Co-creating Systemic Knowledge about Community Acceptance: Guidance for integrating Causal Loop Diagrams and Participatory System Mapping in Acceptance Research

Marius Rogall[1], Jan-Hendrik Kamlage[1 2], David Sasse[1], Klaus Krumme[2 3]

[1]Ruhr-University Bochum, Germany

[2] University of Duisburg-Essen, Germany

[3] National Technical University/ Kharkiv Polytechnic Institute, Institute of Education and Science in Economics, Management and International Business, Ukraine

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Abstract. The energy transition is a key component in achieving Germany's and Europe's environmental and energy policy goals. While public support for the energy transition is generally high, local conflicts surrounding the related infrastructure projects are slowing down the transformation and causing costs to rise. Acceptance research focuses on the factors and contextual conditions under which such projects are accepted or rejected by affected stakeholders. However, previous research approaches are lacking systemic perspectives that consider the interactions of factors in locally specific constellations. In this article, we develop a conceptual framework that enables us to analyse complex local constellations of acceptance formation. Our approach combines systemic and participatory perspectives on community acceptance of renewable energy technologies (RET) and translates them into a systematic methodological approach in the form of causal loop diagrams (CLD) and participatory system mapping (PSM). The potential of this methodology is illustrated using preliminary results from a case study on electricity grid expansion. These show that CLDs are suitable for capturing, visualising and understanding complex causal mechanisms in the process of acceptance formation. Due to the collaborative research process of researchers and stakeholders within the PSM, the results show an increased relevance for the implementation of communication strategies in the local context. Overall, the combination of systemic and participatory research methods in the form of CLDs and PSM is a suitable approach to expand the methodology and analytical framework of acceptance research. It enables complexity to be captured and thus advances our understanding of acceptance formation.

1. Introduction

The energy transition is a key component in achieving Germany's and Europe's environmental and energy policy goals (Bundesregierung, 2023; Europäische Kommission, 2019). The expansion of renewable energies and their integration into the existing energy system represents the central challenge in this regard (Bertsch et al., 2016). This process of transformation manifests itself tangibly in the form of energy infrastructures, such as wind turbines, electricity pylons, large-scale transformers and ground-mounted PV systems (Kühne, 2024; Walker, 2024; Weber, 2019).

The support of the German population for the expansion of these renewable energy technologies (RET) and for the energy transition in general has been consistently high for many years (Bertsch et al., 2016; Setton, 2020). However, in communities affected by the construction of energy infrastructure, conflicts and resistance arise frequently, as the burdens of change become visible and the landscape is transformed (Devine-Wright and Devine-Wright, 2009). Local protests and resistance consistently lead to increased costs and delays in the realisation of RET projects (Löschel et al., 2013).

The acceptance and non-acceptance of infrastructure projects forms at the level of people's individual motives or attitudes and exists on a continuum between the two poles of approval and rejection of a project. On this continuum, positions vary between active support, simple approval or tolerance to complete rejection.[1] Acceptance is fragile and the result ‘of a complex, permanent process of communication and action between acceptance subjects and acceptance objects extending over the entire life cycle of an acceptance object’ (Bentele et al., 2015, p. 5). In addition to the political and social factors that influence acceptance, research is increasingly focussing on structural and spatial conditions, such as the value of landscape or place attachment (Delcayre and Bourdin, 2025; Devine-Wright, 2009).

However, there is a lack of research that (1) adopts a systemic perspective on the complex and dynamic local acceptance formation processes, (2) translates this into a systematic methodology and (3) links it with participatory research approaches in order to validate the findings discursively against the practice of local stakeholders.

Our contribution addresses this research gap. We propose the combination of two complementary methods. Through the integrated use of Causal Loop Diagrams (CLD) and Participatory System Mapping (PSM), we develop a holistic and systemic methodological approach that takes into account the complexity and context-sensitive

[1] The term acceptance is often insufficiently defined in research on energy infrastructures and renewable energies and is often barely differentiated from similar terms such as support, resistance, uncertainty or apathy (Batel et al., 2013).

formation of community acceptance, incorporates discursively validated practical knowledge and thus generates socially robust findings (Nowotny et al., 2001).

In the following chapter, we present our conceptual framework for analysing the acceptance of RET in affected communities with the help of CLDs and PSM. We have translated this conceptual framework into a concrete methodological approach as part of a case study from the German electricity grid expansion. We will explain this approach in more detail in Chapter 3. In Chapter 4, we illustrate the possible results of our approach on the basis of examples from the case study. Finally, Chapter 5 reflects on the gains and challenges of the proposed research procedure.

