Local Energy Oxfordshire

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Annual Interviews with Project Partners, Year 4

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Context

The UK Government has legislated to reduce its carbon emissions to net zero by 2050. Meeting this target will require significant decarbonisation and an increased demand upon the electricity network. Traditionally an increase in demand on the network would require network reinforcement. However, technology and the ability to balance demand on the system at different periods provides opportunities for new markets to be created, and new demand to be accommodated through a smarter, secure and more flexible network.

The future energy market offers the opportunity to create a decentralised energy system, supporting local renewable energy sources, and new markets that everyone can benefit from through providing flexibility services. To accommodate this change, Distribution Network Operators (DNOs) are changing to become Distribution System Operators (DSOs).

Project Local Energy Oxfordshire (LEO) is an important step in understanding how new markets can work and improving customer engagement. Project LEO is part funded via the Industrial Strategy Challenge Fund (ISCF) who set up a fund in 2018 of £102.5m for UK industry and research to develop systems that can support the global move to renewable energy called: Prospering From the Energy Revolution (PFER).

Project LEO is one of the most ambitious, wide-ranging, innovative, and holistic smart grid trials ever conducted in the UK. LEO will improve our understanding of how opportunities can be maximised and unlocked from the transition to a smarter, flexible electricity system and how households, businesses and communities can realise the benefits. The increase in small-scale renewables and low-carbon technologies is creating opportunities for consumers to generate and sell electricity, store electricity using batteries, and even for electric vehicles (EVs) to alleviate demand on the electricity system. To ensure the benefits of this are realised, Distribution Network Operators (DNO) like Scottish and Southern Electricity Networks (SSEN) are becoming Distribution System Operators (DSO).

Project LEO seeks to create the conditions that replicate the electricity system of the future to better understand these relationships and grow an evidence base that can inform how we manage the transition to a smarter electricity system. It will inform how DSOs function in the future, show how markets can be unlocked and supported, create new investment models for community engagement, and support the development of a skilled community positioned to thrive and benefit from a smarter, responsive and flexible electricity network.

Project LEO brings together an exceptional group of stakeholders as Partners to deliver a common goal of creating a sustainable local energy system. This partnership represents the entire energy value chain in a compact and focused consortium and is further enhanced through global leading energy systems research brought by the University of Oxford and Oxford Brookes University consolidating multiple data sources and analysis tools to deliver a model for future local energy system mapping across all energy vectors.

Executive Summary

As an innovation project, LEO encounters multiple sources of uncertainty, including uncertainty around the performance of assets used for flexibility provision and the technologies and approaches used to monitor, control and automate them. Uncertainty also remains around when and how often different types of flexibility events might be called, and the revenues that might be available for flexibility providers, if the arrangements demonstrated within LEO were deployed as part of business-as-usual. Together with relatively high transaction costs for flexibility provision, which largely remain at the end of the project, this uncertainty makes it harder to establish a business case of flexibility provision.

On the other hand, both uncertainties and transaction costs might be expected to reduce over time through processes such as increasing automation, standardisation, training staff, coordination, and familiarisation with processes and protocols through learning by doing. Aggregators may also be able to reduce transaction costs for flexibility providers, through helping to assess and improve assets' flexibility potential, deliver flexibility from assets and participate in auctions.

This report presents findings from the fourth annual interviews conducted with project partners as part of Work Pack 6, focussing on key themes that emerged during these interviews, including:

- Sources of transaction costs for different actors in SLES and approaches to reduce them
- Learnings about co-creation activities conducted with households and communities
- Learnings about coordination and collaboration between the various other actors (industry, public sector and third sector) involved in the project.

It concludes by drawing on insights from the interviews to discuss what this means for the future development of Smart Local Energy Systems (SLES).

Remaining uncertainty

Interviewees described multiple sources of remaining uncertainty and the impact of these on flex delivery. They include:

- Flex-enabling technologies not working as expected
- Competitive markets, which mean that flex providers do not know how much they could be paid for flex delivery or whether their bid would be selected
- The behaviour of end users, which can impact on flex potential and delivery
- Uncertainty of weather forecasts, since weather impacts on the flex potential of assets such as air conditioning and solar PV
- Uncertainty around wholesale energy prices and changing government policy, which was seen as impacting on the development of new offers related to SLES.

Continued experience of SLES delivery is likely to generate further learning that reduces some forms of uncertainty. For example, if more flexibility providers participate in auctions this should begin to reveal the market price for flexibility, and flexibility providers may begin to learn when their bids are likely to be accepted and/or strategies to increase the acceptance of their bids.

However, together with limited revenues available for provision of flexibility to DNOs/DSOs, high transaction costs currently represent a barrier to continued participation in flexibility markets within business-as-usual activities outside of the trial context. This makes it important to consider the sources of transaction costs and how they might be reduced, which are important lessons learned

from the project. Similarly, it is also relevant to consider how revenues available for flexibility provision might be increased.

Transaction costs for flexibility providers

Interviewees reported significant remaining transaction costs for flexibility provision and participation in auctions. These include:

- Staff time required to participate in flexibility provision, including time to manually operate assets to deliver flexibility and to complete the end-to-end process for participating in auctions, which is a significant ongoing cost.
- Understanding the flexibility potential of assets and how this could be improved.
- Investments to improve assets' flexibility potential, including upgrades to energy efficiency, building management systems and other systems for control and communication.

In some cases, transaction costs outweighed the revenues received for flexibility provision. Interviewees also reported non-financial motivations for participating in flexibility delivery, which may be seen as particularly important if relatively high costs and low revenues limit the financial incentive to participate. However, it also emerged that accounting for these benefits can be associated with specific transaction costs, such as developing new processes for organisational greenhouse gas reporting.

High transaction costs need to be seen in the context of LEO as a project demonstrating proof-of-concept, with the potential for transaction costs to be reduced further over time.

Actions to reduce transaction costs for flexibility providers

Increasing automation for both operation of assets and participation in auctions has considerable potential to reduce staff time required for flex delivery, although based on the interviews it appears some steps may be more difficult to automate.

Providing industry standards and guidance could help flexibility providers to make initial assessments of their assets' flexibility and/or to commission third parties to make a more detailed assessment, reducing the costs associated with understanding flexibility potential of assets and how this could be improved. Standards for "flex readiness" of relevant technologies may also reduce the costs associated with preparing assets to provide flexibility, although the costs of doing so as standard should also be considered.

Working with aggregators was expected to reduce transaction costs in diverse ways, as flexibility providers are able to draw on their knowledge and experience when preparing for flexibility provision and hand over responsibility for many ongoing aspects of flexibility provision.

Changing the offer to change transaction costs and potential revenues available for flex provision

Interviewees suggested changes in the design of flexibility offers could both reduce transaction costs and increase the revenues available for flexibility provision.

Changing the end-to-end process for participating in auctions: Aside from automation, more minor changes to make spreadsheets and email notifications more user friendly could reduce the use of staff time for participating in auctions. Interviewees also suggested it could also be useful to review

the requirements for data capture and reporting to establish what is “good enough” to meet DNOs/DSOs current needs, and reduce the burden on flexibility providers.

Changing approaches to baselining: Shifting from baselining to capacity limitations (in other words, contracting for demand or generation to stay within set limits within defined time periods) could both reduce transaction costs and increase access to revenues. It could simplify verification of delivery, reduce the risk of over delivery by weather-dependant assets, and help flexibility providers to participate in multiple forms of demand-side flexibility simultaneously (known as value stacking).

Developing frameworks for value stacking: Accessing revenue from multiple sources simultaneously would be also require optimised operation of flexibility assets, which could be provided by aggregators, and new forms of coordination between different industry actors such as DNOs/DSOs and the ESO to avoid conflicts arising (known as primacy rules).

Reducing times between auctions and delivery: Could increase access to revenue by making it easier to predict delivery of assets dependent on the weather or user behaviour, which can become increasingly uncertain over longer time frames.

Operational costs for actors supporting the provision of flexibility

Actors supporting flexibility providers also bear costs associated with developing and implementing new processes that support the provision of flexibility, and, in some cases, to communicate with users and communities.

