LEO Local Energy Oxfordshire

August 2021 | Version 1

Annual Synthesis Report Year 2

Nick Banks, Sarah Darby & Vicky Grant

Report Title:	Year 2 annual synthesis report
Author(s):	Nick Banks, Sarah Darby, Vicky Grant,
Organisation:	University of Oxford

Version:	1	Date:	09/08/21/
Workpack:	WP6	Deliverable:	6.3.4
Reviewed by:	Project partners		
Date:	16/07/21		
Signed off by:	Sarah Darby		
Date:	06/08/21		

Can be shared (Y/N):	Internally	Yes	Publicly	Final version

Executive Summary

Project LEO was set up to develop a transformative integrated smart local energy system in Oxfordshire. It is an ambitious smart grid trial, improving our understanding of how to make the transition to a flexible renewables-based electricity system involving local energy markets, and how households, business and communities can realise benefits from this.

This report brings together what we consider to be the most significant lessons learned while translating ambition into practice during the second year of LEO. Based on a series of project reports and interviews with project partners, it develops themes introduced in the Year 1 Synthesis Report and indicates issues and pathways that will need attention for the remainder of the project. The first year demonstrated the value of a flexible, modular approach to energy transition through the development of Minimum Viable Systems, designed for rapid learning. It also showed the significance of local conditions and illustrated many roles which people play in energy systems.

In Y2, progress has been made on the organisational, data and connectivity issues that emerged in Y1, with deeper understanding of the processes needed to gain flexibility from electric vehicles (EVs), connect up new distributed resources and operationalise demand-side response in institutional buildings. A major mapping exercise has expanded the quantity and quality of data available to the project. Detailed preparatory work is under way in sites around Oxfordshire – the Smart and Fair Neighbourhoods – where much of the local community-based work will be carried out. Project LEO is also now close to the point at which the TRANSITION trials can begin, taking the level of complexity and challenge up a level. This Summary sets out our main findings from Year 2 of LEO.

Terminology and concepts for an intelligible system

There has been progress in bringing together definitions in a Glossary, ranging from established technical terms used by the Energy Networks Association to emerging terms such as 'smart and fair' or 'neutral market facilitator'. Recently this work has expanded into drafting 'plain English' documents to explain flexibility trading to laypeople, in response to stakeholder requests.

We expect this work of building a shared understanding to continue throughout the project: it is clearly necessary for effective working. Terms need to convey meaning very precisely where operational issues are concerned, and the project vocabulary also needs to reflect the many roles which people play in energy systems, as investors, users and operators of distributed generation, storage and demand-side assets, and professional practitioners.

Three concepts that have been central to the work in Y2 are worth mentioning individually and will be addressed throughout the report:

- a Minimum Viable System (MVS) continues to be a productive concept, applied to an agile way of testing innovations. The more specific technical trials have commonly been referred to as MVSs but a lot of the focus has been on reaching systems that are representative enough to test social interactions with technologies. Note that the MVS concept has limits when it comes to complex socio-technical initiatives that cannot easily be repeated, even in the same place – for example, a neighbourhood smart grid initiative, complex planning process or exercise to influence policy. An MVS typically starts from a relatively straightforward problem, but LEO is also addressing a range of challenges facing communities, with a higher order of complexity. With these more complex initiatives, LEO can 'never stand in the same river twice'; anyone wanting to replicate a complex LEO process in another place will also have to take context into account.

- the Smart and Fair Neighbourhood (SFN) concept is taking shape. The 'fair' element calls for particular attention: can a market-based system be operated in such a way that all can benefit and no-one is left behind?
- the concept of a smart local energy system (SLES) is still developing and LEO is contributing to this process, partly through local experimentation, partly through dialogue with sister programmes and policymakers.

There is still consensus that LEO is engaged in setting up and testing of a local, low-carbon energy system that uses market mechanisms and smart technology to bring value to the electricity network and the people connected to it. This is the basis for a Theory of Change[1] that sets out in detail how this can be achieved: which actors, technologies and processes are involved, how they relate to one another, and what the path dependencies are.

The local ecosystem, replicability and data usage

The project continues to show the importance of local stakeholders and infrastructure for the development of an ecosystem for SLES, in terms of ambition, social capital, knowledge and engagement, planning challenges and network conditions. In February 2021 the Zero Carbon Oxford Partnership was launched with the support of major businesses, the Oxford Health NHS trust, and six LEO partners: Oxford City Council, Oxfordshire County Council, SSEN, Low Carbon Hub, Oxford Brookes University and the University of Oxford. Support of LEO's objectives from this group is important, and engagement with energy flexibility and with LEO is included in the Partnership's Action Plan.

The local ecosystem is very favourable to Project LEO but it calls for a cautionary note about replicability. The more actors and technologies are involved, and the more reliant on local factors, the harder it will become to repeat a given process precisely. The focus therefore needs to be on testing and documenting processes in the context of physical and social conditions - especially for more complex processes - so that others can judge how best to adopt or adapt them. Conversations about replication are already under way with a small number of 'Fast Followers' who are interested in developing SLES in their areas.

Data used by (local) policy makers and planners in decision-making on energy issues continues to be a vital element of LEO. Considerable progress has been made with monitoring and mapping in Y2 and this is informing the design of the SFNs and other trials, along with work on policy and regulation. The mapping is also a means of engagement with potential and actual project participants.

[1] A Theory of Change is a description, often in diagrammatic form, of how and why a desired change – in this case, to a SLES – is expected to happen, in a particular context.

Project management for a diverse consortium

Managing this complex project while meeting requirements for monitoring, evaluation and collaboration continues to be demanding, but the effectiveness of project management was recognised during the third stage gate review in April 2021. Cross-project operational matters are now addressed in monthly Project Delivery Board meetings, while the Executive Steering Board meets every two months to provide direction and alignment with the objectives of Prospering from the Energy Revolution (PFER) and national policy.

A new Work Programme, WP7, has been set up to concentrate on MVS development, while the Communications function has been taken out of WP6 and placed in WP1, with a new Working Group to drive this work.

Market development

LEO envisions a move beyond the traditional producer-consumer paradigm in electricity markets and continues to explore how to create a market that meets network operational needs while delivering social and environmental benefits. The structure identified as best suited for this is a Local Energy Market (LEM), a concept that has been tested in recent years in a number of locations.[2] A LEM uses assets (distributed generation, storage and demand response) within a defined geographical area. Asset owners/operators can sell flexibility locally, or as services in national markets. Especially for the latter, they may be aggregated.

Y2 has seen the development of a trial philosophy along with definitions of flexibility services and the Basic Market Rules to be tested.

The embryonic LEM in LEO was set up to operate at two levels:

- The Neutral Market Facilitator (NMF) platform under construction as part of the TRANSITION project. This is designed to send signals to flexibility providers, manage procurement and contracting, and ensure that conflicts between DSO and Electricity System Operator (ESO) do not arise. This interacts with a Whole System Coordinator, which assesses options for mitigating network constraints. Opus Energy is now responsible for the NMF platform. It is intended for the Oxfordshire network but could work beyond that.
- The NMF platform hosts the Flexibility Exchange Platform, which allows flexibility service providers to contract for services with the DNO/DSO or with third parties in peer-to-peer (P2P) capacity trading.

A key challenge for LEO and for SLES in general is creating a marketplace and local energy services where a range of actors can produce business models and value propositions that work for groups with low levels of capability to participate fully in a local system. The diversity of household and organisational characteristics is being observed and analysed, and work is under way to understand them in terms of capability to participate and benefit.

[2] Examples in the UK include Cornwall and Greater Manchester.

Working with grid edge assets can be challenging but LEO remains keen on doing so for operational, social and environmental reasons. Aggregating small-scale assets, including creation of a community-owned asset, is under investigation.

Market solutions that are judged unfair or environmentally damaging are unlikely to gather popular or political support. But if the transaction costs of widening access become too high, value propositions may be undermined, business models become unviable, and take-up of an offer could be stymied. Therefore, to ensure that access is as widespread as possible, it seems that there will need to be a mix of market actors operating with different value propositions, some of which will not be structured around optimising financial returns.

At the end of Y2 there is much greater familiarity with the nature of the market and potential ways of developing it. However, there remain gaps and uncertainties relating to end-to-end procedures for procuring and delivering flexibility. The purpose of the TRANSITION trials (see $4.6 below), starting in the autumn of 2021, is to explore the detail of end-to-end processes.

Operational learning

Great care is needed to ensure continuous service to customers before, during and after project procedures, and LEO has shown that this is possible - that agile learning about system innovation can take place without disrupting the legacy system.

As in Y1, it has been important for each MVS or procedure to have an 'owner' who is responsible for trialling and communicating it. The main operational lessons from the second year, as expressed in the central learnings log, interviews with partners and at project meetings, have been that:

- the role of an 'owner'/coordinator for each MVS or other initiative continues to be vital, to take responsibility for trialing it and communicating with the actors needed to make it viable;
- consistent, easily-understood terminology is needed for items of equipment, procedures and concepts relevant to SLES development;
- not all assets can provide flexibility services readily; they may need additional work to connect them to the system reliably. EVs, which may need specific chargers, are one example; heating, ventilation and air-conditioning systems another (the controls may not be suited to demand response via direct load control);
- detailed procurement standards for flexible assets can be drawn up;
- land-use planning and energy system requirements can conflict and care is needed to integrate the two.

Data

Work continued on access, protocols, data cleaning and other essential routine operations. Major gains in Y2 have been the development of the Oxfordshire Integrated Land Use Mapping tool, with 79 layers of data, and of the LEMAP tool (by Oxford Brookes University), intended to assist with engagement with local stakeholders. The Data Sharing Agreement has been amended to enable the

County Council to share access to their tool, and a new amendment is anticipated to cover new types of commercial data.

Policy

Local factors continue to show their significance in an energy / commercial ecosystem, including the location, scale and distribution of assets, and the social capital and knowledge needed to turn them into realised assets. All the Oxfordshire local authorities have declared a Climate Emergency and shown willingness to take action. This is obviously favourable to LEO and opens doors for engagement on local policy, including two very productive events with councillors and planners in Y2. The formation of the Zero Carbon Oxford Partnership, involving several LEO partners, has been a further step forward. The Partnership Action Plan includes development of a joint lobbying strategy and there could be opportunities to collaborate with LEO on policy engagement.

At national level, there continues to be high ambition for carbon reduction and for renewable supply (mostly offshore wind), but the 2020 Energy White Paper has very little to say on local energy systems, beyond a general statement of support for SLES and a recognition of the role of local authorities in decarbonisation. There is however a commitment to assess what market framework changes may be required to facilitate the development and uptake of innovative tariffs and products[3] during 2021, prior to a formal consultation.

Policy/regulatory risk relating to SLES continues. The outcome of the Targeted Charging Review, in particular, has removed the financial viability of many potential plug-in projects that could, in favourable conditions, develop into elements of a SLES. The value of flexibility to actors at different locations and times needs to be clearly signalled, yet there are still many uncertainties about this. Settlement of transactions within a LEM, between local markets, and between local and national markets, still poses operational, policy and regulatory challenges.

As noted last year, necessary changes to network infrastructure can only be sustained if there are corresponding changes to the structure and functioning of the electricity market. For example, the value of flexibility to actors at different locations and times must be clearly signalled and tradeable, yet there are still many uncertainties about value. Settlement of transactions within a LEM, between local markets and between a local and a national market (e.g. the ESO balancing mechanism) still poses operational, policy and regulatory challenges.

Achieving fairness, engaging widely

The PFER programme aims for social as well as operational benefits, and equity continues to be identified as an important issue. Achieving equity and inclusion through a market-based system is a challenge and LEO has developed an ethical framework in Y2 to guide the project in addressing this. This was developed by the Low Carbon Hub, with contributions from other partners. It includes principles to guide the delivery of trials and to develop equitable local energy offerings. Specific issues include how household and business energy costs will be affected by building and appliance

---

[3] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf

energy efficiency, ownership of distributed assets such as solar PV panels, EVs or smart appliances, knowledge and skills.

The project now has a set of stakeholder engagement principles, paying special attention to building trust and productive relationships with more disadvantaged stakeholders so that they are not 'left behind' because they cannot benefit directly from owning or operating distributed energy assets. Community-focussed work continues to build public support for a SLES, especially in the areas that have been chosen as SFNs. The County Council and Oxford Brookes University (OBU) have produced a comprehensive set of maps that show great promise for engagement, as well as for understanding Oxfordshire's energy situation in depth and planning for energy transition.

As LEO activities become more complex and involve more stakeholders, including citizens and businesses, it is vital to manage expectations and plan well in advance of trials. Community-level engagement, especially in areas with a high proportion of disadvantaged households, should start early and must be seen to be conducted by a trustworthy, reliable and competent organisation, recognising and sharing the interests of the community. Monitoring and evaluation are carried out with these principles in mind.

KPIs and monitoring in Year 2

KPIs require good data sources and an intelligible framework of aims and objectives, and these are kept under regular review. Following a workshop in August 2020, a more concise set of KPIs was developed, which came into use in November. This now includes sets of social, technical and commercial KPIs, which between them cover all metrics and indicators that the project partners consider essential for demonstrating progress towards their goals.

The Innovate UK monitoring requirements have been time-consuming but have assisted in recording activities, challenges and learnings. Continued dialogue will be needed between LEO, EnergyREV and the Energy Revolution Integration Service, regarding their approaches to evaluation.

Building on the foundations, looking ahead

Project LEO aims to prepare for a smart, fair, renewables-based energy system for almost 700,000 people, while maintaining services through the legacy electricity network. Given the strains of coping with the Covid19 pandemic over the past year, the funded extension to the project for a further year (to March 2023), is very welcome. Y2 work on the project has continued to validate the 'agile learning' approach and has brought exciting innovations such as the comprehensive mapping work in WP4, elaboration of flexibility trading processes and development of the SFN programme.

Y2 has also shown the weight of path dependencies when attempting to build a new system within the regulatory, physical and organisational constraints of the old one. These will continue to need addressing at the appropriate levels. The communication and engagement strategies have been designed to assist with getting messages from LEO trials to the practitioners and policymakers who need to hear them. We anticipate that Y3 will be an exciting and demanding year of flexibility market trials, establishing the first SFNs, gathering new data and putting it to work, and evaluating the outcomes.

Table of Contents

Figures

Tables

1. Origin, aims, structure and processes

In 2018, the Industrial Strategy Challenge Fund (ISCF) set up *Prospering from the Energy Revolution* (PFER), a fund of £102.5m for UK industry and research to develop systems to support the global move to renewable energy. £8m of the fund went into setting up the EnergyREV research consortium, led from the University of Strathclyde and tasked with driving research and innovation for smart local energy systems (SLES). These were to be characterised by the 'four Ds' of decarbonisation, digitalisation, decentralisation and democratisation.

Three large demonstrator SLES programmes were funded to run alongside EnergyREV: Local Energy Oxfordshire (£14m from Innovate UK plus some £26m from project partners), Energy Superhub Oxford and ReFLEX in Orkney. These are required to demonstrate smart local energy approaches that can

- provide cleaner, cheaper, more desirable energy services for the end user;
- lead to more prosperous and resilient communities;
- prove new business models that are suitable for investment and that can grow and replicate in the 2020s;
- provide evidence on the impacts and efficiency of novel energy system approaches by the early 2020s.[4]

The LEO bid for funding from the ISCF stated that LEO *delivers a transformative integrated smart local energy system to maximise prosperity from local energy systems and demonstrate new value creation opportunities* and addresses the near-term need to act on a power system in Oxfordshire that is at or near capacity, by developing a local energy marketplace that can function with the existing infrastructure. The primary output was seen as *an ecosystem for maximising prosperity from local energy systems by developing innovative funding models for new Distributed Energy Resources (DER) and demonstrating novel local energy markets.*[5]

1.1 Energy systems in transition

Project LEO aims to respond to national and local needs, to meet ambitious emission reduction targets in the city-region of Oxfordshire that will require an estimated 2,050 GWh of renewable electricity (mostly solar) by 2030 to contribute its share towards meeting national climate targets. This will need to happen in a distribution network that was not designed for distributed generation or for the new demand patterns that are emerging. The project therefore aims to develop *a skilled community positioned to thrive and benefit from a smarter, responsive and flexible electricity network.*[6] The process, documented and discussed with stakeholders, will inform transition to the smarter, renewables-based electricity system that will be needed in order to meet social and climate goals. Towards the end of the project, the aim is to test replicability with 'fast followers' - communities or organisations with similar goals and the capacity to adopt processes that have been tested by LEO.

---

[4] https://www.gov.uk/government/news/four-leading-edge-demonstrators-to-jumpstart-energy-revolution

[5] Project bid.

[6] Project LEO website, accessed March 2020

Radical changes in how electricity is generated, distributed, traded and regulated call for system reconfiguration (second-order change and learning), not just optimisation of the current system. LEO is exploring next steps with a view to replication and scaling up.

SSEN are piloting the systems needed for transition from a Distribution Network Operator (DNO) to a Distribution Systems Operator (DSO), through the Ofgem-funded TRANSITION project. These systems include more comprehensive data, software interfaces and commercial mechanisms, and the recruitment of DER to bid to offer balancing and other services on the network. Hence LEO and TRANSITION work together, exploring the systems needed to monitor, coordinate and contract out network needs through TRANSITION whilst the systems and services to meet those needs are researched and tested in LEO. TRANSITION is formally incorporated within LEO as Work Package 5.

1.2 LEO vision

A market-oriented smart local energy system, as conceived by PFER, emphasises technical innovation for cleaner systems with more efficient supply, distribution and storage. The LEO project is uncovering the significance of different types and scales of demand, the roles which people play in energy system transition, and the processes necessary to make a smart system work. The vision, as stated in the Communications Strategy (November 2020) is to

> *provide a strong evidence base and practical guidance that will support the UK's transition to a clean, secure and affordable energy system.*

This includes major strands of activity to:

- develop and test market flexibility models for the energy system in Oxfordshire
- grow an evidence base to inform the UK's transition to a smart and flexible energy system
- understand how households, businesses and communities can realise the benefits of this transition

All these activities will require careful engagement with stakeholders. The third, in particular, will need wide-ranging engagement with a range of actual and potential participants in the SLES, most of them non-energy specialists. With this in mind, Stakeholder Engagement Principles were agreed during Y2.[7] They reflect the LEO vision:

- The energy system is understood as a socio-technical system.
- Engagement is informed by needs and priorities of stakeholders. It is ethical and inclusive.
- The framework for engagement is evidence-based, reflexive and facilitates learning and replication.
- Engagement is compliant with statutory rules, regulations and codes of practice, and is aligned with LEO project needs as a whole.

Much of the learning in Y1 related to the ways in which actors connect with each other and with technologies and data, not least within the project with its diverse members. In Y2, there has been a widening of focus. At grid edge, there has been preparation for neighbourhoods that can be both

[7] https://project-leo.co.uk/wp-content/uploads/2020/09/LEO-Stakeholder-Engagement-Principles-.pdf

smart *and* fair, designed for participation and inclusion, with the development of an ethical framework for SFN delivery[8].

At network level, analysing the processes needed to develop LEMs is still very challenging and has taken up a great deal of the work effort. SLES cannot be achieved without a regulatory framework that supports a renewables-based system with distributed resources, and the Project is still some way from this. While Ofgem are committed to energy transition and to the incorporation of distributed supply- and demand-side resources, they are still working with a highly complex regulatory framework that was designed for a centralised system.

The 2020 Energy White Paper[9] has very little to say about local approaches to transition, beyond a general statement of support for SLES, recognition of the role of local authorities in decarbonisation, and a commitment to assess '*what market framework changes may be required to facilitate the development and uptake of innovative tariffs and products*' during 2021, prior to a formal consultation. The 'strategic context' chapter recognises the shift from a centralised to a decentralised electricity system and the need for flexible, responsive management but omits any mention of the potential for smart local control. Yet the LEO vision is consistent with each of the White Paper commitments to consumers (affordability and fairness, smart meter rollout, facilitating competition and switching, removing market distortions, and protecting consumers as new 'smart' services evolve). Hence the urgent need to develop and communicate the vision and the practical case for SLES through a combination of agile learning from experimentation and engagement with people 'behind the meter', in practitioner roles, and in policy-making bodies.

1.3 The centrality of value

The concept of value has kept cropping up throughout Y2 of LEO. There are many actors and assets involved, and they need to be brought together in such a way as to demonstrate value to individual participants, organisations and communities, and to the system as a whole. LEO has created frameworks for exploring local energy value propositions that are ready for testing with stakeholders.

Questions of value are complex. For a start, value is not something that can be captured only in financial terms, as work with the SFNs continues to show. Also, in economic terms, the value of flexibility in different situations can only be estimated in the absence of a functioning market and it is risky to invest in flexibility-providing assets without an assured market for the services they can provide. It is a lengthy process to build and test such a market, working simultaneously from the 'edge' (generators and electricity users) and from the 'centre' (market designers and platform operators). Y2 experience indicates that many iterations will be needed.

A further challenge that LEO has worked on during Y2 is that of value distribution: in particular, within 'Smart and Fair' Neighbourhoods (SFNs). The main concern is that no-one is left behind in any

[8] https://project-leo.co.uk/wp-content/uploads/2020/11/Project-LEO-ethical-framework-2020-final_ext.pdf

[9] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/945899/201216_BEIS_EWP_Command_Paper_Accessible.pdf

move towards smart local systems; the aim is for affordable services, available to all. Last year we noted that 'there is an open question about how far a market-based system is able to achieve equity and democratic control of energy services and assets', and this still stands. Preparatory work with residents of the designated SFNs and the substantial progress with interactive mapping are helping our understanding of equity and the actual and potential distribution of value from the electricity system in Oxfordshire.

The regulatory environment is changing, slowly. During the year, Ofgem has reviewed the Significant Code Review of Targeted Charging, which aimed to bring charges for the 'residual' costs of electricity networks into line with new modes of generation, consumption and storage. A review of the Significant Code Review of Access and Forward-looking Charging is still under way. Both raise issues of fairness, efficiency and options for system development. The outcome of the Targeted Charging review, while aiming for equity through avoiding additional charges on non-generating customers, does whoever undermine the business case for distributed renewable generation.

1.4 Project structure

LEO stakeholders and processes include

- The project lead, Scottish and Southern Electricity Networks (SSEN), which is transitioning to a DSO[10]. SSEN is also primarily responsible for marketing communications.
- Market operators, who develop and support a marketplace in energy and system flexibility so that contracted service providers can meet DSO operational needs. Piclo, Origami Energy and Opus One. Piclo and Opus One are involved in developing marketplace platforms according to rules developed by Origami Energy and SSEN. These platforms interface with the DSO's 'Whole System Coordinator' (WSC) platform.
- Service providers, including organisations that focus on community-led investment, community engagement, planning, mapping and governance (Low Carbon Hub, the City and County Councils), those working with industrial and commercial customers (EdF Energy) and with the public sector and householders (Nuvve vehicle-to-grid innovation).
- Flexible asset providers. Oxford City Council, Oxfordshire County Council, Oxford Brookes University and Oxford University bring flexible load from their estates and vehicle fleets.
- Researchers from the University of Oxford and Oxford Brookes University, consolidating data sources and analytic tools to develop local energy system mapping across all vectors, conduct trials, analyse and evaluate outcomes.

These stakeholders and processes work through a structure of seven work packages (WPs).

1. WP1: Programme management, led by SSEN. The Programme Manager coordinates budget, programme and risk management, and chairs the monthly Project Delivery Board meeting

[10] Work Package 5 of LEO relates closely to the TRANSITION project to accelerate movement from DNO to DSO; this informs the national Open Networks programme.

and weekly catch-up. Following recommendations in the Marcomms report, commissioned in autumn 2020, WP1 now includes the Communications function, previously in WP6.

