

9 Energy Sub-Sector: Findings from Data Analysis

9.1 Factors Affecting Bristol's Energy Sector subsystem

Drawing on the interview data analysis, we have formulated the causal model of Bristol's energy subsystem, as shown in Figure 14¹⁵, and briefly explained below.



Figure 14: Causal model of Bristol's Energy Subsystem (factors local and specific to Bristol are presented in purple).

The business representatives interviewed from the energy sector in Bristol have demonstrated two key focal factors of transition, both driven by the local and UK-wide carbon reduction priorities, and both leading to the emergence of these new business models: (a) digitisation of energy services and (b) investment into new basic assets.

Figure 14 shows that, as the energy businesses are obliged to diversify from fossil-based generation sources to renewable alternatives (i.e. invest into low-carbon generation hardware), they face the immediate need of engaging with data-driven service delivery. This is necessitated by the:

- Intermittency of generation of these (currently prevalent) non-fossil fuel based sources,
- Short supply and high price of the current energy storage facilities (e.g. electric batteries, solar to Hydrogen conversion costs), and
- Optimisation opportunities for reduction of upfront investment into the changing infrastructure (e.g. shift household consumption away for peak times so as to avoid investment into reinforcements of distribution lines).

¹⁵This model can be simulated through this url: https://energysystems.blogs.bristol.ac.uk/2021/03/08/ energy/





However, given the current lack of dedicated infrastructure for collection, storage, exchange, sharing and monetisation of energy sector data, each company wishing to deliver data-driven services faces the challenge of this type of infrastructure set up. There are many challenges for the setup, as it requires, for instance:

- · Installation of various data collection and storage hardware;
- Development of software solutions that enable utilisation and monetisation of data;
- Provision of interoperability between the various hardware components as well as their software interfaces and services;
- Assured checks and balances for regulatory and legal obligations in data use related to both privacy and security concerns, etc.

The above-mentioned challenges of re-investment into assets and tackling the data-driven service delivery issues are leading to a deep re-structuring of Bristol's energy supply sector (e.g. resulting in selling off Bristol Energy as a loss making business by the BCC, as well as the sale of WPD by its American ownership).

On the other side, Bristol has an example of a business emerging whereby the **deployment and management of renewable energy and energy efficiency assets drive the business model, without core focus on the additional digitisation services**. CEPro [42] - a local microgrid service provider - considers the digital service provision to be a future possibility. Instead, CEPro is focused on integration of renewables-based generation and consumption technologies (e.g. community-level PV array and battery, heat pumps or district heating technology, etc.) into the fabric of the local communal landscape at the construction time. The business then undertakes the management of the energy generation assets, ensuring that the local community benefits from these assets as much as possible, while the excess or shortage in supply/demand is purchased from a partner supplier (in this case, Bristol Energy Cooperative).

It is worth pointing out that CEPro is working primarily with new build communities. Although integration of the same assets into an existing community is also possible, CEPro notes the prohibitively high transaction costs (e.g. due to the need of engaging and onboarding of each dwelling owner to commit to energy efficiency and retrofit at personal cost, as well as agreeing to communal ownership and use of energy resources against new build's working with a single builder and architect).

9.2 What skills are needed for Bristol's Energy Subsystem?

The skills deemed relevant by our interviewees to each of the areas of Bristol's Energy sector system are summarised in Figure 15 and are detailed and aggregated into generic types below .

9.2.1 Engineering Skills for Energy Subsystem

- Traditional *Software Engineering* skills are becoming increasingly more in-demand within the Energy sector, as transition to smart systems takes place.
 - Algorithms for Energy System Optimisation is an area where "...there is a lot of sophistication that could be developed for optimisation, trading and improving the value of their hardware" (P2).





