Social fingerprints: Social characterisation of neighbourhoods as design frame for sustainable communities

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Abstract

In this study, survey data were collected for a neighbourhood in the municipality of Pekela, The Netherlands. The neighbourhood takes part in a national programme aiming for natural gas-free neighbourhoods as Living Lab. The study demonstrates how social data can complement economical and technical data to inform the energy planning process. With these data, both the choice for specific measures and the way in which plans should be implemented can be adjusted to the specific features of a community. A theoretical model was developed in which relevant resident and neighbourhood characteristics were identified based on the existing literature. Demographic, community, individual, socio-historic context and participation factors were identified as key concepts. Part of these concepts are related to energy, such as attitude towards energy transition and the willingness to take energy measures, and part of these concepts are more general in nature, such as the social contacts between neighbours. A total of 25 factors within those 5 key concepts were measured for the neighbourhood. With these data, a so-called 'social fingerprint' was constructed, a unique set of scores on the variables that represents the neighbourhoods' identity in a concise manner. The social fingerprint, presented in a graph, can be compared with other neighbourhoods in a way that mutual differences become easily apparent. Notable characteristics for Pekela are the low institutional trust and low scores on neighbour interactions while showing strong neighbourhood connectivity. The social fingerprint can be interpreted for application in the planning practice. Overall, tangible indications can be given for the technical measures to be chosen, the communication with citizens, the degree of citizen participation and the cooperation with third parties.

Introduction

The energy transition in the built environment typically takes places on a local scale. The variance in houses and buildings, living environments, individual residents and among communities often requires a tailor-made approach. Measures, in the form of home renovations and replacement of appliances and equipment, take place in and around houses, and confronts residents with the financial and technical consequences of decisions towards a more sustainable living environment. Several European countries, including the Netherlands, have adopted policies in which the scale of the neighbourhood is chosen for developing transition plans. As a result of these developments, the demand for effective strategies to involve citizens is rising. However, few validated tools and insights are available to design suitable participation strategies.

Challenges in designing participation strategies are knowing how to connect with the needs and desires of residents and how to deal with the variance in target groups. Methods used in practice either treat different types of residents as one, or use labour-intensive methods of first investing in personal contacts with a large number of residents (e.g. kitchen table conversations). Methods that are both pragmatic and able to deal with variety, are needed to respond to the speed that the transition in the built environment requires.

The methodology of social profiling, described by (Bouw *et al.*, 2022), contributes to this challenge by exploring how a social profile of a neighbourhood, which we call 'social fingerprint', can be created. In this paper we further explore the methodology of social fingerprints using an in-depth case-study of the municipality of Pekela, the Netherlands. By exploring one neighbourhood in detail, we aim to show how the data, presented in (Bouw *et al.*, 2022) can be translated to an appropriate approach for a sustainable energy community. The data will be looked at more closely and the focus will be on the meaning and implications for application in practice. The potential functioning of the tool is demonstrated by translating social data to concrete leads for an approach in Pekela. The chosen case-study is part of a larger investigation of multiple cases. Therefore, we also refer to the comparison with these cases, without discussing them in detail.

The paper is structured as follows: we first introduce the case-study and shortly introduce the method. Then the results from the survey in Pekela are summarised, after which we interpret the results and present ideas for how these insights can be translated to a planning approach. The chosen approach in the case-study will be tested for how well it fits with the social profile that was constructed and recommendations can be made.

Case-study

Pekela is one of the 24 selected Living Labs of the Natural Gas-Free Neighbourhoods Program, known in Dutch as Programma Aardgasvrije Wijken (PAW), that received government funding in 2018. A selected area of the municipality Pekela, a rural area consisting of the village of Boven Pekela and a small part of the village Nieuwe Pekela (Doorsneebuurt) with a total of 578 houses, is part of the Living Lab. A bottom-up initiative, called "Pekela geeft gas", with a focus on energy savings, had already started in 2016 before the area became a Living Lab. Decreasing the dependency of natural gas and lowering energy bills was especially important in the villages of Pekela. The villages are located in the earthquake sensitive area of gas extraction that also consist of many old, detached houses with low energetic performance. With the help of the subsidy, it is the aim to equip houses with hybrid heat pumps running on locally produced green gas and electricity from rooftop photovoltaics. 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 and get access to a network of approved local installers. They can also apply for a loan with a low interest rate for the investments, of which the interest is subsidized from the project budget.