2. WP2: Market platform development. Platforms for energy trading, ancillary services to system operators and P2P service provision within localities continue to be designed and tested. The WP is beginning to demonstrate how they can interact to provide routes to market for buyers and sellers of flexibility services, and establishing the interface and data flow requirements between service providers and DSO.

3. WP3: 'Plug-in Projects' for the marketplace under development in WPs 2 and 5, led by Low Carbon Hub (LCH). The projects cover a range of flexibility and energy services to be bought and sold, via power, transport and heat provision. The WP develops and tests business models and local energy offerings that may be replicable nationally. This involves much engagement with participants, including householders, businesses, community groups, building managers and transport managers.

4. WP4: System Learning and Planning, led by the University of Oxford (UoO), has continued to set up processes to monitor, collect, store and assess information regarding energy services and user involvement, underpinned by spatial mapping and temporal data. These provide a 'single version' of the local system across all vectors, as evidence to support future investment and planning of the Oxfordshire energy system.

5. WP5: DSO TRANSITION, led by SSEN, develops integration of the local energy system with the national system. This is a critical element in transition to DSO. SSEN builds on the Ofgem-funded TRANSITION project to establish a NMF platform. This interfaces with WP2 to demonstrate data exchange and the purchase of flexibility to resolve network constraints and provide other services such as P2P flexibility trading.

6. WP6: Learning and Evaluation, led by the UoO, draws on the efforts of all WPs to assess and share learning from Project LEO.

7. WP7: MVS and Trial Activity, jointly led by Origami and UoO. This new WP manages the delivery of MVS and Full Trial activities.

1.5 Process for learning from LEO

During Y2, the processes for documenting and learning from LEO activity have been systematised and streamlined. There is now a Central Learning Log where lessons from all aspects of the project are recorded, along with comments on why they are significant.

The bid document for Project LEO stated the centrality of learning, to provide insights to the team, inform the County's energy strategy and contribute to rapid rollout across the UK and beyond. WP6 is tasked with capturing processes and skills for developing a SLES. Led from the UoO, it includes SSEN, LCH and Oxford City Council and draws on the work of all other partners, who are documenting their learning on markets, value and trading, data management, plug-in projects, mapping and engagement. The main sources are:

- quarterly interviews with WP leaders / representatives
- MVS or other testing processes
- meetings or workshops to tackle practical or theoretical aspects of project activity, within LEO and with current and prospective stakeholders. Examples are market development workshops, seminars with local politicians and planners, and preparations for SFNs.

1.6 Developing the Theory of Change: how does change happen?

LEO is developing a Theory of Change (ToC) that can show the processes and actors needed to achieve project goals: seeking answers to the 'How? What? Where? When? Who?'[11] questions that can be applied more generally in the development of local energy. The project will be evaluated in terms of the aims set out by LEO and the PFER programme.

The ToC evolves throughout the project; it is periodically reviewed by project partners and revised. The most recent version is given in Chapter 6 of this report. This evolution is part of a learning cycle; the figure below illustrates the basic cycle that was originally envisaged for the project.

[11] 'what works, for whom, in what circumstances?' See https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/407568/8_Synthesis_FINAL_25feb15.pdf for an application of these methods to evaluation of the early stages of smart meter rollout in Great Britain.

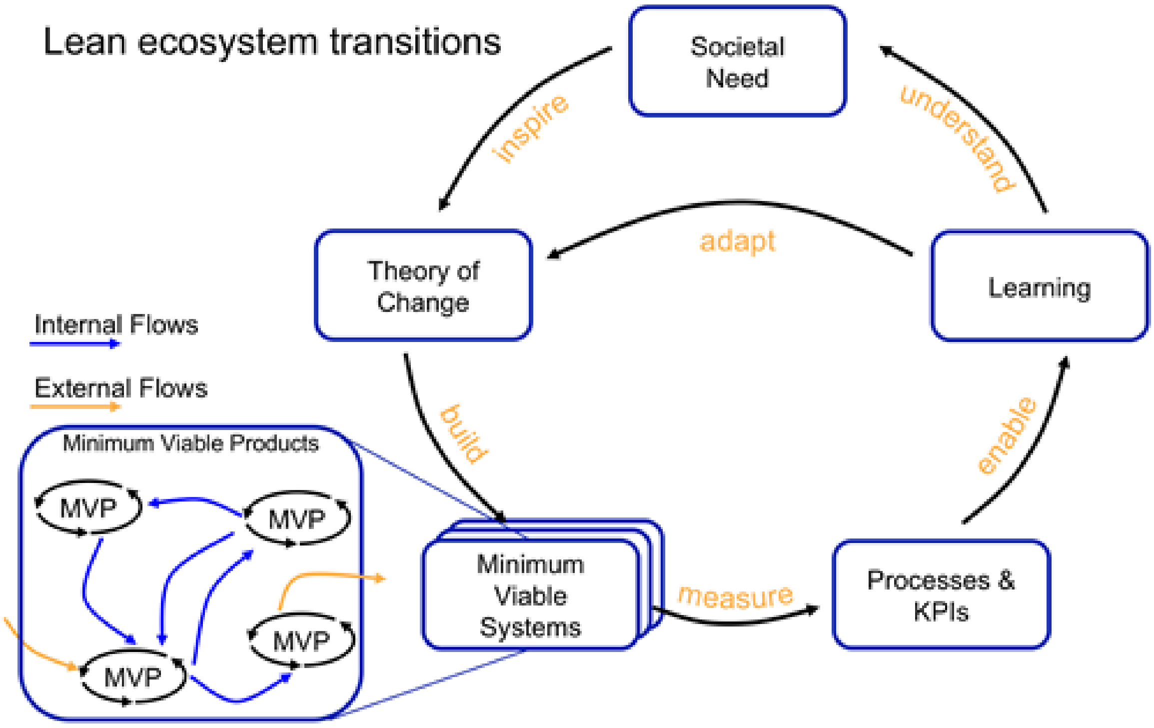


Figure 1: Information flow in the Lean Ecosystem Transition method

In Y2, we have learned that this model does not necessarily work for all LEO activity: for example, it is not possible to iterate a SFN, although it is possible to document learning during the process of setting one up and to assess the potential for replication. For such 'one-off' initiatives, a learning diagram that is more open-ended would be appropriate, for example:

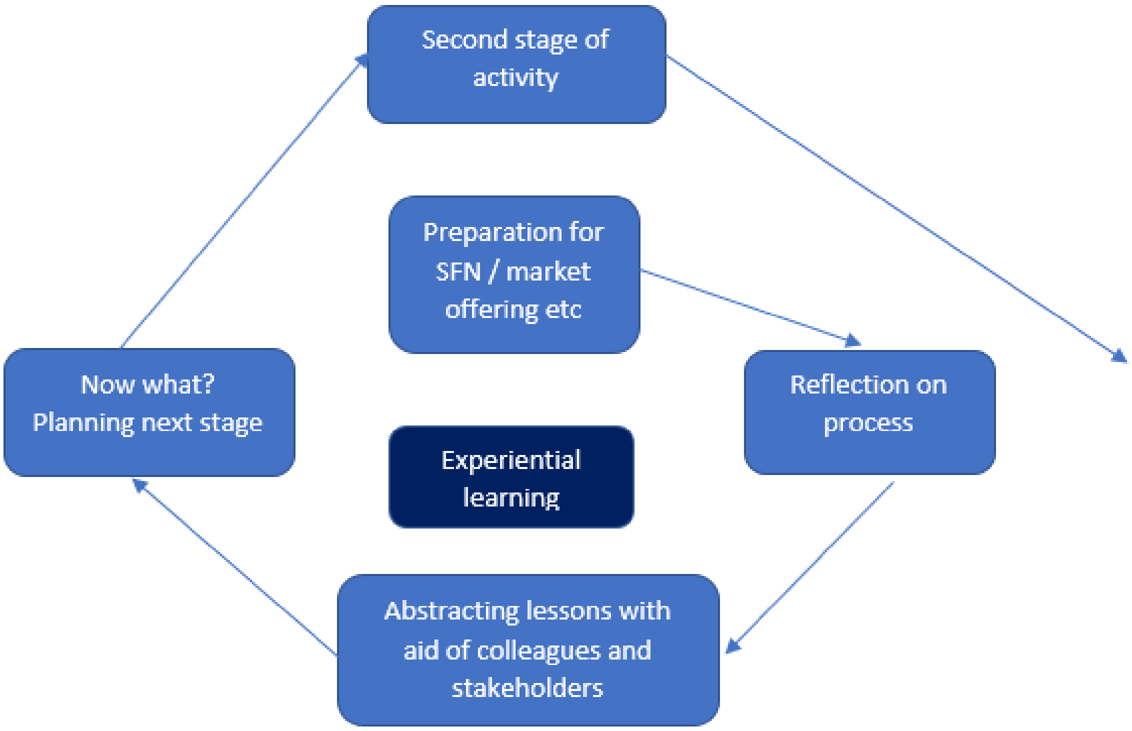


Figure 2 Information flow for more complex processes

LEO evaluation is taking place in association with members of the EnergyREV Consortium, who are also developing a ToC. A complementary evaluation, using quantitative metrics, will be carried out by the Energy Revolution Integration Service, ERIS (based in the Energy Systems Catapult), to *harness the PFER programme to enhance the business case goals or smart local energy systems as a pathway to decarbonisation through helping key stakeholders overcome barriers.*

1.7 Stakeholder learning

Internal stakeholders include SSEN, who operate the electricity network for most of Oxfordshire and have national reach; the Low Carbon Hub, the local anchor for the project, and the network of low carbon community groups who each own a share in the organisation; local authorities; the supply industry and market-enabling partners – Piclo, Nuvve, EdF and Origami Energy; and the universities, Oxford and Oxford Brookes. There has been ample scope for learning. The task of developing a commonly-understood vocabulary of terms has progressed during Y2, but there is a continuing need to check all documents so that they can be as intelligible as possible for their intended audiences. This is done through internal review and, where 'lay' audiences are concerned, by testing drafts with members of the general public.

External stakeholders cover a wider range, categorised as those who:

- make and adapt national policy and regulations e.g. Treasury, BEIS, Ofgem and Elexon;

- design and operate infrastructures for utilities, the built environment and transport, e.g. the National Infrastructure Commission, National Grid, transport operators and housing developers;
- are incumbents and new entrants in the energy supply and communications industries and can support or impede system transition;
- can amplify or 'dial down' initiatives such as LEO through their engagements with civil society and commerce. Examples included social media, demand aggregators, local authorities, NGOs, landowners and the Local Energy Partnership;
- are contributors to system operation via their consumption, generation or storage – domestic and business/organisational customers;
- are actual or potential learners from LEO, including researchers, the Energy Networks Association, local authorities and community groups.

The Stakeholder Advisory Board (SAB), meeting twice a year, is a vital forum in which institutional stakeholders can learn from the project's experience and vice versa, and in which to discuss how best to use that experience in making SLES viable. In Y2 there has been more space for discussion and the development of ideas in the SAB meetings.

At community level, stakeholder engagement strategy has moved forward in various directions. These include building support for the SFNs and engaging with building managers, vehicle fleet managers, landowners and other 'middle actors' in order to develop demand-side response and sites for new renewable generation.

1.8 Learning through mapping

The major mapping exercise carried out in Y2 has been educational for the project and is expected to have influence well beyond it. Described in more detail later in this report, it is already showing its worth as a tool for engagement with stakeholders, not least by identifying sites that may be suitable for renewables at a variety of scales and could be incorporated in the Oxfordshire Plan 2050.

1.9 Dissemination

The second year of LEO saw a shift in responsibility for general communications from WP6 to WP1. this followed a review that addressed the complexity of the task and streamlined it, with the aim of producing action-oriented messages. This work is now well under way with a redesigned website to increase understanding of the challenge and the project, development of interactive possibilities (for example through mapping) and use of brief case studies and commentaries in the LEO newsletters.

2. External challenges to LEO

At national level, there is policy support for some of the key technologies investigated in LEO. For example, in "The 10-point Plan for a Green Industrial Revolution"[12], major investment is promised for electric vehicle charging infrastructure (£1.3 billion) and the manufacturing of EVs. Heat pumps are also supported through a major market-led demonstration programme and changes to

[12] UK Government 10 point plan: https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution/title#foreword-from-the-prime-minister

regulations: gas boilers are not to be fitted in new dwellings from 2025. These measures aim to create a market where 600,000 heat pumps are installed per year by 2028. Unfortunately, the flagship Green Homes Grant was closed to new applications from March 2021. This had funding provision for heat pumps and insulation measures. Heat pumps are still subsidised by the Renewable Heat Incentive but this scheme too is closed to new applications from 31st March 2022[13] . This leaves the UK with no scheme to support low carbon and energy efficient retrofit for UK householders other than the Energy Company Obligation which is solely targeted at improving fabric standards amongst householders on very low incomes and at risk of fuel poverty.

Local authorities have a critical role in creating the local policy and planning framework that fosters take-up of low carbon technologies and ensures, through the planning system, that their adoption is used as a lever to create societal benefit and meet local development goals. The general policy direction shaped by declarations of climate emergency and carbon reduction plans is helpful but not sufficient. Local Plans to drive development in particular directions were often published years before the need for wholesale energy transition was fully recognised. Hence the local plan policies are often only weakly supportive of the types of technology and approaches required in a SLES, or silent. Assessment of the Oxfordshire local plans reveals that they are also focussed on setting out the policy for *new* development; policies to encourage retrofitting of smart energy technologies into *existing* buildings are not present. Local area energy planning offers a much-needed methodology to start plugging these gaps in local authority policy and strategy with respect to SLES.

3. Building a Local Energy Market

Developing flexibility services that can be traded on a LEM platform is a core activity of the LEO project.

3.1 The rise of renewables

Over the last two decades the UK's electricity generation mix has been transformed. The share of UK generation from renewables has grown ninefold since 2010, and wind and solar power's combined share of UK generation grew from 17-22% between 2019 and 2020. This pace needs to continue over the coming decade: the UK Climate Change Committee puts the necessary share of generation from wind and solar at 50% by 2025 and 69% by 2030.

Major drivers of the rise in wind and solar generation have been steep declines in technology costs and the supportive economic environment created by the Feed- in Tariff (FiT), Renewable Obligation (RO) and Contracts for Difference (CfD). Large scale solar, onshore and offshore wind are now the cheapest forms of generation and are forecast to get even cheaper over the next two decades,[14] whilst the cost of rooftop solar has halved over the last 15 years and is forecast to continue to

[13] Ofgem page for the RHI: https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi/applicants
[14] Electricity Costs 2020. BEIS.
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/911817/electricity-generation-cost-report-2020.pdf

drop.[15] The FiT has now closed, but solar PV continues to be installed at rooftop and solar farm scales because of the drop in upfront (capex) costs. Likewise, the RO was closed to new applications in 2017, with CfDs taking up support of larger scale renewables.

3.2 Accommodating renewables

An increasing proportion of the supply mix is from smaller assets (<1MW) connected to the network at the lower voltage substation levels. National Grid scenarios suggest a potential for 45% of installed capacity to be connected at lower voltages by 2030, in comparison to 29% today: energy supply is becoming decentralised[16] .

As much of this new generation connected at LV levels is renewable - solar roofs and farms, small and medium-sized wind and hydro - it is weather- dependent and consequently less flexible, predictable and responsive than conventional gas-fired generation. Equally, the time at which renewables generate doesn't always match the time when there is electricity demand. For large wind generators this occasionally results in generators being paid to turn off the turbines ("curtailment"). In 2020, this cost was more than £250m or about £4/MWh. Excess generation from both wind and solar during some periods of high production and low demand has also resulted in negative pricing - in 2020, 2% of hours had negative wholesale prices for electricity.[17]The proposed solutions to these issues of intermittency and the mismatch between generation and demand timing are a) reinforcement of the electricity supply infrastructure and b) building more flexibility and storage at the grid edge and at intermediate levels of the transmission and distribution system.

Some analysts see an important role for EVs in the creation of storage. 'Green hydrogen' could also be an increasingly important storage technology.[18] Meantime, electric vehicle owners and others with battery storage, signed up to variable rate tariffs, can enjoy the prospect of occasionally being paid to power their vehicles and homes.

3.3 Changing demand

The volume and timing of electricity demand are shifting as heat and transport become electrified. Steep declines in the cost of batteries mean that EVs are forecast to be cheaper than fossil alternatives in the next five years, creating a tipping point in the car industry[19]. Analysis of the whole-life cost of an electric passenger vehicle suggests that they are already cheaper to own and run than conventional alternatives.[20]

---

[15] BEIS solar photovoltaic cost figures: https://www.gov.uk/government/statistics/solar-pv-cost-data

[16] Towards a new framework for electricity markets. Report by Poyry for Energy Systems Catapult. October 2019

[17] Drax Electric Insight Quarterly reports: https://reports.electricinsights.co.uk/reports/q4-2020/

[18] Current news: https://www.current-news.co.uk/news/negative-pricing-will-be-a-big-feature-as-high-winds-get-the-uk-network-off-to-a-strong-start

[19] Bloomberg Electric Vehicle Outlook 2020 https://about.bnef.com/electric-vehicle-outlook/

[20] Going electric. How everyone can benefit sooner. Green Alliance 2019. https://green-alliance.org.uk/resources/going_electric_how_everyone_can_benefit_sooner.pdf.

The carbon case for heat pumps is highly favourable: they already offer at least 30% reductions in emissions over conventional gas boilers and this figure will improve as the grid decarbonises[21]. Of course, heat pumps and some other low carbon technologies (including smart domestic appliances) remain more expensive than incumbent alternatives for the moment[22] , with an air-source heat pump costing between £5000-8000 installed as compared with £2000-3000 for a gas boiler. But prices can be expected to decline as more are manufactured and installed.

3.4 The need for flexibility

These trends in the way we generate, distribute, store and consume energy, combined with net zero carbon targets, create a complex challenge. The electricity distribution network was not designed to accommodate thousands of new sources of generation connected at the low voltage level. Increases in demand from electrified heat and transport, connected at the grid edge, will at some point lead to network stresses and capacity issues, particularly at peak times. Network operators can re-engineer and reinforce the network at great cost or find new ways of getting the most out of the existing network by, for example, creating a market for energy users or producers to be rewarded for being flexible with their power demand or generation, or both.

Analysis conducted for LEO estimates that flexibility has the potential to reduce annual system cost by £4.55bn in this country, with savings from avoided network capacity, reduced peaking generation capacity, and reduced curtailment of Variable Renewable Energy Sources (VRES) which in turn reduces fuel use. Widescale deployment of storage, either utility scale or distributed, has potential to extend these savings to £5.0bn per annum[23].

[21] IEA HPT Programme Annex 42: Heat Pumps in Smart Grids UK Executive Summary 30th January 2018. At: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/680514/heat-pumps-smart-grids-executive-summary.pdf

[22] Rough heat pump prices for 2020 are found at: https://www.renewableenergyhub.co.uk/main/heat-pumps-information/a-guide-to-heat-pump-prices-in-2019/

[23] Modelling the GB Flexibility market — Part 1 The Value of Flexibility. Piclo, Element Energy and Graham Oakes. April 2020 https://project-leo.co.uk/wp-content/uploads/2020/10/LEO-Modelling-the-GB-Flexibility-Market-Part-1-Value-of-Flexibility-new-cover.pdf

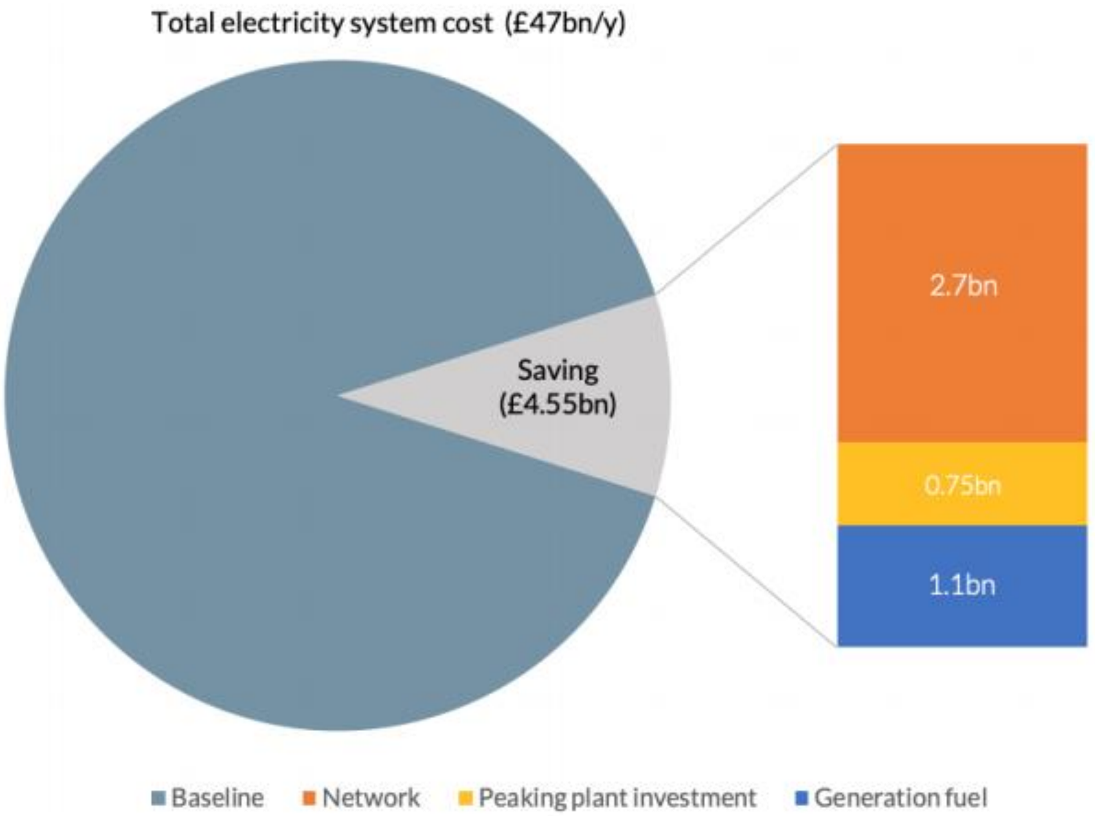


Figure 3 Modelled annual savings from flexibility. Source: Piclo, Element Energy and Graham Oakes (2020) ibid

This modelling suggests there is a great prize to be captured here. Tackling network constraints and making better use of the network using smart technologies to create flexible demand and supply drives the development of new value propositions. These will be built around providing services to the network, meeting real time needs and needs that are forecast days, weeks and months ahead.

3.5 Flex from the grid edge: inclusivity and automation

With microgeneration technology and battery storage becoming widely adopted and the growing availability of affordable smart control systems to flex demand, small businesses and households at the grid edge can become part of an emerging ecosystem of actors involved in system service provision. The involvement of energy users at the grid edge is not only 'nice to have', in that it could result in benefits flowing to system users. In some circumstances it is also an operational necessity: without flexing demand at the grid edge, network constraint challenges will not be addressed adequately. The requirement for a critical number of energy users to flex their demand or generation at a stressed network node foregrounds the need for a market for services to be accessible by as many as possible. "Nobody left behind" as a mantra to guide the energy transition is not only a matter of fairness and ethics – it is also how flexibility solutions will be effective in meeting network needs.

Automation and internet connectivity are critical to the technical viability of an energy system where thousands of assets are coordinated to balance supply and demand. Automation is also key to the commercial and economic viability of such a system, in order to minimise transaction costs that would otherwise undermine business models. Control systems that can automatically transact with one another and with LEM platforms are seen as critical to minimising transaction costs.

