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Smart and Healthy within the 2-degree Limit

Community Energy Networks in the Making
Project SCENe, Nottingham

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ABSTRACT: 'Community Energy' refers to people working together to reduce and manage energy use, and increase and support local energy generation. It can help promote the infrastructural, social and cultural changes we need to reduce the impact of climate change and increase energy security. The core part of community energy initiatives is people, and therefore engagement is essential. In this work, the authors appraised three innovative mechanisms used to engage residents in Project SCENe (Sustainable Community Energy Networks), an ongoing research and development community energy scheme in a real-world setting involving 31 homes in its first phase along the banks of Nottingham's River Trent. New tools for improving crucial consumer and citizen engagement, participation, co-production and demand-side management were used and their efficacy analysed. These included a user engagement platform, an energy interaction model and in-home smart technology. The findings presented here epitomise the centrality of social-technological interdependencies and the importance of social and collective processes throughout these. It was concluded that civil society were essential actors in the services used and shaped through the passive and active processes that underpin what we do and why, and that utilising these in interrelated methods supports the development and outcomes of such projects.
KEYWORDS: Energy, User Engagement, Smart Technology, Community, Socio-technological

1. INTRODUCTION

Energy systems are at the cusp of a vital transformation due to the evolution of technology, the regulatory landscape and interdisciplinary influences. Prime components of this include UK obligations to generate 30% of its energy from renewable sources by 2020 [1], developments in battery storage, smart technology and independent power production policy, and UK ambitions to optimise this [2,3]. Uniting these components is the Sustainable Community Energy Network (SCENe) Project (Figure 1), a pioneering model involving industry, academia and society to demonstrate how community-scale systems can accelerate low-carbon energy, housing, resilience and sustainability goals [4]. In this paper, the project is introduced and the importance of community engagement is discussed.

Project SCENe is a real-world research and development model involving a new housing development in Nottingham, UK. Renewable energy is generated and stored in the housing site using solar photovoltaic panels and Europe's largest community battery. Storage at this scale (2.1MWh) makes community energy a game-changing option as it diversifies and enhances 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. It also helps to reduce costs for consumers by contributing to the significant heat component of domestic energy use and costs.

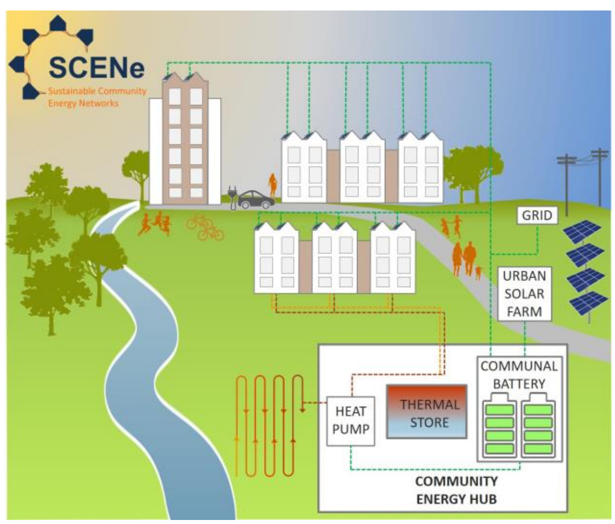

Figure 1: Project SCENe's components

Because the housing development is new, one of the aims of Project SCENe is to support the creation of social networks in order to increase participation [5]. The authors accordingly present here three methods developed to better influence these processes and outcomes, and build community in sustainable energy systems. These three methods are: i) user engagement platform, ii) energy interaction model and iii) in-home smart technology. These methods were outlined in Section 2, followed by an appraisal of their effectiveness in Section 3 and an overview of resulting key lessons and implications in Section 4.

2. CO-DESIGNING A COMMUNITY ENERGY SCHEME

According to Knudsen et al. [6], the acceptance of renewable energy structures in a community requires: democracy and control, fair distribution of the costs and benefits and a decision-making power shared between the partners. This suggests a partnership where the end user is able to participate, benefit and contribute with the generation and consumption of renewable energy. This project integrated different strategies to educate and engage residents about the community energy scheme, influence their behaviour in order to improve the way they manage their energy and provide reliable data and feedback based on their energy management.

2.1 Participatory User Engagement

In order to advance user influences and its impact, a two-way online interaction platform was designed using Stickyworld [7]. Its unique value is that it provides an interactive space to organise and stimulate engagement and consultations upon specific matters; can do so in either private or public rooms; and allows anyone to be invited to be a co-developer for specific rooms. These three attributes can be used effectively for enhancing engagement of various sorts. Here we briefly explained why this is the case, followed by outlining how our approach built-upon these principles to maximise our impact with it.

