Local Energy Oxfordshire

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First Year Synthesis Report

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Executive Summary

Project LEO was set up to deliver a transformative integrated smart local energy system (SLES) to maximise prosperity and demonstrate new value creation opportunities, develop innovative funding models for new Distributed Energy Resources (DER), and demonstrate novel local energy markets. This report sets out what has been learned while translating this ambition into practice during the first year 1 of LEO, with some comments on implications for the remainder of the project.

Year 1 experience has shown the value of a flexible, modular approach to implementing energy transition – development of Minimum Viable Systems (MVS), designed for rapid learning. It has raised organisational, data and connectivity issues that will need addressing throughout the project. The first year's work has also shown the significance of different types and scales of demand in each substation area and the many roles which people play in energy systems, e.g. as investors, operators of generation, storage and demand-side assets, and practitioners in engagement and governance.

1. Concepts

Stakeholder diversity and project complexity have meant that not everyone uses the same terms in the same way. We have made progress on bringing together different sets of definitions (for example, those in use in the Open Networks Project led by the ENA along with those developed by LEO partners to describe stakeholders). There is a need to continue work on developing a common language for SLES. It will need to convey meaning very precisely where operational issues are concerned, and to recognise and reflect the many roles which people play in energy systems - not just as consumers but as investors, operators of distributed generation, storage and demand-side assets, and practitioners in engagement and governance.

The concept of an MVS, developed from the early idea of a Minimum Viable Product, is proving its worth not only to describe LEO initiatives in detail but to identify potential gaps in system services and solutions.

The concept of a SLES is still developing and LEO can contribute to this process. The consensus within the project is 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.

2. The local ecosystem and replicability

Early project experience has shown the importance of local stakeholders and infrastructure for the development of local energy systems. Oxfordshire is a favourable test-bed for this work. It has high ambitions for carbon reduction; an innovative network operator managing a power system close to capacity; high levels of social capital and public engagement allied with DER built up over the past three decades by local authorities, social enterprises and voluntary bodies; and high levels of knowledge and skill among project partners.

Local factors may limit the replicability of LEO as a whole, hence the importance of the MVS, a module that can be described in terms of technologies, actors, data requirements, procedures and potential challenges. Early MVSs show promise for transplanting.

The data used by (local) policy makers and planners in decision-making on energy issues is an important feature of the local ecosystem. Findings from stakeholder workshops in Y2 will be used to map the information environment of planners and local politicians, and the guidance and data they need in decision-making. These will inform the design of MVS sub-projects for policy development.

3. Project management for a diverse consortium

A diverse consortium is needed to address the complexity of setting up a new system while operating the old one. Workshops on market rule simulation, site selection, business model canvases and stakeholder mapping have been valuable, bringing together partners from all work packages and building knowledge and understanding. However, the time and effort needed to manage the diverse partners and their activities is considerable. Information and coordination activities have to be carried out within tight time constraints, while meeting multiple requirements for monitoring and evaluation.

4. Market development

Developing and testing a local market to deliver the objectives of the PFER programme is the core activity of the project. LEO envisions new roles for people, communities and organisations that move beyond the producer-consumer paradigm. It is exploring how to create a market that meets grid and distribution network operational needs and also delivers social and environmental benefits. The structure identified as best suited to delivering these outcomes is the Local Energy Market (LEM), where only assets (distributed generation, storage and demand-side response) within a defined geographical area can participate. These resources can sell their energy or services either locally (e.g. in peer to peer (P2P) trading or to the DSO), or as services on national markets managed by the Electricity System Operator). Especially for the latter, they may be aggregated.

The revenue available to local assets via the marketplace depends on the design of the local market platform and how it interacts with actors in the wider system. 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. The embryonic Local Energy Market in LEO operates at two levels:

- The Neutral Market Facilitator Platform (NMFP) under construction as part of the TRANSITION project. The NMFP interacts with a Whole System Coordinator, which assesses options for mitigating network constraints.
- The NMFP hosts a Flexibility Exchange Platform, under construction by Piclo. This allows flexibility service providers to contract for requested services, either from the DSO or from third parties in P2P arrangements.

The flexibility market must address operational needs resulting from changes in energy demand and supply, supplying constraint management, peak management, Short Term Operating Reserve (STOR), authorised capacity trading and offsetting. The second phase of MVS trials will be developed to align with these services, to be coordinated using the LEM platform (flexibility exchange) under development by Piclo.

5. Operational learning

Year 1 of LEO produced valuable findings on baseline conditions in the network and on the first phase of MVSs. Great care is needed to ensure continuous service to customers before, during and after project procedures, and LEO has shown that this is possible. Key learnings are:

- Each MVS needs an 'owner' to take responsibility for trialing it and communicating with all partners in the system beforehand, to ensure readiness to deploy.
- Consistent, agreed terminology is needed for items of equipment and procedures, for MVS actors to understand each other and ensure reliable operation.
- Not all assets can provide flexibility services readily; they may need additional work to connect them to the system reliably.
- Detailed procurement standards are needed for flexible assets.
- Battery management systems can be very valuable for site flexibility.
- Protocols for two-way communication between flexibility assets and network are needed, to notify changes in operational status.
- A SLES needs a framework to cope with failures to supply agreed services, or delays. This should include agreed penalties and arrangements to fall back on other services.

The 'live learnings' document for each MVS is working well as a way of capturing issues that arise during testing.

6. Data

There have been considerable data-related challenges, including the finalisation of a data-sharing agreement between consortium partners. It has been important to identify, as early as possible, what data needs to be shared and with whom; also to make sure associated metadata are collected and stored in a way that makes sense of each dataset. Consortium members have learned the need for close coordination and a shared understanding of the terms used by different partners, along with carefully documented processes and effective data sharing. All require significant commitments of time and effort.

7. Policy

We identify three principal policy-relevant lessons. One highlights the significance of local factors 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. Development of market platforms is typically at national scale but must be adaptable to a range of local conditions. While local factors may limit the replicability of LEO as a whole, early experience with three discrete MVSs shows their promise for replication now that they are thoroughly documented in terms of technologies, actors, data requirements, procedures and potential challenges.

The second area of learning concerns the policy/regulatory risk that attends SLES, with uncertainties over the direction that Ofgem codes will take. Regulatory uncertainty is a major factor in uncertainty about the value propositions and financial viability of many 'plug-in projects' that could, in favourable conditions, develop into elements of a SLES.

Thirdly, 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 the value of DSO flexibility. Settlement of transactions within a LEM, between local markets and between a local market and national markets (e.g. the ESO balancing mechanism) will pose operational, policy and regulatory challenges. The establishment of new processes for reconciling and settling transactions at multiple levels between markets is an issue that should be considered at an early design stage by parties at all levels.

8. Looking ahead: achieving fairness, engaging widely

Equity, or seeing that 'no-one is left behind' was identified as an important issue for LEO in stakeholder interviews and is a key aspect of the PFER programme. 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.

There are issues to address such as how household and business energy costs will be affected by factors such as building energy efficiency or by ownership of distributed assets such as solar PV panels, electric vehicles or appliances suited to demand response. The concept of energy poverty is changing over time and arguably needs to take into account a person's ability to participate in system operation (e.g. through micro-generation and demand response) and in governance.
LEO has identified a wide range of stakeholders who stand to gain from a SLES and are needed to contribute to its effectiveness. The project is developing an engagement strategy to address each appropriately. Engagement with socially disadvantaged citizens needs time and special attention, to build trust and productive relationships; there is concern that some groups may be 'left behind' because they cannot benefit directly from owning or operating distributed energy assets. Community-focussed work has already built some public support for SLES and will continue.

9. Developing an ethical framework for project design, monitoring and evaluation

As LEO activities become more complex and involve more stakeholders, including citizens and businesses, it will become even more important 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 sharing the same interests as the community. To support this, the Low Carbon Hub, with contributions from other partners, is developing an ethical framework of principles to guide design, monitoring, evaluation and engagement for the ‘plug-in projects’ (assets or systems being developed to ‘plug in’ to the flexibility market).

10. KPIs and monitoring in Year 2

KPIs require good sources of data and an intelligible framework of aims and objectives. A risk was identified in the bid that some KPIs may become irrelevant as changes take place in the energy industry and this remains a possibility. They are kept under constant review.

Current KPIs are almost entirely quantitative, e.g. levels of demand and carbon emissions, connected low-carbon generation, status of planned and tested flexibility services, number and type of system participants, jobs created, engagement activities and skills acquired. This range of KPIs will need some extension in Y2, when multi-participant MVSs – for example, aggregating electric vehicle batteries – will be tested and there will be spatial mapping, further preparation for Smart and Fair Neighbourhoods and issues arising from the pandemic.

The IUK monitoring requirements have been time-consuming but have helped 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.

11. Building on a strong foundation

Project LEO is ambitious, aiming to set up a smart, fair, renewables-based energy system for a population of almost 700,000 while maintaining energy services through the existing networks. The three years of funding from UKRI are enabling LEO to lay foundations for a viable low-carbon system and the first year’s experience of work on the project has been encouraging. It has validated the ‘agile learning’ approach, in which elements of a smart local system are tested, refined and documented with a view to replicating them elsewhere. Above all, LEO is showing the value of developing an innovative energy system with equal consideration given to the social, market and technical dimensions of the challenge.

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1 Origin, aims and structure

In 2018, the Industrial Strategy Challenge Fund (ISCF) set up a fund of £102.5m for UK industry and research to develop systems that can support the global move to renewable energy: *Prospering From the Energy Revolution* (PFER). Eight million pounds of this 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.[1] Further funding was allocated to four large demonstrator SLES programmes: LEO (£14m from Innovate UK plus some £26m from project partners), Energy Superhub Oxford, ReFLEX in Orkney and Smart Hub SLES in West Sussex. These are all 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 can grow and replicate in the 2020s;
- provide evidence on the impacts and efficiency of novel energy system approaches by the early 2020s.[2]

The LEO bid for funding from the ISCF stated the aim primarily in economic and technical terms: that LEO 'delivers a transformative integrated smart local energy system to maximise prosperity from local energy systems and demonstrate new value creation opportunities' and that it addresses the near-term need to do something about a power system in Oxfordshire that is at capacity, by developing a local energy market place to 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.'[3]

1.1 Energy systems in transition

Project LEO is thus an initiative to respond to both national and local needs. It aims to meet ambitious carbon emission reduction targets in a city-region – 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 and will need to accommodate that in a constrained distribution network. The project therefore aims to inform the transition to a smarter, renewables-based electricity system and to develop 'a skilled community positioned to thrive and benefit from a smarter, responsive and flexible electricity network.'[4]

Ofgem is reviewing the regulatory changes needed to support this transition in two key areas. The Significant Code Review of Targeted Charging aims to bring charges for the 'residual' costs of

[1] https://www.energyrev.org.uk/
[2] https://www.gov.uk/government/news/four-leading-edge-demonstrators-to-jumpstart-energy-revolution
[3] Project bid.
[4] Project LEO website, accessed March 2020

electricity networks into line with new modes of generation, consumption and storage; the Significant Code Review of network access and forward-looking charge arrangements is also under way, which will transform the charging structures for assets wishing to connect to the network. Both raise complex issues of fairness, efficiency and options for system development.

Key to system transition is the increase in capabilities of the Distribution Network Operator role, developing it to that of a Distribution System Operator, with some of the electricity network's operational needs being met by third party Service Providers coordinated through a Local Energy Marketplace. Scottish and Southern Electricity Networks (SSEN) is piloting the systems needed for transition to a DSO, through its Ofgem-funded TRANSITION project. These systems include data requirements, software interfaces and commercial mechanisms, and the recruitment of Distributed Energy Resources to bid competitively to offer network balancing and other services on the distribution network. Hence LEO and TRANSITION work together. The systems needed to monitor, coordinate and contract out network needs are being explored through the TRANSITION project whilst the systems and services meet those needs are being explored in LEO. For this reason, TRANSITION is formally incorporated within LEO as Workpackage 5.

Radical changes to the way energy is generated, distributed, traded and supported by regulation call for system reconfiguration alongside optimisation of the existing system through flexibility. LEO is playing its part by exploring the early next steps. But full integration of flexibility will only be achieved once LEO becomes replicated and scaled. Graphically:

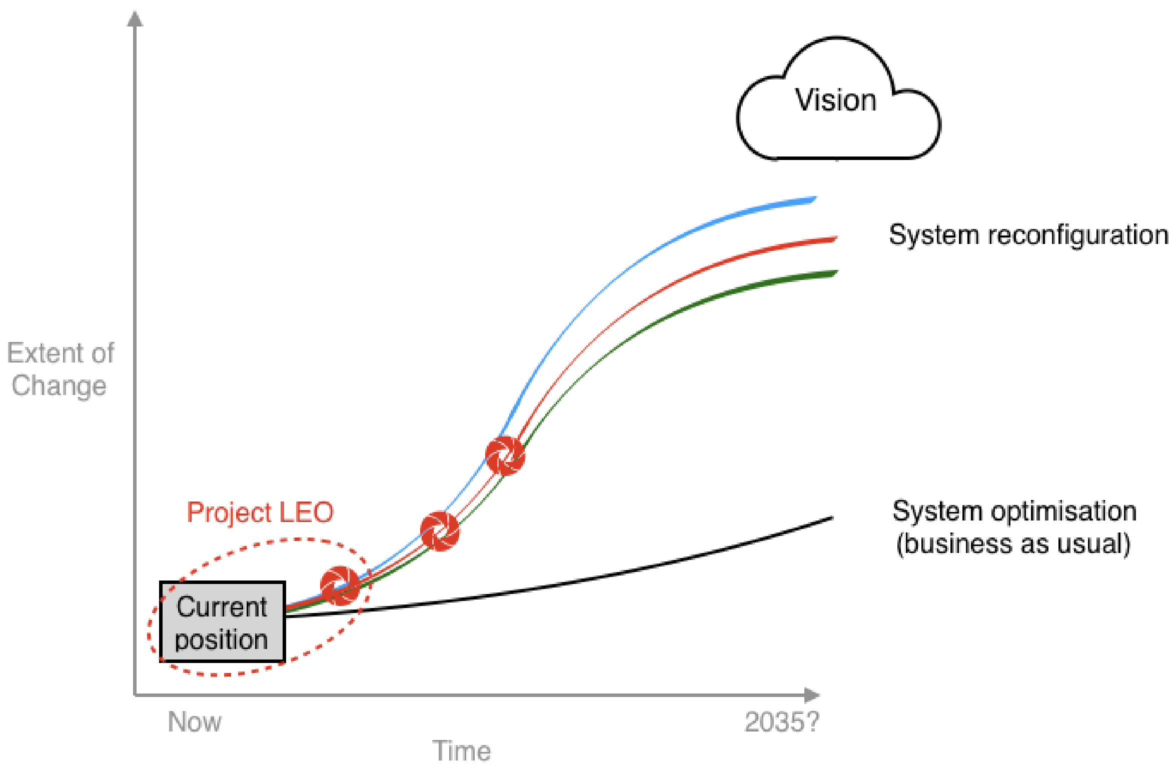


Figure 1: System reconfiguration, from the LEO Inception Report

1.2 Project structure

LEO involves many stakeholders and processes. These include:

