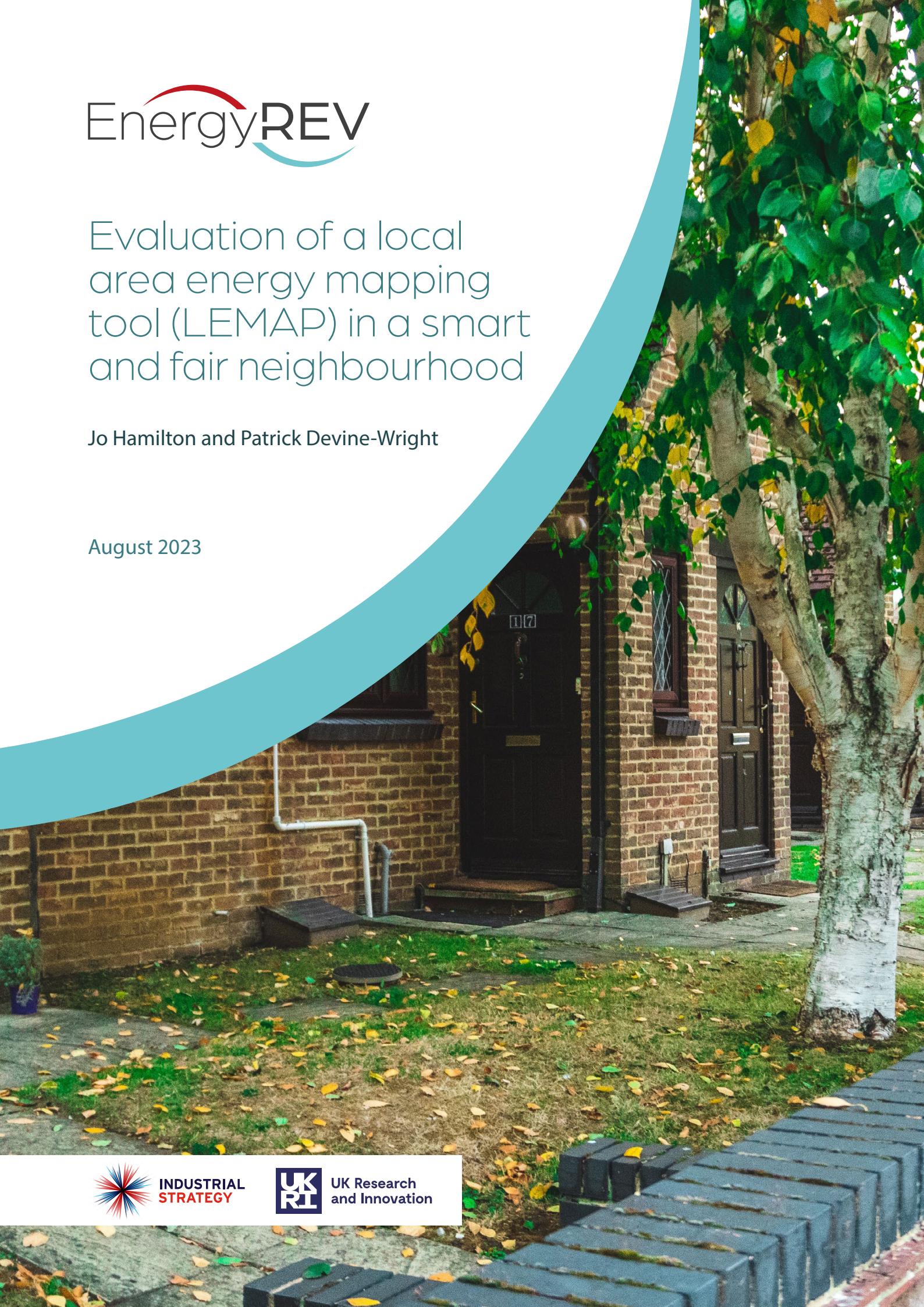




Evaluation of a local area energy mapping tool (LEMAP) in a smart and fair neighbourhood

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August 2023



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This report should be referenced as:

Hamilton, J. and Devine-Wright, D. 2023. Evaluation of a local area energy mapping tool (LEMAP) in a smart and fair neighbourhood. EnergyREV, University of Strathclyde Publishing: Glasgow, UK. ISBN: 978-1-914241-52-9

Acknowledgements

We would like to thank everyone who contributed to this evaluation by participating in an interview, completing an online questionnaire or commenting on drafts of this report. We gratefully acknowledge the funding source for this evaluation from the [EnergyRev project](#).

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1. Executive summary

This report is an evaluation of the trial of a Local Area Energy Mapping tool called LEMAP (LEMAP, 2023), focusing on both the outcomes of the trial, and the process by which it is developed and implemented. The evaluation is funded as part of a wider research project called EnergyRev.¹

Smart local energy systems (SLES) describe local-scale, decentralised energy systems involving the integration of heat, power, and storage technologies (Ford et al, 2019). SLES can play important roles in meeting net-zero targets and deliver multiple co-benefits to places. Effective planning for SLES implementation requires the input of partnerships of stakeholders from different sectors, drawing on their knowledge, experience, and participation over time.

Given the novelty and complexity of SLES, digital tools have the potential to facilitate SLES planning and deployment. These tools need to be designed with the participation of local residents and actors. These actors can be intermediaries such as social enterprises, Local Authorities and community energy and sustainability groups and wider communities of interest. Tools require trialling with these actors to test and improve their usability.

LEMAP was trialled as part of a community scale energy trial called Project LEO: Local Energy Oxfordshire (Project LEO, 2023) and as part of the EnergyRev research project. LEMAP is a powerful and innovative online tool that integrates public, private and crowd-sourced datasets to enable SLES planning. The trial involved local stakeholders learning how to use LEMAP, providing feedback on the design and engagement aspects, and using LEMAP to collect resident data as part of Rose Hill² Smart and Fair Neighbourhood (SFN) project (one part of Project LEO). The trial took place between Autumn 2021 – Summer 2022 across the period of Covid constraints.

The evaluation, conducted using a realist approach (Pawson and Tilley, 1997), revealed multiple outcomes from the LEMAP trial, and different degrees of success for different user and beneficiary groups. Integrating data from the Distribution System Operator (DSO) has provided greater visibility of the electricity network, enabling planning for the electrification of heat and electric vehicle (EV) charging. LEMAP has been instrumental in identifying locations for high density heat pump deployment and will be used for ongoing monitoring of electricity networks.

¹ EnergyREV is a consortium of academics with the multi-disciplinary expertise to address these questions, identify evidence to inform change in both the UK and internationally and provide new tools and insights to accelerate the delivery and roll-out of these systems. We are doing this by considering the whole-system integration required for SLES.

² Rose Hill is a mixed-tenure estate in Oxford city, England.

LEMAP has helped deliver on overall objectives of net-zero planning in Rose Hill through:

- a. Baseline planning (from Oxford Brookes University) of Rose Hill's technical and social capacity for installing solar PV, heat pumps and EV chargers;
- b. Planning for high density deployment of heat pumps through the Clean Heat Streets (SMS, n.d.) project;
- c. Being used by Bioregional (as part of Project LEO) for analysis of home retrofit and flexibility; and
- d. The successful engagement of 101 Rose Hill residents through the household energy survey.

However, some of the expected outcomes of the trial for local stakeholders were not fully met. These include stakeholder's expectations that they would be able to use LEMAP for wider engagement purposes, and to directly use LEMAP to plan SLES and target interventions. During the trial, the LEMAP developer was the only person who had the technical expertise (or could acquire the expertise in the time afforded by their role) to directly use LEMAP for planning SLES. More recently, other organisations have used LEMAP for planning as part of Project LEO. This raises questions regarding where agency for planning SLES could and should reside, and the technical expertise required to enable wider involvement by multiple stakeholders from different sectors in SLES planning.

Implications

Due to their complexity, planning SLES requires high levels of technical *and* social expertise to scope technology deployment and conduct engagement to build a social mandate for action. LEMAP has achieved successful outcomes for decentralised planning of SLES. Further development of LEMAP, alongside training and support, could better enable local stakeholders to directly use LEMAP both to plan SLES and as an engagement tool with local residents, e.g. through visualising the relationships between households and the local energy system.

Learning from the LEMAP trial

The LEMAP trial contains valuable lessons for collaborations involving diverse stakeholders who bring a range of expertise, expectations, and assumptions to SLES. The evaluation reveals the need to further consider *how* social and technical expertise is integrated in the design and application of SLES tools, with particular attention needed to clarify assumptions embedded within terms such as 'engagement' and 'agency' and their implications for tool deployment.

LEMAP was developed to combine technical planning and engagement elements. Changes to the aims of the trial (i.e. the hypothesis tested) during development resulted in a tool which had less emphasis on resident user engagement and more emphasis as an energy planning tool for those with sufficient technical expertise. The evaluation revealed how this change impacted on the intended purposes, uses and users of LEMAP, and meant that some stakeholder expectations around the use of LEMAP for data analysis, planning and forms of engagement were not met. This was exacerbated by Covid restrictions, as LEMAP stakeholder user training was performed online, which affected the depth of training and the opportunity to address concerns in-person.

The development and trialling of LEMAP enabled a degree of co-production of the tool. That said, this evaluation has identified issues that hindered co-production, which include a lack of clarity – and therefore a need for expectation management – concerning the technical expertise required by stakeholders to use LEMAP effectively.

Increasing the co-production of SLES tools requires:

- The degree of agency envisaged for different stakeholders to be explored prior to, and during, tool development;
- The multiple assumptions and meanings of engagement aspects of tools to be explored and clarified according to roles, purpose and competencies of different stakeholders; and
- The technical expertise required to use tools to be accessibly communicated, so that different stakeholders can be involved in SLES planning.

Additionally, this evaluation has revealed the importance of processes to support collaboration in trials involving multiple stakeholders given differing degrees of power, knowledge, engagement, technical expertise and time, and external challenges such as Covid restrictions. These processes include:

- Defining and checking assumptions of key terms;
- Honest and accountable feedback;
- Regular communication and updates to define and explore the impact of changes in emphasis in tool development.

Finally, it is important to put in place mechanisms to acknowledge and work through differences in perspectives and expectations, which can acknowledge power dynamics between stakeholders with different types and levels of expertise.

Overview of report sections

This report contains the following sections:

1. Executive summary
2. Introduction and contexts of the LEMAP trial, scope and intended users, and the organisations involved
3. Methodology of evaluation: the evaluation approach and steps are outlined, the participants are introduced and positionalities are made explicit
4. Context of LEMAP trial
5. Overview of outcome findings: the multiple success pathways are presented according to the theory of change, and the outcomes for different users explained
6. Evaluation of trial process: findings from the evaluation of the LEMAP trial process
7. Evaluation of LEMAP hypothesis and intended users: evaluation of the changes to hypothesis and intended users
8. Discussion and suggestions: key arising messages from the whole evaluation are offered, together with suggestions for improvement where relevant.

2. Introduction and contexts

The challenges of climate change require action at all scales, and across all sectors. The UK Government has set a target of achieving net-zero by 2050 (UK Government, 2021). Local energy systems (LES), and smart local energy systems (SLES, which utilise smart technologies) are terms which describe forms of local-scale, decentralised energy systems, which integrate the supply and demand of heat, power, and storage (Ford et al, 2019). SLES can provide a route to achieving – and exceeding – net-zero targets and can bring about multiple benefits. However, the range of approaches and outcomes are poorly understood, and gaps in knowledge and praxis inhibit cross-sectoral learning and scaling up. To address these gaps, UK policy promoted SLES demonstration projects and funded the creation, trial, and evaluation of innovative tools to achieve SLES, through the Prospering from the Energy Revolution (PFER) funding. (UKRI, 2022)

Public engagement is a key enabler for net-zero (CCC, 2022), both for building a social mandate and for encouraging and supporting the adoption of novel energy services, practices, and technologies. The ‘public’ is a broad term, covering multiple roles in the energy system such as citizens, consumers, producers, residents, influencers, and decision makers. As such it implies differing degrees of involvement and agency. In this evaluation the term ‘resident’ is used to refer to people residing in a specific place (Andersen et al, 2022), which does not prescribe their degree of active or passive involvement and agency.

The term ‘engagement’ can carry a range of assumptions, interpretations, and expectations in academic, practitioner and lay communities. It can cover activities ranging from:

- One-way engagement – communication and information about energy efficiency;
- Two-way engagement – consultation, receiving tailored information and energy feedback, and active interaction with technologies or people; or
- Participation, dialogue, and co-creation (Soutar et al, 2022).

Participatory forms of engagement can increase the number and range of actors involved and require more resources, but can incorporate broader perspectives, draw on unique aspects of context and place, and increase a sense of ownership and agency in resulting decisions or products. Energy management tools, such as digital interfaces and apps, have the potential to enable energy users to observe, learn about and manage production and consumption (Gupta and Zahiri, 2020) and help visualise energy at different scales, such as a neighbourhood.

LEMAP – the local area energy mapping tool (LEMAP, 2023) – was developed by Oxford Brookes University as part of the EnergyRev research theme on User influence tools (EnergyREV, n.d.) (see Box 1: LEMAP framing). This report presents the findings of the LEMAP evaluation, which was conducted between October 2022 – February 2023, several months after the LEMAP trial concluded.

It details the origins and development of LEMAP from 2018 – 2021, the process and outcomes from the LEMAP trial in Rose Hill, Oxford between January 2021 – Autumn 2022, and captures the further development and usage of LEMAP from Autumn 2022 – March 2023 (see Table 1: Timeline of LEMAP development, trialling, and evaluation). It unpacks the reasons behind the successes and challenges encountered in the LEMAP trial process and outcomes and the evolution of the project. It also offers suggestions for further development of LEMAP.

Box 1: LEMAP framing. Source: Local Area Energy Mapping Tool, 2023

‘The Local Area Energy Mapping Tool (LEMAP) brings together public, private and crowd-sourced data on energy demand, energy resources, building attributes, socio-demographics, fuel poverty and electricity networks within a GIS platform. Postcode and dwelling level energy demand profiles are generated using the CREST energy demand model.

The tool has been organised around four technical and four engagement elements that include:

- Baselining local area energy flows in relation to socio-economic characteristics
- Targeting suitable properties for low carbon technologies (LCT) such as rooftop solar, heat pumps, EV chargers
- Forecasting energy demand profiles at postcode level for different LCT scenarios, and
- ‘Capability profile’ to show which areas are likely to adopt LCTs based on their technical, digital, financial and social capabilities

The engagement elements include:

- Participatory mapping to allow residents to visualise their energy demand profiles, compare against the neighbourhood and see how the profile changes with LCTs
- Storymap for creating blogs on local energy flows
- Dashboard to show a summary of information about any postcode in the area; including socio-economic and baselining data;
- Forum to enable chats amongst users of LEMAP and project stakeholders’

Table 1: Timeline of LEMAP development, trialling and evaluation

Date	Description of activity	Impacts on LEMAP design and trial process
August 2018	EnergyRev: LEMAP application written, initial hypothesis presented	
2019	Background research and discussion of collaboration with Low Carbon Hub.	
2020	Review of local energy mapping tools (Gupta and Zahiri, 2020)	Paper revealing gaps in energy mapping tools, including ‘lack of visualisation at a neighbourhood spatial scale level ... and limited focus on residents and community groups’. LEMAP designed to address gaps ‘by adopting a spatio-temporal approach for planning smart local energy initiatives while engaging community groups and residents’. (Gupta and Zahiri, 2020)
March 2020 – March 2021	<p>Covid-related disruption and lockdowns</p> <p>Change of intended direct primary users from residents to energy intermediaries</p>	<p>Planned face-to-face engagement and flexibility trials in Project LEO not possible.</p> <p>Need for mapping tools for planning Smart and Fair Neighbourhoods (SFN).</p> <p>Shift away from householders towards energy intermediaries.</p>
Jan – Feb 2021	Overview and training sessions delivered online with SFN project managers.	Online training limited the number and type of queries and interaction during training.
March 2021	Online survey and feedback with SFN training participants	Discussion about functionality and usefulness of LEMAP tool resulted in improvements, addition of data layers and third-party data. Dashboards were added to user interface. (Gupta et al, 2021)
May 2021	SFN Project specification with LEMAP in Rose Hill [Box 2]	
Nov 2021 – Spring 2022	Rose Hill SFN LEMAP training and trialling session (involving Oxford City Council, RHILC, Low Carbon Hub).	<p>Large number of languages spoken in Rose Hill influenced the household energy report to incorporate more visual aspects.</p> <p><i>“We realised working with Rose Hill ... that the technical capability that is required to understand some of the stuff that’s very obvious to us, is not to be expected among households.” [D1 interview]</i></p> <p>Incorporated functionality to change the boundaries for the mapping elements.</p>

