the social system include actors (A) and governance systems (GS). These variables interact within focal action situations, where inputs are transformed through interactions (I) among multiple actors, leading to specific outcomes (O). Tables 1 and 2 illustrate how the first-tier variables may be further decomposed into second and third-tier variables. While the SESF provides a broad structure for understanding interactions between social system components and the environment, the specific connections between variables within each tier are not explicitly defined. This can make it challenging to fully capture and analyze the nuanced relationships and dynamics at play in CEIs.

Teladia and van der Windt have leveraged the flexible and robust nature of the SESF as the foundation for their own framework on local participation in community energy initiatives (CEIs). Building upon the SESF, they enhance the conceptualization of SESF variables by incorporating insights from the literature on participation [3]. The framework incorporates the concepts of citizen power, tokenism, and non-participation to capture different levels of engagement. “Citizen power” signifies genuine influence and decision-making, while “tokenism” reflects superficial participation with limited consideration of citizen input. “Non-participation” denotes exclusion or marginalization from decision-making. The integration of the SESF with findings from the literature on participation creates a valuable framework for analyzing local participation in CEIs. This approach enables the identification and categorization of key participation components, the establishment of connections between variables, and provides a comprehensive assessment of citizen engagement levels. Consequently,

Table 1
Tiered variables and measurements across the participatory environment (taken from Teladia & van der Windt, 2022).

Participatory environment

Key second-tier variables for PE analysis	**A2 Socioeconomic attributes (High-100, Middle-50, Low -0)** A2.1.- Income level A.2.2.- Education level A.2.4.- # households owned/rented	**A4 Location (Yes-100, No-0)** A4.1. – Population characteristics (not quantified) A4.2. – RE sources are available and accessible A4.3. – There is existing energy infrastructure for integration A4.4.- Energy consumption (not quantified)	**A6 Importance of energy source (Yes-100, Somewhat-50, No-0)** A6.1. Citizens prefer to move away from natural gas	**GS2 Government organizations (not quantified)**
	A3 History or past experiences (Yes-100, No-0) A3.1. – There are existing decentralized energy projects	**A5 Knowledge of Sustainability (Yes-100, Somewhat-50, No-0)** A5.1.- Citizens are aware of sustainability issues. A5.2. Citizens are aware of the project.	**A7 Sustainable energy technologies available (Yes-100, No-50)**	**GS3 Nongovernmental organizations (Mostly local-100, Some local-**
	A3.2. – There is expertise related to sustainable energy or sustainability	A5.3. Citizens are willing to participate in the project		**50, No local-0)**
Linked classification of PE variable analysis	**(C) Classification (added variable):** **C1 Enabling participatory environment (67-100)** (green) **C2 Somewhat enabling participatory environment (33-67)** (yellow) **C3 Little or no enabling participatory environment (0-33)** (red)			

* All the variables in the table may influence participation dynamics, inclusion challenges, and the extent of engagement. The data from case studies further determine the variables that have a negative or positive influence on these factors.

in our study, we have employed this framework to gain granular insights into the dynamics of local participation in CEIs.

The framework consists of two primary components, namely the participatory environment (PE) and levels of participation (LoP). The PE illustrated in Table 1 clusters all the variables that impact the dynamics of participation, citizen inclusion challenges, and the extent of local engagement. These variables are further broken down into lower tiers for a detailed analysis of the participatory environment. The PE variables are evaluated on a scale of C1–C2 to assess the degree of enablement or hindrance to participation. The LoP depicted in Table 2 clusters all the variables that gauge the level of local citizen involvement across the economic, social, and technical dimensions of community energy projects. These variables are also decomposed into lower tiers and assessed according to different levels of participation, such as citizen power, tokenism, and non-participation. Specifically, variables A2 to A7, GS2, and GS3 contribute to the analysis of the participatory environment, while variables GS4, GS5, A1, and I1 to I5 support the examination of local citizen involvement in the levels of participation. A traffic light system using equally weighted variable aggregation is utilized to highlight and pinpoint significant gaps in the participation process. This approach helps identify areas for improvement and potential barriers that may hinder effective participation.

Table 2
Tiered variables and measurements across the levels of participation (taken from Teladia & van der Windt, 2022).