In the Living Lab, the initiative "Pekala geeft gas" is working together with the municipality, as only the municipalities can apply for the PAW funding. There is a strong cooperation between the group of residents and the municipality. Since the start of the project, residents have been informed about the project through information meetings, social media and flyers, amongst others. More importantly, the approach is focussed on personal contact between working group members and residents, and the use of ambassadors. Participants who already have implemented measures are made visible by a sign in the garden for neighbours to see, and are also actively available to tell their story. Pekela is considered to be a close community where people know and help each other, which is helpful in the project where residents have an active role to play. Several renovations have already been implemented, but members of the initiative stress that the participation process is time-consuming and each resident takes decisions in their own time. Most of the houses are private property of house-owners and almost each house is unique, which requires a tailor-made approach.

Method

SURVEY

A survey was conducted among the selected 578 households of the Pekela Living Lab. The survey consisted of 40 questions, which measured 25 factors covering community factors, individual factors related to sustainability, demographic factors, socio-historic factors and participation factors, see Figure 1. More information on the theoretical framework can be found in (Bouw *et al.*, 2022).

Each factor was measured by one or more questions, resulting in multiple variables for some factors. This is the case for neighbourhood attachment, which is measured by a question about how long people have lived in the neighbourhood (neighbourhood attachment 1) and one question about how long people are expecting to stay in the neighbourhood (neighbourhood attachment 2), and for environmental concern. Environmental concern was measured by a question about the attitude towards increasing the share of sustainable energy (environmental concern 1) and one question about the attitude towards decreasing the dependency of natural gas (environmental concern 2). Environmental knowledge was measured in three different ways. The first question was an open question in which the respondent was asked to mention energy sources that currently make up the energy supply in the Netherlands, with the number of correct answers counted. In the second question the respondents were asked to estimate the percentage of renewable energy in the Dutch energy system and the third question was about the familiarity with four different energy technologies, which were also combined into one score. The variable about responsibility for making the neighbourhood sustainable was asked from seven stakeholders. Some other factors consisted of several items on the same scale that were combined into one score. This is the case for locus of control, perceived behavioural control, subjective norm and personal involvement. Remaining factors were measured by one single question, and both ordinal and nominal scales were used (see Table 2). For further clarification of the variables, see (Bouw *et al.*, 2022).

The survey was distributed on paper by door-to-door visits. Each house was visited at least once in the period of September-October 2021. Each respondent was asked to fill in the survey in hardcopy and agreed to a pick-up time. 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. This resulted in a response of 130, of which 110 responses were hard-copy and 20 were on-