Date	Description of activity	Impacts on LEMAP design and trial process
Dec 2021 – Dec 2022	Solar saver trial: Low Carbon Hub and Rose Hill residents	Some Solar Saver trial participants also completed a Rose Hill Household energy survey.
March – April 2022	Rose Hill Household energy survey data collection	Data from household energy survey used to check LEMAP data.
May 2022	Data presented back to Low Carbon Hub	More data layers added: LEMAP now has capacity to identify crowd-sourced data, and wider data layers that can use geocoded data.
May 2022 onwards	Use of data arising from LEMAP – Spatial analysis of a SFN in Oxfordshire (Gupta et al, 2022)	
June 2022	LEMAP Rose Hill baseline report	
Autumn 2022	Clean Heat Streets Project phase 1: feasibility study	Incorporation of Distribution Service Operator (DSO) grid loading at secondary substation dataset.
September 2022 – March 2023	LEMAP evaluation	
March 2023	Clean Heat Streets: confirmation of success for Phase 2 and implementation stage.	LEMAP to be used for ongoing monitoring for Clean Heat Streets

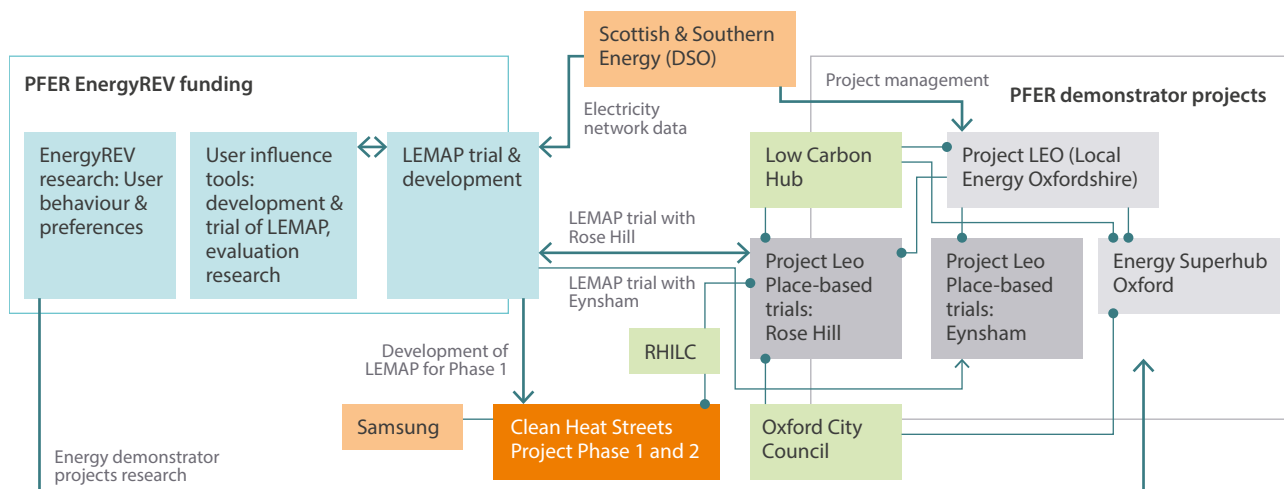
2.1 Origins of LEMAP development and trial

The origins of LEMAP came through the developer, Rajat Gupta (Oxford Brookes University), alongside co-investigators Patrick Devine-Wright (University of Exeter) and Sarah Darby (University of Oxford) securing funding from the EnergyRev consortium to develop and evaluate a set of ‘user influence tools’ (EnergyREV, n.d.). This was connected to EnergyRev research focusing on user behaviour and preferences in the Prospering from the Energy Revolution (PFER((UKRI, 2022) Energy Demonstrator projects.

The process of funding proposal writing and submission for EnergyRev was organised by Innovate UK (UKRI, n.d.) / EPSRC (Engineering and Physical Science research Council), with funding from the UK Industrial Strategy PFER fund. The process was undertaken in a short time frame of 2-3 weeks during August 2018. The developer commented that the ‘fast track’ time span of proposal development limited the amount of co-creation with wider actors at the project inception.

The development and trial of LEMAP was conducted as part of a related energy demonstrator project called Project LEO: Local Energy Oxfordshire (Ford et al, 2019), which was also a recipient of PFER funding. One aspect of Project LEO was a trial of six Smart and Fair Neighbourhoods (SFN). The SFN approach was developed by Project LEO to embed fairness and equity into local energy transitions and informed by their ‘ethical framework for local energy approaches’ (Huggins, 2020). A schematic showing the relationships between the LEMAP project, Project LEO and the SFNs and the PFER funding for the projects and research is shown in Figure 1.

Figure 1: Schematic showing relationships between stakeholders, users and research during the LEMAP trial.



LEMAP was trialled in the Rose Hill SFN – an urban estate in south Oxford city comprising some 2,000 residents. The Rose Hill SFN was developed to support the community group’s aim of becoming a zero-carbon estate.

A range of organisations were involved in the LEMAP trial as ‘stakeholder users’ testing and trialling the development and usage of LEMAP, while others were involved as technology developers and beneficiaries. LEMAP was also used to map another Project LEO SFN trial in Eynsham, a town to the west of Oxford, but this trial did not have the involvement of a community group for engagement or the roll out of the household energy survey.

2.2 Scope and intended users of LEMAP

From the project inception in 2018 until this evaluation there were several changes in the scope and intended users of LEMAP.

The initial scope was to co-create, develop and trial a ‘suite of smart interactive tools’ to address the needs of relevant users. An important change in the hypothesis occurred between 2019 and 2022, which involved a shift away from, and reduced focus on, two-way engagement between tools and residents. The development of one tool, LEMAP, was based on the following factors:

1. **Background research:** Gupta and Zahiri (Gupta and Zahiri, 2020) identified the importance of user engagement in the acceptance of SLES, and the importance of ‘integrat[ing] engagement and evaluation in the delivery of smart local energy initiatives across the UK’ (p.10). Research (Gupta et al, 2023) also highlighted the potential for smart tools to enable ‘users to better manage, control and observe energy ... [and] encourage users to become active participants’ in energy transitions (Gupta and Zahiri, 2020 p.6).
2. The **context of Covid-19** and lockdowns during 2020-2021 limited Project LEO and Energy Superhub Oxford’s (ESO, 2022) intended involvement of residents in energy flexibility trials. Opportunities for face-to-face engagement were limited (for Projects LEO, ESO and LEMAP) and meant that digital household interfaces were not needed. The developer reflected that “*there was not much point in giving them [residents] tools because they were not really shifting anything.*” [D1].

3. The **needs of SFN projects**. The Rose Hill SFN project was co-created through Project LEO with the community group Rose Hill and Iffley Low Carbon, to support their aim to ‘become the first Zero Carbon Estate in the country’ (Project Leo, n.d. a). LEMAP was intended to be used to develop the baseline and roadmap to support that aim.

Responding to these factors, LEMAP was developed as one tool to serve a range of users, and was oriented to help plan energy transitions in the SFN, as the developer reflected:

“ At that time there was very little out there in terms of spatial intelligence to help plan these initiatives in LEO. So it was quite a natural evolution, rather than doing 10 tools, it made sense to put our efforts into one proper tool.” [D1].

This decision was also informed by existing mapping tools that the LEMAP developer had developed and used, such as DeCoRUM (Gupta and Gregg, 2020). LEMAP expanded DeCoRUM’s built environment, energy and retrofit mapping capacity by adding gas and electricity networks and data; socio-economic data such as a capability analysis; and the potential for crowdsourced layers. Since the trial in Rose Hill SFN, LEMAP has been further developed to map connections to secondary substations and to explore electricity flexibility potential.

Changes to the intended direct users of tools occurred between the project inception and the LEMAP trial. Some changes resulted from the changes of scope, and some arose from the experiences of the Rose Hill SFN trial, and the need to cater for a wide range of digital and energy literacy and accessibility needs of residents. This resulted in the focus on community energy project developers and planners as the direct intended users, with engagement aspects aiming to include wider users such as residents but delivered through community stakeholders.

2.3 LEMAP specification, stakeholder users and technology developers

The LEMAP specification (July 2021) (Luddecke, 2021) for Project LEO and the Rose Hill SFN is set out in Box 2. It was developed between the LEMAP developer and the Low Carbon Hub (LCH).³

Box 2: LEMAP specification, from Rose Hill Smart and Fair Neighbourhood Trial Project Specification 4 May 2021 v2. Source: Luddecke, 2021

LEMAP specification

Idea: Model how the energy system of the future might stack up in a defined area.

Goal: A road map to zero carbon tailored to Rose Hill for the community to use as an influencing tool

Approach: Use the online LEMAP tool being developed through EnergyRev to test how to develop a road map for becoming a zero-carbon community, including those residents with least flexibility potential.

- Understand the existing situation affecting the energy system, using data from official sources.
- Check and supplement this with local information using participatory, community mapping.
- Try out different scenarios to understand local options for net-zero by 2050, or even 2040 – see how flexibility, as well as other strategies such as demand reduction and storage, could reduce the local carbon footprint and enable more renewable generation without costly upgrades. [p.4]

³ The [Low Carbon Hub](#) (LCH) is an Oxfordshire based community energy social enterprise.

Outcome T1: We will learn how better data analysis and access to information helps asset owners and communities develop effective energy strategies, both for the short term and for long-term energy planning.

- a. Test techniques to develop an energy baseline by collecting and modelling data for a range of different users and assets (through LEMAP, which is itself an innovation project in EnergyRev and LEO).
- b. Model how the energy system of the future might stack up in a defined area.
- c. Test the use of storage to provide DSO flexibility services.
- d. Explore the potential for aggregated small-scale flexibility services, that is a collaborative and community approach, to help address a simulated network constraint (e.g. peak management, over-solar). By 'simulated' we mean a test: we pretend there is a constraint and people in the trial respond as if it existed to show we could address the problem; some of this exploration may also take the form of thought experiments using data and information being collected as part of the trial. [p.6]

Deliverables

- a. A 'Local Energy Mapping' (LEMAP) tool with some elements for more expert users and others for the community, road tested with both types of users.
- b. As an output from that, a range of local tailor-made scenarios that would take the community to net-zero by or before 2050 (ideally 2040, to align with the ZCOP roadmap and action plan) [p.8].

2.4 Organisations involved in the LEMAP trial

The development and trial of LEMAP involved organisations from different sectors who, directly or indirectly, engaged with LEMAP. The schematic in Figure 1 shows the relationships between the different stakeholder users, technology developers and researchers.

Stakeholder users of LEMAP

Stakeholder users comprised stakeholders from the LCH, Oxford City Council, and the community sustainability group Rose Hill and Iffley Low Carbon (RHILC). All stakeholder users had existing working relationships through Project LEO. All acted as energy intermediaries,⁴ (Barnes, 2019; Kivimaa, 2019), both engaging the local community and being involved in the planning and development of local sustainable energy through their organisations. The specification of LEMAP (Box 2) was already agreed when the stakeholder users commenced involvement in the LEMAP trial. They all had differing expectations about how LEMAP could support their work, and all participated in an online introduction to LEMAP and training between November 2021 – February 2022.

During the LEMAP trial, all stakeholder users provided feedback on LEMAP's design and use, the engagement aspects of the household energy survey collection and resulting household report and the interpretation of data held in LEMAP. All were involved in recruiting residents to participate in the Rose Hill household energy survey.

The LCH stakeholder users were involved in the management, communication, and engagement aspects of the Rose Hill SFN, alongside exploring the strategic impact of LEMAP. The LCH provided financial incentives to residents who completed the household energy survey.

⁴ An 'energy intermediary' is a term used to describe a person/organisation who performs roles such as connecting different people / organisations (in this case Rose Hill residents to Rose Hill SFN and Project LEO) to wider agendas (e.g. net-zero) or technologies (e.g. heat pumps) to facilitate forms of change (in this case to a transition to zero carbon energy).

RHILC was a key stakeholder in the Rose Hill SFN. They provided feedback on the household energy survey and implementation and had access to the arising data but were not involved in the LEMAP scoping. Some RHILC interviewees saw their role as intermediaries between ‘the pros’ of Oxford City Council and LCH and their local community. The LEMAP trial built on RHILC’s positive working relationship with the LEMAP developer that spanned the past decade. Prior to LEMAP, the developer had provided valuable mapping and evaluation for another energy project (Project ERIC) (Bioregional, n.d.), and a thermal imaging survey to explore energy usage and loss in the 1930s homes in Rose Hill. These energy projects were set against a backdrop of RHILC finding it more difficult to engage the broader Rose Hill community in energy events and meetings than other activities.⁵

Oxford City Council were involved in the LEMAP trial through their stakeholder user’s involvement in the steering group of Rose Hill SFN.

Technology users

In contrast to the community-facing stakeholder users, the technology users had different roles in the development and usage of LEMAP.

The Distribution System Operator’s (DSO) involvement in LEMAP was to support the development of “*the [LEMAP] product*” through their role as the Project Manager for Project LEO (see Figure 1). They did not interact directly with the dashboard or engagement elements of LEMAP but provided electricity network information to the LEMAP developer for use in LEMAP. Project LEO has been beneficial to the DSO within the wider context of the change from Distribution Network Operators (DNO) to Distribution System Operators (DSO). They described this as a “*quiet revolution ... we are on a journey [to] understand the impact [that] flexibility ... can provide to the network*” [TU1]. They reflected that “*the whole process that we’re going through in the project [LEO] has really helped [us] understand how we can operate within a smart local energy system*” [TU1].

The Samsung Clean Heat Streets (CHS) project manager [TU2] is a beneficiary of the LEMAP data and interpretation, since LEMAP is the key innovation product that has enabled the development of the CHS project (SMS, n.d.). LEMAP has been an integral part of developing the CHS feasibility study through identifying and targeting areas for high density deployment of heat pumps in Rose Hill, and successfully securing funding for implementation in Phase 2 (Oxford Brookes University, 2023). CHS is distinct from – but builds on – Project LEO’s Rose Hill SFN. The CHS project manager’s engagement with LEMAP came after the LEMAP stakeholder user trials. LEMAP is expected to be further developed through the CHS project.

⁵ RHILC stakeholders reflected that some of their events, such as Repair Cafés, swap shops and tree planting, tended to engage residents beyond the ‘usual suspects’, whereas it proved difficult to attract residents to events about home and community energy.

3. Methodology of evaluation

The evaluation was conducted using a realist evaluation methods approach (Pawson and Tilley, 1997) to discover what works, for whom, in what context, and with what resources. The process and outcomes of the LEMAP trial in Rose Hill were evaluated against the project's theory of change and hypothesis and the resources and reasoning needed to enable these outcomes from the perspective of different users. It was informed by a broader evaluation framework incorporating digital inclusivity and energy justice.

3.1 Realist evaluation

Applying realist evaluation to energy and sustainability projects enables relatively rapid testing of pilot interventions (Fell et al, 2022) and was suitable for evaluating LEMAP because:

- **It is theory based:** It seeks to evaluate according to LEMAP's hypothesis and theory of change.
- **It is intended to inform policy and development:** LEMAP is in the process of further development to increase its functionality and usage in other geographical locations.
- **It uses a framework to explore the interactions and connections between context, mechanism and outcome (CMO):**
 - » **Context(s):** where and how different users encounter LEMAP.
 - » **Mechanism:** focuses on how LEMAP is used, and what reasoning and resources different users bring. **Reasoning** includes what shapes decisions and values, (e.g. values, beliefs, norms, emotions, prior experiences), **resources** include engagement elements (e.g. time, interactions, information, energy and digital literacy).
 - » **Outcome(s):** what happens, to whom/what (people, organisations, models, technologies), over what time period?