- Application Development skills have been in high demand in the energy sector for some time. Since the roll-out of smart meters, many companies have worked to deliver applications which allow their customers to manage their own accounts, view their smart meter data in real-time, and set up the (often mobile) applications as a platform for future new energy services (P9). This trend is set to grow, in line with the increasing need for application development skills within the Energy sector.
- Data-based Systems Management is the underlying aim of the Smart energy system. Consequently, the energy systems move closer to the ICT domain than to traditional mechanical engineering structures. As noted by P9, "...the more innovative energy companies ...are using IT traditional development type guys ...to work with the data rather than operations." This is reiterated by P24, stating that DSO's "will almost become more of an IT data business than it will an engineering business. ...Most of our issues are sufficient data in the right format, right place, quickly enough, being able to analyse it ..." The specific skills noted include:
 - Data Collection is the first essential step for integrating smart behaviour into an energy system. Indeed, the UK has committed to setting up infrastructure for this data collection through smart meters. However, the SMETS1 meters "were all owned and managed individually by energy companies" (P9). Consequently, when a company installed this type of meter at a household, and the household subsequently switched to a new energy provider, the SMETS1 meters data often became inaccessible. Thus, the skills of upgrading SMETS1 to SMETS2 meters are necessary, as are the skills to connect to and undertake data collection from SMETS1 meters; interfacing with the Data Communication Company and Elexon for regulated data submission and access. Moreover, for real time access to data, skills for additional hardware installation (e.g. consumer access devices) may be needed, as well as skills for engagement with customers in compliance with the data-related regulations.
 - Exchange of Data between customers and the energy sector companies as well as between the various companies themselves is a necessary, albeit challenging process. On the one hand, the customers must support the "data requirements" (P24) of the companies, as they "both send them data and they can send us data and information ...getting them to actually properly interface with us is the harder bit." On the other hand, the data often underlies the business model of a SLE company, and so providing access to that data for other businesses could undermine their own competitive advantage. Meanwhile, at the same time, for the SLE SoS ecosystem to operate as a whole, the data must be exchanged across all of the system stakeholders. Thus, *knowing which data to share, what and how to aggregate and anonymise*, is another key emerging skill.
 - Cross Domain Data Integration is seen as the necessary step in harnessing the smartness of the energy system. The energy sector notes that "...lots of data is already gathered in areas that we'd want to bring ...together: ...energy city-based data, so traffic for instance, air pollution, ...mobile data ..." (P9). The sector needs skills both to integrate these datasets and also to define models that optimise how the subsystems from which these data come could best work together.
 - Data Analysis and Machine Learning are noted as the key "...skillsets we really need" (P24) in the traditional energy sector. Such analysis is often supported with statistical and mathematical data handling skills. In particular, the DSO's are "...just starting down

that path of *machine learning* yes. I would say we're in the baby steps of that area at the moment." (P24).