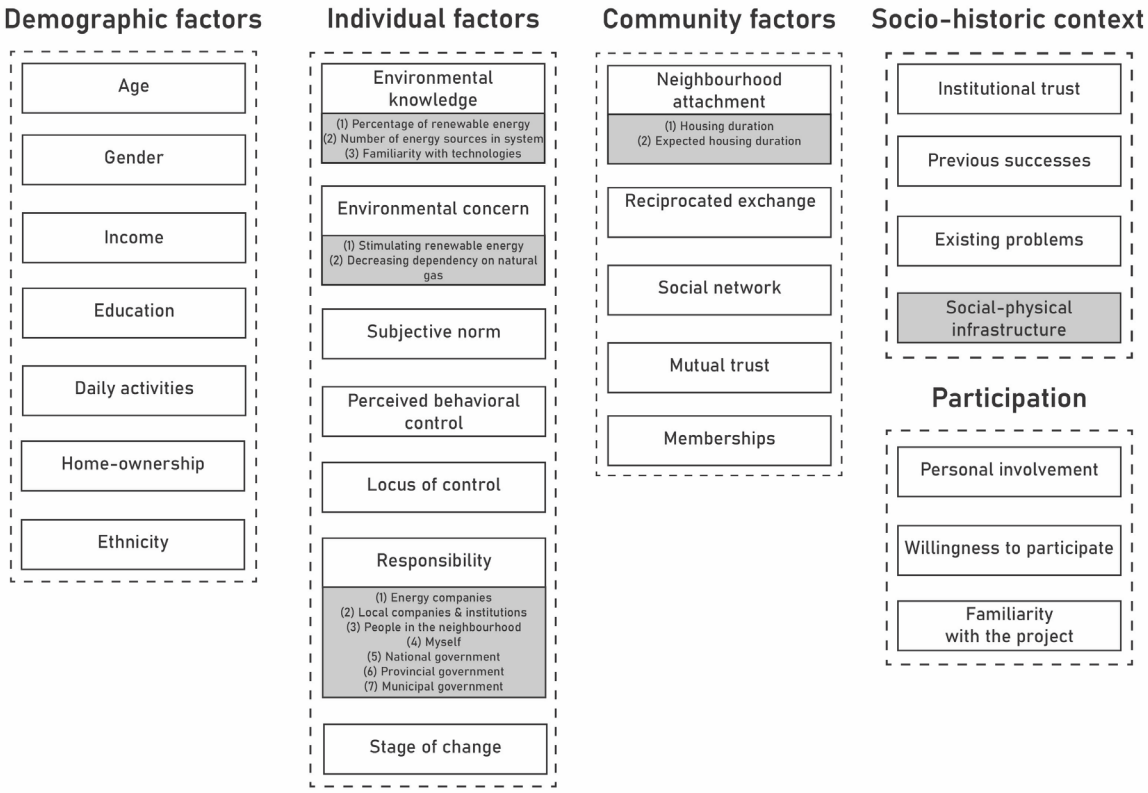

Figure 1. Theoretical model of social context factors with corresponding key concepts. Factors that were measures with multiple items were indicated in the figure by a grey box. Social-physical infrastructure is marked grey as the data is only qualitative and is therefore not included in the quantitative data analysis.

line. One respondent was removed for being under age, so that the total sample consisted of 129 respondents. The sample can be considered representative based on the included groups, but the sample size by itself is too small to be representative (margin of error is 7.57 % at a 95 % confidence interval). Therefore, the results need to be interpreted with some caution. The sample doesn't match the statistics of the municipality for income, education and home-ownership, but this is expected to reflect the situation for the Living Lab area.

INTERVIEWS

Qualitative data was collected through semi-structured interviews with a stakeholder from the community. A total of 2 interviews were held with a representative of "Pekela geeft Gas". One interview was conducted before executing the survey and aimed at understanding the historical context of the neighbourhood, and the renewable energy project in progress. The second interview with the same stakeholder was conducted after the results of the survey were known and aimed at discussing the results with stakeholders to see whether the results were recognised or whether important aspects were missed or misinterpreted.

SOCIAL FINGERPRINT

Based on the results of the survey, a social profile for the community can be constructed. The measured factors can be presented in a graph so that the score on each factor can be visually read and compared to other scores. A visual tool was developed in R Studio that presents the social factors in such a graph: the social fingerprint. The items of this '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 factor to create a 10-point scale. Dichotomous variables[1] were expressed in a percentage of respondents that answered 'yes', instead of the mean. Continuous scales (neighbourhood attachment 1, environmental knowledge 1 and 2) were first categorised after which a weighting factor was assigned to create a 10-point scale, and were further treated as ordinal variables. Some variables were combined into an average variable. The two items of environmental concern were combined into one variable. The government items of responsibility were combined as well, and the remaining items were combined as 'community responsibility'. Although the presented data have no statistical relevance, the visualisation of the results does give an impression of the performance of the variables (see Figure 2). This is needed to get an overall image of the community, easily showing 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.

1. A dichotomous variable is a type of variable that only takes on two possible values. In this case the possible answers were "yes" and "no".