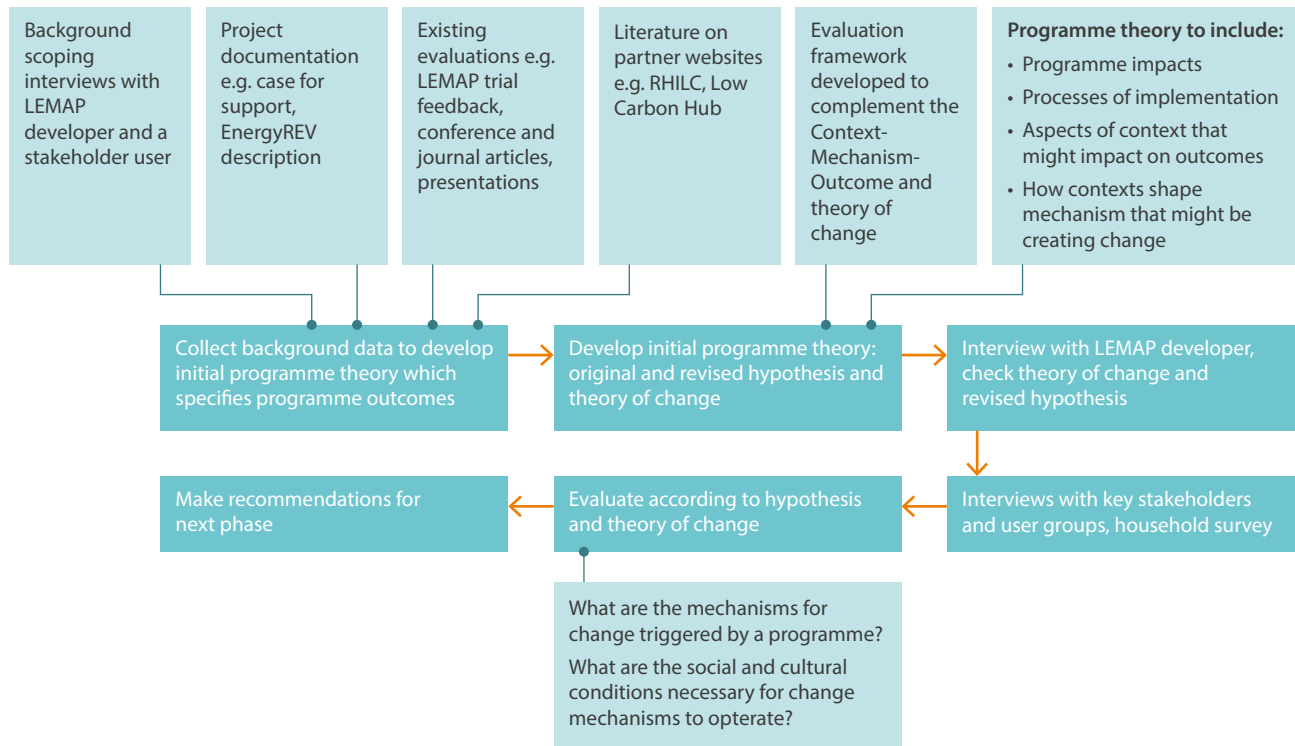
In this evaluation and report, the CMO configuration is integrated into the theory of change (see section 5.2). This evaluation uses the outcomes set by the project to define degrees of success. A realist evaluation seeks to find out what outcomes occurred, and *how* they came about, for a range of different users. This evaluation draws on two types of data:

- Primary data sources comprised semi-structured interviews conducted with the LEMAP developer, six stakeholder users, two technology developers and six residents, along with an online questionnaire involving twenty residents.
- Secondary data sources comprised existing written material about the project and LEMAP such as websites, presentations, journal articles, newsletters and project reports.

3.2 Evaluation steps and participants

The process of evaluating LEMAP with a realist evaluation is shown in Figure 2.

Figure 2: Evaluation process



The LEMAP evaluation is relatively small and contained compared to other realist evaluations focusing on sustainable energy (Gregory-Smith, 2017; Husain and Sidhu, 2021), but the principles remained the same. As shown in Figure 2, background data was used to devise a current LEMAP hypothesis and theory of change, which was tested through primary data gathering to explore the interactions between context, mechanism (reasoning and resources) and outcomes for different users.

User groups were defined by role. Suitable interviewees were identified by conducting background scoping interviews with the LEMAP developer and the SFN project manager and by asking interviewees to suggest other potential interviewees. An online questionnaire was distributed to residents who had completed a household energy survey, and interviewees were invited from these respondents.

Evaluation participants are shown in Table 2. All stakeholder users and one technology developer (DSO) were involved with the Rose Hill SFN. All resident household questionnaire respondents and interviewees had participated in the Rose Hill energy survey.

Table 2: Summary of users involved in tool development and tool evaluation.

Type of User	Participation in tool development/trial	Participation in tool evaluation with details of methods
Tool Developer	<p>LEMAP tool developer [D]</p> <p>Rajat Gupta, Oxford Brookes University</p>	<p>1 scoping conversation</p> <p>2 semi-structured interviews (D1: Nov 2022 and D2: March 2023)</p> <p>Follow up queries and responses to draft report sent via email</p>
Stakeholder users	<p>All stakeholder users provided feedback on the development of LEMAP, the resident engagement elements (Rose Hill energy survey and household LEMAP report) and promoted and encouraged completion of Rose Hill energy survey.</p>	
	<p>Oxford City Council [SU1]</p> <ul style="list-style-type: none"> Feedback user through the lens of Project LEO, involved in Rose Hill SRN steering group 	<ul style="list-style-type: none"> 1 semi-structured interview (Nov 2022) Responses to follow up queries and corrections on draft evaluation report sent via email.
	<p>Low Carbon Hub (LCH) [SU2, SU3, SU4]</p> <ul style="list-style-type: none"> SFN Manager Marketing and Communications Manager Social Impact Director <p>Provided financial incentives for energy survey completion.</p>	<ul style="list-style-type: none"> 1 scoping conversation with SU2 (Oct 2022) 1 semi-structured interview with each stakeholder (Nov – Dec 2022) Follow up queries answered via email.
	<p>Rose Hill and Iffley Low Carbon [SU5, SU6]</p> <ul style="list-style-type: none"> Co-founder and co-chair <p>Both involved in the Rose Hill SFN steering group, advised on household energy survey, promoted household energy survey, and involved in the CHS project.</p>	<ul style="list-style-type: none"> 1 semi-structured interview with each stakeholder (Nov – Dec 2022).
Technology users	<ul style="list-style-type: none"> DSO Project manager of Project LEO [TU1] Project manager of the Clean Heat Streets Project [TU2] 	<ul style="list-style-type: none"> 1 semi-structured interview with each stakeholder (Dec 2022).
Rose Hill resident householders	<p>Resident householders completed a household energy survey in March 2022. The survey data was uploaded to LEMAP. They all received a link to view their household energy report.</p>	<ul style="list-style-type: none"> 20 responses from a questionnaire sent to 78 residents who completed the household energy survey. 6 of the questionnaire respondents then completed a semi-structured interview, which lasted between 15-30 mins each. The interviews focused on the experience of completing the household energy survey, and the feedback received from LEMAP (Dec 2022).

Semi-structured interviews were conducted online with all interviewees (with video using Microsoft Teams, Zoom or Google Meet), apart from one resident interview conducted by telephone. Interview questions were developed by drawing on realist evaluation questions (Westhorp and Manzano, 2017), alongside questions informed by the wider evaluation framework. All interviews were transcribed, corrected by listening to interview recordings, and edited for cleaned verbatim transcription. All interviewees were offered a £25 participation payment and were sent a copy of their transcript to check.

The invitation to complete an online questionnaire was distributed to 78 residents who had completed the Rose Hill energy survey in March-April 2022, and who had given the Low Carbon Hub permission to contact them. An incentive was provided in the form of either a £5 voucher for a local grocery store, or a £5 donation to a local youth group.

Draft evaluation reports were shared with the developer, stakeholder users and technology users to check for accuracy and interpretation and amendments were made accordingly.

3.3 Researcher positionality

It is important to acknowledge the positionality of the researchers, project developers and wider actors.

Rajat Gupta is the principal-investigator (PI) of the EnergyRev 'User influence tools' work package. He has played different roles in Rose Hill over the past 10 years and has built up a trusting research and action relationship with RHILC. This includes conducting evaluation of Project ERIC (Gupta et al, 2019) and providing thermal imaging surveys to explore the energy needs of 1930s housing. As a RHILC interviewee reflected "*Rajat has talked at a number of our events and been very generous to the group in terms of his time*" [SU5].

Patrick Devine-Wright is the co-investigator on the *User influence tools* work package and co-wrote the EnergyRev funding application with Rajat Gupta and others. He is also involved in the tool evaluation research activities.

Jo Hamilton is the lead researcher conducting the LEMAP evaluation. She has played different roles relating to the stakeholder users and developers involved in the LEMAP trial:

- Rose Hill and Iffley Low Carbon: Prior to 2012, Jo provided small amount of support through her role as Oxfordshire ClimateXchange coordinator, working alongside the Community Action Groups project in Oxfordshire.⁶
- Jo was a researcher on the EVALOC (EVALOC, 2013) research project with Rajat Gupta as the PI.
- Jo has known the LCH interviewees in different professional (freelance and research) and personal capacities for over 15 years, and from 2020 – 2023 was a member of the LCH's Community Grants Panel (Low Carbon Hub, n.d.) which decides and distributes funding raised by the LCH's renewable assets.

⁶ Oxfordshire ClimateXchange was a climate change engagement project led by the Environmental Change Institute, University of Oxford. It ran from 2006 – 2009. [Community Action Groups Oxfordshire](#) is a network of over 100 community based groups working on sustainability issues.

3.4 Interviewee positionality

There were pre-existing and ongoing relationships between community energy groups, energy intermediaries, universities and local authorities concerned with energy and climate engagement in Oxford and Oxfordshire. These relationships included histories of collaborations, successes, and reciprocity in time and expertise. In a close-knit community which is reliant on forms of grant funding to achieve equitable net-zero, there are power relations at play which have affected the LEMAP trial and the evaluation process.

This evaluation was conducted when funding for both Project LEO demonstration projects and EnergyRev was drawing to a close, thus an awareness of future collaborations and the need for a range of funding sources may have impeded some criticism of aspects of the trial. There was caution in speaking about some negative aspects of the LEMAP trial, such as unmet expectations. This was apparent through interviewees speaking carefully and pausing at some points, focusing on what a tool 'could' do (i.e., in differing circumstances or if changes were made), and highlighting positive aspects. Power dynamics, agency and ascribed identities were also apparent for some stakeholder users, regarding who could/should decide on energy planning in Rose Hill.

To achieve the learning, development, and collaboration necessary for the transformation to net-zero, it is important to provide mechanisms for honest and transparent feedback and accountability and enable feedback from all perspectives.

4. Context of the LEMAP trial

Rose Hill is a mixed tenure estate on the outskirts of the city of Oxford, in the southeast region of England. It contains approximately 1,200 households (Oxford City Council, 2021), with a population of 3,336 in 2021 (OCSI, 2021). It has a higher degree of multiple deprivation compared to the rest of Oxford and England. It has strong sense of place and civic pride in the context of recent regeneration and development, including new flats and a community centre. Rose Hill is an ethnically diverse neighbourhood with over 20 languages spoken.

The main parts of stakeholder user engagement with LEMAP occurred sequentially between November 2021 and the spring of 2022. As this was part of trialling LEMAP, user feedback was incorporated iteratively to different degrees (see Table 1). This occurred alongside the needs and expectations of both stakeholder users and the developer to provide outputs for the Rose Hill SFN project.

The key dates of testing and trialling LEMAP are shown in Table 1, which relate to the steps below.

1. LEMAP introduction and training with stakeholder users, and defining the area of Rose Hill for LEMAP (Nov 2021 – Jan/Feb 2022).
2. Feedback on the community engagement elements with the wider Rose Hill community through the household energy survey, including the household reports generated by LEMAP (Nov 2021 – Feb 2022).
3. Engagement with Rose Hill residents through the roll out and collection of household energy survey data (March 2022), and household report generated by the energy survey.
4. Engagement between the stakeholder users and developers in using and interpreting the data arising from LEMAP (April-May 2022).

The LEMAP trial and training of stakeholder users occurred when Covid lockdowns were still limiting the ability to meet inside. The level of training and potential to respond to arising queries in real time was diminished. This limited the potential for addressing queries.

The household energy survey occurred during March – April 2022, a time of high public awareness of the impact of energy price rises and of Russia's invasion of Ukraine. There were few grants or offers to assist householders with energy efficiency and renewable generation. The household energy survey also took place in the context of Rose Hill's SFN project and associated interventions such as a *Solar savers trial* (Low Carbon Hub, n.d. a) which involved occupants of the new flats.⁷

⁷ The Solar Saver trial was managed by Low Carbon Hub in partnership with Oxford City Council as part of Project LEO. Participants were recruited from residents of [newly built flats in Rose Hill](#). The project aimed to explore 'how those living in the flats can benefit from solar panels: getting access to cheaper electricity at those times when the solar panels are generating the most energy'. Further information:

The trial also took place in the context of the local energy group, RHILC, experiencing difficulty in engaging residents with energy. One resident interviewee provided a perspective on the difficulties of engaging with energy issues and events organised by RHILC. They reported that the timings of meetings made them difficult to attend because of family commitments. They also suggested that rising insecurity about energy and prices could contribute to low attendance. The interviewee's perception was that their peers did not necessarily know how they could benefit from attending meetings, particularly if they are in rented accommodation. While this is one perspective, it highlights the need and opportunity for different ways of engaging with the local community in order to support the work of local groups such as RHILC.

5. Overview of findings

The findings from this evaluation are presented in three sections: the trial outcomes (this section), the trial process (Section 6), and the evaluation of the hypothesis and intended users (Section 7). In this section, multiple success pathways are outlined, followed by a summary of the evaluation according to the theory of change and the outcomes for different users.

5.1 Multiple pathways of success for different actors

Overall, there have been successful outcomes from the LEMAP trial, but the degree of success differs according to the user group. The LEMAP tool has been successfully used to develop and plan a SLES in Rose Hill and will be used for ongoing monitoring. Resident engagement with household energy through the energy survey and report has been partially successful. However, the stakeholder users have experienced a disparity between their expected outcomes for engagement and planning interventions and their actual experience. The outcomes are presented in more detail below, alongside the context and mechanisms.

Technology for planning and monitoring SLES: successful

An overarching **outcome** of planning and supporting the transition to net-zero in Rose Hill has been met through the innovative combination and interpretation of multiple datasets in LEMAP. This has enabled visibility of electricity grid data and contributed to planning energy infrastructure, which in turn has contributed to the trial of high-density deployment of heat pumps in the **context** of Project LEO and the CHS project.

The successful outcomes for different users include:

- Samsung: enabled the trial and deployment of heat pumps with CHS.
- DSO: enabled electricity network visibility and monitoring.
- LEMAP developer: further academic development and testing of LEMAP to monitor SLES.
- Residents: information about their home energy with some residents possibly receiving a reduced-price heat pump through CHS.
- RHILC: through contributing to their aim to be a zero-carbon estate.

These outcomes have been reliant upon the expertise and resource of LEMAP academic developers, (**mechanism**), for data analysis, interpretation, planning and development.

Enabling stakeholder users to interpret and plan SLES: partially successful

There have been some successful outcomes for stakeholder users when they have had LEMAP explained in more detail. LEMAP has provided an opportunity to engage with residents about household energy, has increased the database of residents who are interested in energy and has provided some data for the Rose Hill zero carbon road map (**outcomes**). This was in the context of the Project LEO LEMAP trial connected to the SFN. The **context** of Covid limited the depth of training possible. The trial has drawn on the expertise, trust, prior working relationships, experience and engagement skills and time of the LCH, Oxford City Council and RHILC to provide feedback on LEMAP, and the incentives provided by LCH to encourage residents to complete the energy survey (**mechanisms**).

The initial expectations of stakeholder users for LEMAP involved broader user engagement (involving communication and participation), which created the expectation – and appetite – for a range of users being trained to explore and interact with LEMAP and directly use it to support community engagement. The technical expertise required to interpret the arising data from LEMAP has limited the degree in which this happened: none of the stakeholder users considered that they could directly use LEMAP to plan interventions and potential pathways to net-zero during the trial, although they are doing this in different ways (e.g., through the Oxford Zero Carbon Partnership) (Oxford City Council 2022). Subsequently, some have received further training and may use LEMAP in the future.

Resident energy engagement: partially successful

For resident householders, LEMAP has provided an opportunity to understand more about their own energy usage and how to save money on energy bills. It has also enabled some to understand more about how energy is used in Rose Hill (**outcomes**). This was in the **context** of an incentivised survey, the resources to complete an online survey, and for some an ongoing involvement in a Solar Savers trial (**mechanisms**). Furthermore, for those residents involved in this evaluation, it has drawn on the participating residents' prior concerns about community energy and/or fuel bills.

These are good outcomes but maintain the role of householders as recipients of interventions, rather than being actively involved in SLES decisions. The level of residential participation could have implications if the transition to net-zero becomes contested, if there is opposition, or if householders will be expected to personally invest in technology and fabric of their properties.

Wider applications of LEMAP: successful

LEMAP has been successfully used in other areas in the UK, such as Energise Barnsley, and modified for use in a project in India by the LEMAP developer. LEMAP has been used for a Project LEO funded study on retrofit analysis and flexibility, conducted by Bioregional on behalf of Oxford City Council. There is current interest from other UK local authorities and designers and sustainable energy consultants, which indicates the potential for broader applications of LEMAP.

5.2 Programme theory of change

The Theory of Change for different LEMAP users is shown in Table 3, alongside the degree to which different stakeholders had their expected outcomes met. Again, the aspects of context, mechanism and outcomes are highlighted.