2. Conceptual Framework

In their framework, Wüstenhagen et al. (2007) distinguish between three central and interwoven dimensions of acceptance: socio-political, community and market acceptance. While the dimension of socio-political acceptance addresses general support in politics and society, market acceptance refers primarily to economic and market players. In this article, we focus on the third dimension of community acceptance. This refers to acceptance of various stakeholder groups at the local level, such as residents, local entrepreneurs, local politicians, and local clubs and initiatives. The level of community acceptance depends on the attitudes of these local actors with regard to a new technology or infrastructure that is realised in the immediate proximity. It is the result of a complex interplay of diverse factors from the local and superordinate spatial levels (Wolsink, 2018). Kluskens et al. elaborate on this idea by understanding local acceptance formation as a process of weighing up different objects of acceptance. Stakeholders at the community level evaluate, for example, the location of an infrastructure or the planning process and finally arrive at an overall assessment of the project. That means, even in cases where there is no active resistance to the project, not all of these aspects are necessarily accepted, i.e. ‘even in the unproblematic cases acceptance is ambiguous’ (Kluskens et al., 2024, p. 842).

In previous research, there is a knowledge gap with regard to such consideration processes and the interaction between various influencing factors. Previous studies have mainly focused on identifying individual factors relating to specific problems (for an overview, see Kamlage et al., 2024), like landscape changes and their effects on place attachment and place identity of the affected community (Devine-Wright and Devine-Wright, 2009; Kühne, 2018), psychological issues like risk/benefit evaluations, trust and perceived fairness (Gross, 2007; Huijts et al., 2012; Richter et al., 2016), public information and participation (Kamlage et al., 2020) or the role of community benefits and financial participation (Cowell et al., 2011; Schönauer and Glanz, 2023).

In contrast, the 'fertile ground' approach by Delcayre und Bourdin (2025) offers a more valuable analytical approach to address the complexity of the local acceptance formation process. In their view, community acceptance largely depends on the extent to which the project characteristics are compatible with a series of ‘territorial characteristics’. These are defined as various specific local factors like socio-economic structures, place attachment, past experiences and historical lines of conflict (Delcayre and Bourdin, 2025).

However, in general, research to date has mostly lacked a methodology that integrates systemic perspectives on local acceptance formation and can thus capture complexity and context instead of reducing or ignoring them. In terms of methodology the predominantly used research methods are quantitative surveys (Huijts et al., 2007; Zoellner et al., 2008) or qualitative methods such as expert interviews, media analyses and participant observation in the context of case studies (Sanchez Nieminen and Laitinen, 2025). While qualitative case studies can capture the complex constellations at least descriptively, through a dense and inductive description of specific cases (e.g. Eichenauer and Gailing, 2022; Fienitz, 2025), it is difficult for studies with a quantitative survey method (Baxter et al., 2013; Hoen et al., 2019; Zoellner et al., 2008) to overcome the isolated consideration of individual factors.

In order to address the lack of systemic perspectives and to comprehend this process of weighing up different factors, we have developed a conceptual framework that translates a systemic perspective on community acceptance into a systematic methodological approach and also integrates participatory research methods (see Figure 1). To capture, visualise and understand the various acceptance factors, their relationships and the complex and dynamic interaction patterns that emerge, we use CLDs as a methodological tool of the system thinking approach (Forrester, 1968; Sterman, 2004). When developing the CLDs, we use the methodology of Participatory System Mapping (PSM) which integrates relevant stakeholders into the research process (Barbrook-Johnson and Penn, 2022). The mutual validation in the dialogue between researchers and stakeholders minimises subjective bias in the construction of the CLDs and increases the epistemic quality of the results. This procedure offers a twofold gain in knowledge: Systemic depth and local, contextualised relevance. In the following, we describe the methodology of CLDs and PSM in more detail.

