User Engagement in Community Energy Schemes: A Case Study at the Trent Basin in Nottingham, UK

Abstract

'Community Energy' refers to people working together to reduce and manage energy use and increase and support local energy generation. It has the potential to support the infrastructural, social and cultural changes needed to reduce the impact of climate change and increase energy security. The core part of community energy initiatives is people; therefore, successful engagement strategies are essential. SCENe (Sustainable Community Energy Networks) was a research and development project focused on community energy application in a real-world setting involving in its first phase 44 new homes built along the banks of Nottingham's River Trent (UK) in 2016. The project team adopted a variety of established and innovative engagement strategies including website and social media channels, an online user engagement platform, a physical community energy hub with an interactive virtual energy model where meetings and workshops were held, and in-home smart voice-controlled and visual technologies. The influence of the project and the effectiveness of the engagement tools to generate behavioural changes were investigated through a survey, workshops and interviews. It was concluded that engagement with SCENe generated awareness regarding energy issues and participation in community energy initiatives.

KEYWORDS: Renewable Energy; Community Energy; User Engagement; Smart Technology; Human Behaviour

1. Introduction

Energy systems in the UK are at the cusp of a radical transformation due to the need to address climate change and limit global warming to 1.5°C (Masson-Delmotte et al., 2018), technology advances, an aging infrastructure, the rapid-changing regulatory landscape in response to a commitment to increase energy generation from renewable sources (HM Government, 2017b, 2017a), and socio-economic pressures . The way energy is generated and used is being transformed, as buildings are becoming more energy efficient and the proportion of local low-carbon generation is increasing. Within this context, individuals and local communities have become more empowered to contribute to maintaining energy security, tackling climate change and keeping costs down for consumers through community-led initiatives (Department of Energy & Climate Change, 2014b).

Over the last year, 23.8% of the energy in England, Scotland and Wales was generated from renewable sources (18.5% wind, 3.9% solar photovoltaic and 1.4% hydroelectric) (National Grid, n.d.). Moreover, it has been reported that energy generated from wind, achieved the highest contribution to the national fuel mix during February 2020 (National Grid, n.d.), evidencing the high contribution that renewable energy systems are doing to decarbonise the grid. Whilst this correspond mainly to large generators of renewable energy, individuals and communities are starting to contribute to maintain energy security, with small-scale renewable energy installations. By the year 2018, 6,107 MW of capacity was installed by small-scale generators benefiting from the Feed-in Tariff scheme (FiT), corresponding to 820,591 installations and 46% of the total installed capacity of the domestic sector (Department for Business, Energy and Industrial Strategy, 2018). The potential of community energy projects is high taking into account the increasing installed capacity in the

domestic sector and the feasibility of uniting households of individual small-scale generators to build community capital. According to the Department of Energy & Climate Change (2014a), community-led actions in the UK can support the energy production, reduce energy use, manage energy demand and drive collective purchasing. Community Energy England (2018) reported that 228 community energy organisations were active across England, Wales and Northern Ireland in 2017. This infrastructure has the capacity to generate 168MW from solar photovoltaics (81%), wind (18%) and hydro (1%). To put this in context, it contributed to save 71,000 tonnes of CO_2 emissions in 2017 by producing 202 GWh of electricity, which is the equivalent to the annual demand of 67,000 homes (Community Energy England, 2018). However, community energy generation remains relatively small, accounting for around 1% of the UK energy fuel mix (Braunholtz-Speight et al., 2018) and it remains an unexploited alternative to maintaining energy security and reducing fuel poverty.

According to Houghton (2010), the concept of developing a community energy project is simple: "a community develops a renewable energy scheme (helping to cut carbon emissions) and makes money from energy sales, that revenue is then available to fund further carbon emission reduction measures in homes, business and community buildings" (p.18). However, the simplicity of the definition differs from the complexity of the real-world application. It has been reported that some of the challenges to set up a community energy come from different streams, such as: obtaining funding to finance the infrastructure, finding investment capital, accessing to the market, requiring expertise, dealing with the legal aspects and engaging the community (Hielscher, 2011; Seyfang, Park, & Smith, 2012). In the UK, the business models for community energy schemes have been adapting over the years depending on several factors, such as policy and regulatory changes, governmental support, environmental

benefits, economic incentives, research funding, commercial feasibility, technology costs, among others (C. Nolden, Barnes, & Nicholls, 2020).

In the national ambit, the future of community energy looks uncertain due to policy changes, such as the Feed-in tariff, which stopped operating and was replaced by the Smart Export Guarantee (C. Nolden et al., 2020; Colin Nolden, 2013; Salazar, Waldron, & Rodrigues, 2019). Nevertheless, different business models looking at other factors to reduce transactions costs are emerging. For instance: i) Acquisition of existing infrastructure to remove costs related to planning and installations, ii) Partnerships between community groups and established utility to reduce transaction costs, iii) Integration of energy storage to refine the power purchase agreements, and iv) Creation of virtual power stations without geographical constrain (Colin Nolden, 2013). These emerging business models will open up the opportunity to apply community energy strategies in contexts such as developing countries where the energy grid is not robust, stable and reliable. Sustainable Community Energy Network (SCENe) was a pioneering project involving industry, academia and a community at the Trent Basin in Nottingham that aimed at developing a model to demonstrate how community energy systems can accelerate low-carbon energy generation and use (Project SCENe, n.d.). Similar to other community energy projects, SCENe's realisation was dependent on a complex participatory process that required a great involvement of all actors, and, in particular, of the community. Therefore, strategies to engage the citizens were key to the project's success.

The objective of these strategies were to identify and prioritise local needs, get buy-in from the potential consumers, and strengthen the relationship with the community (Alvarez, Borsi, & Rodrigues, 2017; Rodrigues, Marsh, Kiamba, Gillott, & Doherty, 2016). This was done by identifying how much people use, shape and reuse

98 something, their influence on others, their levels of understanding and contributions,
99 and the impact on their actions and attitudes. Because engagement is multifaceted
100 (cognitive, emotional and behavioural), and thus related to complex and embedded
101 norms (e.g. cultural, structural, subconscious) (Fredricks, 2011; Sheppard et al.,
102 2011), the methods used were various relating to these domains.

103 Studying engagement includes considering how these cognitive, emotional and
104 behavioural aspects, and norms, are interconnected and maintained or reformed.
105 Thus, engagement methods can relate to social constructivist accounts of capacity
106 and agency, and how these are enacted and embodied. When this is not the case,
107 typically in cognitive approaches to engagement shaped by methods that focus on
108 addressing perceived attitude and information deficits, responses to engagement are
109 generally limited. Owens (2000) and Agyeman & Angus (2003), are among an
110 increasing literature that emphasise this for instance with regards to improving
111 sustainability and sustainable communities, calling for a much more interconnected,
112 social, inclusionary and deliberative approach to communities and public engagement.

113 In the case of renewable energy technology projects, the engagement of communities
114 is highly shaped by expectations that are determined by the information delivered to
115 understand the project (e.g. reading or listening information, attending to meetings or
116 exhibitions, etc.) (Devine-Wright & Howes, 2010). The process of engaging can be
117 divided into several stages: becoming aware of the project, interpreting it, evaluating
118 the proposal and responding to it (Devine-Wright, 2011). According to Knudsen et al.
119 (2015), the acceptance of renewable energy systems in a community requires
120 democracy and control, fair distribution of the costs and benefits and decision-making
121 powers distributed between the partners. However, according to Parra et al. (2017):
122 *"no particular interest is paid to the role of end users"* of community energy schemes

in the literature, despite being an important actor to reduce carbon emissions through renewables. In summary, people are key and must engage with community energy, but often this is erroneously seen as secondary.

In this paper, the authors summarised the user engagement strategies used as part of Project SCENe (Rodrigues et al., 2018) , reported on the perception of the residents regarding these strategies and analysed the influence of the project in the behaviour and energy awareness of the community.

2. Sustainable Community Energy Networks (SCENe) at the Trent Basin

SCENe was a real-world research project involving the phase 1 of a new housing development at the Trent Basin in Nottingham, United Kingdom. The development's phase 1, launched in 2016, comprised of 35 semi-detached and terraced 3-storey houses, ranging from 3 to 5 bedrooms and with areas around 100-110 square metres, and an apartment tower with 9 dwellings of circa 60 square meters and 2 or 3 bedrooms. Phase 1 homes were designed to have an efficient building fabric with U-values lower than 0.15 W/m^2K for the opaque elements, and measured air permeability of less than 4.8 m^3/hm^2 at 50 Pa (Blueprint, n.d.) (IES & SCENe, 2018). The homes being built in the next phases of the development can be added to the community energy scheme as they become available.

Project SCENe was set up as an opt-in alternative for the residents to participate in the community energy scheme, i.e. they were under no obligation to join in. In the scheme, electricity was generated and stored on site using solar photovoltaic panels and Europe's largest community battery (Figure 1).