Table 3: Theory of change and outcomes for LEMAP

User group	Role	Background context that informs the activity	Programme activities: relationship and engagement with LEMAP	Resources and reasoning needed for activities (mechanisms)	Intended outcomes for primary users	Outcomes for wider users	Success of outcomes? Note: orange shading indicates intended outcomes largely met, yellow indicates intended outcomes partially met
Developers	Tool developers at Oxford Brookes University	Part of EnergyRev consortium, prior engagement with RHILC and LHC	Design and trialling LEMMap , training stakeholder users, receiving feedback, exploring wider application and scaling up	LEMMap developed and extended existing tools: LEMUR (Gupta and Gregg, 2018) and DECoRuM (ESO, 2022)	1/ Energy mapping tool that can be developed, scaled up and used in wider areas	1/ Contribution to zero carbon energy transformations 2/ Help to meet policy targets (e.g. deployment of heat pumps).	Outcomes for primary and wider users met LEMMap has been developed through CHS project. Increased functionality for monitoring is being developed for use in wider areas, although some co-creation is required for broader community stakeholder usage
Stakeholder users	Low Carbon Hub / Project LEO	Managing SFN project, involvement with Project LEO	Learning and feedback on LEMMap design and application, household energy survey engagement, incentives, data analysis	Local area knowledge: including different housing types and tenures, existing low carbon technologies, connections to social networks, engagement and communication skills	1/ Ability to target technical and social interventions and offers 2/ SLES planning and development (creation of roadmap for Rose Hill)		Both outcomes slightly met Household survey data has contributed to both outcomes, but LEMMap interface did not meet expectations for querying to plan SLES, and wider data and user interface functionality for roadmap creation was required

User group	Role	Background context that informs the activity	Programme activities: relationship and engagement with LEMAP	Resources and reasoning needed for activities (mechanisms)	Intended outcomes for primary users	Outcomes for wider users	Success of outcomes? Note: orange shading indicates intended outcomes largely met, yellow indicates intended outcomes partially met
Stakeholder users	Oxford City Council	Involvement in Project LEO, Rose Hill SFN and Energy Superhub Oxfordshire	Learning and feedback on LEMAP design and application, energy planning in Oxford, household energy survey engagement, incentives, data analysis	Local area knowledge, knowledge of requirements for City Council planning and SLES development	Mainly to use LEMAP to support the SFN activities Engaging residents about energy and net-zero		Both outcomes met by Oxford City Council, although to lesser degree than intended due to data expectations from LEMAP not being fully met.
Stakeholder users	RHILC	Part of RHILC projects, aspiration for zero carbon neighbourhood, encourage the installation of domestic heat pumps	Learning and feedback on LEMAP design and application, encouraging and engaging householders to complete LEMAP household survey.	Knowledge of area (built environment and connections to social networks), understanding of decarbonisation needed.	1/More accurate community data on energy usage and potential to adopt low carbon / smart technology	2/ Local data gathering for developing offerings for energy efficiency and low and zero carbon technologies	Outcome 1/ slightly met for RHILC usage: some useful data, increased list of residents and energy interest. Data can be interpreted by LEMAP developer Outcome 2/ met from CHS, will contribute to zero carbon aim.

User group	Role	Background context that informs the activity	Programme activities: relationship and engagement with LEMAP	Resources and reasoning needed for activities (mechanisms)	Intended outcomes for primary users	Outcomes for wider users	Success of outcomes? Note: orange shading indicates intended outcomes largely met, yellow indicates intended outcomes partially met
Rose Hill Residents	Rose Hill Residents	Online or as part of community event	Completing LEMAP household survey online, or through in-person interaction at events (e.g. food bank)	Understanding energy survey and feedback, access to online services, digital literacy – or face to face support – to complete the survey.	1/ Stimulates user participation in local energy management 2/ Energy visualisation and literacy 3/ Understanding more about home energy	4/ More accurate community data on energy usage and potential to adopt smart technology	Outcomes 1 & 2: insufficient data to assess outcomes Outcome 3/ partially met Outcome 4/ met for LEMAP developer
Infrastructure	Technology providers e.g. Samsung	Planning technological infrastructural changes (e.g. heat pump installation)	Using the mapping, crowdsourced and network data already in LEMAP	Knowledge about heat pump deployment, needs, network capacity. Data interpretation provided by LEMAP developer	1/ Identifying pathways for heat pump deployment 2/ Business model development	Aligns with RHILC aspiration to be a zero- carbon neighbourhood	Outcome 1/ met with successful CHS bid Outcome 2/ in development
	DSO	Grid constraint issues, Net-zero action plan (SSEN, 2023)	Overseeing LEMAP development, downloading network data into LEMAP	Data interpretation provided by LEMAP developer	1/ Ability to identify bottlenecks and potential 2/ Potential to address grid constraints		Outcomes 1/ and 2/ met

5.3 Trial outcomes for stakeholder users

As shown in Table 3, stakeholder users found that the outcomes experienced from LEMAP did not meet all of their expectations.

The purpose and expected outputs from the household energy survey differed between the stakeholder users and the LEMAP developer. These outputs have variously been described as:

- An engagement element with local residents (RHILC and stakeholder users)
- Obtaining a representative sample to inform road map baselining and planning (stakeholder users)
- A means for verifying the data within LEMAP (developer)

The household energy survey which formed the main engagement elements of LEMAP was successful to some extent. Conversations with residents were valued, and some stakeholder users noted that the survey:

“ Got people to talk about energy and talk about home retrofit and all those good things that we need to have conversations about” [SU1].

There were limits to what the conversations could lead to. While the LCH provided information to survey respondents including sources of grants, energy advice and support (Project LEO, 2022), stakeholder users reflected that at the time of the survey there were few forms of funding to assist householders with making changes. This was illustrated by a resident interviewee, who reflected that *“now I’m informed, but I don’t know what to do with that”* (PID24).

Data arising from the household energy survey was useful for the stakeholder users. The key direct outputs for LCH and RHILC were:

- A dataset of 101 residents who responded to the Home Energy Survey which contained information about their interest in flexibility options, and
- Increased number of residents who are interested in being contacted about local energy issues, as 78 of the 101 respondents opted in to being contacted by LCH and RHILC in the future.

“ [the household survey] did tell us some interesting things ... a good proportion of respondents were interested in finding out more about time of use tariffs ... and I wouldn’t have guessed that ... I think it could be really helpful” [SU2]

However, there was disappointment when expectations for other forms of engagement and the usability of the data arising from the household energy survey for baselining and planning the zero-carbon road map were not met. Some stakeholder users questioned what value LEMAP added beyond what *“a survey [designed and rolled out by them] could have done as well”* [SU4]. However, it was acknowledged that data from the survey and wider LEMAP interpretation would be used by other actors to support RHILC’s aims and so be *“useful to us in a second-hand capacity”* [SU5].

Data interpretation and concerns about assumptions

The majority of stakeholder users experienced challenges when trying to use and interpret the data from LEMAP for their purposes. These challenges revolved around two main issues:

1. Using the data to create a baseline for the Rose Hill roadmap, and
2. Concern about the assumptions contained within LEMAP.

The developer used the data arising from LEMAP to produce a baseline report for Rose Hill, as documented in the *“Spatial analysis of Smart and fair neighbourhood in Oxfordshire”* (Gupta et al, 2022). This report provides an overview of the data layers within LEMAP, along with a detailed baseline of Rose Hill’s technical and social capacity for installing solar PV, heat pumps and EV chargers.

SU1 reflected that they could extract *“useful contextual information and analysis”* from LEMAP, such as the number of houses, level of insulation, numbers of electric vehicles, heat pumps and solar photovoltaic. However, these outputs did not meet their expectations of *“trying to understand how to interpret the Zero Carbon Oxford Partnership Action Plan targets locally... In terms of creating a road map [shakes head] it doesn’t do that at all”* [SU1]. Part of this was due to the needs for milestones and scenarios for the Rose Hill roadmap not aligning with the data contained within LEMAP.

Other stakeholders found it difficult to interpret the data in LEMAP, while acknowledging that the LEMAP developer would be able to use the data to design projects such as CHS because *“[they] are academics. They can understand the survey”* [SU5].

From the developer’s perspective, the crowdsourced data from the energy survey was important in checking the assumptions within LEMAP because *“doing crowdsourcing makes it more updated”*. Receiving updated local intelligence about aspects of the Rose Hill energy system was also useful:

“ We could see that some homes already had heat pumps and we had no idea that they did ... some of them who had heat pumps also showed interest in time of use tariffs which we had no idea about ... So unless and until you do that [crowdsourcing via the survey], you don’t get that local data interpretation” [D1].

The developer reflected that LEMAP already provided the baselining capability, and the household energy survey data was used to check the assumptions and data within LEMAP. He also said that he was *“not sure where it came about that the survey could be used to establish the baseline”* [D2], which indicates that communication and expectations between the developer and stakeholder users could have been improved.

Stakeholder users had raised concerns both about how some assumptions contained in the LEMAP model had been applied and the models informing the capability analysis. Some stakeholder users felt that their concerns regarding assumptions had not been sufficiently addressed, which made it difficult for them to have confidence in the data arising from LEMAP. While LEMAP shows the sources of datasets used, the feedback from stakeholder users is that more transparency and clarity about the source and application of the assumptions would be useful, as illustrated by one stakeholder user:

“ We need to have that robust understanding of how has this been calculated, what are the assumptions that have been made and do they feel logical to us?” [SU1].

5.4 Outcomes of LEMAP trial for technology developers

Two successful outcomes are connected to technology developers, and relate to:

1. The role LEMAP has played in making aspects of the energy infrastructure visible, and
2. Providing the feasibility study for heat pump installation as part of phase one of the CHS project.

Visibility of distribution infrastructure

LEMAP has been the *missing link* between visualising technology deployment potential and substation capacity. It has enabled innovations in data visibility and connectivity which have supported technology planning for SLES. This was driven by the need of technology users to explore technical distribution capacity to plan for the CHS project and required the DSO to share their data on secondary substations. TU1 reflected that:

“ It’s both made things visible in the way that they weren’t before, and it’s also joined things together ... various layers of LEMAP that are now in the one space effectively in this tool ... some elements ... have been brought into focus ... that weren’t given the same focus before It’s highlighted areas of information that people didn’t know about or know how to get to it” [TU1]

This successful outcome underpins effective planning for SLES. It has led directly to identifying and planning infrastructure developments through being able to identify and potentially address distribution bottlenecks and grid constraints. It has also led to the DSO installing monitoring equipment in some secondary substations, so that if heat pumps are installed the grid capacity can be monitored in those substation areas. This data source will also be connected to LEMAP.

Identifying and planning energy infrastructure development

Building on the ability to identify distribution bottlenecks and potential, LEMAP has played a pivotal role in identifying suitable areas and pathways for heat pump deployment by developing a plan for the high-density deployment of heat pumps in Rose Hill. It has now been awarded funding to implement this plan (Oxford Brookes University, 2023), which together comprise phases 1 and 2 of the Samsung-led CHS Project, one of the Department of Business, Energy & Industrial Strategy’s (BEIS) heat pump-ready projects (DESNZ, 2023).

The CHS project manager reflected that:

“ By working with LEMAP, we’ve looked at the whole area of Rose Hill and Iffley and they’ve been able to map based not only on suitability, but also socioeconomic aspects of the neighbourhoods, to then come up with a ranking of which neighbourhood to target in terms of likelihood to take up the offer of the heat pump” [TU2].

The LEMAP developer reflected on the critical importance of DSO data in LEMAP to enable planning by visualising which secondary substation areas are linked to different houses:

“ Without having [DSO] involved and without having ... this kind of platform to talk with, I don’t think it [CHS Phase 1] could have happened ... because people want to visualise, right? They wanted to see what tenure it is and what LEMAP ... offered ... was, how many were social housing dwellings, how many were private rent and owner occupiers because BEIS wanted to see 25% of homes within a secondary substation area to have heat pumps” [D1].

The CHS project manager also reflected that a key part of high-density heat pump planning and deployment is “*having good links with the community*”, indicating a need for involvement of intermediaries alongside technologies such as LEMAP.

Business model development

Another successful outcome for technology developers is to use LEMAP for business model development, as it contains the capability to assess a resident’s likelihood to take up low carbon technologies. The CHS project manager pointed out that targeting suitable areas and properties for heat pump deployment can reduce marketing costs, thus LEMAP could be used as a marketing tool:

“ If you can use a map that says OK in this area you’ve got – even if it’s just a 10% higher chance of someone taking up the offer – then that saves you a lot of money in marketing costs” [TU2].

While LEMAP can be used as a marketing tool to cut costs by identifying *low hanging fruit* for heat pump deployment, it could also be used to identify and prioritise households who experience – or are likely to experience – energy system vulnerabilities in relation to the transition to net-zero and target specific offers or grants to them.

5.5 Outcomes for resident householders

The engagement element of LEMAP data was achieved through collection of household data via the online Rose Hill Energy Survey conducted in March-April 2022. The survey was advertised to householders via RHILC and SFN in March 2022, and was framed to:

“ Help the Low Carbon Hub to understand Rose Hill’s energy needs and could enable us to bid for renewable energy grants which we can use to help our community! It can also help you understand more about energy use in your home” (Project LEO, 2022a).

Each resident who completed a survey received a household report generated from their responses. It contained information about energy usage through modelled data comparisons to UK average household energy consumption in the area, as well as some decarbonising options. An example report is shown in Appendix 2. However, only half the interviewees and survey recipients received and/or read their feedback report.

Seventeen resident questionnaire respondents said that the energy survey was ‘easy’ to complete, and three said that ‘parts were easy, some parts were not’. Of the eleven respondents who received and read the resulting energy report, most understood all or most of it, with eight of those finding it useful in understanding home energy usage.

The process of completing the survey helped them develop curiosity and awareness about their energy consumption. Most other responses from the questionnaire were positive, with one respondent saying that the survey:

“ Was very straight forward. The details of our house seemed to be mostly known and accurate already” [PID 18].

However, some resident interviewees offered suggestions for making the survey more applicable to tenants.

Questionnaire respondents and interviewees found the household energy report helped them to identify some actionable next steps, although some decarbonising options were not included in the report. Fewer found it useful for understanding how energy (electricity, heat and for transport) is used in Rose Hill, primarily because the feedback focused mainly on domestic energy at the household level. However, it was apparent that energy activities such as involvement in the Solar Savers trial had a greater impact on some residents than participating in the home energy survey.

No resident mentioned that they were stimulated to participate in local energy management. This indicates that while information about time of use tariffs was included in the household energy report, more explanation and interpretation may be required to encourage participation in local energy management.

While these are good outcomes, they indicate the need for further refinement to engage a range of residents with decarbonising options, and to visualise the potential for decarbonising and flexibility at a community scale.

Note: the interviewees and questionnaire respondents were a small sample of those who completed Rose Hill Energy survey, and did not reflect the wider demographics of Rose Hill. The interviewees had higher educational qualifications compared to the average resident in Rose Hill, and the majority of respondents identified as white British compared to 58% of the Rose Hill population. In addition, they had high levels of concern and understanding about energy.

6. Evaluation of trial process

To complement the evaluation of the outcomes, this section presents the findings from evaluating the process of the LEMAP trial.

6.1 Introduction, training and feedback on household energy survey

Introduction and training sessions were provided to stakeholder users by the developer's team between Nov 2021 and Feb 2022. The sessions were delivered online due to Covid restrictions. The LEMAP developer considered that this reduced the interactive nature of the training, and limited the degree to which queries could be raised and responded to.

Following these sessions, stakeholder users (Oxford City Council, LCH, RHILC) provided extensive feedback on: the overall aesthetics and useability of LEMAP; the scope and design of the resident engagement elements of LEMAP (energy survey and household report); and the resulting data that could contribute to the roadmap.

Feedback provided about the residents' household energy survey focused on making the language and energy information clearer and more accessible.

“ It was very academic, and it took quite a lot of work to go through and make suggestions about where language could be changed” [SU3].

Contrary to their expectations, stakeholder users felt that they did not see a level of response to their feedback that acknowledged the time invested and expertise they brought to it. Some feedback required repetitive meetings with the developers, as one stakeholder reflected that *“We felt a bit like we were pushing against a wall”* [SU2]. Furthermore, the reasoning behind why some parts of feedback had not been taken on board was not always explained, which led to stakeholder users feeling frustrated, as SU4 reflected:

“There was disappointment that the group spent a huge amount of time suggesting ways that some of the language and ... ways that things were presented could be really simplified to make things easier for people, and not all of those were taken on board. I think there was frustration that quite a lot of that didn't happen, when volunteers had put in quite a lot of time... it may have been that there were good reasons, but that wasn't communicated back” [SU4].

6.2 Data collection of the household energy survey

The engagement element of collection of residential household data through the Rose Hill energy survey was initiated and actioned by LCH, RHILC and Oxford City Council. This required time and human resources for communication, engagement opportunities and outreach, some of which was funded through Project LEO, some given voluntarily. To achieve a broad reach of residents, a variety of organisations, events, activities, and networks were attended or approached.⁸

Financial incentives for survey completion were provided by the LCH, and consisted of either a £10 donation to a local project or a £10 voucher for personal use in a local grocery shop, which totalled around £1,000. The survey response rate was 101 individual responses. Stakeholder users considered that the financial incentives were an important component that enabled them to gather responses from a broader diversity of residents than those involved in RHILC, and that the option of donating to the Junior Youth Club widened the survey publicity. Stakeholder users did not consider that Covid-19 and lockdowns negatively impacted the household energy survey roll-out and data collection.