Levels of participation (LoP)				
Key second-tier variables for LoP analysis	**GS 4 Network structure (Citizens equal power to others or owners-100, citizens involved but not equally to others-50, citizens play a passive role-0)** GS4.1. The connection between actors and the project (not quantified) GS4.2. The roles of actors in the project	**A1 Number of relevant actors (Mostly citizens-100, Some citizens-50, No citizens-0)** A1.1. # Investors A1.2. # Private sector A1.3. # Government A1.4. #Non-governmental A1.5. #Citizen scientist/ researchers A1.6. # Local community	**I2 Deliberation processes (Citizens are highly involved-100, citizens are somewhat involved-50, citizens are not involved-0)** I2.1 Citizens are engaged in key processes prior to decision-making. I2.2 Citizens have decision-making power. I2.3 Methods used (not quantified)	**I4 Investment/Financing activities (Yes-100, No-0)** I4.1. Local residents are included in financing activities. - I4.1.1. Local residents participate in financial decisions. - I4.1.2. Local residents benefit from the project. I4.2. Amount of investment/grant/funding etc. (not quantified) I4.3. The local community is a financial participant in the project. I4.4. Alignment of project to local financial resource capacities - I4.4.1. Locals can afford the participation costs of the project. - I4.4.2. There are financial schemes for those who cannot afford to participate
	GS 5 Rules in use (Citizens equal power to others or more-100, citizens involved but not equally to others-50, citizens not involved-0) GS5.1. Operational-choice rules GS5.2. Collective-choice rules GS5.3. Constitutional-choice rules	**I1 Information sharing activities (separate measurements)** I1.1. Methods used (not quantified) I1.2. Nature of information (Yes-100, no-0) - I1.2.1. Feedback was used in project planning or in improving the project. - I1.2.2. Local residents are satisfied with the information sharing activities. I1.3. Meeting attendance (High/Majority-100, Medium/Some-50, Low/None-0) I1.4 There is some local capacity to collect data and disseminate it (or to outsource) I1.5 There is a dissemination strategy to share information and scientific findings. I1.6 # of scientists participating in publication/reports related to the project (High-100, Some-50, Low/None-0)	**I3 Conflicts (Yes-100, Somewhat-50, No-0)** I3.1. Methods used (not quantified) I3.2. Citizens can voice issues and/or opposition. I3.3. Conflict resolution processes successful - I3.1.3. Local residents are satisfied with the processes	**I5 Self-organizing activities (Yes-100, No-0)** I5.1. The ownership model used allows for sole ownership or joint power. I5.2. Barriers to participation have been explored. - I5.2.1. Research/Surveys of some sort have looked into the potential barriers for local citizen participation. - I5.2.2. Identified barriers have been addressed through strategy changes. I5.3. There are clear avenues for willing local residents to participate. I5.4. The local community has been staffed for the project. I5.5 Local residents participate in the organization of project activities. I5.6 Distribution of responsibilities in the planning process is equal to other partners, or citizens have full control. I5.7 There is sufficient local capacity and resources for local residents to successfully run the project without intervention
Linked outcomes of LoP variable analysis	**(O) Outcomes:** **O1.1. Citizen power: citizens have full or equal control over the project (67-100)** (green) **O1.2. Tokenism: citizens are engaged but have no or less control than others (33-67)** (yellow) **O1.3. Non-participation: citizens are not engaged or are engaged linearly (0-33)** (red)			

*All the variables in the table may be used to determine the level of citizen involvement in various dimensions of CEIs. The level of citizen inclusion is determined by the case study data.

3. Methods and data

3.1. Case study design

We used a case study design to investigate citizen participation in Dutch community heating initiatives, this approach provides detailed insights into complex societal dynamics [17]. Our cases included five heating initiatives within the national Natural Gas Free Program (PAW), a key piloting program for community heating in the Netherlands. Three of these cases (Groningen, Zuidwolde, and Loppersum) were located in the province of Groningen, known for its gas extraction activities and its significance in the Dutch heating transition. By including these Groningen cases, we gained a comprehensive understanding of the unique dynamics and challenges in this region, while also situating our research within the broader context of the Dutch transition from natural gas. To capture other local nuances in the Dutch community heating landscape, we deliberately included cases from Amsterdam and Wageningen, which are renowned as front-runners in adopting and implementing community heating initiatives. Amsterdam, being the capital city of the Netherlands, further represents a diverse urban setting with a large population and unique urban energy challenges. Analyzing these cases allows us to explore the complexities of citizen participation in both larger and smaller scale urban settings. By identifying valuable insights, replicable models, and transferable practices, our research contributes to the advancement of similar initiatives not only within the Netherlands but also in other contexts globally.

3.2. Data collection

To enhance the depth and validity of our research, we adopted a mixed-methods approach. Consequently, data collection involved various sources. We conducted 60-min semi-structured online interviews with local resident groups, municipality leaders, and researchers involved in the selected cases. A total of ten semi-structured interviews and one follow-up interview were conducted (see Table 3). Anonymized interview summaries were created and made publicly available to support future research [18]. These interviews provided in-depth insights into stakeholder perspectives, motivations, challenges, and successes related to citizen participation.

Table 3
An overview of underlying interview and follow-up data.

Interview	Interviewee role in CEI	Case study	Interview/Follow-up date
Interview 1	CEI founder, board member and project lead	Groningen	2020-12-16
Interview 2	CEI founder, board member and project lead	Groningen	2020-12-17
Interview 3	Project leader	Groningen	2021-01-15
Interview 4	Governmental project leader	Groningen	2021-01-14
Follow-up 1	N/A	Groningen	2021-12-16
Interview 5	Former board member	Groningen	2021-12-22
Interview 6	CEI founder, board member and project lead	Loppersum	2020-12-17
Interview 7	Governmental project leader	Loppersum	2020-12-22
Follow-up 2	N/A	Loppersum	2021-12-16
Interview 8	CEI founder, board member and project lead	Zuidwolde	2021-09-29
Interview 9	Governmental project leader	Zuidwolde	2022-01-19
Follow-up 3	N/A	Zuidwolde	2022-01-25
Interview 10	Assistant professor and project researcher	Amsterdam	2022-02-15
Interview 11	Assistant professor and project researcher	Wageningen	2022-02-17

We incorporated survey data collected by Hanze University, which offered quantitative indicators and further insights into citizen perspectives and involvement throughout the projects [19,20]. In addition, we collected project data from project websites, which included survey data, reports (internal and external), newsletters, meeting notes, presentations, news articles, and other media sources. The full list of project content analyzed for each case study and the dates accessed – approximately 113 content data sources – have been made publicly available to encourage replication of the method and as a source of validation of this research [21]. These materials provided valuable contextual information and insights into the initiatives, their objectives, activities, and outcomes.