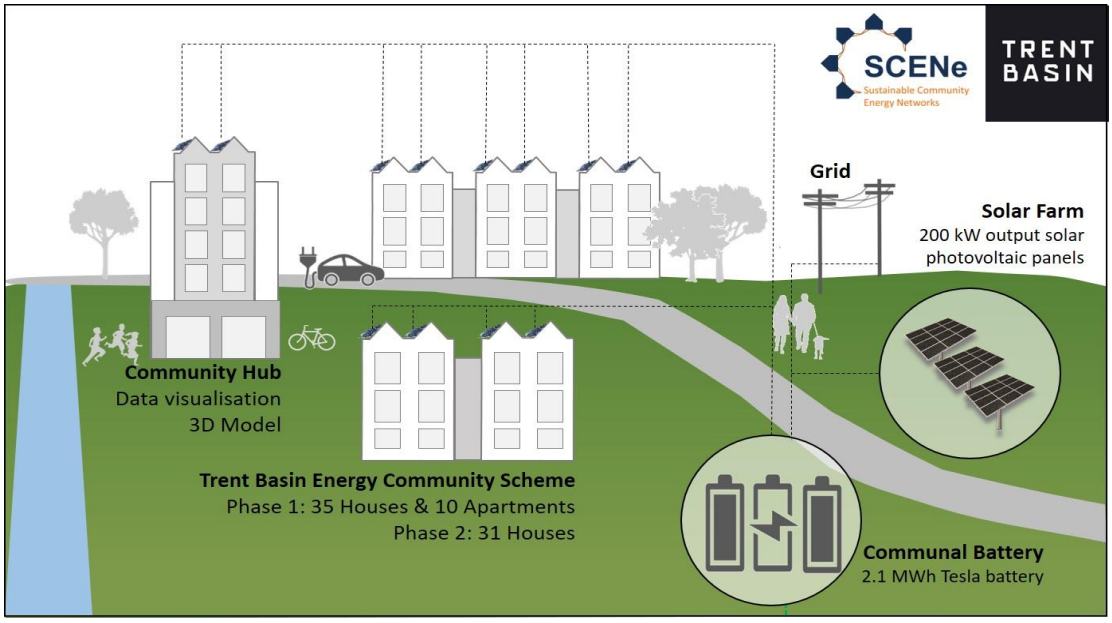


Figure 1 – Components of SCENe's community energy scheme at the Trent Basin in Nottingham

The scheme included a 2.1 MWh Tesla battery charged through 200 kWh output solar photovoltaic panels installed on the roof tops of the participating homes and an urban solar farm (Shipman & Gillott, 2019). Over the course of one year, the latter generated 152.8 MWh, enough to cover the annual electricity consumption of 64 average Trent Basin properties. However, storage at this scale (2.1MWh) made this community energy scheme a game-changing option as it opened up the possibility of diversifying and enhancing income streams through providing grid services, optimising the retailing of locally produced energy and facilitating power and heat arbitraging to further decarbonise the energy system. The current scheme will be combined with a planned heat network, which further reduce costs for consumers by contributing to the significant heat component of domestic energy use and costs.

Because the housing development was new, one of the objectives of Project SCENe was to support the creation of social networks in order to increase participation in energy initiatives and to increase social capital (Alvarez et al., 2017).

3. User Engagement Strategies

It has been reported that one of the obstacles for people to engage in community energy projects is finding time to participate in the community activities (Seyfang, Park, & Smith, 2013), therefore the strategies used in SCENe were designed to provide quick understanding of issues, flexibility and accessibility to all users. There were numerous forms of engagement, verbal and non-verbal, face-to-face and virtual, in order to cater for different preferences (Kampelmann et al., 2016). This meant to facilitate 'purposeful engagement', a person-centred approach to engaging the citizens to participate actively in the amenities offered by the community and better connect with their fellow residents.

The residents of Trent Basin were offered face-to-face meetings, written communication, online information, online discussion and data visualisation, both at community and household levels (Figure 2). The overarching aims were to engage more households, to improve awareness, to facilitate participation and communication, to generate co-production and co-solutions, and to provide the end users with awareness and control of their energy consumption. The variety of methods used allowed us to:

1) Reach out to as many households as possible;
2) Achieve different levels of communication to allow the information flow in several ways according to the purpose of the messages (e.g. one-way communication for informative content, two-way communication for discussions and dialogue, and collaboration forums for interaction);
3) Reach different types of users (e.g. some users prefer to attend meetings in person, while others prefer to watch a video and post comments online);

4) Allow residents to have access to discussion forums and project information when and where was convenient to them (e.g. project website, discussion forums available 24/7 through the online platform);
5) Improve awareness of energy issues and provide information related to the community energy scheme (e.g. explaining how it works, how is the energy generated, stored and shared, defining the Energy Service Company operation, and providing information at different levels);
6) Allow the residents and project partners to have discussions and dialogues regarding the different aspects of Project SCENe (e.g. face-to-face workshops, meetings and online discussion forums); and
7) Deliver energy data from the community and houses in a user-friendly format to allow users to engage with energy management and the community strategies (e.g. voice-activated devices, energy data visualisation on screens and through the 3D interactive model).

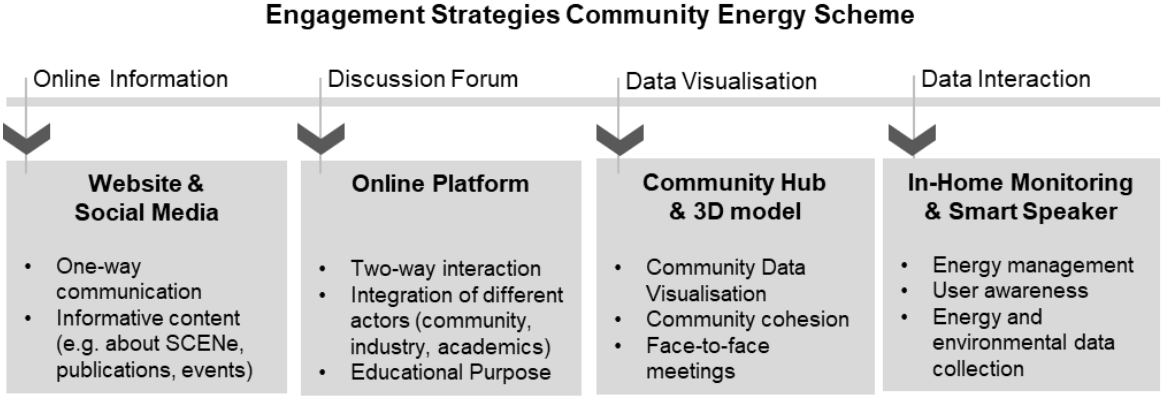


Figure 2 – Startegies used to engage with residents

3.1. Website and Social Media

The website www.projectscene.uk was created to disseminate information about SCENe not only with the residents at Trent Basin, but also with a wider audience.

According to the ISO 9241-11 (2018), usability is defined as the extent to which a system can be used to achieve the goals with effectiveness, efficiency and satisfaction. In the context of website design, some of the key factors to successfully engage users identified by Garett et al. (2017), are: provide effective navigation (e.g. consistent menu/navigation bars and limited clicks/backtracking), integrate graphical presentation (e.g. images with good quality, multimedia content, use of logos and define a colour scheme), organise the content in a logical structure (e.g. cognitive architecture, hierarchical structure and categorisation), define the purpose of the content (e.g. sufficient amount of information, content quality and relevance). In order to enhance the usability of the website, the previous parameters were considered and the structure of the website incorporated commonly used sections (Figure 3): i) Home: providing general information about SCENe and integrating the link to the user engagement platform (described in section 3.2), ii) Trent Basin: describing the location of the community energy scheme, iii) Partners: providing information about the academic and industry partners involved, iv) News: monthly blog publishing content around the project development or topics related to community energy, v) Events and vi) Contact. In a later stage, two additional sections were integrated: vii) Research: linking journal articles, conference papers, magazines articles and press releases related to SCENe, and viii) Impact: linking prizes nominations, awards or appearances of SCENe on public documents/events.