This means that actions to improve the business case for flexibility providers through changing the offer to reduce transaction costs and/or increase access to revenues are likely to themselves create costs for other actors in the SLES ecosystem. As costs and benefits of flexibility provision will be distributed between these various actors, these costs – and not only costs borne directly by flexibility providers – may impact on the business case for flexibility provision. This makes it relevant to also consider how these costs may be reduced.

Reducing costs for actors supporting the provision of flexibility

Similarly to costs for flexibility providers, interviewees identified a number of ways to reduce costs for actors supporting the provision of flexibility:

Greater standardisation: Standardisation and industry guidance could help industry actors to work together more effectively, for example in the context of value stacking and developing and using APIs.

Working with aggregators: In addition to reducing costs for flexibility providers, working with an aggregator could reduce costs for the DNO/DSO by providing a single point of contact to procure and settle flexibility. Payments for aggregators’ services also need to be taken into account.

Communication with end users and communities: Certain communication costs might be reduced, for example by developing business models based on routine behaviour by users rather than dynamic notifications, and accessing data from smart meters. However, this will not substitute for in-depth engagement work.

Coordination, collaboration and co-creation

Developing Smart Local Energy Systems involves creating new roles for existing actors, establishing new actors (such as aggregators), and creating new relationships between them. For example, DNOs must learn how to become DSOs, capable of new ways of managing their network and interacting with their customers. To realise these new roles and responsibilities various forms of coordination, collaboration and co-creation are required, involving different actors in the energy system. Project Partners described examples of these processes from their experiences of co-creative work with households and communities, and collaboration and coordination between organisations.

Working with households and communities

Important considerations when working with households and communities include:

Clear communication: SLES and the energy system more generally are often unfamiliar. Clear guidance and support is needed for households and communities to understand different elements of SLES and their potential benefits, to want to take action. Listening to feedback can help to ensure that communications and tools can be understood.

Upfront costs to low carbon technologies: Even once households want to act, high up-front costs of some new technologies can still be a barrier to participation.

Crowd sourcing data and co-creating plans and solutions: Communities and households can also provide unique valuable information and insights that inform local decarbonisation, including identifying and evaluating opportunities for local action as well as providing more technical information.

Creating a sense of ownership: Households and communities participating in co-creation need to feel their efforts are recognised and that they can benefit by taking part. This can involve explicitly recognising the value of their local knowledge, providing valued information, and engaging in consensus-based co-creation processes.

Trust: Trusted actors are important when engaging households and communities. They may need to engage in skilled work to encourage households to engage in co-creation. For example, Project Partner Low Carbon Hub described how some community groups were surprised by the low level of data available on low voltage network conditions in their area, requiring careful discussions about the reasons for this and how the available data could be used in a positive way.

Making participation easy: Engagement needs to be made as easy as possible, including working in times and places where households and communities do not need to devote their attention to other pressing concerns.

Interviewees reiterated that effectively engaging households and communities in this way offers many benefits, and requires sufficient time and resources.

Collaboration and coordination between organisations

Interviewees described how collaboration and coordination between organisations can be supported by:

Using analogies and familiar language: As with households and communities, SLES and flexibility are often unfamiliar concepts to people working in organisations with the potential to participate in flexibility provision. As well as using everyday language, interviewees described how using familiar analogies can support effective communication: for example, explaining the local flexibility market

platform as a form of a procurement platform transformed the understanding of members of one organisation's procurement team.

Useful communication tools: Tools can be important to support effective communication between organisations. Examples included online technical specifications for flexibility, which can be easily shared, and online collaborative visualisation tools to check shared understanding of different organisations' processes.

Peer to peer learning: SLES actors described educating their peers about different aspects of SLES based on their own learning within Project LEO, with the aim of influencing wider industry development.

Coordination: New formal rules may be needed to coordinate new relationships between system actors. For example, primacy rules need to be established to coordinate value stacking (the ability for flexibility providers to participate in both DSO and ESO procured services). This can require considerable time and effort to develop.

Communication between system actors: Some interviewees also described more informal communications that could help to coordinate the actions of different industry actors. For example, press releases and blogs can help to coordinate expectations about technology development.

Implications for further learning and development of SLES

Partners emphasised how LEO's learning-by-doing approach had been completely validated – the project has generated a huge amount of learning and has explored technical, operational and business model innovation that would not have been possible outside an innovation project in business as usual (BAU). The project demonstrated the potential for DNOs/DSOs to operate local flexibility markets, as well as the potential for a diverse range of grid-edge actors to contribute to providing flexibility. However, it was also noted that precisely because non BAU processes were explored, transaction costs were high and multiple technical, social and economic barriers were encountered. This is itself important learning as it helps to identify how tools and approaches demonstrated in LEO should be developed further.

Transaction costs and other barriers to SLES delivery would be expected to continue to fall over time, for example as different forms of automation and coordination become more developed and familiarity and learning increases. Further experience in developing Smart Local Energy Systems is likely to support these processes, but this can be seen as a chicken-and-egg problem since this experience may not be realised until remaining barriers are further reduced.

Some Project Partners therefore suggested that SLES should be offered further targeted support through innovation funding to explore the potential for transactions costs and other remaining barriers to further reduce, alongside work including developing frameworks for value stacking which would enable revenues received for local flexibility provision to increase. Under current regulatory structures, DNOs/DSOs are not allowed to provide this type of targeted support, as they are obliged to choose the option at current least cost.

Table of contents

1 Introduction

Work Pack 6 of Project LEO has a remit to capture and disseminate learnings and insights generated from across the project. Our primary tool for this is a cycle of quarterly and annual interviews with partners representing each work package.

1.1 Aim of the interviews

The aim of the interview cycle is to:

- Use these interviews to improve all-round understanding of the project, as seen from the perspective of each partner,
- Flag up areas of opportunity or concern, and
- Assist in general project evaluation and reporting.

Specifically, information gathered in the interviews informs:

- Updates to the Central Learnings Log,
- Updates to the LEO Theory of Change,
- Development of briefing notes,
- Development of the LEO reports,
- In this particular interview cycle, reporting on Trial Period 2 of the Transition project.

1.2 Method

This is the report on the 4th round of annual interviews. It is based on interviews conducted in October and early November 2022 with 12 representatives of 8 of the project partners. Interviews were conducted by Nick Banks and Bryony Parrish (both University of Oxford) and Timur Yunusov, Iulia Falcan, David Middleton and Stephanie Budenberg (all at Baringa).

We used a semi-structured format lasting between 45 and 60 minutes. Compared with previous years, the topic guide was very open ended to allow interviewees space to reflect on what they perceived to be their own principal insights and learnings after 3 years of participation in LEO. To help interviewees structure their thoughts, interviewees were asked to consider:

- The social, technical and economic domain or domains that a learning related to,
- Whether the learning posed a barrier or opportunity for the project to achieve its objectives,
- Whether specific technical, digital, economic or social “capabilities” were required to overcome the barrier or make the most of the opportunity,
- What, if anything, should be done with the learning in terms of dissemination.

The interviews were recorded and transcribed, giving us a rich dataset. Transcripts were then thematically analysed using qualitative analysis software NVivo.

Occasionally we use verbatim quotes to exemplify the points coming from the analysis. These are edited to remove pauses etc to improve readability. These quotes are not attributed to individuals and have all been reviewed by the speaker to ensure contributors are happy with inclusion in this published report.

1.3 Structure of the report

What follows is a summary of the main messages coming from the interviews contextualised with information from previous LEO reports and wider discussion of the topic drawn from the literature.

Two brief introductory sections describe what interviewees have told us about sources and impacts of uncertainty within Project LEO, and project partners' strategies for learning. More substantive sections discuss key themes emerging from the fourth annual interviews. These are:

- Transaction costs involved in flex provision.
  Types of transaction cost with possible actions to reduce them. Overall effect on the case for flex provision considering both financial and more-than-financial motivations.
- How design and delivery of flex service offers may impact on transaction costs.
  This section draws on the capabilities approach outlined in the Year 3 Synthesis Report and in other LEO reporting.
- Coordination, collaboration and co-creation within Project LEO.
  This section is structured around 'working with households and communities' and 'coordination between organisations', and includes findings with relevance for LAEP.

