

Smart Local Energy Systems: Training Needs and Provision

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1 Introduction

The energy system is changing across the world, as decentralised solutions are becoming an increasingly common part of the energy landscape, with smaller scale renewable and other technologies becoming more widely deployed at a local level. Energy trends include the promotion of technology-enabled systems such as smart meters and smart appliances, the electrification of transport, the development of heat networks and increasing cross sector interactions. This is the context in which we see low carbon ‘Smart local energy systems’ (SLES) developing. SLES aim to manage and balance local energy supply, storage and use across all vectors (e.g., power, heating and transport), bringing efficiencies to energy supply and demand, and social, environmental, and economic benefits to their locality. This approach to the energy system can be summarised as generation becoming:

- decarbonised and decentralised through smaller-scale renewables;
- democratised as more people and organisations at all scales have a stake in the system and
- digitalised through the capacities of ICT.

A Smart Local Energy System is made up of many sub-systems [1] which (to various degrees) interlink with each other through 4 key interconnecting components [2], which are: (i) policy and (local) governance; (ii) physical infrastructure (such as electricity wires, smart meters, gas/hydrogen pipes, etc.); (iii) virtual infrastructure (such as software platforms and data interchanges), and, at the core of it all, (iv) the people that design, install, maintain and use all of these components.

This changing energy system requires new and different skills and a workforce receptive to upskilling to enhance what they already know (e.g., builders learning to practice passive house building) or retraining to new areas (e.g., electricians learning to install Electric Vehicle (EV) charge points).

In previous work [1, 3, 4, 5] we have researched which skills are (or are expected to be) in short supply in transitioning to smart local energy systems. For that we have conducted three detailed case study of smart local energy localities and projects.

The present report revisits these case studies to identify the training needs and training provision mechanisms that arise (along with the skills needs) in transitioning to SLES both at the system level (as discussed in section 4) and at the sub-system levels (as discussed in section 5).

The report complements the case study-based data with a) a review of the Ofqual accredited qualifications, to ascertain whether the skills noted to be in short supply have any accredited delivery mechanisms as well as b) additional focus groups with senior college representatives (as discussed in section 3).

Some related work, relevant to this report, is presented in section 2, while recommendations on training provision are summarised in section 6.

2 Related work

While there has not been extensive academic exploration of the issue of skills and training for the future energy system, over the last few years there has been detailed exploration of the issues by organisations including National Grid (2020)[6], Federation of Master Builders and the Centre for

Research into Energy Demand Solutions (FMB and CREDS, [7]) and the CBI (2021)[8] amongst others.

The CBI, in their submission to the Green Jobs Taskforce “Skills and training for the green economy” [8] identified 3 key areas: home efficiency, automotive and electric vehicles, and clean energy, and assessed the skills and training requirements and issues on the path to net-zero – including looking at what might be “green skills” and what other skills beyond this narrow definition are required. Key issues revolved around provision of careers and skills advice, lifelong learning, flexible training and quality standards.

National Grid, in their “Building the Net Zero Energy Workforce” [6] listed required future jobs that “include civil, mechanical and electrical engineers, data analysts, machine learning experts and skilled tradespeople” as well as “new roles linked to electric vehicles, hydrogen, and carbon capture technology”. National Grid sets out key goals for this future energy workforce, including the need to inspire young people into STEM subjects and to develop skills through different levels of qualifications, to ensure a fair transition and boost diversity, and to foster strong UK-based R&D.

An area that received extensive exploration in 2021 is that of net zero buildings and specifically domestic retrofit.

1. “*Building on our Strengths*” [7] published by the Federation of Master Builders and the Centre for Research into Energy Demand Solutions (FMB and CREDS) is an analysis of how retrofit can be stimulated noting the need for new policy to set minimum standards, helping the market and providing information to householders. Key findings of relevance to skills and training include transforming occupational standards in order to equip the workforce with the necessary competences to carry out retrofit, **identifying the best training routes** (e.g., colleges, on the job etc) noting that retrofit should create significant numbers of new jobs with new roles and professions emerging as energy retrofit becomes mainstream.
2. “*The future homes delivery plan*” from the Future Homes Taskforce” [9] lays out a detailed roadmap to achieving net zero homes and construction businesses – and is supported by many of the major building businesses in the UK.
3. “*Foresighting Skills for net zero homes*” by the Gatsby Foundation for the Energy Systems Catapult [10] identified structural challenges in progressing retrofit and in their assessment of training, the report made the following comments which are reproduced verbatim here:
 - *Low customer demand* for retrofit in turn leads to **low installer demand for training**. Interviews with sector stakeholders reveal a lack of confidence in the quality and outcomes of existing training courses,
 - *A lack of demand from installers* for training means that colleges and course providers are **unwilling to invest in courses**, and low pay acts as a barrier to recruiting instructors with the required mix of good teaching skills, a theoretical understanding of the subject matter and on-site experience and technical skill (p8)
 - Installer courses tend to focus on a **narrow range of technologies** rather than considering the whole home. Many training courses are often only a few days long, which is not sufficient when attendees might lack some basic knowledge ... (p8)
 - The need for a whole house approach also needs to be *reflected across other roles* [beyond retrofit coordinator] and training courses. While each role has special-

ist knowledge requirements, there is also a need to **understand what knowledge should be common to all roles** and how this can be integrated into courses (p10).

4. “*Building Skills for net zero*” [11] focused on retrofit and usefully broke the process down into three stages with attendant skills. Pre-construction skills include building assessment and design for upgrades. Construction skills include general repair and maintenance, project management for retrofit and key trades such as draught-proofing, insulation or replacing a gas boiler with a heat pump. The post-construction phase requires building evaluation to assure the performance of the retrofit.

Across many areas of industry, low carbon skills gaps are seen to be hindering economic recovery and the net zero transition. The Aldersgate group for sustainable business (which includes KPMG, Siemens, Triodos Bank and National Grid [6] amongst others) have said that low carbon skills provision must become a national policy priority in order to equip the workforce with the skills desperately needed for a net zero economy [12].

3 Methodology

The key research question addressed in this study is:

What are the skills and training needed for transition to SLES?

The transitional approach to skills gaps (i.e., difference in supply and demand of a particular skill) means that identification is carried out through collection of data from government surveys, using industry taxonomies for defined occupations. This leads to skills gaps framed in terms of occupations for a specific industry (e.g., shortage of 1000 nurses in NHS) [13], and advise to government to fund the training of additional nurses next year. However, this approach is not feasible for identification of skills gaps and training needs for SLES, because:

- **SLES** as an area has **not** been defined as **an industry** and no taxonomy for its occupations exist. As a result it is not possible to identify which occupations are in short supply for SLES.
- Many of the needs faced by transition to SLES are essentially needs for **up-skilling** (i.e., top up skills, such as teaching electricians to install electric vehicle charge points), **rather than new occupations** by themselves. As a result, it is not possible to instruct the training providers to deliver training of so-many **new** professionals.
- On the other hand, there are **some** areas in SLES where a completely **new occupation** is formed (e.g., retrofit coordination), and training provision for such a profession needs to be created anew.

As a result, we have adapted a case study research methodology: looking at the skills and training needs within areas that have embarked on a transition to SLES. Thus,

- 3 case studies were selected, driven by the scale of SLES transition activities at their localities. These are case studies of Bristol city [1], ESO project [3] and ReFLEX project.
- Interviews with stakeholders from within these case studies were carried out, and analysed focusing on skills and training needs, drivers and obstacles within each case study. This led

to identification of skills which are currently in short supply, or expected to be in shortage in the near future. Thus, both whole system-wide as well as subsystems specific skills were identified. These are reported in [1, 3] and are summarised in figure 1. These are the skills for which more training provision is needed.

- Having identified the needed skills, we reviewed the available qualifications to ascertain if these skills are already covered by the existing qualifications, particularly in relation to Further Education (FE) colleges. To this end, an extensive search of the OFQUAL register [14] was undertaken using a range of key words based on the identified skills (e.g., ‘installation of heat pump’ or ‘smart meter’). Ofqual is the independent qualifications regulator for England with a role to ensure that qualifications are sufficient in content and can be trusted by students and employers. The Council for Curriculum, Examinations and Assessment (CCEA) has responsibility for the regulation of qualifications in Northern Ireland. The register shows all qualifications and awarding organisations regulated by Ofqual and CCEA Regulation. Searching the register reveals size, level and content of a regulated qualification and recognised awarding organisations.

This search drew out the available qualifications across a range of levels and types, mapping the needed skills to teaching/training provision accredited at present.

- Thereafter, two working group meetings were held with the EnergyREV skills Advisory Board and two focus groups with representatives of further education colleges, to explore how the different defined ‘skills’ are currently delivered in practice and might be better delivered in future, helping to identify good practice and gaps where change is needed.

Given that 70 participants have been engaged into interviews and focus groups in various case studies, in the remainder of this report these participants are identified as follows:

- Bristol case study participants: P1-31;
- ESO Case study participants: E1-19;
- ReFLEX Orkney Case Study participants: R1-17;
- Training providers participants: T1-5;
- Advisory Board participants: A1-10.

The below presented findings first summarise the skills identified in earlier work (see figure 1), then cluster training provision by type, (such as, Undergraduate (UG)/Postgraduate (PG), Post-16, short course, informal training). The Ofqual search is discussed and an example of Ofqual register searches is presented in appendix A, with the focus group discussion results presented in section 4.4.

3.1 Study Limitations

This is a qualitative study, based on data obtained through interviews and focus groups so biases and peculiarities native to the case studies could surface. However, given that three independent case studies from very different contexts have been analysed, we believe that the accumulated evidence allows for generalisable conclusions.

Despite this, the pool of participants was limited to those who responded to our invitation to participate in case studies/focus groups, which may imply a certain self-selection bias to those interested in the future SLES and skills. Again, this does not diminish the presented findings, though this indicates that some skills needs, particularly amongst the dis-interested and dis-engaged groups, could have been missed.

To further the validity of the study findings, data, investigator, and method triangulation were conducted [15]:

- For data triangulation we collected data from 3 case studies, where we interviewed both SLES project partners (who were receiving substantial grant funding) and those who had a purely commercial interest as a supplier; as well as training providers, and representatives of various relevant groups through the project Advisory Board participation.
- For investigator triangulation, two researchers worked on the coding and analysis of all materials, double-checking and verifying each other's work, and discussing and resolving disagreements.
- For data collection method triangulation, we used documentary analysis, interviews and focus groups.
- Finally, for findings triangulation, we independently analysed 3 case studies and drawing on expert group feedback.

4 Findings on SLES as a whole

4.1 Key skills for SLES as a whole

Figure 1 below summarises skills needs across SLE sub-systems and integration of systems – grouped by skill type as drawn from case studies.