- Currently Data Security is "a big area ...to research further" (P9) for the energy sector stakeholders. This is because energy data protection and use is regulated, and, even more significantly, because all new energy services are centred around data. Thus, securing data storage in both hardware and software, controlling access to it, and monetising its use in a secure way is one of the key challenges within the energy sector.
- Ethical Use of Data is mandated through various regulations (such as the GDPR) and enforced by "Ofgem, who would be sense-checking whether we [the companies] were doing that ethically." (P9). To support this, consumer rights and interest protections must be engineered into the data management systems, and engineers must have a sound understanding of *what and how to implement*, as well as knowing how *to set up* a clear data governance structure and plan.
- Platforms for SLE are emerging as the markets for SLE service delivery, data purchase/sale and customer relationships management develop. For instance, WPD uses this type of platform for flexibility contracts trading, while Bristol Energy (in collaboration with Eliq) was considering a mobile platform for potential customer data management and new service provision.
 - Delivery of the in-house platform is an open challenge for the energy companies, as presently most energy companies use platforms "provided by a third party". However, they "...will look to bring that in-house in the next couple of years". This is the practice used within the traditional energy companies who "...do that with most things in terms of when it's a new area, we might well use an outsource provider to start with, but we look to bring it in-house as rapidly as we can" (P24).
 - Interoperability of Systems and Models, with its integration into the SLE platform is another challenge, as "...a lot of research is required from ...an interoperability perspective" and "...lots of data is already gathered in areas that we'd want to bring everything together. But it's kind of managing those systems on a systems by systems basis" (P9) that remains to be handled. This brings along many challenges, such as the granularity of the data collected (e.g. some parties may have one reading every 30 minutes, others collect data on a per-second basis), reliability of data sources, compatibility of various models, hardware, software languages, measurement units, etc.
- *Power Systems Engineering* remains a keystone in all energy systems engineering and transition, yet some areas here are noted to be of concern, such as:
 - System Behaviour Analysis and Control (i.e. understanding of the "...behaviour of networks, behaviour of system protection, behaviour of generators connected to the network" (P24)) is a traditional Power Systems Engineering skill, which remains in high demand in the energy sector. However, "...there is a smaller number of universities that still teach those areas. And equally, even those universities that teach it, they tend to be options so therefore the number of graduates which take those options is smaller as well" (P24). Thus, the traditional energy companies see skills shortages arising in this respect.



- Electrical Hardware Integration skills are also in high demand for the new kinds of hardware technologies that need to be integrated to form SLE systems. While the "...hardware is mostly off the shelf with top-enders like Tesla or Solar Edge", the engineers may need to have skills for "...developing glue to link all the hardware" (P2), focusing on power systems aspects of integration.
- Systems Engineering skills underline the need to consider the energy systems as a whole, including the interconnections of hardware, software and human aspects within this large and complex system-of-systems.
 - Hardware Integration skills underline the need to integrate various energy systems devices, for example, from solar water heaters to PV, ventilation within a single home to district heating systems and transmission and distribution networks of the national grid. Here, the Mechanical and Electrical engineering skills and power system engineering skills must come together with construction and retrofit.
 - Software Integration skills relate to the need to integrate various software solutions into a joined-up system of monitoring and control, for example, from smart meter and battery charging data viewing apps for households, to EV charging stations and weather forecasting applications to help set right electricity prices in real time and charge/discharge EV batteries, etc.
 - "There is a real lack of *Interdisciplinary Skill-sets*", whereby " all the pieces are there but the weak spot is the interdisciplinary trade of being able to assemble it" (P2). This refers to the ability of the engineering disciplines to work together, as well as with the non-engineers in delivering an integrated, well-functioning system-of-systems for SLE.
- Research and Development is one of the priorities within energy businesses, as innovation is seen as the only way to remain competitive. While all businesses are undertaking innovative projects across the whole spectrum of SLE SoS, with the engineering skills discussed above needed for all these projects, a specific skill noted to be missing for R&D projects is:
 - Back Office Integration with Innovation Projects. This is essential for the success of innovation projects, yet "...lots of people overlook those boring aspects of innovation projects when they're very integral to the successful delivery" (P9).

9.2.2 Trades Skills for Energy Subsystem

- Installation skills are not always rare, but are often lacking in quality. For instance, even for smart meters, "installing smart meters is still a relatively new thing for installation engineers" and the energy companies "...have to work with a third-party and we don't pay them enough for them to give us the good installers, so we've had a lot of problems with ...installing" (P9). Given that the volumes of installation of renewables technology must scale up, and it is a relatively new technology, "...what we really need is just lots of deployments of more advanced systems" (P2) to bring the skills levels up, as well as to establish clear supply chains for the technologies. The specific installation skills mentioned in our interviews are listed below, though other renewable technology installations are equally relevant:
 - Charge Point Installation;



- Heat Pump Installation;
- Heat Network Installations;
- Smart Meter Installation.
- Skills for Construction for Net Zero are also still in short supply. These are relevant for the delivery of smart energy services, though building itself is not carried out by the Energy sector. These include both specific skills such as *Building to Passive House Standards* and skills for *Systems Integration*: "So the electricians can do the electrician thing and the heating people can do the heating thing and the architects can do the architects thing. ...So I think it's like all the pieces are there but [again] the weak spot is the interdisciplinary trade of being able to assemble it." (P2).