- A Distribution Network Operator (DNO), Scottish and Southern Electricity Networks (SSEN), which is transitioning to a Distribution Systems Operator (DSO)[5] and leading the project.
- Market Operators developing and supporting a marketplace in energy and system flexibility (Piclo and Origami). The marketplace operates on a Neutral Market Facilitator (NMF) platform under development by Piclo and according to rules being developed by Origami and SSEN. This platform interfaces with the DSO's 'Whole System Coordinator' (WSC) platform. Hence, the DSO's operational needs can be offered for delivery under contract by the Service Providers via the Market Platform.
- Service Providers offering energy services on the Market Platform developed and operated by the Market Operators. Service Providers include 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) and those working with the public sector and private householders (Nuvve).
- Flexible asset providers. Oxford University, Oxford Brookes University and Oxford City and County Councils bring flexible load in the form of their estates and smart energy projects from intelligent street lighting, vehicle to grid and responsive heat networks.
- Market facilitation and research. LEO is further enhanced through energy systems research capability brought by the University of Oxford and Oxford Brookes University, consolidating multiple data sources and analysis tools to deliver a model for future local energy system mapping across all energy vectors.

These stakeholders and processes work across six Workpackages (WPs). Project partner roles grouped by WP are shown in Figure 2.

[5] 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.

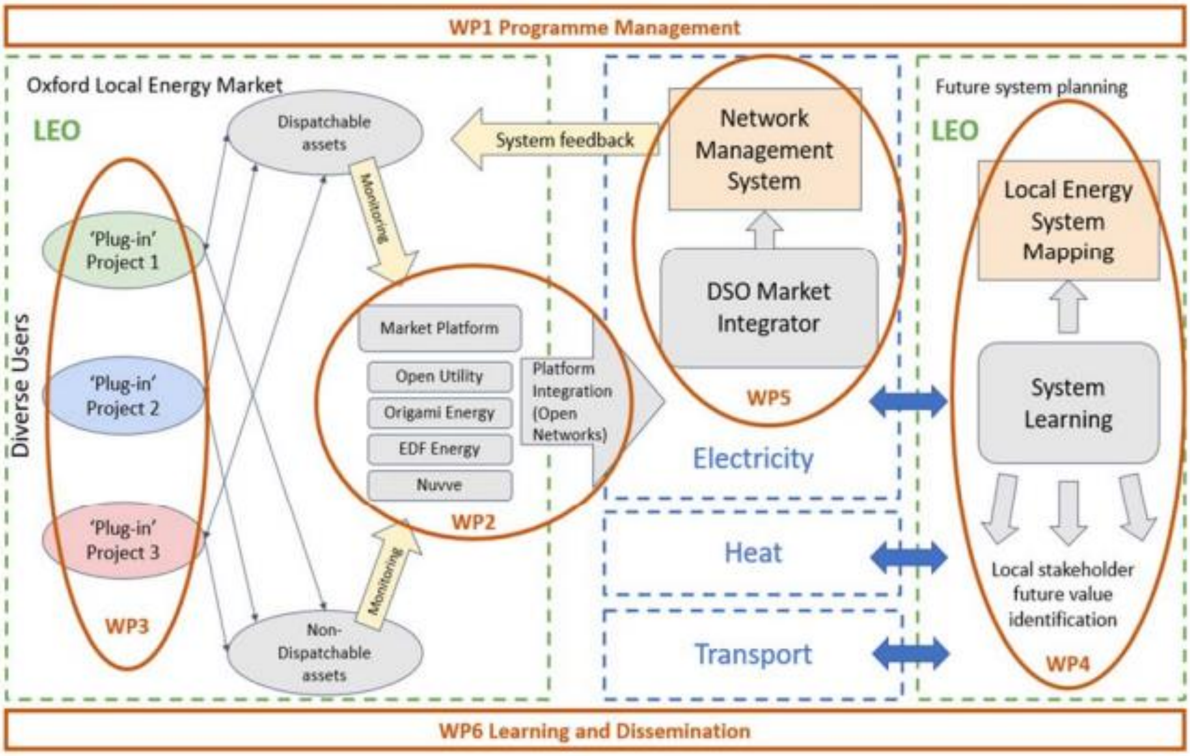


Figure 2: LEO project structure

Workpackages are organised as follows:

1. WP1: Programme Management, led by SSEN. This WP includes a dedicated Programme Manager, who chairs the Project Delivery Board and coordinates budget, programme and risk management for the LEO programme.

2. WP2: Market Platform Development, led by Piclo. A number of market platforms for energy trading, ancillary service to network system operators and potential peer-to-peer (P2P) service provision within the local area are being designed and tested. The WP will demonstrate how potentially competing platforms can interact to provide multiple routes to market for buyers and sellers of flexibility services, the interface requirements between Service Providers and DSO, and the data flows required.

3. WP3: Plug-in Projects, led by the Low Carbon Hub (LCH). In this WP a range of projects that can 'plug-in' to the new marketplace being developed in WPs2 and 5 are under development. The projects will cover a broad range of flexibility and energy services to be bought and sold across the three themes of power, transport and heat. New business models and local energy offerings will be developed and tested through pilot demonstrators which will be able to be replicated nationally.

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

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

6. WP6: Learning and Dissemination, led by the UoO, LCH and SSEN, draws on all project partners to engage local and national stakeholders and share learning from Project LEO.

1.3 LEO visions

The market-oriented 'smart local energy system' (SLES), as conceived by PFER, emphasises technical innovation for cleaner systems with more efficient supply, distribution and storage. Energy users are cast largely in the role of consumers.[6] LEO project partners tend to lay more stress on the human aspect of 'smartness', the significance of different types and scales of demand, and the many roles which people play in energy systems, not least as investors, operators of distributed assets, participants in demand response, and practitioners in energy-related activities and governance.[7]

Experience from the project to date, as set out in this report, indicates that developing the second vision will be necessary for achievement of the first. Much of the learning relates to the ways in which actors connect with each other and with the technologies and data that are being introduced to the energy system in Oxfordshire.

[6] https://www.gov.uk/government/news/energy-systems-of-the-future-local-communities-to-benefit-sooner

[7] This is documented in the Y1 report based on internal stakeholder interviews (available to project partners and monitoring officers) and in the challenges and learnings documented in the Appendices to this report.

2 Process for learning within and from LEO

The aims of LEO and of the PFER programme are the starting point for this report and form the basis for the theory of change. The aim is not to take the usual route of focussing on specific innovations/interventions (assuming that 'if we do x, then y will result'), but to set up and test hypotheses about how the overall aims (to meet Societal Need) will be reached, and to adapt LEO activities in the light of experience.[6] The figure below illustrates the basic learning cycle envisaged for the project; there is a description of the method in Section 5 (Data).

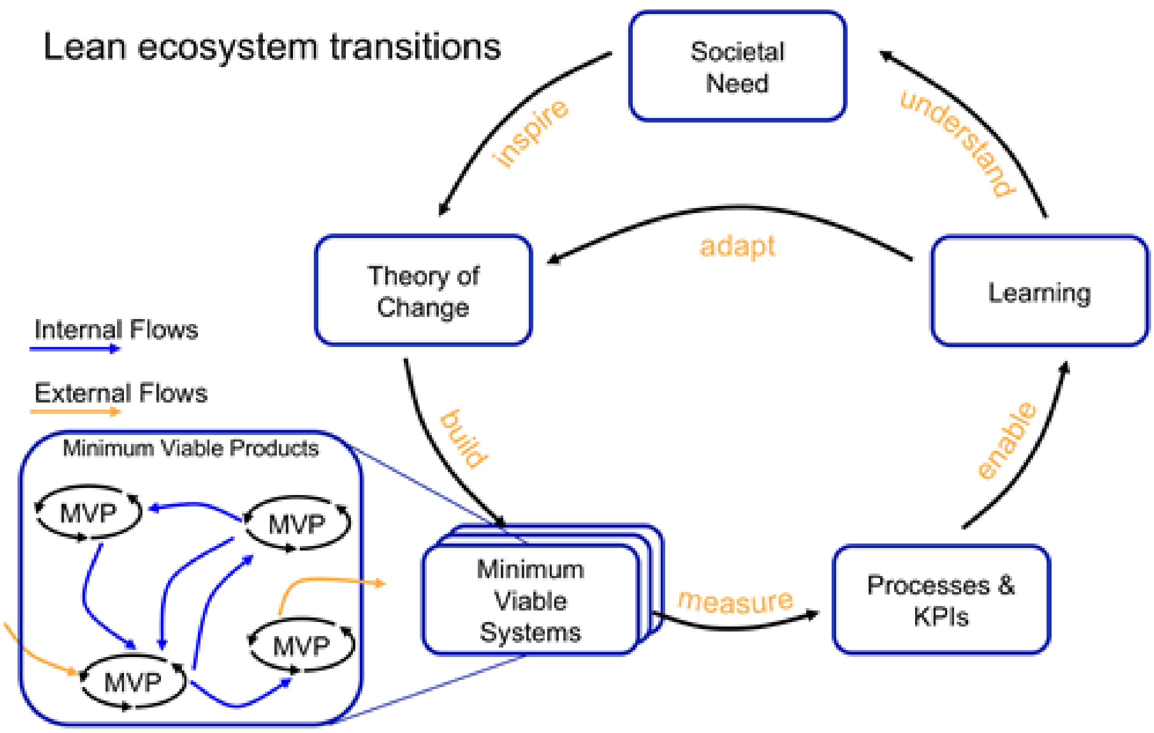


Figure 3: Information flow in the Lean Ecosystem Transition method

The bid document for Project LEO states the centrality of learning: the project will be 'continually improved through the collection and analysis of temporal and spatial data to provide insights to the team and to inform the County's energy strategy. This strong evidence base will enable rapid rollout across the UK and beyond.'

The project has a work package (WP6), to capture processes and skills for developing a smart local energy system; WP6 is also responsible for engagement and knowledge dissemination. Led from the UoO, it directly includes the project partners SSEN and LCH and draws on the work of all other partners.

Project partners are responsible for developing Key Performance Indicators (KPIs) to measure outcomes, in line with the aims stated above. This is not always straightforward, partly because of different interpretations of terms such as 'cheaper', 'more prosperous' and 'efficiency'; partly because of the difficulty in measuring or assessing some qualitative impacts of the project, or in attributing outcomes to specific processes. LEO is also committed to an agile learning approach in which a Theory of Change (ToC) is hypothesised, tested and modified as the project proceeds.

LEO and the other demonstrator projects collaborate with researchers from EnergyREV to evaluate progress. Their evaluation process is broadly in line with theory-based evaluation methods for evaluating complex socio-technical change. Project partners develop an initial theory of change (ToC) to hypothesise how changes are likely to come about during the project. This can be codified in the light of experience. The process can then be made more specific by including Realist/Realistic Evaluation methods, to assess 'what works, for whom, in what circumstances'.[8] These two approaches are not incompatible, but there are some challenges in working out how best to use them to improve learning[9].

Evaluation is not only taking place within LEO (in association with EnergyREV). The Energy Systems Catapult has set up the Energy Revolution Integration Service, ERIS, 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."* ERIS is setting up its own evaluation programme and, based on early discussions, there are significant differences between their broadly techno-economic approach and the combination of Realistic Evaluation and Theory of Change adopted by EnergyREV and LEO. The researchers involved in each are aware of the need to develop common understanding of terms and make explicit what each can contribute, and the metrics and indicators they consider most suitable. More work will be needed on this.

2.1 Stakeholders and actors

The range of stakeholders is broad. Those internal to the project, the project partners, fall into five categories:

- 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;
- the local authorities – Oxfordshire County Council and Oxford City Council;
- the supply industry and market-enabling partners – Piclo, Nuvve, EdF and Origami Energy; Oxford and Oxford Brookes universities.

[8] 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.

[9] A useful guide is given by Blamey and Mackenzie (2010): "We suggest that many policy programmes lend themselves to the explicit testing of a dual Theories of Change/Realistic Evaluation model. This might entail the use of Theories of Change as a means of explicating implementation theory for the purpose of ... planning, improvement and the development of robust monitoring systems at a macro programme level. Realistic Evaluation approaches might then be brought to bear on more micro level aspects of the most promising programme theories. For example, while Theories of Change might help develop a more detailed understanding of how a smoking cessation programme was being implemented at the national and local level and the challenges in giving life to policy aspirations, Realistic Evaluation could help us to illuminate if and why specific elements of the intervention work in particular groups or settings". (Blamey, A. and Mackenzie, M. (2007) Theories of Change and Realistic Evaluation. Peas in a pod or apples and oranges? *Evaluation* 13 (4), 439-455.

Externally, our stakeholder workshop in December categorised and mapped stakeholders 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, such as 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 such as the RSPB, landowners and the Local Energy Partnership;
- are active or passive contributors to system operation, as energy users and domestic/business customers and prosumers;
- are actual or potential learners from LEO, including researchers, the Energy Networks Association and local authorities around the country.

This categorisation is being used to develop a stakeholder engagement strategy, building on a workshop held by EnergyREV that set out potential routes for setting up dialogues with different stakeholder types and attempting to influence and learn from them.

