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How to plan for success? An exploration of social context factors in neighbourhood energy planning

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ABSTRACT

It is essential to consider the social context when designing sustainable energy systems that lead to successful implementation in neighbourhoods. Current methods often only consider techno-economic aspects and are insufficiently capable of including social factors, because they are unclear about which social factors are relevant and how they can be quantified. This paper explores how neighbourhoods can be characterized socially by studying pre-existing neighbourhood characteristics, focussed on socio-economic status and social cohesion. The paper is built around four case-studies in the Netherlands, which are analysed both quantitatively and qualitatively. The paper shows how the social context can be defined by 1) proposing a theoretical framework of social factors, 2) quantifying these social factors by survey research, 3) interpretating this data using qualitative case-study data and 4) quantifying success in the cases and relating this to the scores of the survey data. The results of this explorative study will 1) show how a social profile can be used to find leads for a participative approach towards sustainable neighbourhoods where techno-economic solutions are well embedded in the social context and 2) help to understand and predict success of participation in communities.

1. Introduction

Energy transition increasingly takes place on the local scale in many European countries, including the Netherlands. The role of the municipal level, where decision-making takes place in local settings by local stakeholders, is more and more recognized as important in achieving national energy policy targets [1,2]. The participation of citizens in this process is desired, both from a policy as well as a community point of view. To be able to find solutions that have the best chance of successful implementation, it is important to consider the social context in the planning process because factors such as trust and place attachments are of influence on renewable energy acceptance [3]. By understanding the social characteristics of communities, technologies can be chosen that comply with citizen needs and conditions, and therefore increase citizens' support. Not only factors at the individual level, but also at the community level should be considered, since harvesting the potential for renewable energy measures depends on its ability for collective action and consensus building [4].

Although the focus increasingly lies on the local scale, current quantitative methods and tools are insufficiently capable of including social aspects [5–7]. Techno-economic models largely ignore the social context as it is unclear for modellers which social factors are relevant and how they influence technology adoption. Bouw et al. [5] concluded that in order to better represent the social context for planning purposes, it is necessary to create more insight in the factors that influence the implementation success of local transitions and in how to use them in a planning model. A set of relevant social factors was suggested based on a first literature review with the recommendation to further define these factors by empirical research.

In practice, differences can be observed in success between community energy projects. In some communities, projects don't get through despite various efforts taken, whereas in some communities, citizens take matters into their own hands and are well on their way reaching ambitious energy targets. Various reasons may be play a role in the failure of projects: technological and financial feasibility, organizational complexity, governmental support, community acceptance, and environmental factors [4,8,9]. Understanding why certain communities fail and others succeed is key for shaping a planning process that leads to successful community energy projects. More insight in the factors underlying failure and success may improve the planning and

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implementation process substantially. The existing literature on success of community energy focuses on the internal capacities of the project group itself, the cooperation with authorities and the broader network, and the interaction with the local community [10,11]. Although these insights are relevant and useful in the implementation phase, the use for the (municipal) energy planning processes is limited. In this context, pre-existing characteristics that may be of influence on designing systems that are well accepted by citizens are critical. Knowing these factors and their relation with success, will both help the selection process and implementation process: neighbourhoods with high potential for success can be selected and weak and strong points in the neighbourhood can be detected and incorporated in the planning strategy from early on in order to enlarge the chance of success.

Some authors implicitly mention some pre-existing neighbourhood characteristics in studies on community projects and success that can be used as starting point for further exploration. Haggert et al. [12] in their analysis of social factors of success in Scottish energy initiatives, conclude that the most successful community energy projects are located in less deprived and rural areas, and that pre-existing community cohesion and identity is a critical factor in the success of a project. Existing community groups were also identified as a likely factor in project success. Ziersch et al. [13] confirmed that several socio-demographic characteristics, such as education, gender and employment, and social cohesion influence community group participation. These conclusions suggest that both socio-economic status and social cohesion in a neighbourhood are important social factors in relation to successful participation, but little research has been done on this topic [13]. When we further observe successful community energy projects, it stands out that those show-cases often take place in rural areas, in small communities with high social cohesion, see examples [8,14]. Also Kalkbrenner confirms that living in a rural, rather than urban community, increases the likelihood of participation [15]. The fact that rural areas are assumed to have a higher social cohesion could explain this phenomenon, next to more spatial potential for renewable energies [16]. These examples show that there seem to be strong indications that certain social characteristics of neighbourhoods are of influence on success, but an overview of relevant factors is missing as well as insight in the interdependence of factors.

In this paper, the focus is on pre-existing neighbourhood characteristics as potential predictors of participation success in a community energy project, in which socio-economic status (SES)[1] and social cohesion are taken as a starting point. This paper builds on the work of Bouw et al. [5] and contributes to the existing knowledge by further defining and quantifying these pre-existing social context factors. To further investigate which factors are exactly relevant in the context of energy planning, our research focusses on a broad set of social factors to represent the social context of neighbourhoods and will have an explorative nature. We will provide a theoretical framework that enables a structured view on the matter. The aim of this paper is to examine how neighbourhoods can be characterized socially by creating a social profile as starting point for shaping community energy projects. The paper provides an answer to the following research question: *Which social factors, focussed on socio-economic and social cohesion aspects, are relevant for constructing a social profile of a neighbourhood as starting point for an approach for community participation?*

The research question is answered by analysing data from four Dutch case-studies in the context of the Dutch program of natural gas-free neighbourhoods (PAW). Neighbourhoods that take part in this program receive government funding for realizing a pilot with a limited number of dwellings that decrease or eliminate the use of natural gas [17]. The data were collected in a survey and in semi-structured interviews. The data are described per variable and compared per case-study. Success in the cases was quantified by a multicriteria analysis, and then analysed in relation to the measured variables.

The paper is structured as follows. In Section 2, the research design and methodology are presented. Section 3 presents the theoretical basis for the key concepts for further examination. In Section 4, the results of the analysis are presented, which are subsequently discussed in Section 5. Conclusions, limitations, and policy recommendations are presented in Section 6.

2. Methodology

2.1. Overview of used methods

To explore and test how a social profile of a neighbourhood can be developed, both qualitative and quantitative methods are used. Central to the approach is the quantitative measuring of a set of social factors, which are then placed into the broader context of the neighbourhood under study. Fig. 1 shows how the different methods are being used in interaction. First, potentially relevant social factors have been identified based on a literature study. The selected social factors, which are from a different type and theoretical background, are then aggregated in a theoretical model (see Section 3). The results of the data that were collected with the survey are visualized in a new tool, called 'social fingerprint', to allow an easier comparison of the multitude and variety of factors in multiple case-studies. The idea of the method is to provide a qualitative interpretation of quantitative data in order to understand the weak and strong points of each neighbourhood based on which information can be deducted on which factors influence success and which factors can be used to design successful strategies. To accommodate a

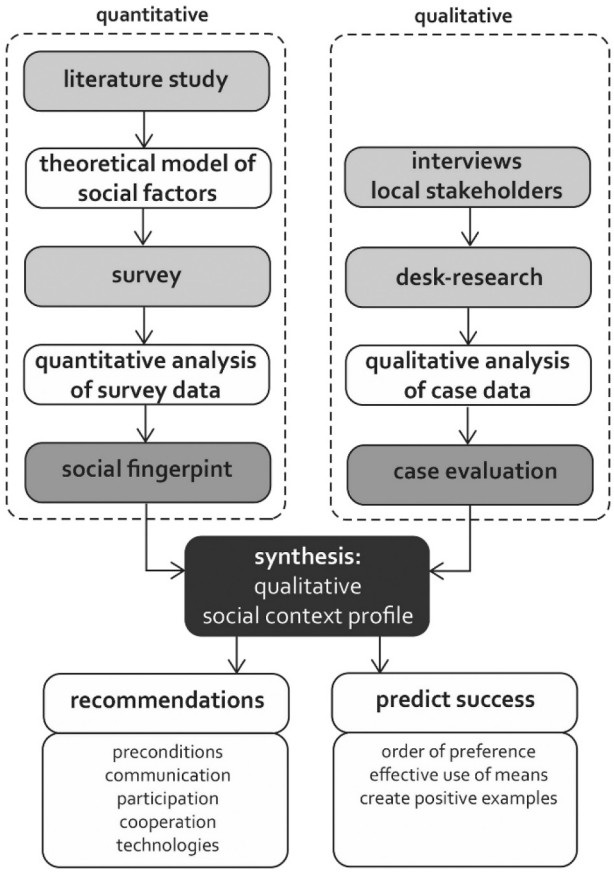

Fig. 1. Model of the method used to identify and explore relevant social context factors. The qualitative case-study data and the quantitative survey data come together in the synthesis (dark box) where a qualitative assessment of the cases is constructed.

[1] Socio-economic status refers to the social class of an individual or group, often measured as a combination of income, education and occupation.

truthful interpretation, the quantitative data are complemented with qualitative case-study data. Available project plans and other relevant documents of the studied neighbourhoods were collected as well as available statistical socio-economic data and household energy data (energy label, type of housing, etc.). Interviews with local stakeholders were held to get more in-depth information on the context behind the data. A total of 9 interviews were held distributed over four cases, with representatives of the energy cooperative or working group (6), residents (2) and a project leader from the municipality (1). The level of success in the cases was identified by a multicriteria analysis. Together, the quantitative and qualitative data are interpreted and combined into a qualitative social context profile. The survey and social fingerprint are presented as both new and central parts of our method and will therefore be further explained in the following sections.

2.2. Survey data collection and analysis

The survey was carried out in four neighbourhoods, focussed on the area that is part of the PAW project. The cases were selected based on participation in the first round of the PAW program (2018), a high a share of owner-occupied houses and variation in technical solutions, top-down and bottom-up approaches, rural and urban contexts and SES. The main characteristics of the cases are summarized in Table 1 and the location is shown in Fig. 2. All cases are situated in the Northern region which is the researchers' working area. The region is characterized by more small villages and towns than other parts of the country, for which we have chosen a variation of villages and city districts. The survey was distributed among the selected addresses via a door-to-door visit in the period August 2020–October 2021. Each respondent was asked to fill in the survey in hardcopy and agreed on a pick-up time (2 choices). If respondents were not able to fill in the survey before one of the pick-up times or wasn't at home during one of those times, the respondent was offered to take the survey online. In one case (Garyp) the respondents were only offered to take the survey online, either directly on iPad or at a chosen time on a personal device. We only distributed the survey in Dutch and didn't include English-speaking respondents.