Tensions of mapping vs privacy

Difficulties were encountered in encouraging some sectors of residents to complete the household energy survey. For example, one stakeholder user reflected that she experienced resistance to completing the survey from members of a minority ethnic group. Some of this she attributed to it not being a priority for group members, and some to concerns about data security. Other stakeholder users also reflected concerns and tensions about the data security implications of any mapping tools that make visible the amount of publicly available data held about people's homes.

6.3 Energy engagement with residents

It became apparent that the LEMAP developer and the stakeholder users began with different assumptions about the type of resident engagement and feedback.

The household energy survey and report were designed as part of the engagement elements of LEMAP. The developer defined their purpose as:

“ Not for householders to understand energies, it's more for community groups to engage with them and then offer this as an outcome of ... that engagement”, and “this is not a feedback tool” [D1].

The intention was to enable householders to:

“ See how [their] home performs in the neighbourhood ... to see whether you're a red or a yellow against the postcodes that you have. And then you can see what decarbonising options you can have, and potentially how it might change your demand profile” [D1].

Different understandings and expectations of engagement were evident, as a stakeholder user commented that:

“ The original plan was that they [RHILC] wanted to use it as an engagement tool ... [but] it's not where I would have started from if I was building a survey that went out to homeowners and regular people who didn't have any background in energy” [SU3].

⁸ These included the Junior Youth Club, Food Bank, Repair café and Rose Hill Community Centre.

They continued by wondering how the survey could best support engagement:

“ We can always think of better ways of engaging people to bring them along on the journey. And a survey can be part of that, so I just want to rethink where that was best placed to go” [SU3].

Stakeholder users had hoped that householders would be able to “*learn about their homes and what they could do*” (as suggested by the phrase *participatory mapping* in the LEMAP descriptions) but reflected that was “*maybe going a step beyond what was ever expected*” [SU2]. However, concerns about accessibility and availability of funding for low carbon technologies meant that some of the potential decarbonising options were removed from the household report at the request of the low carbon community group.

This form of engagement was against a background of RHILC finding it challenging to attract a wider range of local residents to talks and events about home energy. The household energy survey and report provided a way to engage a broader range of residents, and a form of individual scale feedback. While the majority of residents found the survey and report useful, one stakeholder user considered that the engagement elements were “*less accessible to the general public than planned*” [SU5].

The different meanings and expectations attached to engagement, feedback and participation by the developer and the stakeholder users highlights the importance of articulating and clarifying the intentions, meanings, and assumptions of these terms throughout the project.

6.4 Value of LEMAP trial process for stakeholder users

Tensions were evident between the LEMAP trial process, and the need for specific outcomes by the stakeholder users. Despite the training and user manuals, stakeholder users did not feel equipped to directly interpret and understand the data in LEMAP. This could have been due to the limitations of training caused by Covid and so could have been mitigated to some degree. However, other stakeholder users considered that ongoing support would be beneficial if they were to use LEMAP in the future.

The tensions of balancing the need for outcomes and participatory trialling were apparent. The LEMAP developer reflected that “*I opened the whole thing [LEMAP] and I said ‘use it’ because I just wanted to see what happens*” [D1]. As a research and trial project this could have enabled co-production if stakeholders have the requisite time resource and interpretation expertise. This did not seem to be the case from a stakeholder perspective:

“ The biggest difficulty ... is at the end ... it was so ‘here it is’. And it’s like, ‘here what is?’ What’s it telling us? ... So I think there was a real – if it was to be done in the future – focus on helping a group to interpret and understand what the data was telling them, was a really key missing piece; and ‘It was literally a meeting where ... it was ‘well it’s over to you, there you go’ [shrugs]. So maybe it felt as being inclusive and liberating, but actually it was then very hard to move forward with any of it” [SU4].

While LEMAP can provide answers to specific questions, the point made by stakeholder users is that more training and ongoing support would have enabled them to use LEMAP more confidently, and draw on the richness of data to plan interventions.

The process of trialling LEMAP, feeding back suggestions, and sourcing the household data required an investment of time and finances from the stakeholder users, who felt the outcomes received fell short of their expectations and were disproportionate to the time and resources they had invested. This highlights the importance of clear and ongoing communication and feedback between stakeholders as part of a SLES trial, and the potential impacts arising from trialling the tool during Covid restrictions.

Conclusions and recommendations on the evaluation of the trial process

Learnings arising from the evaluation of the trial process highlight that for stakeholders the value of the outcomes received differed from their expectations and were disproportionate to their inputs of time involved in feedback and engagement.

The evaluation has revealed some blocks in communication concerning:

- 1) Process of trial feedback, and insufficient explanation of why stakeholder feedback was incorporated or not;
- 2) Differing understandings, assumptions and meanings of terms such as engagement and participation, as the engagement elements did not fully meet the stakeholder users' needs for engagement.

The evaluation has also revealed a need for more specific or ongoing training and support for stakeholder users to be able to directly use LEMAP, and clearer and more accessible explanation of how the assumptions within LEMAP have been applied.

While the development and trialling of LEMAP enabled a certain amount of co-production, this evaluation has demonstrated some of the ingredients that have hindered co-production, which include:

- Lack of clarity – and therefore a need for clarity and expectation management – concerning the technical expertise needed to directly use LEMAP to plan SLES and to target interventions; and
- The impacts of training and trialling tools during Covid restrictions.

Increasing the co-production of SLES tools requires:

- The degree of agency envisaged for different stakeholders to be explored with them prior to and during tool development;
- The multiple assumptions and meanings of the engagement aspects of tools to be explored and clarified according to roles, purpose and competencies of different stakeholders; and
- The technical expertise required to use tools to be accessibly communicated, so that different stakeholders can enact their agency.

7. Evaluation of LEMAP hypothesis and intended users

The hypothesis and the intended users of LEMAP changed during the project to focus the intended users more on energy planners and community stakeholders and less on direct household level engagement. This section presents the changes in hypothesis, the evaluation of the hypothesis, and the changing definitions of users during the project.

7.1 Changes in hypothesis

Box 3 shows the hypothesis from the original application and the updated hypothesis. The initial hypothesis, developed in a short timescale pre-Covid in 2018, focused on developing “a range of tools to test ... how do you enhance user engagement in smart local energy initiatives?” [D1]. The updated hypothesis was developed by the researcher at the beginning of the evaluation process in Autumn 2022; informed by LEMAP reports, presentations and written materials and an initial scoping conversation with the developer.

Box 3: Changing LEMAP hypothesis

Original hypothesis, from Case for support, August 2018.

“User engagement and acceptance of smart local energy systems can be radically enhanced by deploying a suite of smart and inclusive tools, accompanied by basic training, that actively communicate local interactions between power, heat and transport, and stimulate user participation in local energy management”.

Updated hypothesis, developed from LEMAP reports, presentation and written materials and initial scoping conversation with the developer and tested during evaluation, 2022.

“Socially interactive, inclusive and place-based tools could help to engage a range of different user groups with smart local energy systems; help community stakeholders engage with householders, design appropriate offerings and plan smart local energy initiatives, help energy developers plan smart local energy interventions and **help householders to understand their energy usage and decarbonising potential**”.

The researcher suggested including “to help householders to understand their energy usage and decarbonising potential” (in red) in the updated hypothesis. This was removed from the updated hypothesis by the developer. However, if LEMAP is to help “community stakeholders engage with householders”, then householders need to be able to understand the feedback they receive from LEMAP, thus this text was also tested in interviews.

Between 2019 and 2022 the hypothesis reduced the focus on two-way direct engagement between LEMAP and residents, for the reasons given in Section 2.2, and placed more emphasis on the technical planning elements. The resident engagement with LEMAP was through the household energy survey, delivered by stakeholder users, and resulting report (in English), trialled in Spring 2022. This minimised the need for LEMAP itself to be multi-lingual for primary users, as the user interface and instructions were designed for English-speaking stakeholder users.

7.2 Evaluation of hypothesis

Interviewees were asked to reflect if the revised hypothesis rang true or not, and to give examples where possible.

Two stakeholder users queried whether LEMAP was trying to do too much with the breadth of uses and intended direct users, for example: “[the] hypothesis really contains a lot of different things ... does that try and do too much?” [SU1].

The hypothesis evaluation is summarised below. Full quotes are in Appendix 1 (Table 4).

- **Socially interactive:** The degree of social interactivity was questioned, with one stakeholder user suggesting that the phrase ‘two-way’ created confusion. Other engagement elements such as the ‘storymap’ and ‘forum’ were not used by stakeholder users or residents.
- **Inclusive:** Stakeholder users considered that their direct engagement activities and provision of incentives contributed to increased inclusivity for residents, and that digital security implications of precise online mapping may have excluded participation from residents who were concerned about data security. Given that stakeholder users did not feel they had the expertise to use LEMAP directly for planning interventions, it did not seem inclusive to them without further training and support. This also limited their potential to use LEMAP as an engagement tool with residents.

“ People actually going out into the community and giving people opportunities to participate made it more inclusive” [SU4]
- **Place-based:** stakeholder users did not comment on the place-based aspects of data collection and mapping, although one resident interviewee found they had an increased knowledge of the energy usage in their neighbourhood.
- **Help community stakeholders engage with householders, design appropriate offerings and plan smart local energy initiatives:** Stakeholder users considered that the household energy survey provided an opportunity to engage with householders, but could be further developed to:
 - » consider the range of ways that LEMAP could support community engagement, and
 - » empower community stakeholders to confidently use LEMAP for engagement.

While stakeholder users do have more data on some residents – such as their interest in time of use tariffs – they did not consider that LEMAP helped them directly to design offerings or plan SLES interventions due to difficulties they had with interpreting the data within LEMAP. Stakeholder users appreciated that planning and designing interventions is being done by those with expertise to use LEMAP, and that benefits would accrue to residents.

- **Help energy developers *design appropriate offerings, plan smart local energy interventions***: this part of the hypothesis was successful for the technology developers (DSO and CHS), but required the expertise of the LEMAP developer to interpret the datasets.
- **Helping householders *understand their energy use and decarbonising potential***: The household survey data suggests that it helped those householders to understand their energy use and has contributed to them understanding their decarbonising potential.

7.3 Changing definitions of users

Users, the range of users, and forms of engagement was loosely defined in the original hypothesis and documentation. As shown in Table 2, descriptions of users in the earlier LEMAP literature implied more direct resident interaction with tools, particularly regarding the *acceptance* of SLES.

Following the LEMAP trial, particularly concerning the level of technical expertise required for data interpretation, the developer further refined the definition of LEMAP users to those with technical expertise with mapping and geographic information systems (GIS) such as energy officers and planners: "*It's a tool for intermediaries ... it needs some specialist interpretation and input*" [D] (from the initial scoping interview, 14 Oct 2022). The distinction between the *technical* and *engagement* users is present in the LEMAP specification, although the relationship between them is not clarified.

Table 3 outlines the changing definitions of users from different sources, and the implications for the changing purpose of LEMAP.

Table 3: Summary of changes to the framings of tool users over time.		
Source and timing	Framing of intended tool users	Assumptions about tool users / implications for change in purpose
Research proposal Case for support (2018).	<p><i>"Developing two-way engagement between users and smart local energy systems"</i></p> <p><i>"Enabling demand response and promoting more efficient and effective use of resources"</i></p> <p>Identifies relevant <i>users</i> as local intermediaries, direct energy users, owners of distributed energy technologies and EVs:</p> <p><i>"To explore how different people actually use the tools to engage with local energy management"</i>.</p>	<p>Broad definition of tool users, including intermediaries and residential users.</p> <p>Emphasises two-way engagement, demand response and energy management.</p>
User Influence tools EnergyRev Project review presentation (Gupta, 2020) (25 September 2020 v2)	<p>3. <i>"socially interactive, inclusive and place based ... two-way engagement between users and smart local energy systems"</i></p> <p>7. <i>"enhance engagement with project stakeholders and local energy users ... enhance engagement of users with SLES which is necessary for scalability/replicability"</i></p>	<p>Broad definition of users, including intermediaries and residential users.</p> <p>Two way and interactive engagement emphasised.</p>
Project LEO website (Project Leo, n.d.)	<i>"The LEMAP tool has been designed for community based organisations, local authorities and residents"</i>	Broad definition of users, including intermediaries and residential users
User Influence tools, EnergyRev website (Local Area Energy Mapping Tool, 2023)	<i>"User participation in smart local energy systems is essential for their long-term success. However, the majority of energy users rarely engage in the energy markets. ... communication mechanisms ... will help them to manage, directly, or through delegation, their consumption, production and storage of energy. In this way they will contribute to network and grid balancing at the same time as gaining value for themselves and their communities"</i>	<p>Broad definition of users, including intermediaries and residential users.</p> <p>Engagement is connected to managing consumption and production of energy.</p>
LEMAP specification 2021 (see section 2.3) (Luddecke, 2021)	<i>"A 'Local Energy Mapping' (LEMAP) tool with some elements for more expert users and others for the community, road tested with both types of users"</i>	Broad definition of users, including expert and <i>the community</i>

Source and timing	Framing of intended tool users	Assumptions about tool users / implications for change in purpose
<p>LEMAP, a tool for smart local area energy systems (Jimenez-Moreno, 2022). 22 March 2022</p>	<p><i>"LEMAP stands for Local Area Energy Mapping. It allows residents and operators to visualise energy flows in their local area"</i></p>	<p>Broad definition of users, including expert and residents</p>
<p>Background scoping interview with LEMAP developer on 14 October 2022</p>	<p>During interview, the LEMAP developer said that main intended users are energy officers and planners, that LEMAP was a planning tool, and not designed to be used by residents.</p>	<p>More specific users defined as energy planners, not residential interface.</p>
<p>Email from LEMAP developer received 14 December 2022</p>	<p>LEMAP was designed <i>"to help Community energy developers and local authorities plan for the smart energy initiatives"</i>, to create <i>"spatially mapped capability analysis at a dwelling level"</i> to enable intermediaries to plan a fair energy transition in Rose Hill, and to <i>"help community stakeholders engage with householders"</i> through the resident surveys.</p> <p><i>"The original scope was that the technical elements will be used to undertake local area energy mapping in Rose Hill. This was done by us and published (Project LEO, 2022) since the technical elements require technical expertise. The engagement elements were to be used by LCH, Rose Hill Community Group and Oxford City Council to undertake LEMAP surveys to gather local data from householders. This is what happened."</i></p>	<p>More specific on community energy developers, although does not define such developers or the level of technical expertise required.</p> <p>Technical expertise located within OBU.</p> <p>Stakeholder users play engagement roles through data gathering, not interpreters of the arising data unless they have technical expertise.</p> <p>Engagement elements mainly one-way: to gather local data from householders for use by the Tool.</p>
<p>LEMAP (LEMAP, 2023) (undated, accessed March 2023).</p>	<p><i>"LEMAP is an online and interactive local area energy mapping tool for planning smart energy neighbourhoods in Oxfordshire, UK.</i></p> <p><i>The technical elements present detailed maps showing current and forecasted energy flows in the area. These elements are designed for social enterprises, local authorities and members of the Low Carbon HUB.</i></p> <p><i>The engagement elements present interactive tools to understand your energy flows, including a home energy profile generator. These elements are designed for community groups and residents"</i></p>	<p>Users and their expected interactions with LEMAP are more defined, and clear distinction between technical elements for planning, and engagement elements.</p>

Implications of the changing definitions of users

The gap between the expectations and experience of the engagement elements was apparent from the interviews with stakeholder users, who expected the engagement elements to be more two-way or participatory and interactive for residents, or for stakeholder users to use with residents. For example:

“ We hoped that it would enable people to access the LEMAP website and see, understand the energy performance of their house and I think in that respect perhaps my expectations were unrealistic” [SU5].

Another stakeholder user mentioned that residential users had been included in earlier understandings of LEMAP:

“ It comes across as a bit of a mixed message ... as to who this actually is for... this was never for individuals. But ... that is how it has come across in the past” [SU1].

These expectations – held across all stakeholder users – did not seem unrealistic given the specification shown in Box 2, and from the various descriptions of users on associated LEMAP documentation, shown in Table 2 across years 2018-2022. Clearly, there have been different understandings and working assumptions of *users* and engagement, and what elements of LEMAP stakeholder users will use and engage with.

Initially, stakeholder users expected that LEMAP would be a tool that they used directly for data gathering, interpretation, creation of a roadmap and for resident engagement. The reflection from the developer regarding the need for specialist interpretation and GIS training *following* the Rose Hill trial reinforces these initial expectations:

“ One of the things that has changed over the last few years is that I do believe it needs some specialist interpretation and input. I don't think you could give this tool out to everybody to use it because they would probably not be able to use it because of its technical functionality” [D1].