Some of the identified skills are necessary across all sub-systems, while others are relevant to only a few. Specifically, **software engineering skills** such as data management, software engineering, requirements engineering, algorithms and infrastructure are all essential skills for the future energy system and all its component sub systems, as is the need for understanding the **wider energy system**. At the same time, the non-technical skills, such as understanding of **business models** that make new energy services approaches viable and **inter-sector management** and **communication** between increasingly complex sets of partners and collaborators is equally essential in order to fully realise the smart local energy systems of the future. In parallel, **engagement with the wider public** is becoming an essential component of many organisations and workers as they grapple with the complexities of rapidly changing technologies, interconnected sectors and the need to address both energy efficiency and the financial impacts of increasing prices.

4.2 Types of training

Our initial research conducted through 70 interviews with people involved in different elements of smart local energy projects and training provision, furnished a good overview of the range of ways that people develop the skills needed for future SLES. Whilst formal qualifications are essential

| Skills | Sub-Systems | | | | | | SoS |
|--|---------------|---------------------|--------------------|-----|------------|------------|------|
| | Energy Supply | Transport, Mobility | Building, Retrofit | ICT | Local Govt | Comm-unity | SLES |
| Energy | | | | | | | |
| understanding and managing grid loads and connections, with DNO | x | x | | | x | x | x |
| hydrogen as fuel | x | x | x | | | | x |
| Overview of Renewables/SLE Technology and integration | x | | x | | x | x | x |
| Engineering | | | | | | | |
| electrical engineers | x | x | x | | | x | x |
| data management and security | x | x | x | x | x | x | x |
| software engineering – for energy systems | x | x | | x | | | x |
| systems engineering and integration | x | x | x | x | x | | x |
| low carbon design for architects | | | x | | | | |
| building management systems, building services engineer | | | x | | x | | |
| Civil engineering infrastructure | x | x | | | x | | x |
| Data Analytics and Machine Learning | | x | x | x | x | | x |
| Application Development/Programming | | x | | x | | | x |
| requirements engineering, user exp. | | | x | x | | | x |
| Research and Simulation Skills | | | x | x | | | x |
| Connectivity, networking and telecoms | x | x | | x | x | | x |
| Algorithm design and monitoring | x | x | x | x | x | | x |
| Trades | | | | | | | |
| electrical technicians | x | | x | | | x | x |
| installation and maintenance of renewables | x | | x | | | x | |
| Installation & Integration (heat, smart meters, charge points) | | x | x | | x | | x |
| maintenance and servicing eg EVs, computerised systems | | x | | x | x | | x |
| Gas boiler / network decommissioning | | | x | | | | |
| retrofit | | | x | | x | x | |
| Managerial | | | | | | | |
| technical mgt, eg smart grids, building services | x | x | x | | x | x | x |
| data policy and governance | | | | x | | | x |
| Building Partnerships / Teams across vectors | x | | x | x | x | x | x |
| health and safety, risk mgt | | | | | x | | x |
| Cross-Institutional project manage / integrate | x | x | | x | x | x | x |
| Finance and business | | | | | | | |
| new business / financial models for integrating energy systems, EVs, batteries etc | x | x | x | x | x | x | x |
| operating with complexities of energy markets | x | | | x | | | x |
| securing investment, raising funds, managing grants | x | x | x | x | x | x | x |
| business and financial management | | | | | | x | x |
| commercialisation, product development | | | | | | | x |
| Procurement (materials and services) | | | x | x | x | | |
| Legal | | | | | | | |
| Contract Reading/Writing for SLES projects | x | | | | x | | x |
| Handling User Data (GDPR compliant) | | | | x | | x | x |
| Compliance, regs for financial, building, quality | | | | | | | x |
| planning regs | | x | x | | x | x | |
| Policy | | | | | | | |
| responding to changing regs | x | | x | x | | | x |
| Stable supportive policy for decarbonisation | | | | | x | x | x |
| Regulating Quality & Qualifications (work, heat, security, privacy...) | | | | | x | | x |
| Soft skills and awareness | | | | | | | |
| engagement with changing energy system | x | x | x | x | x | x | x |
| External negotiation and communication | x | | x | x | x | x | x |
| building trust, collaboration, inclusion | | | | | | x | x |

Figure 1: Skills shortages across SLES as a whole

for the technical side of delivery, many people had come into the projects from other parts of energy delivery – eg via working for fossil fuel companies, then moving to wind turbine or solar installation and onto more complex sustainable energy delivery. These people have often been driven by a desire to help address climate change or to work for more forward looking or innovative organisations.

Further analysis suggests 4 types of training provision / skill acquisition, which are:

- Formal training;
- Short courses;
- On the job and peer learning;
- Wider Knowledge acquisition.

4.2.1 Formal training

Formal training is mostly aimed at initial (recognised) qualifications for 16-19 year olds to start work, such as:

- School qualifications: i.e., GCSE, A-level;
- FE Colleges: i.e., A-level, T-level, HNC, HND, BTEC, NVQ, apprentices, level 3-5 qualifications;
- HE at colleges and universities: i.e., under / post-graduate degree: BSc / BA, MSc / MA, PG cert / diploma, PhD;
- Apprenticeships: i.e., Trades, industry, degree apprentices.

In order to end up with sufficient, well qualified workers at all levels up to and including graduates, it is necessary for information and encouragement to be provided at the earliest moment – i.e., before teenagers choose their GCSE subjects, so that future career paths are left open – this is especially relevant for STEM subjects with science compulsory at GCSE level.

Post-GCSE there is an increasing variety of choices and all 16-18 year olds are expected to be undertaking some form of learning whether or not they are also working. It is the FE colleges that are key here in offering a wide range of courses and qualifications aimed primarily, but not exclusively, at this age group.

Degree level engineering is a key skill in the future energy system across many aspects from software engineers to electronics, building services to construction, data analytics to system design and these engineers need to have broad skillsets incorporating not just core specialist engineering knowledge but skills in communication, management and integration of different aspects of systems.

4.2.2 Short courses

Short course aim to build on existing knowledge and qualifications and are provided by a range of organisations such as:

- Registered providers including professional bodies – in person / online

- Manufacturers
- Employers
- Colleges

Short courses serve to upskill or fill particular knowledge gaps. An employee might take a short course to fulfil a particular role e.g., energy assessor; to understand organisational processes e.g., in local government, or to work with particular equipment e.g., plumbers installing heat pumps or electricians installing EV chargers.

Colleges can make parts of longer courses available as individual modules, effectively short courses, to enable people already in the workforce to acquire new skills.

4.2.3 On the job and peer learning

Informal learning opportunities include:

- Learning by doing / learning on the job
- Peer learning
- Secondments, placements, shadowing

In this category of learning, no certification or proof is given, rather it is about developing those skills needed to do a job, learning from colleagues and across an organisation – or, through secondment, from another relevant organisation or different part of the same business. Secondments have value in bringing in external knowledge and fostering better working relations and understanding which ‘can really help cross-fertilisation between different fields.’ (A2).

4.2.4 Wider knowledge

- Conferences, seminars, workshops
- Reading
- Demonstrators
- Raising public awareness

This last category of learning covers all of the most informal learning, undertaken mostly voluntarily in order to explore more widely around a particular skillset. For example, this might involve seeing how other comparable organisations are working, discussing future ways of working and needs, exploring possible collaborations, and reading trade journals, industry publications and professional papers.

Public engagement also largely falls into this category and is recognised as an essential area if the wider public are to understand how the energy system is changing and for them to derive the most benefit from the changes. This is particularly important in understanding smart systems and recognising not only the potential advantages but also how to reduce risks from data sharing or inability to use specific controls.

| Key words | Number of relevant / current quals | Max / min learning hours | Levels | (Examples of) qualifying bodies |
|----------------------------|--|---------------------------------------|---------------------------|--|
| heat+pump, | 16 – including industrial systems and combined with Aircon | 540 / 30 | 3, 2 | BPEC, C&G, LCL, |
| electric+vehicle+charging, | 5 | 20 / 8 | 3 | C&G, EAL, ETCAL, LCL |
| smart+meter, | 3 | End Point Assessment | 2 | Smart Awards, Pearson, EUIAS |
| renewable+energy, | 2 | 60 / 32 | 3 | G&G, ECTAL |
| Solar (PV) | 4 | 160 / 35 | 5, 3 | NOCN, LCL, EAL |
| Solar (thermal) | 2 | 100 / 35 | 3 | LCL |
| wind, | 3 | 480 / 182 | 3, 2, 1 | ITC First |
| retrofit, | 8 | 170 / 30 | 5,4,3,2 | ABBE, OCNWM, ETCAL, NOCN |
| insulation, | 31 – not all are relevant to retrofit | | 3,2 | ABBE, C&G, ProQual, SQA, IETTTL, NOCN, GQA |
| project+management, | 15, of which 1 is directly relevant | 1640 max general PM, 340h specific | (7, 6, 5, 4,) 3 | EAL (Level 3 NVQ Certificate in Building Services Engineering Technology and Project Management) |
| energy+management, | 13 | 250 / 15 | 3, 1 | ProQual |
| data | 60+ across a range of data areas | | All from 7 to entry level | BCS, C&G, Ascentis etc |
| computer | 16 mostly A-level / GCSE in Computer Science | 500 / 120 | 3, 2, 1, entry level | WJEC, AQA, IBO, OCR etc |
| policy | 1 | EPA | 4 | IAO (Level 4 Policy Officer End Point Assessment) |
| engagement | 6 but nothing specific to energy or environment; design, community and social capital are themes | 150 / 30 | 6, 5, 4, 3 | OCNLR, Prospect, NOCN |

Table 1: Search for Ofqual qualifications

4.3 Ofqual Qualifications

The search of the Ofqual register qualifications [14] identified both the range of qualifications that are potentially available to learners and the bodies able to award these qualifications. An example how the search was conducted is shown in appendix A. City and Guilds is prominent but by no means the only relevant awarding body, others include Pearson, ETC Awards Ltd (ETCAL) and the open college networks (OCN) such as West Midlands (OCWM), London Region (OCNLR) and Northern (NOCN); and there are also awarding bodies relevant to particular sectors such as:

- Awarding Body for the Build Environment (ABBE)
- Energy & Utilities Independent Assessment Service (EUIAS)
- Insulation Environmental Training Trust (IETTTL)
- Chartered Management Institute (CMI)

The majority of relevant vocational qualifications are at level 2 or 3. Our analysis shows the variety of qualifications potentially available to learners which span from full time courses lasting a

year or more to short 1-2 day courses.

Interviewees noted that some of the accredited courses are not kept current and that FE colleges struggle to find sufficient funding to update their own provision.

Importantly, as shown in Table 1, most skills noted to short supply (see Fig 1) seem to have training provision that could support their delivery. Yet, the SLES case studies [1, 3] demonstrate shortage of skilled professionals. The question of why the shortages persist was discussed as part of the focus groups, with some conclusions presented below.