3.6 Market mechanisms for network services

LEO's Distribution Network Operator (DNO), SSEN, needs to understand how to forecast and procure flexibility services which meet their operational needs through market mechanisms. Needs can be instantaneous in the case of managing a fault or, to manage peak demand, procured a day, week or months ahead. Understanding the value of flexibility in particular parts of the network at particular times is crucial, and value will be determined by the type of network constraint and the cost of the alternative to flexibility, reinforcement. Alongside the DNO services, LEO is testing market arrangements for some Distribution System Operator (DSO) services, including trades of power capacity between peers.

3.7 Actors in the local energy market

PFER recognises opportunities not only to meet the technical challenges described above but also to use energy transition to build "more prosperous and resilient communities".[24] Project LEO has embraced this approach, exploring how to create LEMs for services that can deliver social and environmental benefits. A key challenge for SLES in general is creating a marketplace and local energy services where a range of actors (including aggregators) are able to develop business models and value propositions that work with customers who have low levels of the capability to participate fully in an emerging local energy system, and to access benefits from it.

3.7.1 Actors, communities and capabilities

LEO envisions roles for people, communities and organisations within the energy system that move beyond the conventional producer-consumer paradigm. Integral to SLES are trading platforms where energy services that help the distribution network operate can be auctioned, procured, dispatched, verified and settled and where peers can trade energy, power and electrical capacity. This means the formation of relationships between actors who are learning new roles, for which they will need capabilities: the ability, suitability and willingness to contribute to, and benefit from, local energy systems. Communities too must learn to act in new ways if they are to benefit from SLES and the system as a whole must also be able to host or integrate a SLES through capabilities such as a conducive planning, policy and regulatory environment, market platforms where services can be traded and sufficient actors to supply liquidity, competition and necessary services. Actor-, community- and system-level capabilities are all explored.

3.7.2 Liquidity and competition

The need for liquidity is particularly important for day-ahead markets for dealing with pre- and post-fault constraint scenarios. Without plenty of actors able to provide services for tackling faults, there is a risk to security of supply.

[24] https://www.gov.uk/government/news/four-leading-edge-demonstrators-to-jumpstart-energy-revolution

Recruiting sufficient market actors for a liquid market could be particularly difficult for services requiring increases in (non-fossil) generation, as the business models of most generation assets are built around generating as much as possible for as long as possible. Therefore, further increases in generation to supply a flex service may not be technically or commercially feasible.

The issue of having sufficient market actors to create liquidity and competition will be different at different voltage levels and points in the network. Clearly, at secondary substation level there will be fewer flex providers connected and available to provide services to that asset than at higher levels of the network. So it may be that a flex provider can name their price depending on where in the network the service is needed, and the number of others that can provide the service at that point. It may be that only one provider is able to deliver the service at some points in the network, particularly as we move closer to the grid edge.

3.7.3 Domestic versus industrial and commercial actors

The domestic sector has very different capacities, capabilities and transaction costs from industrial and commercial organisations and working with householders will require different mechanisms from those suited to industrial and commercial asset owners.

At the most fundamental level, the flexibility available within a single household or small business is tiny compared with what is potentially available with an industrial or commercial organisation[25]. When working at the grid edge, useful flexibility is only achieved if the flex from multiple households and small businesses is coordinated. Clearly monitoring, controlling, dispatching and settling flex from thousands of assets are very different propositions from doing the same for a handful, in terms of transaction costs, operational effort and the systems required. Monitoring, control and decision-making systems that allow small assets to transact automatically with a software platform with minimal transaction cost are now available, and some are under investigation within LEO, e.g., as part of the 'HOPE' strand of MVS activity. (The HOPE group are staff from LCH and UoO who own behind-the-meter assets and have volunteered to test their equipment and procedures).

Whilst working with grid-edge assets is challenging, there are reasons why LEO partners remain keen to explore small-scale flexibility. These are operational and also relate to the creation of social and environmental benefit. Some network constraints at secondary substation and feeder level can only be tackled by flexing demand and generation at MPANs[26] (meters) connected at the low voltage level.

There are multiple routes by which grid-edge flex can produce social as well as operational benefits:

- Even small amounts of additional revenue from flex provision (with minimal transaction cost) can be beneficial for some low-income socio-economic groups.

[25] But note that there is no direct relationship between capacity size and available flexibility. Some very large energy users may have only minimal ability to flex their demand.

[26] Meter Point Administration Number

- A community could fund a community asset from sale of their aggregated flexibility. This is an interesting possibility where the value of flexibility to an individual actor may be so small as to be inconsequential (or perhaps negative once transaction costs are factored in). But, when aggregated, the value may become enough to create change. This idea has been mooted in Oxford in relation to funding the installation and maintenance costs of a publicly accessible V2G chargepoint (Osney SFN).
- Where financial benefit to individual householders from flex is immaterial, there remain environmental reasons why they might want to participate in a LEM.
- Greater flex at the grid edge enables greater penetration of technologies that can achieve substantial behind-the-meter savings. For example, many social housing landlords install rooftop solar on their housing stock in part to reduce energy bills for low-income tenants.
- As a further example, EVs have much lower running and maintenance costs than ICE equivalents and their lifetime ownership costs are already lower, even when their substantially higher capital costs are factored in[27]. EV capital outlay - the main consideration for low-income households - is continuing to decline as the costs of batteries fall, and is thought likely to achieve parity with conventional alternatives in the next five years, at which point the case for their ability to deliver more affordable mobility will be even stronger. Further, Vehicle-to-grid (V2G) EVs can deliver substantial flexibility and therefore revenue. Depending on where the V2G is connected in the network, this can be around £400 per annum according to some estimates[28].

3.7.4 Non-domestic actors and capabilities

Non-domestic organisations have technical, financial, intellectual, cultural and social capabilities and attributes that will influence their decision-making related to adoption of innovative energy technologies and practices and, by extension, their propensity to participate in LEMs.[29] Capabilities will be distributed in different ways depending on the size of an organisation and the sector it operates within. How capability is distributed across non-domestic organisations, and how this an affect adoption of flex technology and ability to participate in flex markets, are exemplified by LEO's experience with V2G technology.

We have found that V2G is best suited to organisations running fleets of V2G-compatible vehicles (primarily the Nissan Leaf) and where the vehicles are used in a pattern of being driven during the day with a return to base around 4pm. This allows reconnection and discharge of remaining power in the batteries into the local network during peak times (4-7pm), alleviating stress.

---

[27] Going electric How everyone can benefit sooner. Green Alliance. 2019. https://green-alliance.org.uk/resources/going_electric_how_everyone_can_benefit_sooner.pdf

[28] CENEX estimates that between £150 and £400 is available to the customer from V2G value streams depending on the amount of time the vehicle is plugged in and able to discharge. The upper rate is only achievable if the vehicle is plugged in around 75% of the time. See CENEX report for Innovate UK, A fresh look at V2G value propositions. June 2020. Available at: www.cenex.co.uk/app/uploads/2020/06/Fresh-Look-at-V2G-Value-Propositions.pdf

[29] DECC (2012) What are the factors influencing energy behaviours and decision-making in the non-domestic sector? A Rapid Evidence Assessment. Centre for Sustainable Energy (CSE) and the Environmental Change Institute, University of Oxford (ECI)

A V2G system is much more expensive than conventional EV charging technology. Also, the case for investment in the technology is based on inherent uncertainties, e.g., the expected value of flexibility at the site in one year's time. This means that only certain types of organisation with financial resources and the ability to absorb certain levels of risk are likely to adopt the technology at this time. The capability to absorb risk is generally associated with larger organisations; struggling SMEs are therefore less likely to participate in the V2G offer. This suggests there are energy equity issues amongst organisations as well as in the domestic sector.

SSEN recognise that some market actors such as energy suppliers and aggregators are set up with the capacity to work with their customers' flex portfolios and to find optimal mixes. In addition, they have the staff and systems to participate in day- or week-ahead markets. Smart energy management and playing in energy markets is not an area of focus for most SMEs, particularly smaller ones that will generally not have the skills or systems to engage in flex markets. SSEN recognise a middle ground of larger energy users such as universities and local authorities who employ energy managers and have staff with the skillsets to flex their demand to meet network needs. However, here too there will be different appetites for risk and differing energy management capabilities. Recognising this diversity and the need to galvanise participation in flex markets amongst actors who may never have heard of the opportunity, let alone assessed the feasibility of participation, SSEN have therefore developed a number of routes to market (see $3.8).

3.7.5 Aggregators

Aggregators must minimise transaction cost to flex providers by simplifying the process of participation and the setting up of contractual arrangements. They take a slice of the cake for performing this service but are still able to offer a viable value proposition in lowering barriers to participation. Aggregators also play a valuable role in coordinating a pool of assets to be more effective than if those assets were acting individually. The current design of the NMF, where assets are registered on the system manually and assessed for suitability in delivering a service before notification is issued, is evidently unsuited to dealing with individual registration of tens of thousands of small assets; these must be aggregated first. Here there is a clear role for a commercial aggregator to add value to the system. (This is distinct from a technical aggregator role, which involves operating the systems which monitor, dispatch and verify aggregated flexibility.)

Aggregators serve other functions in the LEM. For example, they can absorb some fixed costs (e.g., smartening equipment and installing control systems), manage some risks and provide analytics, e.g., forecasting demand at points on the network and developing strategies to tackle constraints.

3.8 Routes to Market

SSEN recognise that markets for specific energy services will develop differently with different levels of liquidity and competition, and that some services need different levels of assurance that they will be delivered. For example, a service delivering pre-fault flexibility (to ensure that power flows do not exceed network capacity) requires greater assurance than peak management, and therefore a more liquid and competitive market to minimise risk.

Recognising the varying levels of risk that participants are taking and are comfortable with, plus the diversity of energy management and financial capability amongst potential market participants, SSEN have developed three routes to market: two types of auction and a market stimulation route specifically designed for entrants who require great simplicity and minimal transaction cost, and/or some financial support to prepare their assets to participate (e.g., to install automatic control systems). Two market stimulation packages are used to galvanise participation.

3.8.1 Competition and liquidity auctions

Markets which are deemed uncompetitive (very few participants) or without liquidity (it is difficult to make transactions quickly and easily) will be offered a price ceiling to participation in a flexibility contract. For example, SSEN will offer a ceiling of £300/MWh for a 'sustain peak management' flexibility service. To help participants convert this into availability (commitment to deliver energy) and utilisation (energy delivery) payments, SSEN will provide a calculation tool.

Markets which are deemed both competitive and liquid are better suited to competitive auctions. SSEN intend to run auctions of two types:

- Auctions that require participants to submit competing bids and offers, with SSEN selecting the lowest cost solutions to its constraint problem.
- A fixed price contract will offer the average price at which auctions settle, minus a degree of risk which TRANSITION absorbs by taking this approach.

3.8.2 Market stimulation packages

The third route option is through market stimulation packages[30]. These are aimed at recruiting neophytes who may have little time or resource to play the markets, or appetite for risk, but wish to participate so long as barriers to entry are reduced and there is minimal transaction cost. Two packages offer simplicity and financial support to help assets enter the market, but may pay less than the auctioning options presented above.

Package 1 (Simplicity Package) is designed to provide simplicity and financial security. It is recommended for those with smaller assets or with less experience in taking part in flexibility markets. SSEN will pay a flat rate of £2/kW of capacity with a maximum payment per asset, capped at £100 (so all assets of 50kW and above will receive £100). In return SSEN require commitment to delivering flexibility across 10 x 1 hour-long events (between 3-7pm).

Package 2 (Upgrade Package) is designed to provide financial security and support to get an asset 'flexibility ready'. It is recommended for those with smaller assets looking to make their participation less manual. SSEN will pay a flat rate of £9/kW of asset capacity. In return they require commitment to delivering flexibility across 50 x 1 hour-long events (between 3-7pm). The increase in level of commitment compared to the Simplicity Package justifies the higher rate paid.

[30] More information on routes to market is available on the TRANSITION website: https://ssen-transition.com/get-involved/market-options-and-routes/

3.8.3 Accessing the market – the issue of fairness

These actor, community and system-level capabilities will be distributed unevenly, with the likelihood that actors and communities with fewer financial resources or less ability to take risk will be less able to access benefits from SLES and may be 'left behind'. Similarly, where the local energy system or distribution network does not have the capabilities to host a SLES, that part of the network will not fully participate in energy transition. Therefore, absence of requisite forms of capability at all levels can be understood as an issue of equity and fairness, where interventions may be needed to reconfigure actor or system capability, or both. Alternatively, the SLES offer itself must be reconfigured to meet local capabilities if unfair outcomes are to be avoided.

It should be noted that market solutions which are judged unfair or environmentally damaging are unlikely to gather popular or political support and are therefore unlikely to succeed – at least in the longer term. But there is a balance to be struck. If the transaction costs of widening access to as many as possible become too high, value propositions may be undermined, business models become unviable, and take-up of the offer becomes stymied. Therefore, to ensure that access is as widespread as possible, there will need to be a diverse mix of market actors operating with different value propositions, some of which will not be structured around optimising financial returns. A not-for-profit community aggregator is one such idea[31]. LEO's approach to fairness is set out in in our engagement strategy[32] and in the ethical framework developed for working with community groups[33].

3.9 Local energy market system architecture

The TRANSITION project, integrated with LEO, is developing the systems required for procuring and trading energy services. In a LEM, only flexibility assets - distributed generation, storage and demand side response - within a defined geographical area can participate. (For this reason, there is a strong argument for renaming a LEM as a Local Flexibility Market.) However, these assets can sell their energy or services either to meet local needs in P2P transactions or to the DSO (here SSEN); or to national markets for ancillary services procured by the Electricity System Operator (ESO) to balance supply and demand, and to ensure security and quality of supply. These opportunities for a flexibility service to capture value in different markets can be 'stacked' to deliver multiple revenue streams or cost reductions.

Local marketplaces can be designed to enable access for users, generators, aggregators, suppliers and DNOs, to allow trading of energy and flexibility between local resource providers and other parties. Settlement of transactions within the LEM, between different local markets and between local and national markets (e.g., the balancing mechanism operated by the ESO) will pose operational, policy and regulatory challenges, but it is critical to the operation of the system[34] .

---

31 Carbon Coop 2018. https://cc-site-media.s3.amazonaws.com/uploads/2019/01/ECAS-Local-Flexibility-Markets.pdf

32 Stakeholder engagement principles. Ruth Harris and Nick Banks. August 2020. https://project-leo.co.uk/wp-content/uploads/2020/09/LEO-Stakeholder-Engagement-Principles-.pdf

33 Developing an ethical framework for local energy approaches, Saskya Huggins, November 2020. https://project-leo.co.uk/wp-content/uploads/2020/11/Project-LEO-ethical-framework-2020-final_ext.pdf

34 The policy and regulatory context for new Local Energy Markets, ERIS (2019) Op.Cit.

TRANSITION explicitly recognises the need for both the ESO and DSO to have sight of flexibility assets that are registered on the market platforms, and for back-end systems able to ensure that conflicts between transmission and distribution level needs are managed. In response to these challenges, the embryonic LEM architecture, under development in TRANSITION and in activities led by Piclo in WP2, has components as shown in Figure 4.

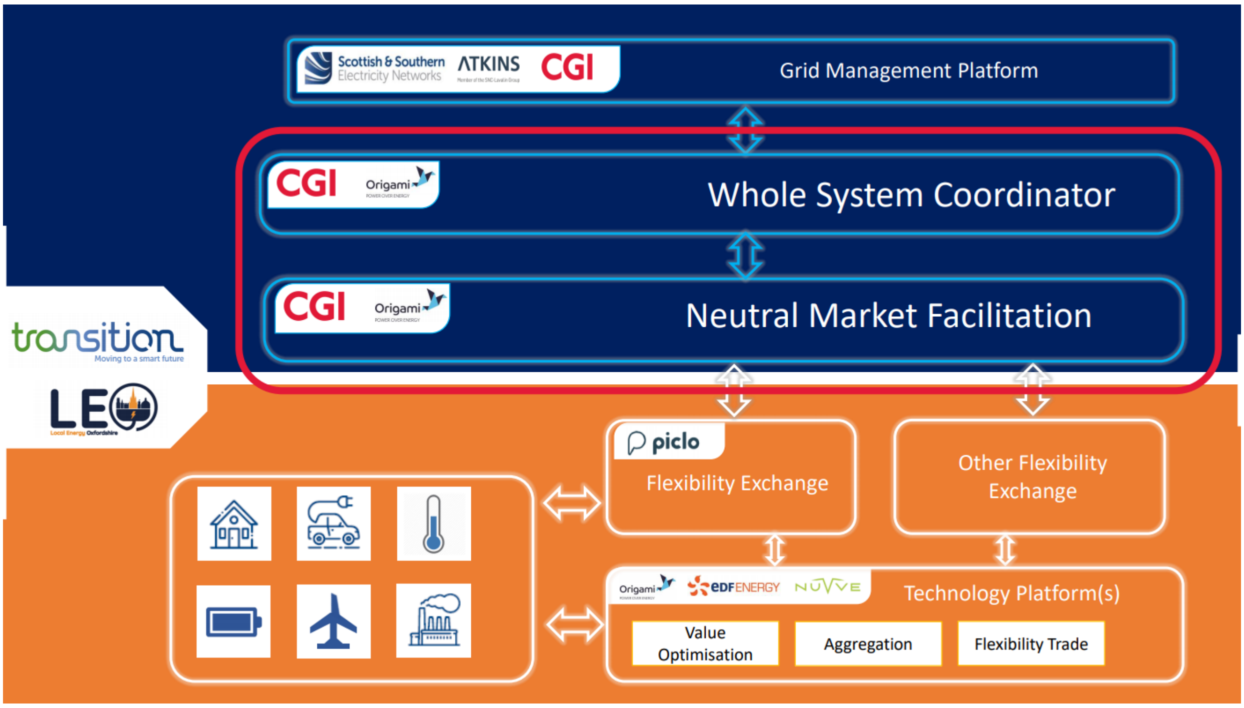


Figure 4: Fundamental market architecture

At the end of Y2 there remain gaps and uncertainties in end-to-end procedures for procuring and delivering flexibility, where the process runs from identification of a network constraint by the WSC through to settlement for provision of the service via the NMF or possibly a third-party flex exchange. The TRANSITION trials (see below), starting in the autumn of 2021, will explore the detail of end-to-end processes.

3.10 Data for the market - monitoring the LV network

- Monitoring of substations and feeders at low voltage levels has been extremely patchy. LEO and TRANSITION have explored monitoring requirements to feed the WSC systems, detect network constraints and verify the performance of flexibility assets.

By January 2021, SSEN had installed 81 low-voltage monitoring sets to gather baseline data from the network, at points feeding flexibility assets which will form part of the TRANSITION trials. They will provide insight into network activity and the impact of the trials[35]. Data from this equipment can be seen on the Eneida DeepGrid portal.

[35] Full detail of the Eneida monitoring solution is available in the TRANSITION report, *Network adaptation for trial deployment* (July 2020) at: https://ssen-transition.com/wp-content/uploads/2020/07/TRANSITION-Network-readiness_final.pdf

3.11 Whole System Coordinator and Neutral Market Facilitator

Throughout the second year of the project there has been development of the WSC and NMF systems. The WSC comprises a set of DNO functions to identify network constraints, existing or forecast, and then assess the mitigation options. These can include:

- use of Active Network Management or Distribution Management Systems where available;
- calling-off from contracted options for the use of suitably-located flexible resources;
- contracting for additional flexibility via the NMF (see below).

The purposes of the WSC also include coordination with the ESO and with other DSOs to enhance reliability and effectiveness of the networks as a 'whole electricity system'[36].

The primary purpose of the NMF is to send a signal to markets and registered flex providers that a service is needed, and to manage procurement and contracting processes for assets able to deliver the required service. It thus allows flexible resources connected at the distribution level to access markets in which flexibility has value at local, regional or national level. The NMF interacts with one or more third-party flexibility exchange platforms, such as that under construction by Piclo.

The NMF is a DSO system and a key related function is to coordinate flexibility between DSO and ESO domains so that conflicts do not arise. The NMF will also allow P2P transactions to be conducted through its software.

The NMF will be open to external parties, including flexibility providers such as aggregators, the ESO, at least one DSO and, potentially, similar parties from other regions. Within LEO, the platform will only serve the network in Oxfordshire, but it could also work at licence area or even national level. TRANSITION hopes to determine the appropriate scale and coverage for an NMF.

The NMF is not specified to deliver baselining and settlement processes, nor does it directly dispatch flexibility. That is the responsibility of the successful contractor for the service.

3.12 Flexibility exchange or platform

Piclo has continued throughout Y2 to develop its flexibility exchange. This allows providers to contract for requested services and is therefore integrated with the NMF. Services accessible on the Piclo platform can be requested by the DSO, the ESO or for third parties in P2P transactions.

[36] High level descriptions of the system architecture for the WSC and the NMF are found in the TRANSITION report, *High Level Solution Design Summary 2019*
https://ssen-transition.com/wp-content/uploads/2019/11/High-Level-Solution-Design-Summary-v1.pdf

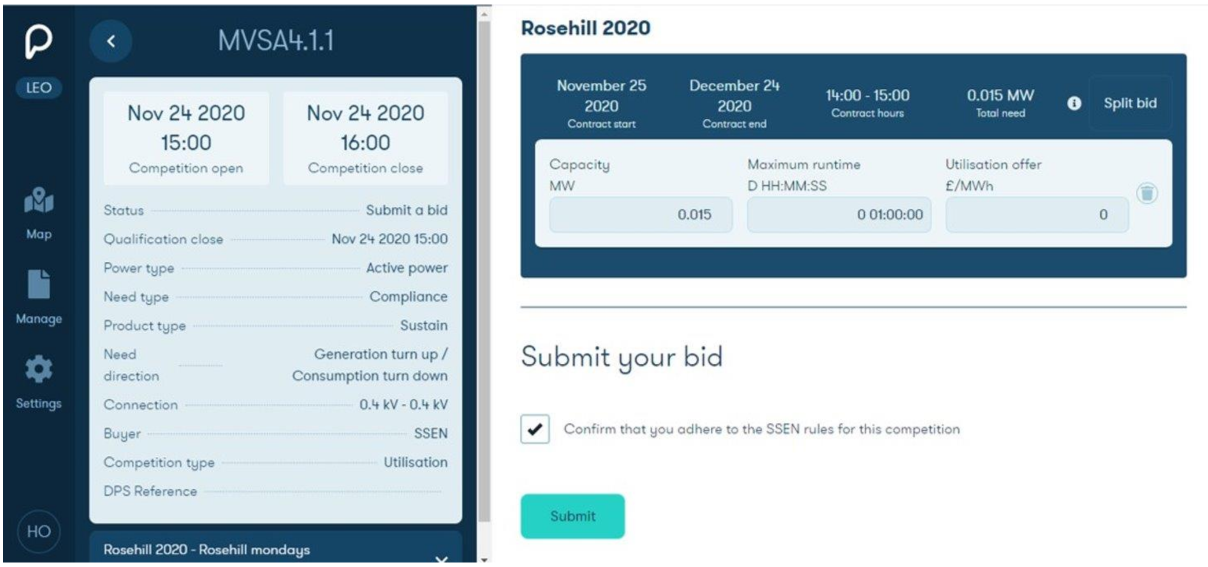


Figure 5: Screenshot of the Piclo flexibility exchange platform

It should be noted that some functions of the Piclo platform, such as registration of assets, replicate those in the NMF. It was known from the outset of LEO that there would likely be areas where the two systems would overlap but it was thought necessary to work through integration of the two systems in order to understand where the boundaries between regulated business and private sector -arty flex exchange platform lie. Table 1 compares the sequence of steps in the Piclo and NMF platforms.