2.2 Developing a common language

WP6 is developing an agreed terminology for stakeholders in relation to their functions in an energy system. Some key terms are shown in Table 1.

Table 1: Glossary of terminology

Term	Description	Example
General		
Project Partners	Consortium partners as named in the collaboration agreement, including Origami	SSEN, LCH
Stakeholder	An individual, group or organisation who may affect, be affected by or perceive themselves to be affected by, a decision, activity or outcome of a project	EV-owning householder, Oxford Bus Company, Cherwell District Council
Minimum Viable System*		
Lead	The lead person co-ordinating an MVS. There is usually only one per MVS.	Usually a LEO partner, WP4
Doer	Those people in the team directly involved in implementing, or 'doing' the MVS. *These would usually be drawn from within the consortium or people acting on the consortium's behalf*	LEO partners in WP4, SSEN, Facilities manager at Sackler Library
Host	The organisation who is the interface or middle actor for the MVS. NB within the organisation host stakeholders may have different roles e.g. gate keeper (giving permission), facilitator	Oxford Bus Company, Sandford Hydro, University of Oxford Estates Dept.
Participant Passive or Active	Any individual who is directly affected by the MVS. An active participant chooses to take part, whereas a	An EV driver who chooses to install a charging point is an active participant, a library

	passive participant is affected by virtue of their relationship with the host, rather than by choice.	user in the Sackler library is a passive participant
Analyst	Take the data from the project and turn it into learning	LEO partners, with lead from WP6
Disseminator	Those who will take the learning and share it with others through a range of different techniques e.g. training, conference and workshop presentations	LEO partners in the first instance
Learner	Recipients of the learning	Anyone! They will have different needs depending on their roles.
Replication and scale up		
Key holders	Those with the power to make binary yes/no decisions that enable, or prevent, any replication in the real world from occurring. ‘On/off switches’	e.g. Ofgem
Amplifiers	Individuals and organisations who can amplify or dampen scale-up ‘volume control’. This could be by directly adopting the opportunity themselves, or through their influence on others	e.g. Low carbon community groups could replicate a business model, Consumers’ Association could caution consumers against participation
Local Energy Markets and DNO transition		
Distributed Energy Resource (DER)	Electricity producing resource or controllable load directly connected to a local distribution system	Sandford Hydro
Distribution Network Operator (DNO)	Distribution Network Operators (DNOs) are companies licensed to distribute electricity from the transmission grid to homes and businesses by the Office of Gas and Electricity Markets (OFGEM).	SSEN in its current form
Distribution System Operator (DSO)	A DSO securely operates and develops the electricity distribution system and facilitates the platforms allowing providers of flexibility to offer services to meet the DSO’s operational needs whilst also opening access for service providers to trade with one another (Peer 2 Peer services).	SSEN transitioning from DNO to DSO
Market Integrator	The Market Integrator is the DSO interface with Market Place Operators	In the TRANSITION project this function is delivered by the Neutral Market Facilitation Platform (NMFP)
Marketplace Operators	A company that operates a Market Platform to provide a route to market for Service Providers	In the LEO project the Marketplace operator is Piclo
Market Platform	The mechanism by which Marketplace Operators facilitate contact between Service Providers and those buying flexibility (i.e. the DSO and others)	Under construction by Piclo – the “flexibility exchange”
Service Providers	These provide flexibility or energy solutions to ends users including the DSO. Service Providers may own or operate DER or trade contracted capacity. They offer their services through the Market Platforms operated by the Market Place operators.	Low Carbon Hub, Nuvve, EdF

*Note that there are three categories of MVS to be tested within the project. These are:

- Flexibility Services (MVS A)
- Geospatial Planning (MVS B)
- Influencing Policy (MVS C)

3 Building a Local Energy Market

Developing and testing a Local Energy Market capable of delivering the objectives of the PFER programme is the core activity of the LEO project. WPs 2 and 5 have carried out the key tasks for this purpose.

3.1 Market forces

Decarbonisation, Decentralisation and Digitalisation are transforming the UK's electricity resource mix. In 2019, renewables already account for over 30% of the capacity mix. In addition, 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 at lower voltages by 2030 in comparison to 29% today: energy supply is becoming decentralised[10]. Digitalisation and internet-connected sensing technologies are also transforming control and monitoring systems and creating platforms for new business models built around meeting the near real time needs of the electricity distribution network.

Two more "D" s should be added to the mix – Democratisation and Demand. With microgeneration technology becoming widely adopted and smart affordable control systems increasingly available, small businesses and households can participate in the provision of system services. The shape and volume of electricity Demand is also shifting, especially as heat and transport become electrified, and Demand is becoming potentially more flexible. Simultaneously, an increasing proportion of generation is becoming intermittent and decentralised and therefore *less* flexible, predictable and responsive. As a result of these changes, spatiotemporal nodes (transformers, cables) in the network are coming under increasing stress but there are also new opportunities to manage network constraints using smart technologies.

Necessary changes to network infrastructure can only be sustained in a way that is economically efficient if there are corresponding changes to the structure and functioning of the electricity market. For example, the value of flexibility to different actors at different locations and times must be clearly signalled and tradeable.

3.2 People in the energy market

The objectives of the PFER programme recognise opportunities not only to solve the technical challenges described above but also to build 'more prosperous and resilient communities'.[11]

[10] Towards a new framework for electricity markets. Report by Poyry for Energy Systems Catapult. October 2019
[11] https://www.gov.uk/government/news/four-leading-edge-demonstrators-to-jumpstart-energy-revolution

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.

LEO envisions new roles for people, communities and organisations within the energy system that move beyond the conventional producer-consumer paradigm. It is exploring how to create a market that not only meets grid and distribution network operational needs but also delivers social and environmental benefits: *"A smarter energy system will provide new opportunities for communities to engage and for low carbon technologies to compete with solutions in an open and fair market. LEO is testing how we turn the aspiration of a system that supports community engagement into a reality."*[12]

3.3 Local energy market design

The market structure identified as best suited to delivering these outcomes is the Local Energy Market (LEM). In a LEM, only assets (distributed generation, storage and demand side response) within a defined geographical area (Oxfordshire) can participate. These resources can sell their energy or services either locally (e.g. in P2P flexibility services or to the DSO, here SSEN), or as services on national markets managed by the Electricity System Operator (ESO). Especially for the latter, they may be aggregated. This allows ancillary services to be procured by the ESO to balance supply and demand, and to ensure security and quality of supply. Flexibility enables lower variable charges to customers for use of distribution and transmission networks. These opportunities can be 'stacked' to deliver multiple revenue streams or cost reductions.

The source of revenue available to local assets via the marketplace depends on the design of the local market platform and how it interacts with actors in the wider system[13].

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 the local market and national markets (e.g. the balancing mechanism operated by the Electricity System Operator) will pose operational, policy and regulatory challenges. The establishment of new processes for reconciling and settling transactions at multiple levels between markets is a key issue that should be considered at an early LEM design stage[14]. In response to these challenges, the embryonic Local Energy Market in LEO operates at two levels:

[12] Melanie Bryce, LEO programme director, SSEN. Reported in pp 32, Network, March 2020, Issue 40. https://networks.online/power/the-pride-of-oxfordshire-project-leo/
13 The Policy and Regulatory Context for new Local Energy Markets. ERIS (Energy Systems Catapult. October 2019. Available at: https://es.catapult.org.uk/reports/the-policy-and-regulatory-context-for-new-local-energy-markets/?download=true
[14] The policy and regulatory context for new Local Energy Markets, ERIS (2019) Op.Cit.

1. The Neutral Market Facilitation Platform[15] (NMFP) under construction as part of the TRANSITION project[16]. This platform will only serve Oxfordshire in LEO but, if successful, could serve all of SSEN's licensed areas. The NMFP interacts with another new DSO system, the Whole System Coordinator (WSC)[17]. The WSC assesses options for mitigating network constraints. These could include contracting for energy and services via the NMFP.
2. The NMFP hosts a Flexibility Exchange Platform, under construction by Piclo. This platform allows flexibility service providers to contract for requested services. Services can be requested either from the DSO or from third parties in P2P arrangements. The service providers in LEO are the Low Carbon Hub, Oxford Behind the Meter (OBM), Nuvve, Origami and EdF.

The structure of the LEO local energy market is shown in

Figure 4: LEO stakeholders and services structuring the Local Energy Market.

[15] The Neutral Market Facilitator (NMF) allows flexible energy resources connected at the distribution level to access, and be accessed by, the different markets to which flexibility has value at regional or national level. The NMFP will be open to external parties, including flexibility providers such as aggregators, the ESO, at least one DSO in a DNO region, IDNOs/IDSOs, local energy markets, and potentially DSOs and similar parties from other DNO regions.

[16] The high-level system architecture under development in TRANSITION is described in High Level Solution Design Summary. November 2019. Available at: https://ssen-transition.com/wp-content/uploads/2019/11/High-Level-Solution-Design-Summary-v1.pdf

[17] The Whole System Coordination (WSC) component for TRANSITION will be the DSO's point of interaction with the NMF. Where the DSO has identified a constraint, the WSC provides the assessment of mitigation options. These can include use of Active Network Management or Distribution Management Systems where available, calling off from existing contracted options for the use of suitably located flexible resources or contracting for additional flexibility via the NMF. The purposes of a DSO's WSC include coordination with the ESO and other DSOs to enhance reliability and effectiveness of electricity networks as a 'whole electricity system'.

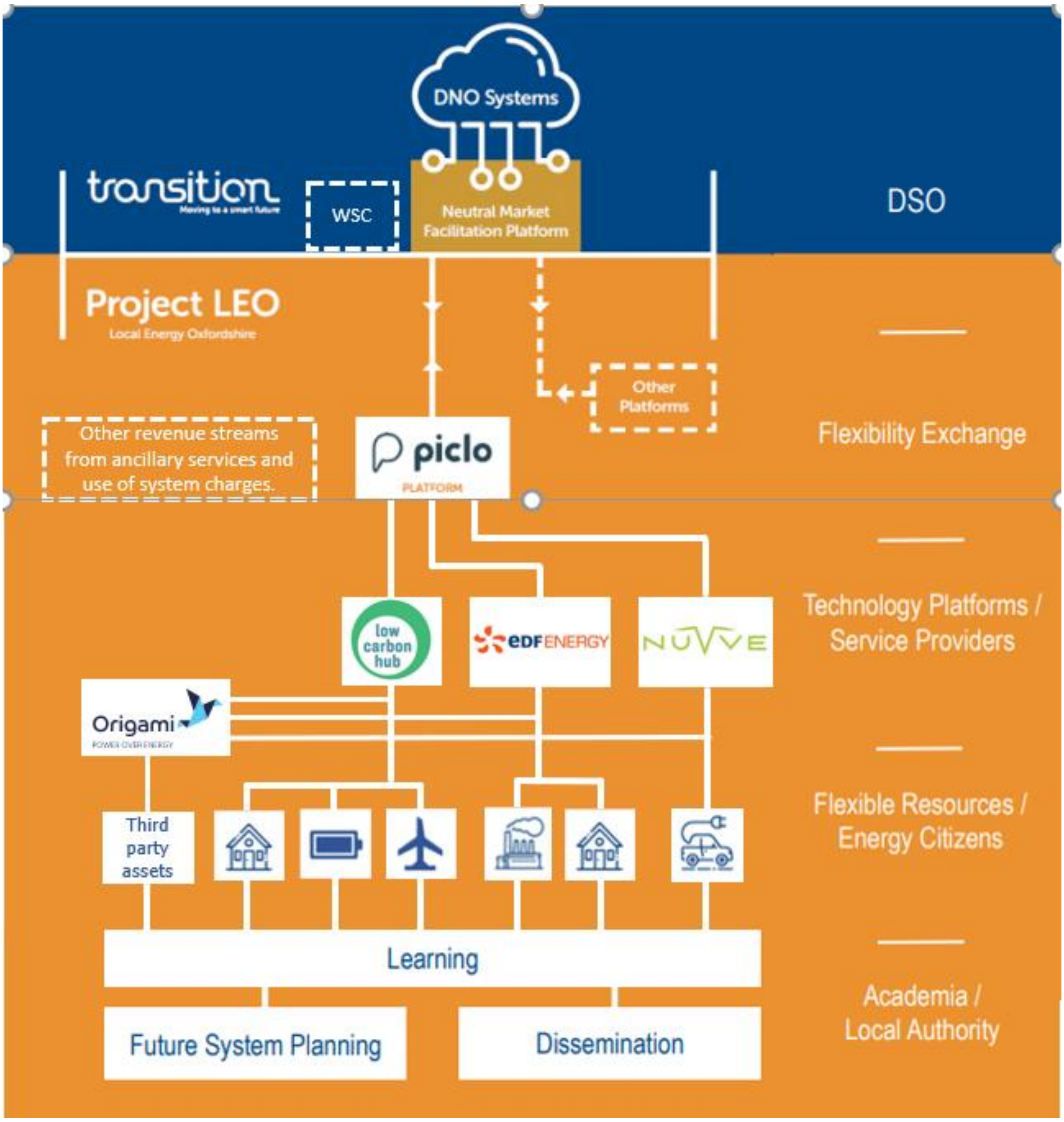


Figure 4: LEO stakeholders and services structuring the Local Energy Market

3.4 TRANSITION market rules and network services

SSEN's Ofgem-funded TRANSITION project is integral to LEO, in particular WP5. Based on the intermediate outputs of ENA's Open Networks project[18], TRANSITION is:

- designing the Neutral Market Facilitator (NMF) platform,
- developing the roles and responsibilities of actors within the marketplace,
- developing the market rules required for the trials, and
- implementing and testing the concept of the platform.

The NMF Platform will be market-agnostic and provide the information and visibility necessary for a range of markets to operate.

A key activity during Q3 and Q4 of the project has been to develop a trial philosophy, flexibility services and the Basic Market Rules governing operation of the flexibility market, to be tested within the Project LEO trial environment. 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[19].

The flexibility market must address key network constraints resulting from the changes in energy demand and supply outlined above. These operational needs have been identified as:

1. Recovery following planned or unplanned outage
2. Conditional increase or reduction of metered output
3. Planned increase or reduction in metered output
4. Conditional reduction or increase in import or export
5. Conditional or planned P2P services.