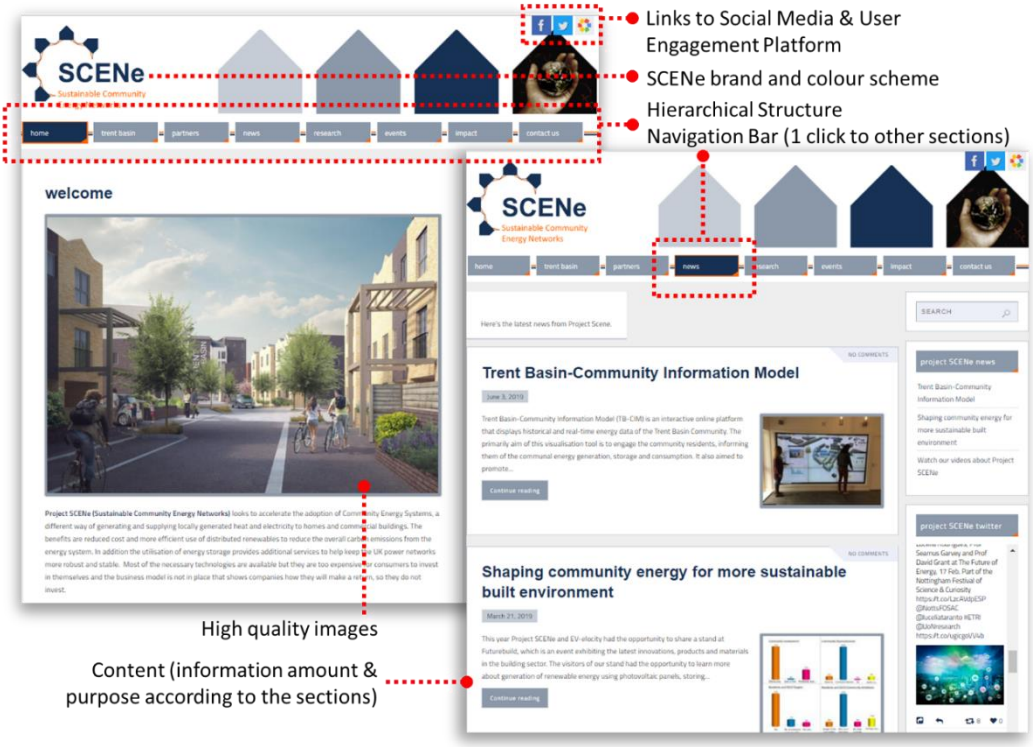


Figure 3 - Project website integrated design elements to optimise user engagement

Social media platforms are providing new ways of interaction, communication and engagement (Arora, Bansal, Kandpal, Aswani, & Dwivedi, 2019). For instance, Twitter is a micro-blog site allowing to send 140 characters messages, specialised in diffusion speed and mobility (Junco, Elavsky, & Heiberger, 2013; Yoo & Gil de Zúñiga, 2014), while Facebook is a more reciprocal platform allowing users to have a closer communication (Yoo & Gil de Zúñiga, 2014). It was created a SCENe account for each of these platforms in order to disseminate informative material, publications, events, press releases, progress on the battery and PV installations, research outcomes, among other relevant information.

3.2. User Engagement Platform

SCENe's user engagement platform was a two-way online site, which provided an interactive space to organise and stimulate engagement and consultation on specific

matters. It was designed to explore topics in a clear, consistent and simple way, and this was key to enhancing its effect (Sheppard et al., 2011). It allowed the creation of different discussion forums or 'rooms' in a common portal that the residents and project partners could access. Selective access could be used to deal with different matters, for example opening up to wider public, all the community, only members of the community energy, etc. The design was enhanced by using a recognisable format throughout the rooms, and sub-sections. Common sub-sections were: i) Home: providing general information of the room, ii) About: explaining the purpose of the room and introducing the topics, iii) Slides: providing in-depth information about the topic under discussion, iv) Comments: allowing participants to post comments, v) Location: including a map of the community scheme components, vi) Get in touch: providing contact details of the organiser (Figure 4). Nevertheless, the research team had flexibility to create sections and to make them more or less interactive. For example, it was possible to post videos explaining how to use particular technology, and to allow viewers to post questions at specific moments during the video screening. Rooms' participants could see each other comments, questions and answers.

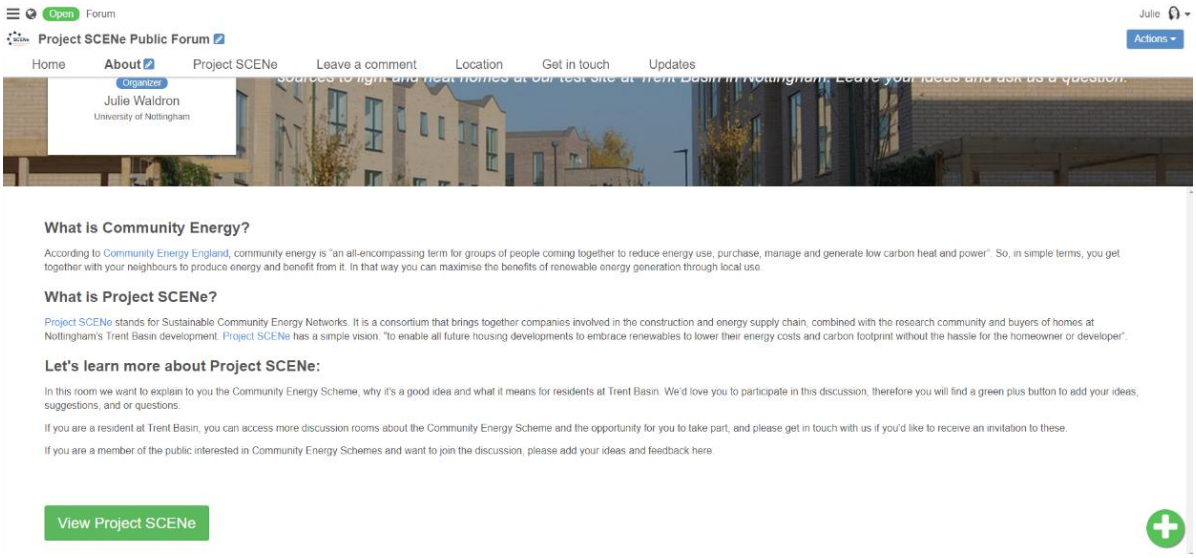


Figure 4 - Online platform format with sections: Home, About, Project SCENe, Comment, Location, Get in Touch and Updates

Participants became increasingly involved with the content as they were subtly guided through the process of purposive participation. Throughout this journey, interactions and contributions were encouraged in multiple complimentary ways. This included positive reinforcement from the project team as well as their community through the use of 'like', 'share' and 'comment' functions, and the ability for organisers to put time-lines on rooms and summarise the results of the discussion forums.

In so doing, the method utilised the strengths of self-led yet supported discovery on a focused topic, as well as relationship building, collective learning, socialisation and a shared sense of mutually generated progress and connections (e.g. Figure 5 presents the comments section of a room, and the way other participants interacted). The platform thus afforded a key tool to build 'community' linked to shared behavioural drivers. This aimed at stimulating engagement, as well as generating action, and impact from this was typically more extensive and inclusive (Parra et al., 2017).

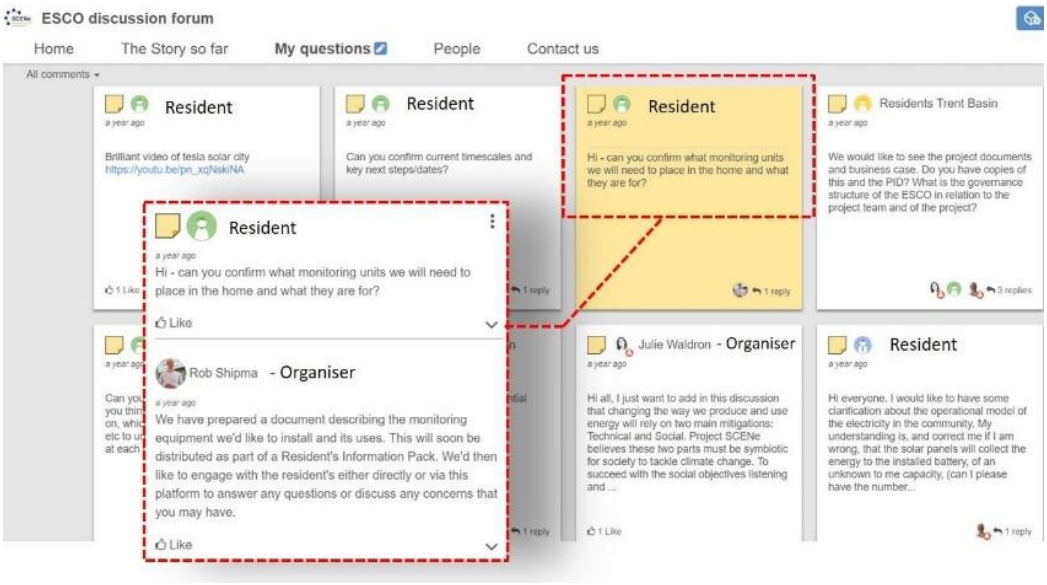


Figure 5 - 'My questions' page on Project SCENe's two-way online site. Each box contains the question made by a resident and the answer / following comments made by other participants or the organisers.

The second core aspect of the online platform advanced this further by enabling both private and public rooms within the same overarching project. This offered purposive engagement through the complimentary yet often opposed pathways of exclusivity and specificity, and linking these with larger, globally resonant themes and practices, such as using sustainable energy routines and smart technology (Banks, 2013; Brodie, Hollebeek, Juric, & Ilic, 2011; Cameron, 2017a; Parra et al., 2017).

The third attribute of the two-way platform was that a developer could invite anyone to be either a 'participant' or 'organiser'. Both allow projects to extend interaction and development capabilities to new audiences. This facilitated potentially invaluable co-design, co-production, co-value and 'community' building (Knudsen et al., 2015; Nambisan & Baron, 2009; Ramaswamy, 2009).