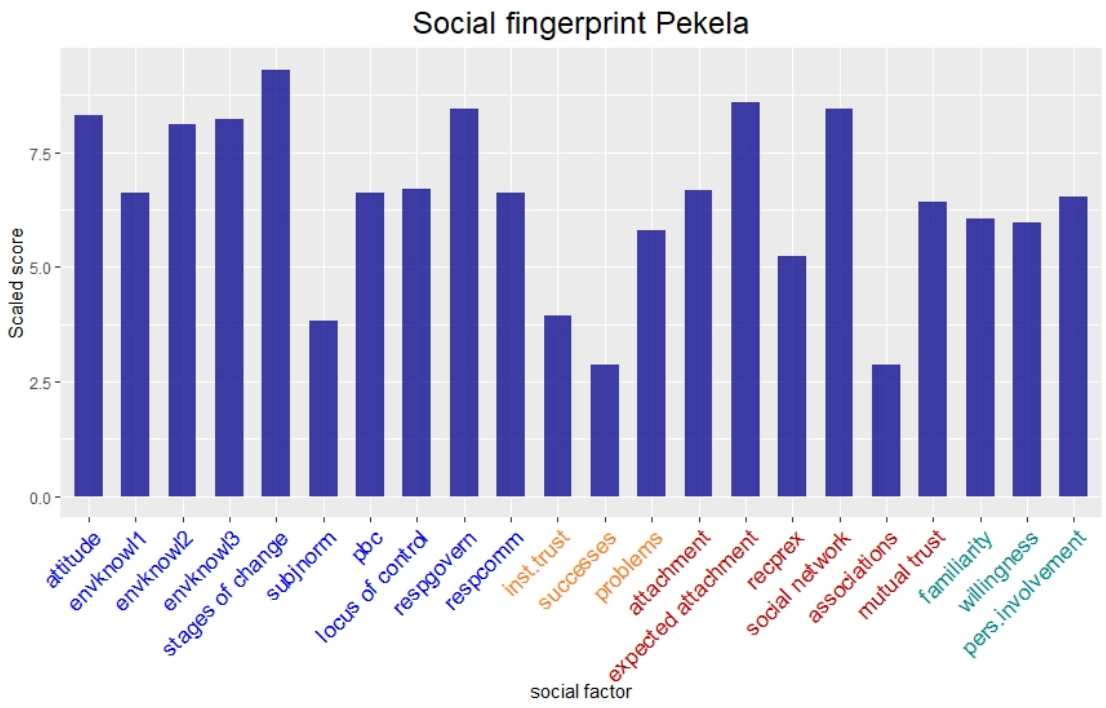

Figure 2. Social fingerprint of Pekela based on the factors. The colours indicate the key concepts (blue = individual factors, yellow = socio-historic factors, red = community factors, green = participation factors).

Results

DATA

The results are summarised in Table 1 and 2 and will be described in the following section. For full results we refer to (Bouw *et al.*, 2022).

Demographic factors

The demographic factors age, gender, income, education, daily activities, ethnicity and home-ownership have been mapped and the results are summarised in Table 1. Compared to the national average (see Table 1), the owner occupancy rate is much higher in Pekela, with almost no rented property. Ethnicity deviates from the national average as well, with most residents having a native Dutch background. The survey results may give a distorted view on income due to a large group of respondents that didn't want to mention their income (27 %). Based on the survey results, income is above national average. Whereas national demographic data shows that the income in Pekela is below the national average, this suggests that some of the respondents that didn't want to mention their income have an income below average. The number of respondents that is working in a paid job is relatively low, and the number of retired people is relatively high. Further, the sample seems to be representative and there aren't any notable deviations on the other variables.

Individual, community, socio-historic and participation factors

Table 2 presents a summary of the survey results. For individual factors, relatively high scores are given for environmental concern and environmental knowledge, which are positive indicators for support for a community energy project. Most people in Pekela also have already taken sustainable energy measures such as placing solar photovoltaic panels and improved insulation, and are in the action phase of stages of change. This is another positive indicator. The subjective norm is rather low, with a score below the average of the scale. This suggests that people are mildly sensitive to the opinion of others and to possible external pressure. Moderate scores are given for locus of control and perceived behavioural control. Slightly higher scores than the average of the scale are given, meaning that people tend to feel a bit more able to take energy measures than not and tend to feel that their individual actions contribute to overarching sustainability goals a bit more than not. Furthermore, respondents consider the government to be most responsible for making their community more sustainable, in particular the national and municipal government. The average responsibility of local stakeholders is estimated to be lower, with relatively high levels of responsibility attributed to oneself.

The results for community factors give an ambiguous view. Some of the variables show high scores. This is the case for neighbourhood attachment and social network. People generally have been living in the area for a long time and are also planning to stay for a long time. Most respondents also know many people in Pekela by name. Other community factors have lower scores e.g., for reciprocated exchange and mutual trust. However, most people trust each other to be able to solve a problem in the neighbourhood collectively and most people exchange favours occasionally. The number of people that is a member in an association is fairly low; only 31 % is active in a local association.

Concerning other socio-historic characteristics, the number of reported successes is rather low with the majority of the respondents not being able to mention a successful collective

Table 1. Demographic factors.

Factor	Explanation	National average	Survey data Pekela
Age	*Mean (continuous scale)/standard deviation*	42.2 (CBS, 2020a)	55.33/14.26
Gender	*%female*	50.3 (CBS, 2020a)	52.7
Income	*%above average/median (3 categories)*	16.5 (CBS, 2020b)[2]	21.7/3.00
Education	*%higher education/median (5 categories)*	32.9 (CBS, 2021b)	34.9/3.00
Daily activities	*%paid job*	56.6 (CBS, 2021a)[3]	44.2
	%retired	17.6 (CBS, 2020c)	27.1
	%entrepreneurs	11.8 (CBS, 2021a)[4]	14.7
Home-ownership	*%owner occupied*	57.0 (CBS, 2019)	96.9
Ethnic background	*%Dutch*	75.8 (CBS, 2021c)	90.7

[2] *Category EUR 30,000–40,000 is considered as 'around average', above EUR 40,000 as 'above average', below EUR 30,000 as 'below average'.*

[3] *Employees as share of the total population 15–75 years (working and non-working).*

[4] *Entrepreneurs as share of the total population 15–75 years (working and non-working).*

Table 2. Summary of results of social factors.