The neighbourhoods were divided in several clusters, based on type of house (row-house, semi-detached, flat, porch) and ownership (rental, owners, housing corporations). We visited each address on the list up until sufficient response was reached while meeting the spread in housing type and ownership by equal representation of the clusters. This strategy resulted in skipping certain similar areas in a neighbourhood to be able to create a representative sample. The samples were representative, although for smaller neighbourhoods it was harder to receive sufficient response and the confidence level is lower than 95 %. The sample in Paddepoel was representative with a confidence level of 95 % and margin of error of 5 % (324 respondents in a population of 1778 addresses) and the sample in the other cases was representative with a confidence level of 90 % and a margin of error of 5 %. For De Lariks, the sample is not entirely representative on ethnic background as there is more variety than the sample shows. A similar thing happened in Paddepoel where there are above-average numbers of international students and expats. By guidance of the interviewers during the door-to-door visits the English-speaking residents could partly be included in the sample, although this remains a limitation of the study.

Fig. 2. Map of the Netherlands showing the geographical location of the 4 cases.

The survey consisted of three parts: 1) questions about the neighbourhood, 2) questions about sustainable energy and 3) personal questions such as age and income. Based on the theoretical model, five key concepts were defined: demographic factors, community factors, individual factors, socio-historic context and participation. The survey consisted of 40 questions, which measured 24 factors. Further explanation of the survey measures can be found in Appendix B.

The survey data was analysed using IBM SPSS Statistics version 27. First, the data were described for each of the four cases. A summary of the main statistics, mean or mode, are presented in Section 5.1. Additionally, the data were analysed for differences between groups of age, income, education, gender and home-ownership to investigate to what extent different social groups can be distinguished. Because the survey consisted of multiple scales, different tests were used: ANOVA for nominal variables and Chi square test for the ordinal variables. Variables were checked for non-normality and a non-parametric test was used when needed. Summarized results are presented in Section 5.2.

2.3. Social fingerprint

To be able to compare the cases in a comprehensive way, a visual tool was developed that presents the social factors in one combined graph, which was constructed in R Studio. The items of this so-called 'social fingerprint' were expressed with a value on a 10-point scale. For both ordinal and nominal variables the mean was taken and then scaled with a weighting to create a 10-point scale. Dichotomous variables were expressed in a percentage of respondents that answered 'yes', instead of the mean. Continuous scales (neighbourhood attachment,

Table 1
Summary of case characteristics.

	Paddepoel	Garyp	Pekela	De Lariks
Urban context	Suburban	Rural	Rural	Suburban
PAW solution	District heating	All-electric	Hybrid	All-electric/district heating
PAW approach[a]	Bottom-up/top-down	Bottom-up	Bottom-up	Top-down
Population	1778	645	578	531
SES	Groups above average and below average	Average	Relatively low/average	Relatively low
Building stock	Rowhouses and porch flats, 1960s–1970s	Pre-war and newer houses, mainly detached	Mainly older, detached houses	Rowhouses and porch flats, 1960s

[a] Bottom-up projects are initiated by citizens, top-down projects are initiated by the municipality or other stakeholders.

environmental knowledge 1 and 2) were first categorized after which a weighting was assigned to create a 10-point scale, and were further treated as ordinal variables. Although the presented data have no statistical relevance, the visualisation of the results does give an impression of how well a neighbourhood performs on a large number of variables. This is needed to get an overall image of the community, allowing an easier identification of its weak and strong points. The treatment of the variables is used to provide a visual tool, after which further analysis can take place for individual variables. The aim is to show the variance among cases in a comparable way and assess social characteristics in coherence rather than isolated, for which we consider the method appropriate.

3. Theoretical model

Insights from different fields were used to construct the theoretical framework which encompasses 25 variables in 5 categories (see Fig. 3). Most of the research related to the social discipline of renewable energy stems from the field of psychology, where determinants of pro-environmental or climate adaptive behaviour have been identified. Social and cultural factors, related to the interaction between people and how they behave as a group, are less evident in energy research, although their significance is regularly reported, for instance by [18,19]. Another limitation is that the available studies only focus on a limited number of factors at a time. In the following paragraphs we further explore and aggregate relevant factors grouped by community characteristics, characteristics related to the socio-historic context of the neighbourhood, demographic characteristics, individual (psychological) characteristics and factors that measure the level of participation in the framework.

3.1. Community characteristics

Social ties in the community would be the first logical condition for a collective energy project. In neighbourhoods where people know each other and interact with each other well, there is a better basis for setting up a community energy project than in neighbourhoods with weaker social interactions. It will be easier to reach different social groups, to facilitate discussion among neighbours and to develop a joint vision in neighbourhoods with stronger community ties. Therefore, the interaction among people in the neighbourhood should be mapped as an essential element of the social context. In the literature this is referred to as social capital or social cohesion. Literature from the field of sociology on neighbourhoods and social cohesion gives some tangible indications on which social factors are worthwhile to consider and contains various studies where those factors are quantified. The main area of attention is the quality of neighbourhoods and how poor neighbourhoods can be improved by stronger social ties. The starting point in this area of literature is the idea that strong social interactions between people leads to less social problems, a better chance of collective action towards solving problems and potentially more wealth and well-being. Social cohesion is presented as the most prominent aspect of the quality of neighbourhoods, although there are different views among scholars on which subcategories it consists and how it can be measured.

Based on the work of [20–24,25–27] neighbourhood attachment, social network, reciprocated exchange and trust seem to be the most common aspects of social cohesion, or social capital as some authors rather refer to. Some key concepts are described by Buckner et al. [20] who describe social cohesion as a 'synthesis of the concepts of psychological sense of community, attraction to-neighbourhood, and social interaction within a neighbourhood', and by Fone et al. [21], who build on the work of Buckner. They differentiate between two different constructs of neighbourhood social capital: 'neighbourhood belonging', relating to individuals' degree of attachment to their neighbourhood, and 'social cohesion', relating to what people do within their neighbourhood in visiting, sharing favours and trust'. These two aspects of social cohesion, neighbourhood attachment and social interactions, are further specified in several other studies: Forrest and Kearns [22] include participation in organizations, social networks, reciprocity and trust among a description of 8 domains of social capital; Wollebaek and Selle [23] use social networks, civic engagement and trust as indicators of social capital, based on the work of Putnam [24]; Kalkbrenner and

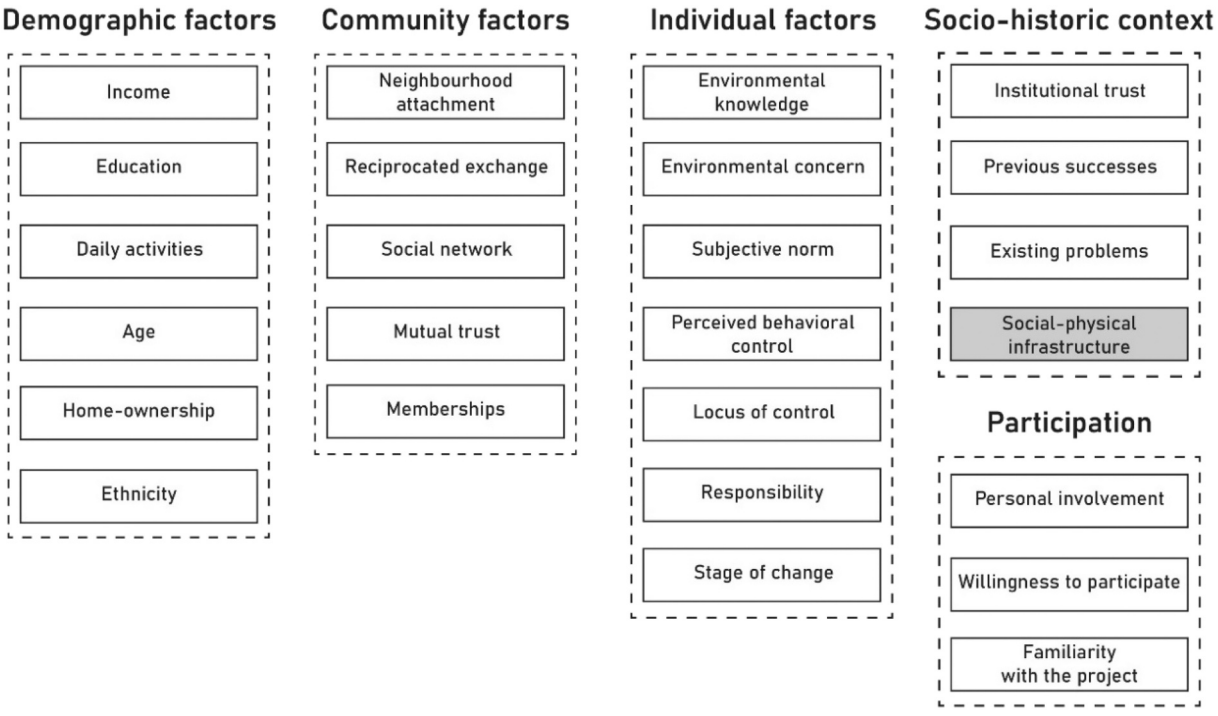

Fig. 3. Theoretical model of social context factors. Social-physical infrastructure is marked grey as the data is only qualitative and is therefore not included in the quantitative data analysis.

Roosen [15] identifies social norms, trust, environmental concern and community identity as determinants for citizen participation; Sampson et al. [28] reports membership in organizations, friend/kin network and reciprocated exchange in their study on collective civic action in Chicago and Middleton et al. [25] mention networks, trust and social capital as key concepts, in which social capital refers to both formal contact, through organizations and informal contact, referring to the contact and co-operation between neighbours. The importance of neighbourhood attachment was also found by [26].

Sampson et al. [28] also found that 'the density of community-based organizations is the only consistent predictor of collective civic engagement in events' compared to 'social class, race, density, or even the traditional indicators of social ties in the community, such as number of friendships'. This corresponds with Wollebaek and Selle's work that identified participation in associations is a good indicator of social capital on three indicators of social capital (social networks, civic engagement and trust) [23]. The explanation is that through organizations, values and norms are shared and trust is being build, which are all needed for collective action. Therefore, memberships in organizations are included in the framework as well.

Among the literature there also seem some aspects of which the importance seems to be less relevant. In the work of Kalkbrenner [15], trust and social norms were found to have the strongest associations with willingness to participate whereas community identity was found to represent one of the weaker predictors of participation as it was only indirectly related positively through social norms and trust. Community identity is therefore not included in the framework.