4.4 Provision of training by Further Education Colleges

The many FE colleges across the UK play an important role in providing students with a range of learning options such as apprenticeships, A-levels, HNCs, vocational degree courses and a variety of short courses. The colleges would be ideally placed to support the evolving training needs of the SLES workforce. However, discussions with college leaders pointed out concerns focused on:

- Obstacles to new skills adoption
- Challenges due to qualifications accreditation processes;
- Challenges of the broader skills provision ecosystem.

Each of these issues are discussed below:

4.4.1 Obstacles to new skills adoption

New skills adoption is discouraged by:

- **Lack of industrial interest**, e.g., as stated by T2 “larger house builders. They are not applying some of these technologies at any scale” which, in turn is driven by:
 - **lack of (front-line) expertise**, as current *staff do not have or value the new skills*. E.g.,: “They are not applying some of these technologies at any scale. Partly because of a lack of expertise ” T2. In other words, as the (front-line) workers do not have the new skills/technologies, these are not used, and as these are not used, they are not “asked for” by the employees and employers either. This is confirmed by data from interviews with the the case study participants [1, 3] where the professionals do not feel the need to take on extra training (e.g., no need to learn to install heat pumps when one has more than enough work installing gas boilers, even more so when there is no real pressure from customers asking for heat pump installation to start with);
 - companies’ **focus on financial gain** rather than adopting new (sustainable) technologies, e.g., “some of these technologies being built into these projects don’t support maximising the bottom line” (T2). This too is confirmed by data from interviews with the case study participants [1, 3] (e.g., “...let’s build quick and deal with the problems later” aiming to build to minimum specification and as cheaply as possible (P11).
- **Lack of student interest**, which (for colleges) is explained by the lack of student’s knowledge about the current technologies or professional development options, as stated by T3 : “Students will come to us and say ‘I want to be a carpenter’. They won’t be saying ‘I want to

be a heat pump engineer' or that type of thing." This is because students do not get this information as part of their career guidance at schools. Thus, T3 suggests that "career guidance from schools should be a consideration as well".

- **Uncertainty due to rapidly evolving technologies.** As stated by T2 what is "quite challenging is a definition of what those skills are in such a dynamic environment where technology is moving so quickly." So, as a result, "there's a lot of people sat there going, well we think it might be this, but it could be that. And we're not going to commit a whole bunch of resources to it." Thus, programme development is postponed till the need for technologies is confirmed through *industrial demand*.

4.4.2 Challenges due to Qualifications Accreditation Processes

Colleges are constrained by the **availability of recognised qualifications** that they are able to offer, noting that "from a curriculum perspective a lot of our teachers will simply teach what's in the core qualifications ...the primary purpose is to get students qualifications" (T3).

Presently, the **process of development and accreditation of new qualifications** is such that the colleges must:

- consult with industry to identify the need for skills,
- develop the qualifications and submit to awarding bodies for accreditation,
- the awarding bodies will carry out their own checks (e.g., own consultation with the industry for need identification, review by specialists for content and teaching method's suitability, etc.) and potentially accredit this qualification.

However, this is:

- a rather **slow process** due to the way that the current awarding bodies accredit new programmes, e.g., T3 "...we could have a conversation with an employer tomorrow and if we weren't bound by the frameworks we're bound by, we could probably get something together in six to eight months ready for launch. But when you start obviously then working with awarding organisations, you delay that process several fold."
- "...there's always an **element of risk involved** ... So of course it comes down to *funding and flexibility with the awarding organisations*" T2. As previously noted, the risk is particularly high when the *technologies are continuously changing and the demand from industry and students is not very strong*. One solution proposed to this "chicken and egg" situation (i.e., where qualifications are not developed because the employers do not ask for them because they are not qualified to use them) is **fostering of the demand for new skills through government policy**. For instance, the policy of phasing out gas boilers by 2035 is creating demand for heat pump installation skills, though given the long lead period, gas boiler installations are still steaming ahead.

In summary, the current accreditation processes required the colleges to take on the risks of new qualifications development. Yet, as previously noted, the majority of skills asked for within the SLES domain seem to have some teaching provisioned in the existing qualifications. How, then, can the qualification development risks be reduced and the skills needs be met?

4.4.3 Challenges of the broader skills provision ecosystem.

This issue is addressed in more detail in the following section

4.5 Recommendation for improvements to Qualifications Accreditation Frameworks

Given the fact that (i) qualifications have various skills and training aspects which could be relevant to other qualifications; (ii) there is a changing technology landscape, as well as (iii) manufacturers having differences in their product offerings and specifications; the focus group participants advocated the need for a more **Agile Qualifications Framework** as well as **government policy fostering demand for new skills**.

The **Agile Qualifications Framework** would:

- Support **hybridisation** of qualifications, which implies that the awarding bodies would “automatically” award qualifications composed from a set of previously accredited units, even if these units were previously approved as part of different qualifications (e.g., take units on data analysis from a Data Science qualification and teach these as part of a mainly Marketing qualification, awarding the “Marketing with Data Science” qualification as a result). Ideally, this hybridisation would be supported within and across accrediting bodies as well (e.g., combining units accredited by Pearsons with those from City & Guilds) (though this maybe an aim to be achieved in a little bit of a longer-term). Such *hybridisation process* (i.e., integrating skills from traditionally one job/qualifications area into another) are observed to be a trend in present-day job market [16, 17] and should have better and clearer support in training delivery models.
- Support **technology hybridisation** (i.e., supporting technology agnostic qualifications), e.g., as stated by T ?¿ ‘...with plumbing technologies, it will be this type of boiler or that type of vented heating system. It just means that they’re rather obsolete. I mean I come from an aviation background and the apprenticeship standard ...there was a part in there about using wood and canvas. Well not many of our apprentices that worked at British Airways would often encounter wood and canvas constructions ...’. It is suggested that it should be possible to replace such specifics with modern techniques and technologies without needing to get the qualifications re-accredited. Furthermore, as professional development continues throughout the lifetime of the employees, there should be a mechanism in place for **accreditation of life-long-learning** activities. In this way, where new skills are required and applied (e.g., retrofitting skills, or heat pump installation), the qualifications gained need to be recognised, respected and work quality checked in-situ so that high standards are maintained, and employers and consumers can have confidence in workers employed to deliver their needs.

5 Findings per sub-systems

Through the initial exploration of skills via the case studies and interviews, we can assess some of the wider training needs and issues in relation to the different sectors and sub-systems identified. The three completed case studies have identified a range of areas where training is particularly needed and the respondents have discussed how this training is best delivered to upskill and

prepare a future workforce in these areas. As with the case studies, this is split into the key subsystems making up SLES and the discussion below explores the different training approaches for each subsystem. We have, separately, listed all of the skills identified and here concentrate on those areas identified by respondents as being most in need of more training.

5.1 Energy Sub-System

5.1.1 Areas of Training Need for the Energy sub-system

The key areas where training is considered to be particularly necessary in the energy sector are detailed below. Energy system understanding is necessary across all these areas, keeping current as new technologies are developed and deployed, alongside a greater awareness of the software and data requirements, regulations and integration potential within and across energy installations.

Engineering:

- Power Systems Engineering integrating with new technologies - traditional Power Systems skills are still essential, but training on integrating and utilising new technologies (such as microgrids, hydrogen supply, etc.) is still limited and ‘there is often a lack of MSc students in Power. More students should be encouraged to complete an MSc degree’ (A1)
- Software and Systems Engineering for the Energy Sector as it transitions from a largely mechanical system to a software-intensive socio-technical one. Thus, hardware deployment with connectivity to data collection and transmission networks is necessary, along with customised hardware to support such networking availability (e.g. smart meters, augmented with consumer access devices). On the software side, the industry needs reliable data analysis and service delivery platforms, applications for user engagement and information, along with algorithms for assets utilisation optimisation. It must be noted that training for all of these skills is currently delivered within Computer Science / Informatics disciplines. The key challenge is in attracting well-qualified individuals with these skills into the energy sector.
- Data Scientists for Energy Sector also need to be trained, as data is fast becoming the key driver of innovation in SLE as well as the essential ingredient for collaboration across the SLE subsystems.
- Battery design as part of engineering degree courses: ‘...it would be great to introduce battery storage understanding into electrical engineering courses ...or other engineering courses so that students could start to understand battery cell chemistry. Where batteries are applied, why they’re applied...battery across the board would be great to be introduced into these types of engineering courses (E18) ... ‘to find people with large scale battery storage skillset is not always that easy. It’s still fundamentally quite a new market and I think it’s not necessarily taught in colleges yet.’
- Hydrogen: with ‘involvement in hydrogen as a transport fuel. ... there will be quite a lot of training as required for that. We’ll need technicians, we’ll need mariners that are skilled in using these systems and developing these systems’ (R2).

- Transmission network operation: ‘the biggest thing is understanding the transmission network that you’re going to be working with... having somebody as a specialism and training people up to understand how that works maybe on a UK basis and how that looks now and how that’s going to look in the future’ (R3)

Trades skills:

Installation needs for various renewables and for low-carbon technologies, such as charge points, heat pumps, heat networks, large and small-scale batteries and even smart meters is continuing to accelerate. Thus, training for new installers is becoming critical, if a bottleneck in skills availability is to be avoided.

- Solar and combined battery installation: ‘solar courses are very difficult to find. I think just the demand for them is much lower now. They used to be available everywhere. (R12). Similarly for integrating batteries into a solar system: ‘information on integration of solar and battery systems. I’ve struggled to find any clear information or guidance on how to do that. I’ve spoken to some suppliers who don’t appear to have software that clearly shows the benefits to the customer of a battery system which is really what the customer would want to see before they spend lots of money on it.’ (R12)
- Combining traditional engineering and trades skills with new IT and data: “...a lot of old boys who are very good at really getting stuck in and getting covered in grease and oil and mud ... And then you’ve got modern whippersnappers ... [who are] quite adept at data. And it’s around trying to see how that skillset requirement matrix changes so that these skills can be brought together and there is mutual understanding across skillsets” (E16).
- New electrical skills for electricians: ‘your standard electrician training, ... should become part of an apprenticeship, these new technologies where they look at how all these new electrical loads are connected and how you do it safely and what the standard has to be. So a lot of the skills are already there, it’s maybe just getting more people involved in them’ (R7)

Management

- Managing multi-stakeholder, large scale implementation projects across sectors and disciplines is the key management skill and an aspect where training would be beneficial. This is because SLE projects require the participation of many stakeholders, and tend to last for a long time, with stakeholders often progressing with their semi-independent agendas. Managing such projects requires skills in integration, knowledge sharing, coordination, and the creation of a long-lasting project identity with shared goals, outlasting individuals/stakeholder participation. From a technical perspective’, ...it’s having people that understand all of the elements that pull together battery [or other energy] projects” (E18). Data understanding is also key, for example, to combine data from “different types of datasets, be they temporal, spatial, behaviour science... You’ve got to have the ability to look at socioeconomic factors. So there’s a number of aspects there and also combining them with traditional engineering” (E16).
- Understanding current regulations as ‘regulation certainly does present a lot of blockers delivering decarbonisation solutions. Both energy and financial regulation. You’d almost need to have a degree in energy regulation to know everything there is to know about it. I don’t

know whether that is worthy of having short courses available for new entrants into the energy sector. It's becoming an increasingly important part in being able deliver solutions is to understand what regulation is all about. (R4)