Key concept	Item (*n* = 129)		Survey data Pekela	Scale
Individual	Environmental concern 1	Mean/SD	4.24/1.02	5-point Likert
	Environmental concern 2	Mean/ SD	4.07/1.08	5-point Likert
	Environmental knowledge 1	Mean/ SD	3.84/1.98	-
	Environmental knowledge 2	Mean/SD	17.2/15.99	-
	Environmental knowledge 3	Mean/SD	3.29/1.03	5-point Likert
	Subjective norm	Mean/SD	1.92/0.62	5-point Likert
	Locus of control	Mean/SD	3.17/0.95	5-point Likert
	Perceived behavioural control	Mean/SD	3.31/0.97	5-point Likert
	Responsibility - energy companies	Mean/SD	3.58/1.28	5-point Likert
	Responsibility - local institutions	Mean/SD	3.00/1.30	5-point Likert
	Responsibility - community	Mean/SD	3.12/1.31	5-point Likert
	Responsibility - own responsibility	Mean/SD	3.53/1.31	5-point Likert
	Responsibility - national government	Mean/SD	4.27/1.03	5-point Likert
	Responsibility - provincial government	Mean/SD	4.20/1.05	5-point Likert
	Responsibility - municipal government	Mean/SD	4.26/1.05	5-point Likert
	Stages of change	Mode	4	-
Community	Neighbourhood attachment 1	Mean/SD	23.6/19.82	-
	Neighbourhood attachment 2	Mode	5	5-point Likert
	Reciprocated exchange	Mean/SD	2.62/0.76	5-point Likert
	Social network	Mode	6	6 categories
	Mutual trust	%yes	64.3	2 categories
	Memberships in associations	%member	30.6	2 categories
Socio-historic	Institutional trust	%yes	39.5	2 categories
	Successful activities	%yes	28.7	2 categories
	Previous problems	%yes	58.1	-
Participation	Familiarity with the project	Mode	2	4 categories
	Willingness to participate	Mode	2	3 categories
	Personal involvement	Mean/SD	3.27/0.95	5-point Likert

activity. At the same time, the number of reported problems in the neighbourhood is quite high. The majority of the respondents (58.1 %) mentioned one or more problems. Most of the reported problems were about road safety and maintenance of roads and bridges. Greenery maintenance and cleaning up the canal were also mentioned. Social-physical infrastructure was included in the survey by asking which facilities (shops, schools, library, community centre, restaurants) were used on a regular basis and where respondents met their neighbours most often. The supermarket, school, horse riding school and football field were mentioned several times, but most people met their neighbours on the streets, in their house or garden and in the community centre. Public meeting places were more limited. This may also have to do with the fact that social-physical infrastructure in the area is limited, with basic facilities, such as a supermarket, and a community centre, outside the neighbourhood.

The key concept "participation" was measured with three factors: familiarity with the project, willingness to participate and personal involvement. Most respondents know the project only by name, followed by a group that is aware of the activities. Awareness of the initiative is therefore fairly high. When the

respondents were asked whether they would like to help make the area more sustainable, a minority indicated that they would like to, but the largest group of respondents would not like to help. The willingness to participate is relatively small with only 16 % of the respondents responding 'yes' and a large group of 35 % saying 'no'.

SOCIAL FINGERPRINT AND WEAK AND STRONG POINTS OF THE NEIGHBOURHOOD

Based on the social fingerprint of Pekela (Figure 2), the weak and strong points of the neighbourhood can be identified. Environmental concern and knowledge get a relatively high score, and therefore provide positive indications for a community energy project. Another strong point of the neighbourhood is that there seems to be a strong basis of social cohesion, based on relatively high scores on attachment and social network. Deeper social ties, represented by associations and reciprocated exchange, are relatively high but not as convincing as the two aforementioned factors. The membership in associations is not as high as you would expect in a community with strong social cohesion.

Weak points of the neighbourhood are a remarkably low score on institutional trust and a low number of reported successes. Scores on the participation factors willingness to participate and personal involvement are not high, but compared to the other cases that were studied there are no major differences. However, with only a small group of respondents that is willing to participate, willingness can be identified as a weakness in Pekela.

Interpretation of results

The following section describes how the various factors that were measured in the survey can be translated to a practical approach. In order to explain how the relevant factors can form input to an approach, different aspects of the approach are treated: preparation, communication, participation, cooperation and technical solutions (see Table 3).