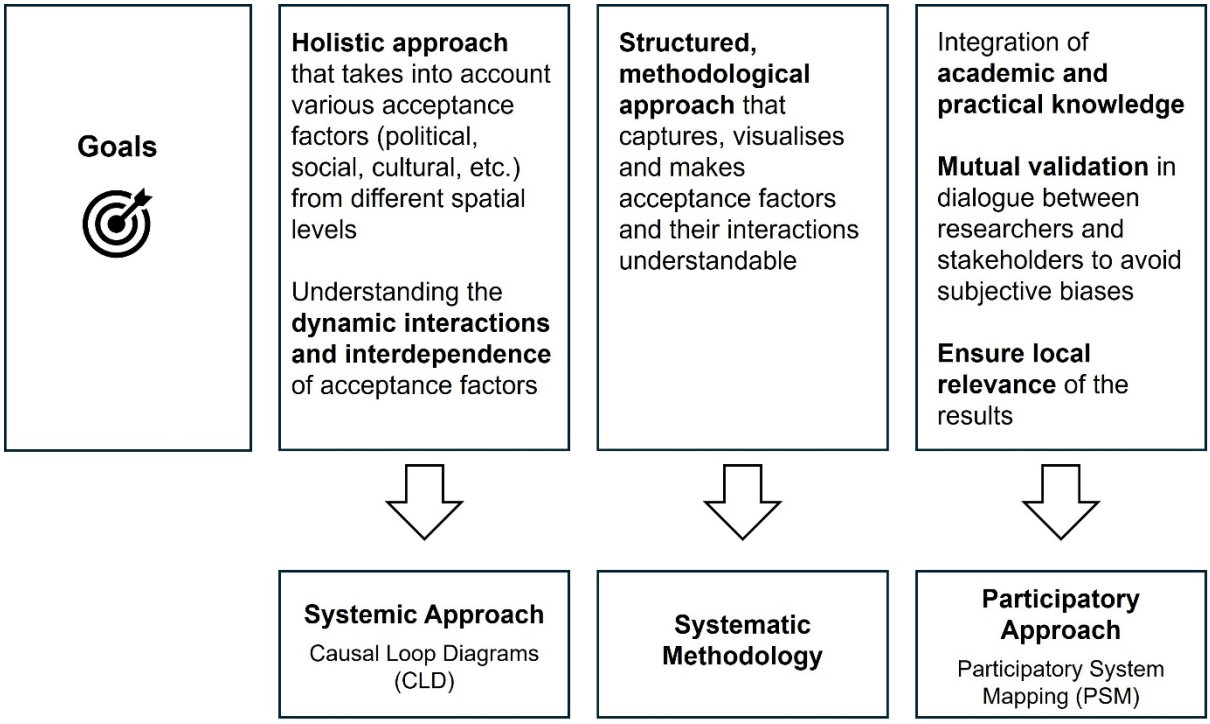

Fig. 1: Illustration of our conceptual framework, authors' own presentation.

2.1. Causal Loop Diagrams (CLD)

CLDs are a tool for visualising causal relationships between different elements of a system. CLDs consist of three core components. Firstly, the variables - in our case the acceptance factors. These acceptance factors are interwoven through causal links, which are the second core component. These links have a polarity, which is indicated by + or - . A + means that both variables change in the same direction. A - on the other hand indicates that both variables are moving in opposite directions. This is illustrated by the examples in Figure 2. If the number of citizen initiatives (CIs) increases, public attention for the power line project also increases, or if the number of CIs decreases, public attention for the power line project also decreases (same direction). If the number of existing infrastructure increases, the amount of available land decreases, or if the number of existing infrastructure decreases, the available land increases (opposite direction).

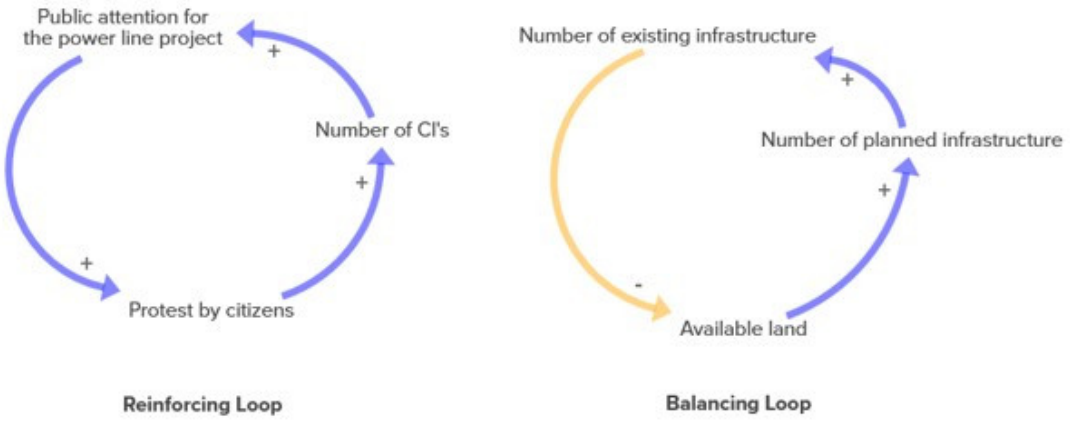

Fig. 2: Examples for a reinforcing and a balancing loop, authors' own presentation. Legend: + / violet arrows = same direction; - / orange arrows = opposite direction

The third component of a CLD are the feedback loops. A distinction is made between reinforcing loops, which represent an exponential development, and balancing loops, which represent an equalising development or an approach to a state of equilibrium. In the example given in figure 1 for a reinforcing loop, the increasing number of CIs leads to an increase in public attention for the project, which reinforces the protest, which in turn increases the number of CIs. The variables reinforce each other and protest mobilisation increases, as the rising attention for the project involves more actors who organise themselves into CIs and thus generate more attention. The dynamics surrounding infrastructure-related land use conflicts, on the other hand, are an example for a balancing loop. A high availability of land in a municipality creates incentives to plan and realise infrastructural projects. The higher the number of planned infrastructure the higher the number of actually existing infrastructure. However, the more infrastructure exists, the less land is available and with little land available few new infrastructure projects are going to be planned.

With the help of CLDs, we are able to take a systemic perspective on our research topic of community acceptance. Factors from different social subsystems (political, social, cultural, etc.) and spatial levels (local, regional, national, global) can be integrated into the CLD and related to each other. The visual form of the CLDs also makes it possible to consider a large number of factors simultaneously without reducing the complexity of the case (Barbrook-Johnson and Penn, 2022). This allows feedback loops and other system-dynamic mechanisms to become visible.