3.3. Data analysis

One crucial aspect overlooked in the framework we have employed is the practical operationalization in diverse case study comparisons that involve different types of data sources, making direct comparisons challenging. Addressing this gap, we developed a comprehensive and standardized approach to ensure the consistent application of the framework across diverse cases in our research, creating a robust coding guidebook [17]. This guide provides detailed instructions, codes, numerical values, and colors for coding each variable, allowing for systematic analysis across interviews, surveys, reports, and websites. It enhances the practicality of the framework employed, enabling meaningful comparisons and insights into citizen participation within different contexts.

The coding guidelines were applied consistently across all variables. Data segments were coded and categorized based on specific criteria, and aggregated scores were calculated by summing relevant sub-variable values. Classifications and colors were assigned to represent the variables' performance, facilitating visual representation and easy comparison. The coded segments were cross-referenced with other data sources to identify patterns and correlations. By employing triangulation, we obtained a more robust analysis of citizen participation, corroborating findings and enhancing the validity of our research. This convergence of data from multiple sources allowed for cross-validation and identification of consistencies or discrepancies, reinforcing the reliability of the research insights.

4. Results

This section presents the key results of the case studies. The findings highlight the importance of energy cooperatives, partnerships, and transparent communication channels in fostering citizen involvement and decision-making.

4.1. Groningen case

Paddepoel, a Groningen neighborhood, comprises 596 households, with gas usage averaging 1080–1260 m3 (A4) [22]. In 2012, six residents initiated a sustainability project (A1, GS3) [23], leading to Paddepoel Energiek's establishment in 2016. Phase 1 (2018) aimed to connect 450 Paddepoel North households to a heating network [23]. In mid-2020, Phase 2 expanded to Selwerd and Vinkhuizen, totaling 3000 households, with gas usage ranging from 1000 to 1210 m3 (A4) [24]. Stakeholders shifted from the neighborhood level to the municipal level during scaling up (A1, GS3). The participatory environment and participation levels shifted between phases. Selwerd and Vinkhuizen had fewer enabling characteristics for local participation compared to

Table 4
Participatory environment overarching case study results.

First-tier variables		Small-scale case studies (<500 residential connections)				Large-scale case studies (>500 residential connections)	
		Groningen Phase 1	Loppersum	Zuidwolde	Wageningen	Groningen Phase 2	Amsterdam
(A2) Socio-economic attributes	Score	50	66.6	100	66.6	50	83.3
	Classification	C2	C2	C1	C2	C2	C1
(A3) History or past experiences	Score	0	100	100	100	50	100
	Classification	C3	C1	C1	C1	C2	C1
(A4) Location	Score	100	100	100	50	100	100
	Classification	C1	C1	C1	C2	C1	C1
(A5) Knowledge of sustainability/ Mental Model	Score	83.3	100	100	100	50	100
	Classification	C1	C1	C1	C1	C2	C1
(A6) Importance of energy source	Score	100	100	100	100	50	100
	Classification	C1	C1	C1	C1	C2	C1
(A7) Sustainable energy technologies are available	Score	100	100	100	100	100	100
	Classification	C1	C1	C1	C1	C1	C1
(GS3) Nongovernment organizations	Score	50	100	100	100	0	100
	Classification	C2	C1	C1	C1	C3	C1
(C) Classification (overall)		C1 Enabling participatory environment	C1 Enabling participatory environment	C1 Enabling participatory environment	C1 Enabling participatory environment	C2 Somewhat enabling participatory environment	C1 Enabling participatory environment

C1- Enabling participatory environment (67-100)
C2- Somewhat enabling participatory environment (33-67)
C3- Little or no enabling participatory environment (0-33)

* For the purpose of clarity, only variables which indicate gaps or challenges are indicated in yellow or red in this table (excluding the classification). The classification of each first-tier variable is indicated in its abbreviated form.

Table 5
Levels of participation overarching case study results.

First-tier variables		Small-scale case studies (<500 residential connections)				Large-scale case studies (>500 residential connections)	
		Groningen Phase 1	Loppersum	Zuidwolde	Wageningen	Groningen Phase 2	Amsterdam
(A1) Number of relevant actors	Score	50	100	100	100	0	100
	Classification	O1.2.	O1.1.	O1.1.	O1.1.	O1.3.	O1.1.
(I1) Information sharing activities	Score	60	60	60	60	50	70
	Classification	O1.2.	O1.2.	O1.2.	O1.2.	O1.2.	O1.1.
(I2) Deliberation processes	Score	50	100	100	100	25	100
	Classification	O1.2.	O1.1.	O1.1.	O1.1.	O1.3.	O1.1.
(I3) Conflicts	Score	100	100	100	100	75	100
	Classification	O1.1.	O1.1.	O1.1.	O1.1.	O1.1.	O1.1.
(I4) Investment/ Financing activities	Score	50	100	100	100	33.3	100
	Classification	O1.2.	O1.1.	O1.1.	O1.1.	O1.3.	O1.1.
(I5) Self-organizing activities	Score	78.5	100	100	85.7	7.1	100
	Classification	O1.1.	O1.1.	O1.1.	O1.1.	O1.3.	O1.1.
(GS4) Network structure	Score	100	100	100	100	0	100
	Classification	O1.1.	O1.1.	O1.1.	O1.1.	O1.3.	O1.1.
(GS5) Rules in use	Score	100	100	100	100	0	100
	Classification	O1.1.	O1.1.	O1.1.	O1.1.	O1.3.	O1.1.
(O) Outcome (overall)		O1.1. Citizen power: citizens have full or equal control over the project	O1.1. Citizen power: citizens have full or equal control over the project	O1.1. Citizen power: citizens have full or equal control over the project	O1.1. Citizen power: citizens have full or equal control over the project	O1.3. Non-participation: citizens are not engaged or are engaged linearly	O1.1. Citizen power: citizens have full or equal control over the project