3.3. Community Energy Hub and the 3D Interactive Energy Model

The Community Energy Hub was a space reserved on the ground floor of the apartment tower at the Trent Basin development, to be used for meetings, presentations and discussions, particularly on the community energy scheme. This place was equipped with a multi-touch screen where a Community Information Model (CIM) of the project showcased information about the energy generated and consumed at the site (Figure 6). In addition, the hub was equipped with two tablets in which visitors could learn more about the project through the online engagement platform.

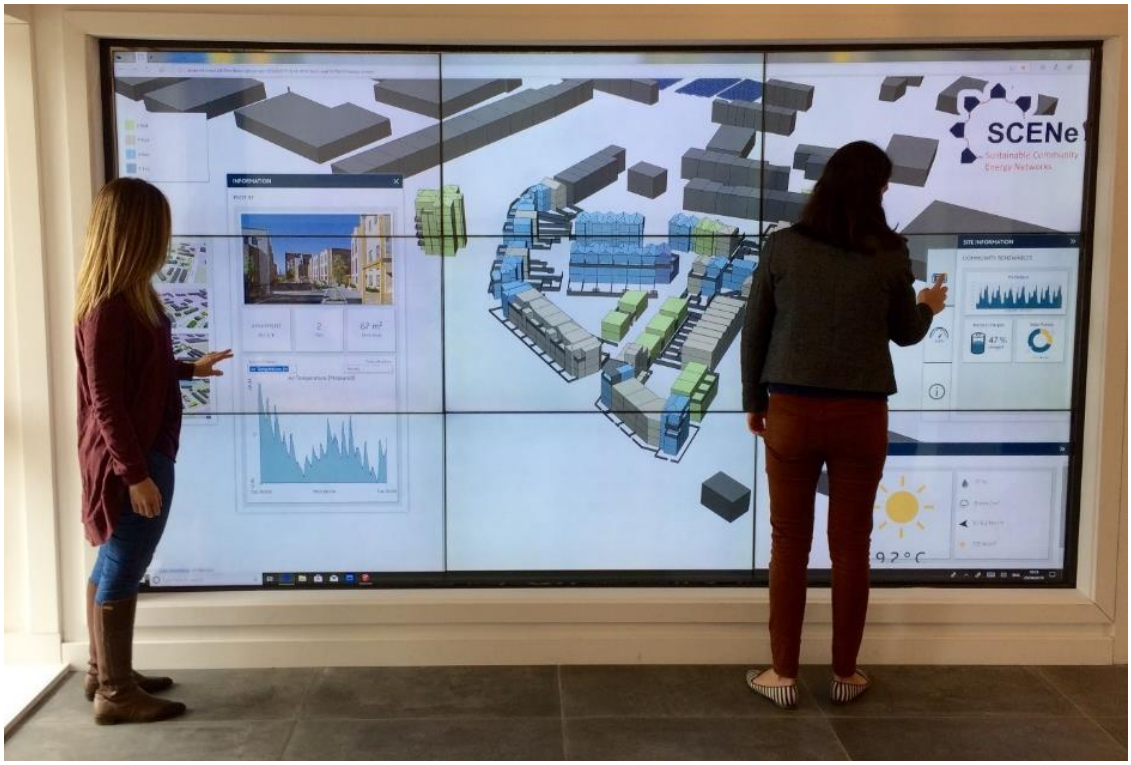


Figure 6 - Community Information model at the screen of the Community Energy Hub

The CIM was an interactive 3D platform developed by Integrated Environmental Solutions (IES) with the collaboration of the University of Nottingham, to display energy

281 data of the community (Cameron, 2017b; Wallace, 2018) and individual homes when
282 appropriate. The aim of this visualisation tool was to inform (and by doing this, to
283 engage) the residents about the community energy generation and allow them to
284 contribute with the operation of the system. It was intended to help the residents better
285 understand the community energy expenditure, informing them of their energy
286 consumption and generation and, thus, helping then make future informed decisions
287 about their energy management. It was also intended to promote broader public
288 engagement with community energy systems and disseminate the results of the
289 project.

290 One of the main features of the CIM was the ability of multiple users to actively interact
291 with the model at the same time, through a multiple-touch screen system. The platform
292 was originally designed to be displayed on a multiple touchable wall screen measuring
293 3.2 m of length by 1.8 m of height located at the community energy hub, however, the
294 3D model was also released to be visualised in other devices (Trent Basin Community
295 Information Model (IES & SCENe, 2018). CIM was designed to be inclusive and self-
296 explanatory, allowing children and people with reduced mobility to also interact.

297 The platform's main feature consisted of a visualisation tool showing the energy
298 consumed by the community, the renewable energy generated on site, and the energy
299 stored in the community battery (Figure 7). The information was displayed showing
300 historical data at community level. The data collection integrated environmental
301 variables measured by a weather station, data from the photovoltaic panels' farm
302 (average and total energy generation), and data from the battery performance (level
303 of charge, discharge and time to charge).

Figure 7 - CIM dashboards. Left: homes' real-time data (e.g. average air temperature). Right: Site information (e.g. battery and solar farm performance) (Wallace, 2018)

The platform had the ability to show real-time data for the monitored homes including variables such as air temperature, relative humidity, carbon dioxide and total energy consumption. The measured environmental variables are displayed in graphs as shown in Figure 7. The 3D model also displayed general information of each house in terms of its area and number of bedrooms, while it graphically contextualised it within the community. The data was anonymised so it was not possible to identify individuals or their homes.

3.4. In-home Energy Kit and Echo Spot

The use of voice-controlled assistants has gained significant momentum in recent years. Initially, these assistants were services delivered via smartphones in the form of Apple's Siri and the Google Assistant. However, their embodiment in smart speakers has been a catalyst for more widespread adoption spearheaded by Amazon's Echo suite of devices. A recent market report concluded that the number of smart speaker users is growing 48% annually, faster than any other technology product since the smartphone (Enberg Jasmine & Chung, 2018). This emerging trend provided an additional method of interacting with residents within the Trent Basin community, as users could obtain via this device the information required to help them better understand their energy usage. This helped also to influence behavioural changes of the users and this way, to encourage energy efficiency for the benefit of residents and the wider community.

In order to achieve this aim, a "skill" (an application for a specific task) was written for the Amazon Echo Spot device that allowed users to enquire about data collected by the monitoring equipment installed as part of the project. This equipment included: sensors to monitor indoor environmental conditions such as temperature, relative humidity and carbon dioxide; electricity meters for overall household consumption and disaggregated consumption of individual circuits such as lighting and cooking; a zonal smart thermostat allowing control of individual rooms (Shipman & Gillott, 2019). The skill also allowed users to enquire about the status of the community assets including the solar panels and community battery.

The core functionality was to provide answers to questions such as "How much electricity did we use yesterday?", "What is the temperature in the bedroom?" or "How much electricity are we generating?" However, this core functionality was extended in

two key ways: a) Behavioural nudging: in addition to factual answers the skill also delivered comparative data on the integrated Echo Spot screen so that a resident could see how they compare to others. For example, when asking about their own electricity consumption, a user was presented with visual information showing his data compared to the average; and b) Automation; when controlling the target temperatures on the smart thermostat, a user was given the option of allowing the digital assistant to take action on their behalf where appropriate. For example, if a user asked to change the target temperature outside of the World Health Organisation recommended range, the user was informed of this and given the opportunity to allow the system to automatically set an appropriate temperature within this range. A demonstration of this functionality can be seen in a project's video (Shipman, 2019). An aim of this method utilisation was to explore the initial perception and interaction of the residents with this device and appraise whether this technology encouraged more energy efficient behaviour.

4. Methodology

The main methods used were:

- A short survey distributed when the research team first met the residents;
- Workshops to develop particular aspects of the project.
- Interviews with the residents conducted during the final stage of the project

4.1. Survey

The first meeting organised between SCENe's partners and the residents at Trent Basin consisted in a presentation about Project SCENe and initial conversations with the first residents that started to move to the new development between 2016 and 2017. At the end of this meeting, a short survey was distributed amongst the

assistants. This aimed at getting the contact details of the homeowners interested in participating in the community energy, and ask a few questions regarding SCENe, as follows:

- Are you interested in taking part in the Community Energy Project?

- If yes, what are your three main reasons for joining?

- If no, can you please advise what your concerns are?

- If you have any unanswered question, please list them below and the Project SCENe's team will get back to you.

- Are you happy to be included in Project SCENe's user engagement platform?

Ten homeowners completed the questionnaires. Their responses were compiled in order to identify the most frequent reasons to join the community energy project, and address the initial concerns and questions. The set of question was used to design the following interactions with the residents.