Finance and business

- Developing, trialling, and roll-out of new business models is another area that should be supported with training provision, particularly within the incumbent energy players. Given the long history of slow change within the traditional energy sector, many incumbents find the current fast-paced changes challenging. To avoid business breakdown (as has been seen with energy companies in 2021-22), innovation in service delivery must constitute a core part of the energy business. Thus, training in formulating sound business models, trialling, and rolling out successful models to the wider business is a very relevant need.
- Business courses too need to include new models for energy, for example “at MBA level where a student could start to understand how to finance or build a business model for a renewables project” (E18).
- Energy trading, grid balancing etc: ‘it takes a year or two years if they’re fresh to aggregation and balancing, it takes that long for them to really get their head around what’s involved in balancing the network. ... how it works, commercially and technically and all of the different types of balancing services from frequency response which is very short-term response to longer term reserve services to balancing mechanism ... I think there’s probably an opportunity for training courses to be developed which provide a good introduction to new energy sector workers as to what grid balancing and flexibility are all about (R4)

Soft skills and engagement

- Understanding energy for engaging the public: ‘we’ve struggled in condensing down our messaging to short consumer sound bites to kind of explain all that kind of stuff and that will continue to be a bit of a challenge. ... in terms of the resources and in the training courses for current and future staff of ours and also in the industry.’ (R4). ‘We’ve learned a lot about battery installation ... to be able to talk to customers about it and to help them’ (R5)
- Public understanding of future energy systems: ‘show the public exactly what the grid is going to look like in the future based on heading towards a fully electric network. And there’s going to be very little fossil fuel use in the next 10 to 20 years in terms of transport.... What the ramifications are for the whole country from adding that additional load... And then just what they can do in their own home in terms of adding solar or battery or any type of renewable. And what the benefits of that are, what their home would need to look like to do that. Whether they need to look at further installation or what the prerequisites are in order to actually electrify your home fully.’ (R7)
- Training in Handling Energy Data is relevant to engineers, managers and the wider public. Here, skills in data protection, aggregation, sharing, and monetisation need supporting.

5.1.2 Training delivery for the Energy sub-system

Training can be delivered in different ways and, as there will be “a step change, in terms of energy and society, we need to rethink how we handle that training” (E16) in order to bring new skills to a

range of energy professionals. It was also noted that ‘Public perception of engineering jobs is very important. There has been a great push on STEM subjects, encouraging students and particularly girls. [However] I am not sure if the image of engineering has changed much in the public eye. This affects then the number of students taking up engineering at university and after that taking up a job as an engineer.’ (A2) This perception is key to recruiting the best students into these key skills for the future.

Formal education:

- Higher education is particularly relevant for engineering and technical skills and engineering is key to so much of this, so university courses have a critical role to play in ensuring sufficiently qualified professionals for the future energy system. However, some universities are not “particularly good at changing quickly as an institution” (E13). This is across engineering courses, and undergraduate and postgraduate courses need to stay current and could benefit from “actually going out and asking what industry wants” (E13), although there can be some reticence from academia to be seen too “subservient to industry”. The undergraduate and graduate degrees in Power Systems, ICT, and Maths were pointed out as the most relevant by the DNOs. However, the energy sector has other close engagement and training collaborations with the universities, including:
 - Training through the IET (Institution of Engineering and Technology) Academy, whereby the “IET actually looks at the universities in terms of the courses they provide in power engineering and their suitability for the sorts of roles and jobs we’re looking for.” (P24). The Academy also mediates as companies “...sponsor students through their university degree as part of that process looking to recruit them at the end of that”, and also delivers “summer vacation training ... they [students] get a bursary plus they get paid over the training periods ... during the summer” (P24);
 - MSc Projects, with “ students ... coming each year to do Masters theses” (P2) based on the ongoing and completed innovative SLES systems (such as the Owen Square microgrid of CEPro in Bristol);
 - Joint Research Projects with companies submitting joint research bids with the universities to undertake new research.
- Apprenticeships “rather than just looking at the graduate intake ... [the companies] are also looking at the more technician type level” (P24) through apprenticeships in “traditional skills, line build, cable jointing” and more recent “schemes for cybersecurity and for IT type areas” (P24). ‘Your standard electrician training, ...that should become part of an apprenticeship, these new technologies where they look at how all these new electrical loads are connected and how you do it safely and what the standard has to be. (R7)
- School Education is a valuable starting point and ‘having something in the curriculum that helps children understand what are the interplays between the environment, society, energy, transport, heating, whether it sits within geography, physics, or another course... with the onset of technology being readily incorporated into the curriculum we’d really like to see that whole system piece being brought in as one of the subjects.... if we can start to shape their thinking from an early age, I think there’s a double benefit there, they might join the industry, they might help advance it. But they also might just be willing to adopt new technologies

and new processes” (E16). Schools are suggested as having a key role in setting up the foundations for the training needed for working in the energy sector, as it provides the basic knowledge of:

- STEM Subjects, which are key for the SLE engineers;
- Renewable Technologies, that must make up the SLE, and notions of it
- Systems and their Interactions, which relate to the SLE SoS subsystem components and their inter-relationships.
- Environment and societal change

Short courses

- Internal upskilling is used, particularly where the training is expected to be ‘.... benefiting the company for a longer period of time” (P9). For example: trainers/ consultants would be hired “to come in and do that training for us” (P9). In the longer term, the companies would often “...look to bring it [i.e. skills and 3rd party platforms supported by those skills] in-house as rapidly as we can.” (P24).
- Professional courses: external training providers (such as ETAL) are often employed to help employees (particularly the newly employed recruits) gain the “detailed knowledge that they need” for specific job roles.
- Online Courses are also noted as a possible training method, however, these are only relevant as “Maybe a starting point” (P2), as more practical skills needed within this sector cannot be acquired without hands-on engagement. However, ‘We have found recently that options have opened up because the option for remote training is much more available since lockdowns’. (R12)
- Webinars: ‘there were lots of webinars, there’s lots of material published by the National Grid which kind of detailed the new services and their technical requirements’ (R4)

Informal and Peer learning

- Peer learning or ‘internal knowledge sharing’ (E18), is carried out in-house (E16) whilst knowledge sharing across partners: for example by ‘bringing up a team of engineers [from the mainland] which also then did some training with engineers in Orkney’ (R5) in order to support smart meter installation is another route.
- Learning by doing / on the job: would be used, in particular, when new roles and responsibilities are emerging for the first time. For instance, when WPD were to move from a DNO role to a DSO, they “... took people and effectively they learnt on the job in terms of what was needed for those areas” (P24). With bespoke systems, ‘there really is only one place to get those skills from and that’s spending time working on our systems. So there’s no course you can go on, there’s no external training you can get for this. You just need to spend time with our control engineers (E7). In some organisations, there is ‘very much an ethos in the business to knowledge share, be open, key learnings, if you get it wrong why did you get it wrong, learn from it, that constant continuous improvement (E18).

- Placements and secondments are used by businesses to support learning about different aspects, this is especially good for graduates or junior staff. Some businesses also train new recruits by shadowing existing staff members.

Wider Knowledge

- Sharing experience across organisations is carried out through pilots/demonstrators, or presenting/discussing their own experiences at conferences and workshops. Pilot and Demonstrator Projects are a valuable source of evidence on what and how the new technologies can deliver. Unfortunately, “There aren’t really a lot of pilots around. ... So we’re not seeing the outcome of those pilots yet” (P9). These, nevertheless, are useful for all SLES stakeholders: from the general public to policy makers and energy companies themselves. Conference Attendance is also used, e.g. P9: “We attended quite a few conferences ... attending as much as possible from a learning perspective”.
- Public awareness is also a model of training, though it is aimed at the general public (not workers within the energy sector per se), informing the public about new technologies, SLE services, and their benefits and impacts. This can be done through the usual channels used by the companies for marketing and advertisement. However, it can also be supported with “visiting sites where they [renewable technologies] are installed more often and being more exposed to that kind of technology” (P2).

5.2 Transport and Mobility sub-system

5.2.1 Areas of Training Need for the transport and mobility sub-system

The key areas in T&M where training is considered to be particularly necessary are:

Engineering

- Specifically, Software Engineering, Electrical and Electronics Engineering and Systems Engineering - within the SLE context, Transport and Mobility is one of the core subsystems, providing both transportation services, and also acting as a massive distributed battery system which stores electricity generation, provides flexibility services (e.g. by deferring or pushing forward the charging times) and regulates grid frequencies. Thus, engineers must be trained to deliver and maintain this smart subsystem. A highlighted focus is placed on such skills as:
 - Requirements Engineering (so that the right system is built)
 - Systems integration (so that the various components, such as EVs, charge points and pricing systems, can exchange data and exercise control)
 - Programming, so that various monitoring, learning, control, and evaluation solutions are developed specifically in the transportation context

Trades

- ChargePoint installation and maintenance: The CP operators say that ‘we train our installers thoroughly ... We don’t just sell a box off the shelf to anyone for them to install, however much of an electrician they might be’. (E12) As the market grows this need will increase.

At the moment, there is no common standard or universal training approach which might allow an operative to become a 'registered EVCP installer' able to install any EVCP so this is "one thing that would be great from an industry perspective ... if you are trained to install an electric vehicle charger, that you are therefore trained to install any electric vehicle charger." (E12). Once installed, CPs need to be maintained and any problems resolved fast in order to engender consumer confidence in EVs. "...there will be benefits to hiring people who we can train up in our fleet of chargers. Because we have a range of different charger manufacturers... there's real added value for us in having the in-house team that know all the foibles of each individual charger ... I think that's the main area for training for us" (E15). In other areas, 'we are really struggling to get guys up to do the maintenance for the chargers and we've been talking to one of the local electricians to see if they would be interested in getting trained up and I think we're going to go down that route now.' (R2)

- EV maintenance: 'There are different levels of training... on high voltage systems and diagnosing on-board charger faults'. (R6) Note that 'training for electric vehicles, a garage would have to pay for somebody to go to a training centre for three days just to do the fundamentals. And that's somebody not working on cars for three days. So I think it is a bit of a problem. Especially if the organisation or the people in charge of the organisation are sceptical that electric vehicles work' (R17)

Management

- EVCP / EV fleet strategy and planning: There are two key areas where planning a future EV strategy needs new skills and where training would help. These centre around:
- (Local authorities) developing a chargepoint strategy for the whole city, or a car park or a business and
- Fleet operators developing a fleet strategy. There is no manual which says "these are the things you need to think about. These are the kinds of teams and people you'll need to get involved. This is how you can apply for the grants" (E12) so developing training in this area would be very beneficial.
- Awareness of Local and National Policy, SLES and Renewable Energy knowledge, helping to show how T&M interacts with and contributes to the SLE SoS agenda at large (e.g. clean air zones; charge point installation only for OCPP standard products, cybersecurity, system integration).