The report concludes with an overarching discussion that draws together these themes and considers the implications for the future development of SLES as demonstrated in Project LEO.

2 Sources and impacts of uncertainty within Project LEO

As LEO is an innovation project, project partners have inevitably dealt with uncertainty emerging from changes from BAU, both in their own operations and in those of other actors in the SLES ecosystem on which their actions also depend.

Partners identified a number of sources of uncertainty described further below.

2.1 Flex enabling technologies not working as expected

Some technologies installed to get assets flex-ready have not delivered as expected, increasing transaction costs associated with flex delivery:

> We had challenges getting rooftop PV sites flex ready. We replaced all the inverters and then we had these communications issues where we couldn't connect to these inverters on sites. And before the project partner […] had been able to do this on other projects, so it was never even a risk that this would happen. But it's happened.

(Project Partner at Low Carbon Hub)

This has the effect of increasing transaction costs for flexibility providers, a theme which is discussed further in Section 4.

2.2 Competitive markets for flexibility provision

The competitive markets for flexibility demonstrated in LEO also increased uncertainty. This market structure is intended to support market price discovery – SSEN's willingness to pay for flexibility and asset providers' willingness to accept SSEN's offer of a certain £ / kW of delivered flex[1] – but this also means that flex providers do not know how much they could be paid (or whether they will be paid) in advance. Together with uncertainty about the frequency of flex events called by the DNO/DSO, this made the business case for flex provision more difficult to assess:

> We found that it was very difficult creating a business case for flexibility, because we don't know how many flexibility events there'll be, and we don't know what the prices will be in a competitive market.

(Project Partner at Low Carbon Hub)

2.3 Behaviour of end-users

The behaviour or actions of end-users can create unpredictability in the availability of flex at different times, in turn impacting on the potential to bid this flexibility into auctions. This issue was particularly emphasised by Nuvve, our project partner providing EV smart charging and V2G services:

> We did not contract the LEO V2G participants to a set utilization of these chargers […] So some partners have been regular in their usage […] they're pretty much the only site that we're really consistently bidding in, and have a good reliability.

(Project Partner at Nuvve)

[1] See Project LEO and Transition Market Trials Report (Period 1) at https://project-leo.co.uk/reports/project-leo-and-transition-market-trials-report-period-1/

2.4 Changing weather conditions creates uncertainty for some assets

Other sources of uncertainty have also impacted on flex delivery. Uncertainty of weather forecasts has created uncertainty in the delivery of flexibility assets that are weather dependent, which, within Project LEO, included solar PV and air conditioning in a public library.

Project Partners at Oxfordshire County Council identified that demand turn down by air conditioning was not possible when outdoor temperatures exceeded around 28 °C, as the comfort of library users and staff was overly impaired. Conversely, demand turn down was not possible when outdoor temperatures fell to around 20 °C, because air conditioning was simply not operational. However, despite learning these characteristics of their asset they reported that, particularly for week-ahead auctions, their participation was restricted by reliance on weather forecasts and the uncertainties associated with these. Project Partners at Low Carbon Hub similarly identified the importance of accurate weather forecasting to maximise revenues from their asset:

> To know how much flexibility you can deliver in a week's time for PV, you need to know exactly when the delivery will be and what the weather's like. If there's cloud cover, sometimes the generation from an asset can drop by 80%. So, we've just been playing it conservatively, but if we were to try to maximise our revenues from flexibility, we'd need really precise forecasting for PV. We're starting to use forecasting. But […] sometimes we're hugely under delivering, or sometimes we're hugely over delivering.

(Project Partner at Low Carbon Hub)

2.5 Uncertainty created by policy context and shifting energy prices

Other project partners highlighted that the current landscape of policy uncertainty and very high wholesale and retail energy prices in the UK have contributed a source of uncertainty that may have impacted on industry's ability to devote resources to the development of offers related to SLES, or to reliably assess their business case.

Many forms of uncertainty associated with innovation would be expected to reduce over time through processes such as learning and increasing coordination and standardisation. This would influence the further development of SLES, which is discussed further in Section 7.

3 Project partners' strategies for learning

Learning by project participants is of course one way to reduce uncertainty. Interviewees described having a adopted a number of strategies for learning within Project LEO.

3.1 Learning through the provision of information and training

Various forms of *information and training* were provided to participants via the project itself. While this is clearly important, interviews suggested that this route to learning can be hindered if details provided near the start of the project are forgotten at later times when they need to be applied, or if people receiving the training have left that organisational role at times when the learning needs to be applied. Written guides are also useful (and continuously available) but can be time consuming to study, with more intuitive processes being preferred where possible:

> You end up going into a spreadsheet and filling out the spreadsheet and calculating the number of hours, and it's quite a time-consuming step. And also, you have to read through a guide to work out how to use this calculator. So, in an ideal world it would all be programmed into the platform, and quite simply, it would just say you've gone over the maximum and you can almost just do trial and error.

(Project Partner at Low Carbon Hub)

3.2 Learning by consulting experts

Consulting experts is another strategy for learning, which was particularly emphasised by Oxford City Council: this partner commissioned a third party to conduct a formal assessment of the flexibility potential of their assets and ways in which this could be improved. Partners reported learning a lot from this assessment, but also explained they were able to use their assets to participate in auctions in innovative ways the experts had not identified.

3.3 Learning by trial and error

Some participants employed trial and error as another strategy to test out how well different features of the flex service offer designs suited their business models, or to learn about the flex potential of their assets and how this varied at different times:

> It was very ballpark. I bid in 60% of our capacity because we were trying for the first time […] we didn't know how the system would react.

(Project Partner at Oxfordshire County Council)

3.4 Combining strategies for learning

These strategies for learning can of course be combined: for example, partners at Oxfordshire County Council described looking forward to receiving formal analysis performed by engineers at the University of Oxford to further develop their own, informal analysis of how the flex potential of their assets varies with outdoor temperatures.

3.5 Learning by doing

Deliberate trial and error as described here is a sub-set of the wider phenomenon of learning by doing, which is widely recognised as an important part of innovation. For example, learning by doing can explain the falling production costs of renewable energy technologies – particularly standardised and modular technologies such as solar PV. The final overarching discussion will consider the potential for further learning-by-doing and what this means for further support of SLES projects and potential for further development.

4 Transaction costs for flexibility providers and the case for flex provision

A range of LEO participants have identified transaction costs as a key barrier to their participation in flexibility provision and SLES[2]. This section starts by describing transaction costs faced by flexibility providers. It considers reported actions by which these transaction costs could be reduced and the potential implications for the business case and non-financial motivations for flexibility provision. It then discusses how changes to flexibility service design might change transaction costs and potential revenues available from flexibility provision. Finally, it reflects on transaction costs that may be associated with making such changes, and other operational costs for actors that support flexibility providers.

4.1 Transaction costs faced by flexibility providers

Partners identified a number of aspects of transaction cost including:

- Staff time required to participate in flexibility provision
- Costs involved in understanding and improving assets' flexibility potential

These are discussed further below.

[redacted] Staff time

Staff time was a key transaction cost for flexibility providers in LEO. Time has been required for activities such as monitoring emails alerting participants to new flex auctions, monitoring weather conditions to assess the impact on flexibility potential of temperature dependent demand and weather dependent generation, and the various steps involved in participating in auctions.

Staff time required for flex provision varied according to the type of flexibility service, with less time required for types of flexibility services that do not require actual control over asset operation:

> We find it easier to participate in DSO enabled. If you're to sell MEC, you don't necessarily have to have any control over the asset, whereas if you're buying MEC, it does require having control, because you have to exceed your allowance. So, selling MEC requires no control. Very easy. Pretty much anyone could do it with an energy asset that's connected to the grid and registered on the NMF, but actually buying MEC and increasing your MEC does require control.

(Project Partner at Low Carbon Hub)

Out of the multiple steps required to participate in auctions, there was some agreement amongst participants that proof of delivery is the most time-consuming step; and that at least within the context of this demonstration project, the end-to-end process can take around one to one and a half hours. Importantly, the time required remains the same irrespective of the size of the asset used to provide flex, and the costs of staff time have often considerably exceeded revenues received for flex provision:

> Our revenue for TP2 has been […] lower than what we, in terms of staff cost, spent on working on it.