Table 1: Flexibility exchange platform and NMF compared

Stage	Steps	
	Flexibility Exchange Platform	Neutral Market Facilitator
Registration	1. Flex providers with assets located in any part of the UK register them on the Piclo platform through automatic and semi-automatic processes in the Piclo API. The process will capture details of the precise location of the asset on the network, asset type and key parameters of the flex it is able to deliver (capacity, availability etc).	1. Asset owners and operators in the Oxfordshire area submit their assets direct to the DSO for registration on the NMF. At present, this is a manual paper-based process.
Procurement	2. The WSC (see above) identifies a network constraint and the type and location of a network service to manage that constraint. This information is then sent to the NMF and to third party flexibility exchanges/ platforms. 3. Assets registered on the platform are matched to required services through 'qualification' procedures (e.g., is the asset delivering the service connected to the required part of the network?). 4. Qualifying assets are then sent to the DSO 5. The service need and qualifying assets are plotted on a network map. 6. The DSO checks that the assets can meet the need – e.g., a check will be run that the asset is located in exactly the right part of the network. 7. The DSO confirms to Piclo which assets meet the criteria. 8. Asset owners are notified that they can take part in the competition and are invited to do so.	2. The WSC (see above) identifies a network constraint and the particular type and location of a network service to manage that constraint. 3. This information is sent to appropriate assets registered on the NMF system. 4. In addition, the NMF can send the network service need to assets registered on the Piclo platform. 5. Qualifying assets signal their wish to enter the competition. 6. Qualifying assets are invited to participate in the competition.
Operations	9. Qualifying assets are compared in a competition and the one delivering best value is selected. 10. Automatic and semi-automatic processes interacting with the NMF then procure the services as necessary (with checks that the service is still available at the time/ location required) 11. Contracts for service delivery are created 12. Instructions to dispatch the service are sent to asset operators. 13. The service is delivered	7. Qualifying assets are compared in a competition and whichever delivers best value is selected. 8. Whichever asset delivers best value is selected. 9. Contracts for service delivery are created which include the requirement for dispatch of the service.
Settlement	14. Dispatch of the contracted flexibility is verified using benchmarking and monitoring processes. It is not yet decided whether this is a service that will be included in the Piclo platform offer. 15. Interaction with NMF or other DSO system to settle payment for delivery of the service.	10. NMF interacts with other DSO function or other third-party service provider to verify dispatch of the service 11. NMF interacts with other DSO function or other third-party service provider to settle payment for the service

Feedback	16. Process is evaluated, capturing ratings and data for analytics so that the system can be continuously improved.	12. Process is evaluated, capturing ratings and data for analytics so that the system can be continuously improved.

The functions of the NMF and the Flex Platform are shown in Figure 6

System	Trial Period	Author	Market Front	Procurement	Contracts	Auction functions	Network Approval	Intent to dispatch notice	Automated Dispatch	Baselining	Settlement Rules	Settlement	Customer queries
NMF	TP1	Opus One	No.	No	Yes	Yes	Yes- WSC	Yes	No	NO- tbc	Yes- tbc	No	tbc
Flex. Platform		Piclo	Yes	Yes	Yes	Yes	Yes	No	No	No	No	No	No

Figure 6: Summary of functions of NMF and Flex platform at different steps in the end-to-end process of procuring, dispatching, verifying and settling flexibility services

The basic business model of the third-party platform provider is to charge the DNO when the platform is used to procure services. Details of the business model are yet to be decided, but one option under discussion is to provide a free base service and then charge for added-value services such as data analytics.

The flexibility exchange platform is not currently set up to deliver automated control or dispatch of assets (unlike some National Grid systems). It is more of a human relationship tool than an asset control tool. Notifications to dispatch flexibility may be automatically generated but the audience for notifications will be a person rather than a machine.

Further value added to the Piclo platform could result in managing P2P settlement and automating the payments from the DSO to registered flex providers.

3.13 Technology platforms

It is anticipated that flex providers will work with various technology platforms to monitor, control and aggregate assets to create flexibility of various types. The platforms will also create the information required to register assets on the NMF platform, the flexibility exchange, or both. Competitions for flexibility published on either the NMF or the flex exchange will be manually notified to suitable asset owners and operators, who will then use their own systems and platforms to respond to competitions, monitor, schedule and dispatch their assets.

There is ongoing work amongst partners to design these systems for monitoring and control and interaction with the flex market IT architecture described above. The Low Carbon Hub is investigating working with two systems:

1. A Smarter Grid Solutions (SGS) product for monitoring, scheduling, control and dispatch of larger-scale assets. The SGS products are targeted at both DSO and asset owners/

aggregators, and offer different mixes of monitoring and control functions, integration with energy markets and DSO operational systems such as the WSC described above.[37] LCH is considering the use of the SGS 'Strada' product to monitor, schedule and control its larger generation and storage assets such as Sandford Hydro, Ray Valley Solar, Rosehill battery and other larger solar installations.

2. An 'Internet of Things' solution using open-source data standards for monitoring and controlling small-scale grid edge assets - primarily demand-side response (DSR) assets such as smart appliances or heat pumps. The electronics and system architecture for this is under development amongst a small group of partners (the HOPE group).

It is anticipated that the two systems will be brought together to underpin the system architecture for LCH's 'People's Power Station 2' programme.

3.14 Services traded in the local energy market

A key activity in Y2 has been to understand how different assets can deliver different services to the market, via the MVS programme and TRANSITION trials development; to develop the flexibility services themselves and, through the commercial programme, develop the Basic Market Rules governing operation of the flexibility market.

These rules have been arrived at after extensive consultation and workshopping, facilitated by Origami. They govern the end-to-end process of procuring, contracting for, supplying and verifying various forms of flexibility and are described in detail in SSEN's Basic Market Rules publication.[38]

The flexibility market must procure energy services that address key network constraints and operational need. It must also allow trading between peers for network capacity. The envisaged P2P services should also help manage the network and address network constraints39. Under the Open Networks Project,[40] TRANSITION and other TEF projects have been working with Origami to develop a common catalogue of flexibility services. These are:

- Sustain: scheduled delivery of flexibility to meet a forecast requirement;
- Secure: scheduled real-time delivery of flexibility to meet a requirement based on system conditions;
- Dynamic: delivery of flexibility to recover from / respond to an incident-driven requirement;
- Restore: support for restoration of the network or system following a planned or unplanned outage;

---

[37] High level SGS product descriptions: https://www.smartergridsolutions.com/products/
[38] See Appendix 2 of the TRANSITION publication, Market Rules Development Phase 1 available at: https://ssen-transition.com/wp-content/uploads/2020/02/Market-Rules-Development-Phase-1-v1.0.pdf

[39] A full description of the various services is found at : https://ssen-transition.com/wp-content/uploads/2021/04/Service-Description-Report-Final-Web.pdf
[40] Energy Networks Association's Open Networks project: https://www.energynetworks.org/creating-tomorrows-networks/open-networks/

- Trading Services: trading and/or sharing of energy, capacity, financial instruments and other commercial obligations for mutual benefit; and
- Risk Management Services: mitigating the effect of uncertainty on objectives, usually provided by financial or insurance products.

The services to be tested in TRANSITION trials41 that meet certain of these operational needs are shown in Table 2.

Table 2: Services to be tested in TRANSITION trials

DSO Constraint Management	To provide the DSO with an immediate reduction in demand or increase in generation following an unplanned or planned outage of one or more critical assets, to maintain security standards and avoid any customer minutes lost.
Peak Management	To provide the DSO with a planned reduction in demand or increase in generation in advance of forecast capacity constraints at peak time, e.g., to reduce loading on a transformer during winter tea-time peak.
Short-Term Operating Reserve	To provide the ESO with a planned reduction in demand or increase in generation in advance of a forecast system imbalance, e.g., to increase the margin of generation over demand at winter tea-time peak.
Import / Export Capacity Trading (previously Authorised Supply Capacity Trading)	One market actor within a constrained area can increase the level of export or import at one of its MPANs through purchasing excess Authorised Supply Capacity for a period of time from another market actor in the same constrained area
Offsetting	One market actor in a constrained area agrees to increase its demand ahead of another in the same constrained area, increasing its generation by the same amount, with appropriate fail-safe mechanisms.

The capacity to deliver each of these services must be mapped to the type of asset available in Project LEO. Ongoing work to understand the technical capabilities of various asset types installed in different contexts (domestic buildings , industrial or commercial buildings, free standing generation or storage, EVs) is being undertaken

- in laboratory settings (Origami facility in Cambridge);
- as a key objective of the MVS-A research programme;
- as part of LCH's People Power Station research programme and the SFN activities;
- in the TRANSITION trials programme.

Work by Origami to map asset types to different services is shown in Table 3.

[41] Full details of the services to be tested in TRANSITION trials are described in: https://ssen-transition.com/wp-content/uploads/2020/11/TRANSITION-WP4.3-Use-Cases-and-Services-to-be-Trialled-v1.1.pdf

Table 3: mapping asset types to services

Services				Appliances	Battery		Electric Vehicles	Heat Pumps	Hydro	Solar		Wind	
Category	Service	Delivery Speed	Delivery Duration	D	D	ND	D	D	ND	D	ND	D	ND
ESO	Balancing Mechanism	3 mins	Variable			Aggregate?			Aggregate?		Aggregate? / Availability		Aggregate? / Availability
	Dynamic Containment	1 sec	Variable		Aggregate	Aggregate?	Aggregate						
	Optional Downward Flexibility Management	Instructed D/A	3-6 hrs		Aggregate	Aggregate? / Capability	Aggregate		Aggregate?		Aggregate?		Aggregate?
	Short-Term Operating Reserve (under review)	20 mins	Min 2 hrs		Aggregate	Aggregate?	Aggregate		Aggregate? / Capability				
DSO	Sustain Peak Management (active)	Instructed W/A or D/A	0.5 to 2.0 hrs	Aggregate	Aggregate	Aggregate?	Aggregate	Aggregate	Aggregate?				
	Sustain Peak Management (reactive)	TBC	0.5 to 2.0 hrs			Aggregate?							
	Secure Constraint Management (pre-fault)	TBC	0.5 to 2.0 hrs	Aggregate	Aggregate		Aggregate	Aggregate					
	Dynamic Constraint Management (post-fault)	TBC	0.5 to 2.0 hrs	Aggregate	Aggregate	Capability	Aggregate	Aggregate	Aggregate? / Capability				
Peer-to-Peer	Exceeding Maximum Export Capacity	Not relevant	Variable	Aggregate	Aggregate		Aggregate	Aggregate		Aggregate		Aggregate	
	Exceeding Maximum Import Capacity	Not relevant	Variable	Aggregate	Aggregate		Aggregate	Aggregate		Aggregate		Aggregate	
	Offsetting	Less than 5 mins	Variable	Aggregate	Aggregate		Aggregate	Aggregate		Aggregate		Aggregate	
Other	Wholesale Trading	Not relevant	Variable			Aggregate? / Capability			Aggregate?		Aggregate? / Availability		Aggregate? / Availability

3.15 Market rules

A LEM must be capable of delivering value to customers and flex providers and operate in a transparent and fair way. It should also have low barriers to entry, to encourage liquidity and competition. Market rules are required to ensure that each stage of procurement, delivery, verification and settlement of flexibility can occur legally and efficiently and that all parties are aware of the consequences of not adhering to the rules. In Y2 there has been further work in the TRANSITION work stream to develop the market rules. Details of the learnings from this are captured in a series of reports published on the TRANSITION website. Key reports include 'The development of Basic Market Rules'[42] and 'Market Rules Development initial variant'.[43]

4. Smart and Fair Neighbourhoods

There has been development of four SFNs, facilitated by LCH working with community groups. Each neighbourhood has a different mix of low carbon technologies and technical, economic and social capabilities. Each also has different wants, needs and aspirations and consequently each can tell LEO and TRANSITION something different about the conditions and processes required to equip SLES with access to local markets for flexibility, whilst creating environmental and social co-benefits. Dimensions of each of these neighbourhoods (e.g., the ability of domestic heat pumps to deliver flexibility) will be investigated in TRANSITION trials.

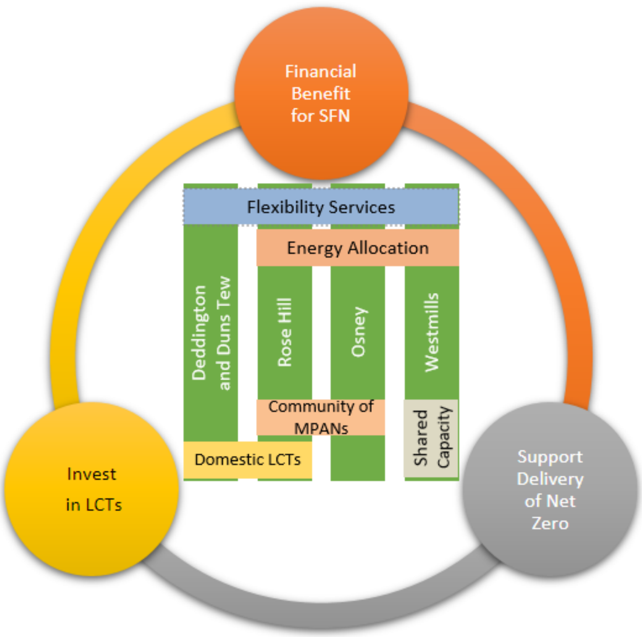


Figure 7 aspects of the 4 assets based SFNs to be investigated

The main aims of each of the 5 SFNs are summarised in Table 4.

[42] Set out in https://ssen-transition.com/wp-content/uploads/2020/02/Market-Rules-Development-Phase-1-v1.0.pdf

[43] Market Rules Development Initial Variant. February 2000. https://ssen-transition.com/wp-content/uploads/2020/02/Market-Rules-Development-Phase-1-v1.0.pdf

Table 4: the main aims of each Smart and Fair Neighbourhood

SFN	Site Description	Aims of the SFN
Osney Island	Osney Island is a small neighbourhood in West Oxford. It includes a 50kW hydro generation station with an associated 9kW solar installation, owned by Osney Lock Hydro Limited, a community benefit company. There are also solar installations on home rooftops, at the community centre and on the university estate.	• To examine the opportunity for, and benefits from, battery storage and EV charging within the Osney electricity system. • To maximise the renewable electricity generated by the hydro and its use locally, including powering the EV fleet at the Environment Agency (who have their depot on Osney). • To give residents access to an EV and explore how the experience of using it informs their readiness for EV adoption.
Rose Hill	Rose Hill is a largely residential neighbourhood in SE Oxford, classified as an area of multiple deprivation with mixed types of housing and ownership. Some residents experience fuel poverty; not many have large domestic energy assets. Some do have solar PV and batteries, and the area has been a site for previous energy studies.	• To explore the potential for flexibility services to help a community with areas of deprivation to progress towards its goal of becoming a net zero carbon estate, in a way that is inclusive and equitable. • To understand what role domestic energy demand may be able to play in the Rose Hill energy system. • To learn about what the barriers might be to participating in a flexibility service in the near future with benefits to all. Behavioural change is seen (see Ethical Framework Report) as key to the UK being able to reach net zero carbon by 2050.
Deddington and Duns Tew	Deddington is a large village that is partially off the gas network; Duns Tew is a much smaller community, completely off the network. Both villages have strong local environment and sustainability groups who are working on the challenge of what a zero-carbon future might look like for a rural community	• To understand how we can enable a zero-carbon future for a rural community with planning constraints. The SFN has 3 subprojects: • 1: Flexibility service trial, working with 15 households in Deddington and Duns Tew to install heat pumps and smart monitoring technology to test the viability of providing flexibility services to the grid. • 2: Unlocking planning. Local communities have identified planning constraints as a potential barrier to installing domestic energy efficiency measures and new technologies. We will work with local authorities and householders to unpick the barriers to energy efficiency improvements in listed buildings and conservation areas. • 3: Effective communication of energy efficiency technologies and flexibility services,

		through a plain English, community-focused guide that debunks myths around energy efficiency and informs people about flexibility services.
Westmill	The Westmill site at Colleymore Farm is home to the UK's first community-owned solar and wind farms. Outline planning for a battery on the site is also in place.	• To look at how the combined solar and wind farms, with potential battery storage, could enable participation in local flexibility markets. • To investigate opportunities for commercial innovation relating to community investment in a large-scale battery project and community leadership in a zero-carbon local energy system.
Eynsham	Eynsham has 2,200 new homes planned plus a business park and park-and-ride in the area north of the village now named Salt Cross (formerly Oxfordshire Cotswold Garden Village). A further 1,000 homes are to be built in the West Eynsham Strategic Development Area. These new developments are driving a local ambition to develop zero carbon energy plans.	• To develop and extend, thought the Eynsham Smart and Fair Futures project, the Energy Plan developed for Salt Cross to cover the whole of the Eynsham Primary Substation Area, creating an Eynsham Area Energy Action Plan. • To develop long-term stewardship structures whereby the community can ensure that this Energy Action Plan reaches the goal of a zero-carbon energy system in advance of 2050

4.1 Understanding technical capacity of SFNs to deliver services

Origami Energy have been working with LCH to map the techno-economic potential of each SFN to deliver the network and transmission levels services described above. The map is shown in Table *5*.

Services		Appliances	Battery		Solar		Hydro	Electric Vehicles	Heat Pumps	Solar	Wind	Battery
		Rose Hill					Osney		Deddington	Westmills		
Category	**Service**	**D**	**D**	**ND**	**D**	**ND**	**ND**	**D**	**D/ND**	**ND**	**ND**	**ND**
ESO	Balancing Mechanism			Aggregate?		Aggregate? / Availability	Aggregate?			Aggregate? / Availability	Aggregate? / Availability	Aggregate?
	Dynamic Containment		Aggregate	Aggregate?				Aggregate				Aggregate?
	Optional Downward Flexibility Management		Aggregate	Aggregate? / Capability		Aggregate?	Aggregate?	Aggregate		Aggregate?	Aggregate?	Aggregate? / Capability
	Short-Term Operating Reserve (under review)		Aggregate	Aggregate?			Aggregate? / Capability	Aggregate				Aggregate?
DSO	Sustain Peak Management (active)	Aggregate	Aggregate	Aggregate?			Aggregate?	Aggregate	Aggregate			Aggregate?
	Sustain Peak Management (reactive)			Aggregate?								Aggregate?
	Sustain Export Peak Management		Aggregate	Aggregate?	Aggregate?	Aggregate?						Aggregate?
	Secure Constraint Management (pre-fault)	Aggregate	Aggregate					Aggregate	Aggregate			
	Dynamic Constraint Management (post-fault)	Aggregate	Aggregate	Capability			Aggregate? / Capability	Aggregate	Aggregate			Capability
Peer-to-Peer	Exceeding Maximum Export Capacity	Aggregate	Aggregate		Aggregate			Aggregate	Aggregate			
	Exceeding Maximum Import Capacity	Aggregate	Aggregate		Aggregate			Aggregate	Aggregate			
	Offsetting	Aggregate	Aggregate		Aggregate			Aggregate	Aggregate			
Other	Wholesale Trading			Aggregate? / Capability		Aggregate? / Availability	Aggregate?			Aggregate? / Availability	Aggregate? / Availability	Aggregate? / Capability

Table 5 Matching assets to services in the Oxfordshire SFNs

As Table 5 shows, nearly all the services provided through a SFN depend on an aggregator. An ongoing topic of discussion within LEO is the appropriate business model for an aggregator working with thousands of slivers of flexibility at the grid edge and seeking to generate community benefit in a fair and inclusive way; also, what is needed as supporting technical system architecture.

Automation and internet connectivity are clearly critical to the viability of an energy system where thousands of small assets are controlled and coordinated to balance supply and demand, and to minimise transaction costs.

Some LEO partners think it should be possible to develop control and decision-making systems that allow many small assets to interact with an IT platform with minimal transaction cost. These can be visualised as little 'black boxes' of electronics embedded in a home intranet. There are potential linkages between grid-edge flex provision and burgeoning technological platforms driving the "smart home". For example, smart thermostats such as Google's Nest are already being used to enable domestic heating and cooling systems to participate in markets for flexibility in California, under the control of an aggregator. If it is possible for thousands of small assets to transact with an aggregator who then transacts with the system operator via a NMF platform, why cannot those assets simply transact directly with the NMF? Such direct transaction would remove the need for aggregators to take a slice of the value cake and could increase the share of value captured by the flex providers themselves. Where the value of flexibility is small, this could be critical in creation of viable business models. Thus the technical possibility of small flex providers dealing directly with the NMF, plus an ostensible business case for doing so, calls into question the role of the aggregator in the system.

However, others think it highly unlikely that individual households or businesses would take the time to set up contractual relationships with DNOs when the financial reward for selling very small amounts of flex into the local market would likely be very small. Therefore the value of the aggregator lies in minimising transaction cost to the flex provider by simplifying participation and the setting up of contractual arrangements. Of course, the aggregator takes a slice of the cake for performing this service but offers a viable value proposition in lowering barriers to participation. For the flex provider, some income from sale of a small amount of flex, when captured fairly painlessly, is better than none. Aggregators further add value, in this view, by coordinating a pool of assets in an optimal way - better than if those assets were acting individually.

4.2 Approach to development of SFNs

SFNs differ from the more technical trials underway in the MVS-A. They are about co-developing, with community groups, socio-technical energy systems that align with their needs, aspirations and capabilities. This is a long, involved process requiring careful and frequent engagement, trust and capacity-building. Work to understand how SFN assets might deliver services tested in the TRANSITION trials is integrated with the social engagement. Social and technical dimensions are both captured in specification documents for each SFN.

A major element of the engagement process for working with the SFNs is co-development of the value proposition. A starting point for this is defining user groups that a value proposition could be targeted at, and understanding their needs and priorities. LCH are approaching this in three ways:

1. System-led

This starts with the flexibility needs of the energy system in a particular location and identifies the system users best placed to deliver the sort of flexibility required. This might be most appropriate when attempting to solve or pre-empt a specific technical issue at a known spot on the network.

2. Community-led

In this scenario, work starts with an understanding of the community, the capabilities and motivations of its members, and the types of flex they are able to provide. The segment of the community to target is prioritised, identifying which flex they may be best able to deliver. Mapping and geo-demographic exercises can help with identifying user groups and the size of each. LCH see this as the approach most likely to be appropriate for the SFNs.

Whilst it is unarguable that the best way to build a value proposition is to start from an understanding of what the target community is capable of (and what it values), there is a danger here that there may be no existing or foreseen network constraints in that community. So the capacity to flex demand may have less value and business models designed to create benefits from flex sales are undermined. However, where flexibility has little economic or operational value, establishment of a SFN can still deliver socio-economic and environmental benefits, for example via greater transport equity through provision of publicly-accessible charge points, or energy and financial savings from installation of behind-the-meter technologies linked to time-of-use tariffs.

3. User-led

This approach starts from a particular system user type and their capabilities, identifies the flexibility they are able to offer into the system, and develops a value proposition and service to facilitate that. This is the approach being taken with trials focusing on LCH's energy assets.

Overall, Y2 experience indicates that the development of flexibility capability within SFNs should be seen as an important subset of approaches to development of an energy strategy for an area.

4.3 Energy equity in development of the SFNs

Project LEO recognises that systems enabling energy transition are only successful if they lead to fair outcomes - if access to the benefits of a SLES is equitable. In practical terms, this translates to the principle that if a householder or a business doesn't have the capabilities to participate in a SLES, a fair approach will be to consider how capability can be increased, whether the offer can be adjusted to match capability, or whether benefit can flow indirectly through other channels.

This is a considerable challenge for the SFNs. Rose Hill, for example, has areas where owner-occupier residents have very low incomes and are highly unlikely to own EVs, solar roofs and smart appliances or to have the money to invest in smart technologies. Others are limited in capability by being tenants. The value-proposition-building exercises are designed to expose capabilities (or lack of them) and to consider how different routes to accessing benefits from a SLES can be found. This could include developing a social time-of -use energy tariff so that non-detrimental changes to the timing of practices such as laundry could yield savings and serve network needs. Alternatively, community-scale assets can be developed, such as solar roofs or large batteries for community buildings, that could operate in local markets and generate revenues for recycling into community benefit projects. SFNs are where the aim of “nobody left behind” can be properly explored.