Finance and business

- New Business Model Development, so that commercially viable organisations are set up and able to progress the agenda for T&M in SLES. Chargepoint developers in particular are exploring different business models.

Soft skills and awareness

- Understanding EVs by fleet managers, policy makers and the public needs more education. It is suggested that 'the best learning is by living and breathing and driving an EV. I talk to people that are doing tenders, that are buying EVs. Responsible for massive budgets

and they've never driven one let alone plugged one in. They have no idea of the quirks, the ease, the nightmare, the worry, the dream that is waking up every morning with a full car battery, until you live with it. (E12) This immersion in the EV experience is not always possible but facilitating it where it can be, such as the OCC taxi trial, is a great way of building that knowledge. Similarly, for citizens: '...what are electric vehicles? How do you drive an electric vehicle and the multitude of chargers...? if you've invested in an electric car do you understand that the way you use your vehicle has changed. And then optimising a charger to fit the grid, your life is going to change again. Like your car is just not going to be charging straightaway. So I think it's all sides of the sector have still lessons to be learned. (R17)

5.2.2 Training delivery for the transport and mobility sub-system

Respondents noted a variety of training modes and levels, given that both highly-skilled and generic trades skills are needed. However, for SLES, the T&M sector is becoming more skilled and more digital. In ReFLEX and ESO, the emphasis was on EVs and EV charging whilst the Bristol study took a more holistic view.

Formal education

- Higher education degrees are prerequisites for many roles. For example, algorithm developers (e.g. for resource/route optimisation problems) are expected to have PhD degrees; those working with telemetries and data analysis would have MSc / BSc level qualifications - mostly in ICT or Electronics Engineering and Power Systems/Energy. University education is sometimes considered to be too theoretical and graduates are expected to supplement the degrees with practical experience.
- FE colleges deliver HND qualifications which are relevant for those employed on the "shop floor" (P21) of the manufacturing sections of the T&M firms and may also deliver short courses to supplement electrician skills to install EVCPs or maintain EVs.

Short courses

- Internal upskilling / training: for example in relation to EV knowledge and for sales and promotion: 'I've been training the staff here myself. I'm not aware of anywhere where you can send somebody to be trained, that's not been set up yet.' (R6). For chargepoint installers, training sessions are delivered to company employees either in person or (due to covid) virtually: "full day face to face and hands on... [or]...it's delivered virtually. They then have access to our installer portal that has all those training slides, supporting documents and everything they need that they can download at any time as well" (E12). This sort of training is also applicable to chargepoint maintenance where the employees are trained "to operate and deal with typical maintenance issues going forward, regular maintenance but also reactive maintenance ..." (E15).
- Training delivered by manufacturers: 'we've got two or three different types of chargers on the island so we need to do two or three different training courses ... it's just really getting signed off with the manufacturers so that they're happy that we can keep the warranties going' (R2)

- Professional courses: At a fleet level, ‘the Institute of Car Fleet Management does actually do fleet management courses which are quite intense but they are constantly evolving to incorporate fleet strategy’ Also, ‘Reed’s pretty good on doing a basic understanding. They do a fleet course but it’s so old school it uses Volkswagen diesels as an example’ (E2).

Informal and Peer learning

- Peer learning: ‘we had more senior, more experienced electricians who had already done that or done professional training who could pass on the knowledge...’ about EVCP installation and maintenance (R12).
- On the job training/ learning by doing - for example, developing a fleet strategy: “You learn a lot by talking to charge point companies but you could also buy a consultant and he could work with your distribution network operator and talk to some charge point companies and then you could work out what your specification is for chargepoint installations or a fleet strategy” (E14).
- Local upskilling, community benefit: ‘we are getting these guys trained up [in charger maintenance]. I think we are probably contributing to the cost of training the engineers and that will give us a resource that we can call on. I think that’s quite a good way of upskilling the local guys and also having a benefit for ourselves’. (R2)

Wider Knowledge

- Public awareness: introducing people to EVs and myth-busting around perceived EV issues is best accomplished through providing opportunities for lived experience, e.g. through rental trial or EV loans and discussions with current/practicing EV drivers/owners, etc.
- Personal development: ‘I did a couple of seminars online and bought the books and read it, so it was just really home study for [EVs and EVCP understanding]. But there are training courses available online, I’ve been looking at a couple of them just out of interest to see if I can push my knowledge a wee bit more’ (R2)

5.3 Building and Retrofit Sub-System

5.3.1 Areas of Training Need for the Building and Retrofit sub-system

Building and retrofit is a key area to address in reducing demand for energy and creating connectivity with other parts of the energy system, it is thus important for upskilling and providing the right training. It is also a difficult sector to engage with, many businesses are small or individual traders with little capacity or desire for undertaking training, coupled with a lack of availability for training in new building methods and lack of capacity or funding for colleges to develop such courses.

Engineering

- Building physics i.e. the understanding of the movement of heat and moisture in buildings, so that the resultant (retrofitted) buildings are more comfortable, energy efficient and healthy – ‘if you don’t understand why some data are behaving in a certain way or what are the relationships between temperature and humidity. OK you can do a specific task but you are not able to provide meaningful information’ (R15)

- Building Biology, i.e. the understanding of health hazards in the built environment: from chemicals in building materials, to allergens, mould and so on. This will help the B&R professionals to choose the right materials and deliver healthy dwellings.
- Building management systems integration: understanding data needs, AI, integration with wider energy systems, building physics and integration with different systems required in the building to optimise energy and heat.
- Low carbon design – should be a core component of architect training so that whole buildings are designed to maximise energy efficiency ...'learn about heat pumps and ... low carbon designs for buildings... fabric first' (R2)

Trades

- Heat pump installation: working with 'qualified plumbers ...[who] usually do a specialist qualification at college for heat pumps' (R12) - this is mostly upskilling existing heating trades. However there are barriers: 'just providing the heat pump courses is not sufficient because they're losing out on the work on that particular day when they're training. So who pays for that upskilling?' (E5)
- Groundworkers will be needed as operations continue to scale up, this is for boreholes, trenching, pipe-laying, cabling related to heat pumps and district heating
- Electricians are predicted to be in short supply as needs increase and existing workforce retires: for someone 'relatively bright and motivated and wants to train as an electrician, you're not going to get him on a 16-year-old apprenticeship rate or minimum wage. You're looking at paying probably £8 to £10 an hour for somebody to get started... That's the big problem, training of electricians is going to be the big issue I think.' (R16)
- Delivery of retrofit, including an overview of the whole house in relation to a number of retrofit measures and their likely benefits and sequencing, eg insulation (ensuring the avoidance of condensation and mould, thermal bridging, sealing the edges of insulation and seams around joists etc), renewable technology installation, such as solar water heaters, PV, batteries, and smart systems to manage domestic technologies efficiently
- Building with new methods, such as brickfree building, passive and low energy house building.

Management

- Operational oversight requires additional knowledge in order to effectively oversee retrofit programmes, ensuring that there is a knowledge of the required processes and standards of delivery on site.

Finance and business

- Understanding grant options, managing citizen referrals, working with 'other organisations that provide information on heating and grants, they did some training with my team so that they knew how to refer people on' (R5)

Soft skills and awareness

- At the consumer end, the current level of public awareness and acceptance is low, so this is a further area of education and training. Many consumers never switch energy suppliers and, switching not just to a new supplier but to a new type of agile tariff requires a level of engagement and education. This also extends to understanding how smart thermostats work and building trust in the system.
- Work Ethic has been flagged as an issue in some parts of the building trades where a conscientious approach to work in order to build to the correct standards is needed to ensure that expected impacts on energy efficiency, health and the environment are delivered, as well as benefiting those who will use the resultant buildings.

5.3.2 Training delivery for the Building and Retrofit sub-system

Training in Building and retrofit spans the full spectrum from graduate courses to community-led training to cover the technical as well as practical skills needed.

Formal education:

- Higher education is key to developing sufficient engineering skills across all areas for theoretical and science-based professions such as architectural engineers or data analysts, eg in the design and presentation of smart home controls and optimisation systems. It is relevant for building services engineering where companies ‘...try to leverage universities which already use and teach [particular] software. ... from a consultancy point of view, people that come from those universities have already had kind of a basic training and they don’t have to start from scratch’ (R15)
- FE colleges are key in bringing new entrants into the industry, but this takes longer ‘in terms of training engineers to be able to install heat pumps and be MCS accredited and things like that. I suspect they’d probably need a 12 to 24 month lead in time between a programme being announced and them actually being able to get enough people through the training that’s required’ (E10). While “NVQs and HNDs in building services are generally focused on new build” (P7) and these skills need updating, trainees also need to learn about retrofitting older buildings. Newer building techniques are still often absent from FE courses and it has been suggested that colleges do not have the funding to update their training provision. Some students might need to be sent further afield to receive the necessary training, eg from Orkney to Inverness or Thurso.
- Apprenticeships are a common way of training many of the trades needed in building and retrofit but, as so many of the companies involved are SMEs, there are limitations to how many of these types of employers are able to support an apprentice. Slightly larger organisations, employing upwards of 20 people might have more scope: ‘every year we have a number of school leavers asking about apprenticeships. ... a few come and do work experience with us and we usually select from them one or two to do their apprenticeship. ...they all do their apprenticeship through block release, ...[to] get their SDQ. ... their apprenticeship training is done at campuses on the mainland in Scotland. So electricians go to Thurso, plumbers go to Inverness’. (R12) More flexible or shorter apprenticeships might also be possible, for example in groundworks where: ‘a mini apprenticeship with the drilling and

trenching companies' could be appropriate. '...it would be a good foothold into the industry and give them a good grounding for going further on in the same industry later on.' (E6)

- Schools have an important role in driving aspiration and helping to steer young people into future-proofed jobs although 'career guidance is very basic still from schools ... it's not nuanced enough to recognise some of these technologies. Students will come to us and say 'I want to be a carpenter'. They won't be saying 'I want to be a heat pump engineer' (T3)

Short courses

- Internal upskilling for example, with heatpumps, a new subcontractor would 'do a morning's training before they start on site' (E3) and then more experienced colleagues would support the initial practical installations. This is also applicable for new software for building services or training in new regulations for electricians: 'they [colleges] come and do courses up here which they can do for numerous people all at once. So if new additional regulations come out then they would normally come here and do en masse training.' (R12). Another example might be where the innovation delivered is new and specific, such as thermal imaging with air pressure use for energy surveying at CHEESE (<https://cheeseproject.co.uk>): "... nobody else is doing what we're doing so we're training people. We run at least one training course a year" (P13).
- Training from the manufacturers of a particular product is delivered to ensure correct installation or to introduce the technology to managers, e.g.: '...undertake a half day training on what installers might do, sort of a lighter version so that they can witness the process and what they need to know when they're overseeing works onsite' (E10).
- Online Courses, such as those from the Association for Environment Conscious Building (AECB) on retrofit are available, yet are limited in content, and new material (e.g. on building Physics and Biology). The Green Register (<https://www.greenregister.org.uk>) has also set up online training, in addition to its in-house provision. This mode, however, is less suited for practical skills development, although AECB uses photographic evidence of completed practical tasks as part of its assessment.