(Project Partner at Oxfordshire County Council)

[2] See Project LEO second annual synthesis report here: https://project-leo.co.uk/wp-content/uploads/2021/08/D-6.3.4-second-annual-synthesis-report-070821-FINAL.pdf

However, this needs to be seen within the context of LEO as an innovative project demonstrating proof of concept and providing various opportunities for learning:

> If you look at it just based on the actual costs just now for the system as it stands versus the offering that they get, the numbers don't add up. Now, I don't think that's necessarily a bad thing to recognize, I think we need to step back and realize that this is a proof of concept.

(Project Partner at SSEN)

[redacted]Understanding the flexibility potential of assets and how this could be improved

In addition to staff time, costs may be associated with various actions to understand and improve the flexibility potential of assets. If third parties are commissioned to assess the flexibility of assets this is likely to involve costs for their labour, unless this is part of, for example, the value proposition of an aggregator that could provide this service for free as part of the process of gaining a new customer.

[redacted]Improving assets' flexibility potential

Costs associated with improving the flexibility of assets included upgrading solar PV inverters, upgrading building management systems to support scheduling and/or remote control of assets, and making bespoke changes to data management necessary for assets to participate in flex-provision. These costs can be considerable, and the issues may be widely present across the UK:

> Quite a lot of money has to be invested in assets, to make them able to deliver flexibility. So, with our rooftop PV sites it's £1000 per site to just enable flexibility.

(Project Partner at Low Carbon Hub)

> The diversity of assets that don't always have these data communications *will* cause inherent problems. We saw that in the Sackler Library, where to access data from the building management system you literally had to go in and take a USB stick to pull the data from there. So doing any sort of flex trial on an automated basis following a request from a DSO was just simply not possible. And we might think, OK, that's a Sackler problem, but actually that's quite largely a building problem in the UK, where building management systems are just not at a level for interacting on the network in that way, and they were largely intended to capture data simply for *monitoring*, not fully engaging.

(Project Partner at University of Oxford)

As project partners at Oxfordshire County Council explained, flexibility of air conditioning assets could be further enabled by upgrading the thermal efficiency of building fabrics, and the systems providing cooling. This would enable flexible operation over a wider range of outdoor temperatures. Similar principles could be applied to increase the flexibility of electricity demand for heating.

4.2 Actions to reduce transaction costs for flexibility providers

Automation, standardisation and working with aggregators emerged as three key categories of action that interviewees expected to reduce transaction costs of flexibility provision.

[redacted]Automation

Automation of asset operation (where this is required) and steps involved in auction participation could significantly reduce required *staff time*. Project partners at Low Carbon Hub expected automations completed within the scope of the Project to reduce time required for flexibility

provision by around two thirds, potentially allowing very small assets to participate in flexibility provision. The invoicing step was seen as more difficult to automate because of the need to align with business-as-usual procedures: namely, processing invoices via the financing team. In a similar vein, another project partner reflected on the potential challenges for public sector organisations to receive revenue for flexibility provision in a way that aligned with business-as-usual procedures to demonstrate transparency and fairness.

Automation that enables scheduling of asset operation can also increase access to revenue by allowing flexibility provision outside of working hours (conditional upon assets being operational at these times). Interestingly, scheduling was seen as having relatively little impact on total staff time required for flexibility provision, at least by the project partners who described it.

[redacted]Standardising flexibility assessment and improvements

Increasing standardisation was seen as a means to address transaction costs associated with both assessing and improving assets' flexibility potential.

Partners at Oxford City Council suggested that industry standards for the *assessment of asset flexibility potential* could increase confidence and reduce transaction costs for non-expert clients commissioning such an assessment, by providing some guarantee of the assessment's quality. Based on their learnings from commissioning a third-party flexibility assessment, they will shortly publish a report with recommendations to the energy flexibility sector about the need to support the first step of quantifying flexibility, especially in the public sector. These include:

- Providing common and clear industry recognised guidance or standards for assessing and quantifying flexibility.
- Support to improve assets' flexibility potential.
- Clarity of communication.

Providing guidance on the likely flexibility potential of various *standardised building or load archetypes* could also support actors to make (at least an initial) assessment, without needing to employ an external consultant. Other project partners suggested that this should help to determine the viability of proceeding with detailed flexibility assessment, through supporting rapid assessment of current data available on building or load performance, as this can be affected by existing metering arrangements. It could also helpfully include guidance on which parts of a system would benefit from automation or remote scheduling to facilitate the implementation of this step:

> Without bringing in a third party to do that assessment, if we had some sort of […] building archetypes […] you know, if you've got a library and if you have this type of chiller, that type of chiller, then you have a potential to do X type of flexibility delivery or if you've got a leisure centre, it might have these opportunities within it.
>
> What would be useful for local authorities who are working on public sector decarbonization projects, and upgrading our systems is to understand what exact control systems are required to be able to participate in flexibility […] we've stuttered and stumbled upon trying to understand what would work, it would be good to have a standard format saying these are the systems that you need.

(Project Partners from Oxfordshire County Council)

[redacted]Standardising communications protocols

Standards that require 'flex readiness' of key technologies, including standards for interoperability of communications, would reduce the costs associated with retrofitting or developing bespoke

solutions. However, in some cases it may be relevant to also consider the impact on up-front costs. For example, the cost of a vehicle-to-grid capable electric vehicle charger is significantly higher than that of a standard electric vehicle charger.

Guidance on minimum standards required for communication and control systems could also reduce costs if they enable greater use to be made of existing infrastructure, such as wi-fi connections, and lower specification systems that might already be available 'off the shelf'.

[redacted]Giving DNOs/DSOs access to smart meter data and working with aggregators

Interviewees identified two further actions with the potential to reduce transaction costs:

- Giving DNOs/DSOs access to smart metering data could reduce staff time required for the time-consuming step of proof of delivery.
- Working with aggregators was expected to reduce transaction costs in diverse ways, as flexibility providers draw on their knowledge and experience when setting up assets, and hand over responsibility for many aspects of ongoing operation of flex provision.

4.3 In-house costs of reducing transaction costs

It should be noted that actions to reduce transaction costs can also be associated with costs of their own. These are likely to include costs associated with hiring third parties and/or in-house staff time to develop such processes, even if these are reduced through forms of standardisation and guidance as described above. Developing automation is also likely to involve equipment costs, which can be considerable:

> Just to be able to remote schedule the chillers, the amount we paid to automate that was quite high. I think we paid like 1600 pounds, which is quite significant and definitely not recovered through smoke tests plus Trial Period 2.

(Project Partners at Oxfordshire County Council)

It can also take time to develop a shared language and understanding with third parties hired to provide services such as flexibility assessment of assets, due to the innovative nature of the grid-edge flexibility offers being demonstrated in Project LEO and their divergence from third parties' business-as-usual. Together with the limited revenues available for flexibility provision, such costs may make it difficult to justify investing in actions to reduce transaction costs – although the balance of costs and benefits may be challenging to calculate.

This may be even more true within the context of this demonstration project, within which activities undertaken for the purposes of learning and proof of concept may not have been subject to the types of cost-benefit analysis normally undertaken in business-as-usual:

> We haven't [assessed payback of the costs of automating]. So, we have, I know with […] the people that we're contracting to build this platform for us they've got another, I think it's 300 hours contracted to us to work on developing it, so we're just, with those 300 hours as far as I'm aware, our strategy is to just automate as much as we can and get as many of our assets on that platform as we can before time runs out.

(Project Partner at Low Carbon Hub)

Calculating relative costs and benefits is also complicated because it is uncertain how transaction costs may change over time.