4.2. Workshops

Multiple workshops were held with the residents of Trent Basin aiming to discuss different aspects of SCENe. As an example, we present here the workshops conducted to discuss the share of the surplus between the community members. Due to the economic activity conducted by the energy service company (such us: managing the energy produced by the PV panels, negotiating the contract stablished with the aggregators, and the use of the battery storage to balance the national grid), the community receives an economic incentive. It was proposed to discuss with a group of residents (volunteering for this workshops), the possible ways the community could

distribute the surplus generated. The sessions held with the residents are explained in Figure 8.

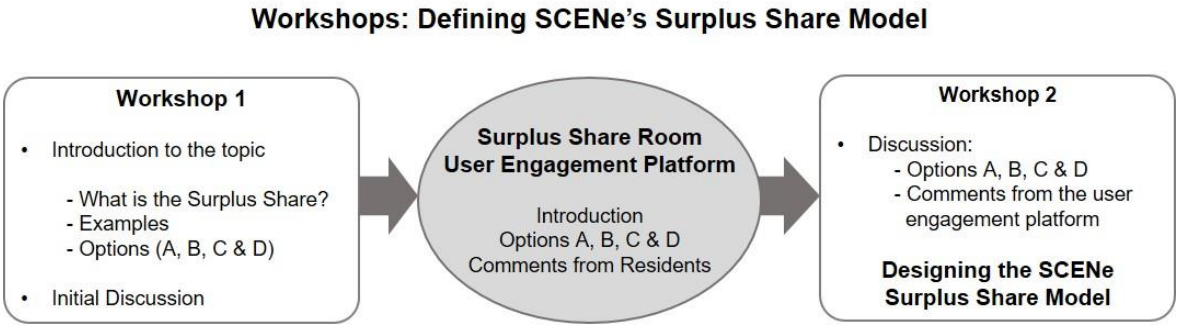


Figure 8 – Two workshops and one online forum were organised with the volunteering residents to discuss the Surplus Share Model of SCENe.

Five homeowners volunteered t5o participate in the workshops. During the first session, the SCENe team presented four possible scenarios to share the surplus between the community members (Arias, 2017):

- Option A: Paying straight pence per kWh subsidy
- Option B: Straight share of pot
- Option C: Group target driven share
- Option D: Tailored target driven share

These options were presented to facilitate the discussion, nevertheless, the aim was to design a model defined by the community. In order to enrich the discussion, these four scenarios were uploaded in an online discussion forum at the User Engagement Platform. The residents were invited to post comments before the following face-to-face workshop. During the final workshop, the comments from the User Engagement Platform were collated and discussed with the residents. The discussion allowed to create the SCENe Surplus Share Model, which was proposed as an initial alternative that could evolve with the time.

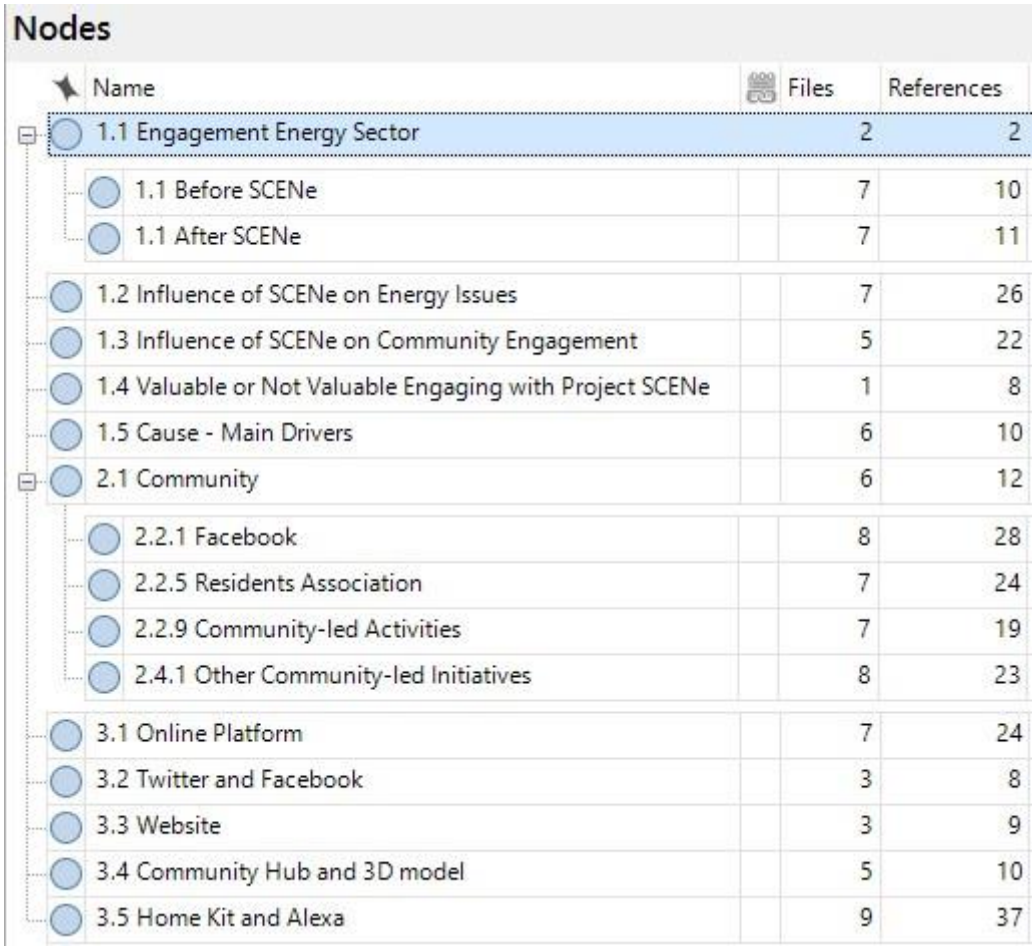
4.3. Interviews

In a later stage of the project, the researchers conducted interviews containing open-ended questions in order to evaluate: a) the motivations of the residents to join and engage with the community energy scheme, b) the residents' engagement with the different strategies proposed, and c) the influence of SCENe on their understanding of, or engagement with, energy issues. The interviews were conducted during November 2018 with the residents of Trent Basin who signed up to be part of SCENe's community energy scheme. This study was reviewed and approved by the Ethics Committee of the Faculty of Engineering at the University of Nottingham. Participants were invited to take part of the study via email and the Trent Basin Facebook page. Nine out of twenty-three households have chosen to take part in the interviews. The interviews were audio-recorded, and the data was anonymised during the transcription process.

A thematic analyses was conducted to identify and interpret patterns in the interviews responses, generating codes and themes from the qualitative data (Clarke & Braun, 2017). It was used to classify the data into workable themes to help draw conclusions. Five main steps were followed (Castleberry & Nolen, 2018; Yin, 2016): 1) compiling raw data into a useable form to identify interesting features of the data across the entire data set; 2) disassembling the data and creating meaningful grouping by coding and identifying themes; 3) reassembling the relevant data into each potential theme and continuously reviewing each theme to determine if it is robust in relation to the coded extracts and data set; 4) interpreting the findings; and 5) drawing conclusion.

The data was analysed using NVivo (**Error! Reference source not found.**) and the answers of the residents were classified into 11 thematic nodes that were then reassembled into six thematic zones as follows:

- Engagement with the energy sector before and after moving to Trent Basin;
- Motivation to move to this residential development and to join the community energy scheme;
- Perception of the Website and Social Media
- Perception of the two-way User Engagement Platform
- Perception of the Community Energy Hub and the 3D Interactive Energy Model
- Perception of the In-Home Energy Kit and the Echo Spot; and
- Influence of SCENe on their understanding of, or engagement with, energy issues.



Nodes

Name	Files	References
1.1 Engagement Energy Sector	2	2
1.1 Before SCENe	7	10
1.1 After SCENe	7	11
1.2 Influence of SCENe on Energy Issues	7	26
1.3 Influence of SCENe on Community Engagement	5	22
1.4 Valuable or Not Valuable Engaging with Project SCENe	1	8
1.5 Cause - Main Drivers	6	10
2.1 Community	6	12
2.2.1 Facebook	8	28
2.2.5 Residents Association	7	24
2.2.9 Community-led Activities	7	19
2.4.1 Other Community-led Initiatives	8	23
3.1 Online Platform	7	24
3.2 Twitter and Facebook	3	8
3.3 Website	3	9
3.4 Community Hub and 3D model	5	10
3.5 Home Kit and Alexa	9	37

Figure 9 – Coding using Nvivo software according to the thematic nodes defined

Each of the thematic nodes were analysed, in order to identify common views across the residents' body, and positive and negatives insights of each theme.

5. Results

The results of the Survey (n = 10), Workshops (2 workshops and 1 online forum) and Interviews (n = 9) will be reported in this section.

5.1. Survey

The answers to the question "What are your 3 main reasons for joining the Community Energy Project?" were binned in similar responses and presented in **Error! Reference source not found.**. Eight out of ten people said that 'Money savings' was one of the main reasons to join the community energy project; this was followed by 'Environmental Impact' and 'Value of Creating a Community Energy' which were mentioned by four people. Three people also reported that 'Reducing Carbon Footprint', being part of an 'Innovative Solution and 'Energy Independency' are reasons to join.