5. Minimum Viable Systems

An agile approach to developing and testing new flexibility services and business models has been devised to understand requirements to operate a local flexibility market. Each minimum viable system (MVS) trial represents the smallest set of participants and processes required to test a process modification or new asset use case. Potential value is identified and evaluated quickly at a small scale, before significant investment is committed. Core work packages enabling the delivery of this are WPs2, 3 and 5, with WPs4 and 7 facilitating, collecting and synthesizing MVS data to provide iterative insights and learnings.

Key activities undertaken in Y1, to enable the running of MVS trials and subsequent development of the LEO Trial Plan in Y2, included

- identifying suitable project partner assets within Oxfordshire;
- engaging with asset owners (such as building managers) to onboard into Project LEO;
- identifying substation sites for installation of low-voltage (LV) monitoring equipment on the network to allow for higher data granularity;
- development of an MVS Trial Procedure which acts as a proxy to prepare assets and service providers for the full end-to-end procedure to be developed for full TRANSITION trials starting in autumn 2021;
- running of initial MVS trials to gather early-stage learnings;
- development of the MVS governance programme to provide a deliverable plan that demonstrates progression towards mature flexibility service provision for each asset to be monitored against.

5.1 Evolution of flexibility services, MVS A

Early in Y1 the use of the 'Lean Ecosystem Transition' approach arose from WP4, to capture learning insights from the project in an iterative manner. This approach led to the creation of MVSs and the identification of three categories to be tested within the project: Flexibility Services (MVS A), Geospatial Planning (MVS B) and Influencing Policy (MVS C). To date, the development work on these categories has centred on MVS A. This is due to the project's core objective of gathering an understanding of distributed energy assets providing flexibility services to enable the local distribution network to support a net zero energy system. The iterative nature of undertaking tests related to assets lends itself to the MVS and to fast-learning loop methodology, due to the ability to collect and analyse results in a short period and to pivot or adapt trials correspondingly. However, the project team struggled to progress the Geospatial Planning and Influencing Policy categories as MVSs. The iterative feedback loop is less applicable to these as they cannot be re-tested within short time periods.

Progress has been made to evolve the Flexibility Services/MVS A to ensure that trials can be developed to maximise the value of learnings and develop thinking around the requirements for a SLES. This largely occurred following the April 2020 Stage Gate, with further work by Origami in the autumn, to allow better oversight of MVS trials for IUK monitoring purposes. This led to the creation of an asset/service matrix to align assets with relevant LEO services.

Early in Y2, the MVS working group began to distinguish between various levels of complexity within the term ‘MVS trials’. These levels were termed ‘MVS’, ‘MVS+’ and ‘Pre-Trials’; with the objective of showing progression of an asset(s) and/or service through key testing stages of the MVS programme. These terms were introduced:

- MVS: an asset’s initial manual test of part or all of an end-to-end process using a project partner’s asset(s);
- MVS+: testing automation of an asset and/or coordination of multiple assets;
- Trial periods 1,2 and 3: early field trials to demonstrate limited end-to-end service delivery using assets in defined areas.

Once assets completed these stages, they could be deemed ready to sign the necessary documents and participate in TRANSITION trials.

A key challenge for the MVS team has been to ensure that all aspects of the local energy system are tested within the MVS environment, not just asset development and operation but also service context and elements such as digital platforms, communications, data exchange and user interaction, which are required for a replicable, integrated system. However, the focus has remained on iterative testing of an asset. This is in part due to the proposed flexibility services and non-asset elements still being developed in Y2, but also stems from IUK monitoring requirements that all LEO assets (i.e., funded by IUK) are tested through MVSs.

In tandem with the development of the MVS levels, the MVS A asset types evolved into the following groupings (previously Electrical Storage, Generation, Load Flex and Aggregation respectively), in which both DSO-procured and DSO-enabled (P2P) services would be trialled:

1. Prosumer (single asset) (MVS)
2. Generation (a single flexible generation asset or site) (MVS)
3. Smart Neighbourhoods (Multi-actor, coordination for local value) (MVS/MVS+)
4. Aggregation (3rd party aggregator service) (MVS+)
5. Portfolios (coordinating a diverse portfolio for network value) (MVS+/Trials).

Y2 trials have largely focused on (1), (2) and (3), with some trials undertaken in (4). The initial intention for Smart Neighbourhoods was for any SFN trial to be undertaken within category (3). However, due to the complexity and size of each SFN, the SFN trials will not be able to go through an iterative learning loop in the time available to the project.

5.2 Development of the MVS Hypothesis Framework and Research Questions

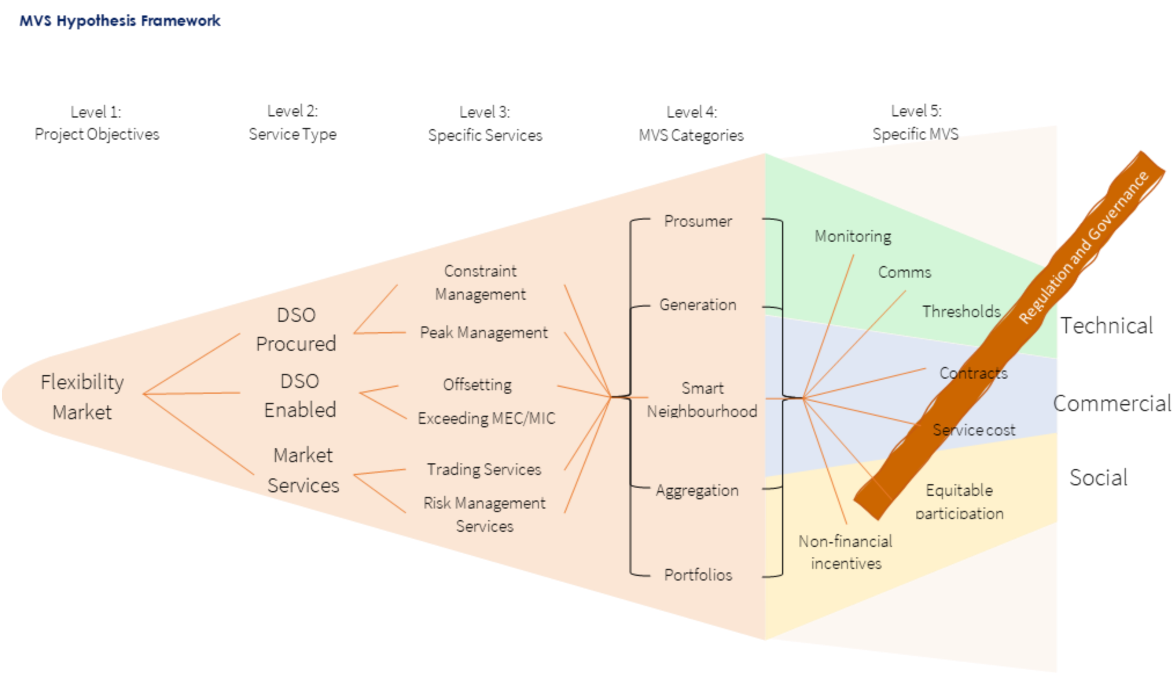


Figure 8: The LEO MVS Hypothesis Framework

Hand in hand with the evolution of Flexibility Services MVS A was the establishment of an MVS Hypothesis Framework (Figure 8) and development of a hierarchy of research questions to direct and collate MVS learning outcomes, for alignment with the overall project objectives. This work was led by the UoO research team and Origami, with input from the MVS team.

The aim of the MVS Hypothesis Framework is to align the detailed technical/commercial/social questions answered in MVSs (termed as Level 5 questions) to higher-level questions in the context of MVS categories (Level 4), services (Level 3), service type (Level 2), and to scale up to overarching project-wide questions (Level 1), which seek to understand the flexibility market as a whole.

Although processes have been put in place within the MVS management to capture learnings associated with Level 5 research questions, a continuing challenge has been to identify questions with MVS trials appropriately and to pull out learnings from these to feed into higher-level questions. However, it may still be too early to form answers to some Level 5 questions and we anticipate that as the project moves into the Full Trials period from November 2021, it will gain traction to begin to answer these questions more readily.

5.3 Mapping of Assets to Flexibility Service Matrix

In autumn 2020, LEO undertook a 'deep' review of the 'flexibility service asset' matrix and devised a new strategy for the programming, management and implementation of the MVS trials. This was to allow the project to map assets to LEO services. A turning point within this review period was a workshop held by Origami on 16th September 2020, which set objectives to develop and review the process of progressing assets from MVS to Trial (clarifying definitions of MVS, MVS+ and Pre-Trial), and to map assets to services. An output from the workshop was the establishment of a detailed

MVS Programme which maps, by month, the MVS and MVS+ trials on a given asset at particular stages within an asset/service plan step and the end-to-end process stages.

The MVS programme encourages trials to be planned across all LEO assets and services, and has enabled greater oversight for the project as a whole on the MVS trials. However, to date the full intention of the programme (i.e., the testing of assets against all services) has not been fulfilled; this has largely been due to services still being fleshed out and understood by the team. We expect this to be fulfilled through the full trials planned in Y3.

5.4 Learning Outcomes from Phase 2 MVS Trials

The MVS programme enabled more effective planning and running of the MVS trials from October 2020 onwards. Over 20 trials were run during this second phase, with learning outcomes summarised in the table below. Two WP7 reports due in summer 2021 will provide further details.

MVS	Asset Specifications	Learning Objectives	Key Learning Outcomes
MVS A2 - Sandford Lock Hydro: Generation – testing Active and Reactive Power Sandford Hydro is owned and operated by the Low Carbon Hub (LCH)	Sandford Hydro is a 440 kVA micro-hydro, situated on the River Thames south of Oxford at Sandford Lock. The hydro consists of 3 Archimedes screws, 2 of which are either on/off, with a 3rd variable screw. When controlled as a set, this allows a full range of power variability up to 440 kVA.	Test the procedure for forecasting the flexibility capacity of the hydro by storing water upstream of the plant. The DSO (SSEN) and Piclo were not involved in the trial as a full procedure run was not required for testing purposes.	• Sandford Hydro can be manually controlled to act as a battery. The Environment Agency needs to be informed, however, and this operation is dependent on river levels and flow at the time of the scheduled service delivery. • Active power (P_{active}) was reduced from ~40 kW at 12:10 on the day in a stepwise fashion to 0 kW by 13:00. During this period, head levels of the river rose from 53.85 mAOD to a peak of ~53.90 mAOD (max. shift 5 cm) just before the release of the backed water at 14:10. Tail levels of the river showed little to no change during this period. • Manual and controlled release of the backed water at 14:10 saw P_{active} rise from –10 kW (the hydro plant drawing electricity from the grid) to a maintained level of ~42-45 kW between 14:30 - 15:22 where the power further ramped up to a peak of ~84 kW (at ~16:00) before dropping sharply (non-linearly) to ~8 kW at 17:00, the official end of the MVS A2.3.1 trial. • The low dip in the power after peak delivery was due to upper river levels dipping below the Sandford Hydro operating limit, and thus the plant reduced the power to allow the level to rise again. The power returned to pre-MVS levels around 18:00 and thus it took roughly an hour for operations to stabilise.
		To test the ability of Sandford Hydro to store water upstream in conditions in which the hydro is already operating at full capacity.	• In order to respond effectively to a flexibility service request, the plant's trash screens must be free of debris. • The theoretical increase in power output when the plant is already operating at full capacity is minimal. The generation losses accumulated from the downturn in power to back up the river greatly outweighed the increase achieved, making it financially detrimental to perform a service in these conditions.
		To test the ability of Sandford Hydro to meet a 10 kVA reactive power request in an end-to-end MVS process.	• When all screws are running, the removal of a single capacitor keeps the power factor within the required range. • Increasing the reactive power output does not affect active power output of the plant. • At an active power output of ~380 kW, the minimum additional reactive power that can be delivered is ~50 kVA
		To test the ability of Sandford Hydro to deliver reactive power in varying river conditions (in this case high flow and high generation periods)	• There is no capacity for the plant to provide reactive power to the grid in flooding conditions but it could act as a reactive power sink. However, it cannot do so while staying within the connection agreement range.
		To test the ability of Sandford Hydro to provide an active power flexibility service by storing water upstream. This MVS would test the full end-to-end process and determine	• Between 06:00 and the start of the service window the variable speed screw increased in speed from ~60% - 90%. This highlights the need for forecasting to help the asset operator to decide whether to commit to a service window, as it can take just a few hours for conditions to change considerably.

		river conditions in which the hydro was able to deliver flexibility.	
MVS A2 Rose Hill Battery: Generation Owned and operated by the LCH.	A 50 kWh, 24 kVA battery situated at Rose Hill Primary School.	To test the end-to-end MVS process using Rose Hill Battery with automated dispatch and delivery of service. LCH would simultaneously learn more about how the battery responds to remote signals (e.g. lag)	• Potential for data comms issue as result of the battery becoming fully discharged, and as a result the router did not have power. To avoid this in future tests, the asset has been scheduled to charge more regularly. • Additional costs are incurred when the battery sits idle (e.g. during winter when there is no excess solar generation to charge it). This will increase the revenue required from flexibility services for the battery to recover its costs. • Gained an understanding of the battery ramp rates for discharge of the battery. (18 second ramp up to 16 kW discharge, with 6s ramp down back to zero). • Discharge of the battery reduced the active power consumption of the site considerably, having a significant effect on the power factor measured at the network connection point. The feeder showed a corresponding drop in demand, demonstrating that the Eneida monitoring is consistent with monitoring of the site.
		To test automated dispatch and delivery of service using setpoint of 15 kW instead of 16 kW. This trial would take place while the school was closed for Christmas, so the effect of the battery on the school/network can be explored with different site energy usage characteristics.	• Dispatching the battery during school closure resulted in net export to the grid due to the low consumption of the school.
MVS A3 Oxfordshire County Library (Westgate Library): Smart Neighbourhoods Oxfordshire County Council owned building.	Potential to provide flexibility in the form of DSR through control of its HVAC system. The largest source of flexibility is a 140kW chiller. The HVAC system has a further 30 kW associated with it.	Determine service and asset parameters.	• Building flexibility is closely tied to outside temperature and solar gains.
		Test building operation in reaction to a change in temperature set point.	• Sensor placement affects estimate of capacity. • Rate of change of temperature has a significant impact on service provision. Steep changes in temperature imply a low thermal capacity. In other words, the temperature would hit the comfort limits much quicker. This means that the asset will only be able to provide a flexibility service for a short period of time.
MVS A4 Residential Batteries (Aggregation)	Four 8kWh residential Powervault batteries	To develop a better understanding of the impact on the SSEN network, and the clarity in identifying it associated with dispatch of a	• The 4 residential battery units can be remotely dispatched with a notice period of a few hours, depending on the action required (i.e. charge or discharge). • The portfolio was dispatched simultaneously and successfully for 3 of the 4 units. One rebooted after 30min of operation and for 2 minutes. It is understood from the data that

Powervault-owned batteries, aggregated by EDF Powershift platform.		portfolio of flexible assets, in this case a set of four battery units	the reason behind this 2min reboot was due to battery overheating. The same unit also presented some irregularities with its power input – non-constant power input – when it reached a high State of Charge level. This is also believed to be due to degradation effects that could have originated with overheating of the battery.

Table 6: Summary of the main learnings of each MVS asset, October 2020 into spring 2021

5.5 Commercial MVS trials

To ensure early input from LEO partners in relation to commercial (contractual and financial) decisions relating to the flexibility markets to be trialled, a Commercial Working Group with regular fortnightly calls was set up in Y2, led by SSEN and attended by all partners. The purpose of these calls was to break the flexibility market into individual elements (e.g. business-as-usual (BaU) processes, auction and bidding mechanisms, market operation, and technical requirements,) to understand how they can be simplified and made clearer for new flexibility providers. The group made significant progress in the second half of Y2, creating market stimulus packages and developing commercial MVSs.

A suite of commercial MVSs has been designed to test the contractual and financial arrangements required to enable a flexibility market to operate smoothly. TRANSITION will be conducting auctions for the selection and delivery of DSO-procured flexibility services from 2021 and throughout the remainder of the project. In preparation, TRANSITION conducted a short study that identified 26 commercial areas that would benefit from feedback to develop the delivery of these services. An evaluation to rank these identified six MVS trials that would benefit from input by LEO partners during the first six months of 2021:

- MVS 001: Assessment of DERs with low levels of flexibility
- MVS 002: Assessment of Reliability Index (implementation under discussion)
- MVS 003: Assessment of Monitoring Granularity for different assets and services
- MVS D4: Baselining methodology and settlement
- MVS 005: Flexibility Service Agreement workshops
- MVS 006: Market Stimuli Package reviews

In January 2021, MVS 001 was conducted by Origami. The objective was to determine the suitability of TRANSITION's suggested pre-qualification questionnaire (PQQ) process and whether changes would be required to accommodate all service providers, including those with assets of low levels of flexibility. MVS 001 therefore involved assessing organisations with DERs that have much lower levels of flexibility than normally encountered in current BaU flexibility markets, and that are unfamiliar with such markets. The responses from LEO partners would provide market information to TRANSITION, aiding them to understand barriers for organisations and thus informing modifications in advance of full trials in September 2021. [44]

A key learning from MVS 001 was that the PQQ process may be time-consuming, particularly for those that are not used to collating such information and/or providing it to a third party. It was therefore prudent to consider giving supporting information for PQQ questions to clarify the requirements and help organisations who aren't used to providing such information. This support would assist in streamlining the process and lessen any negative experience for flexibility providers. Additional commercial MVSs have been planned to run in late spring/early summer 2021.

[44] The updated qualification document can now be found at https://ssen-transition.com/get-involved/participation-qualification-and-contracts/.

5.6 Emerging LEO /TRANSITION trial plan

Following Project LEO's third Stage Gate in August 2020, UKRI and IUK Monitoring Officers identified knowledge gaps as to how the LEO/TRANSITION trials would be conducted, and with which assets. A requirement was for the project to redefine the Detailed Project Plan, focussing more heavily on preparation for assets, market platforms and commercial contracts ahead of the full trial period.

A second requirement was for WP5 to develop a plan, detailing how and when trials would be conducted within the remaining years of the project. The LEO Trial Plan, delivered in February 2021, sets out the approach for the post-MVS+ trial periods and details how this will be enabled through TRANSITION. There will be evidence on the market dynamics and requirements for DSO systems (specifically the NMF and WSC), and management of commercial arrangements for transaction of flexibility services. The trials will also explore the willingness of service providers to make flexibility available and establish the value of services to the DSO and market actors in a whole-system context. The document provides a framework for three trial periods:

- Frosty Winter (Nov 2021 to Feb 2022)
- Long Hot Summer (May 2022 to Sept 2022)
- Stormy Winter (Nov 2022 to Feb 2023).

The Trial Plan is a live document that will act as a guide for delivery of agreed learning objectives and evolve as learnings are collected and analysed from each trial period. Following the publication of the plan in February 2021, the consortium convened a Delivering Trials Steering Board and working groups beneath this, to put in place processes to develop the trials in further detail before they commence in earnest in November 2021.

6. Data

Activities related to data acquisition, processing, storage and evaluation fall within WP4. There are three main areas of work within this work package:

- Developing processes for capturing data to measure the effects of LEO outputs;
- Gathering time series data to allow for analysis and further modelling of LEO products;
- Gathering spatial data to build integrated land use mapping tools to inform planning - a first iteration of the mapping tool has now been shown to some stakeholders.

WP4 activities also provide tools and data for external stakeholders and researchers to help in planning their own local energy systems.

Y1 activities in relation to data and mapping included:

- development of an innovative Data Sharing Agreement between all consortium members and signing of this agreement;
- development of data protocols, cleaning methodologies and storage;
- identification of datasets within the project and readily available to partners through the Y1 Data Survey and workshop;
- development of the first iteration of the Integrated Land Use Mapping Tool; and
- establishment of initial Project KPIs.

In Y2, these activities were developed further.

6.1 Update of Data Sharing Agreement

Understanding partners' data-sharing needs and requirements is ongoing as new systems and new data are developed. A key aspect of project data governance is the Data Sharing Agreement (DSA) which details methods by which data can be shared, along with specific types of background and foreground data brought into and created within the project.

A need to amend the DSA was identified early in Y2 when Oxfordshire County Council came to share access to the first iteration of the Integrated Land Use Mapping tool. Schedule 2 of the agreement was amended and re-signed by all partners. Understanding of when and how to update the DSA remains to be refined and, as Y2 draws to a close, the MVS Working Group are identifying new (commercial) data types to be specified within the agreement, which will require a second amendment.

6.2 Data workshop

A second data workshop was held on July 7th 2020, hosted by the WP4 team to determine the main data and tool gaps within Project LEO. It also showcased the first iteration of the Integrated Land Use Mapping Tool to external stakeholders and sought to understand the main stakeholder needs in relation to the tool. Participants included representatives from BEIS, Energy Systems Catapult, EnergyREV, ERIS, Pure Leapfrog, Regen and Winchester City Council. They identified the following points:

1. LEO's data, data tools and documentation will have maximum impact in easily-accessible and open-access data repositories. Fast-followers and external stakeholders need greater access through dissemination.
2. The Integrated Land Use Mapping tool provides useful energy insights and further work should aim to incorporate more temporal datasets. More levels of the network, LEO assets and plug-in projects will facilitate data access and improve the maps' utility. These improvements should include more tools and Application Programming Interfaces (APIs) to improve use of the maps, data access and data queries within the platform.
3. MVS data and learnings can be disseminated more broadly to external partners and interested parties. Data access can also be improved through potential API workflows for external organizations.
4. Projects and organizations outside the LEO consortium have temporal and spatial tools that can be incorporated into LEO to improve data utility, visualization tools and data access.
5. Baselining is an important aspect in MVS trial and data validation, thus steps must be taken to ensure that the data requirements are met. This should be complemented by more dissemination around the business use-cases for flexibility services within LEO.

A second data survey was launched following the data workshop to enable internal and external stakeholders to log new datasets available to the project. No new datasets were logged via this survey, which was attributed to their being brought into the project frequently on an ad-hoc basis.

6.3 Data Protocols and Cleaning

A number of processes and standards for the management of data within Project LEO were put in place in Y1. A key development in Y2 was adoption of a system whereby all shared datasets are linked with a data certificate. This has increased the data provenance within the project and has allowed partners and stakeholders to more readily understand the complex data being shared.

To ensure LEO remains an accessible springboard for agents in local energy systems, the project has sought to transition existing data-cleaning tools to become more readily available online, and develop user-friendly dashboards. In doing so, the need for skilled users or complex training is negated and the replicability of the project improves. WP4 developed an online Data Cleaning Dashboard, using Dash (by Plotly) cleaning tools, to provide a responsive portal for accessing tools and information which stakeholders will require to clean datasets brought into their projects. WP4 also created a LEO Data Health Tool, featured within the dashboard, which scans the health of incoming datasets before performing data- cleaning. Development of the dashboard and cleaning tools is ongoing, with significant development to these tools anticipated in Y3.

6.4 Data access

The current LEO database, which is held on MongoDB, does not allow for easy access by partners. Foreground data catalogues give partners the opportunity to access data from LEO's Drive database, but this presents a number of issues as it limits the data to internal access and causes duplication of data storage where both MongoDB and Google's Drive service are utilised. It is clear from the second data workshop that external stakeholders have an interest in gaining access to LEO's data where possible and this, amongst other factors, has driven WP4 to explore a more tailored platform service to provide increased resource and functionality.