The services required to meet these needs have been identified as:

1. Constraint Management
2. Peak Management
3. Short Term Operating Reserve (STOR)
4. Exceeding Maximum Import or Maximum Export Capacity (MIC/MEC)
5. Offsetting.

Further details can be found in the 'Services in a Facilitated Market' document, available on the TRANSITION website[20]. Table 2 below shows how these services address each of the DSO's needs in maintaining a balanced local network and creating opportunities for third parties to provide flexibility energy services (e.g. P2P trading).

[18] https://www.energynetworks.org/electricity/futures/open-networks-project/
[19] 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
[20] Services in a Facilitated Market; SSEN, Origami; 2019; https://ssen-transition.com/library/

Table 2: DSO needs and required services to be facilitated by the local energy marketplace

Service	Delivery	Recovery following planned or unplanned outage	Conditional increase or reduction of metered output	Planned increase or reduction in metered output	Conditional reduction or increase in import or export	Conditional or planned P2P services
DSO Constraint Management	Triggered	X	X	X		
Peak Management	Dispatched			X	X	
Short-Term Operating Reserve	Dispatched			X	X	
Exceeding Maximum Import or Export Capacity	Dispatched				X	X
Offsetting	Dispatched and / or Triggered		X	X	X	X

The second phase of Minimum Viable System (MVS) trials will be developed to align with these services, along with consideration of operational and near-term plug-in projects. These services will be coordinated using the LEM platform (flexibility exchange) under development by Piclo.

3.5 Design and testing of the Flexibility Exchange

Piclo created an innovation environment on the Piclo Flex Platform during Q1-2 of the first year. All LEO partners were given accounts to access this and were provided with a demonstration on how to use the platform. This allowed testing of the new online flexibility trading services. Piclo also hosted a workshop to establish the project's MVS concept. This proved very valuable in setting out an agile and iterative process for testing flexibility within LEO, utilising the Flex Platform.

Piclo's flexibility exchange process has four stages:

1. Procurement. Asset operators and aggregators make available their flexible capacity through automatic and semi-automatic processes facilitated by the platform. These are matched to required services through 'qualification' procedures (e.g., is the asset delivering the service connected to the required part of the network?). Qualifying services are then compared in a competition and whichever delivers best value is selected.
2. Operations. Automatic and semi-automatic processes then procure the services as necessary (with checks that the service is still available at the time/location required) and the instructions to dispatch the service are sent.
3. Settlement. In the penultimate stage, the dispatch of the requested flexibility is verified and the settlement process is triggered.
4. Feedback. The final stage evaluates the process, capturing ratings and data for analytics so that the system can be continuously improved.

These stages are shown in sequence in Figure 5.

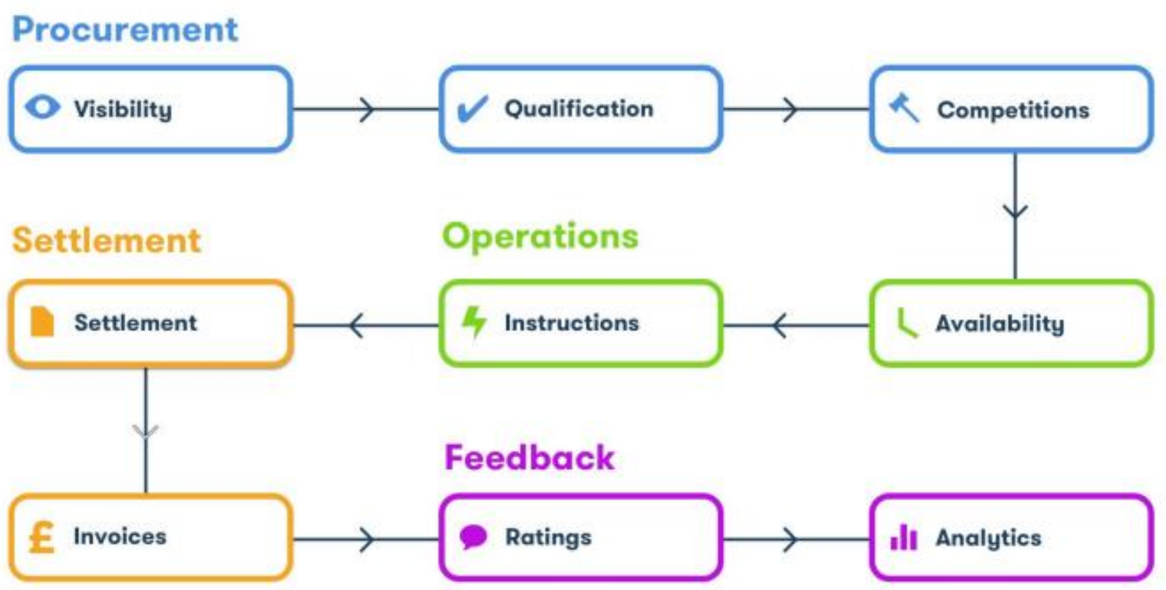


Figure 5: Stages in procurement of flexibility. Source: Flexibility and Visibility, Piclo, 2019[21]

Piclo will carry out further development and testing of new flexibility services on their platform and expects to publish a White Paper on its findings on the value of flexibility markets.

Work has also been ongoing to review new types of flexibility services and analyse the value of different markets. Independent consultant Graham Oakes was commissioned to analyse and report on sources of value in flexibility markets.

3.6 Learnings from local energy market development

Detail of the learnings from this part of the project are captured in a series of reports published on the TRANSITION website. Key reports include:

- The high-level system architecture under development in TRANSITION, described in *High Level Solution Design Summary*. November 2019. Available at: https://ssen-transition.com/wp-content/uploads/2019/11/High-Level-Solution-Design-Summary-v1.pdf
- The development and rationale for key flexibility services, described in *Services in a Facilitated Market*; SSEN, Origami; 2019; https://ssen-transition.com/library/
- The development of Basic Market Rules, set out in https://ssen-transition.com/wp-content/uploads/2020/02/Market-Rules-Development-Phase-1-v1.0.pdf

Other learnings from WPs 2 and 5 relate to processes and procedures, addressed below.

[21] Flexibility and Visibility. Investment and opportunity in a flexibility marketplace. Piclo. 2019. Available at: https://piclo.energy/publications/Piclo+Flex+-+Flexibility+and+Visibility.pdf

3.6.1 Developing system architecture and protocols

There remain gaps and uncertainties in the end-to-end procedure of procuring and delivering flexibility. There is a need for clearer requirements for parts of the procedure relating to testing, baselining and settlement. A particular area of challenge is the development of processes to facilitate shorter-timescale flexibility procurement. At a higher level, partners also mentioned ongoing work to ensure integration with the Neutral Market Framework.

Testing MVS on the platform also highlighted the need for standard definitions across partners, to reduce confusion. For example, when specifying an 'excess' or 'deficit' competition, is excess or deficit defined in terms of the network or the assets? A project glossary for financial, technical, commercial and social terms is needed and work on this has begun in WP6. It will include the glossary compiled for the ENA led Open Networks Project.

3.6.2 Developing flexibility processes

Platform partners within the WP2 together with Origami have developed flexibility process consistent with the flexibility exchange process in Figure 5, developed from the perspective of market actors. The flexibility process includes 22 detailed steps considering the actions and roles of the market actors, as depicted in Figure 6:

Figure 6: Bringing flexibility to the market

This draft process will be refined to reflect the functionality and requirements for NMFP and WSC before being published and trialled though the MVS process.

3.6.3 Sources of learning

There has been a mix of learning from within and beyond LEO. Partners reported good learning from the Origami Market Rule Simulation events and the MVS Group A (flexibility services) process - particularly around dispatch instructions and competition requirements. Partners also report developing deeper understanding of the market rules around Authorised Supply Capacity Trading and Peak Management and where they could be improved as a result of the Origami sessions.

Stakeholder mapping and site selection workshops have also been valuable as events where partners learn from each other. Also, trial planning, to identify LEO partners' goals, has helped to align objectives and identify sites for monitoring. The WP5 Site Selection Questionnaire was also very helpful for this. Thinking through market rules and services has established needs for additional MVS to test ideas.

SSEN also report that TRANSITION collaborations with the other two major projects funded by Ofgem exploring transition to DSO are proving extremely useful (Electricity Flexibility and Forecasting Systems (EFFS), led by Western Power Distribution and FUSION, led by SP Energy Networks)[22]. Particularly fruitful learnings are related to the use of forecasting, creating procurement efficiencies and reducing stakeholder fatigue.

There are still many uncertainties on the value of DSO flexibility for WP2 participants. Analysis of a report on the GB flexibility market for Piclo by Element Energy and Graham Oakes is still ongoing. Partners are considering how best to use this report's findings, for example in the creation of new services or other trading opportunities facilitated by the platform.

4 Minimum Viable Systems and Site Selection

WPs 3 and 4 involve development and testing of flexibility services and other supporting systems needed for a local energy market to thrive. A minimum viable version of the proposed service is developed to tackle a pseudo-grid problem or an aspect of the LEO local energy ecosystem that needs to change (such as analytic processes to generate data on network constraints, or new build housing policies). These prototype products and services are termed, "Minimum Viable Systems" (MVS).

In order to capture learnings effectively and rapidly, a generic MVS Trial Procedure was developed. Learnings from each trial inform the next iteration of the MVS. This procedure nests within the 'Lean Ecosystem Transition' methodology, the framework used to develop components of the LEO Local Energy System. The Lean Ecosystem Transition approach led to the identification of three categories of MVS that will be tested within the project. As noted above, these relate to flexibility services (MVS A), geospatial planning (MVS B) and Influencing policy (MVS C).

[22] Collectively the 3 projects are known as T.E.F. A condition of the Ofgem funding for these three projects was that they should share learnings where possible to avoid replication.

MVSs will be developed using assets that are 'internal' and 'external' to Oxfordshire, as shown in Table 3.

Table 3: Potential internal and external flexibility assets to be deployed.

Internal assets	External assets
• Oxford Behind the Meter buildings, including the Oxford University Sackler Library • Oxford City and Oxfordshire County Council buildings and vehicle fleets. Also, Council data and expertise in developing a land use map and planning tool (geospatial planning MVS B) • Buildings, systems and neighbourhoods from the LCH portfolio of owned or operated assets, including Sandford Hydro • Nuvve aggregation of vehicle charge points	• EdF portfolio of Industrial and Commercial customers able to participate in demand side response • EdF generation and storage • Origami clients

In year one, the project has focused on MVS category A but significant work has also been completed on developing a land use map for energy master-planning in Oxfordshire (category B).

4.1 Site selection approach

Selection of sites for trialing the next round of MVS, and then the pre-trial and full-trial local energy systems, is ongoing. The primary criterion for selection is that a trial at a particular site delivers the maximum learning possible in the context of the portfolio of LEO trials. That is, repetition of trial conditions (e.g. technology, voltage level, service type) should be avoided if possible. However, there may be a case for some trials to be repeated so that some conditions (e.g. technology type) can be controlled for, so that the effects of iterative changes can be more easily observed.

4.1.1 Site selection logic

Site selection is an iterative process with overlapping steps. In outline, these are:

1. Each partner identifies their flexibility assets in Oxfordshire –already in existence or potentially available in the short to medium term.
2. All assets are placed on a register, recording technology type and location.
3. Each asset is assessed on criteria including ability to deliver the network services outlined above (constraint and peak management, P2P trading and STOR).
4. Asset connections are mapped to SSEN secondary and primary substations.
5. Primary substations offering the best mix of assets and potential deliverable services to the network at that node are selected (12 have been selected).
6. The area served by each primary substation is characterised by socio-economic and physical criteria (e.g. housing type).

7. The twelve selected primary substations are grouped by their geography and network dimensions, including connectedness. (Four groups identified.)
8. The mix of flexibility technologies, housing and other development types in the area served by each grouping of primary substations is identified.

Figure 7 illustrates the process.

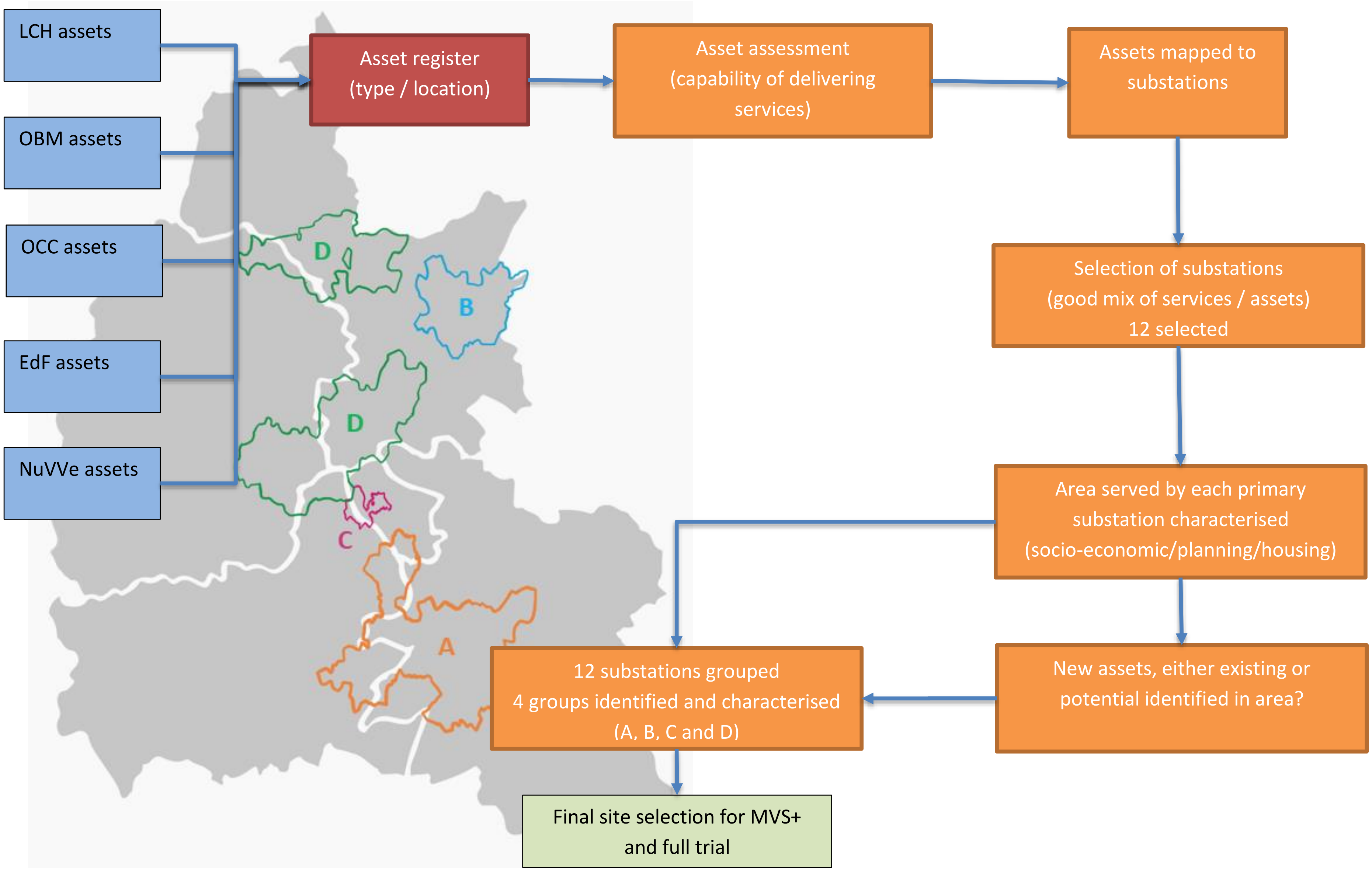


Figure 7: Site selection process

4.1.2 Site selection process

Site selection involved a mix of workshops, desk-based analysis and the completion by all partners of a questionnaire. A Site Selection/Trial Planning workshop was hosted by SSEN TRANSITION / WP5 team on the 30th - 31st January (2020) in Cumbernauld. The purpose of the meeting was to