Stakeholder users mentioned that they lacked sufficient understanding or technical expertise so did not feel *expert enough* to use it – or to provide a sufficient evaluation – despite training. This is illustrated by the following example:

“ We appreciate that we're non experts... I certainly appreciate that a bunch of it might be down to gaps in my own understanding. But if the plan is for people like us to be able to use it and to be able to trust it then that's relevant” [SU2]

If LEMAP is to be used directly by a range of stakeholder users, it needs tailoring to the needs and competencies of specific user roles, with clarity about the users, and what LEMAP will enable them to do. One stakeholder user reflected that at present, LEMAP:

“ Sits uncomfortably in between an academic tool and something usable. It's just not quite there yet ... I'm not sure quite who in a local authority is going to use this tool, which is such a shame” [SU1].

Summary of evaluation of hypothesis and users

It is evident that there were blocks in communication about the changes and implications of the changes to hypothesis, specification and users, and that there is a need for clarity when using terms such as engagement (and one-way/two-way engagement), and users.

While LEMAP has been developed to combine technical and engagement elements, the emphasis on who uses the tool for what purpose has changed from inception until the end of the trial. The main change is that LEMAP puts less emphasis on being a user engagement tool, and more emphasis on being an energy planning tool for those with sufficient technical expertise. This change has reduced the range of roles played by stakeholder users such as community groups and intermediaries.

This has implications for the agency of different users. If a range of stakeholder users are to use LEMAP to engage with residents, then they need to be able to use and understand the tool and have confidence that the household level data and feedback is accessible *to both them* and a range of *resident householders*. At present this is not the case without further training for stakeholder users. This can limit the engagement potential of the tool, for example to enable residents to learn about home and community energy, become active participants and to broaden the social mandate for energy transitions.

This suggests that there is a need for:

- a. Clarity and consistency in the expected uses, users and competencies and skills required to use LEMAP in different ways, and further interrogation of the relationship between the technical and engagement elements;
- b. Clarity about the assumptions, purpose, means and expectations of different forms of engagement;

It also suggests that either the interpretation and accessibility of LEMAP could be tailored to enable LEMAP to be used by a wider range of stakeholders, or that a different model of working with community stakeholders needs to be considered.

8. Discussion and suggestions for improvement

This evaluation has demonstrated the successful outcomes from the LEMAP trial for planning and development of SLES, and those that contributed to SLES engagement in the community. For stakeholder users, the LEMAP trial did not deliver some of the outcomes of engagement and capacity to plan SLES and technical and social interventions to the degree that they had expected.

Learnings, insights and suggestions for improvement are to be expected since this evaluation focused on the outcomes and the process of the trial. The LEMAP training occurred online as a result of Covid restrictions, which affected the depth of training, and the whole process revealed a need for closer attention to the processes of collaboration between different actors.

8.1 Agency for stakeholder users to plan SLES

Technical expertise is required for interpreting LEMAP and planning SLES, and there is a need for clarity regarding what technical expertise is required to use the technical and engagement elements of LEMAP.

LEMAP has delivered successful outcomes to model and develop strategies to identify pathways for heat pump deployment. This has been dependent on the expertise and confidence in using, analysing and interpreting the LEMAP datasets, which resided with the developer's team during the trial, and more recently with Bioregional as part of Project LEO.

While some stakeholder users were content to leave the data interpretation to other organisations, others wanted to directly use LEMAP themselves to plan energy interventions and create roadmaps and reports. Without further training or support in using LEMAP, stakeholder users did not consider that LEMAP increased their agency to directly plan interventions and SLES. This highlights a tension of agency regarding planning SLES and raises a question about where agency for planning SLES could or should be located.

A stakeholder user reflects on agency and the need for accessible interpretation:

“ It highlighted that really, for a tool to be useful to the community, they need to be able to use it ... if it's going to be owned by the community, either the community has to have somebody in it that has got the specialisms to be able to interpret and put everything together for other people and translate it in a way that they understand and that is embedded in the community so it is still community owned. I.e., you can't bring that person in from outside and do it for them because then they lose their agency. Or that tool has got to be sufficiently simple and straightforward and provide an output that can be used by the community so that they can input their inputs and it gives them an output. And unfortunately, Rose Hill had neither of those things. It neither had a tool that gave them an output that they could take away and use ... [and] it didn't really seem that we had anyone who could actually understand that data and put it together to form a roadmap, except possibly [the developer]. But that wasn't what he was setting out to do” [SU1].

Implications for process of planning SLES and engagement

If LEMAP's ambition is to enable a broader range of stakeholders to be involved in SLES planning and development and to have the ability to target technical and social interventions, further consideration of the models of stakeholder interaction with LEMAP is required. This undertaking needs to consider the role, agency and technical capabilities of different stakeholders, and the degree of co-creation or tailoring needed for different stakeholder users.

If stakeholder users are to directly use LEMAP for engagement beyond residential data collection, there is a need to explore what forms of engagement are desired and the relationship between the technical and engagement elements of LEMAP. Furthermore, some tailoring to specific roles could be considered, which is detailed below.

Suggestion: more clearly target LEMAP at different users

If LEMAP is to be used directly by a range of stakeholder users, it needs to be tailored to the needs and competencies of specific user roles. It also needs clarity about who the specific users are and what LEMAP will enable them to do.

One suggestion was for tailoring to better support planning roles within local authorities. Improvements to enable greater functionality could involve:

1. Being able to overlay and compare maps, and
2. Adding datasets specific to roles, such as heritage zones for planning.

The facility to upload/download data in a compatible format has since been added to LEMAP. However, tailoring and adding the ability to upload and interact with data and combine datasets could potentially increase the technical complexity for the user. Additionally, aligning the mapping elements of different layers would require further work by the developer. It may also lead to a need for a range of data security consents and GDPR.

8.2 Engagement elements

More consideration is required concerning how LEMAP can be used for engagement purposes, the competencies and skills needed to do so, and the relationships between the engagement and technical elements of LEMAP. More clarity is required concerning the aims, assumptions, models and means of engagement and participation embedded within tools such as LEMAP, what this means for different users and purposes, and how community stakeholders can best access and use the data within LEMAP.

Suggestion: more clearly identify the varied engagement needs of different types of users

Given the difficulties reported by RHILC in attracting residents to meetings and events about energy, it would be useful to identify the engagement needs of a community stakeholder – and the perceived engagement needs of the wider community – then explore how a tool such as LEMAP could be used to engage people in different and complementary ways. For example, this might include aiding deliberation and engagement concerning SLES plans and local roadmaps to net-zero.

Resident energy survey

The engagement that happens alongside a resident energy survey has implications for how useful a survey – and community data crowdsourcing – can be as an engagement tool.

Suggestion: improve accessibility of language for survey and household report

Surveys could most effectively be used alongside other forms of engagement, and/or integrated into ongoing engagement plans where there are specific funding or grant opportunities. The language of the survey, and the resulting household report, could be further improved to aid accessibility.

Digital inclusivity

Online mapping has the potential to exclude participation from residents who distrust giving identifiable data to third parties. This can reinforce existing patterns of inclusion/exclusion from local energy projects and SLES. It also highlights the need for awareness of the ways in which digital security and literacy intersect with existing patterns of marginalisation; some sectors may not participate in online energy surveys with mapping or household identification components for fear the data security will be breached, or that their information may be used for other purposes. These are important considerations for future planning of LEMAP and other online energy mapping tools.

Suggestion: explore different forms of mapping which address data and inclusivity concerns

If LEMAP is to be used to ensure fairness and justice in the transition to net-zero, the tension between accurate participatory mapping and inclusion will need to be explored through different formats (e.g., online/paper survey) and differing consents for how data will be shared and used (e.g., at postcode level, or for community stakeholders to communicate with residents).

8.3 Trial process

Stakeholders were clearly disappointed that some of the feedback they provided was either not incorporated, or the reasons for not incorporating were not provided. This resulted in the inference that the feedback was not valued.

Suggestion: increasing transparency and accountability for trials of tools

This could have been improved with:

1. Avoiding wasting community stakeholders' time by asking them to repeat suggestions that had already been made, and
2. More transparency about the reasons for some feedback being incorporated and some not. If this had been provided, then the feedback could have been a learning journey for both the developer and the stakeholder users.

This highlights the need for attending to the process of smart technology trials and collaborations across different stakeholder groups, and the need for an accountable feedback process.

8.4 Place

The transition to net-zero through SLES happens in place: in this instance in Rose Hill, Oxford. Associations with Rose Hill were mainly positive for residents, some of which has been enhanced by participating in some energy trials such as the Solar Savers trial. The household energy survey respondents learnt more about their individual property than their locality.

Suggestion: consider how to represent local energy systems in resident feedback

Given the technical capabilities of LEMAP, there is potential for the engagement elements to more strongly portray how changes in the local level energy system could contribute to net-zero and link individual residences to community and place.

8.5 Process of grant proposal and trial

The short timescale to write the proposal for this project limited the possibilities for co-production. Co-producing tools to support technological transformations and SLES presents an opportunity to involve local actors (e.g. intermediaries such as social enterprises, local authorities and community energy and sustainability groups, wider communities of interest) and residents. Such co-production is important to contextualise the technical, engagement and wider uses of tools.

This evaluation has demonstrated some of the ingredients that have hindered co-production, including mismatched expectations and the need for expectation management for different users and clarity concerning the skills and technical expertise required for trialling and using a complex tool.

Suggestions: explore key terms with stakeholders, and attend to processes that support collaboration and co-production

Co-producing tools requires the degree of agency envisaged or desired to be explored with relevant actors and the engagement and technical aspects clarified.

Projects involving a range of local actors with differing degrees of power, knowledge, technical expertise and time, will inevitably encounter challenges, whether external (e.g. Covid or internal (e.g. intra-group communication), which can alter activities. This trial has revealed the importance of attention to processes of collaboration, such as regular communication and updates on changes, and a cultural mechanism for dealing with conflicts and differences in perspective/negative impacts of projects which can acknowledge the power dynamics.

8.6 Evaluation methodology

This evaluation and the interviews with stakeholder users and residents occurred several months after the LEMAP trial was completed.

For the resident evaluation, the context of different energy projects occurring in Rose Hill meant that household interviewees had received information about energy from different sources during the LEMAP trial. Participants in the Solar Savers trial will have received home energy information from the LCH and Oxford City Council and were asked to complete surveys and questionnaires more recently than the LEMAP-related Rose Hill energy survey. Asking for reflections on a home energy survey completed over 6 months previously meant that resident responses were sometimes not sure where their survey requests, or energy information, had originated (e.g. LEMAP survey, LEO, RHILC newsletter). In addition, around half the resident respondents did not receive or access their energy survey feedback from LEMAP so were unable to offer comments or reflections on it.

Suggestion: conduct evaluation closer to trial completion if possible.

Appendices

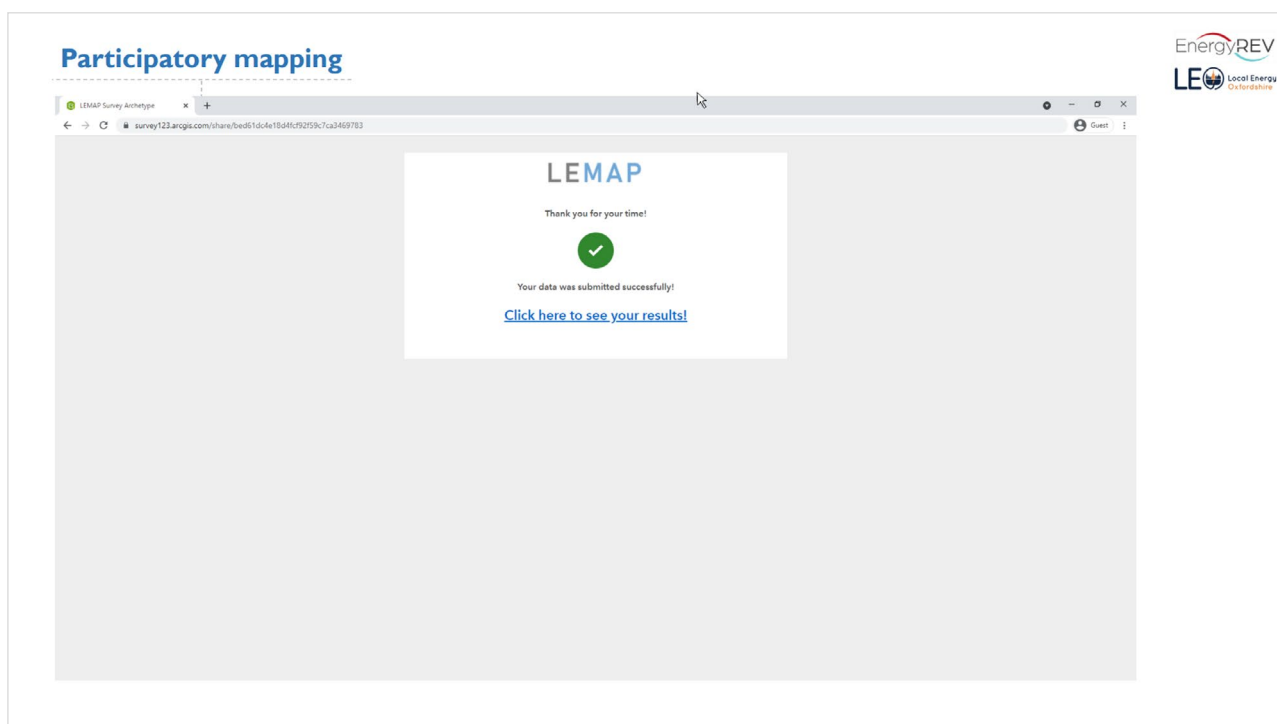
Appendix 1: Evaluation of hypothesis

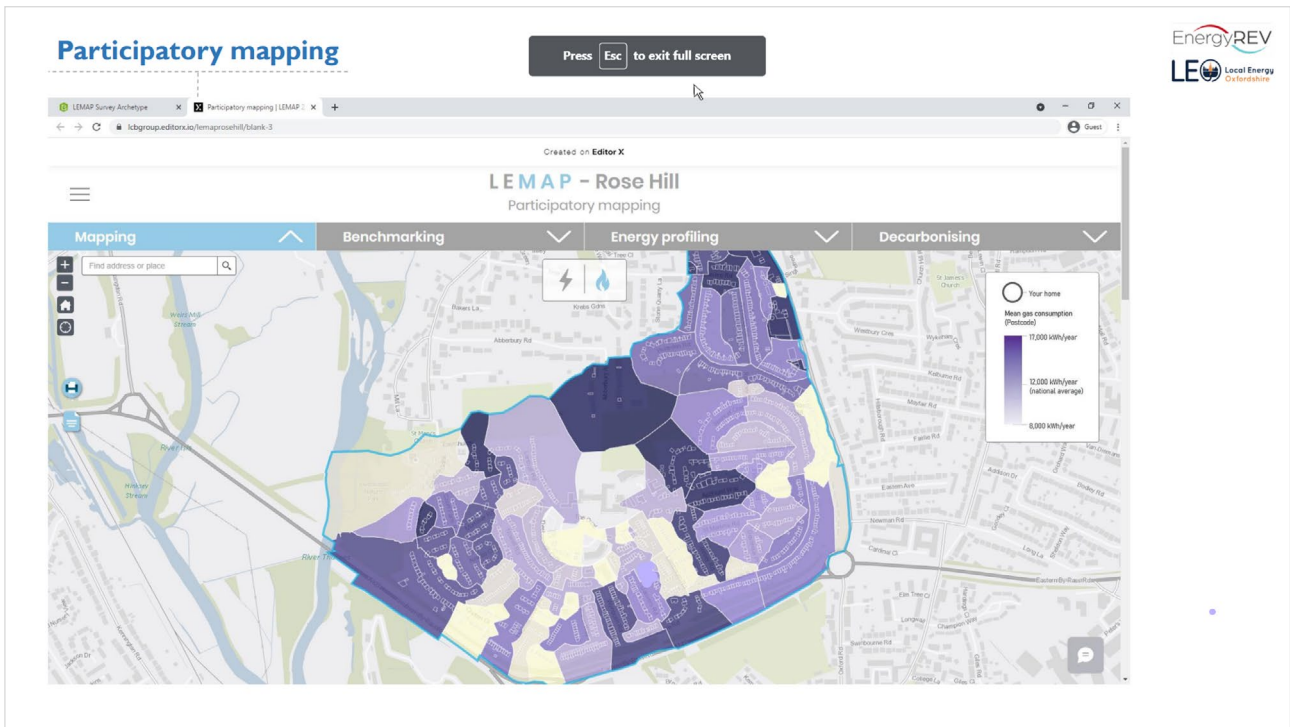
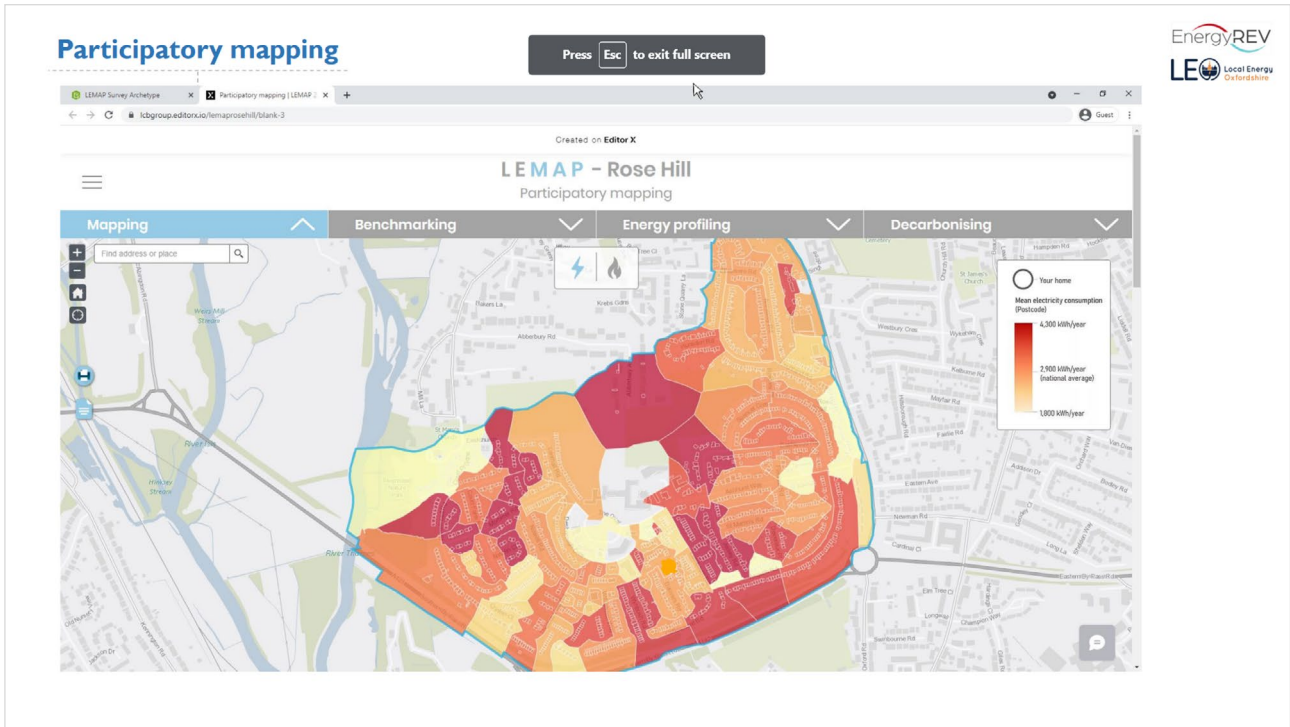
Table 4: Hypothesis reflections and implications