3.2. Individual characteristics

Apart from community aspects, it is essential to map the individual attitudes, actions and motivations concerning sustainable energy as well. Neighbourhood cohesion may be a reason for people to participate in a collective project, but when measures to individual houses are involved, personal motivations become increasingly important, as well as in cases where cohesion is low. In psychological research, place-attachment and place-identity, trust, and individual values have been mentioned [29,30]. Koirala et al. [31] identified environmental concern, renewables acceptance, energy independence, community trust, community resistance, education, energy related education and awareness as factors influencing peoples' willingness to participate in community energy. Heeren et al. [32] focussed on the role of sustainable knowledge which was found significant but showed a weak correlation with behaviour. In relation to collective action, Rees et al. [33] found the perceived participation norm to be the most powerful predictor. Particularly relevant, as highlighted in the existent literature, seem to be the extent to which people trust community members [31], the influence of social norms [29,33] and the extent to which people consider themselves capable of taking measures [29].

The theory of planned behaviour describes some key elements for mapping individual preferences. It is based on four constructs that influence behavioural change: attitude, subjective norm, perceived behavioural control and intention [34]. These common factors are included in the framework as they have already proven their relevance, at least in a general context. Behavioural control, sometimes called 'self-efficacy', was found by [29] as one of the key determinants of adaptive behaviour.

Intentions are proposed to be measured with 'stages of change', which measures not only if there are intentions to take measures, but maps the stage someone is in concerning the adoption of measures based on whether someone already took measure (maintenance and action phase), intends to take measures on the short term (preparation) or the longer term (contemplation) or is not yet planning to take measures (precontemplation) [35]. Past actions are not decisive and found less relevant than intentions [29].

Although useful, the theory of planned behaviour is a general model, not specifically construed to predict pro-environmental behaviour. Environmental issues have specific challenges related to, for example, uncertainty about the future, social practices and shared responsibility for solving issues. Environmental issues affect multiple people, in case of climate change even the world population, and even though an environmental issue is considered important to an individual, one can still attribute the responsibility for solving the issue to someone else, a government for instance. Additionally, as environmental issues have a collective nature, individuals may not feel that that their individual actions matter, a phenomenon that is referred to as 'individual locus of control': the extent to which people feel they can create an impact with their actions. The more one feels an internal locus of control, the more one will tend to change behaviour and join in (collective) action, in this case to improve the sustainability of the neighbourhood. Fielding et al. [36], applies these basic constructs in a study on environmental behaviour among young Australians. They used the following constructs: environmental knowledge and concern, responsibility and locus of control, and attitudes (pro-environmental intentions and behaviour). They found that young people with higher environmental concern and knowledge, and a more internal locus of control in relation to the environment, reported stronger pro-environmental intentions and behaviour, and less environmentally harmful behaviour. The constructs environmental concern, environmental knowledge, locus of control and responsibility are adopted into our theoretical framework.

3.3. Demographic and socio-economic characteristics

Neighbourhoods differ in their demographics and a social profile of a neighbourhood would not be complete without an accurate description of demographic variables. Without measuring community and individual factors, they may already provide information about the likeliness of participation in a certain neighbourhood. Although the relation between demographic factors and successful participation is not consistently studied so far, various studies on community action and renewable energy report some of those relations. Especially income has been mentioned in previous studies, in which also the relation between income and home-ownership and income and education is often mentioned. Kalkbrenner for instance reported that 'determinants such as higher income and education, and home-ownership tend to increase the willingness to volunteer' [15]. Also Forest and Kearns report the positive influence of income in community action: 'Community spirit, interpreted as the capacity to act collectively as and when required, is rated higher in mature and wealthy home-owning areas, perhaps indicating the importance of a combination of material and social resources' [22]. Also Middleton [25] found a positive relation between home-ownership and social capital. Home-ownership is also associated with more knowledge, interest in the energy transition and trust, resulting in more positive attitudes [37]. In addition to income, Bernards [38] found age and household composition of influence on the adoption of energy transition technologies, with increased technology adoption for large size households with young children, higher income levels and home-owners and decreasing with a larger percentage of elderly people. Koirala et al. [31] found education to be the only relevant demographic factor as predictor of willingness to participate, whereas other studies only found age to be the only predictor [33,39]. Hence, findings from literature are not conclusive.

The literature reports less about gender, daily activities (people that work in paid jobs or as entrepreneurs versus unemployment and retirement) and ethnicity. Some indications for the relevance of a broader inclusion of demographic factors can be deducted from the literature, such as [40] who found that entrepreneurial background of individuals can be considered an indicator for organizational power in communities whereas [41] state the overall role of local entrepreneurs in evoking community energy. To be complete, we included age, income, education, daily activities, homeownership, household composition and ethnicity in our framework.

3.4. Socio-historic context

The socio-historic context may be of interest in organizing a community energy project and could provide relevant information. For one, potential previous successes may point at organizational strength in the community. When people in the neighbourhood are already familiar with setting up collective actions, they are more likely to be successful in the future, similarly to past protest experience more easily leading to new protest [42]. Additionally, in many cases of energy planning or community energy, there is/are an external stakeholder(s) involved in the management of the project, for instance a municipality. If previous experiences with this stakeholder have been negative, this might affect the project and might call for re-organization. Institutional distrust can be an important barrier in technology adoption, especially when this is rooted in the historical context of the neighbourhood [43]. Gölz and Wedderhoff [44] also found a significant relation between trust in local stakeholders and acceptance of renewable energy, but not for all regions included in the study.

Another factor that may be of influence on setting up a community project is the social-physical infrastructure, the meeting places for people in the neighbourhood. This aspect is related to organizations as underlying infrastructure in the community where people meet, which is mentioned in the work of Sampson [28,45]. Potential meeting places are for instance community centres, sport facilities and religious places. It is relevant to identify these places to be able to connect with people in the neighbourhood during the project. In the analysis presented in this paper, where the focus is on identifying predictors of success rather than translating measures items to practical participation strategies, we did not further include social-physical infrastructure.

3.5. Participation

The dependent variables in the model should be related to the desired outcome, which is successful participation. Individual factors, community factors and demographic factors all influence the willingness to participate in a local energy project or not. For the factors measuring participation, we propose three indicators. The first one is the level of personal involvement, which measures the personal affinity with community energy, so in a broader sense if one is interested in the topic and is willing to be involved in the topic. The second one is the willingness to participate in the community energy project. The third one is familiarity with the project, referring to the extent to which people know the project which indicates how interested people are in knowing the project and potentially getting involved in the project.

4. Case study

4.1. Short case description

4.1.1. Garyp

The projects' ambition is to disconnect 80–90 % of the households from natural gas with an all-electric solution, focussed on heat pumps and insulation. Inhabitants of Garyp can apply for a subsidy for retrofitting their own home and receive support for selecting the right measures and contractors. The municipality is working closely together with a local energy cooperative. The cooperative, Enerzjykoöperaasje Garyp (EKG), was established in 2014 and prior to taking up the natural gas-free project they focussed on the construction of a 7 MWp solar park that was realized in 2016. The cooperative has a solid member base and is well-known in the village. EKG has a physical meeting place for residents to come talk about the project, the so-called ‘Energyhus’ (energy house), and deploys many activities to inform residents, whereby personal contacts between neighbours on communal meeting places play an essential role.

4.1.2. Paddepoel Noord

Paddepoel Noord is a popular district for expats and students thanks to its location near the university campus. The neighbourhood is quite diverse with both social housing with residents of a lower SES and owner-occupied houses with a higher educated population. Some of the apartment buildings have recently been connected to the cities' district heating network. The ground-bound dwellings however were considered too expensive to connect and are therefore the focus of the PAW project. A group of inhabitants initially took on the district heating project as a bottom-up initiative within their existing energy cooperative ‘Paddepoel Energiek’. Later on, a formal organization was set up between ‘Paddepoel Energiek’, the larger energy cooperative ‘Grunneger Power’ and the company Shell, called ‘050Buurtwarmte’. Finally, the municipality decided to take the lead in developing the technical plan and work with Grunneger Power for organizing participation in the neighbourhood, which gave the project more of a top-down orientation.

4.1.3. De Lariks West

The district De Lariks, consisting of 6 neighbourhoods including De Lariks West, is characterized by a low SES. The original proposal focussed on all-electric energy retrofitting, with a collective finance construction. One apartment building in the neighbourhood has been renovated likewise. This would mean a substantial investment from the residents since the neighbourhood mainly consists of privately-owned houses with a low energy label. The retrofit solution appeared to be challenging to implement in practice for both technical reasons, namely that the houses were too different for the envisaged solution after past individual retrofits, and for financial reasons, namely that the financial resources of residents were low. Currently, a district heating grid is considered as alternative solution. De Lariks does not have a bottom-up initiative, but the municipality has initiated a co-design group with residents.

4.1.4. Pekela

Pekela is a rather poor municipality with relatively high unemployment rates. Recently, induced earthquakes due to gas extraction in the region created additional issues by causing damage to the houses. Decreasing energy bills has been one of the starting points for the project. A hybrid solution was chosen, using hybrid heat pumps and locally produced green gas. Houses are also equipped with gap sealing to provide a basic form of insulation that is highly beneficial in the old houses. Residents can apply for a free energy scan of their home, and once they decide to participate, they can apply for an investment subsidy. A small group of residents called ‘Pekela geeft gas’ initiated the project. As the PAW funding can only be applied for by municipalities, they started to cooperate with the municipality. There is a strong cooperation between the group of residents and the municipality.

4.2. Multi-criteria analysis

To be able to better understand the relevance of the identified social factors, more specifically their function in predicting and influencing success, the success in the cases was evaluated using a multicriteria analysis (MCA). The results of the MCA can be compared with the survey results to understand their mutual influence. The level of success of participation in the four cases was evaluated according to predefined evaluation criteria (see Appendix A):

- Attendance at project meetings: usually, either the municipality or the local project group organizes public information meetings to inform inhabitants about the project. By monitoring the attendance at those meetings, an estimation is possible of how large the reach of participation of inhabitants is. In Paddepoel, about 4 large project meetings were organized by 050Buurtwarmte in the period January 2019–November 2019. The attendance laid between 60 and 120 people. In addition, there were many smaller meetings where people

were invited on a more personal basis. In Garyp, several large meetings were organized with high attendance as well. In De Lariks, multiple meetings were organized at the start of the project, with moderate attendance. In Pekela, the focus has been on more personal contact between neighbours. They also started later with the implementation, and possibilities for physical meetings due to the Covid pandemic were limited. Before the pandemic there was an information meeting with more than 100 people.