- provide the LEO partners with an understanding of the DSO services to be trialled by TRANSITION,
- understand the current landscape of flexibility assets from LEO partners and their approach to recruiting new assets, and
- establish the suitability of the assets to fulfil service trial requirements.

The workshop provided all LEO partners with a clear understanding of the five DSO services to be trialled by WP5, and of the available flexible assets provided by each of the LEO partners in terms of technology, geography, demographics and whether they were generation or demand-led. WP5 delivered a teaching session on system configuration and options for alternative flows in the event of faults or planned maintenance work, giving all partners a basic understanding of regulations such as P2/7 which govern the security standards on the distribution system.

Partners began to identify the preferred primary substations for running service trials. A follow-up workshop on the 20th March 2020 was held online, which continued the discussions held in January, finalised the selection of primary substations, developed the site selection process further and clarified requirements for the next round of MVSs.

4.2 Processes for site selection and recruitment of flex providers

WP2 partners are determining strategies for identification of flex providers and customers once substations are chosen. Each partner’s process as currently developed is described in outline below.

4.2.1 EdF

EdF has developed a process for identifying and recruiting flexibility providers amongst its Industrial and Commercial (I&C) customers. For LEO, EdF have analysed the size and distribution of their I&C customers in Oxfordshire. This includes analysis of which primary substation these customers are connected to, average and maximum power, and total electricity consumption. Customers are then filtered by minimum power demand and by sector, as some sectors have consumption profiles and on-site activities which are better suited to flex, such as large amounts of cooling or electric heating. To assess the technical suitability of each customer for participating in flexibility markets more precisely, EdF have developed a suite of in-house tools including a demand response profile tool that analyses half-hourly consumption data in conjunction with data about activities on site, behind-the-meter generation etc. Outputs of this tool include:

- bill analysis (energy costs and non-energy costs by half hour period),
- power histogram (number of operating hours at each power band),
- disaggregation of energy consumption by use (lighting, computing, ventilation, heating etc),

- impact of external temperature on heating and cooling energy demand,
- annual 'heatmap' of energy consumption, and
- pattern analysis.

Once desktop analysis establishes technical feasibility of a site, the customer will be contacted to validate assumptions in the desktop analysis, arrange a site visit and progress to becoming a flexibility provider.

4.2.2 City, County and District Councils

The councils are exploring opportunities for flexibility across their corporate assets. These include:

- 130 buildings across Oxfordshire (offices, libraries, fire stations, family centres etc.). There is ongoing analysis of energy consumption and power demand at these buildings;
- exploration of the potential for rooftop solar on Council buildings;
- electrification of their vehicle fleets and installation of charging infrastructure on Council-owned housing estates;
- upgrading to smart streetlighting, including converting all streetlights to LED and introducing a wireless central management and control system. The streetlight upgrade programme includes ambitions to include EV charging facilities. Dimming and trimming of the smart lighting is also being trialled.

In addition to this technical work, the Councils have partnered with Low Carbon Hub to work up engagement strategies for residents in social housing. This will be integrated in the engagement strategy under development in WP6.

4.2.3 Low Carbon Hub

In addition to using some of their existing portfolio of generation assets, LCH is exploring development of a software platform to communicate with and control DER. The aim is to build a system capable of delivering different types of automated flexibility service using real- time high-resolution data, able to interface with different market platforms (including those under development in LEO) and to allow distributed assets to be aggregated and accessed by third parties. LCH is developing an ethical framework to govern the recruitment of assets, project design and evaluation. Integral to this is the guiding principle that for the transition to local energy systems to be effective it must deliver both technically and socially, so that all sectors of society benefit from a transformed energy system, particularly low income, vulnerable and disadvantaged groups.

4.2.4 Origami

As a technology platform, Origami has the capability to enable flexible assets to deliver flexibility services, providing visibility, control and monitoring functions. For projects LEO and TRANSITION, Origami has engaged with project partners to use its commercial platform and support the delivery of a variety of flexibility services for the benefit of ESO, DSO and P2P markets.

As a market expert, Origami has also developed analysis and processes to identify suitable assets to provide flexibility for the DSO services and P2P services. The process of assessment consists of:

- Identification of flexibility
    - Identification of flexibility provider and flexible assets.
- Flexibility validation
    - Assessment of ability of an asset to deliver flexibility services.
- Estimation of income from flexibility services
    - Understand the value of DSO enabled and DSO procured services to determine viability of business case.
- Flexibility enablement
    - Enable the use of flexibility from assets and prove services can be delivered from assets.

In addition to collaboration with project partners to enable the delivery of services, Origami clients may participate in the LEO marketplace as external flexibility providers if appropriate.

4.2.5 Nuvve

The process for site identification for Nuvve differs from that of other partners, who must first conduct technical feasibility work to assess the suitability of consumption or generation profiles. Nuvve must simply identify sites that have EV chargers installed. It does this through collecting data from

- EV charger installers,
- the Oxford 'EV Breakfast' events,
- other projects with charger funding,
- word of mouth from customers.

Word of mouth has proved the most successful channel. Eight sites in Oxford have been identified and engaged in discussions; one has signed and completed a DNO application; one has an application contract in progress; and four sites are in discussion about contracts. Once engaged, the site/ fleet usage is analysed for V2G potential, flexibility service offerings and estimated financial rewards.

Figure 8: Installation of 10 V2G chargers in London

4.3 Completed first round of Minimum Viable Systems

Year 1 has seen completion of the first round of MVS in category A. The specifications and learnings from each are briefly summarised in Table 4.

Table 4: MVS A design and learnings

MVS	Aim of trial	Asset specifications	Learning outcomes
MVS A1.1 Oxford Bus Company (OBC) Battery: Export to Grid MVS A1.2 Remote Dispatch  The Low Carbon Hub (LCH) own the solar array while OBC own the battery storage.	To trial the dispatch of a flexible storage asset in response to a SSEN advertised flex request through the Piclo platform. MVS A1.1 consisted of a 30kW export (demand reduction equivalent) for 1 hour between 13:00 and 14:00 on the 18th November 2019. MVS A1.2 consisted of a semi-automated 30 kW export (reduction in net demand) scheduled for the 5th December 2019 for 1 hour, 11:00 - 12:00.	A 30 kVA, 90 kWh battery system, co-located with a 140 kWp solar array at the Oxford Bus Company (OBC) depot on Watlington Road, Cowley, Connected at the 400V LV level	• The battery was only configured to import power from the grid and was unable to feed power back to the grid. This was remedied through changes to system software. • Clarification of metering infrastructure for the DSO or service provider, to be able to validate that the correct service was delivered by a particular asset. • Clarification of procedural steps and the recording of data on the Piclo platform. • More data to understand future MVS attempts and trials – e.g. email and text threads. • MVS A 1.2 revealed new issues with use of the Piclo platform e.g. a lack of clarity on the registration of constraints on the platform. 'Deficit'/ 'surplus' meanings were unclear and needed to be amended.
MVS A2.1 - Sandford Lock Hydro: Generation Increase  Sandford Hydro is owned and operated by the Low Carbon Hub (LCH)	A planned DSO constraint management service using a flexible generation resource. The trial was planned as a 100 kW increase in generation event at Sandford Secondary Substation, for 1 hour between 11:00 and 12:00 on the 28 th of November 2019. A competition was registered on the Piclo LEO platform for the proxy flexibility service.	Sandford Lock 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.	• Although delivery of the Sandford Hydro service failed (compared to the procured 100 kWh), due to a failure with one of the sluice gates, important questions were raised for the DSO, SSEN on delivery failures e.g. penalties, notice periods and the secondary bid process associated with assets and services that fail to deliver. • MVS A2.1 allowed further refinements of the Piclo platform, as a few technical issues were raised when registering the asset and delivering the subsequent service
MVS A3.1.1 – Oxford Behind the Meter: Sackler Library Demand Side Response  MVS 3.1.2 rerun of the trial	MVS A3 concerns building demand-side response (DSR) for flexibility services and initially focusses on buildings within Oxford through the Oxford Behind the Meter (OBM) plug-in project. MVS A3.1.1. was a 20 kW demand turn-up event, to run between 13:30 and 14:30 on the 12th December 2019. This was postponed to following week due to comms issues in the BMS. MVS A3.1.2 was the rescheduled trial on the 17th December.	The increase in demand was to be achieved by increasing the fan speed of two, 15 kW fans from their standard day setpoint of 42% to 100% in the Sackler Library HVAC system	• Trial established need for a two-way communication strategy between DSO and service provider, particularly relating to failure or delay in service delivery. • Also raised the question of what processes need to be in place for the DSO to be notified of this, and what is the mechanism that follows to procure reserve services if this failure happens after bid acceptance but before dispatch requests? • The MVS trial also saw a delay of 10 minutes in delivering the service due to human error during manual control. Questions arising include: how strict are the windows for dispatch? and what penalties might apply?

4.4 MVS and site selection learnings

The MVS concept has been widely accepted by project partners and external collaborators as an agile, low risk approach to trial new concepts in a complex energy system. This has allowed the planning and running of numerous trials in a short space of time. The learnings captured here represent the first step in evaluating successes and failures of the procedure, to inform future iterations of the trials.

4.4.1 MVS and data collection

A detailed trial framework has evolved over Phase 1 to ensure learnings from the MVS trials are captured. This involves tracking when each procedure step is completed, with associated timestamps. Data to prove the step has been completed are also required, and processes for uploading this data through the Project LEO data log are now in place.

There has been partial success with the process. This is due in part to the continued delay in signing of the data sharing agreement, which impacted data upload, and time constraints of trial coordinators.

4.4.2 MVS and use of the platform

Other than a few minor issues which were quickly rectified, the Piclo Platform successfully hosted the competitions, registered asset availability and facilitated the bidding process for all MVS trials. The trials have also enabled the instruction to dispatch to be better defined and applicable to the range of technology types.

4.4.3 Procedures for MVS failures or delays

Some of the trials resulted in a 'failure to deliver', which highlighted some important issues to address for future trials and the need for protocols or frameworks to deal with failures or delays. These are discussed later in the report.

4.4.4 Site selection

Site selection has been a difficult and complex process. This is inevitable, given the need to include a wide range of criteria to identify sites that will deliver the best learnings for the project within scope, timescales and budget. The site selection process has also needed to identify and then reconcile differing goals and aspiration of LEO partners. A variety of approaches has been used, including two lengthy workshops and inputs from Atkins, which highlighted lots of unforeseen considerations for the trial phase.

The process has however succeeded in identifying 12 primary substations, each of which offers different possibilities for trials. For example, six of the substations have been identified as suited for LCH's Smart and Fair Neighbourhood programme (Table 5).

Table 5: Primary substations suited to smart and fair neighbourhoods

Compatible with LCH Smart and Fair Neighbourhood programme	Others
1. Rosehill	7. Milton
2. Kennington	8. University Parks
3. Osney	9. Bicester
4. Deddington	10. Bicester North
5. Eynsham	11. Berinsfield
6. Yarnton	12. Wallingford

5 Data

Activities related to data acquisition, processing, storage and evaluation fall mainly into WP 4. There are three main areas of work within this workpackage:

- Developing processes for capturing data to measure the effects and success of LEO outputs. This includes review of Key Performance Indicators;
- Building a land use energy master-planning tool;
- Gathering time series data to allow virtual testing and further modelling of LEO products.

These activities will help partners develop components of LEO, in particular the MVSs, and monitor LEO's progress in meeting project objectives. WP4 activities will also provide tools and data for external stakeholders and researchers to help in planning their own Local Energy Systems.

5.1 Data acquisition and learning framework

5.1.1 Inception Data Survey

An initial Data Survey was implemented as part of WP4 in the form of an online questionnaire, circulated to all LEO partners in June 2019. The aim was to establish an understanding of the available datasets within the LEO Consortium and to identify data gaps. Within a month, 19 responses were received, providing an overview of 59 datasets believed to be relevant. A data survey report was produced by Oxford Brookes and Oxford University, from which the following insights are drawn.

Datasets were submitted by all project partners, with 68% of these coming from the Oxfordshire County Council. Of the datasets classed as 'temporal', 'spatial', 'socio-economic' or 'power networks', there was an even mix of 'temporal' and 'spatial' (nine each), with one 'socio-economic' and 'power networks' dataset also submitted. Most temporal datasets are single-source and fall under the headings of buildings/networks (energy supply; even mix of domestic and non-domestic buildings), or transport (mostly roads). Most spatial datasets fell into 'land use' or 'boundaries' categories.

