EnergyREV

Bristol's ICT subsystem: Case study on skills and training needs for transitioning to smart local energy systems

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Contents

1 Summary

This briefing analyses the role of Information and Communication Technology (ICT) for the Smart Energy sector as a sub-system in the city of Bristol's transition to a smart local energy (SLE) system of systems (SoS). It identifies three key challenges as the result of a case study of the city:

1. How to reduce the complexity of the SLE systems,
2. How to tackle the challenges of scaling up, and
3. How to build capacity for transition within both infrastructure and human stakeholders.

It examines how to meet these challenges, as well as highlighting the skills and training needed to address them and how that training should be delivered.

We have previously noted (Chitchyan and Bird, 2021) that the SLE domain should be viewed as a system of systems (SoS), as it is comprised of operationally and managerially (semi-)independent sub-systems that work towards a common goal of optimised local energy generation and use and carbon neutrality. In Bristol, we have identified seven sub-systems, including ICT for SLE (Chitchyan and Bird, 2021).

ICT constitutes a part of the future SLE SoS, since "smart" systems must provide opportunities for data collection for the system's assessment and control, as well as support optimal decision making to reach set goals. Thus, as part of the energy system transition to SLE SoS, the ICT sector should undergo a change too.

These findings are based on a case study of the city of Bristol, where such a transition is underway. This is a qualitative study, based on data obtained through documentary analysis, interviews and focus groups. Findings from this study are grounded on the evidence from the city of Bristol, but can serve as a "food for thought" and trigger reflection on similar challenges within other localities as well.

2 Factors affecting Bristol's SLE ICT sub-system

The factors affecting the ICT sector in Bristol are illustrated in Figure 1.[1] We find that a key defining feature of SLE ICT projects is complexity due to the need to integrate multiple hardware and software interfaces. This is because SLE projects need to integrate across multiple energy vectors, including PV, wind and biofuels; and SLE SoS sub-domains such as transport and mobility, household consumption, community generation and digital energy services. Each of these vectors and domains is, by necessity, supported by custom hardware and software solutions. Orchestrating a consistent solution across these heterogeneous sets of hardware and software is a complex challenge in itself. It is further aggravated by the varied provision of networking and connectivity infrastructure, as well as by the fast evolution of renewable energy technologies with their supporting software services.

Networking and connectivity are essential for data exchange for the monitoring and control that ICT solutions are expected to exercise within the SLES. Yet, availability of this infrastructure is uneven across the city of Bristol (as well as the UK). In localities with high income and dense economic activity, the networking provision is assured, while in more deprived areas, it is scarce.

Given the unprecedented rate of research and development dedicated to zero carbon SLE technologies, it is not surprising that technological progress leads to a rapid cycle of hardware and software obsolescence. This fast technological change, in turn, disrupts convergence to standards and the emergence of stable SLE SoS infrastructures.

On the positive side, example technical solutions have a substantial role to play in demonstrating the positive impact and role of ICT-based SLE solutions. This, in turn, allows other organisations/projects to replicate solutions, thus reducing the complexity of the task. The growing number of examples also improves the state of connectivity provision: the examples demonstrate viable business use cases and reduced environmental impacts. These viable use cases also motivate policy makers to provide market stimulus to foster replication of the solutions.

Finally, where the intended user communities are deeply engaged, and are involved with co-designing prospective digital SLE services, the likelihood of successful adoption and use of such services also increases. This is demonstrated by the REPLICATE project in Bristol, for example.

1 * This model can be simulated on Bristol's ICT sub-system's causal loop diagram.