9.2.3 Managerial Skills for Energy Subsystem

- Managing New Business Models, while supporting the business transitioning is an implied skill in the whole of the SLE SoS, the new business models (e.g. as outlined under Finance Skills, similar to those based on the value of data or integration of microgrids into the construction fabric of the communities, etc.) require flexible management skills, if they are to succeed.
- Large Scale Project Implementation Management skills are particularly relevant, as the majority of the SLE projects are large scale, multi-stakeholder and long-term. Although these skills are neither novel nor specifically unique to the energy system, they are still at a premium, as they require well-qualified and experienced professionals to undertake:
 - Cross Institutional Management, whereby several businesses may be collaborating or even joining together to deliver a project (e.g. Bristol's City Leap project creates a joint venture between the city and the net zero delivery partner(s)).
 - Setting Up Common Systems and Processes is a particularly relevant skill where multiple stakeholders/organisations must collaborate across their specific platforms, which are likely not to be accessible to each other. The project manager must then find a way for the parties to share information and collaborate, despite the platform incompatibilities or access restrictions (e.g. "I kept everything in a Google Drive that everybody could access and [even] that was actually really difficult, getting everybody from different organisations to be able to access the same systems so that they could see data." (P9)).
 - Skills of setting up *Cross-Team Collaborations* are also in short supply, as "teams don't work well enough together. They're very siloed in their ambitions and their project planning" (P9) and it is the project manager's (often ignored) responsibility to bring these teams together.
 - Preservation of Historical Knowledge is another skill which has suffered from underinvestment, yet it is essential in long-running projects, as those working on (and newly joining) the project need to understand the reasons and evidence for past decisions, as well as the progression towards the set goals, especially if projects (like SLE developments) last for several years.



- Stakeholder Management skills in multi-stakeholder projects (e.g. with over 10 stakeholders engaged into a newly built microgrid development) cannot be over-emphasised, as all stakeholders must be involved, communications channels set up and progress monitoring and support established.
- *Research and Development* management skills are particularly relevant in the current energy systems, as they undergo whole-scale transition. Some of these skills are:
 - Working towards *Roll Out of Innovation Projects* for adoption within the company. If not accordingly propelled by a champion (e.g. manager), an innovation project with promising results may never be rolled out if it is considered to be "ahead of its time", or benefits are likely to be received directly by the customers, rather than the company (P24).
 - Aligning Innovation with Business Priorities to foster the likely roll out of the innovation project, as well as increasing the chances for the project's success. Without this type of alignment, the innovation projects would likely fail as they will clash against "other priorities that just couldn't be moved" (P9).
 - Sharing R&D Leanings Across the Company, so "...that learning and those skills" obtained from focused project work by a small team "would go back into the business" and "become part of how the business works" P(9).

9.2.4 Energy Skills for Energy Subsystem

The energy company interviewees in our study did not flag many concerns about skills specifically related to the Energy domain (beyond the engineering and other skills discussed previously). The only notable exceptions were skill shortages in *district heating* and *flexibility engagement of community energy groups*.

- "District Heating more generally has quite a lot of skills gaps in the UK" (P9). This is not surprising as the UK has not been actively using this technology until very recently. Thus, BCC is looking for commercial partners (e.g. Eurovia [43] and Vatenfall) from outside of the UK to deliver Bristol's district heating projects.
- Engagement of Community Energy Groups in Flexibility Services is hampered as "...their skill levels are quite low" in delivering and using flexibility services and "...they're not as fleet at foot as some of the commercial organisations" (P24).