Submitting parties classified their datasets as Licensed (~39% of the whole), Open-access (~32%) or Private (~22%), with the remaining datasets having specific ownership according to the circumstances under which the data are to be accessed. Most datasets are available in CSV or Shapefile formats, with some open-access datasets having public URLs for data retrieval from their respective partner platforms. Restrictions for data use within publications largely relate to appropriate referencing, with some privately-owned datasets requiring formal customer approval.

A Data Workshop was held on 30th September 2019, hosted by WP4 team, to establish data management protocols and identify data gaps, in particular with respect to near-term MVS trials. The workshop brought together the LEO partners with external stakeholders, including representatives from ERIS and EnergyREV.

5.1.2 Lean Ecosystem Transition

A key early output of WP 4 was the elaboration of the '"Lean Ecosystem Transition' conceptual framework and associated set of agile processes for developing LEO components and systems. The aim is to provide a fast, agile, iterative framework to develop new services and systems, along with associated business models capable of disrupting existing markets and unlocking new value. The scale and speed of transition required to a zero-carbon future requires a full system reconfiguration. In addition to technical innovation, it requires social innovation and new economic thinking, with changes in culture and practices to develop new socio-technical systems.

The Lean Ecosystem Transition learning cycle is shown in diagram form in Figure 3 above. The process is as follows:

1. Identification of **Societal Need**. Stakeholders identify and agree on core societal values which should be upheld by the emerging ecosystem.
2. Key steps to meet societal value are identified through a **Theory of Change (ToC)** process, by backcasting to the present. From the ToC, processes and KPIs are derived to assess progress.
3. Creation of **Minimum Viable Systems (MVSs)**. From the ToC, a 'minimum stress set' of participants and processes is identified and tested. This is likely to include connected Minimum Viable Products (MVPs), each undergoing their own development cycles.
4. Measurement of ecosystem effectiveness via **Processes and KPIs.** The effectiveness of each step within the ecosystem is measured and carefully documented, to assess how far the societal needs are being met.
5. **Learning –** understanding the need to adapt or pivot. Analysis of the KPIs informs the ToC, which is then updated (adapted) as necessary for the next iteration. If required, the core values are also updated (a pivot). From understanding the challenges of process implementation, and careful consideration of the KPIs, a new MVS can be developed and operationalised, completing the loop.

5.2 Land use mapping and resource assessment tool

A key output of WP 4 is 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 Smart Local Energy Systems and associated trading platforms. MVS category B will describe the set of spatio-temporal planning tools required. Design, data collection and data processing for this tool is ongoing but some of the thermal imagery has been captured. Figure 9 shows areas selected for property-level thermal image analysis, so that the image layers can be combined with GIS layers relating to built form and building fabric; Figure 10 an estimate of solar PV potential in the county.

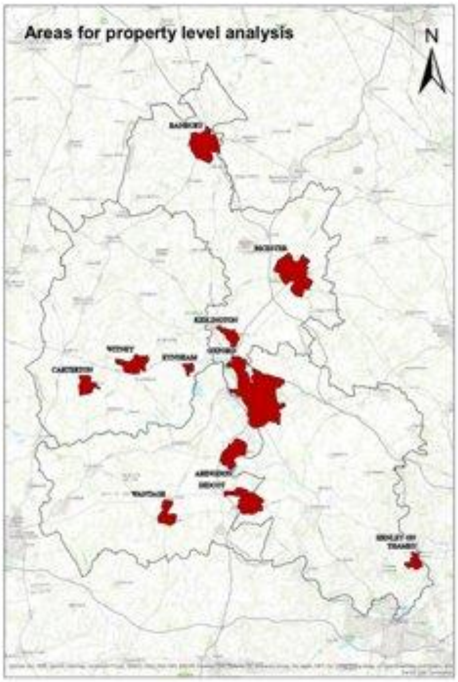
Areas selected for study
Significant growth locations (showing population in 2017 and at 2027)[1]

1. **Bicester & surrounding area** (Cherwell District)
51,700 to 70,400 (+40%)
2. **Didcot**
(In South Oxfordshire): 36,400 to 51,400 (+41%)
(In Vale White Horse): 11,500 to 23,000 (+50%)
3. **Witney & Carterton** (West Oxfordshire District)
Witney: 28,800 to 33,800 (+18%)
Carterton: 22,600 to 28,800 (+28%)
Data capture for this area to include **Eynsham.** Supports energy modelling and planning at the Garden Village and wider area.
4. **Oxford**
159,600 to 176,200 (+10%)
5. **Wantage & Grove** (Vale of White Horse)
17,300 to 27,000 (+56%)

Other settlements

6. **Henley** (South Oxfordshire District)
18,000 to 18,200 (+1%)
7. **Kidlington** (Cherwell District)
19,100 TO 16,600
8. **Banbury** (Cherwell District)
62,100 to 76,200 (+23%)
Outwith SSEN area and offers opportunity to extend LEO in Year 3 (Banbury is in Western Power Distribution area).

In addition, property level data for **Abingdon** (Vale of White Horse District, population 26,100, forecast to increase to 49,500 (+7%) by 2027) is available from a previous feasibility study carried out by Energeo and will also be provided for LEO.



[1] Population data from Oxfordshire County Council, Research & Intelligence Team, 2019. Oxfordshire housing-led population forecasts 2017 to 2027

Figure 9: Areas selected for thermal imaging at property level

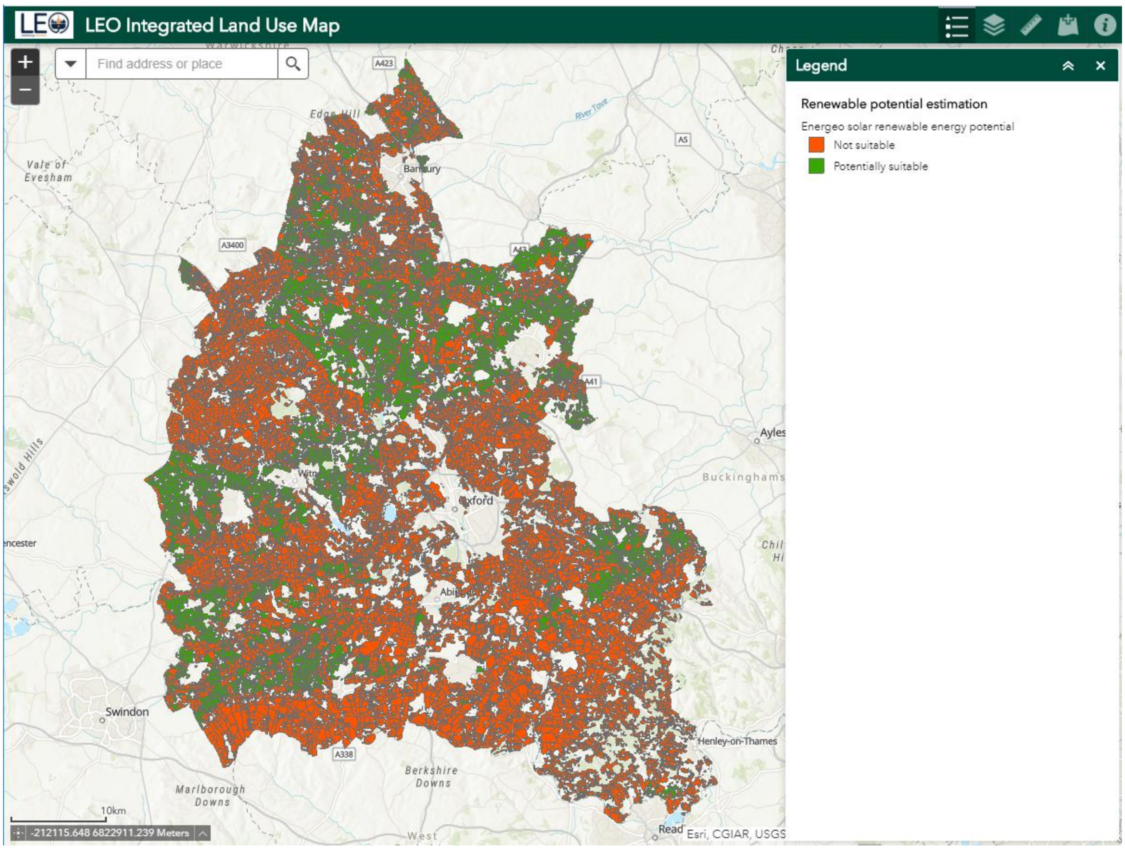


Figure 10: LEO solar potential estimation

5.3 Data sharing and data governance

A key aspect of data governance is the Data Sharing Agreement. Incorporating all partner comments into the DSA template so that the agreement could be signed by all took longer than expected, although the need to establish processes for data governance and to identify each partners' data needs and protocols as early as possible was anticipated and a Data Workshop was conducted in the first quarter. This was partly because many of the systems and processes under development in LEO are entirely new to the industry or to partners. For example, given its licence conditions, SSEN has been justifiably cautious about sharing information about the detail of the network, such as network connections at address level. Making this data available to partners for building tools requires proper scrutiny.

A key learning is the need to identify as early as possible what data needs to be shared and with whom. Project partners learned that

- there would be more users of data than anticipated, particularly in relation to the land use mapping tool;
- appropriate data governance needs to be agreed on a case by case basis; and
- data governance processes must identify as many data issues in advance as possible, to prevent delay.

Understanding partners' data-sharing requirements is an ongoing process as new systems are developed. For example, a challenge in WP4 has been to understand how much of the data within the land use mapping tool can be shared with partners without a Data Sharing Agreement in place.

5.4 MVS monitoring processes and data gathering

The novel data generated by the MVSs has created challenges in ensuring that processes are followed appropriately to capture learnings. However, the monitoring protocols are generally working well, with a 'live learnings' document capturing unforeseen issues that crop up (for example, those relating to the OBC battery configuration).

Lessons learned from each iteration of an MVS trial need to be captured and fed back in timely fashion into an improved procedure, ready for the next iteration. As a result, the MVS procedure document is ever evolving! For example, a key update has been to identify an MVS *owner* for each trial to ensure that they are responsible for the trial and completion of the procedure. A further challenge is to ensure that the latest updated procedure is being used.

Each MVS generates a host of questions and learnings (as it is designed to do) such as:

- The need for better understanding of the procedures and multi-participant communication protocols necessary for dispatch.
- What happens when a dispatch isn't met?

- The need for clear and shared understanding of technical terms used in the procurement, dispatch and settlement processes – such as what is ‘surplus’ or ‘deficit’?[23]

This has led to recommendations for changes to MVS procedures, including a protocol for bi-directional communication between participants to notify changes in operational status, and a framework setting out the consequences for failures or delays to deliver a service, including possible penalties for service providers and the dispatch of secondary services where available.

There is a challenge in keeping up with questions raised from each MVS and in knowing when to attempt to address an unforeseen situation arising in an MVS trial within the trial itself, or to record the situation as a learning and then change the operation of the MVS in its next iteration.

5.5 Data protocols

Automation, control and monitoring of energy technologies depend on devices being able to talk to one another through configuration in specified protocols. MVS A is already uncovering aspects of this issue. For example, communications with Oxford University’s Building Management Systems has been problematic. WPs 3 and 4 are tackling issues related to data protocols.

WP4 has reviewed existing data repository options. Data needs to be securely stored and retrieved to meet near-term LEO requirements and, for the longer term, to establish a repository of datasets for use by others. Conversations are ongoing with the Data Analytics Facility for National Infrastructure (DAFNI) about how to get data from current LEO storage into a DAFNI platform.

5.6 Data for policy

MVSs for influencing and guiding policy (MVS category C) have yet to be developed. However, partners have begun to identify the kinds of data needed for policy to encourage flourishing Smart Local Energy Systems, including data to support policy change for new build and the use of renewable energy data as an evidence base to inform countywide strategic planning. The latter is under discussion by the County Council.

[23] A glossary of LEO terminology is in development as part of WP 6.

6 Engagement, learning and replication

WP 6 comprises a set of research and engagement activities having three main purposes:

- to understand the behaviour, priorities and attitudes of stakeholders in a Local Energy System;
- to engage with stakeholders, locally and nationally, facilitating awareness of the LEO project and encouraging developments that will allow a Local Energy System to thrive in Oxfordshire;
- to create engagement tools, processes, datasets and analysis that can be used by others and will help LEO to be increased in scale and scope and replicated in other parts of the country.

6.1 General approach

Our approach to these tasks is founded on understanding the Local Energy System as fundamentally sociotechnical in character. That means we see system activity as an outcome of the stakeholders' interactions with social, economic, political, communications and material infrastructures.

A good analogy for this is an ecosystem: each stakeholder occupies a niche in the ecosystem and to survive and replicate, must offer something of value to the system, an ecosystem service. In return it will receive something of value, allowing it to continue in existence. The nature of the service and how it is valued depends on the stakeholder role (or niche) within the system and the 'laws of the jungle' which determine the overall direction in which the system evolves. In this analogy, the laws of the jungle can be grouped into four domains:

1. Regulatory and policy context for local energy systems.
2. Material. Physical infrastructure, structure of the network, specifications of equipment, design of housing and buildings.
3. Market. Supply chain relationships, product characteristics, customer relationships.
4. Social and cultural. Institutional 'ways of doing things', social norms (including right of access to affordable energy services), codes of practice, 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 survive and thrive will be determined by the character and 'friendliness' of the system. The properties of the system as a whole will be the emergent outcome of interactions between the stakeholders that make it up.

Ecosystems change and evolve naturally. 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 the entire system to transform, perhaps rapidly. This is the challenge for LEO and for research activity in WP6: to understand the character of the socio-technical system and the conditions that will allow local energy systems to become accepted and then replicated so that the whole system becomes transformed 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 Minimum Viable Systems are thus tests of new connections and relationships between stakeholders in the ecosystem. Activity at each of the steps is measured to determine if the systems are working successfully or need to be adapted.