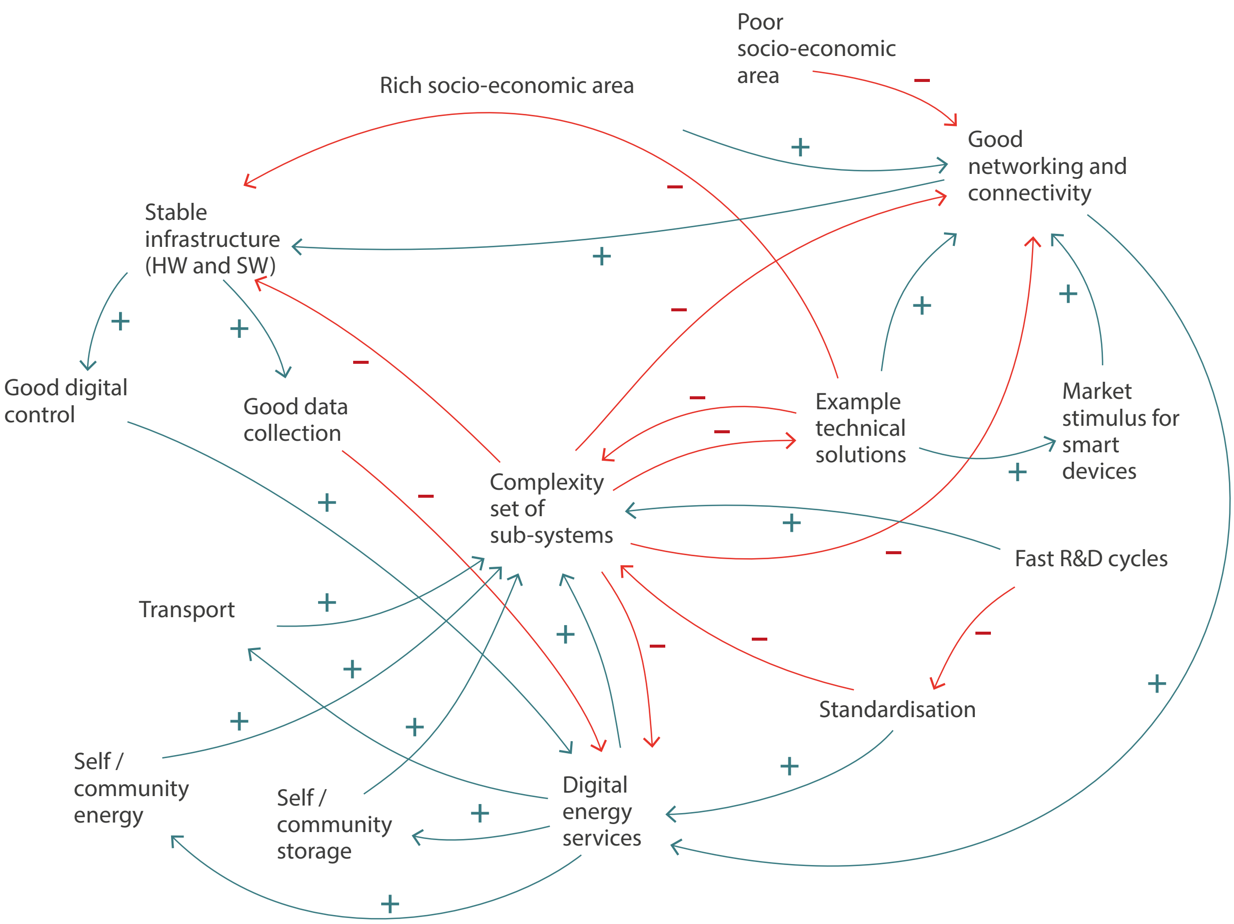

Figure 1: Causal model of the Bristol's ICT for SLE Sub-system.

3 Insights and recommendations on Bristol's ICT for SLE sub-system

3.1 Reduce SLE project complexity through good Software Engineering practice

For a successful project, we need to reduce its complexity as much as possible. The suggested strategies for this include:

- **Plan for flexibility in the work process**: Given that the hardware and software planned to be used within the SLES are likely to evolve within the project lifetime, it is only prudent to expect such evolutionary change. Correspondingly, a methodology which incorporates co-design and iteration cycles would suit such projects best. Moreover, "*putting a bit more co-design …and not having [the work plan] really fixed*" (P27)[2] also allows for better integration of end user concerns, as the project progresses.
- **Minimise technology in trials**: SLE projects expect to integrate a large set of technologies and devices. Yet, when trialling a solution, it is essential to start with the bare minimum; trials of the full set of intended technologies are likely to fail, due both to technology immaturity in some components, and the evolution of others. Thus, P30 suggests to "*…start with the minimum amount of failure points*" in a skeleton solution, and only then add one aspect of technology at a time (e.g. the functionality of "*an insecure VPN-less architecture for a start*" should be tested before adding a VPN).
- **Limit the number of initial users**: This reduces the number of "failure points" both in communication with users, and in setting up the technical solution. To illustrate this, one of the failure points in Bristol's REPLICATE Smart Home trial was the need to "*install several pieces of hardware which were supposed to be kept connected to the mains*". However, as trial participants at times wanted to use the power outlets for other purposes "*the hardware was often disconnected*" (P26). Because the solution was rolled out to 150 households without an initial limited trial, the project wasted a high number of person hours chasing trial participants and asking them to reconnect the equipment to the mains sockets.
- **Use mature technology where available**: This helps reduce complexity due to technological flux.
- **Engage experienced systems integration engineers**: Practical experience is particularly helpful in quickly identifying and addressing integration and interoperability challenges.