2.2. Participatory System Mapping (PSM)

The complex systems of acceptance formation can be assessed comprehensively and plausibly through the collaboration of researchers and stakeholders. Kates et al. very early pointed out that: 'participatory procedures involving scientists, stakeholders, advocates, active citizens, and users of knowledge are critically needed' (Kates et al.,

2001, p. 641). Lang et al. argue that complex real world phenomena and problems need the constructive knowledge inputs of various affected societal groups and perspectives to be relevant for the practice (Lang et al., 2012, p. 25f.). According to Norström and others, co-production processes should be context based and locally embedded, pluralistic and inclusive, goal-oriented and interactive in nature (Norström et al., 2020).

To properly represent this productive and collaborative basic understanding, we integrated participatory research methods into our conceptual framework. We used the Participatory System Mapping (PSM) method (Barbrook-Johnson and Penn, 2022), to develop a CLD through a participatory process with stakeholder, reflecting local acceptance formation in our case study.

First coined as a formal method by Sedlacko et al. (2014) in the context of knowledge brokerage on sustainable consumption, PSM has since diversified rapidly and has been used in several sustainability related domains, such as last-mile logistics and local food networks (De La Torre et al., 2019; Gruchmann et al., 2019; Melkonyan et al., 2017), tourism policy design (Suno Wu et al., 2021; Tourais and Videira, 2021), ecosystem-service governance in marine coastal zones (Lopes and Videira, 2017, 2015), business sustainability in rural dairy enterprises (Kamath et al., 2019), and transport-decarbonisation strategies (Penn et al., 2022). Collectively, these applications demonstrate how the original CLD-based workshop format has become a versatile, stakeholder-centred tool for tackling complex sustainability challenges across multiple domains.

In our collaborative research methodology, we draw on deliberative design principles (Niemeyer et al., 2024) to conceptualise a process that facilitates transparent, open and free discourse on acceptance factors, while minimising the effects of interpersonal power structures. Such a process enables the discursive validation of problem structures and system understandings. The perspectives and validity claims that come up during the process are based on shared and mutually recognised arguments. From this perspective intersubjectively confirmed knowledge is not discovered, but co-produced under conditions that promote communicative rationality (Habermas, 1981; Thompson, 1983).

3. Implementation in Methodology

Based on the conceptual framework described above, we have developed a concrete methodological approach in the context of a case study from the German electricity grid expansion in order to investigate community acceptance in relation to the construction of a new power line.

There are templates in the literature for structuring PSM workshops with stakeholders and generally for the iterative process of PSM from collaborative mapping workshops and post-production phases of the researchers (Barbrook-Johnson and Penn, 2021,

2022; Lopes and Videira, 2015; Sedlacko et al., 2014). Usually, the first step involves a joint workshop of researchers and stakeholders to jointly develop an initial draft of the CLD. For pragmatic considerations and against the background of experience from a previous case study, we decided to deviate from this proposal. Instead of starting the first workshop with a blank sheet, we created a first draft of the CLD as part of the case study described here on the basis of qualitative data collected by us and validated and further developed this in discourse with stakeholders in the PSM workshop. This decision was primarily made due to time constraints on the part of the stakeholders involved - the representatives of the Transmission System Operator (TSO), which is responsible for the planning, construction and subsequent operation of the power line. We had 3.5 hours available for the PSM workshop. As the development and discussion of a CLD is very time-consuming and methodologically demanding due to the complex interrelationships in the social systems under consideration, there is a risk that a workshop for the joint construction of an initial version of the CLD will fail due to excessive demands on the stakeholders involved and will end with results that are of little use and biased.

Accordingly, our research process is divided into the following four phases (see Figure 3): (1) Drafting a CLD; (2) Conducting a PSM workshop; (3) Iterative feedback and further development of the CLD (editing); (4) Final Workshop. The individual phases are explained in more detail below.

3.1. Drafting a CLD

Prior to the first draft of the CLD, a comprehensive process of data collection, evaluation and analysis took place. The first step involved collecting a large amount of qualitative data (see Table 1). This came from participant observations at TSO information and participation events in affected municipalities. In addition, various text documents were analysed, including articles from the local press, statements from local stakeholders and websites of protest actors.

Source		Number
Documents	TSO Statements	9
	Public Media / Press	93
	Political Publications	7
	Social Media Posts	7
	Formal Statements	4
	CI websites	12
Observations	Information events of the TSO	6

Table 1: Overview of the empirically collected qualitative data in the case study presented here.

The resulting empirical material was analysed and coded with regard to the identification of acceptance factors and relationships between these factors. In a second step, these were transferred to a cross table.

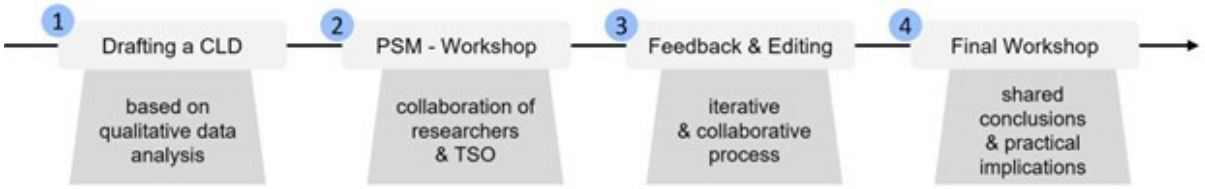

Fig. 3: Illustration of the research process, authors' own presentation.