O1.1. Citizen power (67-100)
O1.2. Tokenism (33-67)
O1.3. Non-participation (0-33)

* For the purpose of clarity, only variables which indicate gaps or challenges are indicated in yellow or red in this table (excluding the outcomes). The categorization of each first-tier variable is indicated in its abbreviated form.

the original neighborhood, as depicted in Table 4 [18]. As the project transitioned from a neighborhood to a municipal-level initiative, the active participation of residents was reduced.

Location (A4) and sustainable technology availability (A7) remained consistent. The project concept included a high-temperature district heating system with heat pumps, aqua thermal energy, and distribution network [25]. Socio-economic attributes remained consistent, with mostly low-income residents and some with higher education largely residing in rental homes in all neighborhoods (A2) [21]. The experience (A3) of decentralized energy projects grew between phases but local expertise decreased because the active stakeholders changed. Sustainability knowledge was higher in Paddepoel but not prevalent overall (A5) [19]. Paddepoel had greater awareness and willingness to participate (A5) than the neighborhoods to which the project expanded [26]. Residents' skepticism toward new energy sources was greater in the additional neighborhoods (A6) [18]. The decline in the participatory environment resulted from the absence of resident involvement in project decision-making during Phase 2 (A1, GS3).

The shift from Phase 1 to Phase 2 led to a decline in various levels of participation variables, as illustrated in Table 5. Phase 1 exhibited greater involvement of local residents compared to Phase 2. In Phase 1, Paddepoel Energiek (a local foundation) and Grunneger Power (a municipal cooperative) formed a hybrid ownership structure for the project, supported by Shell's financing. In Phase 2, the Municipality of Groningen became the primary funder, granting €5.2 million to Grunneger Power, which took over as the project lead (A1, I4, I5) [24]. In Phase 1, the local foundation had equal participation in decision-making, while in Phase 2, the Municipality and Grunneger Power played more significant roles (GS4, I5, I2) [18]. Although the broader group of local residents participated in working groups, their involvement in the overall decision-making process was limited. In Phase 1, residents had the opportunity to express opposition, and they generally expressed satisfaction (I3). However, in Phase 2, residents had a passive role and were not engaged in shaping the rules (GS4, GS5, I5). Despite an apology, residents remained unsatisfied with the scaling decision made by the Municipality and Grunneger Power [18].

Financial activities in Phase 1 were primarily driven by the local initiative, without options for co-investment, while Phase 2 lacked resident involvement in financial decision-making altogether (I4). Surveys conducted in Phase 1 identified participation barriers, highlighting the need for transparency in the governance structure of the local foundation (15) [26]. The broader group of residents received project information through various channels, and project leaders actively exchanged knowledge with them, contributing to project planning (I1) [21]. In Phase 2, additional surveys and similar channels were utilized for information sharing, but it remained unclear how feedback influenced decision-making. There were no designated neighborhood cooperatives to facilitate active citizen participation (I5). Information dissemination continued through similar channels as in Phase 1, but participation in workshops and meetings decreased (I1) [18]. Project coordinators collaborated with scientific institutions for data collection and dissemination (I4). However, a clear dissemination strategy was still lacking. These Phase 2 changes resulted in more missing or lower scores in variables, compared to Phase 1. A key contributing factor to the decreased levels of participation was the absence of clear pathways for local citizens to actively engage in project decision-making (I5).

4.2. Amsterdam case

Wilhelmina Gasthuis, situated in the Noord-Holland Zuid energy region and Amsterdam municipality, comprises 4585 households with an average gas usage of 930 m3 (A4) [27]. In 2018, a group of approximately 10 local residents initiated plans to create a heating cooperative, targeting around 400 homes, which later expanded to include approximately 3000 households [18,28]. By mid-2020, the energy cooperative was established. Amsterdam's case showcases a positive participatory environment, providing a solid foundation for increased local resident participation, as highlighted in Table 4. Furthermore, the levels of participation variables indicate high levels of inclusion across all project spheres, as depicted in Table 5. The neighborhood benefits from existing infrastructure for integration and has access to sustainable energy technologies (A4, A7) [21]. Socio-economic attributes in Wilhelmina Gasthuis reveal that most homes are rentals, with middle and high-income earners who are highly educated (A2) [23, 27]. The project benefited from wide-scale buy-in from local residents, who had a good understanding of sustainability issues (A5). Local residents demonstrated a favorable attitude toward transitioning away from natural gas usage, which remained consistent throughout the project's scaling process (A6). The initiators of the project were also highly educated individuals, with technical expertise in infrastructural projects and a robust understanding of sustainability issues (A3, A5) [24, 49]. Established local energy cooperatives provided valuable knowledge and support to the project (A3) [49,53]. The energy cooperative and its local residents remain the leading stakeholders in the project and are even planning to establish their own heating company (A1, GS3) [18, 21].