4.4 Transaction costs associated with non-financial motivations for flex provision

Flexibility provision can also be associated with various non-financial motivations, and these may be seen as particularly important if relatively high costs and low revenues limit the financial incentive to participate. For example, supporting greater connection of low-carbon distributed energy resources to low voltage networks was identified by interviewees as a key non-financial motivation for flexibility provision:

> It would be a really exciting space to free up a lot of [grid capacity] – because we believe, and we're most interested in it, because we believe that it means that more low carbon technologies will be able to connect to the grid, especially in constrained areas.
>
> (Project Partner at Low Carbon Hub)

> Flexibility - it's one of the key measures to be able to make that shift to the renewables-based energy system that we know we need, and that was very much the driver for us as a County Council for participating in the project.
>
> (Project Partner at Oxfordshire County Council)

This could be supported by peer-to-peer import and export capacity (MIC/MEC) trading and demand flexibility, but potentially also by information on local network conditions provided to DNOs/DSOs from, for example, smart electric vehicle chargers. Although this was not the focus of Project LEO, shifting electricity demand to times of lower grid carbon intensity at the national level was cited as another non-financial motivation for flexibility provision.

However, achieving, or at least recognising these benefits can be associated with additional transaction costs beyond those already identified. Business-as-usual organisational greenhouse gas reporting may not be performed at a sufficient level of granularity to identify the benefits of shifting demand to times of lower electricity carbon intensity, so that achieving this would require additional staff time and potentially training.

This would likely be even more challenging if organisations tried to quantify the impact of flex provision on local connection of distributed energy resources, although this possibility was not discussed by interviewees. However, some interviewees did discuss the idea that reporting required to verify flexibility provision, while time-consuming for themselves, should be maintained in its current form if this was necessary to give DNOs/DSOs the information and confidence to enable greater connection of distributed energy resources locally.

4.5 Data and communications also carry costs

Finally, it should also be noted that managing data and communications associated with smart systems bears its own financial and carbon impact:

> The other thing is data itself. If you want to keep these communications live, they cost money as well, and produce their own carbon. So, more data is not necessarily more carbon neutral.
>
> (Project Partner at University of Oxford)

4.6 Changing the offer to change transaction costs and potential revenues

The capability approach being applied in LEO highlights that capability – the ability to act – results not only from the characteristics of individuals or organisations but also their interaction with diverse influences including characteristics of technologies, communities, product/service suppliers,

and the wider policy environment, amongst other things[3]. The value of this type of approach was recognised by interviewees reflecting on how participation in flexibility provision could be increased through the design of value propositions:

> I think for me, we really need to drill down into, instead of working from a technology point of view to put something in place, identify what people actually want […] we really need to look at the offering to the customer, and then figure out the technology side of things.

(Project Partner at SSEN)

A capabilities approach points to the potential for transaction costs to be reduced by changes to the design of flexibility offers, as well as via actions on the side of flexibility providers.

Interviewees suggested five general ways in which the design of flexibility offers could be modified to reduce transaction costs or increase access to revenues:

1. Changing the end-to-end process for participating in auctions
2. Changing approaches to flexibility verification
3. Changing baselining methodologies
4. Reducing times between auctions and delivery
5. Developing coordination necessary to support value stacking.

In line with this approach, this section examines how various design features of flexibility service offers might increase or decrease transaction costs faced by flexibility providers and other actors in the SLES ecosystem.

[redacted]Changing the end-to-end process for participating in auctions

As discussed in Section 4.2.1, automation of steps in the end-to-end process for participating in auctions has the potential to significantly reduce the need for staff time. However, interviewees suggested other changes to the design of the end-to-end process that could also help:

- Providing more specific information in notifications of upcoming auctions could save time by allowing participants to make an initial assessment of their potential participation without logging in to the platform.
- The design of spreadsheets used to transfer data could be made more user-friendly. This could include removing the requirement for format changes (such as transposition from rows to columns) when copying information between sheets.
- Developing macros could save time by automating the extraction of data.
- As described in Section 3.1, re-designing spreadsheets to be more intuitive to use could also save staff time.

Some interviewees also suggested the requirements for data capture and reporting as part of verification of flexibility delivery should be reviewed to understand what is “good enough”, given current low levels of monitoring of the low voltage network. This could be particularly useful as interviewees identified verification as the most time-consuming step in the end-to-end process.

The burden of flexibility verification could also be reduced by changes in approaches to baselining, which is discussed further below.

[3] Third annual synthesis report downloadable at: https://project-leo.co.uk/reports/annual-synthesis-report-year-3/

[redacted] Changing approaches to baselining

Baselining refers to estimating the level of electricity generation or demand in the absence of a flexibility event, for the purposes of specifying the level of flexibility being procured and verifying its delivery. Different baselining methods were trialled as part of Project LEO. However, some interviewees suggested a shift away from baselining towards *capacity limitation* would help to reduce their transaction costs and/or increase revenues available for flexibility provision. Capacity limitation refers to contracting for commitments not to exceed set limits of electricity demand or generation export within defined time periods. This can be contrasted with baselining, which involves contracting for dynamic changes in electricity demand or generation.

Shifting to capacity limitation could simplify verification as it simply requires the capture and reporting of metered generation or demand during flexibility events so that this can be compared with the contract terms, instead of requiring capture and reporting of data required to establish baselines. SMETS 2 smart meters offer capabilities that could support dynamic limitations on importing electricity to meet demand.

Shifting to capacity limitation could also change access to revenue for weather dependent assets such as solar PV. Changes in cloud cover can rapidly reduce generation output, and hence the *dynamic* reduction of generation export:

> With cloud cover, it can drastically change the amount that we deliver […] a better idea would be that we commit an amount of our export and say we will not export this much onto the grid as opposed to saying we will turn down by this much. So, it's more about limiting export as opposed to reducing export.
>
> (Project Partner at Low Carbon Hub)

Although this may have the same absolute effect in terms of management of the low voltage network, it would not be rewarded equivalently under current methodologies.

Finally, project partners at Nuvve identified current baselining methods as a barrier to accessing additional revenue through participating in local flexibility markets alongside other forms of demand-side flexibility. Nuvve's smart charging and vehicle-to-grid control strategies are already optimised, for example, to shift electricity demand and battery discharge in response to time varying electricity pricing. This type of demand-side flexibility can also be beneficial to DNOs/DSOs, for example by shifting electric vehicle charging outside of peak periods and thus reducing the impact of electric vehicles on low voltage network congestion.

However, under methodologies taking the current behaviour of an asset as the baseline when calculating flexibility provision, participating in other types of flexibility such as demand shifting reduces the revenue available for DSO-procured flexibility compared to 'dumb' charging:

> For a lot of our customers, specifically if they have a time of use rate, or they're already wanting to charge off-peak, with the way the baselines are currently calculated, we essentially have little value to offer DSO services […] we pretty much always are going to discharge or not be charging during the peak, or kind of late afternoon periods. So therefore, the baseline looks like we never have anything available […] And I think that's for us been a big, big learning outcome, because as much as we'd like to participate in DSO services, and we see a good value for the system in having them, the way they're currently calculated, I think as regulations evolve with mandated default off-peak charging as the standard, EVs are not going to be able to participate. By looking at some flexibility assets as "guarantees" for reduced capacity at certain times, EV users would be compensated for

> benefiting the network or adding greater discharge than their usual consumption, either to alleviate a constraint or ensure EVs are not adding to a constraint.
>
> (Project Partner at Nuvve)

Shifting EV charging and discharging in line with time varying pricing currently offers greater financial value. As such, the upshot is likely to be reduced availability of flexibility to support further management of the low voltage network, as this interviewee describes. This is because participating in DNO/DSO procured flexibility is associated with its own transaction costs, but would offer marginal additional revenues. However, under different price signals, this type of baselining methodology could also create perverse incentives that actually discourage helpful demand shifting away from peak periods:

> We played around with looking at a customer with a flat tariff to charge during the peak period and discharge only when there was a DSO event. This was a bit of gaming that a customer on a flat tariff could benefit from due to the innately flexible nature of plugged in EVs.
>
> (Project Partner at Nuvve)

Similar issues would likely be faced by other flexibility providers going forwards. This also highlights the importance of changes to support value stacking.

[redacted] Enabling value stacking

Value stacking describes accessing revenue for flexibility provision from multiple sources (such as DSO, ESO and wholesale energy markets) simultaneously. It has the potential to significantly increase revenues available to flexibility providers. Taking advantage of opportunities for value stacking may require strategic, optimised operation of flex assets, which could potentially be provided by third party experts. Enabling value stacking will also require new forms of coordination between different industry actors, which is discussed further in Section 5.2.