9.2.5 Finance Skills for Energy Subsystem

- Skills for Development of New Business Models, including, for instance:
 - Business Models Based on Value of Data, whereby real time data is becoming central for managing the energy businesses (e.g. data on "...24/7, 365 operation" and skills to "...look at that and can decide what is needed when" (P24)). Thus, the data suppliers (e.g. "...car manufacturers or possibly aggregators, ...with portfolios of electric vehicles ...trade in terms of both location and volumes of energy" or "suppliers or aggregators ...[who] contract directly with the customer and then provide the service ...at a more

aggregated level" (P24)) need to be identified and integrated into the business models, along with the costs and benefits of these arrangements.

Business Models Based on Building Dwellings with Integrated Microgrids, whereby either the new build or retrofit projects are designed so as to integrate community level generation, storage and heat systems, which supply the needs of the given community, as well as delivering additional services (as necessary) to the wider grid. Here the community level aggregator (such as CEPro) acts as the energy service manager as well as the initial financier of the project.

Irrespective of the business model selected, the finance skills needed are:

- Raising funds for the projects;
- Financial modelling for the projects;
- Comparing the Net Present Discounted Value of alternative renewable-based projects.

9.2.6 Legal Skills for Energy Subsystem

- Contracts Preparation skills are needed whereby the legal professionals are able to account for the real (rather than perceived) risks brought about due to the renewable technologies and new business models. (e.g. contracts are to be set up between energy companies and 3rd party data providers, such as, aggregators, EV car manufacturers, charge point operators, community microgrids, etc.)
- Handling Data under Data Protection Regulation, as well as with the protection of own business interests while also allowing for the SLE ecosystem to operate, is a challenging task. Overprotection of data prevents other stakeholders from new service delivery, as well as the data owners from value creation on the basis of their data (e.g. "So having access to the data that they [WPD] CAN share with us if they want to was quite difficult" (P9)). However, over-sharing could lead to business losses too. Balancing these priorities is a skill which is currently missing across all of the SLE SoS subsystems.
- Regulation of Heat is currently only voluntary, thus, "...a lot of existing heat networks don't really worry about regulation". However, this "...will become compulsorily regulated eventually" (P9), thus, energy companies should upskill in working under the regulated heat conditions.

9.2.7 Policy Skills for Energy Subsystem

 Local Authorities SLES Delivery Skills, in particular when engaging with the challenge of handling the distribution network constraints, are noted as lacking for BCC. As noted by P24: "The ability of Bristol City Council to deliver has never been that great, has been our experience ...I don't know whether it's budget constraints or resource constraints within Bristol of actually converting that aim and desire into reality, which is the problem, or not. But something makes it slow in Bristol." It was suggested that having "sufficient funding, and a permanent project team who don't change their personnel too often" charged with the responsibility to deliver the specific net zero objectives would foster a better delivery at BCC.



- Setting *Policy on Subsidies for Renewables* "has been a mess for years and it remains a mess now" (P2). This, in turn, prevents larger deployments for SLE. Skills for clear, long-term policy making in various areas of renewables (akin to solar FiT) are much desired.
- Skill in *Local Authority for Future SLE SoS Scenario Planning* is currently lacking in many local authorities. The distribution companies, such as WPD, could provide support for this to the local authorities (e.g. "…help almost hand hold to some extent on how to produce some of these plans" (P24)). However, the national regulator must decide if DSO's are to take on this role: " …questions for our regulator in terms of, do they want us to do that process of helping local authorities get these plans in place to help deliver overall net zero? Or do they see that as someone else's role …" (P24).