The cooperative structure provides citizens with clear avenues for participation and decision-making (I5, GS5) [23]. Local residents play a significant role in decision-making processes, participating in voting at the Annual General Meeting and driving project decisions (GS5, I5). However, the cooperative leveraged its extensive network to form key partnerships with the municipality, the water company (Waternet), an advisory board comprising university employees, the housing corporation (Stadgenoot), and consultancies (A1, GS4, I5) [24,54]. The cooperative has also filled its skills gaps by including Baas Kuijpers and the Amstel, Gooi en Vecht Waterboard (AGV), which provides technical expertise and support (A1) [54]. Although the municipality provided a subsidy of €5000 per home, a €150,000 subsidy and a €7.7 million grant to the cooperative, the decision-making of the project remains with the cooperative (GS4, I4) [21]. Incentive schemes, such as subsidies for connection costs and natural-gas-free cooking, make the project affordable for local residents, ensuring income neutrality and providing home improvements, heating network connections, and gas-free cooking options (I4). Engagement with local residents involves door-to-door research, addressing concerns, and incorporating feedback into strategy changes (I5) [18,21]. Information sharing occurs through various channels, allowing residents to voice their opinions and preferences (I1, I2). Meetings witness high attendance, and residents generally express satisfaction with the cooperative, fostering a sense of local ownership and pride (I1). Amsterdam's case demonstrates a successful participatory environment, high levels of local resident inclusion, and active engagement throughout the project. Local residents, supported by key partnerships and incentives, remain the driving force behind decision-making processes.

4.3. Loppersum case

The Warmtenet Loppersum-Noord project, initiated by the Municipality of Eemsdelta in 2018, saw the active involvement of the local energy cooperative LOPEC in 2019 (GS3). The neighborhood consists of 1545 households with an average gas usage of 1550 m3 (A4) [29]. Initially starting with 10 residential connections and 4 non-residential connections, the project expanded to include 60 residential connections, and, most recently, it had reached 210 residential connections and 4 non-residential connections. Loppersum demonstrates an enabling participatory environment, and its close-knit village structure fostered high levels of local participation in the project (Tables 4 and 5).

Location (A4) and the availability of sustainable technology (A7) facilitated the project. While a biomass heating plant was initially considered, past negative experiences in the region led to significant resistance (I3). Consequently, the project shifted focus to wind energy with storage [18]. While the percentage of low-income residents had a negative socio-economic attribute, the level of education and home ownership were enabling factors (A2). With a positive history in sustainable energy projects, the pre-existing LOPEC cooperative played a vital role, having experience in running successful community energy projects (A3). A survey revealed that residents' support for transitioning away from natural gas and their awareness of sustainability issues were enabling factors (A5) [30]. The municipality played a key role in getting citizens to participate in the project through its door-to-door approach. The active involvement of local residents as key actors through the energy cooperative (GS3) played a significant role in the project's success.

The inclusion of local residents through the energy cooperative (A1) empowered participation and showcased high levels of citizen power. The cooperative provided a clear avenue for residents to engage in the project through membership and working groups (A1, GS5, I2). Loppersum's project structure involved a public-private partnership, with the municipality, LOPEC, and Enpuls (owned by DSO Enexis) forming a project team (A1, I5). The Municipality made a grant of about €3 million available, an additional €1.2 million was contributed through PAW, and Enpuls is expected to contribute €1.5 million to finance the network (I4) [31]. Decision-making power was shared among project planners, and residents had a say in project finances through cooperative representation and voting on budget decisions at the AGM (GS5, I2, I4). Residents were also kept informed through common communication channels (I1). Feedback was actively incorporated into project planning, and residents had opportunities to voice concerns through street ambassadors and meetings (I1, I3). Local capacity for data collection and dissemination further facilitated project activities. However, information sharing activities were rated as mid-range due to the level of meeting attendance and the absence of a clear dissemination strategy [18].

4.4. Zuidwolde case

In Zuidwolde, a neighborhood situated within Het Hogeland municipality, there are approximately 2300 households with an average gas usage of 1670 m3 (A4) [32]. The pre-existing Durabel cooperative, in collaboration with the municipal council, Hanze University of Applied Sciences, and Groninger Energie Koepel, applied for the PAW subsidy to initiate a heating project in 2020 (GS3, GS4, A1). The project aims to connect 382 houses and 18 houseboats to a heating network, eventually expanding to cover the entire neighborhood by 2028 [33]. Zuidwolde showcases an enabling participatory environment, leading to high levels of local participation in the project (Tables 4 and 5).

The project in Zuidwolde involves the development of a fifth-generation heat network with seasonal storage and a time-variable supply temperature (10–45 °C). Various technologies, such as aquifer thermal energy storage (ATES), vacuum tube collectors, and PV panels, have been utilized to maximize renewable energy sources and sustainable infrastructure integration (A4, A7). In terms of the socio-economic attributes, Zuidwolde has a small percentage of low-income households, with a majority of highly educated residents and a high rate of home ownership (A2) [21]. The Durabel cooperative, with prior experience in successful community energy projects, played a significant role in raising awareness and garnering participation from citizens (A3, A5) [18]. Given Zuidwolde's history as an earthquake-affected area, residents were eager to transition away from natural gas and address sustainability issues related to gas extraction (A6). The energy cooperative served as a platform for local residents to actively engage as key actors in the project (GS3).