PREPARATION

Before the start of the project, it should be checked whether there are important issues going on in the neighbourhood that could be in the way of a successful project and that should be dealt with first. Major issues with the houses, living environment or the residents themselves may hinder the willingness and ability of people to participate. The problems identified by residents of Pekela are, amongst others, road safety, and maintenance of bridges and canals. The number of problems reported by the respondents is rather high, with the majority of the respondents (58 %) reporting one or more problems. Even though these reported problems do not seem to concern sustainable energy projects, the impact of these problems on daily life, for example on the experienced interaction with, and decisiveness of the municipality and the experienced self-efficacy when handling these problems, may influence the roles of the municipality and the community in the project. In this case, the unsolved problems may lower positive expectations from the municipality.

COMMUNICATION

The survey results can provide starting points for communication with residents, in particular for how/where to meet them and for finding the right argumentation in the communication message. Concerning the information channels, the survey mapped where residents meet each other. For Pekela, the analysis has shown that there is a limited social-physical infrastructure in the area, and most people meet their neighbours in and around the house and in the community centre. Best opportunities for meeting residents seem to be the community centre and through personal contacts between neighbours. Physical meeting places such as the supermarket, football field and school could be used in an approach as well to reach certain groups. These results, therefore, indicate for the planning and implementation process that people could be approached in these locations, for instance by sharing an information folder or invitation near the school or football field and by organising meetings in the community centre.

Table 3. Summary of social factors linked to aspects of a practical approach.

Interpretation aspect	Factor	Information
Preparation	Problems	Issues to be solved
Communication	Social-physical infrastructure	Meeting places
	Willingness to participate	Argumentation
	Trust	Sender
Community participation	Memberships in associations	Organizational power
	Previous successful activities	Organizational power
	Entrepreneurship	Organizational power
	Subjective norm	Organizational power
	Willingness to participate	Motivation
Cooperation with third parties	Institutional trust	Stakeholder selection
	Responsibility	Stakeholder selection
Technologies	All community factors	Individual vs. Collective
	Previous successful activities	Individual vs. Collective
	Institutional trust	Individual vs. Collective
	Entrepreneurship	Individual vs. Collective
	Willingness to participate	Individual vs. Collective
	Personal involvement	Individual vs. Collective
	Income	Investment space
	Perceived behavioural control and locus of control	Investment space

Concerning the use of argumentation in the approach, the open answers to the question whether people are willing to help with making the neighbourhood sustainable indicate that people that answer 'maybe' could be convinced 'if others help too', 'if the government/municipality helps too', 'if the costs are low' or 'if there is a good plan'. These conditions can for instance be taken into account by communicating progress and successes to show that community members are indeed joining, by clearly communicating the costs and benefits for individual cases, and showing a clear plan rather than having people participate in the process. Reasons given for respondents not being willing to participate are old age, lack of money, lack of time and the idea that each individual should make their own decisions. These groups may be addressed with specific means within the participation approach.

COMMUNITY PARTICIPATION

Some of the measured factors can give an indication of what can be expected from the community in the execution of the project. Memberships in associations and previous successful activities for instance, can be considered as indicators of organisational power in a community. Associations increase the number and intensity of social contacts, thus influencing social cohesion/social capital and the extent to which people participate in associations can therefore be considered an indication for the (social) involvement in a neighbourhood (Sampson *et al.*, 2005; Sampson, 2013). Low scores on associations and medium to low scores on successes indicate a limited organisational power in the community of Pekela. Also, entrepreneurial background of individuals can be considered an indicator for organisational power, as identified by (von Schönfeld *et al.*, 2019), which is above the national average here. From the interviews it became clear that people in Pekela do organise activities, such as a children's activity week, for which sufficient volunteers can always be found. It seems that people in the community help each other when needed but there is not that much self-organisation. For participation in the Living Lab, this means that the working group can probably count on sufficient cooperation from community members when called for their help, but that strong coordination of the initiative will be needed, preferably by one or more members of the working group, since trust in community members is good, or by or with assistance of an external party.

Subjective norm is categorised as an individual factor in the theoretical model, but also provides information on how community members relate to each other as well. When people experience pressure from the community to take measures, this may have a positive effect on the participation of people to the project. The measured subjective norm in Pekela was quite low, with a score below the mid of the scale (M=1.92, SD=0.62). The mutual influence could be supported by facilitating the conversation between neighbours in which they can inspire and motivate each other.

COOPERATION WITH THIRD PARTIES

Concerning the involved parties, two factors in particular are relevant: responsibility and institutional trust. Trust in the municipality is low in Pekela, which is remarkable in a project where the municipality has a strong role. When institutional trust is low, it is not a logical choice to choose the municipality as 'sender' in the communication of the project, and it is a potential weak point in an approach if it is not handled well. In this case, the municipality has appointed a project leader to coordinate the project. In addition to general project management, their main role is to decide how the budget is being spent. The working group is therefore dependent on decisions made by the municipality and the speed at which they do so, as indicated in the interview. However, the working group is the most prominent communication channel for the community whereas the municipality is the provider of the subsidy. The execution of the subsidy programme is not handled by the municipality, but by an external, independent party. The role of the municipality is rather indirect. The issue seems to be handled well-enough in the way the project is shaped and roles are divided.