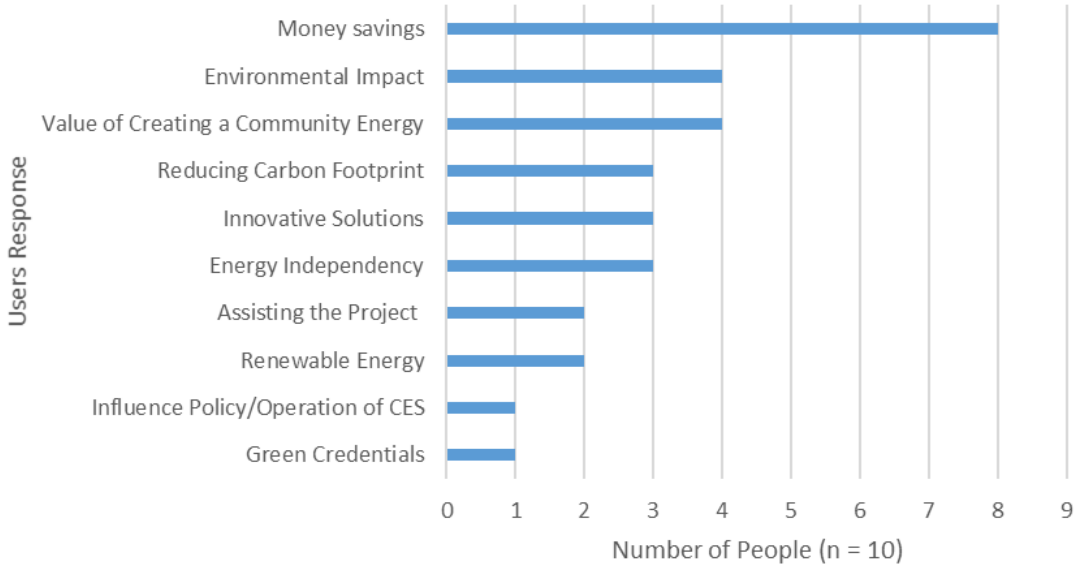


Figure 10 - Responses to the question "What are your 3 main reasons for joining the Community Energy Project?

To the question "Can you please advise your concerns about the project?, only one resident responded: *"I'm not sure the ongoing negative impact (or perceived impact) has been fully considered. Things that may seem insignificant but are real to people who live here".*

To the question "If you have any unanswered questions, please list them below and the Project SCENE team will get back to you" six residents replied:

- *"We are purchasing using 'Help to Buy' - will they allow the panels to be installed"*
- *"Will the collected data be encrypted"?*
- *"Do you plan to engage into reducing the carbon footprint also through E7 tariffs (TESLA model of loading battery at night from grid and uploaded later on)?"*
- *"Concern about legal consequences on roof warranty"*
- *"What's the payback in carbon footprint terms, (of all the gadgets (tablets, Alexa, Battery, Big Screen…). Equipment that's sourced from China, India,*

USA. The extra electricity they will guzzle, and this is included in the benefits case?"

- *"I would like to understand: The business model for the ESCO LTD"*

These questions were used as a starting point to design the following workshops and online discussion forums covering common topics of interest (e.g. legal concerns, operation or carbon savings).

5.2. Workshop

The two workshops and the online discussion forum with the residents about the Surplus Share Model generated two outcomes: The first is the perception of the resident regarding the different models proposed (Options A, B, C and D) and the second one is the resulting model to share the surplus generated by the Energy Service Company.

Table 1, presents a classification of the key comments made by the residents during the workshops and using the User Engagement Platform. The comments were filtered as 'Positive', 'Negative' and 'Comments'. Options A and B were more positively perceived than C and D. For instance, A was perceived as simple and easy to implement, and option B was perceived as a fair distribution between community members. Conversely, Option C was rated as a possible hazard to maintain community cohesion, and C as a complicated model that could lead to disengage people. Some of the general comments included the need of linking the model to reduction of energy usage, a fair distribution of the surplus, a possible model integrating the best of A and B and the alternative of creating a community pot to reinvest the surplus in community projects (contributing to carbon savings).

485 Table 1 – Comments from the residents regarding different models for the Surplus Share

Positives	Negatives	Comments:
Option A: Paying straight pence per kWh subsidy:		
- Simple in its approach - Easy to implement - Good idea having a discounted energy via kWh subsidy	- May encourage greater usage of power	- It needs to be linked to a reduction in usage to an optimum goal for each unique household - Is there a fairer way to avoid the "more you use the more you save"?
Option B: Straight share of pot:		
- If households are already benefiting from reduced energy cost and are in-tune with the concept of what is trying to be achieved in the community then this, Option B may prove the most effective		- Possible hybrid with option A: so all residents receive discounted energy and those that lower usage get added bonus share? - A "community fund" using the pot earnings would be useful e.g. say we are generating so much more than the battery can store & want to purchase a 2nd battery
Option C: Group target driven share:		
	- This can create friction within the community and prove divisive and counterproductive - Not good for community cohesion - Even if targets were anonymised and based on average occupancy and size of home it would make it meaningless	
Option D: Tailored target driven share:		
	- Simplicity over margin needs to be maintained - This seems a lot more effort	Profit share needs to be designed I a way to encourage energy reduction and or eco initiatives and encourage green behaviour

486

487 The model designed to share the surplus was the result of co-design and co-
488 production between residents and SCENe's partners. The aim was to define a method:
489 i) easy to understand and simple to implement, iii) encouraging energy saving
490 behaviour, and iii) keeping the residents motivated regarding their performance
491 (individually and as a community). The method selected was called 'Target driven +

Community Fund' (Arias, 2017). This model would allocate the surplus generated every year as follows:

- 50% to reward users with lower energy usage: This would be based on targets according to the baseline (current energy usage, occupancy, property size). This model would encourage energy savings behaviour.
- 50% allocated to the community fund: this money would be invested in green initiatives for the benefit of the residents.

5.3. Interviews

Out of the nine participant households, it was observed that five were actively engaged with Project SCENe (attending meetings and participating in the discussion forums) and the other four were passively engaged (using the online platform as observers and/or attending to the meeting when possible). The overall feeling regarding the project was positive, however some of them thought there were things to be improved. The sub-sections that follow will summarise the findings of the interviews and quote some of the residents' thoughts for each theme.

Engagement with the energy sector before and after moving to Trent Basin

The household's engagement to the energy sector before moving to a community energy scheme was diverse. Some of the residents were not very active in the field before, one of them commented about their interest in sustainability issues before SCENe: *"Well to be honest we're not very proactive when it comes to that I don't think [sustainability issues]. It's something that's always at the back of my mind really…" "…So if there is an opportunity for us to help, then I'd say that's what we would do really".* Other resident mentioned: *"…energy was an area that I hadn't really engaged with or knew much about at all".* The residents also reported to have had an intention

to engage in these kind of themes, but that they did not have the knowledge or opportunity to do it. For most of the residents, moving to a development including a community energy scheme was not a deciding factor, however it was mentioned by one of them that the energy project *"… certainly had an influence on me buying the house in the first place"* and referred to the top factors to move to this development as: *"It was certainly to be buying a house that had lower electricity bills and gas bills, but it was location I would say. By the river and then environmentally friendliness as well would be key and so we bought a Nissan Leaf very soon after moving in as well"*

The interviewees showed a positive attitude towards engaging more with the energy sector; however, it was also expressed that the day-to-day life of people needs to be considered in community energy schemes as this engagement can bring additional commitments. One of the residents commented about their availability to commit more with this type of strategy: *"Well it depends on what's on offer and what we can do. Again, what we then are able to do based on our obligations or day-to-day life. So it depends on all those factors".*

Other residents had reasonable pre-project engagement with sustainable actions, such as: *"…things like plastic and recycling, but I don't know. I was pretty much into those as well before anyway"*. The community also has people with a wider experience due to their professional background: *"I've been involved with a couple of energy projects in the past in trying to get them off the ground. Energy projects, sustainability projects".*

The majority of the people thought that moving to this housing development influenced their way to engage with the energy sector, as they are able to monitor and manage their energy consumption. Other participants commented on their desire of seeing the

community energy scheme successfully working, as this can contribute to solve social and environmental issues:

"I think if everybody does a little bit, eventually the world hopefully will be a slightly better place, but we've all got to do our own little bit and I guess a little community like this, that's a big step in the right direction"

"I'm still keen to be involved in anything that the project does and Project SCENe in particular and try and help influence in a positive way the success of the project".