A total of 49 different variables and 68 relationships between them were identified. A first version of the CLD was developed on the basis of the cross table, which served as the basis for the PSM.

This included a total of six central mechanisms. We define mechanisms here as a construct of relationships between various interdependent local factors which, in their specific combination, have an effect on the acceptance of the power line project. One of these central mechanisms is the core engine of our CLD. The core engine is the centrepiece of a CLD. It forms the basis from which the entire diagram is developed and expanded (Barbrook-Johnson and Penn, 2022). In our case, the core engine is the mechanism that represents the process of protest mobilisation against the planned power line in the form of a reinforcing loop (see Chapter 4).

3.2. PSM-Workshop

The next step was to organise a PSM workshop, which plays a central role in our research process. In addition to the researchers, six representatives of the TSO took part. The workshop served to validate the first draft of the CLD from the perspective of the stakeholders involved in a transparent, open, inclusive and moderated collaboration process and to develop it further in the discourse. The perspectives, assumptions and validity claims of the researchers and TSO representatives were critically reflected upon and mutually acknowledged in dialogue in order to arrive at a common understanding of the acceptance formation process under consideration (Lopes and Videira, 2015). The dialogue about the CLD deepened the understanding of the acceptance formation process among all participants and opened up new perspectives.

An introduction to the CLD methodology is essential in order to enable stakeholders to participate constructively in the workshop. For this reason, the TSO representatives were introduced to the methodology and systemic perspectives on acceptance in advance of the workshop, and the workshop itself also began with a brief introduction to the perspectives of system thinking and the syntax of CLD. In this way, a basic understanding of the method and thus a basis for discussion for the content part was created.

In order to avoid overwhelming the stakeholders in the workshop with the extensive CLD, it was sent to them in advance along with some introductory information to aid understanding. In addition, the six central mechanisms of the CLD were explained step by step by the researchers during the workshop, and previous steps and assumptions in the research process were made transparent. The mechanisms were then discussed separately with the stakeholders and gradually linked together. This enabled the stakeholders to develop a good understanding of the CLD. During the workshop, the mechanisms and the CLD were projected onto the wall using a projector and also laid out on the table in printed form. The comments, questions and additions that arose during the workshop were recorded in written form on the printed copy of the CLD. Finally, the workshop participants were given the opportunity to prioritise certain variables, relationships or sub-areas of the CLD.

3.3. Iterative feedback and further development of the CLD (editing)

Following the PSM workshop, the comments and additions collected there were processed and incorporated into the CLD (post-production phase). In some cases, this also meant more in-depth research, the results of which were incorporated into the CLD in the form of new variables and improved the analytical depth. In total, 5 new factors and 11 new links were incorporated into the CLD following the workshop. One variable from the first draft of the map was removed. The revised CLD will be returned to the workshop participants from the TSO with a request for further feedback. Depending on the amount of comments and questions, this can be done by email or in an online meeting.

The CLD will be further developed in the course of the case study. This will be done in close cooperation with the representatives of the TSO in the form of recurring feedback meetings and subsequent post-production phases in which the comments will be incorporated.

3.4. Final Workshop

The case study concludes with another workshop with the TSO representatives. Here, the final version of the CLD is discussed and validated once again. The aim of this workshop is to bring together the results of the participatory process and the qualitative data collected in a final, plausible and coherent CLD, whose conclusions are shared by all participants. Furthermore, effective points of intervention are to be identified in a joint discussion that can have a decisive influence on local acceptance. These intervention points may then be incorporated into the TSO's future communication strategy and addressed where possible.

The workshop will conclude a process lasting several months, during which researchers and representatives of the TSO developed shared knowledge about local acceptance formation in a specific case study and recorded it in the form of a CLD and implications for practice.

4. Empirical Implications

The following section illustrates the results of the approach described in the previous chapter and the insights that CLDs can provide. For this purpose, simplified excerpts from the CLD developed in our case study are shown below as examples. The case study has not yet been finalised, which is why the following illustrations and conclusions do not claim to be complete or conclusive.

Figure 4 shows the central mechanism, or core-engine, of our CLD.

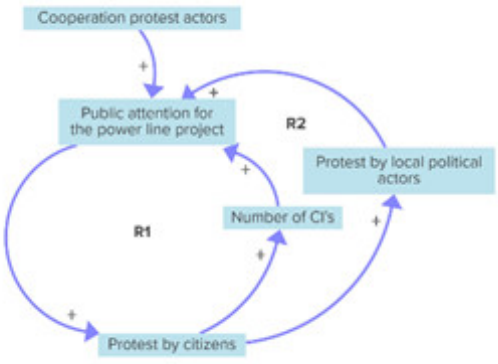

Fig. 4: Loop of protest mobilisation (core engine) from the CLD of the case study presented here, authors' own presentation. Legend: + / violet arrows = same direction; blue marked factors = factors of the core engine

It consists of a reinforcing loop that depicts the dynamics of protest mobilisation in our case study. Due to the difficulties in empirically capturing the often tacit acceptance of infrastructure projects such as power lines, we worked with a negative definition and used the CLD to map how constellations of factors affect the dynamic development of protest against the project.