- Citizen support: the group of inhabitants can be very strongly organized, but that does not necessarily mean that the community as a whole will support the project. This will depend, among other things, on the representativeness of the members of the project group. Support is difficult to measure in ongoing projects in a uniform and reliable way. However, we can give some indications by looking at the number of members in case of formal organization, or the (e-mail) list of interested people. In Garyp, a significant share of the residents is a member in the energy cooperative. In Paddepoel and Pekela, there is no formal community organization but, there are e-mail lists of interested people that are informed by the working group. In De Lariks there is an e-mail list from the municipality for spreading a newsletter.
- Representation of social groups: Garyp reports that they do have different social groups under attention, but that some groups are difficult to reach. In the village there is an increasing number of people from outside the region that moved to the countryside. This group has little attachment to the village and the people. Another group that can be identified are the people with an old, pre-war house. Making an old, poor-insulated house all-electric, requires a larger investment, while the subsidy remains the same. The cooperative is aware of this and is trying to step up for their interests by talking to the municipality about making measures more attractive. Garyp is given a high score, for considering and representing different social groups, and focus on the community as a whole. Like Garyp, the target group in Pekela is more homogenous and though personal contact between the working group and other residents, people are involved in a more inclusive manner. In De Lariks the focus originally laid on home-owners of single-family houses, but increased focus on renters and owners of apartments during the project. Sufficiently involving residents from non-Dutch ethnic backgrounds and a low social-economic status remains an issue. Paddepoel consciously chose to exclude certain groups, by focussing on homeowners only, thereby excluding young people who generally rent a property. In addition, in the activities of the project, the ethnic variety seems not to be well represented. Although they may be successful in targeting a specific group (homeowners), they are apparently less successful at participation among the community as a whole.
- Adoption of measures: In Garyp, where the same technical solution (all-electric) was chosen, in February 2021, two years after the start of the project (subsidy), 42 households adopted measures. In Pekela, between the start of the project and August 2021, about 20–25 participants signed up for the project. In Paddepoel and De Lariks, this is harder to measure, as district heating projects may take several years to develop. At the current stage of the project no measures could have been adopted since the heating network is still under development. However, the fact that 130 out of 450 residents in Paddepoel declared support indicates that a significant share of the residents is willing to adopt measures, whereas the intention of residents in De Lariks is yet uncertain.

The results of the evaluation of the cases on each criterion are summarized in Table 2. Although the projects are still ongoing and many things have yet to be materialized, a first indication on the level of success can be given. For De Lariks there are little results so far and therefore the project can be considered not (yet) successful. In the other case, there are positive indications on multiple criteria that the project will be successful, at least to some extent.

Table 2
Results multi-criteria analysis on participation success.

	Paddepoel	Garyp	Pekela	De Lariks
Attendance at project meetings	High	High	Medium	Medium
Citizen support	High	High	High	Low
Representation of social groups	Medium	Medium	High	Medium
Adoption of measures	Medium	Medium/ high	Medium	Low
Level of success	*Potentially successful*	*Successful*	*Successful*	*Not (yet) successful*

5. Survey results

5.1. Description and comparison of social factors between cases

5.1.1. Demographic factors

The four cases can be differentiated by demographic characteristics (see Table 3). Paddepoel is characterized by a mixed population: there is a disproportionally high share of students, a group with a lower SES mostly living in social housing and a group of owner-occupiers with a higher SES. Compared to the other cases, Paddepoel has a relatively large group of university-schooled inhabitants (23.8 %), and overall education level is also high. Like Paddepoel, De Lariks has a young population as well with 14.0 % students (Paddepoel: 15.4 %) and the highest share of respondents in the age category of 25–34 years. The education level in De Lariks is however low (lowest of four cases and slightly lower than national average) with most of the respondents having attended vocational education, and income for the highest group of respondents being below average. Despite of the low SES, there is hardly social housing in De Lariks, most inhabitants are owner-occupiers. Notable is also the high share of people in a paid job (65.7 %) compared to the share of entrepreneurs (4.2 %) and compared to other cases. The other two cases have a similar distribution in education level, with about 35 % of the respondents in higher education. Income however is higher in Garyp, with a large group of 38.3 % earning above average whereas Pekela has relatively low income with 21.7 % earning above average.

5.1.2. Individual factors

For *environmental concern* and *responsibility*, there are only minor, non-significant differences between the cases (see Table 4). The results for responsibility correspond to general conclusions from a previous national survey with similar questions [52]. People attribute most responsibility to the government and some responsibility to themselves and the community. Although differences in these cases are small, the items of responsibility could give information on potential roles of stakeholders in a collective energy project.

For *environmental knowledge* we explored 3 different ways of how to measure this factor. The first two items, where respondents were asked to estimate the percentage of renewable energy and to list the energy sources of the Dutch energy system, seem to measure more general type of knowledge and shows a different result than the third item, where technical knowledge was tested. Knowledge is an influenceable factor, and may increase as a result of the information spread in the project. This may be the case in the collected data. In Pekela for instance, it can be observed that knowledge on the chosen technologies, heat pumps and green gas is relatively high.

Stages of change gives the same mode among all cases, meaning that most people already took energy measures and are in the action phase of *stages of change* (*Mo* = 4.00). People that have not taken measures, are most often not planning to do so in the near future. Looking at the data more closely, we can see that in Garyp and Pekela, the number of people

Table 3
Demographic factors.

		NL	Paddepoel	Garyp	Pekela	De Lariks
Age	*Mean (continuous scale)/std.dev*	42.2 [46]	48.1/19.7	50.36/16.74	55.33/14.26	43.86/17.65
Gender	*%female*	50.3 [46]	–	34.8	52.7	44.0
Income	*%above average/median (3 categories)*	16.5 [47][a]	28.4/3.00	38.3/3.00	21.7/3.00	17.5/2.00
Education	*%higher education/median (5 categories)*	32.9 [48]	52.8/5.00	34.6/4.00	34.9/3.00	30.8/3.00
Daily activities	*%paid job*	56,6 [49][b]	44.1	47.4	44.2	65.7
	%entrepreneurs	11,8 [49][c]	9.0	16.7	14.7	4.2
Ethnic background	*%Dutch*	75.8 [50]	–	–	90.7	93.0
Home-ownership	*%owner occupied*	57.0 [51]	57.1	88.7	96.9	76.0

[a] Category 30.000–40.000 EUR is considered as 'around average', above 40.000 EUR as 'above average', below 30.000 EUR as 'below average'.
[b] Employees as share of the total population 15–75 years (working and non-working).
[c] Entrepreneurs as share of the total population 15–75 years (working and non-working).

Table 4
Individual factors.

		Paddepoel	Garyp	Pekela	De Lariks	
Environmental knowledge – item 1 (#sources)	*Mean/std.dev.*	4.28/2.15	3.70/2.03	3.90/1.94	3.49/1.83	$F(3,598) = 4,72$ $p = .003$
Environmental knowledge – item 2 (%RES)	*Mean/std.dev.*	25.62/16.57	27.70/15.91	17.2/16.0	21.01/14.86	$H(3) = 8393$ $p = .039$
Environmental knowledge – item 3 (4 technologies)	*Mean/std.dev.*	3.19/3.25	3.48/3.50	3.29/1.03	3.03/1.00	$F(3,598) = 3,53$ $p = .015$
Environmental concern – item 1	*Mean/std.dev.*	4.03/1.33	3.84/1.269	4.24/1.10	3.91/1.13	$H(3) = 8399$ $p = .038$
Environmental concern – item 2	*Mean/std.dev.*	4.07/1.21	3.78/1.227	4.07/1.08	3.86/1.08	$H(3) = 11,937$ $p = .008$
Subjective norm	*Mean/std.dev.*	1.92/0.65	2.43/0.79	1.92/0.63	1.79/0.53	$H(3) = 60,828$ $p < .001$
Perceived behavioural control	*Mean/std.dev.*	285/0.47	3.38/0.86	3.31/0.97	2.98/0.80	$F(3,566) = 20,72$ $p < .001$
Locus of control	*Mean/std.dev.*	3.23/1.08	3.44/1.07	3.36/1.02	3.02/1.07	$F(3,566) = 3,05$ $p = 0,028$
Responsibility - community	*Mean/std.dev.*	3.46/0.97	3.37/0.89	3.31/0.90	3.26/0.93	$F(3,566) = 1,91$ $p = 0,126$
Responsibility - government	*Mean/std.dev.*	4.11/1.01	4.05/0.98	4.23/0.95	4.06/1.06	$F(3,566) = 0.273$ $p = 0,845$
Stage of change	*Median/mode*	4.00/4	4.00/4	4.00/4	4.00/4	$\chi^2 = 157,57$ $df = 12$ $p < .001$

that previously took energy measures is larger than in the other two cases, and this difference is also significant. This may have to do with the fact that those cases consist of older dwellings with low energetic performance.

Concerning *subjective norm, perceived behavioural control* and *locus of control*, some notable differences between the cases can be observed. *Subjective norm*, which indicates the amount of pressure that is experienced from others, clearly shows higher values for Garyp than for the other cases. It seems that subjective norm is related with community factors rather than other individual measures. Respondents in Garyp also experience a higher control on taking measures (perceived behavioural control, $M = 3.38$) as well as a higher effect of individual

Table 5
Community factors.

		Paddepoel	Garyp	Pekela	De Lariks	
Years of residence	*Mean/std.dev.*	15.5/15.5	27.9/19.6	23.60/19.82	12.82/15.53	$H(3) = 67,42$ $p < .001$
Expected years of residence	*Median/mode*	4.00/5	5.00/5	5.00/5	3.00/2	$\chi^2 = 135,19$ $df = 18$ $p < .001$
Reciprocated exchange	*Mean/std.dev.*	2.26/0.87	3.41/0.68	2.62/0.76	2.25/0.88	$F(3,550) = 49,78$ $p < .001$
Social network	*Median/mode*	3.00/2	6.00/6	6.00/6	3.00/3	$\chi^2 = 225,41$ $df = 18$ $p < .001$
Mutual trust	*%trust/median*	54.6/1.00	88.7/1.00	64.3/1.00	60.1/1.00	$\chi^2 = 51,98$ $df = 6$ $p < .001$
Memberships	*%memberships*	24.7	57.1	28.7	11.9	$\chi^2 = 98,54$ $df = 6$ $p < .001$

measures on the collective goal (locus of control, $M = 3.44$). Pekela closely follows Garyp, with similar scores (not significant) for *locus of control*.