There were also some negative comments regarding the timing of Project SCENe, as the project faced challenges in the installation process and fulfilling legal requirements, which generated delays in the process of getting the residents involved: *"I think the big issue for most of the residents here is actually snagging. I think that's the big issue. I think that's what's colouring everybody's view and of course it all feeds off each other doesn't it. So I think that just creates a bit of a negative vibe for some people, but at the same time I think a lot of people have moved here because of the vision that it's trying to be achieved and I think the location is fantastic".*

Motivation to move to this residential development and to join the community energy scheme

There were different drivers for residents to participate in a CES. Nevertheless, the most common reason (mentioned by five of the residents) was to take part in sustainable activities, as the residents shared a common mind-set. One of them commented about this: "*I think because the majority of people have got that mind-set, it works well that if we implement something that's sustainable and that's saving energy and that kind of thing, that most people are going to be on-board with that".*

There were also other drivers mentioned by the interviewees, such as:

- Two residents talked about the possibility to reduce energy costs: "*I think it's going to be a combination of both. Sustainability, cost as well, hopefully bring our costs down".*
- Two residents talked about the opportunity to access energy data, learn more about their energy consumption and energy generation: *"Again, data driven and we like to see where the trends are and then do stuff about it really"*.
- Two residents mentioned the possibility of working as a community to solve shared issues: "*We've also been slightly working together to try and sort out all the developer related, builder related, problems that we've experienced as well".*
- It was also mentioned by one of the residents that the economic benefits are not the main driver, as they do not represent a high revenue *"…So if you're doing it, you're doing it for other reasons"*.

Perception of the Website and Social Media

The website of SCENe registered 15,349 visitors by March 2019. This tool allowed the research team to post general information of the project and aimed to reach a local, national and international audience. When asking to the residents if they were aware of SCENe's website, the responses were diverse: a few of them did not know that the project had a website, other were confusing it with the user engagement platform, and a few of them successfully interacted with the page. Some of the negative comments were about the need of refreshing content more often and improving the style. In the positive comments, it was said that it is responsive, it works well on the phone, and one of them said that he use the website to talk to friends about SCENe.

Project SCENe has 375 followers of Twitter and 95 on Facebook. Most of the residents were not active on Twitter, but the only one active expressed to find value and often retweeting the posts from SCENe. Regarding the use of Facebook, the residents created a private group to maintain communications between them. It has been reported that most of them use this as the main way to communicate. In the positive side of this platform, they reported that you can get a quick response from neighbours, it is an effective way to communicate inside the community, and it is easy to keep track on messages and events even when you are away. In the negative side, it was mentioned that it is becoming less used in the world due to data protection, it can be too invasive and it is severely limited.

Perception of the User Engagement Platform

The user engagement platform allowed residents and people involved in the project to interact and share ideas and knowledge. In general, the residents perceived the platform as complicated to navigate, but the idea of having a centralised place to discuss and access information was seen as positive.

Participation style on the platform was varied amongst the interviewees: three of them were 'active participants' uploading questions and comments, three residents were 'observers' as they were only reading the material available, and the other three residents never logged into the platform. Similarly, their opinion regarding the platform was mixed: three of them mentioned the platform was not user-friendly and two residents though it was good in essence. However, many mentioned that the existence of simpler and readily available social media platforms (such as Facebook) made the engagement with a new tool less attractive and less necessary: *"I think the [engagement platform] in essence is a good idea and everything. I guess people are*

not too involved in it because nowadays it's more convenient to use Facebook for everything…".

The interviewees also suggested what in their views should be included in an engagement platform for a community energy scheme: user-friendly design, availability as an app for mobile devices, option to integrate it with other apps, interactive functions, content with sustainability tips, room for consultation about community decisions to be made and the inclusion of new content.

Perception of the Community Energy Hub and the 3D Interactive Energy Model

The residents described the Community Energy Hub as the place to have 'face-to-face' communications. The existence of this space was seen as positive. As having the option to interact both in person and online, created flexibility and convenience to different users. The residents reported the desire to have more control over the activities held at the Community Energy Hub and integrate other type of uses, such as a co-working space or yoga classes.

"I think it's a good space for us to have meetings as a community. So every time something needs to be discussed or somebody's got some information they would like to share, it's good to have a place where everybody can come together and have a face-to-face discussion".

The engagement with the Community Information Model (CIM) varied amongst the residents, as some of them never interacted with it, other had the opportunity to see it working with dummy data and other residents tried to operate the screen and reported that it was difficult to set up. The 3D model was a tool developed during the time of this project, therefore, it did not reach a stage on which the residents were able to interact completely as there were constraints regarding the data publication and

dissemination. Consequently, most of the interviewees were not aware of it or had the opportunity to engage with the tool, but reported their interest in being able to interact with it.

Perception of the In-Home Energy Kit and the Echo Spot

The general perception and engagement of users with the in-home kit and Echo Spot was very positive. During the interviews period, they were in a period of learning what they could do with the devices. Some of the residents mentioned, that the comments around the community about the equipment were very positive.

One of the interviews reported that the in-home kit allowed him to have more awareness regarding his energy consumption, as he could see data to assess the way he was spending energy and improve its performance: *"I think what happens is before you weren't aware of it right. So you would just go by your own life without thinking about it, but now you know that if you switch the microwave on, it just goes straight to the red. So, "Do I actually need to use that?", so it just means you are more conscious about what's going on. So I guess the more data we get, then the better behaved we will be".*

They used the smart thermostat app to check the temperature in different rooms, turn on/off the heating according to the use of the space and, set the house temperature according to the size or type of use of the space (as there are places that require more temperature than others). Families with children reported that they would like to see new ways of using smart controls, to help children create awareness of their own energy consumption (e.g. leaving everything on when leaving home). A resident mentioned that the smart thermostat gave them more options for the different users as it allows setting the conditions of the room according to the needs of the occupier.

The main uses reported for the Echo Spot were listening to the news, playing music, radio, asking weather forecast, bus times, traffic reports, setting the alarm and doing shopping list connected to the user shop. However, even though residents have been provided with training material both via the online engagement platform and individual e-mails, some of the participants were not aware about the kind of interactions they could have with SCENe's smart speaker skill the potential answers they would obtain from it. This reflects a difficulty in encouraging residents to adopt and sustain this new mode of engagement, as highlighted in **Error! Reference source not found.**. The graph shows a flurry of activity in January and February immediately following a batch of new installations before a return to a more consistent low level of usage. Note that beyond initial introduction of the skill there was no follow-up activity or advertisements to encourage ongoing engagement.

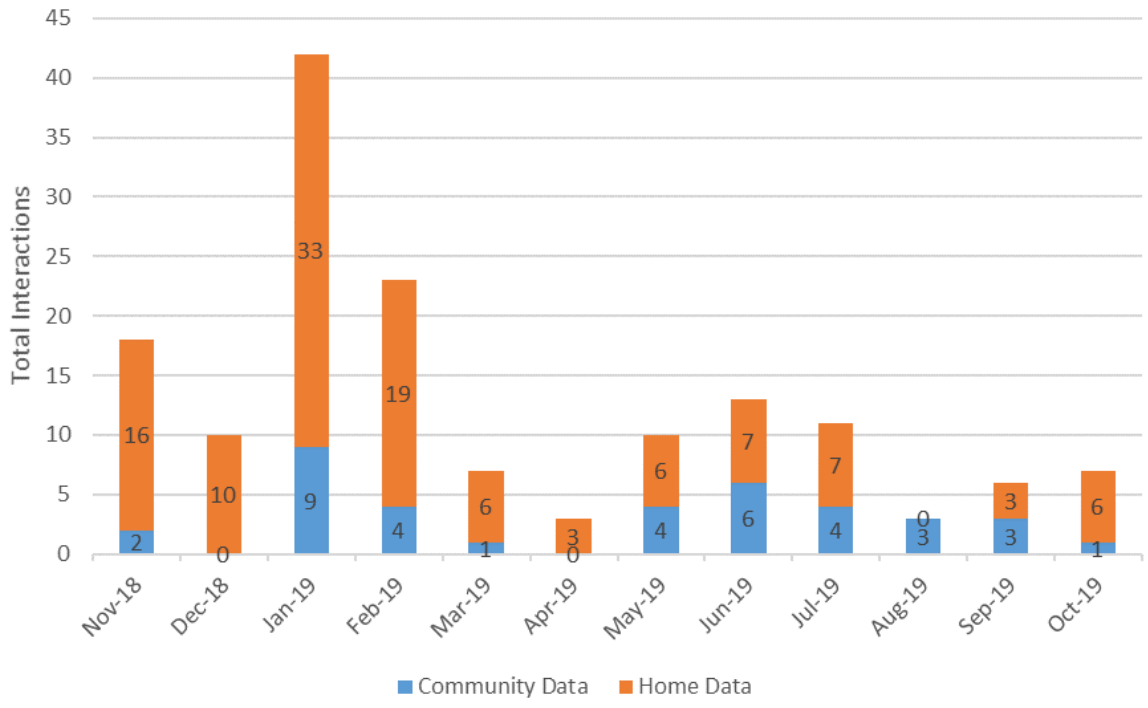


Figure 11 - Total monthly interactions with the smart speaker skill for the whole community over a 12-month period, categorised by requests related to community data and individual home data

The residents showed a genuine interest of learning more and integrating on their routines new strategies to improve their energy consumption. Even more, a remark

was made regarding the possibility to make future comparisons not only with them but also with other community systems: "*Yeah. So we can compare with other… So compare the community with other communities would be great or to compare as individuals. That would be great too. But yeah to know something about that and how effective it is, because that's part of your community building tools as well. Yeah. That would be great".*