The reinforcing loop R1 describes the mechanism by which citizens join the protest, organise themselves in the form of CIs and thus draw the attention of a wider public to the issue and their position. This attracts new members to the protest movement and so on. This feedback loop is reinforced by the fact that other actors, such as the affected municipalities, join the protest alliance and thus give it further attention and legitimacy. This can lead to an exponentially growing protest mobilisation. For us, the research question linked to this dynamic is: What factors reinforce or hamper this reinforcing loop of protest mobilisation?

In order to answer our research question, we first identified various primary factors and linked them to the variables of our core engine (see Figure 5). By primary factors, we mean those factors that have a direct influence on the factor ‘protest by citizens’ and thus on the protest mobilisation loop. ‘Local burdens’ associated with the new power line, ‘doubts about the need’ of the power line and the perceived ‘threat to local identity’ intensify the protest and thus also drive the protest mobilisation loop. Perceived procedural fairness, on the other hand, tends to lead to greater acceptance of the project and can slow down the loop of protest mobilisation.

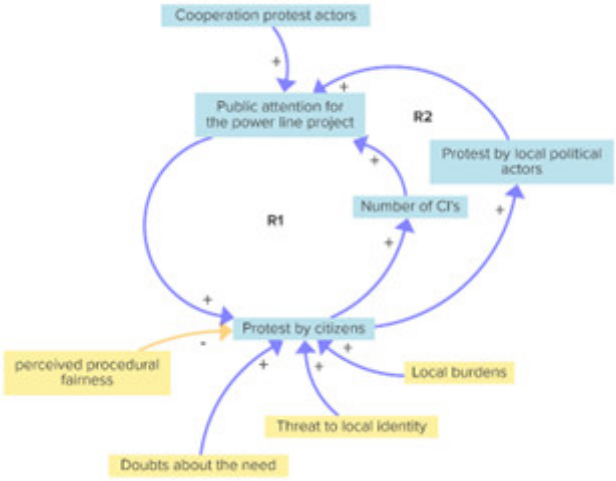

Fig. 5: Loop of protest mobilisation (core engine) and primary factors from the CLD of the case study presented here, authors’ own presentation. Legend: + / violet arrows = same direction; - / orange arrows = opposite direction; blue marked factors = factors of the core engine; yellow marked factors = primary factors

However, in order to go beyond the identification of direct influencing factors, further secondary factors were identified and discussed, which are linked to each other and to the primary factors and thus have an indirect effect on the loop of protest mobilisation (see Figure 6).

This clarifies further modes of action that explain the relevance of the primary factors identified in this case study and were part of the driving force that has driven protest mobilisation on a large scale in our case study so far.

It is also worth taking a closer look at these secondary factors in order to identify possible leverage points in the system of local acceptance formation. These are ‘places to intervene in a system’ (Meadows, 1999). In other words, these are the acceptance factors in our system that have a particularly strong influence on the rest of the system and on protest mobilisation. Candidates for these intervention points can be found among the factors that have a high out-degree, i.e. that themselves influence many other factors, but at the same time are themselves only influenced by a few other factors - i.e. have a low in-degree (Kiekens et al., 2022).

In the simplified representation of our CLD in Figure 6, the factors ‘bundling with other infrastructure’ and ‘traceability of planning decisions’ are important candidates for effective leverage points (marked in green). Both factors are not influenced by any other factors in the system shown, but themselves influence other key factors.