[redacted] For some asset types participation in flex auctions could be boosted by reducing time between auction publication and event

Flexibility providers' ability to access revenue could also be increased by reducing the time between auctions and flexibility events in cases where asset flexibility might be uncertain because of changes in the weather or end-users' behaviour. For example, Project Partners at Nuvve explained:

> For EVs and kind of V2G services, typically we are positioned well for very close short-term notification. So, can you ask me, can you deliver in 10 minutes? And I know pretty confidently what I have in 10 minutes from now, or tomorrow. Two weeks from now is harder, so we like short, close to real time, and short bid windows, so one hour versus 24 hours. We could work with longer bid windows if more EVs are connected and aggregation pools get larger, because more redundancy will be built in, which is especially important for DSO-procured services as these need enough EVs to be connected in a very localized area. For smaller aggregation sizes, we need highly reliable connection times to be able to work with longer bid windows.
>
> (Project Partner at Nuvve)

5 Operational costs for actors supporting the provision of flexibility

Section 4 focussed on costs and potential revenues faced by flexibility providers, but interviewees also described transaction and operational costs faced by actors supporting the provision of flexibility. As well as being important in their own right, such costs are likely to be associated with actions to change flex offers to improve the business case for flexibility providers. As costs and benefits of flexibility provision will be distributed between these various actors, they also have the

potential to impact on the business case for flexibility provision. This section therefore considers sources of these costs and actions to reduce them.

5.1 Costs of developing and implementing new processes

A key category of such costs is associated with developing new processes to enable the provision of flexibility. For example, while transaction costs for flexibility providers could be reduced if flex delivery is verified by DNOs/DSOs, the DNOs/DSOs incurs cost in developing and maintaining the processes required to access and analyse the smart meter data needed.

Similarly, costs would be involved in developing processes and systems to support coordination between DSOs and ESO to enable value stacking. An interviewee from project partner SSEN highlighted that negotiating the relative roles and responsibilities of different actors involved in this process is likely to be the most significant cost:

> You know the IT systems, the interfaces, the communications, the hardware is available or could be developed. It's a cost and a time issue. I don't think that is a barrier largely now. It might be a barrier from a cost perspective, but it's not a barrier from an actually solving the problem perspective. I think the work to me is more in the space of the regulatory and the organizational, and in the process side of things […] I think there's quite a lot of regulatory development needed between the different organisations to understand really, when the dust settles, who performs which role.

(Project Partner at SSEN)

In addition to coordination between DSOs and ESO, this would require work by other actors to develop appropriate and coordinated processes within market platforms:

> It's one thing building out API's, but then all the checks and everything that have to happen behind the scenes in terms of qualification and making sure that there's no duplication and people aren't gaming […] There's still I think a lot of like, structural and rule architecture that needs to be set up in terms of how all those platforms can interact. Every party is going to have a different ideal scenario.

(Project Partner at Piclo)

5.2 Costs of communicating with users and communities

Communication with end users and communities was another key category of costs described by interviewees. For example, there are costs associated with notifying households or other end users of flexibility events. Time and resources are required when working with community groups, to build trusted relationships, create a shared understanding of the work to be done, and gather crowdsourced information.

5.3 Reducing operational costs

Partners described a number of potential approaches for reducing operational cost of flex support systems.

[redacted] Greater standardisation

Greater standardisation and industry guidance could help to reduce some of these costs, in a similar way to that described in Section 4.2 for costs borne by flexibility providers.

Interviewees anticipated that current work on primacy rules within the Energy Networks Association Open Networks Project will support the development of value stacking. Guidance from Energy

Systems Catapult on data and communications was also seen as helpful in quickly developing a shared understanding and saving project partners' time:

> Now that you're getting more of these sort of data documents coming from like Energy Systems Catapult, etcetera, so you don't have to develop it yourself, you don't have to spend time in a project developing it yourself and then a year later then telling stakeholders what they need to do. You can kind of establish that from the get go.

(Project Partner at University of Oxford)

Project Partners at Piclo have also actively worked towards promoting standardisation of APIs through creating blog posts and press releases on the topic, as well as sharing code for the APIs they developed on an open-source licence.

[redacted] Working with aggregators

SSEN anticipate that their own costs for communicating with end-users could be significantly reduced by the involvement of an aggregator, which would effectively provide a single point of contact. Some flexibility providers also anticipated that working with an aggregator could reduce their own transaction costs to such an extent that it may be a prerequisite to participating in flexibility provision. However, the involvement of an aggregator would also increase costs and/or decrease revenues available for flexibility provision, by introducing another actor to be rewarded for their contribution. This should be considered when assessing how value from flexibility provision is distributed between different actors, and the impacts on the business case for flexibility provision:

> [By working with an aggregator] the number of customers you engage with, the number of contracts obviously goes down to one [...] So I think for me the offering through the aggregator is critical. However, that brings a challenge in […] that there's an overhead for an aggregator to operate in that space. And I don't think we're quite there yet with who pays for that, and how that cost might ultimately be distributed between different actors like the generator, the consumer and the DNO.

(Project Partner at SSEN)

[redacted] Reducing communication with end users and communities

Costs associated with notifying households or other end users of flexibility events could be avoided if business models are based around more routine behaviour by users at certain times (which can also be enforced via contracts). Time required for crowdsourcing information could be reduced to some extent if data can be accessed via smart meters. However, this approach would not be applicable to much of the most valuable information that can be shared by communities, for example regarding features of their community and local area that might affect the opportunities for different SLES offers.

6 Coordination, collaboration, and co-creation

Developing smart local energy systems involve creating new roles for different types of actors and new relationships between them. For these new roles and responsibilities to be realised[4] various forms of coordination, collaboration and co-creation are required.

[4] See Principles section of LEO report, Developing an ethical framework for local energy approaches at https://project-leo.co.uk/wp-content/uploads/2020/11/Project-LEO-ethical-framework-2020-final_ext.pdf

This section presents learnings related to these themes. It first considers these processes as they relate to working with households and communities, and then considers coordination and collaboration between organisations.

6.1 Working with households and communities

The last year saw the start of flexibility trials with households and communities within Smart and Fair Neighbourhoods, as well as continuing work with the LEMAP (Local Area Energy Mapping) tool to engage households and communities, including through crowdsourcing data on their homes and local areas.

[redacted] The importance of clear guidance and support, and the upfront costs of low carbon technologies

Interviewees highlighted the importance of providing households and communities with easily understandable support and guidance. Community groups involved in Project LEO often expressed a strong desire for clear and specific help in identifying and taking actions towards decarbonisation in their local area.

Clear and easily understood communication on energy issues can also act a powerful motivator of action. Where tools such as LEMAP (the Local Area Energy Mapping tool developed in Project LEO) are used to engage with households and communities, it is important to co-design them with their intended users to ensure their content will be understood:

> We had to simplify our graphs *a lot* […] we understand graphs, you know, that's what we do, and we think everybody understand graphs and that's not how things work. […] Even we had discussions about why do you say heating and non-heating season, why can't you just say winter and summer? […] It took us a lot of e-mail meetings to convince that non-heating season includes summer plus other bits, because that lasts from May to September, and the heating season lasts from October to April, which is not exactly winter. But then we were told it doesn't matter, people don't care, just say winter/summer because that people understand. So, you know, that kind of accessibility and understanding in communication that a community group has is absolutely vital for the tool to become accessible.

(Project Partner at Oxford Brookes University)

In this case, a local community group working on energy and carbon helped to communicate the likely needs of a wider set of LEMAP users to expert developers with different ways of understanding. The support of such intermediaries can also be important to help household members to interpret the outputs of the survey built into LEMAP, which provides information on their own home as well as crowdsourcing anonymised data for use in the wider tool:

> If they come to an event they're [..] not filling it themselves. You make it easy for them […] also I think it helps with data interpretation as well. So, you can actually get someone to interpret data for you, and I think that's quite an important thing

(Project Partner at Oxford Brookes University)

Alongside the importance of clear guidance and support, experiences in the Deddington and Duns Tew Smart and Fair Neighbourhood illustrated that high upfront costs can act as a barrier to action even though the desire for this may otherwise be strong.