Various data management tools have been reviewed by WP4 during Y2. It was concluded that Microsoft's Power BI, a data analytics platform, is the option that will provide the project with the most holistic and cost-effective approach to data management. The UoO has a licensing agreement with Microsoft that will allow WP4 to use the Power BI platform at no added cost (along with access for all partners), with the capability to significantly increase storage (also included) that would be an unviable option at a similar storage scale with MongoDB.

6.5 Data Collection & MVS Logging Tools

LEO's data can be categorised into two main streams: foreground (produced within LEO activities) and background (sourced from databases external to LEO). Foreground data largely consist of datasets associated with MVS trials, and these datasets take on a life of their own in terms of reporting and data collection. LEO captures foreground and background data differently, but both are securely logged and described through the project's online Data Sharing Log, developed in Y1. Only foreground data are stored within LEO.

The reporting and data sharing for MVS trials now focus more on collecting data specific to assets at various stages, to ensure more comprehensive trial evaluation. A significant update in Y2 to the Data Sharing Log allows users to report data in a more flexible manner, using one form for both background and foreground data logging. The steps in conducting MVS trials (known as MVS Procedures) can now be individually logged, allowing partners to transition through the form in a customised manner to log data only for procedures associated with their activity. (One MVS trial of a flexibility service usually involves multiple LEO partners and procedures, end-to-end).

Y2 developments in the MVS Programme meant that many of the Y1 MVS learning-capture processes were streamlined or found obsolete. The main learning-capture documents in Y2 for the MVS team are the MVS Programme, and an 'Asset Tracker' for each LEO asset used in an MVS. The novel data generated by the MVSs have created challenges in ensuring that processes are followed appropriately to capture learnings; however, the monitoring protocols are now generally working well. Each 'Asset Tracker' document captures information about the asset and specific MVS trial, and enables asset owners to log learning insights for each trial, to inform later MVS iterations.

6.6 Spatial data and land use mapping tools

A key output of WP4 has been the development of a land use mapping and energy planning tool. This is an important 'system' for providing information for planners, policy makers and network operators in early decision-making around the establishment of SLES and associated trading platforms, in addition to assisting replicability.

6.6.1 Spatial dataset review

To assist with developing the mapping tool, WP4 reviewed geographical areas, and the spatial and non-energy datasets that had been identified as relevant to the project. Some of the geographical areas of interest to Project LEO have been further refined over Y2, due in part to confirmation of the SFNs and better understanding of primary substation areas of interest.

Nine categories of spatial data have been grouped as non-energy (1-5) and energy (6-9):

1. Context – boundary layers
2. Land Use
3. Buildings
4. Socio-economic
5. Lifestyle
6. Network
7. Electricity
8. Heat
9. Transport

Of the 79 layers of data in these categories, 69 were acquired either by Oxfordshire County Council or OBU and a further 10 are yet to be acquired (including aerial thermal imagery, property value information, ACORN geodemographic data and network-constrained areas). Updating the Integrated Land Use Mapping Tool with the SSEN secondary substation areas involved a major acquisition of spatial data in Y2. A learning has been the time taken to acquire datasets from different organisations, checking data quality (e.g.Energy Performance Certificates) and verifying assumptions made (e.g. Energeo data).

6.6.2 Review of local energy mapping tools and platforms

To inform the development of LEO's mapping tool, OBU reviewed local energy mapping platforms and tools to identify areas to focus on. Approximately 18 platforms and 17 mapping tools were examined in detail, on national and international scales. Key conclusions, which have been taken on board for the next iterations of the LEO Integrated Land Use Mapping tool, are as follows:

- the legacy of any tool arising from Project LEO must be carefully considered, to ensure maintenance of datasets and access after the project comes to an end;
- to stand out from the crowd and offer the most useful insights on land use and energy from a planning perspective, there is a need to develop platforms and tools that address electricity, heat and transport holistically, rather than as single vectors (as most current tools/platforms do);
- to engage with resident and community groups as well as planners and developers, the tool and/or platform should utilize publicly-available datasets as much as possible, to allow unrestricted access and avoid the need for costly licences.

6.6.3 Updates to the County-level Integrated Land Use Mapping Tool

The LEO integrated land use map has developed in Y2 to include additional data, for example network details and further socio-economic indicators. Oxfordshire County Council has continued to collate new data provided by Energeo Ltd for use in the next iteration of the map, including (for the largest built-up areas in the county) an assessment of the potential for domestic rooftop solar PV and ground source heat pumps; availability of off-street parking to aid identification of EV charging infrastructure needs; car counts to assess on-street parking. Capture of aerial thermal imaging for the same areas had to be postponed to winter 2022 as a result of Covid19 lockdown restrictions.

The land use map will be further developed to create a county-wide LEO mapping tool with additional features and functionality to enable users to view and query geospatial data, to inform strategic energy planning. This tool will complement the high-resolution property-level mapping being developed by OBU (see following section) for planning SFNs. The County Council have also been working with EDF-Urbanomy to trial a method for assessing pathways to net zero carbon for new developments, considering not just overall energy supply and demand but also the potential of flexibility services to minimise peak demands and provide revenue to support community energy and other models. The findings form this will help inform the local area energy plan being developed by the Eynsham SFN project.

6.6.4 Development of LEMAP

Mapping tools have the capability to provide spatial intelligence and engage local communities if they move beyond a one-way flow of representing local energy flows to two-way interaction. Project LEO provides the perfect test-bed to develop and trial an interactive spatial-temporal community engagement tool due to the high level of interest shown by Oxfordshire communities, particularly through the emerging SFNs.

OBU has been using high-resolution property-level data to develop a local area energy mapping approach (LEMAP) for planning SFNs. In contrast to the Interactive Land Use Mapping Tool discussed above, LEMAP operates at the neighbourhood and property level. It brings together public, private and crowd-sourced data on energy demand, energy resources, building attributes, socio-demographics, fuel poverty and electricity networks within the ESRI ArcGIS platform. The spatial-temporal tool has been designed for community groups, residents and local authorities, to assist in the planning for smart local energy neighbourhoods. It has been applied to the Rose Hill SFN, a socially-deprived and data-rich neighbourhood in Oxford.

LEMAP was organised around three technical elements (baselining, targeting and forecasting) and three engagement elements (participatory mapping, storymap and forum). The technical elements were targeted towards project teams (local authorities) and intermediaries (e.g., community interest companies, project managers of smart local energy initiatives) involved in planning SLES projects, while the engagement elements were designed for engaging residents and community groups.

Low Carbon Hub project managers, working closely with the Rose Hill SFN, were trained online to use LEMAP to plan for energy management at the neighbourhood level. A key aspect of the engagement side of LEMAP has been the participatory mapping that will allow Rose Hill residents to provide data about their dwellings, using an online survey, and to obtain mean daily energy profiles based on their survey inputs, as well as visualise their home's annual energy consumption on a map. Through crowd-sourcing, accurate and timely data about physical and household characteristics will be gathered from residents through an online survey; this can be used for selecting the appropriate energy profile (archetype), to help residents understand benchmark electricity and gas consumption against national averages.

Feedback from the first iteration of LEMAP has shown interest in scaling it up to the county level and rolled out to other communities for planning and delivering smart local energy initiatives. It is anticipated that LEMAP will be further deployed in SFNs that aim to install low carbon heating with time-of-use tariffs, EV chargers and rooftop solar with batteries. Furthermore, it is hoped that the tool could assist DNOs to overlay network-constrained areas with areas that have potential for deploying DERs to support local balancing.

7. Learn and evaluate, engage and share

7.1 General approach

Our approach to the tasks of understanding stakeholder roles, engaging with them and evaluating the project as a whole is based on an understanding that a SLES is fundamentally socio-technical in character and that system activity is an outcome of stakeholder interactions with people and things - with social, economic, political, communications and material infrastructures.

In ecosystem terms, each stakeholder occupies a niche, offers something of value to the system and receives something of value in return. The nature of the service and how it is valued depends on the stakeholder role (or niche) within the system and the 'laws' that influence how the system evolves. In this analogy, the laws can be grouped into four domains:

- regulatory and policy – formal rules and agreements;
- material - physical infrastructure, structure of the network, specifications of equipment, design of buildings and vehicles;
- market - supply chain relationships, product characteristics, customer relationships;
- social and cultural - institutional 'ways of doing things', social norms (including right of access to affordable energy services), professional conduct, informal rules and rules of thumb, folk understandings and social licence to operate.

This approach means WP6 is often concerned with mapping the stakeholders in the ecosystem (their position or niche) and in understanding the relationships each stakeholder has with others. This will allow us to assess and predict the behaviour of a stakeholder to some extent. Whether a local energy system can thrive will be determined by the character and 'friendliness' of the system - whether it is an enabling environment. Its properties will be the emergent outcomes of interactions between the stakeholders and artefacts that, together, make it function.

Ecosystems evolve. If a local energy system can become established and then go on to create new niches that make social, economic and technical sense in the context of the wider system, we could expect an entire system to transform, perhaps rapidly. This is the challenge for LEO and for research activity in WP6: to understand the character of the Oxfordshire socio-technical system and the conditions that will allow local energy systems to become accepted and then replicated, to deliver greater social benefit than under existing arrangements.

This general approach is integrated with the Lean Ecosystem Transition methodology used to structure project activities and described above. The MVSs are tests of new connections and relationships between stakeholders in the ecosystem and the trials are now becoming more complex.

7.2 Communicating a vision for LEO

In the context of the Government's Clean Growth Strategy and the rationale for PFER, social benefit is about creating systems of energy provision that deliver prosperous and resilient communities, whilst allowing the UK to meet its carbon reduction targets. The LEO inception workshop held in

June 2019 achieved an early consensus on the values identified as best representing the overall Project LEO vision:

- Local balanced energy system;
- Ecosystem benefits – CO_2 and beyond;
- Reducing inequalities – affordable energy to meet all needs.[45]

Agreeing a set of objectives for a long-term vision for LEO helped align partner priorities and begin forming the project's Theory of Change (ToC). The design of a local energy system to realise the vision and support the values identified is informed by an evolving theory of how system actors will behave in different circumstances and how they will respond to change and innovation.

Developing this theory requires mapping the capabilities and roles of stakeholders, then describing how they are expected to interact, along with developing an understanding of the techno-economic aspects of current and potential energy systems.

Below, we offer an account of how the project narrative, stakeholder engagement and ToC have developed over Y2, including the contribution in autumn 2020 from a marketing communications consultant, Alison Stibbe. She assisted in supporting the project's ambitions to facilitate systemic change in the energy sector, at a point where the narrative was thought to be growing too complex to communicate clearly. Her report distilled the vision to a single desired outcome:

> *For Project LEO to make real and recognised contributions to securing an affordable and resilient net-zero energy system in which consumers benefit and businesses prosper.*

This was accompanied by an 'elevator pitch':

- Project LEO is:
  Accelerating the transition to a zero-carbon electricity system

- It does this by:
  Building an evidence base of the technological, market and social conditions required for a greener, more flexible and equitable electricity system.

- Through projects which:
  a) Test and enable new market and service flexibility models.
  b) Advance the capabilities of networks to manage smart, renewable and storage technologies.
  c) Facilitate local participation in the electricity system.

- In a way that:
  Demonstrates how a local balanced electricity system can bring social, economic and environmental benefits for all.

[45] These are not the same thing, but the general intention to make energy services equitable comes through.

The report also identified three levels of communication activity that would be needed to create an ‘enabling environment’ for systemic change:

- **Awareness** of the challenge and knowledge of potential solutions,
- **Engagement**, to motivate the desire to learn or participate more actively,
- Inspiring and directing **Action**, for behavioural (consumers, industry) and regulatory (government) change.

There followed an analysis of stakeholders and the communication goals for each.

LEO can act as a “content curator”, harnessing publicly available resources and organising information to provide a clear and accessible introduction into the different elements of understanding the energy system. For more specialist and bespoke communications needs, LEO can cultivate, procure or create content that is more detailed, directive and specific to project findings and objectives.

These functions now rest with WP1 and with a Communications Strategy team that meets fortnightly. A dedicated web address, https://project-leo.co.uk/stay-connected/, is now set up so that any interested person can easily find the latest newsletters, blogs and videos about the project. The number of people signed up to receive newsletters and showing further interest are recorded as a KPI: this is an indicator of progress in building an enabling environment for SLES and a community of skilled people. The newsletter has been redesigned and is published via the customer relationship management platform Mailchimp. Social media outreach has expanded over Y2.

Implementation of the Communications Plan has now moved into Phase 2, with redesign of the website, development of communication tools including videos, animations and case studies. The aim is to use real-life exemplars, increasingly, to illustrate SLES concepts: work with the proto-SFNs, for example, showed that members did not fully understand what was made by flexibility trading. The current response is to write a user-friendly blog on the topic, but as time goes on it will be possible to point to local examples of trading in practice. This is all part of the ‘learning by doing’ approach, widening the circle of those who are learning.

There is continued testing of messages for intelligibility - ‘plain English’. There is a schedule for each activity and for ‘synergistic’ communications with partners such as the County Council and Nuvve communications teams, EnergyREV and Energy Superhub Oxford, and UKRI/PFER.

This work represents a major step forward. There is still work to do in developing appropriate language for different communications – and adding to the project Glossary – but communication functions are now ordered and situated in such a way as to run more systematically, and smoothly. This makes a more secure foundation from which to build the ‘influencer’ work scheduled for autumn of 2021, including the likelihood of a presence at CoP26 in Glasgow.

7.3 Evaluate and learn

A key aim of WP6 is to promote replication successful LEO approaches to the wider community of stakeholders in the transitioning energy system. The learn/evaluate remit of WP6 plays its part in this in five main ways:

- Synthesis of learnings from across the project
- Evaluation of project learnings through contextualisation and comparison
- Research into the SLES and LEM ecosystem – actors and their interrelationships
- Continued development of a Theory of Change
- Informing design of tools and approaches for use by others – guidance and reports.

7.4 Learn / evaluate modes

7.4.1 Synthesis of learning from across the project

Learn / evaluate work can draw together and synthesise learnings from across the project to address the fundamental questions that LEO is designed to answer:

a) Are a SLES and LEM technically, economically and socially feasible?
b) What are the environmental, economic and social co-benefits of a SLES?
c) Who are the winners and losers in an energy transition that deploys the approaches and processes demonstrated by LEO? How do we transition to a new energy system which ensures nobody is left behind and where the benefits are shared widely and fairly?

7.4.2 Evaluation of project learnings through contextualisation and comparison

Learn / evaluate work can assess the significance of LEO learnings by placing them in the regulatory and policy landscape. It can also assess viable value propositions in the local energy marketplace and capacity / capability to participate in and benefit from SLES.

7.4.3 Research into LEO ecosystem

Learn / evaluate work can include research into the actor ecosystem that must be in place to create favourable conditions for a SLES. An initial mapping of the LEO ecosystem is shown in Figure 9. This will be elaborated and investigated further in the next stage of the project.

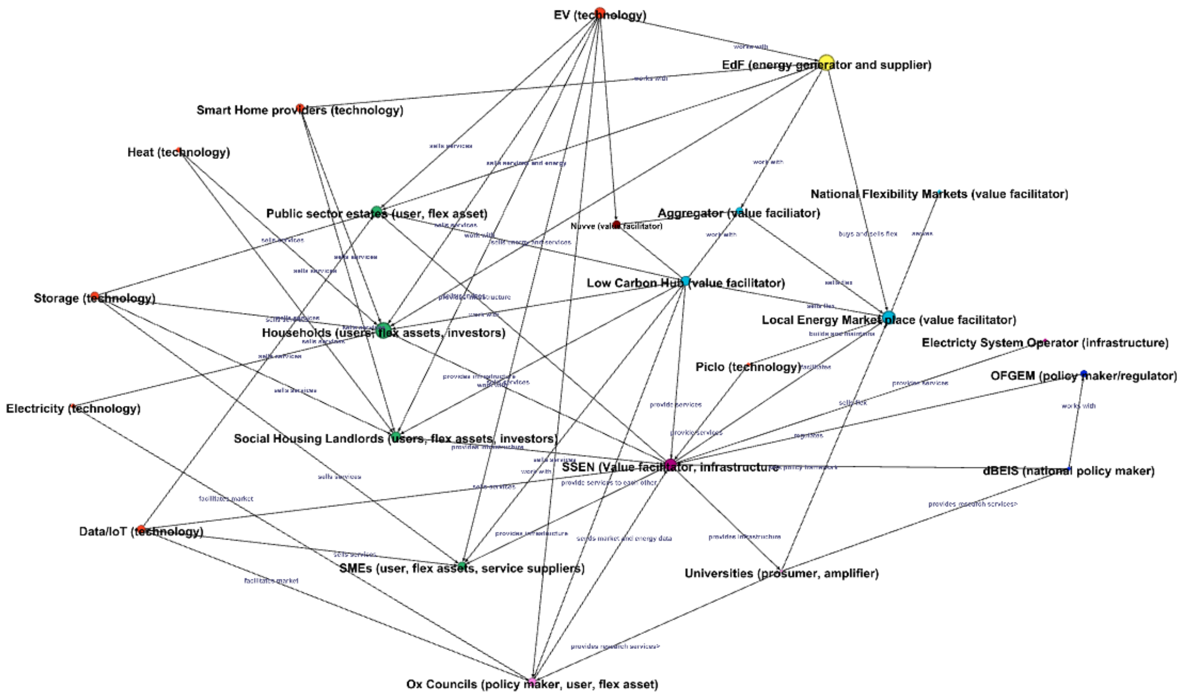


Figure 9: the LEO commercial ecosystem mapped in the first commercial ecosystem report

7.4.4 Developing a Theory of Change

Learn/evaluate work can be used to develop a Theory of Change that explains in an accessible way how change happens in the course of transition to a renewables-based SLES.

7.4.5 Designing tools, developing guidance

Learn / evaluate work can inform the design of tools and approaches to be used by others as part of the project's legacy - particularly approaches for targeting communities and organisations and for encouraging engagement and participation in SLES. In particular, such research can inform the functionality of the land use and energy mapping tool.

7.5 Approach to evaluation

WP6 has produced an evaluation framework for evaluating LEO and capturing learnings for the remainder of the project. It describes the purposes of various evaluation and learnings-capture workstreams, approaches to be adopted, how learnings and findings can be used within the project and more broadly, and sets out a timetabled plan for the work (Deliverable 6.1.7).

Captured learnings are evidence for or against the viability of processes proposed in the ToC, which needs to be continually modified and updated based on the evidence. In this way, the theory becomes an increasingly detailed, accurate and useful account of how the project is achieving its objectives. Critically, using evidence and learnings gathered through evaluation to appraise the ToC allows assessment of the replicability of LEO approaches and components (primarily, the MVSs).

ERIS expect that LEO and other PFER demonstrators will wish to make use of ERIS evaluation findings and data for their own purposes and are open to this possibility. ERIS evaluation of LEO can also generate useful evidence and data in its own right. LEO and ERIS evaluation activity should integrate where possible, to avoid duplication of effort.

The general approach to evaluation of LEO learnings is to establish regular collection for learnings and information, then to contextualise and analyse these using evidence review and primary research (mainly workshops and interviews). The main processes for gathering learnings are a quarterly interview with WP leads and monthly reporting on a set of internal KPIs. Further detail on these is given below.

Four workstreams of research activity have been identified to help with the evaluation process:

1. **Regulatory and policy context.**
   LEO needs to deepen its understanding of how the existing and proposed policy and regulatory landscape affects value propositions and business models in LEMs in a transitioned energy system. Findings from this work are used to contextualise learnings and to inform stakeholder engagement strategy.

2. **Aspects of capability to participate, engage, and benefit from Smart Local Energy Systems**
   WP6 will conduct an evidence review supplemented with interviews with partners and other stakeholders on aspects of capability to participate in SLESs and LEMs. This will explore dimensions of household, business, neighbourhood and system capability to participate in a SLES or LEM. It will consider who receives benefits and incurs costs, and which groups are at risk of being left behind in the energy transition, or made vulnerable by new market arrangements. Dimensions of capability to be explored will include technical, economic, social (capital) and lifestyle (including energy demand profiles). As preparation, in Y2 we produced a conference paper on this topic.[46]

3. **Value Propositions in the SLES ecosystem**
   This work aims to understand the principles of existing and potential business models in a LEM, beginning with value propositions and business models being tested in LEO.

4. **Actor networks in the local energy ecosystem**
   This research aims to identify key actors in a viable SLES and to characterise the relationships between them. Actors will include householders, SMEs, technology companies, local authorities, public sector buildings estates teams etc, the DNO, energy companies, aggregators and others.

[46] This paper is published on the LEO website here: https://project-leo.co.uk/wp-content/uploads/2021/06/ECEEE21-Banks-and-Darby_140521_final-1.pdf

7.6 Tracking progress: Key Performance Indicators

KPIs require good sources of data and an intelligible framework of aims and objectives. They have been kept under review and revised substantially during Y2, giving a more workable and accountable system. The new arrangement classifies them under the headings of

- Social: dissemination, engagement, desirability (value proposition development) and action (trials to test value propositions)
- Technical: connected assets, substations monitored (this is now closed, as all monitors were installed by May 2021), system maturity and number of trials
- Commercial: market participation, commercial maturity and transactions

Each KPI has one or two people responsible for it. The spreadsheet on which they are documented gives a description of each, along with the motivation behind it and the method for measuring it.

Note that LEO may also be required to report against further KPIs, developed by Innovate UK and ERIS. These are designed to measure overall project impacts and the degree to which LEO is meeting PFER objectives. There is also ongoing work within EnergyRev to identify viable indicators to measure 'co-benefits' of smart local energy systems[47].

7.7 Engagement

Engagement is a two-way process that takes many forms and affects all aspects of the project, so the commentary on engagement is spread through this report to some extent, from MVS trials with their necessary procedures[48]through to preparatory work for the SFNs and engagement with the Stakeholder Advisory Group and policymakers.

As we noted last year, the stakeholder engagement strategy to be developed in Y2 was to focus on what each type of activity is intended to achieve, and how. This has been carried out with the aid of a set of stakeholder engagement principles[49] to guide engagement, with the Stibbe report to organise and focus messaging, and through the experience of engagement itself. Creation of the engagement log is helping to highlight that an energy system is as social as it is technical.

7.8 Stakeholder mapping with communications and engagement development in Y2

The Stibbe analysis followed early attempts to map LEO stakeholders by members of the project team, categorising their roles, potential value creation and interactions. It added a stronger focus on

---

[47] See page 6 of Framework for Smart Local Energy Systems https://www.energyrev.org.uk/media/1273/energyrev_paper_framework-for-sles_20191021_isbn_final.pdf

[48] https://project-leo.co.uk/wp-content/uploads/2020/10/MVS-A-Procedural-Learnings-V1final-front-cover.pdf

[49] https://project-leo.co.uk/wp-content/uploads/2020/09/LEO-Stakeholder-Engagement-Principles-.pdf

developing distinct communications and engagement methods that were seen as necessary in the Y1 Synthesis Report, and provides guidance for interactions.

Stakeholders have been identified through the kind of relationship they have with the project and the effect their actions have on project progress and outcomes, as Keyholders, Amplifiers and Learner-actors (Table 7). LCH have been using this categorisation to frame stakeholder mapping for some trials.

Table 7 communication goals for LEO stakeholder audiences

Audience	Goal
Keyholders (powerful) – stakeholders with the (financial, operational/technical or regulatory) power to make decisions that affect project progress and outcomes.	Provide persuasive evidence to support Keyholders in taking actions or decisions that facilitate change in an economic, reliable, fair and sustainable manner.
Amplifiers (influential) – people and organisations that have influence in the sector and can use this to amplify or dampen any project outcomes.	Make it easy and desirable for Amplifiers to consult, collaborate and share knowledge with LEO to support policy and investment for systemic change.
Learner-actors (interested/supportive) – parties who can provide useful insight and feedback on project developments and could replicate or take up findings in future work.	Increase the number, range and knowledge of Learners to become empowered actors in the UK transition to a Net Zero economy, by engaging with LEO resources.

