2 Methodology

At the time of writing, the SLE SoS domain does not constitute a separate industry. Instead, as shown in Fig. 1 above:

- It comprises of a number of industries (such as building and retrofit, (renewable) energy generation, community energy, electric/fossil-free transport, etc.);

- However, it cannot be assumed that any company operating within the above listed industries automatically contributes to SLE SoS. For instance, a car manufacturer may produce EVs or diesel engines. Similarly, it is debatable if building centrally gas-connected building stock is relevant to SLE SoS.

- Given that SLE SoS is currently a fledgling area, many companies do undertake some SLE SoS projects for a time, while simultaneously delivering their mainstream (non-SLE) activities (e.g. vehicle fleet operators trialling EVs, or energy companies piloting demand-response or peer-to-peer trading services for local energy, while continuing to serve as mainstream fossil-based suppliers).

- Locality factors have a substantive impact on how a smart energy system is delivered in each given location, so it is likely that no two SLE SoS are identical.

Thus, in order to ensure that information on skills obtained from stakeholders who would prospectively operate in the SLE SoS sector is relevant, and that locality factors can be studied, we opted to:

1. Carry out a case-study research, whereby some locations with substantial SLE-focused activities would be chosen as case study localities, and

2. Undertake data collection and analysis from projects that are directly identifiable as SLE-focused within the given locality.

The city of Bristol was selected as the first case study for this work, as it is one of the UK's **energy champion localities** (using rankings suggested by [7–9]) and reviews of 119 SLE demonstrator projects carried out by Flett et al. [16]. Thereafter, the following methods were used to carry out this case study:

1. Review of grey literature [17] and materials to identify the set of SLE projects undertaken in Bristol;

2. Per-project stakeholder identification [18] and [19], to build up the picture of the participants in Bristol's SLE scene and their roles;

3. Interviews and focus groups [18] with members of SLE projects from Bristol to obtain their perspectives on required skills and expected growth for such skills needs.

2.1 Materials Review for Bristol's SLE Projects Identification

In order to identify the SLE projects within the Bristol area, we undertook a grey literature examination, reviewing the:

- Web materials from the prominent local stakeholders within the energy sector (e.g. from Bristol City Council, Bristol Energy Network, etc.). We also integrated the stakeholders identified as being relevant to the SLE within Bristol from the dataset of the EnergyREV research on SLE businesses in UK [19].

- The databases on funded projects from the UKRI [20].

- Datasets of 119 energy system demonstrator projects collected by previous research [16]

The list of the relevant projects identified through this review is provided in Appendix C. This review also resulted in a full picture of Bristol as a SLE locality, which is detailed in section 3.

2.2 Per-project Stakeholder Identification

Along with the project identification process, for each project, the set of relevant stakeholders were identified (see sample shown in Figure 2, thus developing a picture of those who engage with the SLE domain in Bristol. The list of Bristol SLE stakeholders is presented in Appendix B.

2.3 Stakeholder Interviews and Focus Groups

Primary data collection was carried out through:

1. Interviews with 24 stakeholders at 23 interviews (one interview was carried out with two interviewees present together);

2. Two focus groups with 10 participants overall;

3. Writing of one collaborative reflective summary report with 7 participants;

4. Interview study with 30 citizens through 28 interviews (two interviews were carried out with two interviewees present together).

Given that the data collection took place in the period between Oct 2019 and Oct 2020, during which time COVID-19 restrictions were imposed on Bristol, some of the interviews were carried out face-to-face, while others were arranged through videoconferencing. The focus groups and reflective reports were carried out via videoconferencing.

Data was collected by researchers from the University of Bristol, in accordance with the University's ethics committee data collection and handling processes and rules. The participants either signed and returned a consent form, or (during the COVID-19 restrictions period) were emailed the study materials and consent forms and asked to confirm their consent verbally at the time of interview recording and to return the form by email. In all cases, the conversations were recorded and transcribed for qualitative data analysis. To ensure participant anonymity, the stakeholder data is segregated into two sections, whereby the participant roles are reported separately from the organisations interviewed.