Informal and Peer learning

- Peer learning: i.e. learning from colleagues, either from within the same company, or from peers outside of one's own organisation, is another well-established method. 'It's really just with people pairing up on site. ... a skilled person taking onboard a younger electrician and training them ...[eg in installing] car chargers or batteries ...to pass on the knowledge' (R12). In Bristol, the Toolbox Talks programme was initiated by Green Register through the Futureproof project (<https://www.futureproof.uk.net>), whereby if "... a builder would like an hour's training on site from another builder about a particular area" a Futureproof qualified (FAB: Futureproof Associate Builder) peer will be invited to deliver the training.
- Learning by doing: in building services for example, 'it's a field where experience is important... We are training ourselves on our software but experience and seeing loads of cases and loads of different projects and systems makes the difference.' (R15) This is also relevant for practical skills, where the content '... is not complicated but it does require patience. And it does require you to want to learn and not to rush it' (P11), such as laying insulation or learning to be a "draught buster" (P13).

- In-Community Training: is delivered by local community organisations and for community benefit “... skilling up of local people who might be unemployed” (P13). It is aimed at developing the sense of ownership and engagement within the local community, as well as upskilling the local residents “.. it’s not a company coming in and just doing it and leaving again... you can have ownership” (P18).

Wider Knowledge

- Public awareness raising is necessary to improve understanding and acceptance of technologies by the citizens, e.g. ‘Agile tariffs are not for everyone, but I think people should be first educated to understand how they work’ (E5).

5.4 ICT for SLE Sub-System

5.4.1 Areas of Training Need for the ICT sub-system

ICT is identified as a separate sub-system but as we have already noted above, it is a key component in connecting across technologies and systems and is developing rapidly. The key areas for training in the ICT subsystem are primarily focused on Engineering and Technical Management.

Engineering

- Software Engineering training to deliver applications and platforms which fit the user needs (for homeowners who would be controlling heat pumps at home, to energy traders who would be using buying and selling energy supplied and demanded by their customers). Related skills range from requirements elicitation to algorithms development, systems programming, and deployment - this is not surprising, as any software development project is critically dependant on all these skills.
- Data came up as a significant area of training need, both in terms of how to set up a system for data governance and the legal rules around GDPR and data science, analysis and interpretation:
 - GDPR: ‘The data side of things, I think people need to be more aware of their obligations under data and we have to train people in their obligations and under GDPR and stuff and that was pretty much a project wide thing’ (R1)
 - Data use and value: ‘... there’s so much data out there you can drown yourself in data if you’re not careful with it. ... it’s definitely an area [where] most would need to learn on these smart grid projects. Because assets will give you a lot of data and they will keep giving you that data and unless you know what you’re doing with it, what’s the point in collecting it?’ (R10) Understanding that energy data is a thing. Understanding the social side of data was also really, really important (R9)
 - Data management: ‘everyone needs to do data management training and every organisation needs to take that on ... it is an understanding of data relations. ...What is data management actually for, as opposed to the thing that people feel they have to do and stick on a shelf and forget about’. (R9)

- Data collection, storage, exchange, standardisation, interpretation, analysis and management is another critical area, as all decision making is SLES SoS (and so the services delivered by the ICT subsystem to this SoS) are based on the results of the (nearly) real time data analysis.
 - Data Science, Analysis and Management: as noted above, all SLE solutions are rooted in use of data for designing optimised ways of resource (e.g., EV, battery, heat pump) use.
 - Systems Integration Engineering is an area where the SLE projects are somewhat more diverse (i.e., require integration of heterogeneous hardware and software APIs, across differently networked (and sometimes with missing network access) localities with differing additional constraints (e.g., on telecommunication network's bandwidth availability, etc.). Despite these characteristics, we note that the SLE domain is not the only one with these demands, but so is, for instance, any domain that relies on Internet of Things architecture. Thus, the combination of Software and Embedded Systems/Electronics Engineering skills training would be particularly popular in the SLE domain at present (or until the telecommunications infrastructure is modernised, standardised, and stabilised across the UK.
- Understanding energy sector, eg by software developers: 'if software developers were coming to us saying that they had done a module or a two or three month course in grid balancing or the energy sector, generally with a very kind of applied nature to how coding relates to the labyrinth of smart energy systems, brilliant we'd hire them much quicker' (R4)
 - Installation Engineering (i.e., installing PV/wind turbines, EV charge points, etc.) is another area of training needs, as the ICT solutions are to be developed for the hardware that is installed across the SLE subsystems to support 'smart' optimisation of energy and resource use.
 - Cross-Domain training, whereby the ICT solution developers (e.g., algorithm designers, security professionals, platform developers, etc.) are well informed about the:
 - energy and power systems properties (e.g., from criteria affecting battery degradation rate, to factors impacting heat pump operation),
 - energy market mechanisms (e.g., what services – such as firm frequency response or demand side management - and markets (e.g., real time or day ahead) can a particular device participate in, and what returns can be expected from such participation), and
 - user behaviours and perceptions which impact how they engage with devices and software solutions.

Trades

- Installation of assets, whilst not seen as a major issue is an area where upskilling is required: '...the installation side of things, ... there's a lot of contractors out who whilst they're busy, there's good opportunity for them in this area so they will probably educate themselves and making sure they can deliver installed assets' (R10)

Management

- Technical management skills, along with the ability to manage very large projects with a multitude of stakeholders is not a new challenge for the ICT sector but is equally relevant for SLE.
- Integrating knowledge across sectors: ‘If we want to get smart local energy systems or smart energy systems in general, it’s bringing people from the different sectors. Like the energy suppliers, ... Some of the grid people from electricity networks and electricity grids. People from installers potentially or technology companies like ourselves. To bring their level of knowledge up a step when it comes to this space (R10)

Soft skills and awareness

- Engaging with ‘smart grid stuff... what does smart grid mean? What are the services that people talk about when they talk about delivering smart grid? And it’s just educating people about that and what’s current and what’s the future because this is changing a lot. So what is coming down the tracks in this space, so that people aren’t focused on what’s here today if it’s going to be changed in 12 months time. So they’re better off focusing their efforts on what’s coming 12 months down the track in regards to technology readiness. (R10)
- Social and community building coupled with tech: ‘things you’re looking at in terms of training is almost a perspective of what kind of broad expertise do you have in community making, in social relation making? In Orkney there is a high level of technical expertise in terms of energy, but it doesn’t translate immediately into data, that takes additional kind of work (R9)

5.4.2 Training delivery for the ICT sub-system

ICT is seen as a fast-moving area where skills need to be kept current and courses, whether as under / post- graduate or on-the-job are inadequate (although essential grounding) with additional learning coming from working on systems and learning from peers.

Formal education:

- Higher education is a clearly assumed expectation for most entrants into the ICT area. Yet, they note that this is (necessary but) an insufficient level of training to work within the SLE ICT sub-system, as many skills are not “... skills that someone would get as a computer science degree. It’s usually experience that you’d get from ... working with this kind of scale of software” (P1). Thus, ‘practical training top up’ is considered essential. It is recognised that “there was a lot of stuff that ...[one]... picked up on during the ... engineering degree”. But also by getting “...involved in projects outside of his university degree” (E5) (e.g., as part of an electronics club or computer science club, attending hackathons) where the skills and knowledge from the degree level program can be applied and expanded upon.
- Doctoral Training is another method mentioned for both algorithms development and networking areas. These skills are relevant particularly at present because most SLE projects come with a large Research and Development component since much of the required work is new with no pre-set solutions to draw upon. Interestingly, the research for SLE does not seem to require any other than “traditional ICT” research and development skills, e.g.: “I think a couple of postdocs were recruited, networking and embedded systems people so we

didn't deviate from the typical ICT skillset that we would recruit on a technical project like this" (P28). Maths degree graduates are also well regarded for algorithm development work (P10). PhD level education is also very relevant to get a "...good understanding of the bigger picture, how different things fit in..." (E5) as well as to undertake focused research into novel technologies and solutions.

Short courses

- Internal upskilling is undertaken for- "... people that need additional training, [identifying] which courses they would like to take and the company would pay for it ..." (E5). This relates to very specific technical ICT courses, e.g., React Native for GUI development, etc. Another example is where data awareness is needed and a respondent was: '...running little training programmes. We offered them like once a week, sort of turn up and do it and get it ticked off everyone's list. Just trying again to raise awareness and understanding what data is and what data matters' (R9)
- Training from manufacturers / suppliers: for example in system modelling where 'The supplier of the software ran a training programme. We had a face to face one before Covid and then they had some online training on how to use it' (R8).

Informal and Peer learning

- Peer learning is undertaken in-house and a company would "need a couple of key people who have the background experience that could be training and upskilling people from other backgrounds" (P1) to help them gain the practical skill, such as, for instance, handling production scale platforms and projects.
- Learning by doing is considered particularly relevant, as given the wide range of new contexts and projects that arise, the employees are "pushed me to learn a bit more" (P26) while working. This is often done through online code repository searches and reading, as well as through peer-learning. Most importantly, as noted before, the 'practical skills around handling projects of very large scale and interacting with many stakeholders and collaborators from across various organisations can only be acquired through such on-the-job experience. 'There really is only one place to get those skills from and that's spending time working on our systems. ... getting your hands on the kit. ... and spending time working on it" (E7).
- Example (Blueprint)-based Learning: e.g., "... what we're trying to focus on really strongly in ESO is developing a blueprint alongside what we've done...to then give a kind of a cheat sheet to any other city that wants to do it. And I think that is part of the training" (E4).

Wider Knowledge

- Personal development / growth: ICT professionals very often engage into self-directed learning by using materials/lecture slides and web resources to pick up a particular skill or knowledge that they need.

5.5 Local Authorities Subsystem

Local government is another key sector which engages across all areas of a local energy system. Some of the key areas for training identified by interviewees focused around knowledge of energy

systems, policy and planning. It was noted that ‘Quite a lot of change will need to be initiated at leadership level and then an expectation on ways of working needs to be communicated to and supported in employees’ (A4). It is thus essential that these new skills and changes in working practices are recognised at all levels across local government and supported at the highest level.