Attributed responsibility could also provide leads for deciding on cooperating parties. Although the desired role of parties is not specifically asked, the responsibility that people attribute to parties could indicate what people expect from different parties in a community energy project. For Pekela, most responsibility was attributed to the government, which suggests that a role of the government would be beneficial to the project. Some role for the municipality is therefore justified. The role of people in the community as well as local institutions is considered small. It is unclear whether 'responsibility' is understood as a more financial or guiding role by the respondents, but apparently the respondents feel the community should not be overburdened with such a project. Own responsibility on the other hand has scored higher than the other community items concerning responsibility, which suggest that people do feel responsible for participating in improving the sustainability of the neighbourhood to some extent. The pattern in which responsibility is attributed is not unique in Pekela, as there were no significant differences in the four cases that we studied. In addition, similar scores were found in a national survey on sustainable energy in which respondents were asked to attribute responsibility to different parties as well (Lelij, Graaf and Visscher, 2016).

TECHNICAL SOLUTIONS

Based on this survey, technical preferences cannot be identified as the focus is to provide an initial social characterisation of the community based on which further steps can be taken in de planning process. However, some of the factors can provide some boundary conditions for designing a technical solution. One of the main issues to decide on concerning sustainable heating technologies, is the choice between individual and collective measures. When a collective system is chosen, for instance a district heating system, it is not only important that sufficient people are willing to participate, but that they can make decisions collectively as well. Strong social cohesion and/or affinity with the topic of sustainable energy are then helpful factors. To get everyone on board there should be a strong organisation behind the project as well. At the same time, the nature of a district heating project requires a very different project approach than individual home renovations, and therefore places different requirements on residents. Preconditions are that there is a skilled project organisation that is able to coordinate the technical and financial project development and that one or more stakeholders are willing and

able to own and operate the network in the future. Examples of community-owned cooperative district heating networks show that communities could be able to take up this role, as shown in a study on cooperative district heating by (Mulder *et al.*, 2020). Indications from the survey as to whether a community could be able to take up such a role would be a high matter of self-organisation, expressed in a high score on successful activities, entrepreneurship and local associations, and sufficient support from the community to be actively involved, expressed in high scores on willingness to participate and personal involvement. Other organisational forms for collective systems are also possible, under the condition that sufficient trust in the key stakeholders is present. With low institutional trust, the municipality would not be a logical choice in such a system as well. For Pekela, the conditions for a collective system are not convincingly present. First of all, there is a lack of institutional trust, secondly the level of self-organisation is moderate and the support is doubtful, considering the large group of respondents that is not willing to help and the moderate score on personal involvement. Several social cohesion scores are relatively high, however, which are a positive indication for collective measures.

Next to the aforementioned factors, the level of control over the measures that is experienced by people (perceived behavioural control and locus of control) could also provide useful information for the technical solution to be chosen. People that consider themselves to have insufficient means to take measures, cannot be expected to take a lot of initiative in large home renovations. Especially in communities with a high share of owner-occupiers, this is a relevant issue. In the open answers to the question on perceived behavioural control, technical knowledge and financial hurdles are mentioned multiple times as issues that respondents run into. Next to technical knowledge, the financial situation of the residents should be taken into account. When income is low, the investment space is small and large self-investments, which are associated with all-electric renovations for instance, may not be realistic. Appropriate financial programs, providing loans, discounts and subsidies, as well as the technical knowledge provided in the project could increase the action perspective. In Pekela, we can see that the technical knowledge of the chosen technology, heat pumps, is relatively high compared to the other cases, potentially due to the information provided within the project. In cases of lower perceived control, the approach could respond to these issues by focussing on unburdening solutions. However, the starting situation should be sufficient when choosing individual home renovations.

For Pekela, the perceived behavioural control score is slightly above the mid of the scale (M=3.31, SD=0.97) and is also relatively high compared to other cases. This means that on average, people consider themselves sufficiently capable to take measures. For the fifth item of this question, related to financial capabilities, the score is also above the mid of the scale (M=3.27, SD=1.40), indicating that there are no major issues for this aspect. Income is not particularly high, which leaves investment costs and financial feasibility of measures a point of attention. Another point of attention is the difference between age groups, income groups and groups with a different occupancy that occurs on the control factors, as older people generally experience significantly lower behavioural control as well as people with a rented property or a low-income. These groups may require a different approach if they are to be sufficiently involved in the project.