The inclusion of local residents through the energy cooperative (A1) facilitated high levels of citizen power in Zuidwolde. The cooperative offered membership and working group opportunities, empowering willing residents to participate (I5). Project planners had equal decision-making power and there was a significant level of self-organization by local residents (GS5, I5) [18,33]. The project received a €4 million government contribution, accounting for 24% of the total investment [34]. Combining loans, subsidies, and residents' financial participation through the cooperative, the project's total investment has been estimated at around €14.5 million (I4). Local residents had decision-making power through the cooperative's representation in the project decision-making body and voting on financial matters at the AGM (GS5, I2). Extensive information sharing activities were conducted through typical communication channels (I1). Open access to annual reports and newsletters further enhanced transparency [21]. Feedback from residents was integrated into project planning, and mechanisms for voicing concerns through street ambassadors or meetings were provided (I1). Contention areas were effectively addressed through open dialogue, and adjustments were made to align with local preferences (I3) [18]. Local capacity for data collection and dissemination further contributed to project success. However, there was room for improvement in optimizing information sharing activities as there was no dedicated dissemination strategy. Durabel's previous success in community energy projects was instrumental in developing a solid financial and support basis for the project.

4.5. Wageningen case

In 2016, a group of local residents in Benedenbuurt, Wageningen, initiated plans for a heat network (A1). The neighborhood consists of 3110 households with an average gas consumption of 1150 m3 (A4) [35]. Subsequently, in 2018, the energy cooperative, Coöperatie WOW, was established with the goal of connecting 450 households to the heating network. Wageningen fostered an enabling participatory environment, leading to high levels of local participation, and it positioned itself as a Dutch front-runner in community heating (Tables 4 and 5).

While sustainable technologies were available, there were some challenges with the project location (A4, A7). The distance from the Rhine river was too far and geothermal turned out to not be feasible, which made the project location and technology choice a challenge for the CEI [23]. Research was then done, which indicated that a heat pump which extracts heat from ambient air would be the most feasible [21]. In terms of the socio-economic attributes, the majority of residents are well educated, largely middle-income and are evenly distributed between rental and owned homes (A2). The Benedenbuurt Wageningen initiative predated the project, benefitting from the expertise of technicians, financial experts, and even an ex-alderman (A3, A5) [21]. The residents' higher education levels correlated with their awareness of sustainability issues, and the neighborhood meeting turnout was relatively high, ensuring widespread awareness of the project's existence. Approximately 44% of local residents submitted support statements, indicating their favorable stance toward moving away from natural gas use [18]. As mentioned above, after considering geothermal options, a heat pump utilizing ambient air as a heat source was deemed the most feasible alternative [101]. Local residents played a pivotal role in the project through their involvement in the energy cooperative (GS3).

The participation of local residents through the energy cooperative empowered them with significant citizen power (A1). The cooperative facilitated participation through membership and engagement in working groups (I5). The WOW cooperative, municipality, housing association, and a consortium of two companies (Kelvin/Groendus) collaborated closely on the project, with the consortium joining as the heat supplier in 2021 (GS4) [21]. The project received a grant of €5.3 million through the PAW program, leading to the establishment of the heating company, Warmtebedrijf WOW (I4). Local residents participated as street ambassadors and in working groups, while project planners had equal decision-making power (GS5). Residents were actively engaged in project decisions and technology design through various meetings and the AGM of the cooperative (I2). Financial decisions were also made through voting on the cooperative's budget at the AGM. Representatives of the cooperatives also had a say in project finances, allowing local residents to contribute to financial decision-making (I4.). Local residents received information through meetings, the cooperative's website, general meetings, street gatherings, working groups, house visits, and newsletters (I1). They had open access to annual reports and newsletters through the cooperative's website, ensuring transparency [21]. Feedback from residents was incorporated into project planning, and overall, residents expressed satisfaction with the information sharing activities. Opportunities for residents to voice their concerns were provided through street ambassadors and meetings (I1.3). Technological options were reviewed and adjusted based on local preferences, highlighting their inclusion in the overall project design.

5. Discussion

5.1. Unfolding dynamics of local participation processes in community energy initiatives

The analysis of participatory processes within community energy initiatives reveals the significance of the participatory environment in shaping levels of citizen participation. Four of the five cases had enabling factors for participation and correspondingly high levels of citizen participation. In contrast, the Groningen case study demonstrated how a poor participatory environment can impact citizen participation in community energy initiatives. However, reflecting on the application of the framework used to analyze the case studies, it is evident that socio-economic attributes (A2) do not seem to directly negatively impact participatory outcomes. However, they strongly correlate to a sustainable knowledge base and willingness of residents to shift away from fossil fuels in the project location (A5, A6). Lower levels of sustainability knowledge and willingness to transition were demonstrated to have a direct impact on the level of participation in a project. Furthermore, history and past experience (A3) were shown to have a positive impact when they were present but not necessarily a negative impact when absent.

The results highlight the importance of including local residents in all areas of participation, such as financial/economic, technical, and social aspects, in an active rather than passive manner. Four out of the five cases successfully achieved this goal, demonstrating high levels of citizen power across their operations. The analysis of participatory processes within community energy initiatives revealed the significance of the participatory environment in shaping levels of citizen participation. In most instances, information sharing methods were commonly used to engage the broader local residents, and feedback from residents was generally incorporated into project design.