5.5.1 Areas of Training Need for the local government sub-system

Engineering

- Technical management of integrated systems: as building management systems become more complex and interconnected, there are new training needs ‘the IT side, the networking, how it all connects together. ... that’s certainly been the bit that I’ve had to catch up on’ (R7)
- Engineering Skills for Management of SLE Projects are essential, as the technically knowledgeable manager is able to make decisions based on facts, rather than on a third party’s interpretations and opinions (e.g. which generation technology will best fit the local environment? Is the given platform suited for the data analysis task at hand?).

Energy

- Knowledge of energy and its implications is needed across all departments and levels of local and national government, a basic understanding of how the energy system and infrastructure is changing and its implications for the operation of LAs. We noted in particular how legal and procurement teams need new knowledge to support these developments: “education comes back down to educating the policy makers in order for them to make policy to enable the development to happen. Or to at least make the development happen in an easier manner” (E17). A basic Overview of SLE SoS and Renewable/Energy Efficiency Technologies is also necessary to enable council employees to handle SLES concerns in all areas of the council’s activities (e.g. integrating energy efficiency measures by the planning department, installation of charge points by the Highways department, upgrading of social housing and council estate).

Management

- *Management* is another important area for upskilling so that project managers not only understand LA processes but can deal with a range of new stakeholders and collaborators and *manage multi-stakeholder projects*. Managing a Large Set of Stakeholders on a Project is likely to become the daily practice as, within the SLE SoS environment, the interconnected subsystem stakeholders become relevant for other subsystem projects (e.g. time of vehicle charging within the Transport and Mobility Subsystem becomes relevant to heating within the Energy Subsystem).
- These managers also need to *understand SLES technologies and principles*.

Policy and regulation

- Evidence-Based Policy Making skills are critical in practically linking policy to technology and commercial delivery opportunities (e.g. given the evidence of EV and the performance of biogas fuelled buses, a policy for a city’s transport can be put in place).

- Policy teams need to learn how to connect energy with other policy aims (e.g. housing, land use, transport, air quality): where ‘training would have to extend to local authorities to be more sympathetic and understand not only their own policies but government policy as well’ (E6).
- Understanding the changing nature of transport and policy drivers from government, eg in developing EV adoption strategies:
 - from a fleet perspective, educating the operational teams in development, management and maintenance of the EV fleets;
 - from the infrastructure perspective, learning from previous experience of EVCP infrastructure development, understanding electrical load implications, land use, CP competition, etc.
- Planning team upskilling for energy developments is critical, else planning teams struggle to evaluate and process new types of development and their needs in relation to existing planning and other local policy.

Soft skills and awareness

- Citizen engagement is necessary for local government to undertake across all areas of responsibility and upskilling in relation to the changing energy system is a necessary prerequisite to effectively engaging on buildings, transport and a range of other policy areas.

5.5.2 Training delivery for the local government sub-system

Local government employees have a wide range of skills and specialisms reflecting the breadth of responsibility but, increasingly, these specialisms, whether in procurement, legal, financial management, transport or planning also need cross cutting knowledge to navigate the complexities of facilitating local energy systems.

Formal education:

- Higher education: It was recognised that young people might have the most current knowledge but not the experience: ‘you’ve got loads of students coming through that are good in environmental policies and sustainability, but they don’t have the experience’ (E12). Thus practical training provision is needed to better support utilisation of theoretical knowledge (e.g., through placements, internships, projects with industry etc.).
- Internships and placements are often used to support specific scoped project needs (e.g. community engagement; peripheral software development). These provide a valuable opportunity for collaboration between a local authority and nearby universities and colleges, as interns are often (yet not exclusively) taken in from these institutions.

Short courses

- Online / short courses are used to fill some knowledge gaps or to address particular skills needs, and ‘are really useful for understanding processes (e.g. procurement) and giving an overview of the knowledge needed to support a role (e.g. in how the energy system is

connected' (A4), for example 'the Coursera courses that I've done have been very, very good. Then there's the government ones which do courses on environmental and sustainability' (E2). Motivated staff often take the initiative to look for upskilling and it tends to be done voluntarily, in their own time, e.g. "So, for my own benefit I did an IOT course, just to try and get fundamentals and understanding of what that was because it was completely new to me. ... just six-to-eight week course" (P31). This could be formalised with recommendations on the best and most relevant opportunities as well as training time allocation to further such initiatives. Short courses are increasingly online: 'the EPC training for doing the assessments is a week-long course and it's usually away somewhere or another... [but] the last year or so it's been online training' (R2)

- Training from the manufacturers, suppliers or contractors: for example, in relation to a building management system where training comes 'from the actual contractor, working with them. And the documentation that comes with it. They've given us a bit of training on it as well so that's been the main sources of information' (R7)
- Consultants: are often invited to help with learning specific skills, e.g. '... if you need to know other tools then maybe you need to go and get a consultant' (P18).

Informal and Peer learning

- Peer Learning is both a valued and a well-practised mode in local authorities: "the Head of Highways [at BCC] is actually willing to send his electrician to London and spend time with the electrician in London 'cause it's about peer-to-peer learning. They wouldn't trust getting this from a manual and they definitely don't trust the manufacturers" (P18). This mode is also supported through groups and bodies set up specifically for this purpose, such as the UK's Core Cities Group (REF) and the Association for Public Service Excellence (ref apse), where peer groups for experience exchange and mutual support are regularly convened. 'Workshops with other local authorities will be useful to see what systems and skills they have put in place and how they have done this, vs the skills they contract out. (A4)
- Working with expert partners, .e.g., members of the Oxford council team have 'learnt a lot from Pivot. And a lot from any consultants or other people we're working with' (E14).
- Secondments are particularly relevant for acquiring background technical skills (e.g. heat pump installation, etc.) that are then drawn upon for policy/project decision making: "... you really gain that ... knowing whether or not that company's good at installing heat pumps ... and how they manage the project is a little difficult to discern from a classroom-based training exercise" (P4). Thus, a short-term secondment of Energy and Policy teams within SLE companies could be very beneficial.
- Learning on the job by bringing new knowledge from graduates together with more experienced colleagues can be a way to upskill a team. Sharing knowledge across departments is another form of learning on the job, e.g.: "we've just learnt through experience. And we've learnt through creating technical specifications and talking to people" (E14). This approach to upskilling is recognised as necessary '...as a lot of these skills are new, e.g. working across disciplines to integrate thinking, I think learning by doing will be a key part of how local authorities change the way they do things' (A4)

Wider Knowledge

- Conferences and Workshops are often used to learn about technology and practice: “... the most useful thing I found was going and engaging at conferences ... hearing people talk through live use cases from different companies or research institutes, that was far more useful to me than reading things online because you could go and have a conversation with those people afterwards” (P29).
- Demonstrators are particularly relevant in reducing uncertainty for the planning of novel projects, risk, and the decision making as “ you could go and see this working” (P18).
- ‘...and just a bit of background reading myself as well when I’ve had some free time’. (R7)

5.6 Community Energy sub-system

5.6.1 Areas of Training Need for the community energy sub-system

When considering the successful set up and operation of a community energy group as a (pro-social) renewables-based (or energy efficiency) business, the training needed for establishing such groups is not different from that of training for any other business, although with a deeper ‘customer engagement’ in its earlier stages both in relation to approval and potentially funding. Additionally, there is a need for ongoing engagement within the community and for maintenance of equipment. Community groups come with a range of relevant skills but there are often gaps to be filled.

Trades

- Local maintenance of new equipment: ‘making sure that there are local people who can keep these systems going is really important otherwise we’re going to have a lot of legacy, fancy equipment that isn’t working that well...from the more remote community side of things, more training or access to that training within those communities is important ...we needed the local technicians to have that training in order to deliver those services. (R11)

Management

- Whole Life cycle Project Management, whereby the daily activities or developing and maintaining the community energy group and its projects are handled from the start to the end, including:
 - Procurement;
 - Reading and interpreting contracts;
 - Risk assessment and management; and
 - Technical project management.

Finance and business

- General Business and Financial Literacy, which includes the abilities to make financial assessments of “do nothing versus use renewable or energy efficiency solutions” (P2) are essential in members of the community in deciding whether to volunteer for - and champion - the community energy causes. For more specialist skills such as developing business models and commercialisation, ‘volunteers involved with community projects pay consultants to deliver these services (A8)
- Engaging with Investors through:
 - Fundraising with investors and community;
 - Engaging the local authorities as a contributing party; and
 - Writing grants and project proposals to obtain funding.

Policy, regulation and Legal

While these are necessary part of developing community initiatives, they are often specialist skills bought in or offered pro-bono by local specialists.

Soft skills and awareness

- Leadership and confidence, i.e. the ability to communicate, motivate and engage the members of the community with the goals of the community energy group.
- Community engagement and behaviour change: ...’ bringing together of the technical with the community side of things. Because we need the technical stuff obviously. We need people who know what they’re doing and can implement it well. But that’s not all we need, we also need to be able to bring people along. The (ReFLEX) project is dependent on people being interested and wanting to get involved. And I think if we negate to have that training around the communication and the engagement and the behavioural piece, then we’re going to miss out quite a large chunk of the population, we’re only going to get those people who are already onboard and they want to get an EV and they can afford to get an EV’ (R11)
- Understanding of the Smart Local Energy System, including “what the difference is between the old energy system and the new energy system” (P5), which, in turn, will enable innovation for developing new business models and engender enthusiasm for proposed solutions..

5.6.2 Training delivery for the community energy sub-system

When discussing how training should be delivered with community groups, there is a preference for more informal, short training opportunities. This is unsurprising, as community energy groups are often volunteer-led, with less available time (and funding) for extensive training. This is starting to change as community groups and supporting intermediaries such as BEN in Bristol and Community Energy South (CES) are growing and professionalising. Our respondents noted the following training modes as relevant:

Formal education:

- Higher education (research) collaborations with community energy groups where local universities can often support both technical and business innovation development and technical and societal impact evaluation activities as well as student project support: ‘thesis, interns, ug projects can all help engagement with CE’ (A10).
- Further education colleges are noted as venues where learning about new technologies and practices (such as energy efficiency assessment, operation of community energy generation facilities, etc.) could be taught, particularly to young people. However, it is also noted that some Bristol community groups have “failed in our attempts to talk to ... [colleges about] directing their training courses to support our local community in these skills” (P19).
- Apprenticeships, some community groups would aim to find local contractor who can support an apprenticeship: ‘we’re hopeful through an island contractor we can actually find some funding, ... to get him as an apprentice electrician’ (R16). Other new types of apprenticeship, such as a ‘Community Energy Specialist’ apprenticeship programme, are also suggested as a good opportunity for younger people to acquire skills for community energy, although this is complicated - while the local colleges in Bristol are interested in delivering such programmes in general, they “ need 12 apprenticeships as a minimum to come through the doors. And obviously each of those apprentices would need an employer to pay for them” (P18).