5.1.3. Community factors

There are clear differences between the cases on community factors, with Garyp in particular showing high scores on all of those variables, with peaks in *memberships in organizations* and *mutual trust* (see Table 5). In Garyp, 88.7 % percent of the respondents trusted people in the neighbourhood and the majority of the respondents (57.1 %) was a member in at least one local organization. Pekela shows high scores on community variables as well, but there is a difference between more superficial social connections, such as the amount of people that one knows by name and how long a person lives somewhere, and deeper ties with the community such as exchanging favours and memberships in organizations, which is a unique and important characteristic of the neighbourhood. The two urban neighbourhoods, De Lariks and Paddepoel, both show lower values on community factors. De Lariks shows some particular low scores on *memberships in organizations* (11.9 %) and *attachment* ($Mo = 3$). Further inspection of the data shows that more people with higher income are planning to move out of the neighbourhood short-term.

5.1.4. Socio-historic context

Significant differences among cases exist for both *institutional trust, existing problems* and *previous successes* (see Table 6). For *institutional trust*, in most cases, the majority of the respondents has trust in the municipality in solving a problem in the neighbourhood, whereas in Pekela, most respondents do not have trust. De Lariks shows low values on institutional trust as well. Concerning *successes*, the number of respondents that was able to mention at least one successful collective activity was significantly higher in Garyp (82.4 %) than in the other cases, with performed similarly, whereas the number of respondents that report problems is much lower. De Lariks shows the highest scores on *problems*, and the open answers to this question also reveal more serious problems such as crime e.g., stabbings and issues with drugs. This illustrates that not only the number of problems but also the nature of the problems mentioned provide relevant information for a social profile.

5.1.5. Participation

Notable are the relatively small, but significant differences between the cases on *willingness to participate* (see Table 7). For all cases, the group of respondents that answers 'yes' is smaller than the groups that answer 'maybe' and 'no', and the largest group answers 'maybe'. The highest number of respondents that is willing to participate was found in Garyp (27.8 %), whereas the lowest number was found in De Lariks (16.3 %). What should be noted here is that the nature and familiarity with the project may play a role here. Respondents were able to give an explanation to their answer. In Garyp, where inhabitants are stimulated to implement all-electric solutions, many respondents gave a financial motivation when answering 'no' or 'maybe', whether in Paddepoel, where a district heating network is planned with less self-investment upfront, the financial motivation was less frequent and conditional motivations such as the cooperation of neighbours and professionals was more prominent. Hence, the technical solution (all-electric vs district heating) and stage of the project (implementation vs preparation) in combination with the provided information on the project, may influence these results.

Personal involvement showed small, but significant differences between the cases ($M = 3.43$, $SD = 0.90$; $M = 3.44$, $SD = 0.90$; $M = 3.27$, $SD = 0.95$; $M = 3.14$, $SD = 0.94$), but the differences between neighbourhoods is still significant. The items are in line with the items on environmental concern, but are more specific and therefore provide better information, showing larger differences among cases.

For *familiarity* with the project, there are large differences with particular high scores for Garyp. In Garyp, most people are familiar with the activities of the project (66.2 %) whereas in Paddepoel, which shows the lowest score, this is less than half the amount (30.9 %), most people here say they only know the project by name ($Mo = 2$ vs $Mo = 3$). What could be relevant here is the definition of the target area. Garyp focusses on all 645 households in the village, whereas Paddepoel mainly focussed on a cluster of 450 households in the first phase of the project. For a fair comparison, this cluster was also compared within the Paddepoel case and then to the case of Garyp as well. A significant difference was found between the focus area and the remainder of the neighbourhood of Paddepoel ((χ^2 (3) = 25.92, p < .001). In the cluster of 450 households, 46.2 % of the respondents was familiar with the project compared to 22.4 % outside of the cluster. This is closer to the familiarity score in Garyp (66.2 %), but still significantly lower.

5.2. Comparison of social factors within groups

The data were also analysed and compared for age, income, gender, education and ownership (see Table 8). The variables were recoded into groups with the same size. For age, six groups were created with the lowest category until 35 years and a highest category from 75 years and older. For education two groups were created, one representing higher education (applied university and university) and one representing lower education (all other training). For homeownership, two categories were made: rented property, in which the different categories of rent were merged, and own property. The remainder of the variables kept their original categories apart from the 'I don't know' category that was filtered out.

Homeownership seems to have a large effect on both individual and community factors in which homeowners behave as a distinguished social group. Owner-occupiers seem to be more interested in the topic, showing higher scores on *environmental concern* and *personal involvement*.

They also have already taken measures more often than tenants and experience more *control* over measures to be taken. Homeownership also shows differences on all community factors and most of the socio-historic factors. Apparently, homeowners have stronger ties in the community than people with a rented property. More importantly, they are better informed about the project and are more willing to cooperate than people with a rented property.

Concerning age, most differences can be observed in community

Table 6
Socio-historic context factors.

		Paddepoel	Garyp	Pekela	De Lariks	
Institutional trust	*%trust/median (3 categories)*	57.1/1.00	68.4/1.00	39.5/2.00	50.3/1.00	$\chi^2 = 35,71$ df = 6 p < .001
Previous successes	*%respondents that name activity/ median*	38.0/2.00	81.2/1.00	28.7/2.00	37.8/2.00	$\chi^2 = 113,77$ df = 6 p < .001
Problems	*%respondents that name problem(s)/ median*	59.3/1.00	44.4/2.00	58.1/1.00	67.1/1.00	$\chi^2 = 51,98$ df = 6 p < .001

Table 7
Participation factors.

		Paddepoel	Garyp	Pekela	De Lariks	
Willingness to participate	*%yes/mode*	24.4/2	27.8/3	16.3/2	19.6/2	$\chi^2 = 21,17$ df = 9 p = .012
Personal involvement	*Mean*	3.43/0.90	3.44/0.90	3.27/0.95	3.14/0.94	F(3,550) = 4,14 p = .006
Familiarity with the project	*%familiar/median*	32.9/2.00	81.7/3.00	46.4/2.00	37.2/2.00	$\chi^2 = 134,68$ df = 12 p < .001

Table 8
Demographic variables versus individual, community, socio-historic and participation variables.

		Age (6 groups)	*Gender*	*Income*	*Education (2 groups)*	*Homeownership*
Individual factors	*Environmental knowledge 1- % RES*	–	F(2,331) = 7,15 p = .001	–	F(1,483) = 12,97 p < .001	–
	Environmental knowledge 2 - #energy sources	–	U = 17,437,00 p < .001	–	U = 38,853,50 p < .001	–
	Environmental knowledge 3 - technologies	F(5,631) = 4,16 p = .001	F(2,350) = 11,55 p < .001	F(2,462) = 7,14 p = .001	F(1,483) = 11,65 p = .001	–
	Environmental concern	–	–	H(2) = 9,50 p = .009	U = 32,407,00 p = .001	U = 17,175,50 p = .004
	Subjective norm	H(5) =14,54 p = .013	–	–	–	U = 14,733,50 p < .001
	Perceived behavioural control	–	F(3,353) = 3,96 p < .05	F(2,359) = 20,97 p < .001	F(1,483) = 5,43 p = .020	F(1,476) = 51,41 p < .001
	Locus of control	–	–	–	–	F(1,476) = 16,55 p < .001
	Responsibility - community	–	–	–	F(1,647) = 6,67 p = .010	–
	Responsibility - government	–	–	–	–	–
	Stage of change	χ^2 (8) = 81,2 p < .001	–	χ^2 (6) = 31,06 p < .001	χ^2 (3) = 11,44 p = .010	χ^2 (4) = 83,32 p < .001
Community factors	*Years of residence*	H(5) = 206,22 p < .001	–	–		U = 14,492,50 p < .001
	Expected years of residence	χ^2 (10) = 224,9 p < .001	–	χ^2 (10) = 27,10 p = .003	χ^2 (5) = 39,76 p < .001	χ^2 (4) = 15,25 p = .018
	Reciprocated exchange	F(5,635) = 4,93 p < .001	–	F(2,460) = 11,03 p < .001	–	F(1,476) = 54,93 p < .001
	Social network	χ^2 (12) = 105,9 p < .001	–	χ^2 (10) = 22,44 p = .025	χ^2 (6) = 13,74 p < .033	χ^2 (6) = 92,4 p < .001
	Mutual trust	–	–	χ^2 (2) = 7,65 p = .022	–	χ^2 (1) = 12,09 p = .001
	Memberships	χ^2 (4) = 22,0 p < .001	–	χ^2 (2) = 9,69 p = .008	χ^2 (2) = 8,47 p < .014	χ^2 (2) = 27,22 p < .001
Socio-historic context	*Successes*	χ^2 (2) = 31,4 p < .001	–	–	–	χ^2 (1) = 22,42 p < .001
	Problems	–	–	–	–	–
	Institutional trust	–	–	–	–	–
Participation	*Willingness to participate*	χ^2 (4) = 19,2 p = .001	χ^2 (2) = 6,92 p = .031	–	χ^2 (2) = 14,69 p = .001	χ^2 (2) = 7,01 p = .03
	Personal involvement	–	–	F(2,463) = 8,76 p < .001	F(1,483) = 18,65 p < .001	F(1,476) = 12,14 p = .001
	Familiarity project	χ^2 (8) = 53,0 p < .001	χ^2 (3) = 13,82 p = .003	χ^2 (6) = 17,69 p = .007	χ^2 (3) = 10,80 p = .013	χ^2 (3) = 74,09 p < .001

factors and participation factors. The older one gets, the stronger the social ties in the community. The social network is larger and the exchange of favours with neighbours is higher. Older residents often already have taken measures, are more familiar with the project and more willing to participate. Above 75 years, respondents are much less willing to participate. In the open answer possibility, respondents indicate as reason that they consider their age as a practically challenging as well as transferring the responsibility on younger generations. Respondents in the age category until 35 years are especially distinguished by a low involvement in the community, showing especially low scores on *neighbourhood connectivity, social network, successful activities* and *familiarity of the project*.

Participation (*personal involvement, willingness to participate* and familiarity with the project) is higher under people with a higher education and higher income. People with low income are generally less involved in the community as indicated by, among others, low *memberships* in local organizations, a smaller *social network*, lower *mutual trust* and lower *familiarity* with the project. They also show less *knowledge*, less *control* over measures (also when they own the property) and have also taken measures less often than people with higher income. They are however not less *willing to participate* in the project. Differences between the average and high-income group are minor. For education a similar pattern can be observed with some differences between individual factors.

Gender show differences on *environmental knowledge* and *control*: women have less knowledge on technologies (significance level is high) and experience less control over the measures to be taken. Therefore, women could form a fourth group.