2.3.1 Participant Recruitment for Study with Stakeholders

The process of project and stakeholder identification discussed in sections 2.1 and 2.2 above was carried out iteratively. A snapshot of this analysis is presented in Figure 2. Figure 2 demonstrates that a number of institutions have participated in more than one project, which indicates the presence of a longer-term interest and commitment to SLE SoS within these organisations.

Furthermore, as the stakeholder list in Appendix B demonstrates, Bristol SLE SoS stakeholders primarily belong to the following categories:

- Local authority (Bristol City Council, West of England Authority);

- Transportation with a focus on EVs or smart mobility (e.g. Esoterix and Travel West);

- Building and Retrofit (e.g. CHEESE, Urbane);

- Energy supply (e.g. Bristol Energy, Ovo);

- Digital solutions and infrastructure (e.g. Bristol is Open, Zeetta Networks)

- Community Energy (e.g. Easton Energy Group, Ambition Lawrence Weston wind and solar);

- Citizens and community support intermediary groups (e.g. Bristol Energy Network)

The repeatedly engaged organisations and the above stakeholder types are kept in mind, while undertaking stakeholder engagement for interviews:

- We aimed to recruit interview participants from within organisations with more than one SLE project engagement;

- We also worked on identification of those individuals within the organisations who, if at all possible, had themselves been part of more than one SLE project; this was done in the hope of obtaining more experience-based data from these particular participants;

- We then attempted to engage a mix of roles: a good proportion had hiring and project management responsibilities, as well as those who were directly engaged with the project delivery;

- Finally, the invitations to take part in the study were sent out to a set of organisations that covered the above-mentioned categories.

The summary details of the interview study participants are presented below, with the participating organisations listed in Table 1, and the participants in Table 2. Note that the organisations are listed in alphabetical order, while participants are listed in order of their (not shown in the table) names, to ensure the anonymity of the participants.

Table 1: Organisations that took part in Bristol City's Smart Local Energy Study

Organisations		
1. Ambition Lawrence Weston	9. CEPro	18. South West Energy Hub

Table 1: Organisations that took part in Bristol City's Smart Local Energy Study

Organisations		
2. Ascent Architecture	10. Centre for Sustainable Energy (CSE)	19. Trakm8
3. Bristol City Council (BCC)	11. EnergieSprong	20. TUC
4. Bristol Energy Network (BEN)	12. Energy4All	21. University of Bristol
5. Bristol is Open (BIO)	13. Esoterix	22. Urbane Eco
6. Bristol and Bath Regional Capital	14. Futureproof / CSE	23. Western Power Distribution
7. Bristol Energy	15. Knowle West Media Centre (KWMC)	24. x-BCC, now Freelance
8. Cold Homes Energy Efficiency Survey Experts (CHEESE)	16. Lockleaze Loves Solar	25. x-Greenheart, Green reg
	17. NEC Labs	

Table 2: Details of Bristol SLE Stakeholder interview Participants

ID	Role within Organisation	Field of Work	Data Collection
P1	Software Engineer	ICT	FG
P2	SME Energy Project Developer	Energy	Interview
P3	Community Project Developer	Community Energy	Interview
P4	Regional Project Manager	Local Authority	Interview
P5	Technical Developer, Community Energy	Community Energy	Interview
P6	Local Authority Partnerships Manager	Local Authority	Interview
P7	Retrofit Project Manager	Building & Retrofit	Interview
P8	NGO Community Manager	Community Energy	Interview
P9	Energy Company Innovation Manager	Energy	Interview
P10	Chief Marketing Officer: Smart Mobility	Transport & Mobility	Interview, FG
P11	Sustainable Building Consultant	Building & Retrofit	Interview
P12	Consultant for Business Case Analysis	Building & Retrofit	Interview
P13	Community Energy Project Manager	Community Energy	Interview
P14	Building Company Managing Director	Building & Retfrofit	Interview