Short courses

- Training from the manufacturers where local technicians are trained by suppliers of particular technologies in order to install and maintain them
- Local or online workshops such as ‘community energy futures workshops where communities can come in and learn about different aspects. ... the technical side of things, the legal side of things, the financial side of things and then after those workshops we will provide a level of ongoing support whilst they then implement certain things within their community’ (R11) Skills such as engaging with households on energy topics ‘tend to be learned in online workshops for community projects’ (A8)

Informal and Peer learning

- Peer learning and sharing delivered by local community energy organisations for the benefit of other community energy groups and individuals. This can take the form of:
 - Local community networking activities, as “the best people to learn from are the people that have done it, so it’s that networking amongst community energy groups” (P3) that provides an opportunity to share experiences and identify learning opportunities.
 - Online networking events with geographically separated communities with similar interests;
 - Open Home events (such as Green Doors) whereby, for instance, energy efficiency or retrofit upgrades completed by some houses are shown to all interested households by the homeowners.
 - Cross-sector reflection, whereby the interactions and questions between community groups and authorities/other groups lead to “breaking barriers down where oh, you can’t do that because we’re not allowed ... And just going through that process of getting them

- to reflect” (P3) builds understanding, mutual learning and provides opportunities for new solutions.
- Workshops, where community groups/members could bring ideas for project development, and/or learn from other (invited) group representatives about their solutions to common challenges and successes which could be appropriate to replicate.
 - Learning by doing: people involved in community energy activity bring varied skills and learn from each other as projects develop: ‘...when you were speaking to multiple different people, part of that is I guess is just life experience. ... it was just learn by doing at CES’ (R17)
 - Internships with community energy groups or similar organisations (e.g. Centre for Sustainable Energy) are recognised as valuable training opportunities for engaging with citizens as well as developing local talent for expanding the community energy groups’ activities. For instance:
 - CHEESE project provides internship opportunities for citizens/young people from disadvantaged communities to learn how to undertake energy efficiency audits, while getting a paid-for placement within the project
 - BEN’s Energy Champions programme helps to develop an understanding of home energy efficiency, renewable energy technologies and novel solutions (such as demand-response services) for the volunteer local champions, who, in turn, work with the local communities to educate and engage them with the community energy and retrofit activities.
 - Demonstrators to see practice in action and discuss how they work:
 - Informal Demonstration, whereby members of one community see the success of another and set out to replicate it for their own locality.
 - Formal Demonstration at locations, such as the planned Ambition Lawrence Weston’s wind turbine’s energy learning zone, the learning zone will serve as a place to show and tell to schools and citizens about what the renewable energy projects are.

Wider Knowledge

- Online through webinars: ‘A lot of people do online stuff through webinars, it’s kind of part of the thing you do the webinars to follow up’ (R14)
- CE conferences are a good place to learn what others are doing and to build knowledge through workshops eg ‘Energy4All educates the Directors of its Community Energy Groups at the E4A AGM/Conference’ (A8)

6 Discussion and Recommendations

Skills are acquired in different ways. For many of our interviewees, their original skillset has been enhanced by learning on the job, or has evolved as they moved across roles and different companies/domains of the SLES. These **multi-skilled workers** are in demand as they bring a broader knowledge base to bear on their roles. For example, in understanding electrical engineering as

well as installation of renewables, alongside understanding of the local government and planning processes.

As technology continues to change and develop, **rapid training modes** are needed, often in-house, in order to develop specific or cross-sectoral skillsets.

In relation to ICT, for SLES to work and be optimised, all sub-systems need to have (some) smart components which need to be inter-connected for data exchange and exercising of optimisation controls. Thus, operation of the smart solutions, data exchange and control application skills must be kept current either through formal upskilling or continuous on the job learning.

While conventional training models are necessary in some areas of skills – for example degree courses for engineers, college and apprenticeships for trades etc., our case studies have shown that other modes of training are also valuable in bringing the right skills and knowledge into a project:

- *Knowledge sharing across project partnerships* – where partners bring sectoral knowledge and support upskilling of the wider partnership. This is about bringing in people with specific knowledge and ensuring dissemination as needed across different parts of the project – for example in relation to EVs or data management.
- *‘Learning on the job’ / ‘learning by doing’* - where employees learn from their more experienced colleagues, is an effective way of making new skills real in the workplace, for example electricians learning about EVCP and battery installation, community members sharing skills within a community group or software engineers working on different systems.
- *Training by suppliers / manufacturers* plays an important role where new technology is involved in order to ensure installers understand the product, how it works and what is needed to validate any warranty, and users can correctly operate an installation e.g., BMS software.
- *Online courses and webinars* are widely available and are especially useful for widening knowledge of a particular area.

6.1 Recommendations for government

Policy and drive from central government can send crucial messages to employers, educators and workers about what skills are worth developing and the market alone cannot provide the drive to net zero. It is essential that government schemes are properly developed and have longevity – the market has been deterred by the Green Deal and Green Homes Grant schemes which were ill thought through and short-lived. Regulations for fully future-proofed new housing alongside quality certification and retrofit requirements might improve demand for these skills and training.

Funding is needed to encourage workers to develop new skills and for employers to release employees to undertake training.

Funding is also needed **for colleges and qualifying bodies** to develop new qualifications that fully address the needs of net zero – allowing flexibility for modular courses accessible to all according to their starting point and existing skills.

6.2 Recommendations for educators

The HE sector is crucial in delivering highly qualified engineers and managers but has been observed as being slow to keep abreast of the changing needs of industry and inflexible in the way it

delivers courses and combines the wider knowledge of the energy sector in order to equip graduates for working in this area. Placements, industry secondments and projects all help to close the gap. New technologies such as large-scale battery design and deployment are not yet regularly taught.

Slow as they are, doctoral programmes are needed to produce the very highly qualified engineering scientists needed for some roles.

FE Colleges are the other key qualification delivery bodies, though these are too often seen as delivering basic and fixed qualifications which have not kept up with changing needs of the energy system. This can be explained by low levels of demand and underfunding hindering their ability to recruit, develop and deliver in some of the new areas needed for the future. Availability of appropriate recognised qualifications is another barrier.

Apprenticeships are an important element of skilling the future workforce but rely on employers' ability to employ unqualified staff, which many small organisations are unwilling or unable to do.

Schools have an important role in steering the future workforce but are often ill-equipped to keep up to date with technology changes and future career choices. It is recognised that STEM has been encouraged across all students, particularly focussing on those traditionally less likely to have engaged in the past but more needs to be done – and particularly in understanding how future systems will operate and combine across sectors.

6.3 Recommendations for qualifying bodies

The organisations developing new qualifications are essential components in ensuring that the right provision is available for the future. Ofqual's register shows that many courses that were previously available – probably in response to government drivers and funding schemes, no longer exist, hindering colleges' ability to deliver the required net-zero skills needed for the SLES of the future.

Greater consistency in addressing skills gaps and forecasting future need – working with employers but also with policy makers to ensure future needs - is necessary.

One of the most promising ways to achieve this is through the “**hybridised qualifications framework**”, which was discussed in section 4.

Additionally, a framework **recognising the life-long learning education** and training activities and accrediting them is also very desirable.

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A Appendix: Example of Ofqual qualifications search

Example: renewable energy

The Ofqual register search used the terms renewable+energy, wind energy, solar.

The register showed a total of 56 courses of which only 11 are still currently available. The majority of current qualifications are shorter courses at level 3.

Renewable energy, available courses:

- City & Guilds Level 3 Award in Renewable Energy in the Home (60hrs total learning time)
- ETCAL Level 3 Award in the Fundamentals of Renewable Energy Types (32 hrs learning)

This contrasts with previously available qualifications which ceased to be operational in 2018/19 and seem to offer more detailed learning and higher credit-awards such as:

- AIM Qualifications Level 3 Diploma in Renewable Energy System Skills (711 hrs)
- NCFE Level 3 Diploma in Preparing to Work in Renewable Energy Engineering (1100hrs)
- AIM Qualifications Level 3 Award in Rational Use of Renewable Energy (79hrs)

Wind energy has only safety related qualifications currently listed:

- ITC Level 3 Certificate in Safe Working Practice in the Wind Turbine Industry (182hrs, 19 credits)
- ITC Level 2 Diploma in Safe Working Practice in the Wind Turbine Industry (480 hours, 50 credits)
- ITC Level 1 Certificate in Safe Working Practice in the Wind Turbine Industry (234 hours, 26 credits)

The course specification document (ITC) states:

This qualification is designed to support an individual's entry to the Wind Turbine Industry, it is aimed at those who wish to gain essential safety skills and knowledge to allow entry to employment in this sector.

The qualification has been developed with support from the Global Wind Organisation (GWO) and RenewableUK (RUK) as well as several sector training organisations, employers and further education providers.

This contrasts with previously available qualifications which covered installation and operation and included:

- ABC Level 2 Award in Converting Wind into Energy (90 taught hours)
- City & Guilds Level 3 Diploma in Electrical Power Engineering - Wind Turbine Operations and Maintenance (QCF) (768 taught hours, 140 credits)
- City & Guilds Level 3 Diploma In Electrical Power Engineering - Wind Turbine Engineering Installation and Commissioning (QCF)

Solar PV:

- NOCN Level 5 Certificate for Certified Solar Photovoltaic Practitioner (160hrs)
- NOCN Level 3 Award for Solar PV Installer and Operator (160hrs / 16 credits)
- LCL Awards Level 3 Award In the Installation and Maintenance of Small Scale Solar Photovoltaic Systems (35hrs, 4 credits)
- EAL Level 3 Award In the Installation of Small Scale Solar Photovoltaic Systems (60 hrs, 6 credits)

Solar Thermal:

- BPEC Level 3 Award in the Installation and Maintenance of Solar Thermal Hot Water Systems
- LCL Awards Level 3 Award in the Installation and Maintenance of Solar Thermal Hot Water Systems

B Appendix: Abbreviations

ANM: Advanced Network Management

BCC: Bristol City Council

BMS: Building management system

CES Community Energy Scotland

CSE: Centre for Sustainable Energy

DNO/DSO: Distribution network / system operator

EMEC: European Marine Energy Centre

ESO: Energy Superhub Oxford

EST: Energy Saving Trust

EV / EVCP: electric vehicle / electric vehicle charge-point

GSHP: ground source heat pump

IES: Integrated Energy System

IES: Ltd Integrated Environmental Solutions Ltd

MCS Microgeneration Certification Scheme – installer standards (<https://mcscertified.com>)

NG: National Grid

OCC: Oxford City Council

ODS: Oxford Direct Services

OIC Orkney Island Council

PFER: Prospering from the Energy Revolution

ReFLEX: (Responsive Flexibility) Orkney (<https://www.reflexorkney.co.uk/>)

SLE(S): Smart local energy (system)

SMS: Smart Meter Services

SSEN: Scottish and Southern Electricity Networks

WECA: West of England Combined Authority

WPD: Western Power Distribution

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