9.2.8 Soft Skills for Energy Subsystem

- Collaboration across Teams within an Organisation is a missing skill in many 'established, traditional' companies, which precludes successful innovation and change. (For example, as commented upon by P9: "our plan was to essentially bring a load more data into the company and we didn't engage with the smart metering team who would have to gather that data. And we didn't engage with the IT team who would have to process that data before we planned this. It got worked out and we resolved some of those issues but we didn't make friends to begin with and that's a really important thing to do.")
- The skills of *Engaging Citizens* into the innovation projects undertaken by the energy sector are particularly relevant to the energy utilities (like Bristol Energy), but are also necessary for other energy sector companies, as their innovations need to be grounded in what the customers need/want.
- Educating households/ general public on topics of SLE SoS for them to:
 - Overcome fear of Smart Systems and Data Sharing, as "...the fear of smart and the fear of data and the fear of big brother is huge and massively outweighs the benefits that people see" (P9), which prevents SLE adoption;
 - Gain Financial Literacy on Costs and Benefits of Renewable Energy Alternatives, so that householders could make informed "assessments of do nothing versus ...[renewable installation] pathways forward" (P2).
 - Understand the Uses of New Technology so that they can "change behaviour", e.g. about their car use or EV charging patterns (P24).

9.3 Training needs for Energy Subsystem

9.3.1 Areas of Skills and Training Needs

The key areas where skills and training are considered to be particularly necessary in Bristol's energy sector are:

• *Power Systems Engineering with new technology integration*. Where the traditional Power Systems skills are still essential, training on integrating and utilising new technologies (such as microgrids, hydrogen supply, etc.) is still limited.





- Software and Systems Engineering for Energy Sector as the energy sector is transitioning 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 (presently often) custom-based hardware to support such networking availability (e.g. even smart meters are to be 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 the Networking and Computer Science/Informatics disciplines. The key challenge is in attracting well-qualified individuals 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.
- *Installation* needs for various renewables and low-carbon technologies, such as charge points, heat pumps, heat networks, 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.
- Managing multi-stakeholder, large scale implementation projects is another aspect where training is beneficial. This is because the SLE projects both 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.
- Developing, Trialling, and Roll Out of New Business Models is another area that should be support 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 (which came to pass in the case of Bristol Energy Co., for instance) innovation in service delivery with various models must constitute a core daily part of the energy business. Thus, training in formulating sound business models, trialling, and rolling successful cases out to the wider business is a very relevant need.
- Training in *Handling Energy Data* is relevant to engineers, managers and the larger public. Here, skills in data protection, aggregation, sharing, and monetisation need supporting.
- *Policy & Regulation* for speedy and supported transition is the skills area needed within local and national authorities. Here, it is paramount to have long-term policy stability for new technologies stimulation, funding support and regulatory enforcement.

9.3.2 Modes of Training

When discussing how training should be delivered, the respondents noted a variety of relevant training modes:





- Universities are noted as particularly relevant for engineering and technical education (e.g. the undergraduate and graduate degrees in Power Systems, ICT, and Maths were pointed out as the most relevant by WPD). 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);
 - 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).
- *External Training Providers* (such as ETAL) are often employed to help employees (particularly the newly employed recruits) to provide the "detailed knowledge that they need" for specific job roles.
- *In-Company Training* is also used, particularly where the training is expected to be "...benefiting the company for a longer period of time" (P9). In such cases:
 - 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).
 - On the Job training 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).
- 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 really seeing the outcome of those pilots yet" (P9). These, nevertheless, are useful for all SLES stakeholders: from general public to policy makers and energy companies themselves.
 - *Conference Attendance* is also used for energy companies, e.g. P9: "We attended quite a few conferences ...attending as much as possible from a learning perspective".



- 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.
- Public Awareness raising 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).
- School Education is suggested to have 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.

9.4 Insights and Recommendations for Bristol's Energy Subsystem

9.4.1 Digital Innovation Drive

As previously noted, digital innovation and data-driven service delivery are becoming critical requirements within Bristol's energy sector. Thus, we suggest an update to the training provision for those aiming to work within the energy sector in Bristol and its surrounding region (as well as nationally) to provide additional training opportunities with a focus on digital technologies. For instance:

1. Expanded Power Academy Provision

During this case study we observed that the University of Bristol was not part of WPD's Power Academy training provision, and we have already initiated the process of joining the Academy.