This audience segmentation is further developed according to type of interest and levels of knowledge. At the same time, goals are adapted according to what project partners would like stakeholders to know, feel and do. For example, among the ‘keyholders’ are people with the power to direct change who may be baffled by competing policy initiatives or complex evidence. We therefore want to provide accessible communications that clearly explain the scale of the challenge, solutions being sought and ways of taking action.

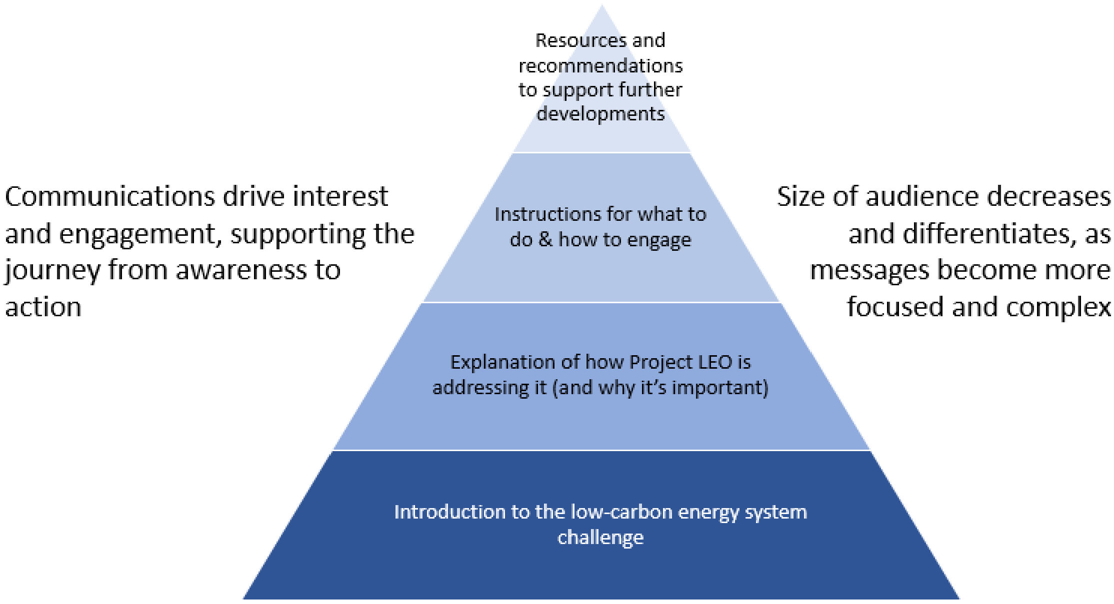


Figure 10: the LEO communications pyramid

Some Y2 engagement lessons have been that:

- When reaching out to new audiences, it is important to set the context. For example, explaining to community groups how engaging with LEO and with work on flexibility is important and relevant in a global, national and local context.
- Consistent use of technical terms within Project LEO must be reinforced, e.g. through continued development of the shared glossary.
- Plain English versions of terms for non-technical audiences are needed.
- Where possible, LEO should focus more on benefits for the energy system, carbon reduction, and the people using energy than on the features and mechanisms underpinning services. (There is no need to know the minutiae of how an engine works to drive to work.)

Community co-creation for flexibility trial design is an ideal, but one that is hard to realise when the flexibility market is still at a largely theoretical stage. It is also hard to explain to prospective participants. There is a lot of interest from potential small-scale flexibility providers in a plain English version of what LEO is attempting; there have also been inquiries from local and from major commercial organisations (including aggregators), who will require a version more tailored to their needs. it is important to be transparent with all potential participants about the early stages of market testing, and about the possibility of failure.

The attempt to set up value propositions that reflect what is important to potential participants is an exercise in listening as much as in design. Propositions have to be understood from the standpoints of all stakeholders. The exercise begins by defining the type of proposition: is it governed primarily by system needs, or those of a particular type of user or community? In either event, the proposer needs a thorough understanding of the people who will be involved in providing and using the service, and any particular roles that individuals or organisations can play. One lesson from engagement to date is that financial reward alone is unlikely to motivate the owners of relatively small flexibility assets.

Workshops and meetings for particular purposes (e.g., preparations for SFNs, informing councillors and planners) continue. It is worth remembering that all the Oxfordshire local authorities have declared a Climate Emergency, have made plans to address this in conjunction with post-Covid recovery, and have dedicated staff in place to work on climate action. But there is still a long way to go, not least in reconciling conflicting objectives – for example, between energy demand reduction and permissions for new development - and developing realistic detail in the plans.

7.9 Developing the LEO Theory of Change

Agreeing a set of objectives to form a long-term vision for Project LEO helped align partner priorities. The proposed values, ideas, system properties and actions were mapped at an early stage to an action-values-vision scale to begin forming a ToC – a theory of *how* the objectives might be achieved. This early work was summarised in the first Synthesis Report.

Not everyone in LEO has been comfortable with the idea of a ToC – the most pressing need often seems to be for guidance on operational issues. A useful ToC therefore needs to have a framework that reflects project experience and also to offer guidance on specific activities and their role in achieving particular goals.

Two years into the programme, the ToC has developed into something more complex and detailed, based on learnings documented in the LEO library and on the annual interviews with internal stakeholders. There was also a major step forward with the detailed mapping of processes by Barbara Hammond in the autumn of 2020.

The latest version is shown in Appendix A. This will change further as the evidence accumulates and is analysed and interpreted by stakeholders. In verbal terms, the left-hand side of the ToC diagram shows a roughly linear process through which policy, technical, social and economic drivers are influencing system development, along with their implications: greater need for flexibility at transmission and distribution levels, slow emergence of new value propositions and business models, and opportunities for new energy services that can offer social and environmental benefits. Stating this rationale has proved very necessary, as it is not self-evident to many people.

The orange box to the right of the 'Implications' states the starting point for LEO activity: that a SLES offers a socio-technical means of addressing the issues raised by the drivers and enablers of change, via innovation in six domains: governance, social, data/IT, technical, commercial and regulatory[50]. Moving beyond this starting point, the various colours represent enablement (light blue), processes or activities (orange), achievements or milestones (green, salmon), and assumptions underlying the mapping of processes and outcomes (magenta). On the far right sit the three aims against which the

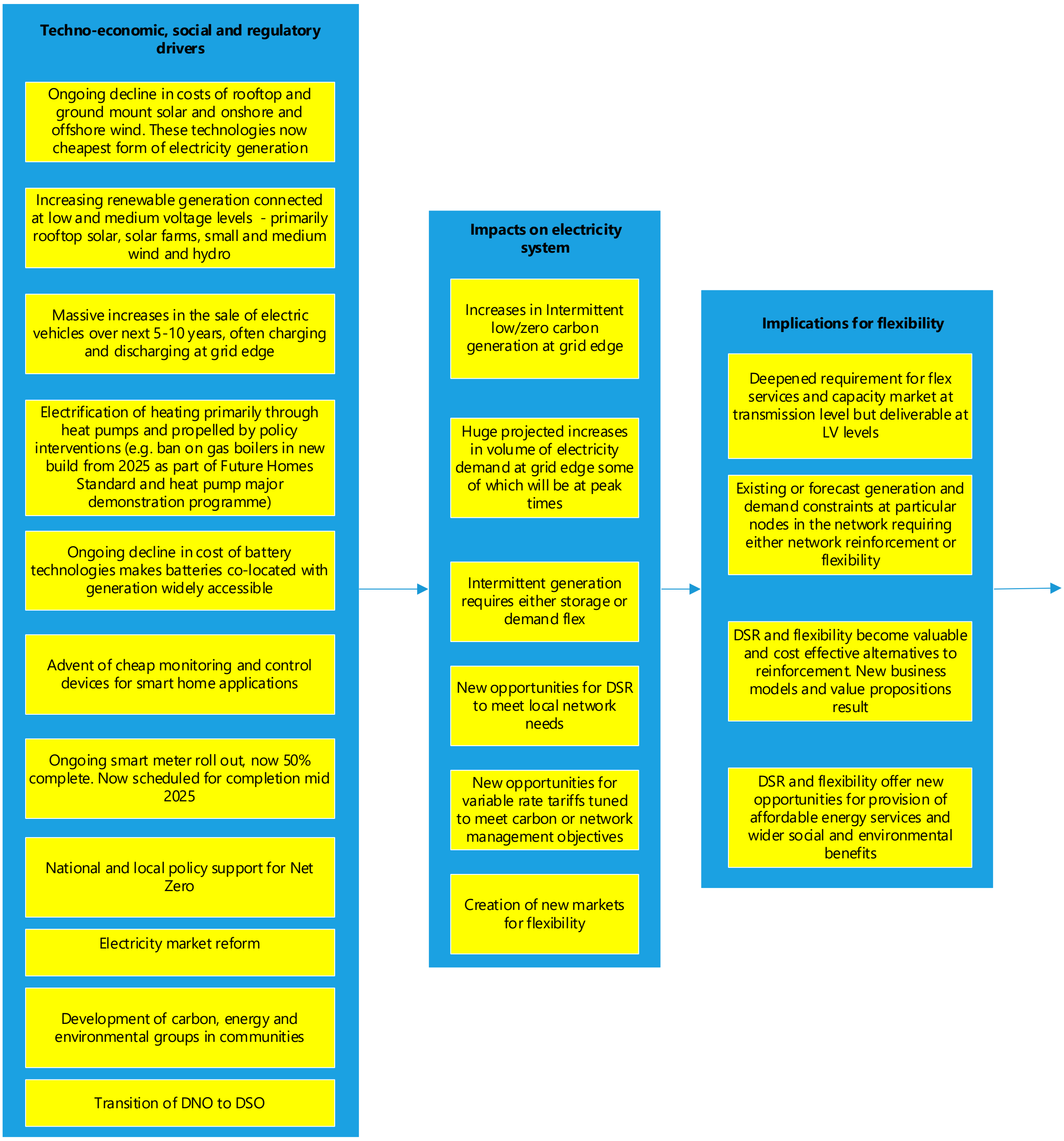
[50] The current EnergyREV draft ToC shows quite a similar approach, setting out four 'challenge area layers': digital, people and organisations, services and whole systems. It differs by setting 'policy and governance' outside or beyond these layers.

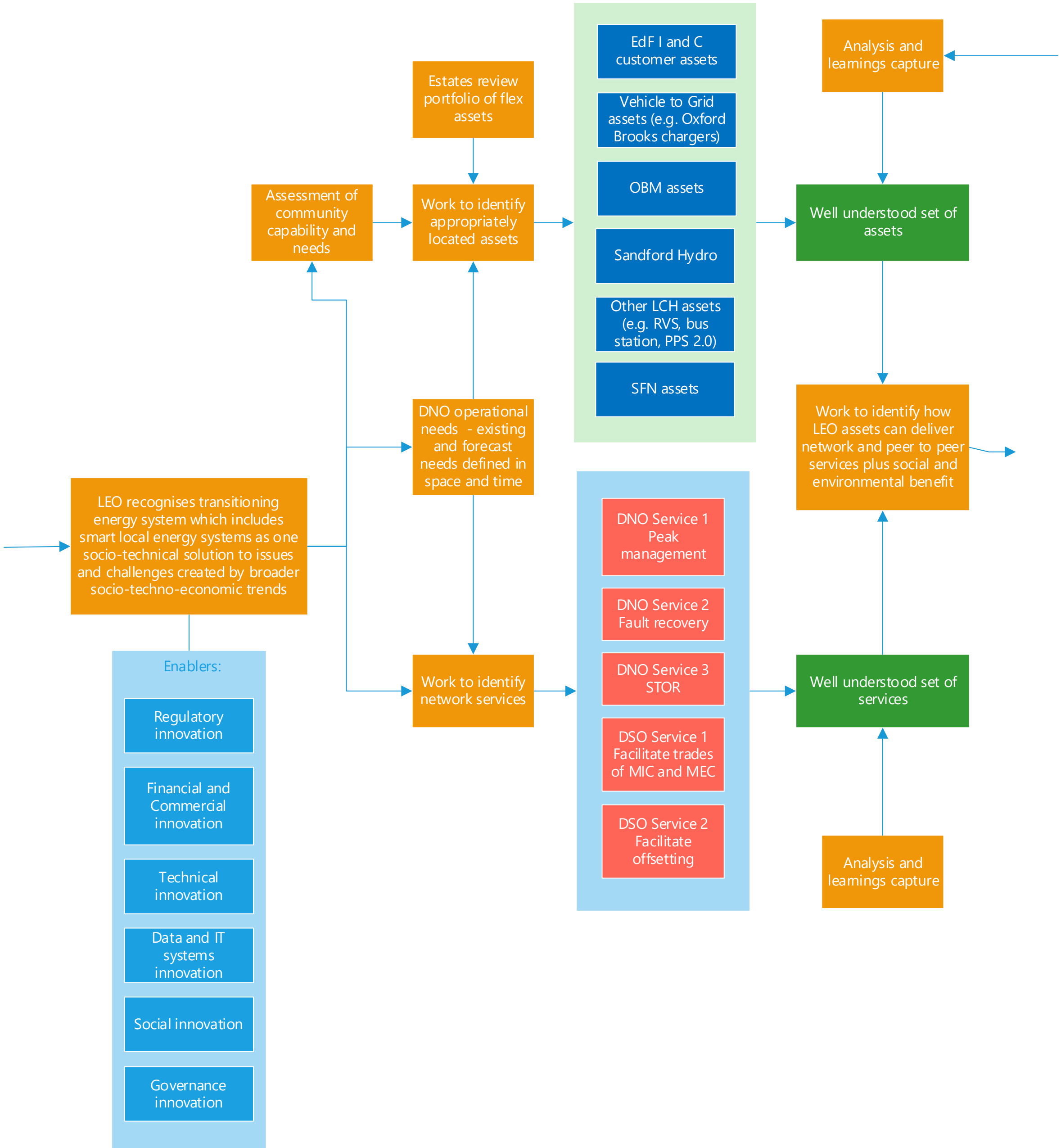
SLES is being evaluated. Note that the new diagram pays more attention than the initial ToC to social/human elements of an embryonic SLES, and to the significance of data. Looking ahead, we may see more feedback loops emerging into the diagram, illustrating learning over time.

The EnergyREV programme is developing a ToC for SLES as a tool for organising their 'realist' evaluation of the PFER programme, an evaluation method designed to offer a detailed explanation of *how* a programme will work, *for whom* and *in what circumstances*. Their evaluation sets out to test the ToC against evidence from the whole SLES programme and also from previous research projects or case studies. By contrast, the LEO ToC reflects experience in a particular locality and its value will stem from the insight it can offer from the detailed experience of building a SLES in that locality and with a specific mix of resources, actors and skills. The two theories of change will ideally be complementary and we plan to work with the EnergyREV researchers to that end.