5.3. Results dashboard

In Sections 5.1 and 5.2 the data of four cases have been described. Although the difference between cases has been tested statistically, it is still difficult to get an overview of the unique characteristics of each neighbourhood. Considering the complexity and large number of measured items in multiple cases, a visual tool could help provide insight in how well the cases perform on each factor, and allow an easier case comparison. This case comparison is helpful in evaluating the meaning of certain scores, by showing their relative value. For instance, subjective norm seems low in each case, but it is not directly clear that the score in Garyp is substantially higher than in the other cases. By visualizing the data, the weak and strong points of the neighbourhood become more visible.

Fig. 4 shows how such a visual could look like. The data of the four neighbourhoods are plotted on a comparable 10-point scale. Each neighbourhood can be given a unique profile of scores on 22 items. The demographic factors are left out of the graph, whereas the different items to measure the same factor are included. Differences between cases become easily visible, so that an individual high or low score can be placed in perspective. It now becomes directly clear that the subjective norm in Garyp is quite high compared to the other cases. The main differences between the neighbourhoods are observed in social cohesion factors (mutual trust, social networks, reciprocated exchange, neighbourhood attachment and organizations) and socio-historic context factors (institutional trust, previous successes, existing problems). Difference on the other factors also exist but are smaller as can be seen from Fig. 6.

The social fingerprint gives a quick insight in the weak and strong points of the neighbourhood, see Fig. 5 and Table 9. Particular high and low scores can be identified by looking at the difference between cases, in addition to the individual case score. The visuals function as relatively quick identification tools, but more thorough analyses are needed to correctly interpret the data. For instance, there doesn't seem to be a major difference between cases on *willingness to participate*, but individual case scores show a higher mode for Garyp.

The social profile of the neighbourhood was discussed in an interview with at least one local stakeholder to check whether the social profiles were recognized. In general, the social profiles were recognized by the stakeholders and the results could be further clarified by their personal experiences. For instance, the role of social cohesion in the success of Garyp was stressed by the interviewee and was also supported by the results. Similarly, the low institutional trust was recognized in Pekela and the mixed population of Paddepoel with social renters and students, and associated problems, was also confirmed by the interviewed residents.

6. Discussion of results

6.1. Relation between social factors and level of success

To determine which social factors are good predictors of success, we compared the social fingerprints of the cases with the results of the multicriteria analysis that identified the level of success. One of the main differences between cases that were identified as successful and less successful concerns community factors. In Garyp, a case that was identified as successful, all five community factors, and especially *mutual trust* and *memberships in organizations*, were higher than in less successful cases. We also found small differences in participation factors in communities with high social cohesion. Apparently, people in communities with high social cohesion are not necessarily more aware of the importance of energy transition or at first instance not more willing to participate in a community energy project than people in communities with looser social ties. The difference in success that was observed in practice indicates a more complex relation between social cohesion and success.

Previous successes also showed large differences between cases. In successful cases these factors seemed to be higher. A history of commonly organized activities and more individuals with an entrepreneurial profession could be considered as measures for the organizational power in a neighbourhood, which is supported by higher scores in more successful cases where active citizen participation plays a role.

Although *trust* is often indicated in the literature as an important predictor of success (i.e. [15]), the relation between trust and participation did not become evident from the analysis. We did not see clearly high scores on trust in successful cases. In Pekela for instance, there is a close cooperation between municipality and the working group of citizens, although mutual trust is rather low. It seems to be more important

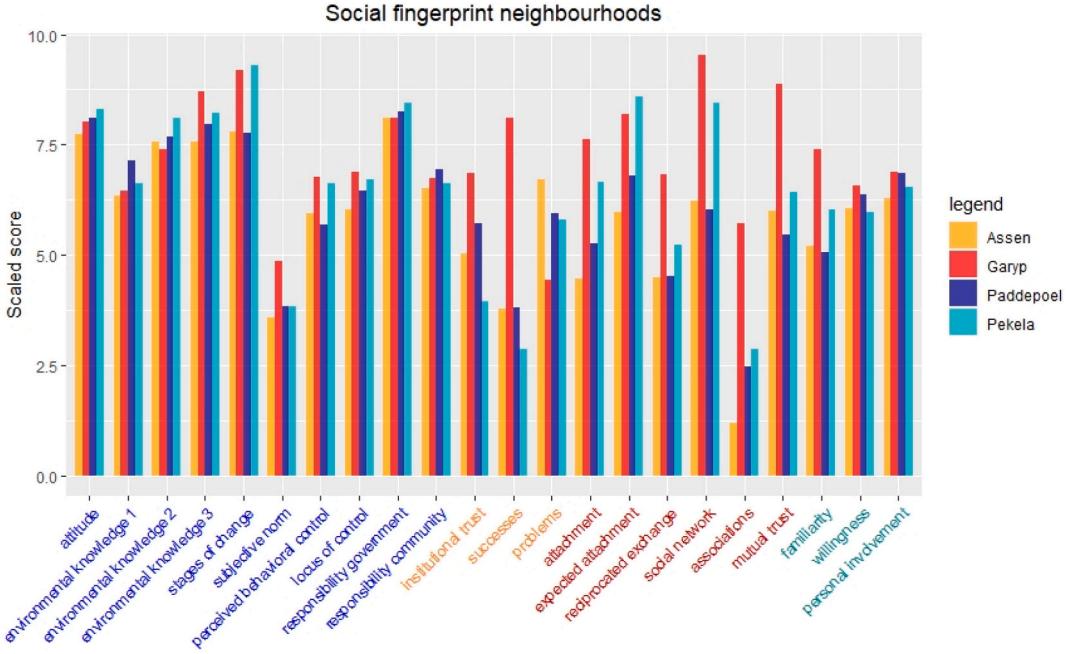

Fig. 4. Social fingerprint.

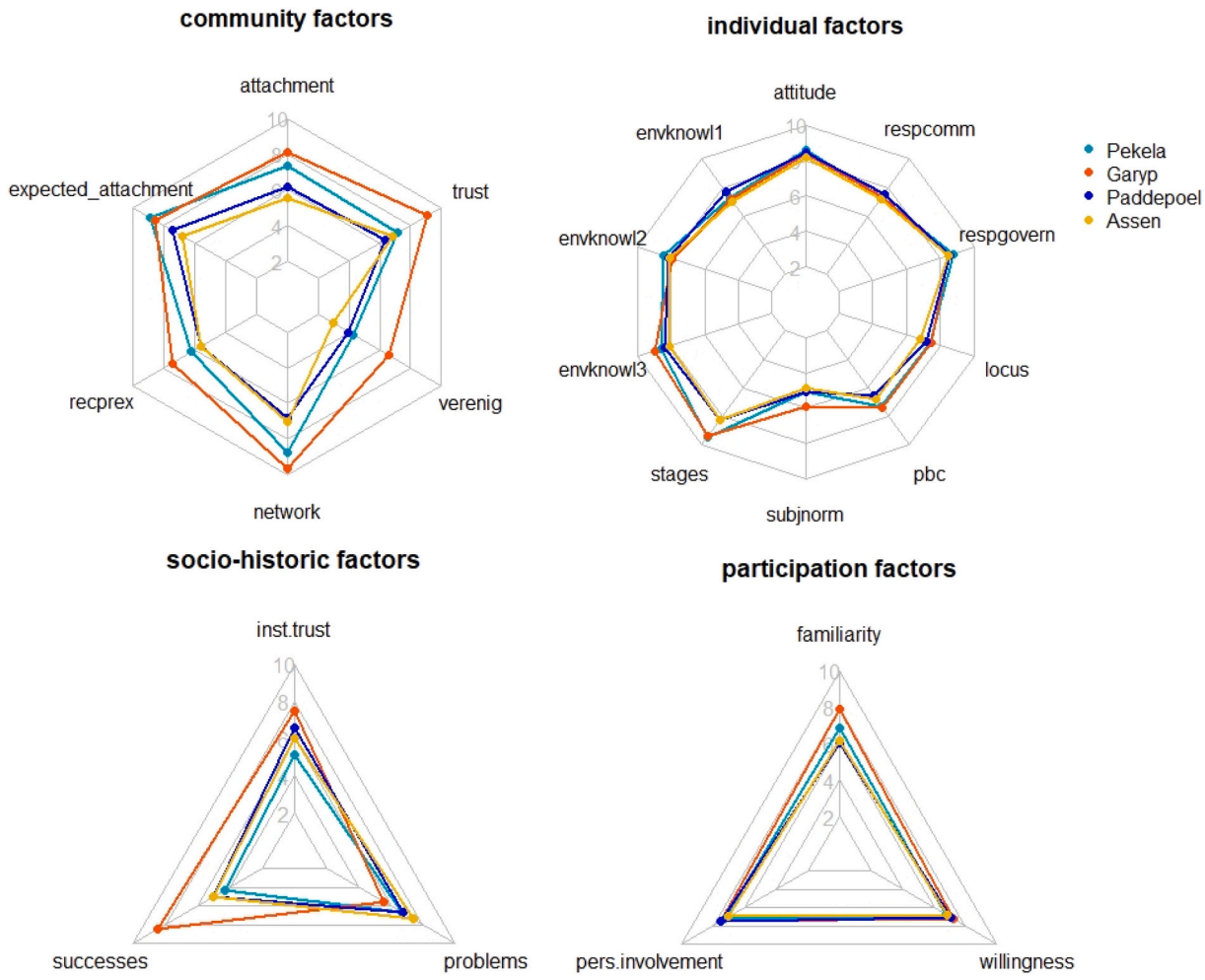

Fig. 6. Radar charts of results split in 4 categories.

that the involved stakeholders operate in the right roles, such as the municipality operating in a project management role in Pekela rather than being actively involved in the participation process. Similarly, the bottom-up approach in Garyp where residents are in the lead, fits well with high levels of mutual trust. Hence, the results indicate that the chosen participation strategy, either top-down or bottom-up, in relation to trust seems to play a role. The combination of a high level of social cohesion and trust between the community and the local government authorities as strengths in local energy initiatives was also mentioned by Warbroek et al. [10].

6.2. Role of socio-economic status

Groups with a lower SES (lower income and education) have less *knowledge* and lower *concern,* show lower *perceived behavioural control* and are in a lower *stage of change* than people with a higher income and education. They are also less involved in the community, especially in the form of *memberships in organizations* and *social network*. Middleton also found that residents in the better-off areas were much more likely than those in the poor areas to participate in civic organizations [25]. Lower income and education groups also show lower levels of participation, indicated by lower scores on *personal involvement* and *familiarity with the project*. *Willingness to participate* seems to relate to education rather than income, which is in line with previous findings, e.g. [31], and can therefore be considered a strong predictor.