[redacted] Crowd sourcing data and co-creating plans and solutions

While households and communities often seek support and guidance from 'experts' on local energy decarbonisation, they can also provide uniquely valuable information and insights in support of this process. This includes checking the accuracy and completeness of publicly available information, for example from EPC (Energy Performance Certificate) data, but also insights into the characteristics of their community and local area that can help to identify innovative opportunities for local action, as well as assess how actions imported from 'outside' (for example, commercial offerings) might fare when introduced into this setting. Work with households and communities within LEO can thus helpfully be characterised as co-creation.

[redacted] Creating a sense of ownership

Partners involved in delivering the LEMAP (Local Area Energy Mapping) tool highlighted the importance of creating a sense of ownership when engaging with households and community groups. For example, they described how presenting households with publicly available information, such as EPC data on their home, and asking them to correct it can help to create a sense of ownership by recognising the particular value of their personal or local knowledge. At the same time, a sense of reciprocity can be created by ensuring that people participating in crowdsourcing surveys gain immediate access to information and findings that might be of interest to them.

Partners involved in developing and implementing LEMAP also described the importance of listening to local people when defining the boundary of the 'local' area. After realising the boundaries of 'local' areas they would typically adopt in their work may not be accepted by the community, they adopted a consensus-based process to define local, allowing the community to decide the boundary based on streets/neighbourhoods, then overlaying postcode and lower super output area boundaries onto this to create a "meeting point" where local community input was translated into formats that would work with LEMAP tools (Project Partner from Oxford Brookes University).

It appears that in this case the process of creating ownership may have been even more important than the output since in subsequent work, households from outside the co-created area boundary were accepted for participation in LEMAP surveys at a community event.

[redacted] The importance of trust

The trust of communities and households is also centrally important as part of this process. Interviewees felt that users of tools such as LEMAP tended to trust academic input into technical aspects of these tools by default:

> We explained to them, we got it [time varying grid electricity carbon intensity] from National Grid and all this, and they just said, but we trust you. I'm sure the data is OK.

(Project Partner at Oxford Brookes University)

LEMAP also includes data on socio-economic characteristics, derived from MOSAIC classifications developed by Experian as these are available as a purchasable data set. In contrast to technical data, some interviewees suggested that this may generate a certain amount of mistrust or resistance if people are concerned about how much information is available about their household[5] or question the extent to which post-code level classifications actually provide useful information about the people who live there.

[5] LEMAP users who create an account are able to view dwelling-level data specifically for their household.

Partners also described how some community groups lost trust after being surprised that relatively little data was available on low voltage network conditions in their local area – requiring skilled discussions led by convenor, Low Carbon Hub, to understand the reasons for this and to agree ways in which it might be possible to use the data that is available in a positive way.

[redacted]Make participation easy

Interviewees emphasised the importance of making engagement and co-creation as easy as possible. For example, providing information that is publicly available and asking for corrections facilitates and speeds up the process as well as helping to create a sense of ownership.

Similarly, when engaging with households it is important to look for or create times and spaces where people have sufficient time and attention to devote to this, rather than other pressing aspects of daily life:

> The door to door doesn't work well, because people are busy with their lives, and if you start doing that you get a poor response rate. Essentially you know, people say I'm cooking, I can't do that, my kids are crying […] Whereas if they come to an event they're coming with – they know what they are going in for

(Project Partner at Oxford Brookes University)

[redacted]Effective engagement requires time and resources

Finally, interviewees highlighted that effectively engaging households and communities takes time, and will need to be appropriately resourced as part of the wider deployment of Smart Local Energy Systems and Local Area Energy Planning.

6.2 Collaboration and coordination between organisations

Interviews highlighted that effective communication, interpretation and education can be equally important between industry, local authority, academic and third sector actors as between these actors and households and communities.

[redacted]Using analogies and familiar language

This included project partners using familiar ideas to explain aspects of Project LEO to other members of the organisations – for example, describing the NMF as a type of procurement platform through which flexibility providers could submit tenders and the DNO/DSO could select winning bids, and explaining congestion in the low voltage network using the analogy of water flowing through pipes.

[redacted]Useful communication tools

Interviewees mentioned specific tools to support effective communication can include simple online technical specifications that can be shared with third parties contracted to support flexibility delivery. This would avoid the need for flexibility providers to develop their own understanding of these technical specifications, and then to communicate these to third party providers. Online collaborative visualisation tools can be useful to confirm a shared understanding of the processes being discussed:

> It was getting to a point where it was a bit difficult […] making sure that we were talking about the same things, and we're talking about the same part in the process between the two platforms. So usually using visualising tools like Miro, online whiteboards, and whatnot, to make sure if we mapped out our process, and they mapped out ours, we were talking about the same parts of it.

(Project Partner at Piclo)

[redacted]Peer to peer learning

Some interviewees also described directly educating third parties about aspects of Project LEO, for example about the potential for grid-edge flexibility, that differed from their business-as-usual operations. They explained that collaborating by sharing learning with industry peers can be mutually beneficial when this helps to influence the wider development of practice:

> We had started conversations with National Grid ESO as well. They're building out their single market platform. And so, they just wanted to have some general discussions around API standardisation, how we had, I guess, created our documentation. Understanding the kind of process we went through working with Opus, and in terms of what was that like for two different platforms to work together to do these API's?

(Project Partner at Piclo)

[redacted]Coordination

Coordination is also important: because of the complexity of relationships between actors in SLES, the development of value propositions by one actor can be dependent upon the actions of other actors. For example, one interviewee explained how "external" factors hindered their organisation's development of market platforms to support peer-to-peer transactions of the types demonstrated within LEO:

> We've had a couple conversations with some of our flex provider users outside of the project as well. And while there's some level of interest in it, I think, also just the amount of kind of external things like getting the agreement changed with the DSOs. A lot of DSOs don't have those things in place.

(Project Partner at Piclo)

Coordinating new roles can take considerable time and effort, and the development of guidance, standards and new formal rules could help to reduce this. However, newly created arrangements can also create unintentional barriers, while standardisation may not always be desirable or possible:

> So there are a few types of different standards that come into play, and there's no one guideline on how the data coming from smart meters from each company needs to be. And that's the problem. The messy bit is that industry doesn't have regulation on this – for good reasons, because the regulation will reduce competition to some degree, but competition in terms of flexibility in software development. You know, JSON [computer language] may not work for every company in terms of data management and the back end and so on. Also, some companies for their own reasons may find value in having more unique software that is not necessarily interoperable with others, it may be purely competitive that they don't want that interoperability.

(Project Partner at University of Oxford)

This highlights the potential for tension between standardisation to support coordination and reduce transaction costs, and flexibility to respond to uncertainty. Interviewees identified a number of strategies that might be useful to address this tension. For example, mandatory standards for interoperability of data could focus on elements that are commonly accepted, and implementation of these could be driven by the development of organisational culture and norms around 'good practice':

> There are also standards in terms of just very basic, generally applied data standards that work for every data set, for example, working with a medium that is commonly acceptable formatting wise […] those standards are things that should be mandatory and not mandatory at the same time, and the mandatory ones need to be in my opinion the very commonly accepted ones.

(Project Partner at University of Oxford)

> There's no one-size-fits-all model for these things. And so it really has to be company driven, to say that this is what we value and we're going to go out and implement it.

(Project Partner at University of Oxford)

[redacted] Communication between system actors

Interviewees also described how communication between industry actors can influence expectations in ways that could help to coordinate the actions of different actors without necessarily requiring formal rules to be in place. For example, press releases from car manufacturers signal the future availability of vehicle-to-grid technologies:

> We're seeing announcements every other day from auto manufacturers on building in V2G technology […] It's clear that the trajectory of auto manufacturers is going in this direction.

(Project Partner at Nuvve)

Project partners at Piclo also actively contributed to influence industry expectations around the development of APIs, through producing blog posts, press releases, and by making APIs they developed available on an open-source licence:

> That was our kind of general philosophy around API's is that they should be open-source, anyone should be able to go in and get them. I think if the industry is going to move towards standardisation as well, they must be seen to be open and public.