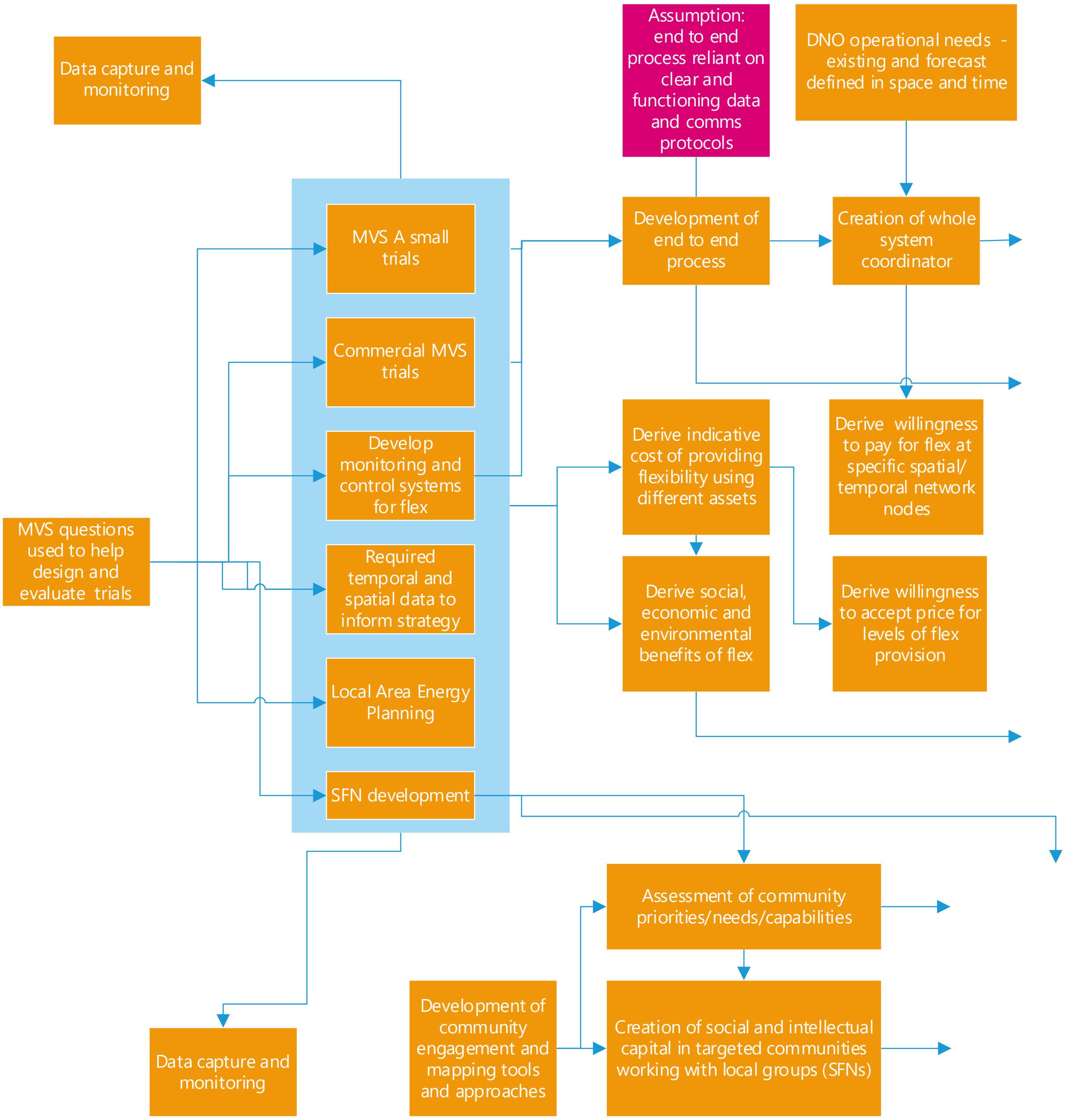
8. Appendices

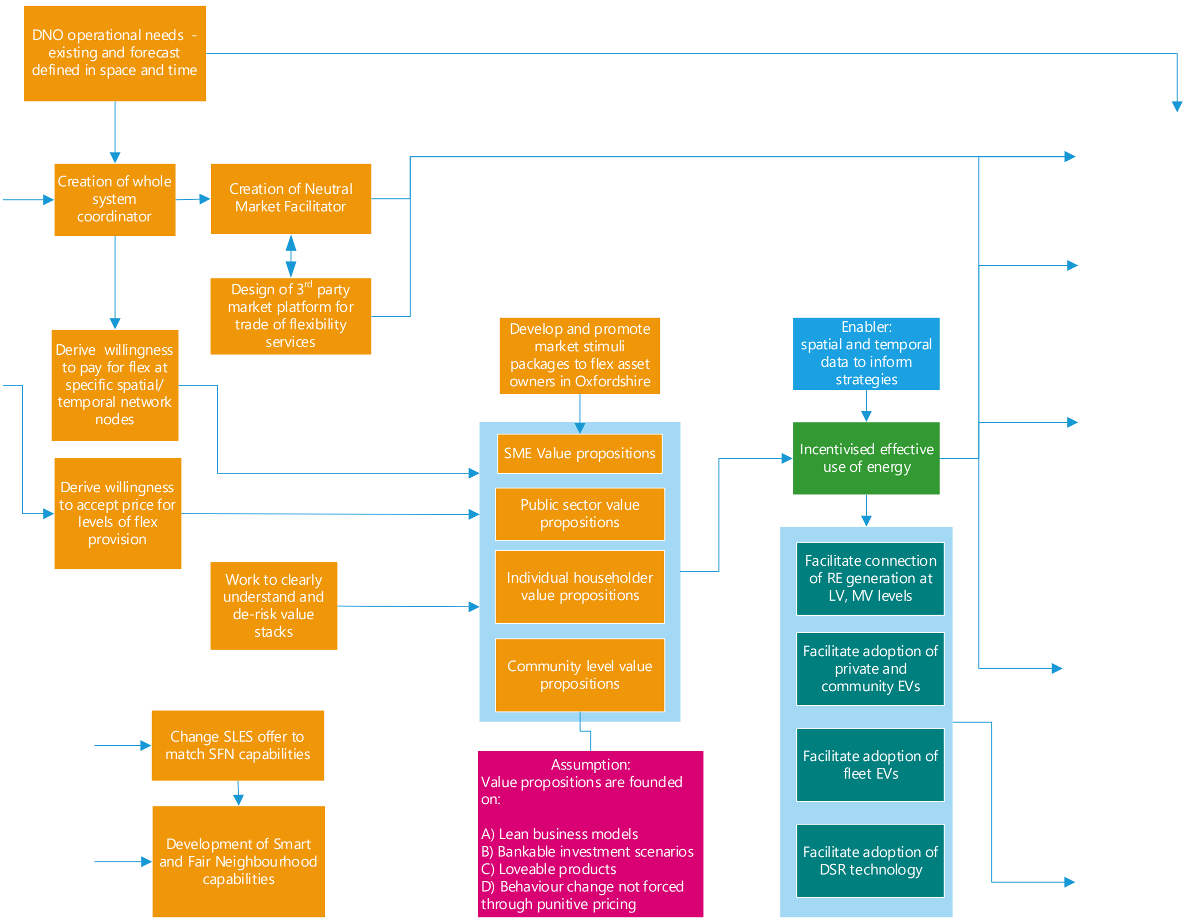
Appendix A LEO theory of change



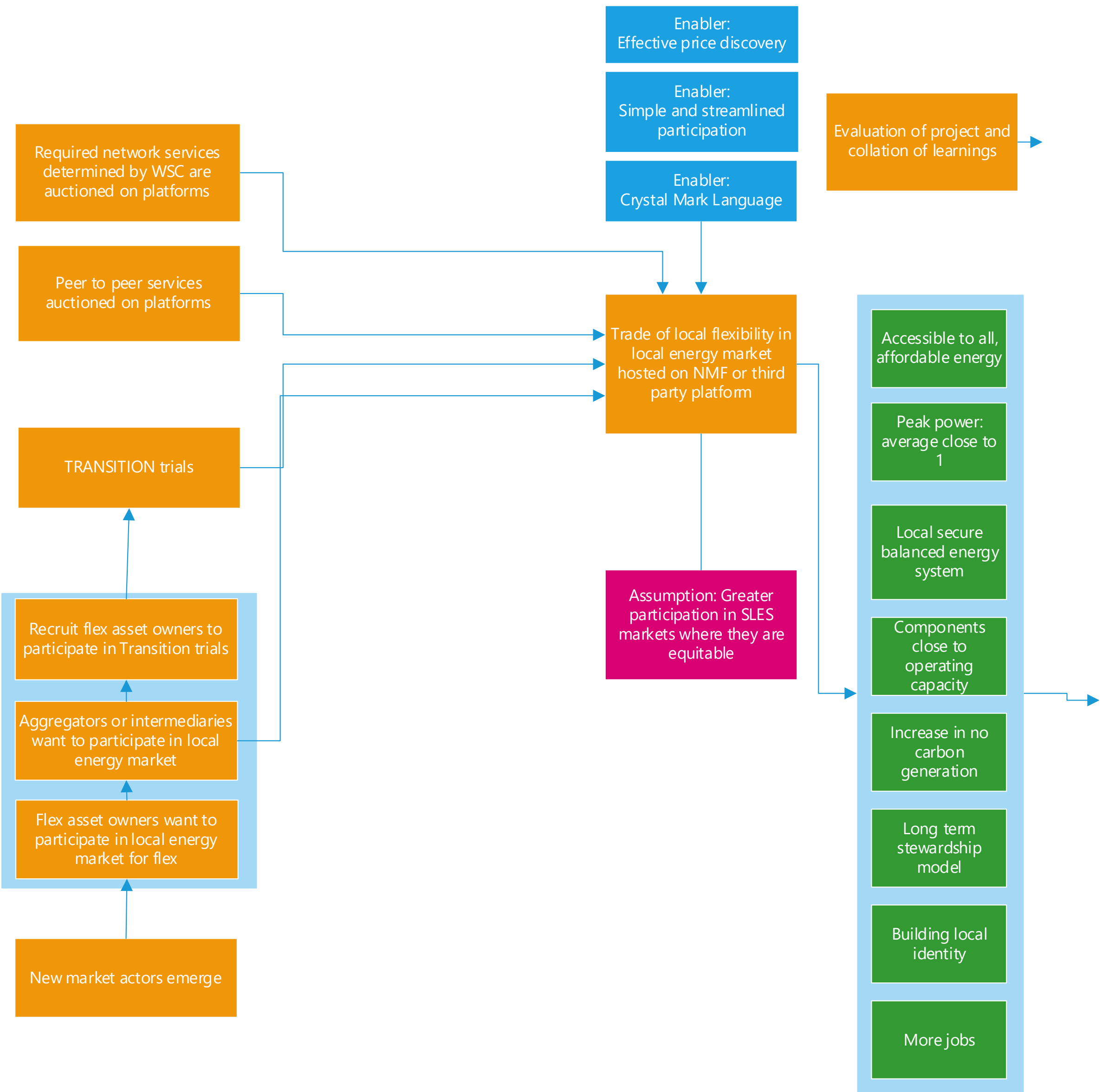


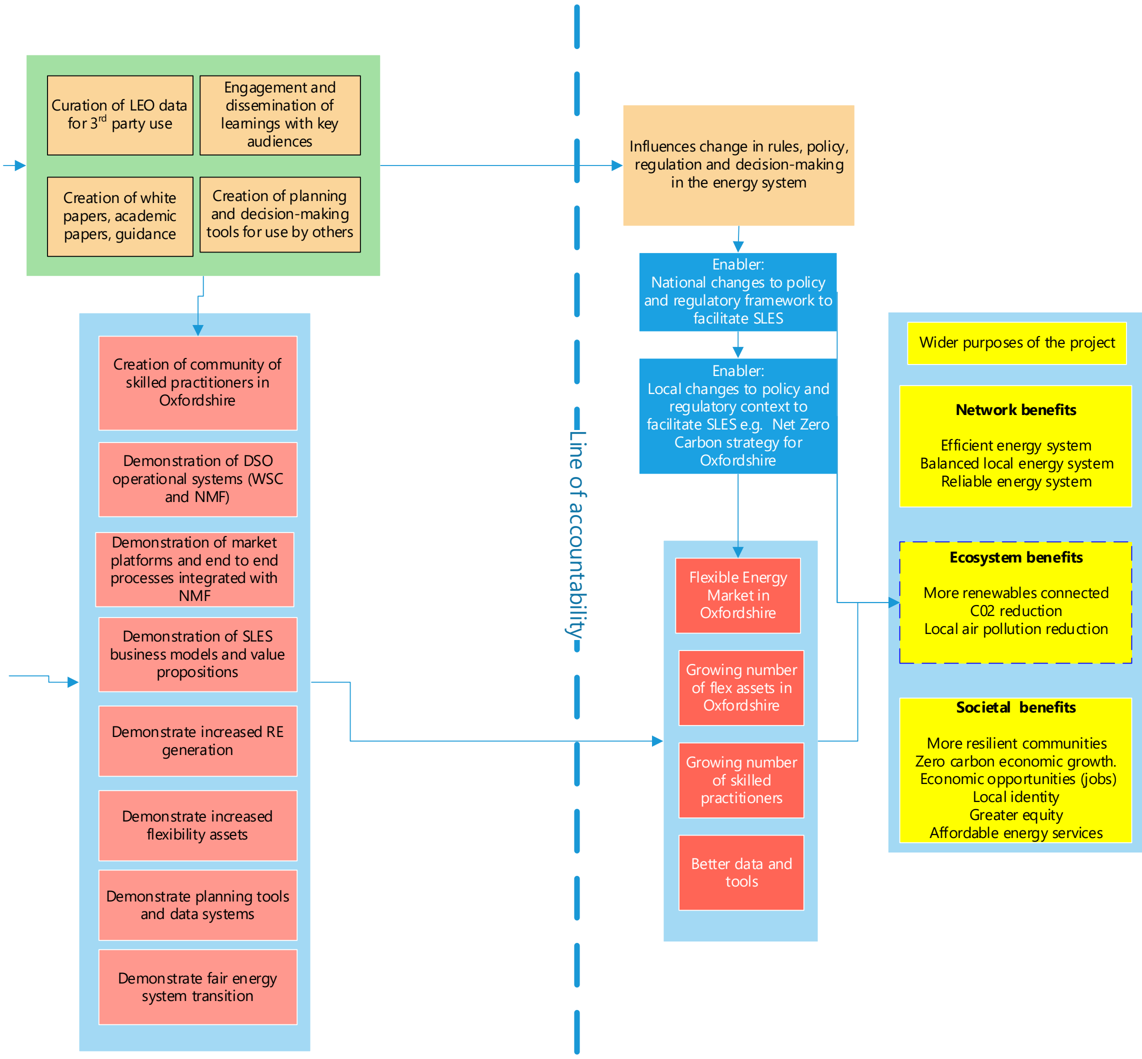
EdF I and C customer assets
Vehicle to Grid assets (e.g. Oxford Brooks chargers)
OBM assets
Sandford Hydro
Other LCH assets (e.g. RVS, bus station, PPS 2.0)
SFN assets
Analysis and learnings capture
Estates review portfolio of flex assets
Assessment of community capability and needs
Work to identify appropriately located assets
Well understood set of assets
Work to identify how LEO assets can deliver network and peer to peer services plus social and environmental benefit
DNO operational needs - existing and forecast needs defined in space and time
LEO recognises transitioning energy system which includes smart local energy systems as one socio-technical solution to issues and challenges created by broader socio-techno-economic trends
DNO Service 1 Peak management
DNO Service 2 Fault recovery
DNO Service 3 STOR
DSO Service 1 Facilitate trades of MIC and MEC
DSO Service 2 Facilitate offsetting
Work to identify network services
Well understood set of services
Analysis and learnings capture
Enablers:
Regulatory innovation
Financial and Commercial innovation
Technical innovation
Data and IT systems innovation
Social innovation
Governance innovation


Data capture and monitoring
Assumption: end to end process reliant on clear and functioning data and comms protocols
DNO operational needs - existing and forecast defined in space and time
MVS A small trials
Development of end to end process
Creation of whole system coordinator
Commercial MVS trials
Develop monitoring and control systems for flex
Derive indicative cost of providing flexibility using different assets
Derive willingness to pay for flex at specific spatial/ temporal network nodes
MVS questions used to help design and evaluate trials
Required temporal and spatial data to inform strategy
Derive social, economic and environmental benefits of flex
Derive willingness to accept price for levels of flex provision
Local Area Energy Planning
SFN development
Assessment of community priorities/needs/capabilities
Development of community engagement and mapping tools and approaches
Creation of social and intellectual capital in targeted communities working with local groups (SFNs)
Data capture and monitoring



DNO operational needs - existing and forecast defined in space and time
Creation of whole system coordinator
Creation of Neutral Market Facilitator
Design of 3rd party market platform for trade of flexibility services
Derive willingness to pay for flex at specific spatial/ temporal network nodes
Derive willingness to accept price for levels of flex provision
Work to clearly understand and de-risk value stacks
Change SLES offer to match SFN capabilities
Development of Smart and Fair Neighbourhood capabilities
Develop and promote market stimuli packages to flex asset owners in Oxfordshire
SME Value propositions
Public sector value propositions
Individual householder value propositions
Community level value propositions
Assumption:
Value propositions are founded on:
A) Lean business models
B) Bankable investment scenarios
C) Loveable products
D) Behaviour change not forced through punitive pricing
Enabler: spatial and temporal data to inform strategies
Incentivised effective use of energy
Facilitate connection of RE generation at LV, MV levels
Facilitate adoption of private and community EVs
Facilitate adoption of fleet EVs
Facilitate adoption of DSR technology


Enabler:
Effective price discovery
Enabler:
Simple and streamlined participation
Enabler:
Crystal Mark Language
Evaluation of project and collation of learnings
Required network services determined by WSC are auctioned on platforms
Peer to peer services auctioned on platforms
Trade of local flexibility in local energy market hosted on NMF or third party platform
TRANSITION trials
Assumption: Greater participation in SLES markets where they are equitable
Recruit flex asset owners to participate in Transition trials
Aggregators or intermediaries want to participate in local energy market
Flex asset owners want to participate in local energy market for flex
New market actors emerge
Accessible to all, affordable energy
Peak power: average close to 1
Local secure balanced energy system
Components close to operating capacity
Increase in no carbon generation
Long term stewardship model
Building local identity
More jobs


Curation of LEO data for 3rd party use
Engagement and dissemination of learnings with key audiences
Creation of white papers, academic papers, guidance
Creation of planning and decision-making tools for use by others
Creation of community of skilled practitioners in Oxfordshire
Demonstration of DSO operational systems (WSC and NMF)
Demonstration of market platforms and end to end processes integrated with NMF
Demonstration of SLES business models and value propositions
Demonstrate increased RE generation
Demonstrate increased flexibility assets
Demonstrate planning tools and data systems
Demonstrate fair energy system transition
Line of accountability
Influences change in rules, policy, regulation and decision-making in the energy system
Enabler: National changes to policy and regulatory framework to facilitate SLES
Enabler: Local changes to policy and regulatory context to facilitate SLES e.g. Net Zero Carbon strategy for Oxfordshire
Flexible Energy Market in Oxfordshire
Growing number of flex assets in Oxfordshire
Growing number of skilled practitioners
Better data and tools
Wider purposes of the project
Network benefits
Efficient energy system
Balanced local energy system
Reliable energy system
Ecosystem benefits
More renewables connected
C02 reduction
Local air pollution reduction
Societal benefits
More resilient communities
Zero carbon economic growth.
Economic opportunities (jobs)
Local identity
Greater equity
Affordable energy services

Appendix B: One page slide descriptions of the SFNs

Osney Island Smart & Fair Neighbourhood Project

Using local energy to enable electric vehicle adoption

A wide range of energy assets at the 'grid edge' being used together to provide flexibility services

Key questions	IDEA	GOAL	APPROACH	PARTNERS	PRINCIPLES
How can the Osney Island community use energy, generated at Osney Lock Hydro, more effectively	1. Automating systems and energy modelling	Maximize the hydro system's effectiveness Model battery storage opportunity	**Community-scale energy…** 1. Installation of automation at the weir 2. Engaging with the Environment Agency's feasibility study of battery and EV chargers at their site 3. Modelling the opportunity for combining OLH with a battery to increase local use in general and for EV charging 4. Learning from Sandford Hydro flexible operations 5. OLH participation in LEO trials as appropriate	1. LCH 2. Environment Agency 3. Origami	Whole community approach
How can domestic flexibility services help a community to adopt electric vehicles?	2. Household flexible EV charging	Learn how to control energy assets and what value this can generate	**Domestic flexibility joined up with footway charging solutions…** 1. Facilitating participation of residents in Oxfordshire County Council footway charging solution trials 2. Flexible home electric car charging as part of the HOPE project 3. Possible shared use of footway charging via smart cables	1. LCH 2. Oxfordshire County Council 3. Oxford University 4. SSEN	Increased customer choice
How can community power enable community e-mobility?	3. Establish an electric car club	Explore local flexible energy use can fund community cars and chargers	**Getting an electric car club vehicle and exploring business models for on-street public charging** 1. Demonstrate demand for a car club vehicle 2. Engage with car clubs to secure provision of an electric car 3. Secure funding for an on-street electric chargers (TBC GULO) 4. Identify a suitable location for the car/charger 5. Explore the role of flexible energy use to contribute to the business models for funding of on-street electric vehicle chargers for public and car club use	1. LCH 2. Oxfordshire County Council 3. Oxford City Council 4. Others TBC	Not just about private car ownership

www.project-leo.co.uk

Eynsham Smart & Fair Futures

An Energy Action Plan for the Eynsham Primary Substation Area

Develop an Energy Action Plan for the Eynsham area for a zero-carbon energy system before 2050

Key questions for a low carbon future / energy transition?	IDEA	GOAL	APPROACH	PARTNERS	PRINCIPLES
Q. 1: How can existing and future communities benefit from major new development by making it a catalyst for achieving zero carbon?	1. Bridge gaps between: ▪ Climate emergency & planning policy ▪ Developer & householder interests ▪ Existing & new residents	Planning policy is aligned with climate goals and new developments help improve existing ones	**We will collaborate on energy plans for both Salt Cross and then West Eynsham, so they can be net zero carbon, energy positive developments:** **1. Review existing studies, models and proposals for Salt Cross** **2. Model the optimal scenario for it, embedding a smart local energy system and a local energy market which can provide clean energy through viable commercial business models** **3. Review current national standards and policies to propose:** • **Updated standards in relation to the Future Homes Standard consultation** • **Definition of net zero development to inc. embodied energy** • **Updated Viability Assessment process** • **Scrutiny process to monitor implementation**	1. WODC 2. Developers for Salt Cross, West Eynsham 3. Oxfordshire County Council 4. Urbanomy (contractors of OCC) 5. Green TEA 6. Low Carbon Hub	Joined-up approach Overall net zero (inc. embodied energy) Win-win approach
Q. 2: How can our area's energy become net zero carbon by 2050 at the latest?	2. Develop Local Area Energy Plan combining: ▪ Energy modelling (new developments) ▪ Energy data (existing) ▪ Pilot programmes for residents to take part in the transition	A clear and replicable, evidence-based Local Area Energy Plan (LAEP) covering both new and existing settlements	**Produce the overall Energy Plan for Eynsham Primary Substation Area, including new and existing settlements:** **1. Provide an overview of the current and future energy demand across the area** **2. Develop from that an integrated energy planning study** **3. Consider mechanisms and incentives to influence energy demand** **4. Test action-oriented pilot programmes from other LEO Smart & Fair Neighbourhoods also in the Eynsham area**	1. SSEN (data) 2. Oxfordshire County Council 3. Green TEA 4. Local Parish Councils 5. Low Carbon Hub 6. Cosy Homes Oxfordshire / ESOx	Energy reduction / demand management Integrative approach Learning by doing
Q. 3: How can we ensure that our zero carbon energy solutions are sustained over the long term (i.e. beyond 2050)?	3. Ensure the Local Area Energy Plan is delivered: ▪ Propose a suitable local governance structure ▪ Plan how to resource this (inc. business models for new renewable projects)	A long-term sustainable (i.e. resourced) governance structure for the LAEP	**Consider options for an independent mechanism for stewardship of all aspects with a long-term monitoring and management plan, agreed resourcing and reporting, including:** **1. A brainstorm on scenarios and future-proofing** **2. A process for a regular review of the energy plan** **3. A process for a regular review of compliance reporting** **4. A range of potential funding models**	1. WODC 2. Oxfordshire County Council 3. Developers 4. Renewable energy generators (local) 5. Smart & Fair Futures Inspiration Panel 6. Local Parish Councils? 7. Low Carbon Hub	Co-ordinated approach with other structures Resources are specified Community-owned as an option

[These are examples of symbols you could use to represent project principles – we can create new ones]

Smart and Fair Neighbourhood Trials

Local Energy Oxfordshire

Rose Hill Smart & Fair Neighbourhood Project

Using flexibility services to help a mixed community move to net zero in a way that is fair, inclusive, equitable?

A wide range of energy assets at the 'grid edge' being used together to provide flexibility services

Key questions for a low carbon future / energy transition?	IDEA	GOAL	APPROACH	PARTNERS	PRINCIPLES
How can a better understanding of local energy systems and the role of flexibility services support a community in developing a zero carbon roadmap (potentially a Local Area Energy Plan, or feeding into one)?	1. Model how the energy system of the future might stack up in a defined area	A road map to zero carbon tailored to RH for the community to use as an influencing tool.	**Use the online LEMAP tool being developed through EnergyRev to test how to develop a road map for becoming a zero carbon community, including those with least flexibility potential.** 1. Understand the existing situation affecting the energy system, using data from official sources 2. Check and supplement this with local information using participatory, community mapping 3. Try out different scenarios to understand local options for net zero by 2050 or even 2040 - so how flexibility, as well as other strategies such as demand reduction and storage, could reduce the local carbon footprint and enable more renewable generation without costly upgrades	1. EnergyRev partners: Oxford Brookes University, Exeter University 2. RHILC 3. LEO partners 4. Other local groups (tbc)	e.g. Customer journey focus Joined up approach Whole house approach
How much potential flexibility can a diverse community such as Rose Hill offer to the energy system and how much self-consumption and peer-to-peer trading is possible?	2. Trial using a range of energy assets, larger and smaller, in real life in flexible ways	Learn how to control energy assets and what value this can help generate.	**Start by working with owners of larger energy assets and then others to test how they can be controlled to provide flexibility and other energy services.** 1. Owners and hosts of energy assets in the area trial participating in flexibility services, as well as trial balancing generation and demand on-site with the help of storage 2. LCH will test how the PPS2 in development may help 'control' assets to automatically deliver flexibility without the need for individuals to press switches 3. As we learn, extend the trials, also exploring how flexibility services can leverage financial, social, and environmental value to users, without increased financial risk	1. LCH 2. OCC 3. Others tbc – e.g. owners of domestic PV, ERIC-PV on social housing	e.g. Customer journey focus Joined up approach Whole house approach
How can we find ways of involving those with least flexibility potential and ensuring they benefit too, e.g. through a 'time of use' tariff?	3. Find out what enables and motivates everyone to take part in the energy system	Design the energy system so as not to inadvertently disadvantage those with the least flexibility potential.	**Start by working with those in social/shared ownership flats to discover what barriers there are to this – from legal, regulatory, technical, financial, to communication.** 1. Develop a partnership model between Local Authority, residents, and social enterprises to enable residents to benefit from 'over-size' rooftop solar owned by their landlords or another third party 2. Work with an energy supplier to simulate a time of use tariff that enables households with less flexibility to offer to benefit from participation 3. Identify issues around about institutional barriers ,access and ownership of data (and energy assets) that might prevent replication and scale up	1. OCHL 2. OCC 3. LCH 4. Co-op Energy/ Octopus 5. Tenants / shared ownership 6. Tbc – if to be extended	e.g. Customer journey focus Joined up approach Whole house approach

Smart and Fair Neighbourhood Trials

Local Energy Oxfordshire

v.1 (22 March 2021)

Deddington and Duns Tew Smart and Fair Neighbourhood Project

Decarbonising your heating and the National Grid through flexibility services ?

Renewable heating as a flexibility service

Key questions for a low carbon future / energy transition?	IDEA	GOAL	APPROACH	PARTNERS	PRINCIPLES
How do we incentivise the de-carbonization of heat in off gas rural areas and at the same time trial up-and-coming grid flexibility services?	1. Decarbonisation of heating as a flexibility service	Warmer, more efficient, greener homes that can provide flexibility services to National Grid.	**Facilitate the installation of smart renewable heating technologies allowing households to provide flexibility services to the grid.** 1. Have a Cosy Homes audit - specifying the process and interventions that could allow the household improve their home (more efficient, comfortable, reduced carbon emissions) PLUS engage in flexibility services (Register here) 2. Work with the Low Carbon Hub, Cosy homes and the Community group to install these measures 3. Allow Low Carbon Hub to monitor those technologies installed, participate in trials simulating payment for flexibility services and provide feedback for the length of the project.	15 houses - e.g. housing developer(s), local authority, mortgage provider	Customer journey focus Activate for ESO services too Whole house approach
How can communities in conservation areas and individuals living in listed buildings better engage in the planning process to improve uptake of Low Carbon Technologies (LCTs)?	2. Unlocking the planning process	Improved routes to engage with planning process for conservation and listed buildings wanting to engage in LCTs.	**Work with the community and local planning officials to develop a more informed and effective process for approving LCTS in conservation areas and listed buildings.** 1. Identify past Low Carbon Technologies and energy efficiency measures that have not been able to pass planning via our survey (Typeform link) 2. Compare that list to Cosy Homes audit recommendations 3. Reach out to planning officials to provide guidance on LCTs 4. Mediate a process by which a more discursive and informed planning process can occur to improve installation of LCTs.	Local community members Local Authority Local Planning Authority	Emphasis on individual experience? A joined up iterative approach to planning A better informed , discursive and
What are flexibility services? How can we better understand them? How can we better communicate them to aid the uptake of Low Carbon Technologies?	3. Raise awareness of benefits of low carbon technologies and flexibility	Greater uptake of LCT's and more awareness of flexibility services.	**Provide communication material to inform homeowners and local community about LCTs and flexibility services** 1. Create suite of material (flyer, graphics, video) to explain benefits of Low Carbon Technologies and flexibility services 2. Host events, presentations, workshops for local communities to attend (sign up for our next event here) 3. Host information on the Project LEO website and encourage people to sign up to the LEO newsletter [link] 4. Sign up to your local DEN or SDT newsletter for updates on the SFN project.	Local community members	Minimize user inputs Ongoing check-in with Ofgem Inclusive of all techs

Local Energy Oxfordshire

Westmill's Smart & Fair Neighbourhood Project

Flexibility services with community-scale assets

A wide range of energy assets at the 'grid edge' being used together to provide flexibility services

Key questions	IDEA	GOAL	APPROACH	PARTNERS	PRINCIPLES
What do emerging flexibility services mean for existing community-scale assets?	1. Desktop assessment, trials and options appraisal	Assess opportunity with existing assets and identify trials	**Community-scale energy…** 1. Desktop assessment of generation profile to assess suitable services and relevant LEO trials 2. Confirm hardware needs for trial participation and confirm go ahead: implement trials as appropriate 3. Identify and assess future developments of the solar and wind farms if flexibility services are included in the business model	1. LCH 2. Origami	Open to new ideas
Explore the battery connection and how to maximize the opportunity for all three organizations	2. Modelling and business case development	Identify what a flexible connection and/or P2P services could offer	**Development of Westmill Smart Grid CIC's proposals…** 1. Developing a shared understanding the current business model for the Smart Grid CIC's proposed battery facility 2. Desktop assessment of the relevant flexibility services at Westmill including the proposed battery 3. Bringing learning about flexibility services to the process for engagement between the Smart Grid CIC and Co-ops regarding potential contracting between the organisations	1. LCH 2. Origami 3. SSEN	Co-operative principles
What is needed for the Westmill organisations to work well together to take advantage of this opportunity?	3. Leadership workshops	Develop ways of working and governance	**Establishing the environment for developing and deciding on future operations and developments…** 1. Focus group and workshop to develop a shared purpose and vision across the four Westmill organisations 2. Further activities as needed	1. LCH	Collaborative leadership Strong governance

www.project-leo.co.uk