Engagement is key to influencing the impact society has on projects. In the case of community energy schemes, it helps to prioritise local needs and strengthen the relationship with the community [8]. This includes how much people use, shape and reuse something, their influence on others, levels of understanding and contributions, and how it relates to other actions and effects. Yet engagement is multifaceted, being cognitive, emotional, behavioural, and thus related to complex and embedded domains (e.g. cultural, structural, subconscious) [9, 12]. Engagement methods must thus relate to these, and also relate to action and ends. Stickyworld facilitates such 'purposeful engagement' and tenants of social science and engagement theory in various ways [11].

Firstly, it supports organising engagement and interactions in a clear, consistent and simple to use way, key to enhancing their effect [10]. One way it facilitates this is by allowing individual rooms to be created within a project's overall portal with clear, succinct markers of their purpose and commands. These markers increase in depth, enabling essential information to be gleaned immediately, optimising the vital window of initial attention time, and coupling this with markers of and links to increasingly higher-levels of engagement. This is enhanced by the markers following a recognisable format throughout the platform, such as of title sub-sections for 'Home', 'Welcome' or 'About', 'Slides' (for most in-depth information), 'Comments' or 'Questions', 'Location', 'Action' (to highlight a specific action from them). This is exemplified in Figure 2.

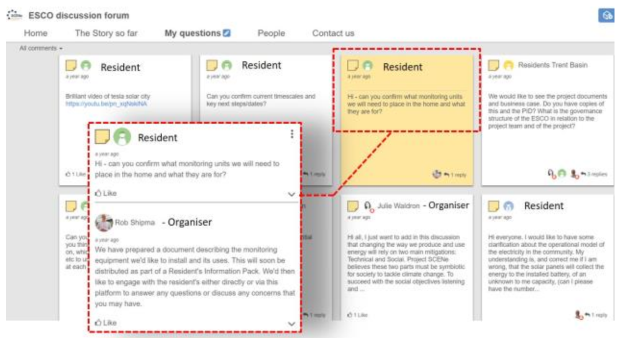

Figure 2: One of the pages on Project SCENe's Stickyworld portal for questions and answers. Each box contains the question made by a resident and the answer or following comments made by other participants or organisers.

This successional approach stimulates deeper and more purposive participation. This occurs as participants become increasingly involved with the content and its links to action as they are subtly guided, or nudged, through the process. Throughout this journey, interactions and contributions are encouraged in multiple complimentary ways. This includes positive reinforcement from our 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, summarise rooms and to thank everyone publicly for their inputs and insights.

In so doing, the method utilises 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. These attributes are reinforcing, normalise the process of using or doing something, and in such a way that accords with the collectively developed ensemble of ideas, intentions, understandings, skills, commitments, and bonds that enable and embed new ways of doing things.

The platform thus affords a key tool to build 'community' linked to shared behavioural drivers. This is invaluable for stimulating engagement, as well as for actions and impacts from these that are typically more extensive and inclusive [11].

The second core aspect of Stickyworld advances this further by enabling both private and public rooms within the same overarching project. This enhances 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 [11, 12, 13, 14].

The third key attribute of Stickyworld is that a developer can invite anyone to be either a 'participant' or 'organiser'. Both allow projects to extend interaction and development capabilities to new audiences. This facilitates potentially invaluable co-design, co-production, co-value and 'community' building [6, 15, 16].

2.2 Energy Interaction Model: Environmental Measurement and Data Visualisation

The community energy scheme was monitored with the aim of generating an energy community dataset, informing the energy use across the community to help the operation of the scheme and also the residents to better understand their energy expenditure to make future informed decisions about their consume. The initial stage of the monitoring system consisted of data acquisition of environmental variables at building and community use levels.

The selected buildings for monitoring were the show apartment and show home of the community. They were selected for their availability, occasional occupancy and lack of data protection restriction. The monitoring of these buildings was experimental and intended to give indications of potential improvements to be considered on the monitoring system before the real monitoring started in the community homes. The data collection included variables such as air temperature, relative humidity, Carbon dioxide (CO2), total energy consumption and total electricity consumption.

At community use level, the data collection consisted of environmental variables that mainly feeds the local weather station and also data of Photovoltaic (PV) panels' farm (average and total energy generation) and battery (level of charge, discharge and time to charge). The last stage of the monitoring system consisted of the acquisition of data of the community houses and this is preceded for legal agreements. The monitoring of the community homes required an effective engagement of the community residents.