Influence of SCENe on understanding of, and engagement with, energy issues

Seven residents thought SCENe influenced to some extent the way they think or feel about energy. It was found that many of them had a previous interest on environmental issues. However, moving to a development with a community energy system influenced new behaviours into their day-to-day habits, for instance:

- Looking for clean transport options. Many of the residents considered reducing the use of cars, change to electric vehicles, use bicycles and walk more: *"I'd say the environmental things are a bigger point for me. So I try and live quite plastic-free. Try, which is very difficult. I'm vegetarian. So obviously I've not got the meat aspect issues. I have cut down using my car. Like I used to use my car to go everywhere. Like if I was going to the shop up the road, I'd go in the car, whereas yesterday I walked up to the shop"*
- Willing to change to an energy provider with 100% of renewable sources: *"Probably going to move to an energy company 100% renewable now. Whereas at the minute we're just with the energy company because they were the cheapest at the time and it was just the easiest to do, but yeah, we're probably going to change…"*

- Communicating with other neighbours to improve their house energy performance or share tips: *"I think it made people think more about what they're doing. I've overheard comments about people's heating and things like that. So yeah. I think it has made people more aware and obviously, because we're all kind of using the same system, it makes it easier. Going back to what I said before about hints and tips sort of stuff. I'd just like to be able to do more"*
- Sharing community projects such as a compost bin and a communal garden *"I guess within the community there's always going to be suggestions for being more sustainable…" "…We've got the community compost bin which has had its issues but obviously it's producing compost. Yeah. Things like that".*
- Learning more about energy, climate change and sustainability issues. *"If we weren't here, then I probably wouldn't have read that BBC news article. I might have just gone past it, but because we're here and obviously talk about sustainable energy and we're part of this project, then that's probably the reason I'd have read that article".*
- Feeling in control of their energy consumption and taking informed decisions. *"…the awareness has increased particularly when I plugged in the smart meter in the socket and I said, "What the hell is going on. Turn that off. No more coffee in the morning! [laughing]".*
- Feeling and knowing that they are contributing to a global problem. *"And it feels like that's the purpose of this development, whereas if you went to another housing development, it's just you move into that house and that's it. Whereas this feels like it's maybe got a purpose to it or something else other than just this is where people live".*

Some of the residents thought SCENe did not influence the way they think or feel about energy. They thought themselves to be 'fairly green' or have enough experience in environmental issues before moving to the new development, nevertheless they suggested the housing development and SCENe's propositions may have steered them to buy a home here.

6. Discussion

In general, it was observed that the residents' engagement with the energy sector changed: they became more aware of energy issues, involved in the decision-making process within their community, and took part in community-based activities more often.

The technical challenges in the development of community energy schemes, such as delays in the installation of technologies or in the implementation of engagement strategies due to legal or technical issues can affect the overall engagement of residents. It has been reported in the literature that some of the main barriers for community energy schemes in the UK are: i) overly complex regulation for electricity generation and marketing, ii) choosing the legal structure and iii) obtaining the required permissions (Brummer, 2018). These barriers can affect the time scale of this type of projects. Moreover, it was also reported by Berka, Harnmeijer, Roberts, Phimister, & Msika, (2017) that community energy projects have longer development times than commercial energy projects.

The evolution of the role of the end users in community energy schemes is driven by several factors. According to Parra et al. (2017), people are usually interested in benefits such as reducing energy bills, generate and manage their own energy, reduce their carbon footprint, and monitor and manage their own demand. In this study, the

744 responses of the residents were in line with the mentioned benefits. It was also
745 observed that at an early stage (Survey) 'Money savings' was a very important driver,
746 while in the selection of a surplus share model (Workshops) the main driver was to
747 reward low energy usage and reinvest the community pot in sustainable initiatives.

748 According to Van Der Schoor & Scholtens (2015), some of the challenges in
749 community energy schemes are: i) the amount of effort required to maintain continuity
750 of involvement, ii) the time spent in organising activities, and iii) the effort to keep
751 members engaged. This research introduced a new online platform to promote the
752 discussions and keep the residents engaged; however, learning how to use it was
753 perceived as an additional effort for the residents. Nevertheless, aspect such as the
754 richness of the data, metrics, moderation of the discussion, privacy control options,
755 flexibility to share different types of content, reliability of the platform and personal data
756 management would be hardly found in a social media platform. Therefore, it was found
757 that: i) introducing a new platform to a community was challenging due to the issues
758 associated with effort, time and continuous engagement, ii) user interface design is a
759 key point to engage different type of users, and iii) other social media channels could
760 support the engagement process, but an online community hub provides a richer
761 discussion process and more reliable research data.

762 It was also observed that users adapted the different engagement methods according
763 to their needs; in some cases, they preferred face-to-face meetings, while in other
764 cases they preferred an online platform to access the information of the project at any
765 time/place.

766 The engagement strategy integrated tools that promoted and facilitated the discussion,
767 visualisation and interaction. This allowed delivering timely information to the residents

about the project and their own data; but also enabled them to understand and take an active role in the community energy scheme (Kiamba, Rodrigues, & Marsh, 2017), since information constituted one of the most important factors to generate engagement.

This research proposed a combination of methods aiming to engage the residents of a community energy scheme: a) website and social media, b) an online user engagement platform, c) a physical community energy hub with an interactive virtual energy model, and d) in-home smart voice-controlled and visual technologies. According to the perception of the residents, Figure 12 presents some of the key aspects that will be needed to be improved when integrating these type of engagement tools to a community energy scheme.

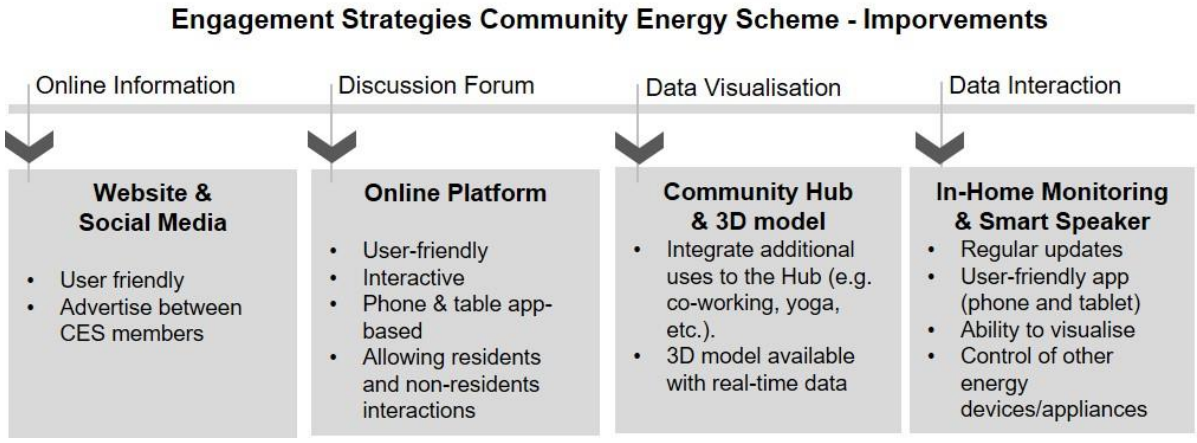


Figure 12 - Key aspects to integrate user engagement tools for community energy schemes

Some of the engagement tools were not fully integrated to the routine of people, such as the interaction with the screen located at the community energy hub or the smart speaker. However, the residents still in an explorative stage and are learning how to insert these new technologies in their routine. In addition, the dynamics generated around the sense of community also created symbiotic interactions between residents such as co-learning and sharing tips to improve their energy performance. This

785 dynamic interaction between elements and relationships are a fundamental part of the
786 innovation theory for sustainable technologies (Cameron, Rodrigues, & Gillott, 2018).

787 7. Conclusions

788 The integration of different engagement tools was a positive strategy as this helped to
789 achieve better levels of engagement in this project. It is justified by the fact that
790 individuals engage differently (according to the interests and availability, etc.) and the
791 levels of engagement varied according to the use of different tools. Some individuals
792 prefer face-to-face interaction whereas others prefer to engage through online
793 platforms.

794 In the case of Trent Basin, the outcomes regarding the user engagement platform
795 suggested that independently of the tool or method used to promote online
796 engagement, the platform must be easy to handle by any type of user, be intuitive and
797 allow access through mobile phones as well as links with familiar technologies. Online
798 engagement through social media or other platforms must be kept updated at all times
799 in order to keep the audience interested. This condition can be time consuming and
800 require planning of the information delivered.

801 Through this work, community support and interaction proved to increase the levels of
802 awareness in the energy sector, which was reflected in the increase of the
803 engagement levels of residents. It would be interesting to see in future research if this
804 characteristic of the community correlates to better energy usage. Further
805 investigations in this case study would contribute to understand the dynamic behaviour
806 of the end users at this type of community energy schemes at different stages.

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