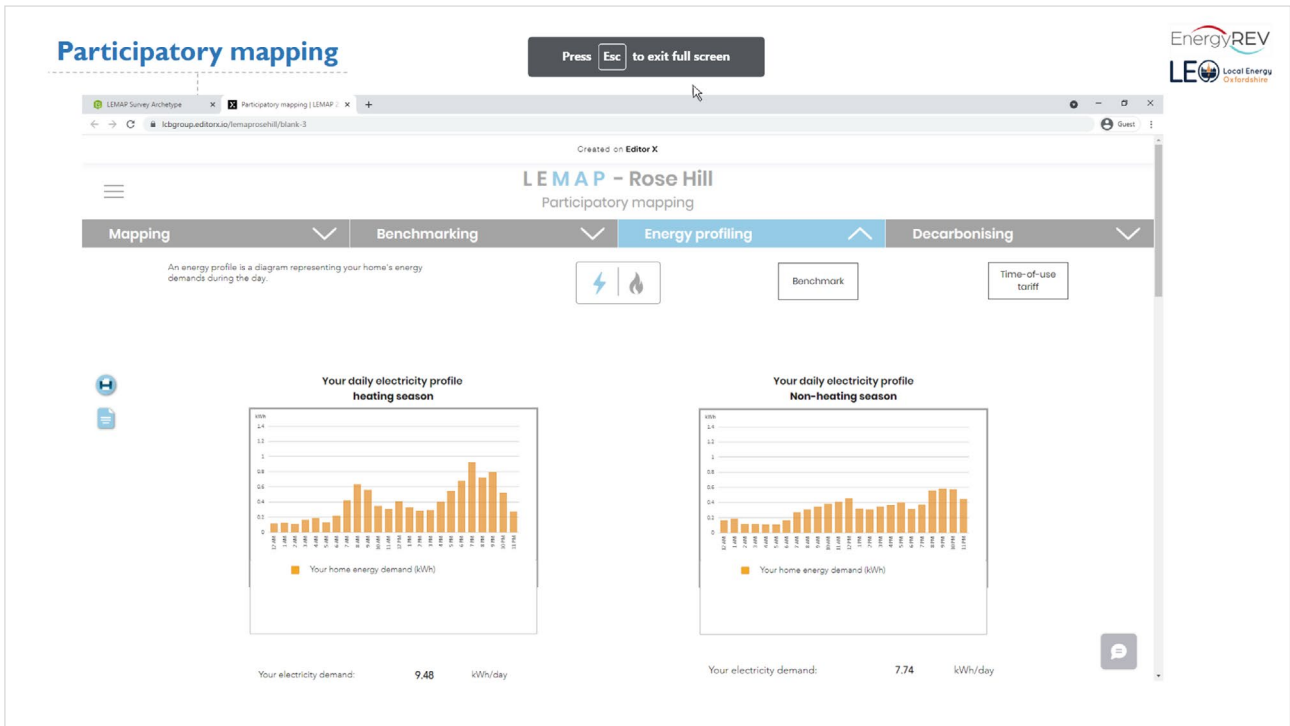
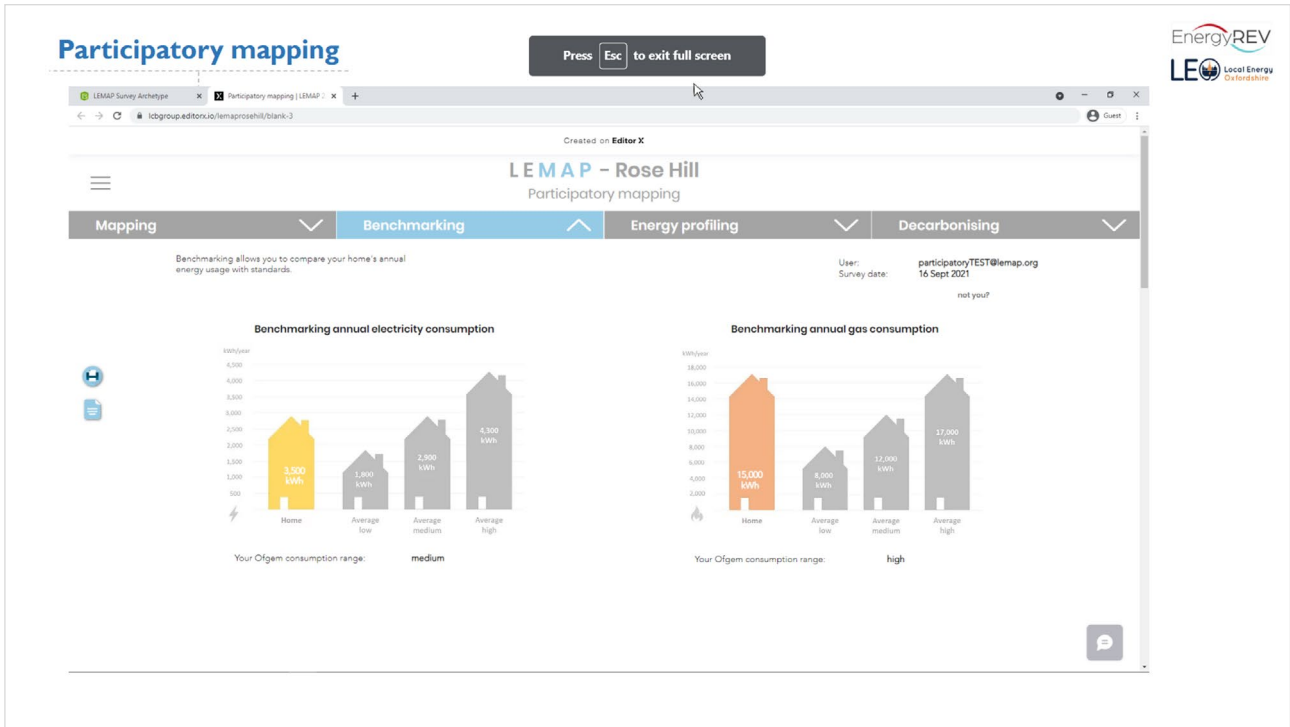
Hypothesis	Example quotes reflecting on hypothesis
Socially interactive	<p><i>"Socially interactive not sure ... it had the function, but the ambition was that it created some kind of vibrant online community all chatting about Rose Hill and heat pumps, I don't think that happened" [SU4]</i></p> <p><i>"I'm really interested in caveating whether it should have been a one way or two-way tool for people ... that created more confusion than it needed to" [SU3]</i></p> <p><i>"It gives mixed messages. Who do you want to use that forum? ... if it was a local authority trying to engage with communities and individuals, I don't know whether that would be the route that we would choose" [SU1]</i></p>
Inclusive	<p><i>"We made it inclusive ... so the tool itself wasn't because it's online ... people actually going out into the community and giving people opportunities to participate made it more inclusive" [SU4]</i></p>
Helping community stakeholders engage with householders, design appropriate offerings plan smart local energy initiatives	<p><i>"If participatory mapping is the route to that, but I would have tweaks, but I think it definitely could do that" [SU3]</i></p> <p><i>"It created an opportunity for community stakeholders to engage with householders, but I don't think any value added that just a survey could have done as well" [SU4]</i></p> <p><i>"I don't think that we have engaged with the local community very much. I think we're using the data and using the expertise from the LCH and other people involved in the project ... I would hope it would come, but smart energy systems and flexibility are quite sophisticated concepts in a way" [SU6]</i></p> <p><i>"It's not been our experience that we've been able to take LEMAP as it is, improve it with data, and the idea was then that 'OK great, we can extract this and come up with a local road map for Rose Hill" [SU3]</i></p> <p><i>"I don't know how it helped design appropriate offerings and plan smart local energy initiatives ... it collected some more data ... it's a missing interpretation piece" [SU4]</i></p>

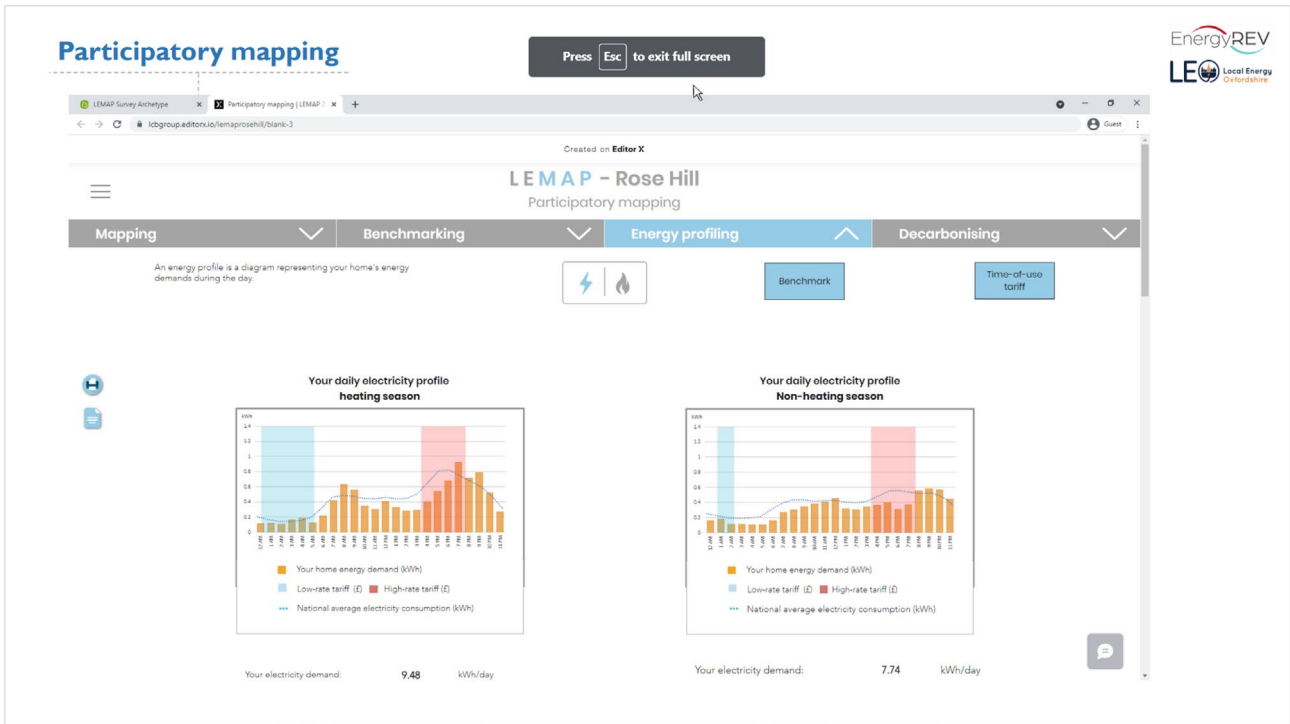
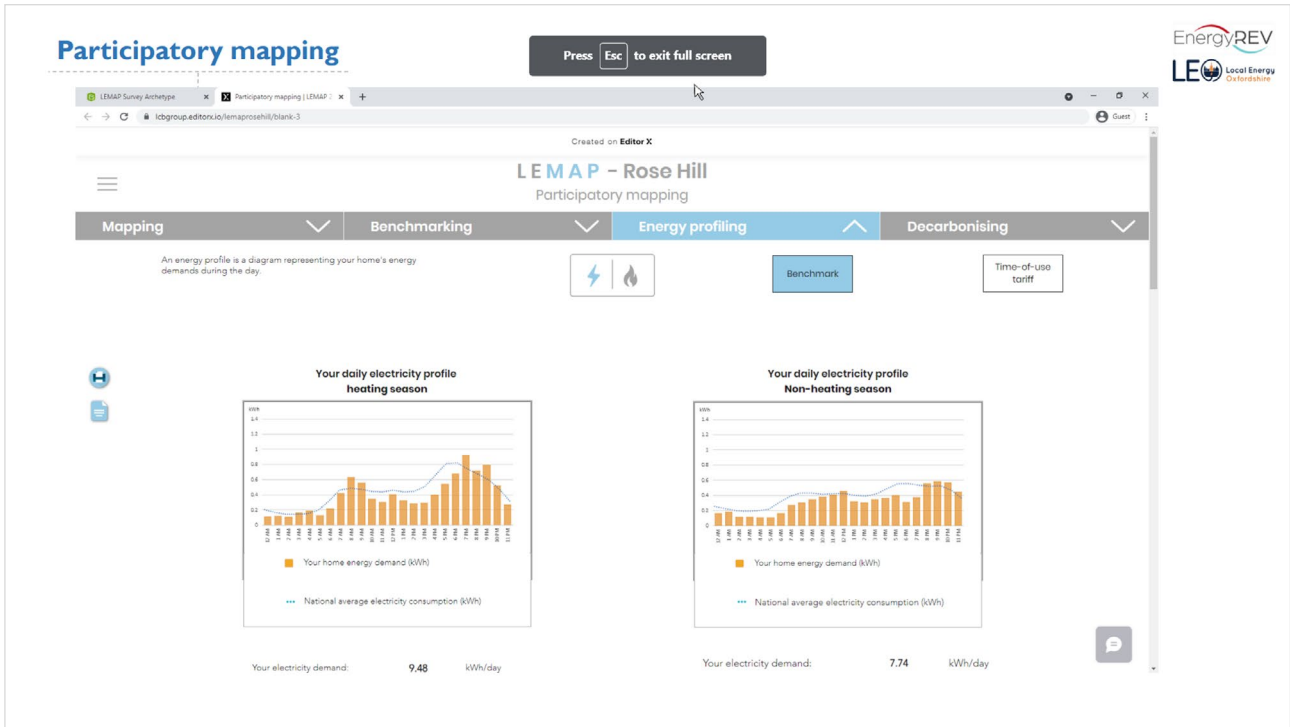
Hypothesis	Example quotes reflecting on hypothesis
Help energy developers design appropriate offerings plan smart local energy interventions	<p><i>"Yes, definitely. So I think that's the key benefit I think that we'd see, being able to identify the low hanging fruit for installations" [TU2]</i></p> <p><i>"I think it could, but with all the things I've heard about some of the issues ... I'm not sure about the potential for that" [SU3]</i></p>
Help householders understand their energy use and decarbonising potential.	<p><i>"I'd suggest it could do that but it's just I think it needed more of an engagement follow through ... if the route to that is through the participatory mapping or surveying, I would build it in a slightly different way, and also build a plan for more follow up and engagement" [SU3]</i></p> <p><i>"I don't think it helped householders understand their energy usage and decarbonising potential because of the way in which individual householder information was fed back". [SU4]</i></p> <p>Data from household questionnaire and interviews suggests that the process of the survey and the feedback received has helped some householders understand their energy usage and has contributed to helping them understand their decarbonising potential.</p>