The Community Information Model (CIM), was created to display energy data of the community. The CIM is an interactive 3D platform (Figure 3), developed by Integrated Environmental Solutions (IES) Company with the collaboration of the University of Nottingham (UoN) [4, 17, 18]. The main aim of this visualisation tool was to engage the residents of the community, informing them of the local energy consumption and generation. It also aimed to promote public engagement of the community energy schemes and disseminate the results of the project.

One of the main features of the CIM was the ability of the user to actively interact with the model through a multiple-touch screen system. It also allowed multiple users to interact with the tool at the same time. The platform was displayed on a wall screen located at the community energy hub, measuring 3.2m length by 1.8m of height. It was designed to be inclusive and self-explanatory, allowing children and people with reduced mobility to also interact as the dashboards were designed to be easily accessible (Figure 3).

The platform was a visualisation tool showing the community energy data and renewable production, which displays historical-community level data in terms of the energy consumed and generated, respectively. The model also displayed general information of each house, such as the area and number of bedrooms (Figure 4).

Figure 3: Sketch of the data visualisation tool - IES study of the CIM platform. Source: IES, 2017 [17, 18]

Figure 4: Snapshot of the CIM platform displaying community energy data and community house data.

The model had also the ability to show real-time community level data for the monitored show apartment and show house. For these buildings, a set of measured environmental variables were displayed in graphs along simulated data for comparison purposes (Figure 5).

Figure 5: Examples of the dashboards of real-time data collection of the show apartment and show home.

2.3. Smart Technology: Digital Assistant

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. This emerging trend provided an additional method of interacting with residents within the Trent Basin community to provide information required to better understand energy usage and to potentially influence behavioural changes to encourage energy efficiency for the benefit of residents and the wider community.

In order to achieve this aim a Skill was written for the Amazon Echo Spot device that allowed users to enquire about the environmental conditions within their home such as temperature, relative humidity and CO2, electricity usage of the overall home and disaggregated circuits such as lighting together with the status of heating controls via a smart thermostat that was installed as part of the project. The core functionality of the skill was to provide answers to questions such as "How much electricity did we use yesterday?" or "What is the temperature in the bedroom?" However, this core functionality was extended in 2 key ways; 1. *Behavioural nudging*; in addition to factual answers the skill also delivers comparative data on the integrated Echo Spot screen so that a resident can see how they compare to others; and 2. *Automation*; when answering a question relating to temperature, a user is given the option of allowing the digital assistant to take action on their behalf where appropriate. For example, when the temperature is high the user is asked if they would like to reduce the thermostat temperature, which is chosen automatically by the assistant based on recommended ranges. An aim of this research was to explore the effectiveness of these techniques in encouraging more energy efficient behaviour, their acceptance and adoption by residents.

3. CRITIQUE OF THE ENGAGEMENT METHODS

As the use of these methods increases, so too are their anticipated success. This section summaries their success to date, which is early-stage and ongoing.

3.1 Participatory User Engagement

The effectiveness of the bespoke online portal developed to boost meaningful user engagement and wider impacts can be attested in 4 main ways: the number of users/viewers, the number of users inputting (often defined as active users or contributors), the progression of these inputs, and the outcome of these actions. For the overall project portal, the number of views is 2,787 (as of 11.05.18). Inputs are typically questions or opinions. In addition to these are 'likes', 'shares' and 'replies'. All of which bolster and give an indication of levels of active engagement. It indicates that engagement varies considerably according to topic and that this correlates positively with the degree participants expect to benefit from their involvement, providing further empirical exemplification of this influential relationship [7, 15]. Engagement by these metrics was greatest for instance in the ESCO rooms in which participants could co-design how they wanted to divide potential surplus from the Project SCENe model. The economic, social and environmental value of the surplus according its design, such as to incentivise collective rather than individual changes to energy behaviours, is significant and was clear to the participants. The forum and subsequent exchanges facilitated this clarity, and thereby further reinforced interactions and engagement.

This high-level of engagement volume also correlates with high interaction progression and outcomes, becoming increasingly consensual and in-depth, resulting in an inclusively co-designed direction for how to divide the ESCO surplus. To support this enhanced user-engagement, the rooms have increased in number over time, increasing by 12 or 300% from the end of 2017 to 16, and becoming increasingly focused per topic and action, such as moving from the ESCO concept, to co-designing the share method for it, to adopting the in-home energy kit. Finally, the total number of views per rooms has increased relative to the time rooms have been published, suggesting that such methods, as with innovations in general, become increasingly used and effective with their increasingly familiarity [12, 19]. For this and the link between engagement and action, engagement is likely to notably increase with more in-person activities [11, 12, 15].