The findings suggest that residents with a lower SES generally have lower capabilities than residents with a higher socio-economic status and require an approach that meets their specific needs to be able to sufficiently involve them. The experience in De Lariks indicates that a technical solution that requires high investment may not connect so well with a target group with low income and education in combination with home-ownership and self-investment. Vice versa, residents with high income and education could be indicated as more able-bodied citizens which can act as initiators (the relation between income and activity in energy cooperatives is also evident from other literature).

6.3. Role of social cohesion

From the analysis a difference in community variables between the four cases can be observed. In line with [12,15] social cohesion, as well as participation, was found to be higher in rural than in urban neighbourhoods. Based on the theoretic background, it could be expected that social cohesion would have a higher effect on (intended) participation. The difference in *willingness to participate* between cases was significant, but moderate in comparison to the large differences in community factors (see Fig. 2. Social fingerprint). In the study of Koirala et al. [31], a slight majority of the respondents answered positively to participation in a community energy system. The higher scores could be explained by the fact that the data in this study was based on a fictional case whereas our data was collected in ongoing projects with significant practical implications and self-investment of participants. Notable is the high score on *familiarity with the project* in Garyp, which is more in line with the high scores on social cohesion in this neighbourhood. One explanation would be that familiarity increases with higher social cohesion

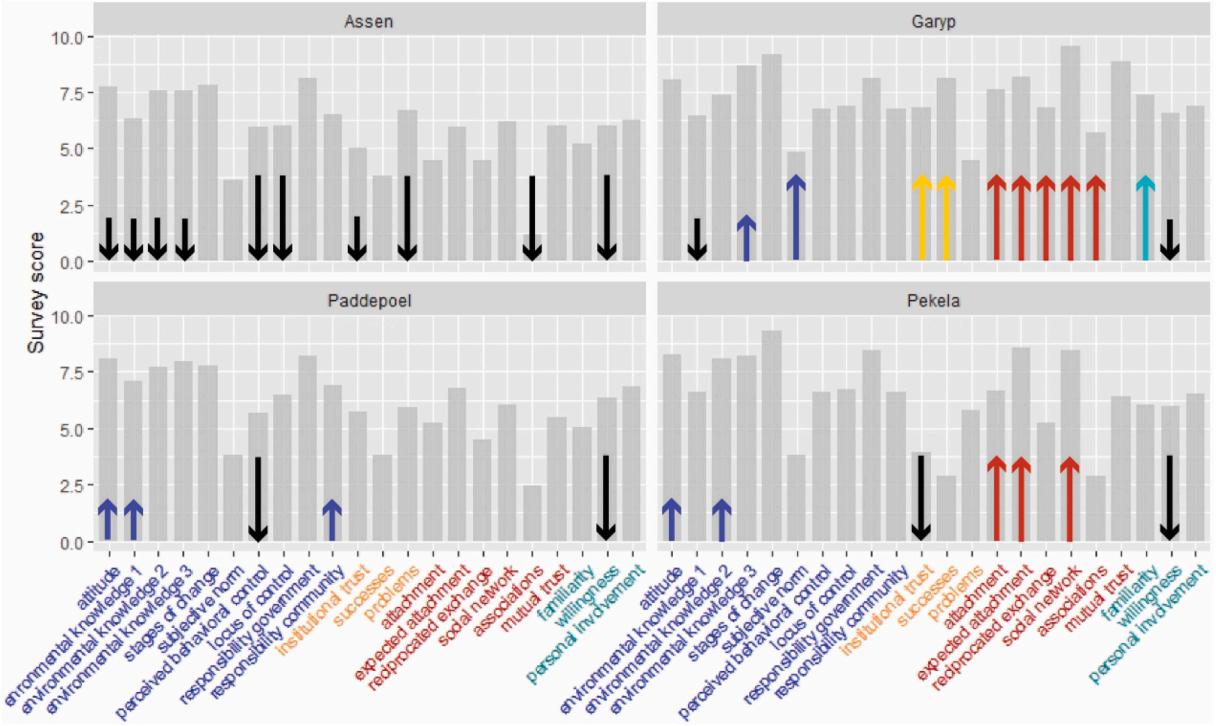

Fig. 5. Social profile per case showing the weak points (black arrows) and strong points (coloured arrows) of each neighbourhood. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

Table 9
Overview of weak and strong points of the studied neighbourhoods.

	Strengths	Weaknesses
Paddepoel	- basis in environmental knowledge & concern - responsibility community is relatively high	- control is low in at least some groups (social housing, low-income groups) - low willingness to participate
Garyp	- strong social cohesion - relatively high subjective norm - familiarity with the project is high - high institutional trust	- potentially low willingness to participate
Pekela	- basic level of social cohesion (attachment, social network) - attitude and knowledge	- low institutional trust - low willingness to participate
Assen		- low environmental knowledge & concern - low institutional trust - low willingness to participate

because information is spread more easily with more interaction between members of the community [53]. Another explanation would be that the question in the survey was too broad and people were unsure of what 'helping to make the neighbourhood more sustainable' exactly meant, and that a measurement error may play a role.

Subjective norm shows a similar pattern among cases as community factors, and is, in line with the literature, a distinctive variable. This could be explained by the higher social cohesion, where people tend to care about each other's opinion when they interact with each other more. Therefore, subjective norm could be an indicator of social cohesion rather than a personal characteristic.

6.4. Role of home-ownership, gender and age

We found differences in *home-ownership*, in particular concerning social cohesion (see Section 5.2). Differences in homeownership in relation to social cohesion have been pointed out by Forrest and Kearns who say that 'neighbourliness' (such as the exchange of favours) is lower in areas with social housing compared to wealthy, home-owning areas [22]. Similarly, Middleton found that owner-occupiers were much more likely than those in rented accommodation to say that people mainly help each other [25]. However, some authors didn't find significant correlations with home-ownership, such as [31]. In this study, differences between owners and renters on willingness to participate are however small. This may be caused by the financial consequences of the projects for home-owners compared to tenants, that decreases their natural tendency to be more involved in community energy projects. Home-ownership probably depends on the context and project focus, and a general relation cannot be presumed.

Gender show differences on several individual items, including knowledge and control, which translate to a difference in participation as well. The results are in line with what can be observed in practice, where much less women are actively involved in the project, as initiators indicated in interviews. The lack of knowledge and perceived control may in fact form a barrier for women to join. To sufficiently involve woman, their specific needs and concerns need to be addressed.

Age negatively effects the willingness to participate. Age was also found to be a negative predictor of intended acceptance by [39] in relation to battery storage and was also the only socio-demographic predictor in the study. At the same time, social ties in the community are increasing with age. Older people live longer in the area and build more and more intensive contact with neighbours. Similarly, Middleton found that social investment in relationships with neighbours increases with age and length of residence [25]. Therefore, older age groups can form an important social group in the involvement of the community in energy initiatives once they are participating themselves.

7. Conclusion

The aim of this paper was to answer the following research question: *Which social factors, focussed on socio-economic and social cohesion aspects,*

are relevant for constructing a social profile of a neighbourhood as starting point for an approach for community participation? In answering this question, 25 social factors were mapped for four neighbourhoods and differences between neighbourhoods were studied. Based on the results from both the survey data and the qualitative case-study, it can be concluded that with these factors, it is possible to generate a unique social profile that creates insight in the weak and strong points of the neighbourhood. Differences between cases were significant, except for *responsibility*. Therefore, the identified social factors indeed seem to be relevant for creating a unique social profile. Our initial hypothesis that SES and social cohesion is of influence on participation success was supported by the results, and in addition, measures of organizational power, including previous successes and memberships in associations, were identified as potential additional factors of participation success.

In conclusion, this exploration of which social factors are relevant, and influence success, has provided a first sketch of how to make useful and truthful social profiles. However, since the focus has been on investigating the possible use of many different types of social factors, individual factors have not been investigated in depth. Therefore, this study does not provide a complete model, but provides insights in relevant social factors and the possibility to design successful strategies based on social data (see Section 7.2).

7.1. Limitations and suggestions for future research

Identifying success is a highly complex issue as there are many different aspects related to success in community energy projects and it is difficult to determine which aspects exactly lead to success, to what extent and in which combination with other aspects. In this paper we focussed on pre-existing neighbourhood characteristics, while extracting project and technology related issues as much as possible. As these issues are highly intertwined, it is not possible to see those completely separate. Therefore, the results of this study should be interpreted carefully.

Results are in particular sensitive to the technical solution and the participation strategy. The technical solutions in the cases that we selected are diverse; the practical and financial consequences for residents in a district heating system are hardly comparable to that of an all-electric solution. The characteristics of the technology may have influenced the results concerning the attitude of residents towards the project. For instance, if we measured that willingness to participate was low, we do not know to what extent people are reluctant to participate in any project or just not in this particular project. It may be the case that people are more eager to participate in a district heating project than in an all-electric project. In other cases, the chosen participation strategy may have influenced the results. When we measured that familiarity with the project is low, we do not know to what extent the efforts to bring the project under attention have been unsuccessful or that people are simply not interested in the topic or the project. We have tried to overcome this issue by looking at the cases both qualitatively and quantitatively, thereby placing quantitative results into the context of the project. However, shortcomings are inevitable and results should be considered as preliminary in the wider academic discussion.

Another limitation of the study is that we measured in ongoing projects, where a baseline measurement was not possible and intermediate progress to measure the level of success, rather than end results, was used. Therefore, besides measuring prospectively, our suggestion is to measure the level of success in terms of the final share of participants a second time when the project has terminated, and relate the survey results with the success level to draw final conclusions. Finally, with only a limited number of cases, we were only able to determine the most prominent trends in the data. To understand more specifics about the cases, such as the role of the chosen technology, urban context, characteristics of the dwellings, etc. more cases would need to be studied.

7.2. Recommendations for the professional practice

Based on the results of the data-analysis, it can be concluded that different social groups can be identified and that these differences are largely the same among cases. The data has shown that there are important differences between owners and renters which occurred for most of the social factors studied. Differences between age groups, gender and SES are identified as well although there were less factors where these differences occurred and those were also less consistent among the cases. For the professional practice this means that in designing participation strategies, it is important to be aware of these differences and to connect with the needs and challenges of each group. A one-size-fits all approach is likely to be insufficient to get everyone on board. In addition, inclusivity is a precondition for making use of the social capital of the neighbourhood in a community project. It should be prevented that the project drives a wedge between different social groups in the community by stimulating some people to participate while the needs of others are not met. Instead, constructive conversation and co-operation with and between groups may strengthen the community.