2 Hereafter we use Px to identify quotes used from interview participant (P) with the specific identifier number, as all respondents are anonymised. Thus, for instance P11 refers to participant 11.

All the above noted practices are also proposed within the agile software development paradigms in the "traditional" ICT sector (Martin, 2002; Beck et al, 2001). We observe that project management and decision making within SLE projects is often not led by professional software engineers, and so the good practice within the software engineering domain remains unknown and unavailable to members of such multidisciplinary SLE projects. Thus, we recommend that the technical management, as well as the development teams, across all areas of the SLE projects be introduced to agile development and management practices.

3.2 Scale up considerations

We note the following recommendations for scaling up ICT solutions for SLE, based on our Bristol study:

- **Make it easy**: The principle to consider for successful adoption of new technology is to ensure that it "*Fits into other people's business as usual*" (P20) as much as possible. This is not surprising, as the alternative is to engender conscious behaviour change, which requires that the intended prospective users/participants are reached, informed and on-boarded with the change programme and rewarded and motivated to carry it out – all of which requires substantial time, effort and cost commitments. While, if it is *"very simple, very easy …to be part of the trial …people don't have to worry too much about it*" (P26), then participation and engagement are much easier to achieve.
- **Use mature and robust technology**: This makes scaling up much easier because it allows for tested and validated hardware and software such as car-based monitoring technology for EV monitoring, or cloud-based encryption and storage solutions for securing data (P29) to be acquired. This avoids the high risk and cost of untested or proprietary developments. Here scale up can progress through working with:
    - **Specialist industry partner**, as such a partner would already be developing and delivering the required hardware/software technology (e.g., as Trakm8 for car monitoring boxes). This removes the need for production/development process set up.
    - **External skilled professionals**, via consultants or experienced installation parties (e.g., building and retrofit service providers). This avoids the need to develop, finance, and maintain all varied skill-sets internally.
- **Plan for commercialisation pathways**: This is essential for successful scale up of SLE ICT projects, as only a commercially viable solution driven by the interests of one or several organisations will maintain momentum in the longer run. Indeed, many good solutions derived through SLES Research and Development projects fail to gain momentum when there is no dedicated industry partner driving this prospectively lucrative commercial interest.
- **Aim for achievable regulatory compliance**: Without this, even the most promising technologies fail to scale up. For instance, this is currently the case with peer-to-peer electricity trading platforms. These platforms are technically viable (Stoker, 2019) and prospectively profitable. However, because (as per current regulations) a household can have only one supplier at any given time, peer-to-peer electricity trading amongst households remains impossible.

3.3 Capacity and expertise

Within the SLE ICT sub-system there is an implicit assumption that once data for a particular sub-system of SLE is available, the business that owns that data will be able to derive additional benefits by creating value from this data. This, however, is not always the case. Often the businesses working within a specific domain have neither the capacity, nor the skill-set for such value creation.

This is particularly true of small and medium sized companies, which, despite utilising SLE technology, are not focused on SLE SoS activities for value creation per-se. For instance, a car rental company may have to move away from fossil to electric vehicles, yet continue to see its key business as renting out vehicles, rather than charge/discharge optimisation and battery use. Indeed, customers would still rent and return the vehicles with the set 'fuel' levels (be it battery charge or petrol in the tank). And though the company would, by default, be able to aggregate the vehicle tracking data, as noted by P20, the company may not be "*that interested in looking far and wide for other possible applications of tracking data when basically they think they've got all the value that they can get*".

This issue can be addressed as follows:

- **Explain and provide opportunities for value creation from SLE technologies to all SLE technology users across all SLE sub-systems**: This might be achieved by offering a choice of monetising access to a company's own or aggregated business data. For instance, in the above example, the EV charging data could be monetised by distribution service operators in forecasting energy demand. The first steps towards this have already been taken through the recommendations of the Data Task Force and their implementations across UK Research and Development funding providers (Energy Systems Catapult, 2019). This, however, also needs to be scaled up and integrated at the technology distribution points (e.g., at the point of EV sale) allowing the buyer, business or citizen to choose a value from data creation options.