Table 2: Details of Bristol SLE Stakeholder interview Participants

ID	Role within Organisation	Field of Work	Data Collection
P15	Trade Union Regional Secretary	Trade Union, Community	Interview
P16	Trade Union Education Officer	Trade Union, Community	Interview
P17	Community Energy Development Manager	Community Energy, Funding	Interview
P18	Local Authority Investment Manager	Local Authority	Interview
P19	Community Worker	Community, Community Energy	Interview
P20	Research Associate: ICT for Smart Mobility	Academia, ICT, Transport	Interview
P21	Transport Technical Projects Director	Transport & Mobility	Interview, FG
P22	Funding Associate	Community, Funding	Interview
P23	Architect	Building & Retrofit	Interview
P24	DSO and Future Networks Manager	Energy	Interview
P25	Data and Technology Architecture Manager	ICT	FG, Reflect. Summary
P26	Network & Developer Engineer	ICT	FG, Reflect. Summary
P27	Sustainable Neighbourhoods Manager	Community	FG
P28	Associate Professor: ICT	Academia, ICT	FG
P29	Project Manager: Smart Energy	Local Authority	FG, Reflect. Summary
P30	SLE Senior Researcher	ICT	FG, Reflect. Summary
P31	SLE Senior Project Manager	Local Authority	FG
P32	SLE Project Researcher	Academia, Community Energy	Reflect. Summary
P33	Senior Lecturer: ICT for SLE	Academia, ICT	Reflect. Summary
P34	SLE Senior Researcher	ICT	Reflect. Summary

The interview questions were split into several sections:

- Participant and organisation background details;

- Activities within the SLE domain;

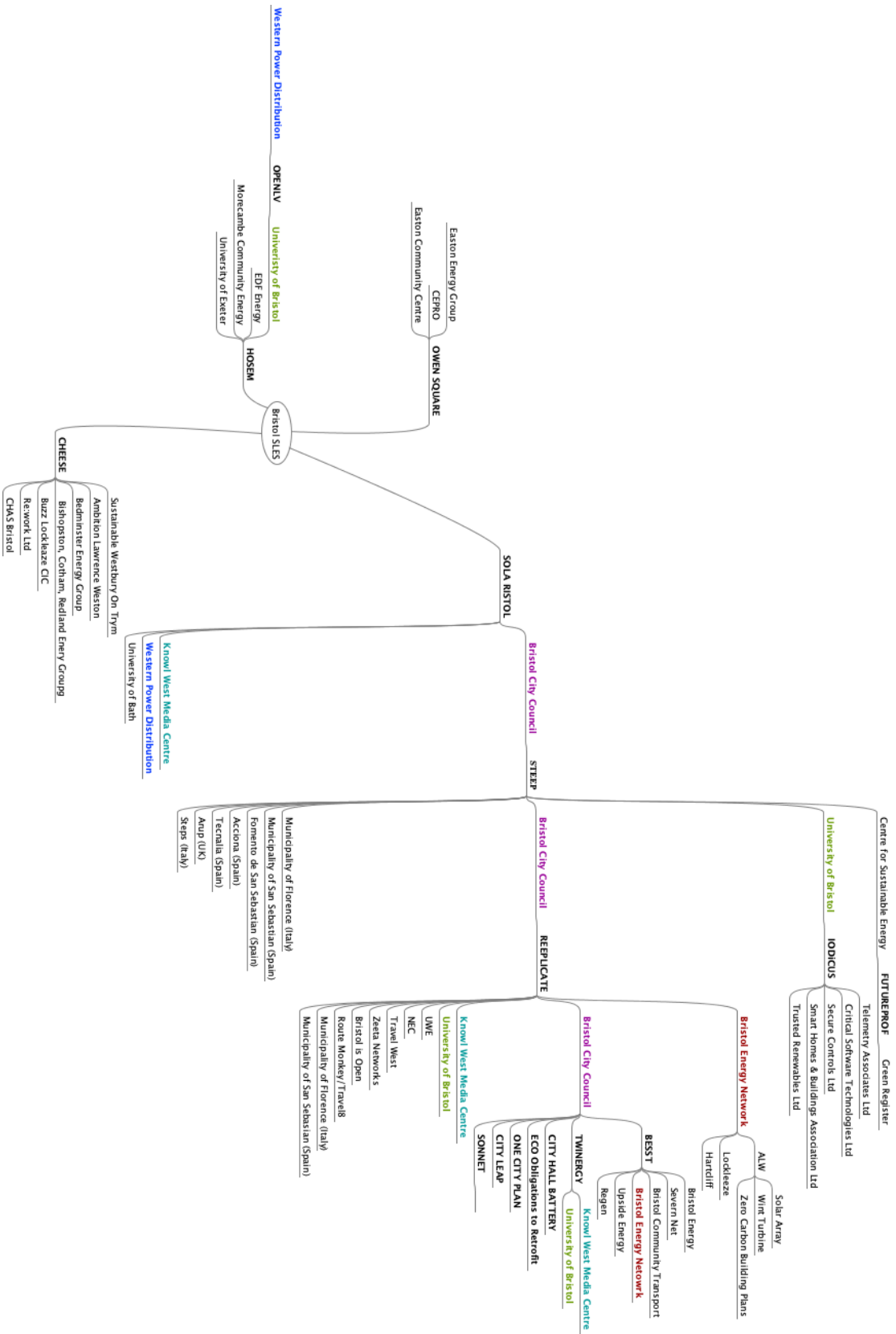- Skills needed now (i.e. shortages);