Conclusion and discussion

This paper has shown how a social fingerprint of a neighbourhood can inform the planning process with the use of social data. Social data can complement the techno-economic planning process by providing guidelines for identifying solutions that can count on peoples' support. For the case-study of Pekela, the indications for a collective system for instance, were not very strong based on the identified social factors. However, techno-economic modelling may suggest a district heating network to be the most optimal solution, whereas the community prefers a hybrid solution. Hence, solutions can have a lower social preference than what is indicated by techno-economic analyses based on trusted stakeholders, personal and communal values, financial situations, etc. Either way, social data can either support technical choices, or provide argumentation for choosing a different system.

The concrete example of Pekela has shown how various characteristics of the social fingerprint can be taken into account in different aspects of the process of a community energy project (communication, participation, etc.). The data can inform the implementation process by indicating places where people meet each other, who is trusted, which arguments are important, which issues need to be addressed etc., before it is possible to start thinking about energy. Relevant information can also be obtained from the combination of different types of social factors, like organisational power in the neighbourhood, which is based on multiple indicators. The answers to open questions and possibilities to clarify answers in the survey can provide valuable information as well, by giving more specific information on certain issues, for instance on reasons why people are willing to participate or not. Additionally, the survey itself can be used as communication tool by bringing the topic under attention and starting interaction with the residents in an open and accessible manner. This can have important advantages over a first interaction focussed on technical solutions and tangible plans and could help create support for the project.

Further work, in the form of more cases, is needed to improve the statistical modelling through which more standardisation of the measuring method can take place, including the construction of a reliable benchmark. With more cases to compare, it would be possible to categorize factor scores as low, moderate or high, so that the interpretation of the data becomes more reliable. In addition, it would be relevant to test the method in other contexts and countries. The method is now applied to the Dutch context of natural gas free neighbourhoods, but has the potential to inform other types of energy projects with a collective aspect as well, such as neighbourhood improvements combined with sustainable energy measures.

References

Bouw, K. *et al.* (2022) 'Social context factors: an exploration towards defining the social context of neighbourhoods for energy planning purposes', *Concept manuscript*.

CBS (2019) *Kerncijfers wijken en buurten 2019*. Available at: https://www.cbs.nl/nl-nl/maatwerk/2019/31/kerncijfers-wijken-en-buurten-2019 (Accessed: 18 March 2021).

CBS (2020a) *Bevolking; Kerncijfers*. Available at: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/37296NED/table?fromstatweb (Accessed: 18 March 2021).

CBS (2020b) Inkomen van huishoudens; inkomensklassen, huishoudenskenmerken. Available at: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83932NED/table?ts=1565008102724 (Accessed: 18 March 2021).

CBS (2020c) Werknemers in 2018 gemiddeld 65 jaar bij pensionering, Cbs. Available at: https://www.cbs.nl/nl-nl/nieuws/2019/32/werknemers-in-2018-gemiddeld-65-jaar-bij-pensionering

CBS (2021a) *Arbeidsdeelname; kerncijfers*. Available at: https://www.cbs.nl/nl-nl/cijfers/detail/82309NED (Accessed: 18 March 2021).

CBS (2021b) Bevolking; onderwijsniveau; geslacht, leeftijd en migratieachtergrond. Available at: https://opendata.cbs.nl/statline/#/CBS/nl/dataset/82275NED/table?fromstatweb (Accessed: 18 March 2021).

CBS (2021c) *Kerncijfers wijken en buurten 2020*. Available at: https://www.cbs.nl/nl-nl/maatwerk/2020/29/kerncijfers-wijken-en-buurten-2020 (Accessed: 18 March 2021).

Lelij, B. van der, Graaf, M. de and Visscher, J. (2016) *Energievoorziening 2015-2050: publieksonderzoek naar draagvlak voor verduurzaming van energie*.

Mulder, G. et al. (2020) Projectverslag Buurtwarmte.

Sampson, R. (2013) 'When disaster strikes, it's survival of the sociable', *New Scientist*, 218(2916), pp. 28–29. doi: 10.1016/s0262-4079(13)61183-5.

Sampson, R. J. *et al.* (2005) 'Civil society reconsidered: The durable nature and community structure of collective civic action', *American Journal of Sociology*, 111(3), pp. 673–714. doi: 10.1086/497351.

von Schönfeld, K. C. *et al.* (2019) 'Social learning as an analytical lens for co-creative planning', *European Planning Studies*. Taylor & Francis, 27(7), pp. 1291–1313. doi: 10.1080/09654313.2019.1579303.