The results of this study should be interpreted as a starting point for designing participation strategies that fit within the specific context of a neighbourhood. It is not our intention to give the impression that one ideal solution exists. Two considerations in particular are pillars of an appropriate approach. The first is related to a collective versus an individual approach. When choosing a technical solution with a collective nature, such as a district heating grid, a certain level of social capital is required as joint decision-making is a prerequisite. In neighbourhoods with less social capital on the other hand, an individual solution is likely to be preferred. The second consideration concerns the issue of a top-down versus a bottom-up approach. Previous success, entrepreneurship and community responsibility are more likely to support a bottom-up approach whereas institutional trust, government responsibility and low community organization rather support a top-down approach. Either of those approaches could lead to successful participation. Similarly, factors like income, education and behavioural control influence the extent to which technologies are considered feasible by people. In addition, relevant input for a communication and participation strategy can be obtained from the identified meeting places, argumentation for participation provided in open answers and experienced control over measures, among others, see further [54]. A concrete technical solution cannot be deducted from the data, but the social profile creates insight in important boundary conditions for shaping those solutions.

The results show that the specific characteristics of a neighbourhood make the chances of success higher in some neighbourhoods than in others. Some of the social characteristics, such as age, income and education, are not changeable. These may play a role when selecting neighbourhoods that are chosen first, when considering a neighbourhood-by-neighbourhood approach. There could be reasons for prioritizing neighbourhoods that have a high chance of success, for instance for creating positive examples that can stimulate an upscaling. The aforementioned factors can be mapped at the beginning of the project based on general data, and give a first indication of potential success in a neighbourhood.

Some of the social factors that are identified as predictors of success are influenceable, such as knowledge, attitudes, trust, subjective norm, and social ties. A limited knowledge level for instance, may be increased by better information, a lagging attitude can be dealt with by discussing the urgency of the matter, addressing misconceptions, utilizing social influence, and the subjective norm can be increased by stimulating conversation between residents etc. Institutional trust can be increased by creating and communicating clear plans, and strong communication with residents. The Cities4Zero project for example has demonstrated the value of cocreated strategic energy plans that are capable of engaging relevant stakeholders [55], whereas a top-down approach is still dominant in municipal energy planning [56]. In this paper the focus

was on the identification of determinants of success, rather than identifying if and how specific factors can be influenced and used to support and potentially increase the level of participation. When adequately translated into practical participation strategies and approaches, the chances of success cannot only be predicted but also enlarged.

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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

The authors do not have permission to share data.

Appendix A. Evaluation criteria

Table 10
Evaluation criteria for multicriteria analysis on participation success.

Criteria	Checks
Attendance at project meetings	• How many people show up at project meetings? • If people are offered to volunteer in working groups or similar activities, how many people sign up? • Do new faces show up at project meetings when the project proceeds? • Does the attendance increase or decrease when the project proceeds?
Citizen support	• How many names and faces are informed on a regular basis: e-mailing list, memberships, etcetera? • Is there resistance: action groups, protest signs, signature campaigns, formal complaints or similar?
Representation of social groups	• Have some groups indicated not to be able/willing to participate in the project that are meant to participate in the project? • Is it difficult to reach certain groups?
Adoption of measures	• How many people already adopted physical measures as a result of the project? • In case adoption is not an option yet, are there any indications of how many people would adopt measures: declarations of intent or similar?

Appendix B. Survey measures

The survey consisted of three parts: 1) questions about the neighbourhood, 2) questions about sustainable energy and 3) personal questions such as age and income. Based on the theoretical model, five key concepts were defined: demographic factors, social capital, individual factors, socio-historic context and participation. The key concepts were measured as follows:

Community characteristics: In the social cohesion subset, 5 factors were mapped that measure the level of social interaction between people in the neighbourhood. *Reciprocated exchange* indicates the level of interaction between neighbours, and was measured with 5 items of a 5-point scale ('never', 'rarely', 'sometimes', 'regularly' and 'often'). The 5 items indicated different levels of interaction, from meeting neighbours on the street to discussing personal matters, based on [45]. The items correlated highly and were therefore combined in one internally consistent scale by taking the average of these scales. *Social network* indicates the number of contacts between neighbours. Respondents were asked how many people they knew by name in their neighbourhood, with 6 answer categories (defined as 0, 1–3, 4–6, 7–9, 10–12, more than 12 people). *Mutual trust* was measured by asking the respondents to what extent they trusted people in the neighbourhood to be able to solve a problem in the neighbourhood collectively, and was answered by 'yes' or 'no', followed by an opportunity to clarify the answer. *Memberships in organizations* was measured in a similar way as Wollebaek and Selle [23] propose, dividing organizations in semipolitical, religious and leisure. We also asked how much time respondents invested in these organizations on a weekly basis (defined as 1 h/week, 1 daypart/week, more than 1 daypart/week). *Years of residence* and *expected years of residence* were assessed as two separate items of neighbourhood attachment. The first one was an open question and the second one was guided by multiple choice options (0–2, 2–5, 5–10, 10 years or longer, but not forever and preferably forever).

Individual characteristics: The second subset consists of 7 individual factors. *Environmental concern* was measured by two items. In the first item respondents were asked about their attitude towards sustainable energy ('What do you think of the commitment to make the energy supply in the Netherlands more sustainable?') and the second was focussed on natural gas ('What do you think of the commitment for decreasing the dependency of natural gas in the Dutch energy system'?). The two items are strongly correlated (correlation factor). Hence, we use the average score for the two items to represent environmental concern. *Environmental knowledge* was measured by three items. In the first item, respondents were asked what the percentage of renewables in the Dutch energy mix was (open question). The open answer was compared with the correct answer (the actual percentage of renewable energy in the Dutch energy system). In the second item, respondents were asked to name as much energy sources of the Dutch energy supply as they could, which was again an open question. The answers were evaluated on correctness, and the number of correct answers was used to represent the second knowledge item. In the third item, respondents were asked about their familiarity with four renewable energy technologies (solar PV, district heating, biomass boiler, heat pump) on a 5-point scale ('unfamiliar', 'somewhat unfamiliar', 'not familiar/not unfamiliar', 'somewhat familiar', 'familiar'). *Subjective norm* was operationalized based on a scale of Flower et al. [57], that used the Theory of Planned Behaviour, which was translated to the specific topic of sustainable energy measures in dwellings. Responses were recorded on a 5-point Likert-type scale from 1 (strongly disagree) to 5 (strongly agree). *Perceived behavioural control* was also based on a scale of Flowers et al. [57], and translated in a similar matter as subjective norm, and measured on the same Likert scale. The five items were defined as: 'I have sufficient knowledge and resources to take measures to make my home more sustainable', 'I am able to invest in making my home more sustainable', 'I can take sustainable energy measures at any time if I want to', 'When it comes to taking sustainable energy measures, I am dependent on others' and 'Taking sustainable energy measures is too complicated for me'. *Locus of control* was operationalized based on a scale of Fielding and Head [36] and consisted of three items: 'My individual actions can make a difference to the energy transition', 'I can make decisions now that influence the future of sustainability in my neighbourhood', 'I am only one person, I can't make a difference to the energy transition'. The items were measured on a 5-point Likert-type scale (1 = strongly disagree, 5 = strongly agree).

Higher scores on this scale indicate a more internal locus of control. *Responsibility* was measured based on the scale of Fielding and Head [36] which consisted of 6 items (municipal government, provincial government, national government, companies and businesses, local community, they themselves) on a 5-point scale (1 = not at all responsible, 5 = entirely responsible) to which we added 'energy companies'. Based on the items that correlated the highest, we grouped the items in two categories: community responsibility (own responsibility, community responsibility, energy companies and local companies and institutions) and government responsibility (municipal, provincial, national). *Stage of change* measures the intentions for sustainable energy measures. There are four stages: action (already implemented measures), preparation (planning to implement measures within 1 year), contemplation (planning to implement measures within 5 year) and precontemplation (not actively planning to take measures). Three separate items were included in the survey to determine the stage of change ('Did you already take measures?', 'How likely is it that you will take measures within 1 year', 'How likely is it that you will take measures within 5 years?'. In the explanation to the question, respondents were given varying examples of possible measures varying from draught excluders to solar panels. The examples were focussed on physical measures and behavioural measures were excluded. When respondents did not already take measures, they were asked to indicate the probability of taking measures within 1 year and within 5 years, by means of a slider. When the slider score was above 5.5, the intentions were interpreted as positive for that item and the associated stage was assigned. The lowest score (precontemplation) was attributed to respondents who answered the final question (within 5 years) with a score lower than 5.5. In the final representation of stage of change we assigned each respondent a number 1 to 4, based on the identified stage.

Socio-historic context describes matters that may have happened in the past that influences peoples' attitude towards a potential project and gives an indication of how experienced the neighbourhood is with engaging in activities. *Institutional trust* was assessed in a similar way as mutual trust. Respondents were asked whether they trusted the municipality to be able to solve a problem in the neighbourhood. *Previous successes* maps the collective activities that already have taken place in the neighbourhood, such as a cleaning-up activity, realisation of a playground or another activity that was aimed at improving the neighbourhood. For the final scale we interpreted the answers dichotomous: successes reported yes/no. *Existing problems* maps the problems reported by respondents, which was presented as an open question. For the final scale we interpreted the answers dichotomous: problems reported yes/no. Socio-physical infrastructure was materialized by asking respondents how often (once per year/once per month/once per week/daily) they visited communal places in the neighbourhood (shops, restaurants, community centre, church and school) and where they would meet their neighbours most often (open question).

Participation was measured by four items: the willingness to participate, personal involvement, familiarity with the project and local organization. *Willingness to participate* was operationalized with a question whether respondents wanted to participate in making the neighbourhood more sustainable, answered by a multiple choice (yes/maybe/no). *Personal involvement* was measured with 4 items on a 5-point scale (1 = strongly disagree, 5 = strongly agree). Respondents were asked how much they were interested in the topic and to what extent they were willing to be involved in the topic. *Familiarity with the project* measured whether people are familiar with the activities of the project, answered by a multiple choice ('I do not know the project', I know the project by name, 'I am aware of the activities of the project' and 'I am actively involved in the project').

Demographic and socio-economic variables: The survey concluded with demographic questions including *age*, *gender, education and home-ownership*. To assess *income,* we included four answer categories in which salary is related to the modal income of 36.500 EUR ('Below modal', 'Around modal', 'Above modal', 'Don't know/don't want to say'). In addition, respondents were asked about their main day-to-day occupation ('Employed', 'Student', 'Entrepreneur', 'Retired', 'Unemployed', 'Volunteer', 'Caregiver', 'Housekeeper').

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