Moreover, building on the Power Academy initiative, and working with the local universities (e.g. UoB, Bath and UWE), we suggest establishing training provision, through the IET Power Academy, specialising in:

- Digital Services (e.g. working with the UoB's departments of Computer Science, and Networking and Communications);
- Data Analytics (e.g. working with the UoB's AI and data analytics doctoral training centre);
- Privacy and Cybersecurity (e.g. working with the UoB's Cybersecurity Research Centre, as well as the doctoral training centre on Security of Critical Infrastructures)

2. Student Projects and Internships



The local energy sector has the opportunities to both invigorate its own innovation and to attract young people into their companies through a wide set of activities engaging with the local universities, e.g. via

- Posing projects to undergraduate, MSc, and PhD students (working with the departments of the Energy Management, Computer Science, Networking and Communications, Mathematics, Cabot Institute for the Environment, etc.). (It is worth noting that some companies, e.g. CEPro, already actively participate in such projects, although they tend to focus on working with a single university/department, and so broadening their engagement would also prove beneficial.);
- · Setting up internship projects for students over the summer break;
- Posing research and development competition challenges through the Student Union and/or various student societies (e.g. Computing Society, Women in Engineering Society, etc.).

3. Funded Research and Development Programmes

Establish a pipeline of research and development projects with a clear path to rolling out the successful results.

A number of initiatives are in place to apply for funding to run R&D projects (e.g. UKRI funding has some support for company innovation; WPD's innovation programme is funded through Ofgem, EU Horizon 2020 framework, etc.). Indeed, most interviewed companies noted that they have applied (with various degrees of success) to funding programmes. However, current collaboration between research institutions (such as universities) and companies is weak. Strengthening such collaboration is mutually beneficial for both researchers and industry, as it will both increase the likelihood of successful funding applications, and foster local research and innovation. For this, as an example:

- the previously mentioned student projects and internships can be used to explore initial ideas and build larger research programmes around them and
- direct links between academics and businesses can be set up through networking events and scientific seminars/cafe scientific events, etc.

9.4.2 Practice of Systems Engineering

While the previously discussed points would support improvement of training and expansion of R&D, the processes and procedures for the roll-out of successful trials/research results should also be put in place explicitly. This relates to both:

- developing a set of internal, company-specific processes and procedures (not discussed further below, but some issues are addressed under the Management Skills topic in the above subsection), and
- taking a system-wide perspective on the energy sector, with some points noted below:

1. Local Energy Service Consortia

As previously noted, CEPro is already pioneering a new model of community-level power system deployment and operation. This model:



- Is focused on consumer/community level benefit optimisation and emissions reduction, yet it also
- Supports the agenda of the energy distribution companies (such as WPD) by ensuring that the local energy needs are met locally and no wide-scale network reinforcement investments will be required. Furthermore, it
- Provides opportunities for new service delivery models by the energy utility companies (such as Bristol Energy), where digital services can be employed to integrate local microgrids through an electricity trading platform.

This, and similar initiatives, would blossom if a collaboration is established between local energy companies, which can support, expand and build on each other's business. Thus, while WPD can minimise investment needs into its network expansion, CEPro will focus on managing local community microgrids, and Bristol Energy could provide a trading platform for inter-microgrid trading.

2. Engagement with Local Authorities and Communities

Given the key roles that both local authorities and communities play in the success of local energy initiatives, we also suggest that the energy companies redouble their efforts in engaging with both of these stakeholders. In particular, while engagement with BCC can be carried out through discussions with the Energy and Innovation teams, engagement with communities would most likely be best carried out through education and demonstration campaigns (similar to what is discussed for the local market orchestration of section 4.4.1).