Unidirectional information sharing, as illustrated in the Groningen case, can hamper the enthusiasm for community energy projects and the willingness to participate in them. This may be attributed to the lack of perceived ownership and importance of local residents. Across cases, community meeting attendance was generally not high, suggesting the need for more effective engagement strategies in community energy projects to encourage broader participation. Importantly, the presence of energy cooperatives emerged as a key success factor in ensuring local resident participation. Transparency and uniformity in governance by energy cooperatives provides a clear avenue for local residents to actively participate in project decision-making. The energy cooperative model facilitated demonstrated levels of citizen power in decision-making processes, investment and financing activities, and self-organizing activities. The energy cooperative model coupled with strong communication channels allowed local residents to decide the degree of participation that was suitable for them. The lack of a neighborhood-level cooperative model in Phase 1 and Phase 2 of the Groningen case, coupled with poor communication, proved to be key factors in the decline of participation throughout the project. Furthermore, our research indicated the benefits of smaller scale projects in terms of local resident inclusion. In cases such as Loppersum and Zuidwolde, the smaller scale allowed for one-on-one engagements, direct communication with the municipality, and awareness and trust in local cooperatives. Smaller projects can more effectively align the interests of local residents and foster strong community engagement.

It should also be noted that several first-tier indicators were scored 100 across the case studies. Based on our interpretation of the data, scores of 100 indicate that there were no gaps or negative relationships with the first-tier variables, and subsequently with citizen participation. However, despite several cases scoring 100 for one variable, no case scored 100 across all first-tier variables. This means that while the case study CEIs may have excelled in certain areas of participation, all the CEIs had areas which could be improved. Additionally, our understanding of citizen participation is constantly evolving and therefore the measurement of citizen participation should be expanded and/or improved through additional or refined variables in future research.

5.2. Barriers and challenges to citizen participation within CEIs

Barriers and challenges to citizen participation in CEIs have been identified through our research. The case of Groningen Phase 2, specifically in the Paddepoel neighborhood, exemplifies some of these challenges. The lack of inclusion and transparency in the decision-making process, along with a disconnect between the project and the neighborhood residents, resulted in decreased satisfaction and non-participation among residents. One significant challenge this case identified is the dilemma of scaling up projects, which requires a level of professionalization to optimize design and implementation. However, increased professionalization can create a sense of distance between project planners and local residents, leading to a decreased sense of local ownership. This challenge was evident in the Groningen project, where the larger and more professionalized Grunneger Power cooperative was not considered “local” by the initial neighborhood residents, impacting support in Phase 2.

How “local” is defined by different stakeholders is a further challenge to participation in CEIs. The Groningen case exemplifies this issue, where the municipality framed the project as local, but the residents of the Paddepoel neighborhood did not perceive it as such, leading to a lack of support for the initiative. Defining “local” without engaging with the community and reaching a consensus can result in a disconnect between the project and the residents it aims to serve. It undermines the sense of ownership and inclusion among local stakeholders, ultimately hindering their support and participation in the initiative. This highlights the importance of transparent and inclusive decision-making processes when defining and interpreting the meaning of “local” in community energy initiatives.

In contrast, the Amsterdam case provides insights into how to successfully balance professionalization and maintain local resident control. The factors contributing to this success included the higher expertise levels of project initiators, accompanied by a strong network providing technical knowledge, funding avenues, and partnerships. The project incorporated financial instruments to incentivize broad participation. Consistency in the cooperative’s role and the segmentation of the project area into smaller blocks also facilitated personalized engagement and a sense of local involvement.

5.3. Finding significance and applicability

Our research is of significance in the realm of thermal energy communities, addressing notable gaps in the existing literature. Previous studies, particularly the review by Fouladvand et al. [36], highlighted the scarcity of research exclusively dedicated to thermal communities. Most studies focused on technical and economic aspects of thermal CEIs, neglecting behavioral and institutional dimensions. Van der Schoor and Scholtens [37] emphasized the need for a transdisciplinary approach and for the involvement of local stakeholders. Consequently, our findings contribute to bridging this research gap, shedding light on the understudied aspects of thermal CEIs. Moreover, our results have broad relevance and are connected to the existing body of literature. In light of this, the following paragraphs delve into specific examples and analyses that demonstrate the extensive relevance of our findings in the context of existing literature.

In our research, we found that strong social capital and close ties between leadership and villagers in smaller villages correlated positively with community collaboration. These close-knit relationships not only fostered cooperation but also created a strong sense of community. Within these communities, structured decision-making processes within energy cooperatives played a pivotal role in ensuring successful collaborations. Conversely, our study in Groningen shed light on the challenges associated with informal configurations. In such contexts, misunderstandings and discontent among community members were prevalent, highlighting the importance of formalized structures and clear pathways for effective collaboration. Our findings closely align with the research conducted by Von Bock et al. [38] in German CEIs. They emphasized the indispensable nature of social connections and clear rules. Their findings mirrored ours, emphasizing the inadequacy of informal rules and emphasizing the necessity of shared understanding and proximity between leaders and the community, coupled with formalized legal frameworks. Similarly, our research corroborates the insights from Van Dam and van der Windt [39] in their analysis of a Dutch CEI. They noted that while informal processes and structures can nurture creativity, a more structured approach is essential for ensuring effectiveness and long-term sustainability.