- Future training needs.

Figure 2: Sample of projects and organisations in Bristol's SLE

Table 3: Characteristics of Citizens' Study Participants

Age		Income		House Type		Household Size		Gender	
16-25	1	<25K	13	Semi/Detached	4	Single	4	M	11
25-49	17	25K-50K	10	Terraced	20	Couple	3	F	19
50-65	10	>50K	5	Flat	4	House-share	4		
N/A						Couple, adult kids	1		
						1 parent, young kids	3		
						Couple, young kids	4		
						Couple, young kids	9		

2.3.2 Participant Recruitment for Study with Citizens

The citizens' interview study was carried out on 28 households (with two interviews carried out on couples, with a total of 11 males and 19 females). The interview questions were split into 3 sections:

- Participant background details;

- Current practices of appliance and energy use;

- Responses to the idea of automation for energy management.

Interviewees were drawn from households that had received smart appliances from BCC as a part of REPLICATE [21] Smart City project (16 in total) and households with no direct relationship to BCC or REPLICATE (12 in total).

In the recruitment of participants, an active effort was made to obtain a representative sample of participants, balancing for both demographic and owned/occupied property characteristics of the households.

Using the Grounded Theory analysis approach [22] (see Appendix A, we stopped the interview process when no new significant code categories emerged from the last 3 interviewees (i.e. *theoretical saturation* of the Grounded Theory Analysis method [22] was deemed as being achieved).

The participants' demographics are summarised in Table 3.

Interviews were carried out face-to-face in English; these were recorded, transcribed and analysed. The collected data was analysed and a set of relevant topics and skills were identified.

2.3.3 Data Analysis

Data collected from both stakeholders' and citizens' studies was analysed using the constructivist strand of the Grounded Theory (GT) analysis methods [22] (see more detail in Appendix A). The interview texts underwent a line-by-line text analysis, resulting in a set of text codes during the initial coding stage (e.g. systems integration skills, lack of certainty on subsidies, etc.), which were then integrated into a set of main categories during the *focused coding* activity. These are:

- 7 main subsystem categories for the overall Bristol energy system (i.e. Local Authorities; Energy Sector; Community Energy; Transport and Mobility; Building and Retrofit; ICT sector and Citizens) with Barriers, Drivers, issues specific to Bristol, Skill Shortages, Training Needs

and Insights sub-categories considered for each subsystem. In addition, the Stakeholders and Projects categories were populated for the Bristol's SLE system as a whole.

- 8 categories for the citizen's interview study: Practices, Appliances, Data, DSR Automation, Motivations, Concerns, Knowledge, Smart.

The *theoretical coding* then helped to establish relationships between these categories and formulate a cohesive theory of causal loops around each sub-area of SLE SoS (presented as section 1 for each sub-system in chapters 4-10 of this report). The detailed description of the theory derivation and coding activities is not presented in this report.