6.2 A vision for LEO

What constitutes 'social benefit' is a political decision. 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. Agreeing LEO aims and objectives was the principal objective of the LEO inception workshop held 26th June 2019, where a consensus on the shared vision of LEO was achieved utilising a Service Value Method. The values identified as best representing the overall Project LEO vision were:

- Local balanced energy system;
- Ecosystem benefits – CO_2 and beyond;
- Reducing inequalities – ability to afford energy to meet all needs.

Collaboratively agreeing a set of objectives to form a long-term vision for Project LEO was found to help align partner priorities. Some 'societal vision' objectives were dropped as explicit LEO objectives, but were still judged important for informing a strategy for system transition. All the proposed values, ideas, system properties and actions were mapped to the action-values-vision scale in Figure 11 to begin forming the LEO Theory of Change.

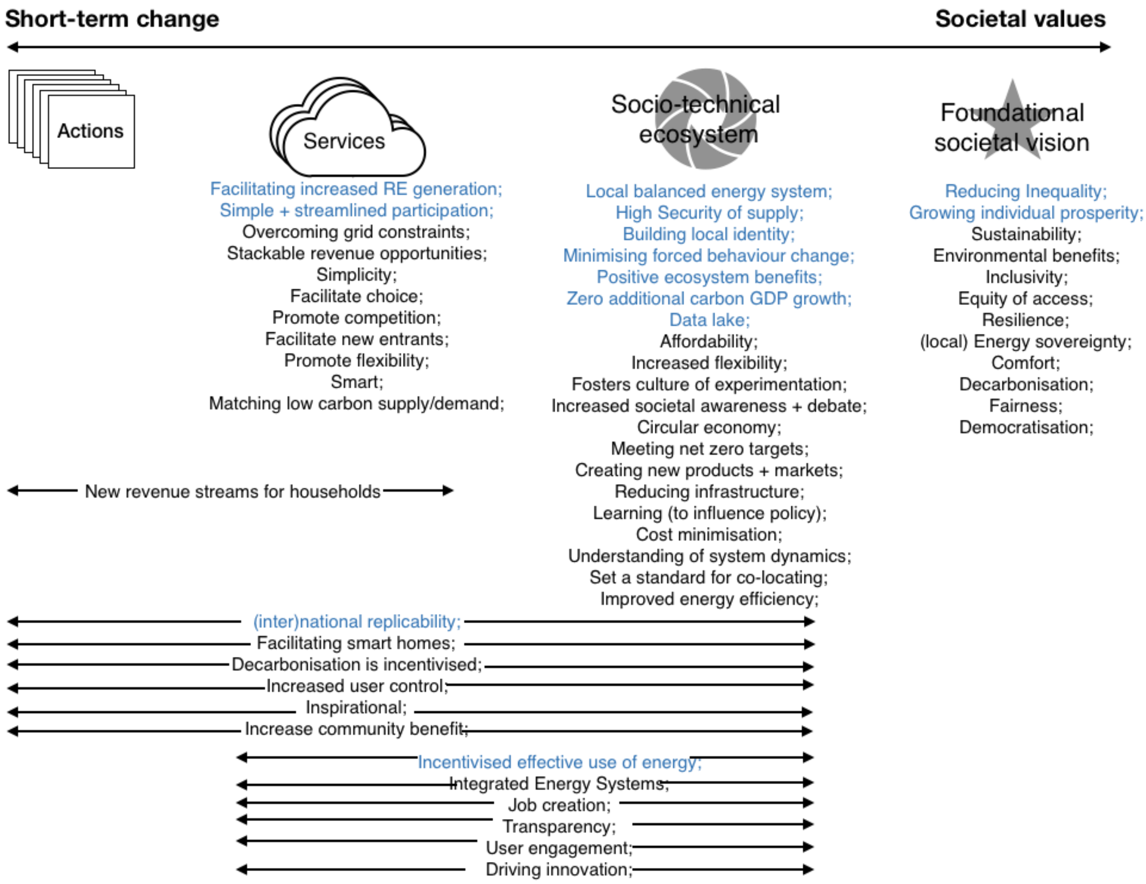


Figure 11: Values and vision for LEO agreed at the inception workshop

It is notable that this foundational societal vision for LEO has the welfare of people and communities at its heart. The creation of a thriving Local Energy System will rely on people's buy-in and the LES will be integral to achieving societal benefit.

The design of a local energy system to achieve these goals and support the values identified above is informed by theories of how ecosystem actors will respond to interventions (as well as contributing their own unprompted actions). Consequently, a starting point for WP6 activity has been an articulation of the ways in which the system is expected to change. Understanding these mechanisms requires mapping the capabilities and roles of stakeholders and then describing how they are expected to interact, via a Theory of Change.

It then becomes possible to construct a narrative for the project – a compelling and communicable 'story' for how it will achieve its objectives. We expect the narrative to change with time, reflecting changes in the ToC and in the stakeholders themselves. What follows is a summary of progress to date.

6.2.1 Stakeholder mapping

Several attempts to map LEO stakeholders have been undertaken. For example, UoO have produced an initial mapping that groups stakeholders by their role or niche within the LEO ecosystem.

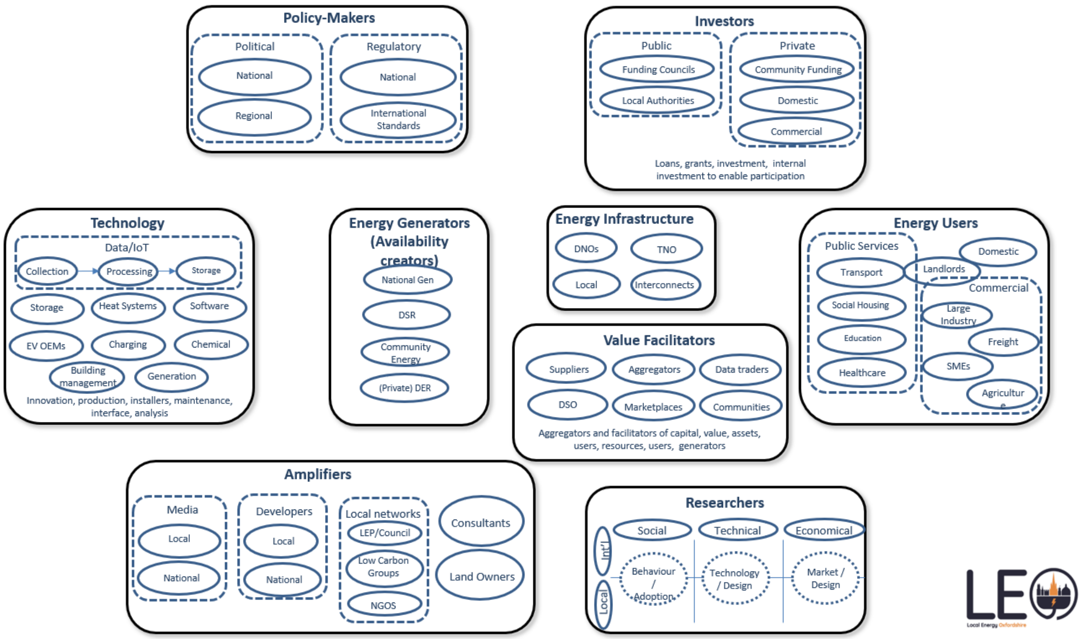


Figure 12: Stakeholder roles and value creation within the LEO ecosystem

This grouping is extremely useful in describing the essential components and stakeholders for a LES to be sustained and also in suggesting how these groups should be engaged with. Another stakeholder mapping exercise, this time in relation to prospective users of the LEO website, places stakeholders on two dimensions: degree of stakeholder interest in the project and likely degree of stakeholder influence of stakeholder influence over project outcomes. Initial results for LEO are shown here:

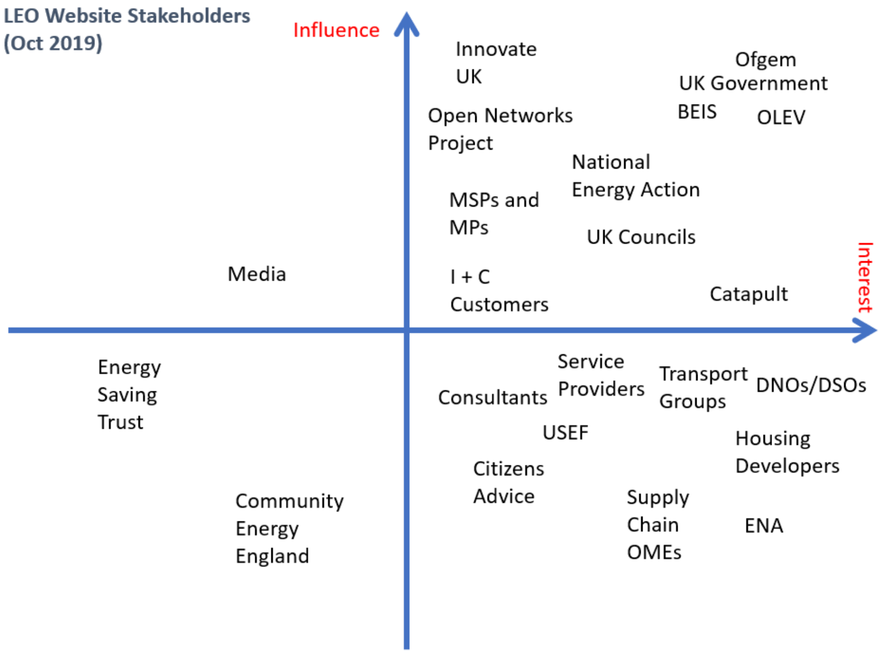


Figure 13: Stakeholder interest and influence on LEO

Distinct communications and engagement methods should be developed for each stakeholder, depending on which quadrant they fall into. For example, those in the top right-hand corner who are both very interested in project outcomes and potentially influential over the direction of the project should receive regular and detailed information on project progress. Those in the quadrant below who have a strong interest in the project but less influence over its outcomes could be given less detailed briefings but still be communicated with regularly, for example by newsletter. WP6 will use this kind of analysis as the basis for development of a stakeholder engagement strategy.

6.2.2 Theory of Change

An initial Theory of Change for a cost-effective, balanced and zero-carbon electricity system (expressed in technical and economic terms only) has been developed by UoO and is shown in

Table 6: An initial Theory of Change for a cost-effective, balanced, low-carbon electricity system**. Each line in the table represents a condition that needs to be met before the previous line can be achieved. At each stage of the ToC, suggestions for measures of activity at that stage are given (shown in blue). Some of these measures can be used as KPIs.

Table 6: An initial Theory of Change for a cost-effective, balanced, low-carbon electricity system

Societal Value - cost effective balanced low (zero) carbon electricity system	
10 Increase in low (no) carbon generation Identify potential new load and generation.	Total energy produced (and net cost) MWh, £/MWH
9 Sweated assets within operating limits	Components close to operating capacity
8 Balanced system in time	Peak power to average ratio close to 1?
7 Efficient markets	Effective price discovery. Market behaviour well understood enabling bankable decisions
6 Testing of market mechanisms Needs willing trial participant(s). What market mechanisms can be deployed How traded? - Auction, open, blind? Etc	
5 A market of traded services	Well understood set of necessary and sufficient services capable of being deployed
4 What are the procedures to facilitate trade are required?	Market place, 'dispatch', verification and settlement procedures well defined
3 What useful services are being traded? What is the effect of different classes actions/ services? Testing of different service actions on network? Willing trial participant(s) What services (actions) can be undertaken by assets?	Set of services verified to create system value
2 Asset coordination	
1 What are existing (potential) asset classes and what actions can they undertake?	

This initial technical-economic ToC is expanded and shown graphically in Figure 14. This ToC will be improved and refined as knowledge of the system grow.

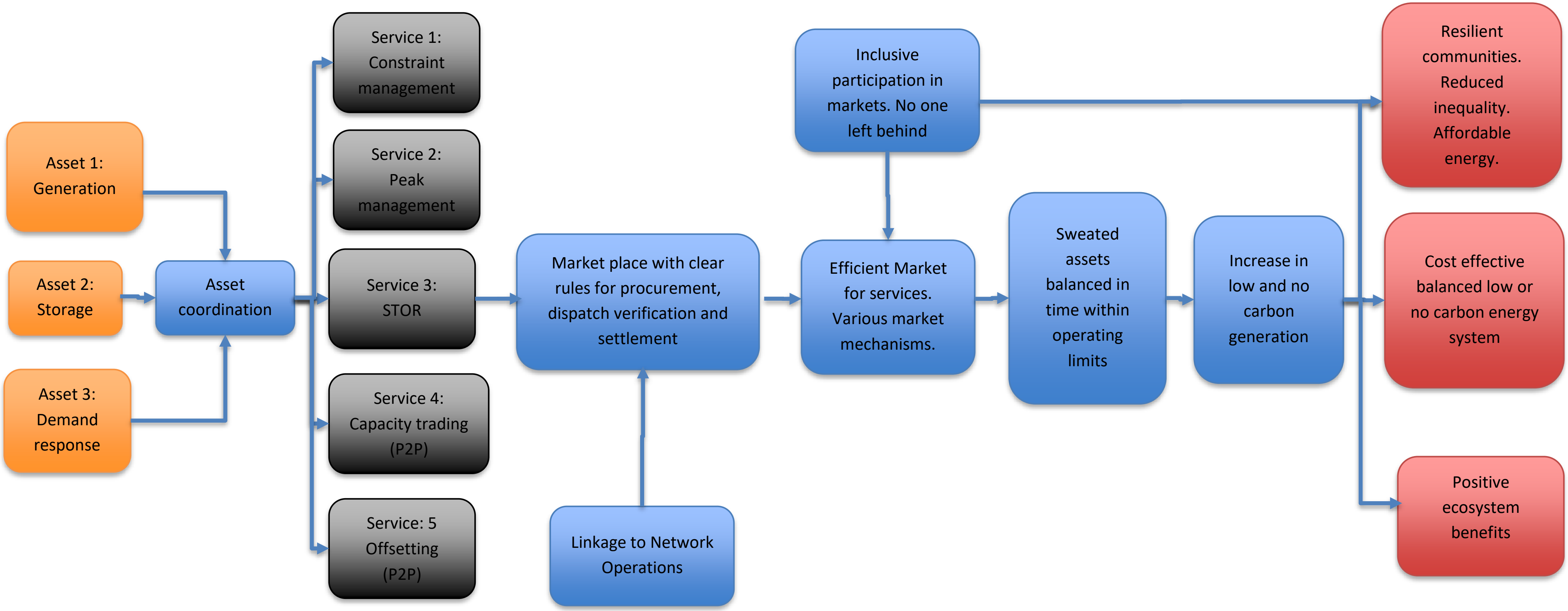


Figure 14: An initial techno-economic Theory of Change for LEO

Note that EnergyRev is developing a Theory of Change for Smart Local Energy Systems 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*. The evaluation sets out to test the ToC against available evidence from the SLES programme and also from previous research projects or case studies. The LEO team will need to pay attention to this work, as it will give insight from across the PFER programme to inform design of LEO components.[24]