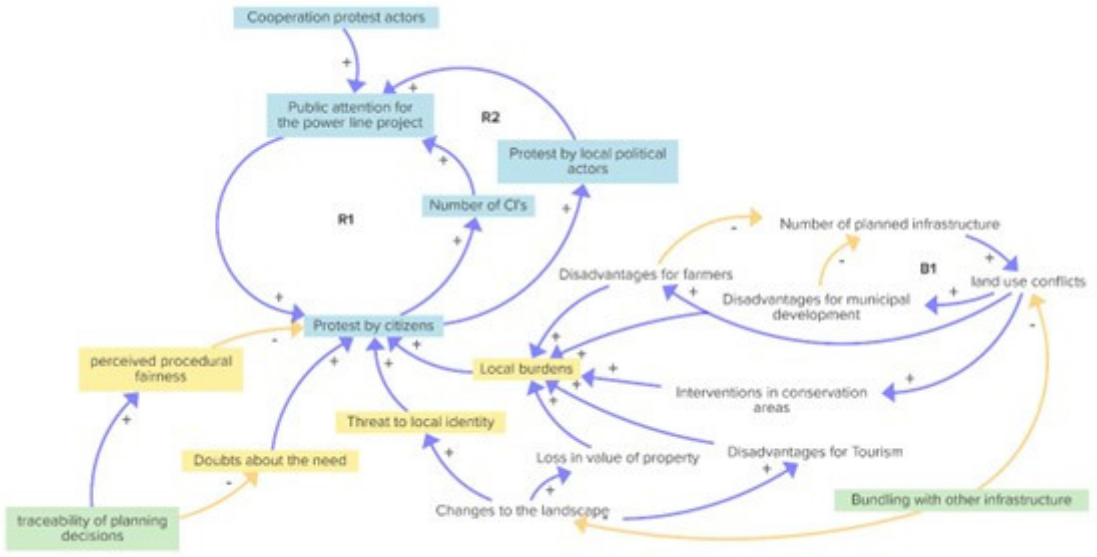

Fig. 6: Simplified and condensed version of the CLD from the case study presented here, authors’ own presentation. Legend: + / violet arrows = same direction; - / orange arrows = opposite direction; blue marked factors = factors of the core engine; yellow marked factors = primary factors; green marked factors = potential leverage points

The ‘traceability of planning decisions’ has an impact on two primary factors (‘perceived procedural justice’ and ‘doubts about the need’), which have a direct influence on our

core engine - the protest mobilisation loop. The ‘bundling with other infrastructure’, on the other hand, has an influence on the ‘changes to the landscape’ and the ‘land use conflicts’. These are both factors that are themselves potential points of intervention, as they each influence three other factors in the system.

Based on the (simplified) CLD illustrated here, it can be hypothesised that actors such as the TSO could mitigate the protest against the planned power line or increase acceptance of the project by striving to justify all planning decisions in a comprehensible manner and planning the line as often as possible in close proximity to other existing or planned infrastructure. These hypotheses can be discussed well in the context of PSM workshops with the stakeholders involved and developed into concrete intervention measures (Barbrook-Johnson and Penn, 2021; Sedlacko et al., 2014).

In any case, the importance of some secondary factors for the genesis of local acceptance formation processes is likely to be overlooked or at least underestimated without systematic analysis with the help of CLDs.

5. Discussion

Our Goal was to enrich research on community acceptance by expanding it with systemic and participatory methods and perspectives and to integrate them into a systematic methodology. In this final chapter, we reflect on the extent to which the methodological approach proposed here can fulfil this goal and what challenges and limitations need to be considered.

Previous research has mainly identified bundles of individual factors influencing acceptance, without paying sufficient attention to the dynamic interaction patterns between the various factors that cause escalating protests and conflicts. Overall, we believe that CLDs are indeed a suitable method to capture, visualize and understand these complex interaction patterns between a large number of acceptance factors. They therefore offer a valuable analytical addition to previous acceptance research. The inductive approach of our methodology allows us to integrate factors from different social subsystems (political, social, cultural, economic, etc.) and spatial levels (local, regional, national, global) into the analysis and to relate them to each other. It does not set any thematic boundaries. From the analysis of various text documents and the discussions in PSM workshops, a large number of acceptance factors and links were identified. The visual representation of the CLD makes it possible to include them all in the analysis at the same time. It is not uncommon for CLDs to contain between 20 to 50 or even more different variables (Barbrook-Johnson and Penn, 2022). CLDs make it possible to visualise system-dynamic modes of action which have a decisive influence on the acceptance formation process, such as feedback loops. Identifying these dynamic mechanisms is important in the context of analysing community acceptance, as it allows

us to better understand, for example, rapid escalations of protest and conflict. Furthermore, CLDs offer the potential to identify effective intervention points for influencing the system of community acceptance. The potential impact of these ‘leverage points’ can only be recognised from a systemic perspective because they are ‘often not intuitive’ (Meadows, 2008, p. 147).

The attempt to analyse acceptance from a systemic perspective with the help of CLDs is not entirely new. Ketzer et al. (2020) used a system dynamics approach to analyse factors that affect the acceptance of agro-photovoltaic systems and González et al. deal with the acceptance of renewable energy projects in poor rural communities (González et al., 2016). However, these studies rely exclusively on scientific literature or their own empirical data when constructing their CLDs, which poses the risk that the subjective perspective of the researchers causes distortions in the CLDs and its analysis (Barbrook-Johnson and Penn, 2022). To avoid these distortions and to increase the validity of our CLD we worked with a participatory system mapping (PSM) approach. The central component of this is the collaborative work of researchers and representatives of the TSO on the CLD in a workshop setting where an open discourse based on mutual recognition takes place and a common understanding of the local acceptance formation process is developed.

At the end of this participatory process stands a CLD based on judgements that were collaboratively and discursively validated by researchers and TSO representatives. The findings on acceptance formation that are produced by this process are highly relevant for the local context of the analysed case of a municipality affected by the expansion of the electricity grid.

Our experience with the approach outlined above also shows that researchers need to consider and reflect on a number of challenges. These are both methodological and theoretical in nature. The methodological challenges include (1) involving all relevant stakeholder groups in PSM and (2) the time-consuming iterative nature of the participatory process.