2.3.4 Treats to Validity and Study Limitations

2.3.4.1. Treats to Validity

We have made maximum efforts to engage with a **representative sample** of participants for both of the interview (and focus group) studies. However, we note that these are only representative of the community living in the city of Bristol, and the results are in the context of the SLE projects that have been taking place in Bristol.

In addition, the pool of participants was limited to those who responded to our invitation, and we note that this may imply a certain **self-selection and self-reporting biases** with those interested in SLE skills and energy management and energy efficiency coming forward more prominently. This concern, however, is mitigated to some degree by the fact that these are also the very same organisations and households that would likely engage with the broader SLE SoS adoption.

To test the validity of our findings further, we draw on the notions of data, **investigator, method and theory triangulation** [23]:

- For data triangulation [23] we reached out across both the *space* and *time*. With respect to space triangulation, the interview participants were drawn from across the whole city, reaching out to stakeholders wherever the SLE projects were identified, as well as recruiting citizens from various areas of the city: both in areas where BCC had initiated the activities related to SLE SoS (16 households) and to those areas that are completely independent of formal SLE SoS initiatives (12 households). We also ensured that participants of varying demographics were engaged (see Table **??**). With respect to time, the overall data collection span covered about a year, during which time we engaged with citizens' data collection in a more focused four-months period (mostly pre-COVID-19). Data from other stakeholders covers both pre-COVID-19 and COVID-19 periods.

- For investigator triangulation, two researchers worked on the GT coding and analysis, continuously double-checking and verifying each other's work, and discussing and resolving disagreements.

- For the data collection method triangulation, we used interviews, focus groups and a reflective writing method, so a variety of data inputs thus inform the analysis.

- Finally, for theory triangulation, we will be undertaking additional case studies and expert group feedback, which are planned as the next steps in this ongoing work.

2.3.4.2. Study Limitations

We note the following limitations:

1. **No Generalisation:** Given that this is a qualitative study, based on data obtained through interviews and focus groups, we do not claim that the findings are *generalisable beyond the scope of this case study*. Given that the GT results are *grounded* within the studied context and collected data, this is an expected limitation.

   While further case studies will be designed to add to the evidence that could validate and generalise the results obtained from this case study (as indeed is our intention for future work), findings from such additional studies will not change the validity of the study for this given context.

2. **Lack of Detailed sub-skills**: The topics that relate to the skills are extracted from the interview records, and are named as the interviewees name them. We observe that, in many cases, such topics are quite general and can be interpreted in different ways by different people/sectors.

   For instance, the commonly noted skill of "Data Analysis" can include a large set of sub-skills: from statistical analysis, to machine learning, and more. However, the uncertainty analysis skills within data analysis are very often missing, both in application, and in recognition of their need. In other words, *data is often analysed without correctly quantifying (or even considering) the **uncertainty associated** with the data* (say, when values are missing, defaults have been used to populate the data, or parts of the data could be missing due to communications failure, etc.). The sub-topics related to uncertainty in data analysis include:

   - measurement of uncertainty,
   - decision-making under uncertainty,
   - risk analysis if relying on (partially)incorrect data, etc.

   Another example is that of **Legal Metrology**. Legal skills are mentioned in several sections, and a gap is often identified between legal skills and engineering skills. An important part of this gap is related to a lack of legal metrology skills, which are essential in SLE. To illustrate this:

   - When smart meters are used, the power consumption is calculated using algorithms (instead of being measured, as with analogue meters). However, policies and regulations in relation to calculations transparency and methods have not been adequately updated with the introduction of the smart meters. These aspects are not adequately regulated because legal teams don't understand the differences and implications of possible mistakes as well as the wrongdoings.
   - In SLE, the responsibilities in terms of power quality are not well-defined. Although power quality can be monitored, there are no clear procedures to determine who is responsible for providing acceptable power quality to all users, and who should be blamed in the case of poor power quality, etc.

Thus, in summary, we note that more detailed sub-skills can be enumerated for many of the skills identified in our study. However, given that our interviewees did not enumerate them, we are unable to list the (many) specific sub-skills in this report.