3.2 Energy interaction model and Digital Assistant

This has proved a powerful tool for engaging publics and influencing consumption behaviour by making energy more visible, social and interactive. In the case of the Community Information Model, the replication of this tool may be limited at present as it is time-consuming and requires technical skills to be fully designed and implemented.

Despite the fact that the Digital Assistant and the CIM are tools not been fully implemented yet, it has a great potential to disseminate community energy data and engage the residents as the interfaces are simple to use and interactive. The users are able to learn about the community energy scheme and it is likely to be an effective way to inform community residents about their own energy consumptions against the overall community energy expenditure. In the case of the CIM, the tool has also a potential to be transferable for use in different contexts, such as city-level modelling and analysis of building, electricity, EV, among others.

4. CRITICAL LESSONS AND IMPLICATIONS

Engagement and community are key behavioural drivers. The experience from Project SCENe and the three user-centric methods signifies that these are dynamic states best approached as a multifaceted and variable and uncertain process and best optimised by approaches that reflect this and tap into the social nature of behavioural drivers and actions.

This was most effective when co-designed with the end users, iteratively discussed and shaped, highly contextualised and specific to the community and sub-groups therein, yet linked to collective actions and broader scales of importance and contextualisation. Multi-dimensional interactions were essential for this. Examples include the virtual space for ongoing multi-media, private and shared content and actions on Stickyworld; the highly visual and intuitive 3D model; and the digital assistant that afforded in-home energy audio and visual feed-back and interactions with a recognised brand and community-specific capabilities.

Moreover, through having these also set-up in the community hub these methods were all compatible with individual, in-home, family and community-level use. The multi-user touch-screen further accentuated these interactive, multidimensional and multi-scale qualities of the engagement approach by allowing people to collectively see, use, discuss and play with the Stickyworld platform and digital assistant.

The suitability of using these things in conjunction with other activities and existing routines further enhanced their effectiveness. This is because the engagement methods could slot into existing patterns of behaviour rather than conflict with them by educating, supporting consumers' choices and capturing behavioural data (Figure 6). Using Stickyworld, for instance, whilst online and perhaps reading and communicating anyway, and the use of the digital assistant when doing everyday things in the house. This complementarity to existing norms and routines supports the uptake and regular use of innovations, and the impact of engagement [7, 15].

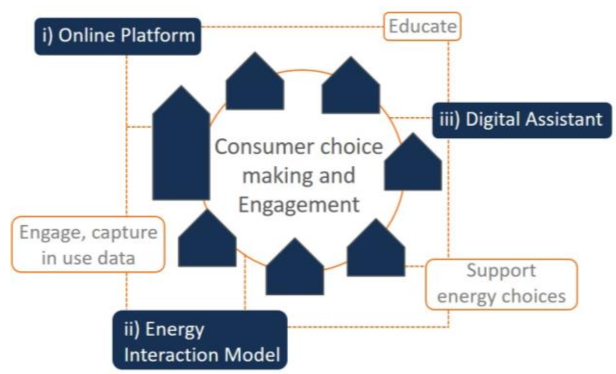

Figure 6: Diagram of engagement strategies and the overlapped aims

Finally, the community building experience of Project SCENe to date evidences these are most significant and effective when linked to clear and contextualised actions. The Stickyworld rooms for the tour, in-home kit, digital assistant and ESCO surplus share attests this most clearly, reinforces others evidencing the highly experiential and subjective nature of engagement [15, 16]. Yet the more they were collectively used, discussed and otherwise experienced, the more routine and effective they were. The sum is to link engagement with actions through the multiplicities of everyday actions, and to facilitate this through relational, multi-dimensional and contextualised methods. This paper reveals three methods for this.

5. CONCLUSION

This paper presents three methods used to engage residents of a community energy project and through this improve the outcomes of the project. It showed that this occurs through enhancing processes of co-design, socialisation, normalisation and routinisation. These methods and processes can relate to different aspects of a scheme and that engagement and community are broader processes that provide prime drivers of behaviour. The methods presented for energy-related behaviours are thus instructive far beyond the energy sector. It suggests that methods are most effective when relational, multidimensional and linked to specific contexts and actions.

These findings are of increasing significance as technology and services become increasing 'smart' and digitalised and risk marginalising users and publics and our need to visualise, feel, and variously interact with what and how we consume. This paper suggests, however, the central importance of engaging with such stakeholders and processes and that doing so remains dependent on deep-rooted 'non-technological' factors. How these socio-technological factors interplay and the long-term impact of such methods outlined thus offer significant avenues for future research and development.

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