It is difficult to maintain up-to-date technical expertise across the SLE ICT sub-system because of the quickly evolving technological scene in SLE, and even faster evolution in the ICT sub-system. This is particularly relevant to project managers, who are not themselves technical developers, but need sound knowledge of current solutions and opportunities.

To address this, we suggest:

- **Report findings widely**: Projects and businesses undertaking funded SLE ICT projects should periodically report their findings at open forums, rather than at by invitation-only events.

SLE ICT SMEs are often reluctant to employ new graduates, but aim to hire professionals with proven track records and past industrial experience in similar technologies, because they need people who can "hit the ground running".

- **Use year-in-industry schemes and internships**: Address this issue with wider use of 'with industry' projects at universities, as well as through 'year in industry' schemes and internships, aiming to provide hands-on practice opportunities for university graduates.

4 Training needs of the ICT sub-system

4.1 Areas of training needs

The key areas for training in the ICT sub-system for SLE are primarily focused on engineering and technical management:

- **Software engineering**: These 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 collection, storage, exchange, standardisation, interpretation, analysis and management**: This is critical since all decision making in SLES (and so the services delivered by the ICT sub-system to this system of systems) are based on the results of the (nearly) real time data analysis.
- **Systems integration engineering**: 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. This is because systems integration is an area where SLE projects are somewhat more diverse. They require integration of heterogeneous hardware and software application programming interfaces, across differently networked localities with differing additional constraints such as on telecommunication network bandwidth availability, etc.
- **Installation engineering**: Training on how to install PV/wind turbines, EV charge points, etc. is required because ICT solutions need to be developed for the hardware that is installed across the SLE sub-systems to support "smart" optimisation of energy and resource use.
- **Technical management skills**: The ability to manage technology, as well as very large projects with a multitude of stakeholders is as relevant for SLE as other parts of the ICT sector.

4.2 Modes of training

When discussing how training should be delivered, we find that:

- **University education** (or equivalent) is a clearly assumed expectation for most entrants into the ICT area. Yet, this is a necessary, but 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-ups are considered essential.
- **Apprenticeship** "*is a good opportunity of … training …*" (P31) though apprenticeships tend to be used more by larger organisations.

- **On-the-job** training is considered particularly relevant as, given the wide range of new contexts and projects that arise, employees are "*pushed … 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, the practical skills around handling large-scale projects and interacting with many stakeholders and collaborators from across various organisations can only be acquired through such on-the-job experience.
- **Peer training** capacity is often accounted for during the hiring process. Companies "*need a couple of key people and seniors who have that background experience that could be training and upskilling people from other backgrounds*" (P1). Peer training helps them gain practical skills, such as, for instance, handling production scale platforms and projects.
- **Doctoral training** is another method mentioned for both algorithms development and networking areas. These skills are relevant particularly at present; 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 anything 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).

Appendix 1: List of skills in short supply for ICT in Bristol

Engineering and design skills

- Software engineering skills:
  * Agile Processes and Practices skills
  * DevOps skills, i.e., continuous collaborative process between the development and operations roles within the SLE projects.
  * Requirements engineering
  * Programming skills with various environments and languages
  * Machine Learning and Data Science
  * Data engineers
  * Deployment skills
  * Privacy and security delivery skills
  * Robust hardware/software manufacturing skills
- Networking and telecommunications skills
- Systems engineering skills:
  * Systems architect skills to oversee the "complex web of different partners doing different things"
  * Skill of considering scalability of the system-to-be
- Multidisciplinary engineering

Energy domain skills for the ICT sub-system:

- Understanding of the fundamentals of power systems and renewable energy

Trades skills for the ICT sub-system:

- Installation engineers

Managerial skills for the ICT sub-system:

- Technical project management
- Systems integration management, where the manager ensures that the team members:
  * have a clear understanding of the capabilities of chosen technologies; these technologies must work together, across the organisational boundaries, for the integrated system to function;
  * build collaborative relationships between project teams (which could often be distributed across several organisations);
  * provide the "coordination clout" that enables teamwork while maintaining "oversight to critically appraise" the progress.
- Team management with remote working
- Procurement skill

Finance skills for ICT sub-system:

- Skills for planning commercialisation pathways
- Skills to utilise data for business improvement

Policy skills:

- Having insight into overseas markets
- Skills for lobbying regulators

Soft skills for ICT sub-system:

- Engineers with skills to engage citizens
- Manage public expectations of technology
- Fundamental ICT skills and understanding of engineering technologies by citizens

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About EnergyREV

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