In our investigation, we observed that CEIs with robust technical expertise advanced rapidly in their endeavors. We found that collaborations with existing neighborhood organizations, as evidenced in Amsterdam, Loppersum, and Zuidwolde, offered invaluable support and networks, facilitating the progress of district heating projects. Furthermore, active citizen participation in technical decisions, coupled with subsidies such as those provided by the PAW program, emerged as pivotal factors contributing to the success of these initiatives. Our findings parallel the research conducted by Van der Schoor and Van der Windt [40] in their study on Dutch heating CEIs. They emphasized the crucial role of technical expertise and financial investment in district heating projects. Additionally, their research highlighted the effectiveness of diverse community engagement strategies, particularly emphasizing the success achieved by CEIs with partnerships with local neighborhood organizations. Moreover, their study emphasized the impact of community input on technical decisions, emphasizing the significance of democratic structures and transparent decision-making processes. These aspects were also evident in our research, reinforcing the importance of active citizen participation and transparent decision-making in successful CEIs. Similarly, the challenges related to initial costs and lack of proper funding schemes, as noted by Papatsounis, Botsaris, and Katsavounis [41] aligns with our research findings. While our study highlighted the positive influence of subsidies such as the PAW program, it also pointed out the need for further research on addressing initial costs and ensuring financial accessibility within CEIs.

In our study, we uncovered a significant barrier hindering the progress of CEIs: the challenge of accessing finance. This finding echoes Wierling et al.'s [42]extensive analysis of 2671 cooperatives across various countries, where they underscored the financial hurdles faced by energy cooperatives.

We also found that internal configurations played a pivotal role in shaping democratic structures within CEIs. Additionally, our research highlighted the significant impact of positive community interactions, especially when supported by local government, on increasing participation rates. These findings mirror the observations made by Koirala et al. [43], who emphasized the importance of adapting institutional design and business models within community energy projects. Nevertheless, our study also illuminates a research gap within the existing literature. Further exploration is essential to delve into the specific aspects of adapted business models and internal organizational factors within CEI frameworks. Addressing these areas through future research endeavors can provide in-depth insights necessary for enhancing the effectiveness and sustainability of community-driven energy initiatives.

6. Conclusions

The analysis of participatory processes in community energy initiatives highlights the significance of the participatory environment in shaping levels of citizen participation. The findings revealed that enabling factors in the participatory environment contribute to higher levels of citizen participation, while a poor participatory environment can hinder engagement.

In the investigation of lessons learned and good practices for addressing the dual challenge in the application of local ownership and participation in energy transitions, our findings suggest the importance of inclusive participation, where local residents are actively involved in all aspects of the initiative. Information sharing and feedback mechanisms played a crucial role in engaging the broader community and incorporating their perspectives into project design. The presence of energy cooperatives emerged as a key success factor, facilitating citizen power in decision-making processes and fostering transparency and local ownership.

Furthermore, the practical implications for EU energy policy that is seeking to incorporate CEIs into energy transitions are evident. Creating an enabling participatory environment that promotes active citizen engagement and transparency is crucial for successful CEIs. Policies should emphasize the importance of energy cooperatives, effective communication channels, and tailored engagement strategies. Clear definitions and inclusive decision-making processes that align with local perceptions of "local" are essential for fostering a sense of ownership and support among residents. Existing studies suggest that regulatory barriers and policy incentives are crucial for CEIs, future research could thus explore policy and regulatory factors which support or challenge CEI development. Furthermore, investigating the role of technology, governance models, business models, and financing mechanisms in community energy initiatives would provide valuable insights.

While the study has illustrated its usefulness in understanding citizen participation in CEIs, there are some limitations that should also be considered. Data availability, particularly at the neighborhood level, posed challenges, and alternative data collection methods may be necessary. Furthermore, a reluctance to share financial reports and conflicts within projects highlights the need for more in-depth research methods to capture these dynamics.

Teladia and van der Windt [3] noted that the SESF is not commonly used to understand CEIs, despite it providing a good conceptual foundation for understanding the polycentricity of CEIs. They argued that connecting the SESF to the literature on participation allows for the analysis of participation across the technical, scientific, political, and economic dimensions that cut across CEIs. Overall, our study showed the value of exploring the SESF enriched with the participation literature as an analytical tool to understand local participation in CEIs. The framework allows for comparison between diverse case studies and effectively identifies participation gaps; however, it would benefit from several improvements.

First, the scoring methodology used highlights gaps and negative relationships to the selected variables. It is evident that in many of the cases reviewed, CEIs scored 100 on several variables. The results may be reflective of the fact that several of the case studies are front-runners in citizen participation in Dutch CEIs. However, it is also possible that the variables selected encompass a sufficient number of variables or subvariables that reflect challenging or problematic areas of citizen participation in CEIs. Consequently, further research could focus on revising, improving, and/or expanding the framework variables based on the evolving participation literature on CEIs to ensure that the variables selected allow for a robust analysis of citizen participation barriers in CEIs. Additionally, ecological factors and their connection to participation require further exploration to strengthen the framework's comprehensiveness. Future research can build upon our study by conducting additional case studies in diverse contexts and various scales.

Funding sources

The research institute Energy Systems Transition Centre (ESTRAC) provided financial support to conduct the background research which has been used in this article. The sponsor did not have any role in the study design, collection, analysis and interpretation of data, in the writing of this article and in the decision to submit this article for publication.

CRediT authorship contribution statement

Aamina Teladia: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Writing – original draft, Visualization. **Henny van der Windt:** Supervision, Writing – review & editing, Resources, Investigation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

All data is public and accessible

Acknowledgments

We gratefully acknowledge financial support through the research institute, Energy Systems Transition Centre (ESTRAC), which supported the background research which informed this publication. We are extremely appreciative of the survey data provided by Sarah Elbert, Carina Wiekens, Kathelijne Bouw, and Cyril Tjahja. Helpful comments and revisions were provided by Klaus Hubacek. We would like to thank colleagues from the University of Groningen, Hanze University of Applied Sciences, and TNO, who provided useful feedback and insights during preliminary presentations of the work.

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