(Project Partner at Piclo)

7 Implications for further learning and development of SLES

This section discusses applying learnings from LEO outside the project context, and insights from interviewees on next steps to support the further development of Smart Local Energy Systems.

7.1 Learning by doing within Project LEO

As an innovation project, LEO was intended to support activities that might not otherwise be undertaken as part of the current business-as-usual. Examples described by interviewees include:

- Choosing which actions to take on the basis of which might contribute the most to learning.
- Working with small asset portfolios in order to learn and extrapolate value.
- Financing the development of processes such as automation using resources that may not be available under business-as-usual.

On the other hand, a large part of the rationale for supporting these types of activities is the potential for transaction costs and barriers to coordination to be reduced through processes such as learning by doing.

Numerous examples of this were described by interviewees. For example, flexibility providers described improving their familiarity with the end-to-end process, decreasing the staff time required to participate and thus associated transaction costs, as well as gaining a better understanding of the business case for flexibility provision.

They also described learning about how to understand and increase the flexibility potential of their assets. Section 3.3 described how Project Partners at Oxford County Council learned how external temperatures imposed a boundary on the flexibility of electricity demand by their asset: air conditioning units in a public library. In addition, they described how through learning by doing they "noticed" strategies to increase the flexible operation of this asset:

> Pre-cooling we've noticed has helped, because again this is a library, there is a lot of thermal storage in the building. So it would trap both heat and cold, the books would do that […] What we've also noticed this trial period is that we also should have automated scheduling our air handling units because the way they function impacts how much load the chiller is able to provide or reduce, and that was not included in our initial automation.

(Project Partner at Oxfordshire County Council)

Participating in Project LEO also supported partners to develop and test new tools, and learn about how to do so more effectively in the future. For example, one interviewee explained:

> Once you actually start to put these, like API's and things into use, it's just good learning because the documentation and the API had been built out, but no one had really used it in that actual real-world scenario. So that was, yeah, useful ones for us.

(Project Partner at Piclo)

> I think we've been able to refine how we've done it and kind of clean up the testing methods between the two parties and make it a little bit more efficient […] At this early stage, definitely a lot of work and hours were required to make sure [the APIs] were working properly. And this is the first time we've done it. And it's the first time [collaborator have] done it. So hopefully it does start to get a little bit easier next time around. And yeah, I think coming up with a testing process of how to do this, and which environments should we do these things? Have been good lessons we've learned from this.

(Project Partner at Piclo)

As these quotes suggest, learning-by-doing can also apply to working with other actors. In addition to describing learning about how to collaborate effectively with another industry actor, our project partner at Piclo described making changes to their product after learning more about functionality that might be appreciated by its users. Other project partners described learning about how to engage with households and community groups more efficiently and effectively.

Interviewees also described how real-world deployment helped to identify previously unanticipated users and/or uses of tools:

> We, in developing or writing the specifications, or project managing this mapping project, have not identified as many opportunities as users who've come back with suggestions, when they see *their* data that's most relevant to their specific bit of work, and then are both able to enhance our tool, but also find opportunities or the right ways to use it, which has been quite gratifying, to say the least.

(Project Partner at Oxfordshire County Council)

> The people who used it were the Local Authority. They are very interested in it. And not the person who we worked with [… someone else became involved...] And that person enjoyed using LEMAP quite a bit, because LEMAP was helping her in seeing how zero carbon Oxford partnership's targets could be met […] So I think it has these unexpected kind of users – but going forward I've realized how important LEMAP is as a planning tool for smart local energy initiatives, both for Local Authorities and Community Energy project developers.

(Project Partner at Oxford Brookes)

As these project partners indicate, this can support the further development of tools through incorporating users' creative input and through making the tool's original developers aware of new opportunities for its application.

Multiple interviewees also highlighted that taking part in Project LEO has prompted them to reflect on their previous assumptions, and sometimes revealed new questions about how to effectively develop different aspects of SLES. For example, project partners at SSEN described learning about how different parameters could influence the future deployment of low carbon technologies, and that this understanding could inform the development of new strategies to manage the low voltage network.

7.2 Opportunities for further learning and development of smart local energy systems

The preceding section identified a sample of the wide range of learning that occurred within Project LEO. However, despite the considerable progress that has been made, interviewees suggested that more work is needed if the development of Smart Local Energy Systems is to reach its full potential.

Barriers include remaining high transaction costs, as described in Section 4, and uncertainties around smart local energy systems' future development. Impacts of this include making it more difficult to develop a business case for flexibility provision, because it is uncertain how transaction costs may continue to fall in the future, and because future revenues that might be available from flexibility provision are also unknown. As one interviewee remarked:

> We found that it was very difficult creating a business case for flexibility, because we don't know how many flexibility events there'll be, and we don't know what the prices will be in a competitive market.

(Project Partner from Low Carbon Hub)

Uncertainty can also make it more difficult for different actors to work together effectively. For example, project partners from Low Carbon Hub described how working to engage communities with Smart Local Energy Systems can raise enthusiasm and expectations around action, which is sometimes not matched by the availability of reliably defined value propositions with which communities can engage. Indeed, the development of SLES value propositions is likely to at least partly emerge out of the engagement of communities, households and other users rather than being fully developed before initiating engagement.

This can be seen as a chicken-and-egg problem: further experience in developing SLES is likely to support further learning-by-doing and coordination, but this further experience may not be fully realised until barriers including high transaction costs and uncertainty are further reduced.

Because of this, some interviewees suggested that the development of SLES is deserving of further targeted support. They expressed frustration that under current regulatory structures, DNOs/DSOs are not allowed to provide this type of targeted support, as they are obliged to choose the option at current least cost.

At present, this may mean that network reinforcement is preferred to grid-edge flexibility provision – but this does not take into account the much lower technology readiness level of grid-edge flexibility, and the potential for costs to decrease over time. As an analogy, interviewees referred to the way in which the targeted support provided by Feed-in Tariffs supported cost reductions in renewable electricity generation technologies such as solar PV, ultimately resulting in previously innovative value propositions such as community energy becoming standardised as part of business as usual.

In the context of smart local energy systems, they identified a further issue in that vertical disaggregation during UK electricity market liberalisation has resulted in the benefits of flexibility becoming 'smeared', or distributed across multiple actors, so that no single market actor is fully incentivised to support innovation.

8 Limitations of this report

This report discusses how uncertainty may impact on flexibility providers, but not implications of the different types of uncertainty for application of demand-side flexibility as a resource to manage low voltage network. E.g. shorter times between auction and delivery can reduce uncertainty for flexibility providers with weather-dependent assets, but what are implications for reliability of this type of flexibility as a system management resource?

9 Conclusions

Project LEO has demonstrated the potential for DNOs/DSOs to operate local flexibility markets, as well as the potential for a diverse range of grid-edge actors to contribute to providing flexibility. In doing so, it has generated a wealth of learning around delivering Smart Local Energy Systems (SLES). This includes learning about barriers to delivery as well as opportunities to address these. As the final annual interviews report for Project LEO, this report has focused on identifying some of the key remaining barriers to SLES identified by interviewees and opportunities to address these, and discussed what this means for the future of SLES delivery.

Interviewees described multiple sources of remaining uncertainty and the ways in which these impact on flex delivery. Continued experience of SLES delivery is likely to generate further learning

that reduces some forms of uncertainty. However, together with limited revenues available for provision of flexibility to DNOs/DSOs, high transaction costs represent an important barrier to continued participation in flexibility markets outside of the trial context.

Interviewees identified multiple ways in which transaction costs could be reduced, including through changes to the design of the flexibility offer. However, these changes carry costs of their own, such as investments in automation technologies and staff time to create new processes. Further costs associated with SLES delivery are the time required to effectively engage households and communities, and to further develop collaboration and coordination mechanisms between different industry actors, for example, to facilitate value stacking.

This can be seen as a chicken-and-egg problem: further experience in developing SLES is likely to support further learning and coordination, but this further experience may not be realised until barriers including high transaction costs and uncertainty are further reduced. In light of this, some interviewees argued that SLES development should be provided with further targeted support, to promote further learning and continue to reduce costs and uncertainties associated with flexibility provision. The Strategic Innovation Fund (SIF) could contribute to provide such support.