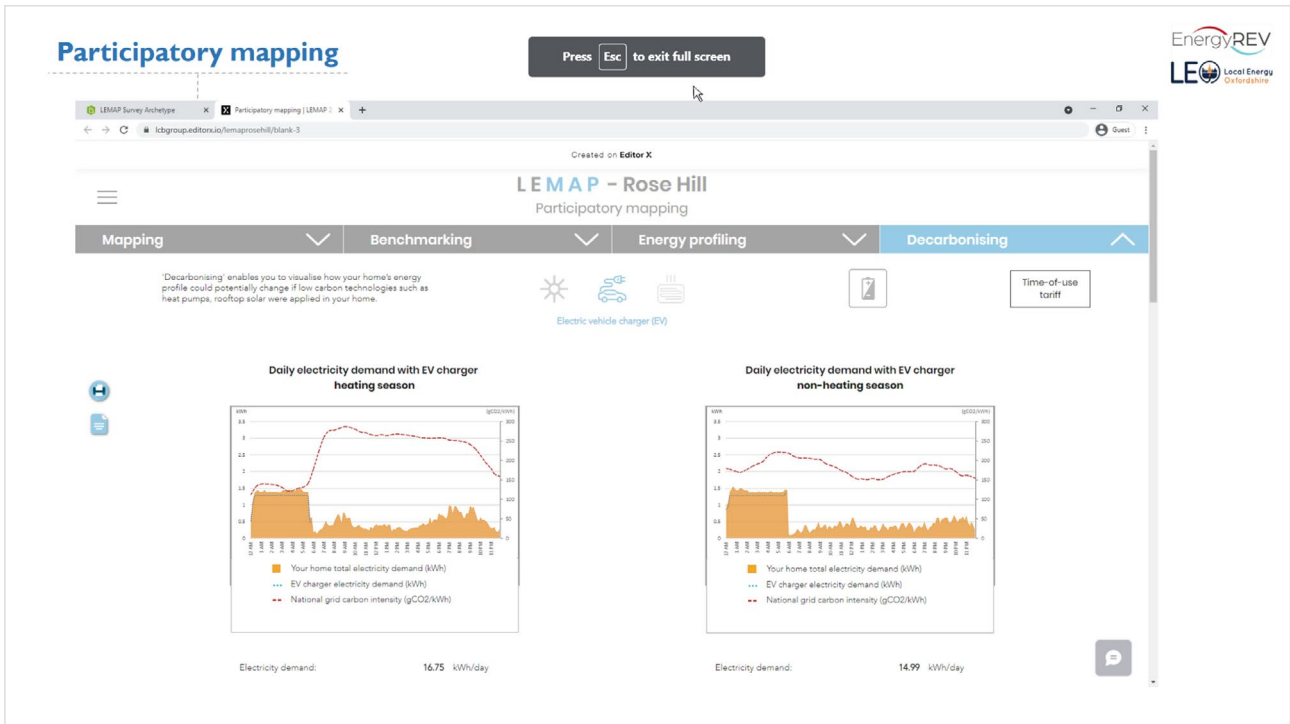
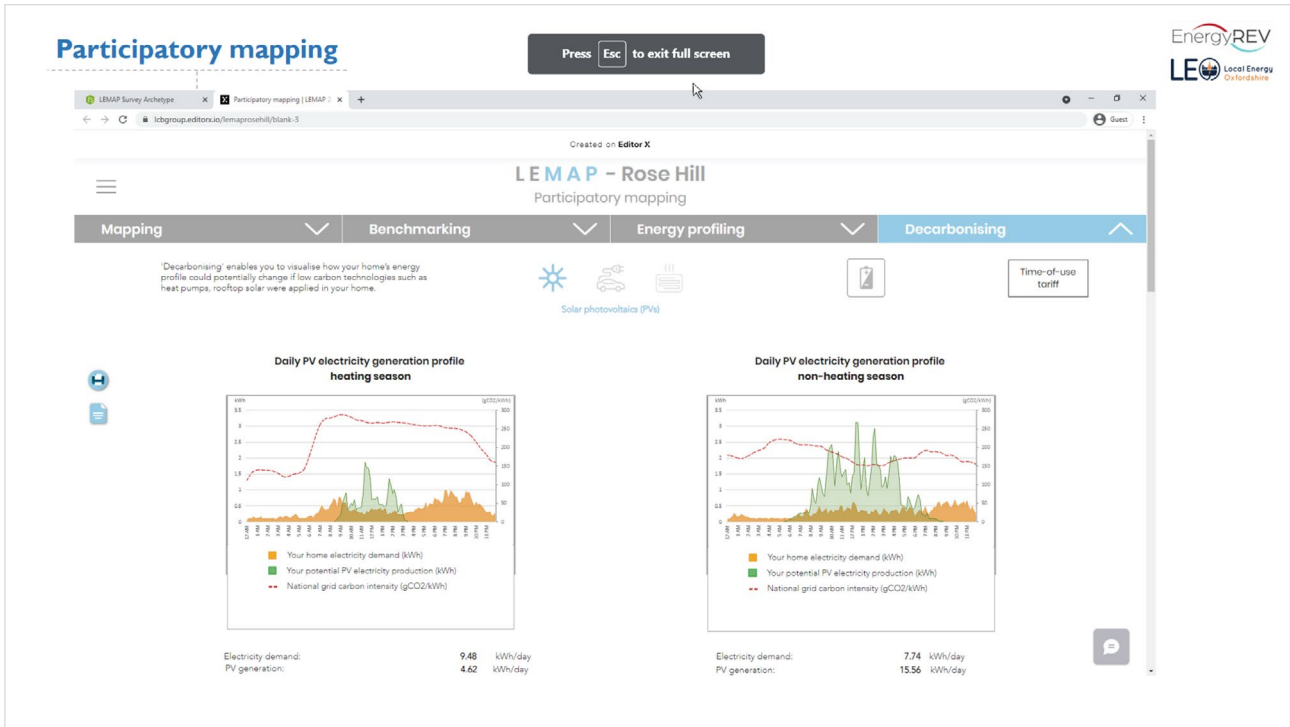
Appendix 2: Example of feedback given to residents on completion of a household energy survey.

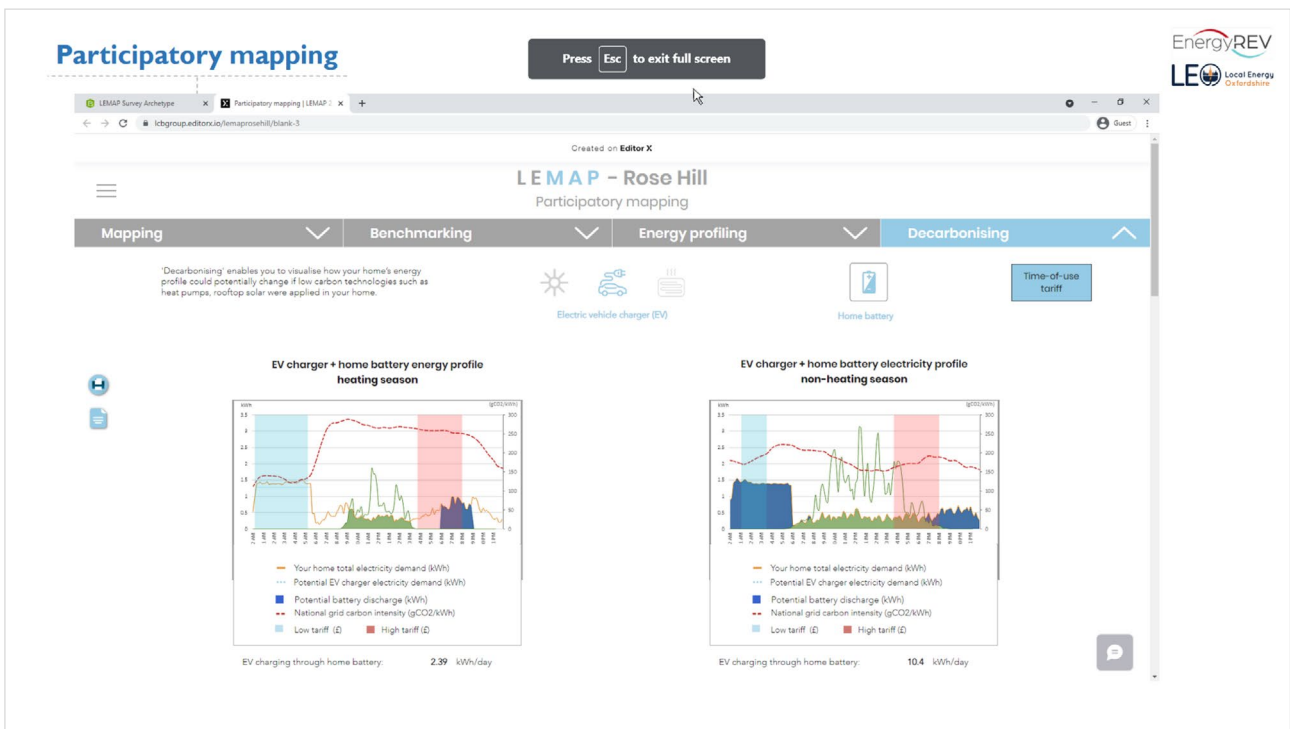
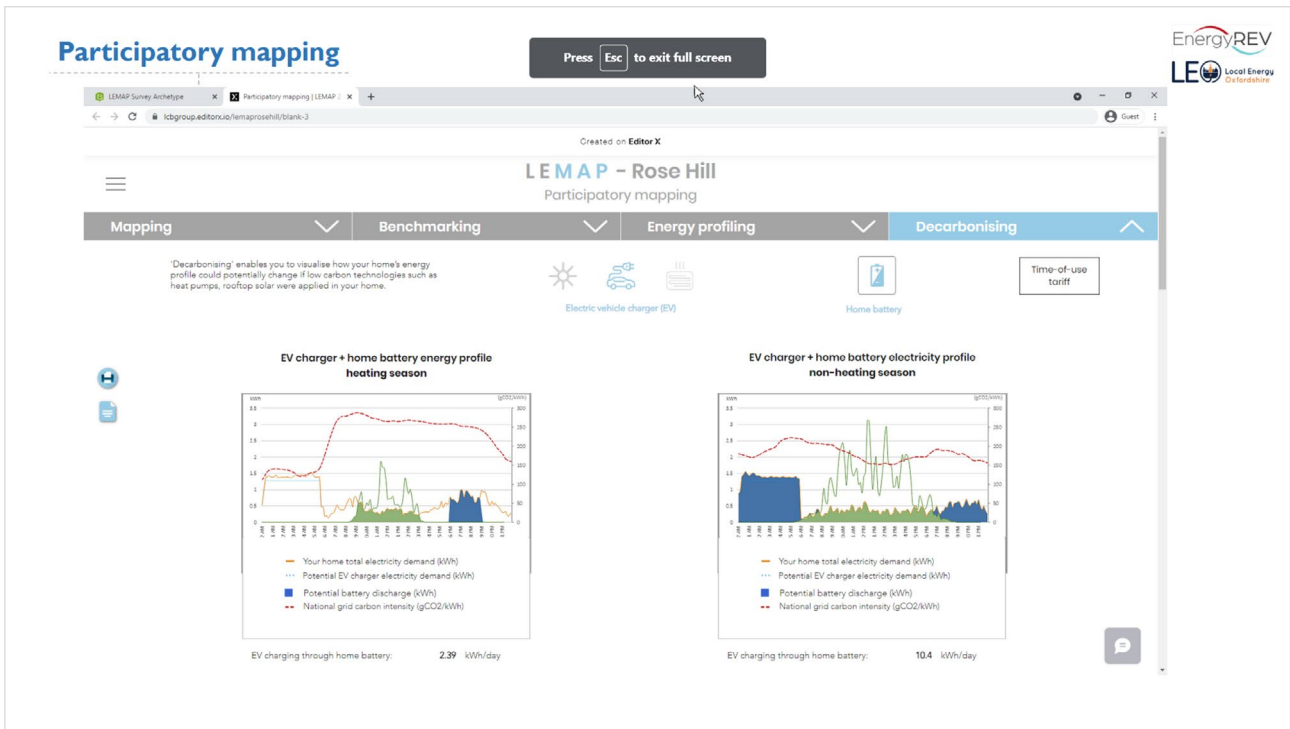








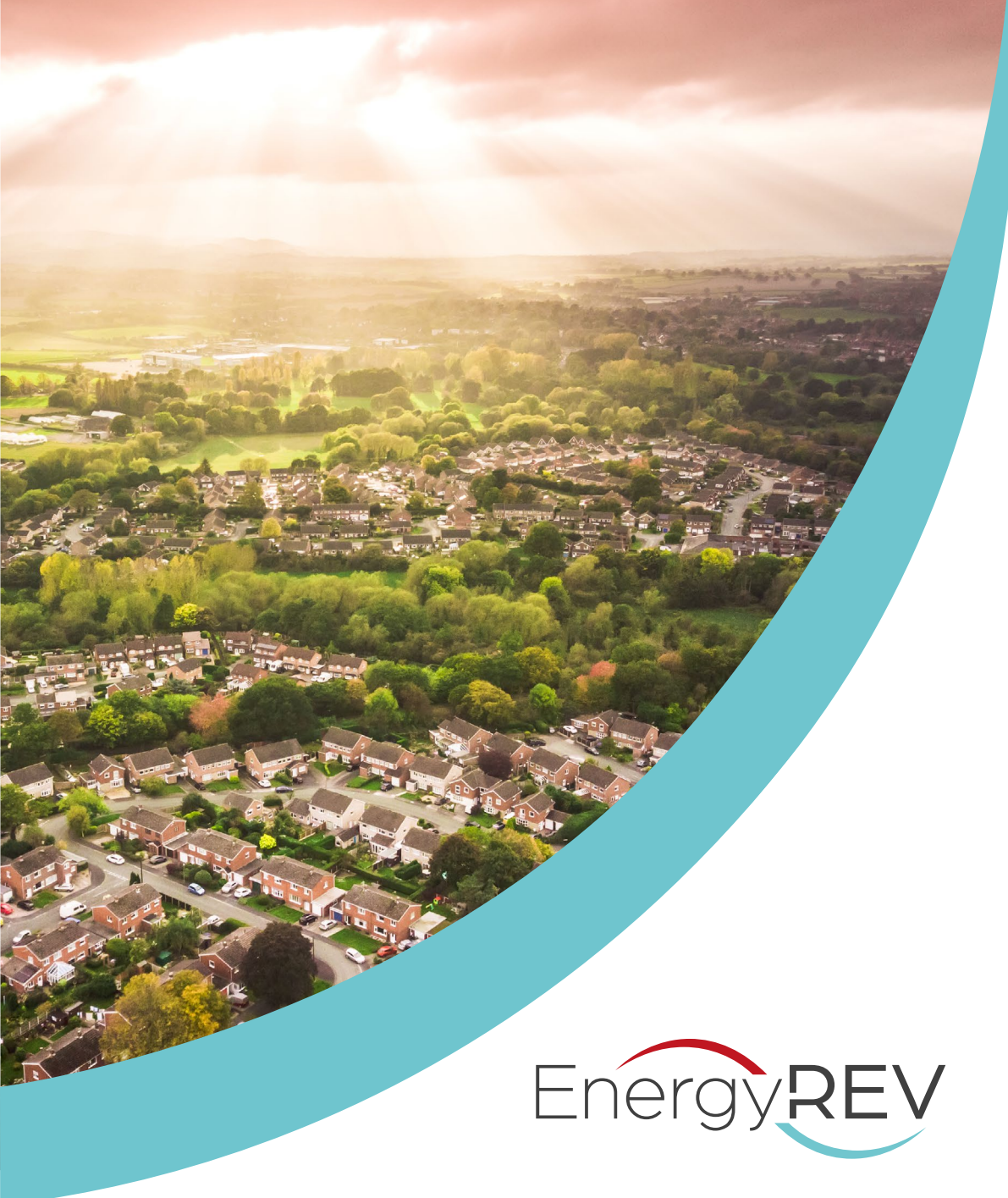




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About EnergyREV

EnergyREV was established in 2018 (December) under the UK's Industrial Strategy Challenge Fund Prospering from the Energy Revolution programme. It brings together a team of over 50 people across 22 UK universities to help drive forward research and innovation in Smart Local Energy Systems.

ISBN 978-1-914241-52-9

EnergyREV is funded by UK Research and Innovation, grant number EP/S031863/1