For the best possible result, it is recommended to integrate several or all stakeholder groups into the PSM (Barbrook-Johnson and Penn, 2022). Nevertheless, our case shows that this is not always possible, especially if stakeholders are on different and possibly opposed sides of a latent or even manifest conflict. These potentially conflicting framework conditions must be reflected in the research design and its implementation. The fact that we only involved representatives of the TSO is a significant limitation of our approach that leads to distortions in the representation of the system of acceptance formation. At least some perspectives of local stakeholders were gained through participant observation at information events and document research. These were included in the draft of the CLD, but the contents of the CLD are still only validated from two perspectives (TSO and researcher). However, it was not possible to speak with the

TSO representatives in a protected atmosphere in any other way. In workshops with other stakeholders, they would have been less open about their perspectives and assessments. That is why we decided to focus solely on the workshops with the TSO representatives in order to first test and further develop the methodology of CLDs and PSM for acceptance research. With a more validated methodology, further PSM workshops with other stakeholder groups should also be conducted in the future to obtain a comprehensive picture of local acceptance formation that includes various relevant perspectives.

Our previous experience has also taught us that developing CLDs within the framework of PSM takes up a lot of time, both for the researchers and the stakeholders involved. During the workshops, sufficient time is needed for discussion and the development of a common understanding. In addition, stakeholders must be carefully introduced to system thinking and the methodology. Outside of the workshops, familiarisation with the topic and the iterative process of revision and feedback also require a significant amount of time. The literature on PSM estimates the time required for a PSM workshop at between 80 minutes (Sedlacko et al., 2014), 3 hours (Barbrook-Johnson and Penn, 2021) and 4 hours (Lopes and Videira, 2015). In our experience, however, this is not enough time to adequately introduce the stakeholders to the CLD methodology and to collaboratively develop an initial draft of the CLD. This was the main reason for creating an initial draft of the CLD based on our empirical data, before involving the stakeholders in the design process. With this pragmatic decision, certain limitations are created. The idea behind PSM is that CLDs are ‘intended to be ‘owned’ by the stakeholders who create them, rather than researches’ (Barbrook-Johnson and Penn, 2022, p. 64). By creating the first draft of the CLD as a research team at the forefront of the workshop, we shifted ownership of the CLD away from the stakeholders and channelled the discussion in a certain direction.

The theoretical challenges of CLDs include (1) the temporary validity of evidence and (2) their lack of generalisability. Although CLDs are sometimes characterised as mere ‘snapshots’ of a system at a single point in time (Sedlacko et al., 2014, p. 36), they actually embed temporal information implicitly through feedback loops, delays and accumulations. Classic system-dynamics archetypes such as Limits to Growth or Shifting the Burden (all expressed solely as CLDs) capture characteristic time-dependent behaviours including exponential growth, overshoot-and-collapse, and path dependence (Senge, 1990; Sterman, 2004). What CLDs cannot provide on their own is a quantitative trace of when those behaviours will manifest; translating the diagram into a stock-and-flow model or complementing it with longitudinal evidence (e.g., process tracing) is necessary to generate testable predictions (Sterman, 2004). Moreover, because variable selection and boundary assumptions are context-specific, the explanatory power of any given CLD remains tied to the socio-ecological conditions under which it was constructed (Sedlacko et al., 2014). Future research should therefore pair participatory CLDs with

explicitly process-oriented methods (such as repeated mapping sessions, sequence analysis or process tracing) - to examine how stable the depicted feedback structure remains as contextual factors evolve (see for an empirical example Fienitz, 2025).

Because the causal-loop diagrams (CLDs) generated by our participatory procedure encode the perceptions of a particular community, the insights they yield are inherently context-specific and not directly generalisable (Sedlacko et al., 2014). At the same time, every CLD uses the same syntactic elements - variables, signed causal links, and feedback loops - so maps from different cases can be systematically compared as long as their boundaries and variable names are documented consistently (Lane and Oliva, 1998). Comparative work of this kind has already uncovered a set of recurring feedback configurations known as system archetypes that appear across very different domains (Kim, 2000; Senge, 1990). As more case studies of local acceptance for energy-infrastructure projects are visualised as CLDs, future research could search for such archetypal patterns to identify feedback structures that repeatedly shape community responses to energy infrastructure. Doing so would strengthen the external validity of individual maps and provide theory-informed leverage points for stakeholder engagement.

6. Conclusion

Despite extensive scholarship on community acceptance, researchers still lack a convincing explanation of how interacting social, institutional and spatial factors and feedbacks determine whether RET-projects are welcomed or resisted. By adopting a participatory systems lens, our study addresses this gap.

Using Participatory Systems Mapping in a case study from the electricity grid expansion, we engaged representatives of the regional TSO to co-develop a causal-loop diagram (CLD) that makes the interdependencies among various factors such as trust, perceived fairness, landscape attachment and procedural efficacy explicit. This collaborative process enabled mutual validation of perspectives from practice and science and the development of a common and in-depth understanding of the local acceptance formation process.

Although the absence of municipal stakeholders inevitably biases the current CLD towards the operator’s viewpoint, the exercise demonstrates that systemic, participatory modelling can enrich acceptance research by capturing complexity rather than reducing it. Future iterations should iterate the CLD with local residents, local politicans and NGOs, enabling cross-case comparison and the identification of recurring system archetypes that shape acceptance dynamics across projects.

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