6.2.3 Identifying Key Performance Indicators

As part of the Inception Workshop, partners were taken through a series of steps to identify Key Performance Indicators (KPIs) to track progress towards LEO's long term goals (local balanced energy system; reducing inequalities; ecosystem benefits). These were later revised at the Data Workshop held on 30th September 2019. The first list of KPIs covers:

1. Oxfordshire net electricity demand
2. Oxfordshire associated carbon emissions
3. Oxfordshire renewable generation capacity
4. LEO renewable generation capacity
5. Oxfordshire self-sufficiency ratio
6. Flexibility services and status
7. Capacity and diversity of flexibility assets connected to LEO
8. LEO system participants
9. Substations monitored
10. Network utilisation
11. Project engagement
12. Jobs
13. Skill development
14. Knowledge development

A second set of KPIs was identified for use, where appropriate, in the MVS trials:

1. Process Maturity Stage which measures the degree of automation for each service delivery step
2. Capacity under flexible control
3. Net change of network utilisation
4. Service response time
5. Levelised cost of flex event
6. Additional generation capacity unlocked
7. Number of participants in service delivery
8. Number of vulnerable customers
9. Net cost to service provider
10. CO_2 impact of service
11. Impact on passive participants

[24] How do we get smart local energy systems with good outcomes? Developing a Theory of Change. Report to EnergyRev WP5.1 Fell, M. et al 27/01/2020.

The most valuable KPI to date has been the first, Process Maturity Stage.

Both sets of KPIs will be reviewed as part of MVS phase 2 planning and the Consolidation Phase Workshop planned for July 2020.

There are two further sets of metrics and KPIs that LEO may be required to report against, developed by InnovateUK and ERIS. These are designed to measure overall project impacts and the degree to which LEO is meeting PFER objectives. Both sets are under revision to ensure they do not impose an undue administrative burden on project participants. There is also ongoing work within EnergyRev to identify viable indicators to measure 'co-benefits' of smart local energy systems[25].

6.2.4 LEO narrative

Development of a strong narrative for LEO is a key objective in WP6. A clear, communicable narrative is critical in engaging participants and audiences for LEO's work. It also helps in reminding project partners of their long-term objectives and the overall vision for LEO.

We have the beginnings of a narrative for LEO from interviews with 15 project partners, in which they were asked some fundamental questions about the nature, processes, challenges and goals of the project. In the course of the interview, they were also asked about *how* the goals might be achieved – in effect, for a Theory of Change. The responses reflect early experience of working on LEO – the interviews took place about six months into the project – and also the experience and insights that interviewees brought into the project.

There was substantial consensus around the idea that LEO involves setting up and testing of a *local, low-carbon* energy system that used *market* mechanisms and *smart technology* to bring *value to the electricity network and the people* connected to it. All respondents mentioned at least one of these elements and some referred to all, e.g. that "*LEO is trying to create a new ecosystem of people, to accelerate a low-carbon energy system using markets, with equity".* There were some differences in emphasis within the responses, with strands of thinking centred on people, network management and markets:

1. People. There was an image of people as the motive force behind the project – "*It's low carbon that underpins the whole thing, but it's driven by people*" – through organisations and human networks, ownership of assets and passive or active engagement in network management. Developing low-carbon energy could enable people to do new things and to share networked resources in new ways. It should not leave behind those people who did not want to be active partners: equity was a very significant consideration.

2. Network management for renewable generation. The message centred on accelerating the adoption of renewables with the help of digitisation and smart management, including demand-side response. There was excitement at the prospect of rethinking

[25] 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

electricity networks so that they can be managed dynamically from the edge for resilience: "*Instead of energy being a top-down flow, it's a many-to-many experience*".

3. Markets. Development of a local energy market to maximise the use of assets, support carbon reduction and enable business models for smart local energy was a key part – perhaps *the* key part – of the project aim for five of the respondents. For example, *"Smartness will eventually come from a market-supporting structure, letting small players engage and enabling feedback"*; [LEO will] *"enable a local energy system that includes market operation to achieve national low-carbon goals'; it is about grassroots, bottom-up system balancing, empowering people to make their own energy decisions and to be active market players or 'passive players that choose".*

Development of the narrative for LEO's aims, objectives and methods will be crucial to effective communications for the remainder of the project. There will be two more rounds of stakeholder interviews, at yearly intervals, to assist with this.

6.3 Stakeholder engagement

WP6 has three main stakeholder engagement activities:

- an annual workshop with internal and external organisations, to explore and map the evolving commercial ecosystem and raise awareness of the project;
- a quarterly workshop (12 in all) with stakeholder groups (e.g. residents of a potential smart neighbourhood, local authority councillors), to raise awareness of the project and identify the capacities and priorities of each stakeholder group;
- developing content about LEO and disseminating it through various channels (website, newsletter etc) to internal and external audiences.

The stakeholder engagement strategy to be developed in Y2 will develop the focus on what each type of activity is intended to achieve, and how.

6.3.1 Commercial ecosystem workshops

The aim of the initial commercial ecosystem workshop was to capture information about relationships between LEO stakeholders and the sources of value in the LEO commercial ecosystem. To do this we used a standard template which captures aspects of the LEO value proposition from the customers' and providers' perspectives.

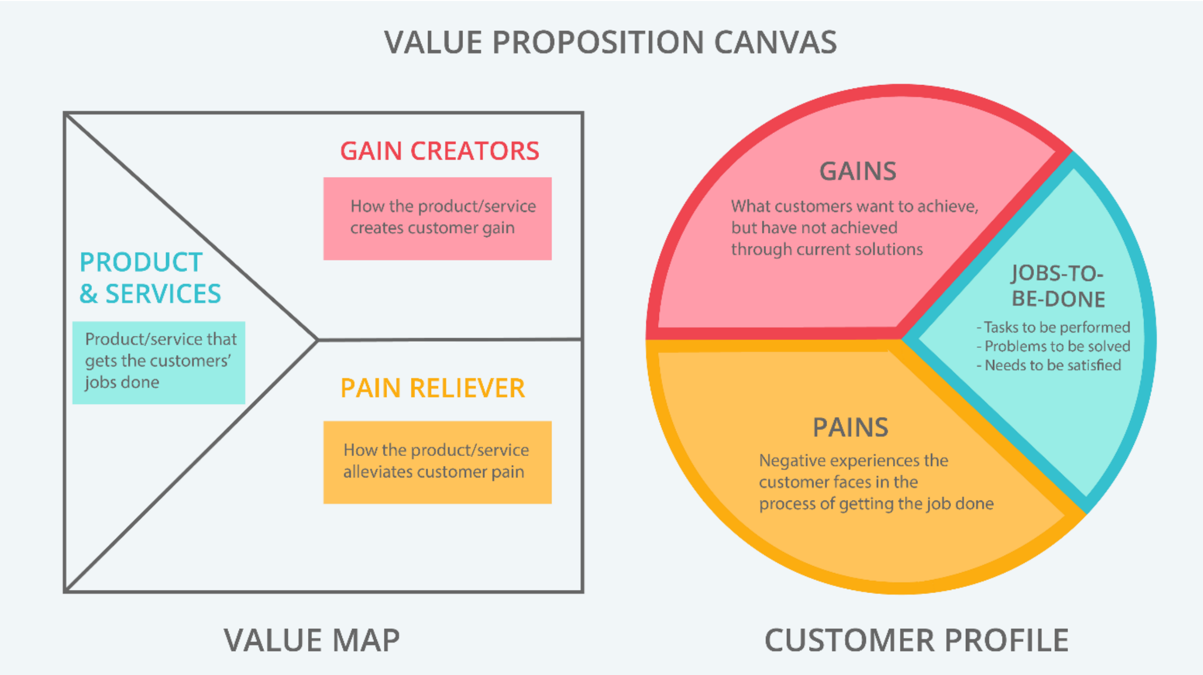


Figure 15: Value proposition canvas

Information captured in this exercise was transcribed and thematically analysed, allowing a picture of the commercial relationships between all LEO participants to emerge. These are documented in a series of Business Model Canvases (see below for an example).

6.3.2 Twelve stakeholder engagement workshops

The general approach to the design and delivery of the stakeholder workshops is to use them as a flexible resource that can serve a variety of purposes depending on LEO's needs at any time. These purposes could include

- targeted awareness-raising;
- consultation with a local community or group e.g. in co-design of a Smart and Fair Neighbourhood;
- exploratory research, e.g. to understand decision-making within a specific stakeholder group;
- evaluative research, e.g. to understand how a LEO activity / initiative is working for stakeholders and whether/how improvements could be made.

They can be used for any stakeholder group and repeated if necessary. For example, a series of workshops with a local community group may be needed to co-design a smart neighbourhood. Three workshops / engagement events have been held:

- the LEO launch event in Oxford, to raise awareness locally;
- An event with internal LEO stakeholders and EnergyREV researchers, at Oxford Brookes University, to develop a method of mapping, planning and tracking purposive engagement with different types of stakeholder;

- An event with residents of the Rose Hill area of Oxford, to prepare the ground for involvement in a Smart and Fair Neighbourhood initiative, building on the established relationship between a local community group and the Low Carbon Hub.

The next workshop to be held will be with City and County Councillors.

The design of each workshop and the overall programme of workshops should be integrated in the stakeholder engagement strategy. As such, the timing of the workshops needs to be synchronised with the next phase of MVSs and with full trial planning. Also, learnings from the workshops need to be fed back into the stakeholder engagement strategy (see below) and into communications and dissemination activity.

6.3.3 Developing and disseminating information about LEO

Dissemination and communications are handled by WP6. Five principal channels are used to disseminate project findings and progress and to raise awareness of the project:

1. Website. The LEO website has been approved by IUK and is live (https://project-leo.co.uk/). Content is managed by SSEN. LEO outputs are also accessible via the TRANSITION website (https://ssen-transition.com/).
2. Quarterly Newsletter distributed by email. It has not been possible to distribute the Newsletter via the stakeholder database because this was unavailable until the Data Sharing Agreement was in place.
3. Attendance and presentation at events. A list of events where LEO has had a presence is shown in Appendix A.
4. Programme of 12 workshops with stakeholder groups.
5. Academic publications.

The effectiveness of these channels for different stakeholder audiences will be reviewed as part of the development of the stakeholder engagement strategy. LEO is also building a stakeholder database, held within a Customer Relations Management tool, to support communications e.g. dissemination of the quarterly newsletter. LEO is conscious that internal and external communications are improved when a common language is used – free of jargon wherever possible. Consequently, LEO has built a glossary of project terms, to be developed during Y2.

6.4 Replication and scaling

WP6 activities to facilitate replication and scaling of LEO have included:

- Development of a stakeholder engagement process as part of a stakeholder engagement strategy. This will be turned into a tool for others to use when developing engagement processes for local energy systems.
- Adaption of existing engagement and planning tools such as the Business Model Canvas.

Both are proving extremely useful in focussing attention on the actors, value propositions, assets/resources, skills and processes necessary for bringing about change.

6.4.1 Engagement strategy

LEO is developing a stakeholder engagement strategy in close partnership with the Low Carbon Hub and the City and County Councils. These partners have already worked up an approach to engagement, with particular attention to engaging the public; their relationships with the people of Oxfordshire, and the trust built over the years, is an incalculable asset for LEO.

The strategy will also be informed by engagement strategies and communications protocols held by other partners (SSEN, EdF, Origami and Nuvve) and is meant to integrate with the timetable for MVS development and rollout. It will be used to plan the two remaining commercial ecosystem workshops and the remaining stakeholder workshops, starting with a workshop planned for councillors. The strategy is a live document, to be updated and modified.

6.4.2 Mapping tools for engagement

- WP 4 is developing an integrated land use map and energy mapping tools to assess the technical potential of measures at particular nodes in the network. It can also be used to answer questions such as whether widespread fitting of rooftop solar at specific locations is likely to cause a network constraint. A map of technical potential can become a powerful engagement and planning tool if it is overlaid with socio-economic data (at postcode level or lower resolutions). Therefore, LEO partners in WP4 are also exploring layering socio-economic and lifestyle (MOSAIC) data at address level.[26]This would allow us to build a map that can be used in:

- designing engagement strategy for particular areas of interest on the network, on the assumption that messaging can be tailored for different types of household.

- calculating estimates of the rate of adoption of technologies and services from households connected to specific network nodes – for example, projections of acquisition of electric vehicles on a street by street basis.

The assumption that different types of household will adopt specific technologies at different rates is the basis of market segmentation. For example, market segmentation for the adoption of electric vehicles in 2011 revealed that, under prevailing market conditions, the earliest adopters ('Plug in Pioneers') were typically male, relatively young and had very high incomes. Following close behind

[26] The county council is licensed to use the geodemographic database, MOSAIC (https://www.experian.co.uk/business/marketing/segmentation-targeting/mosaic/). MOSAIC's founding principle is that people living at a particular location will tend to be alike in terms of their political orientation and consumption habits. Hence every postcode in the UK has been matched to one of 11 main groups and 61 distinct types. Each type is characterised by multiple socio-economic, "lifestyle" and physical variables including life stage of occupants, income levels, newspaper readership, built form of the home etc. MOSAIC has been used in a wide variety of ways including political campaigning and in forecasting energy demand at particular locations on the distribution network.

were the 'Zealous Optimists', who tended to be older, also male and also on a high income[27]. See Figure 16.

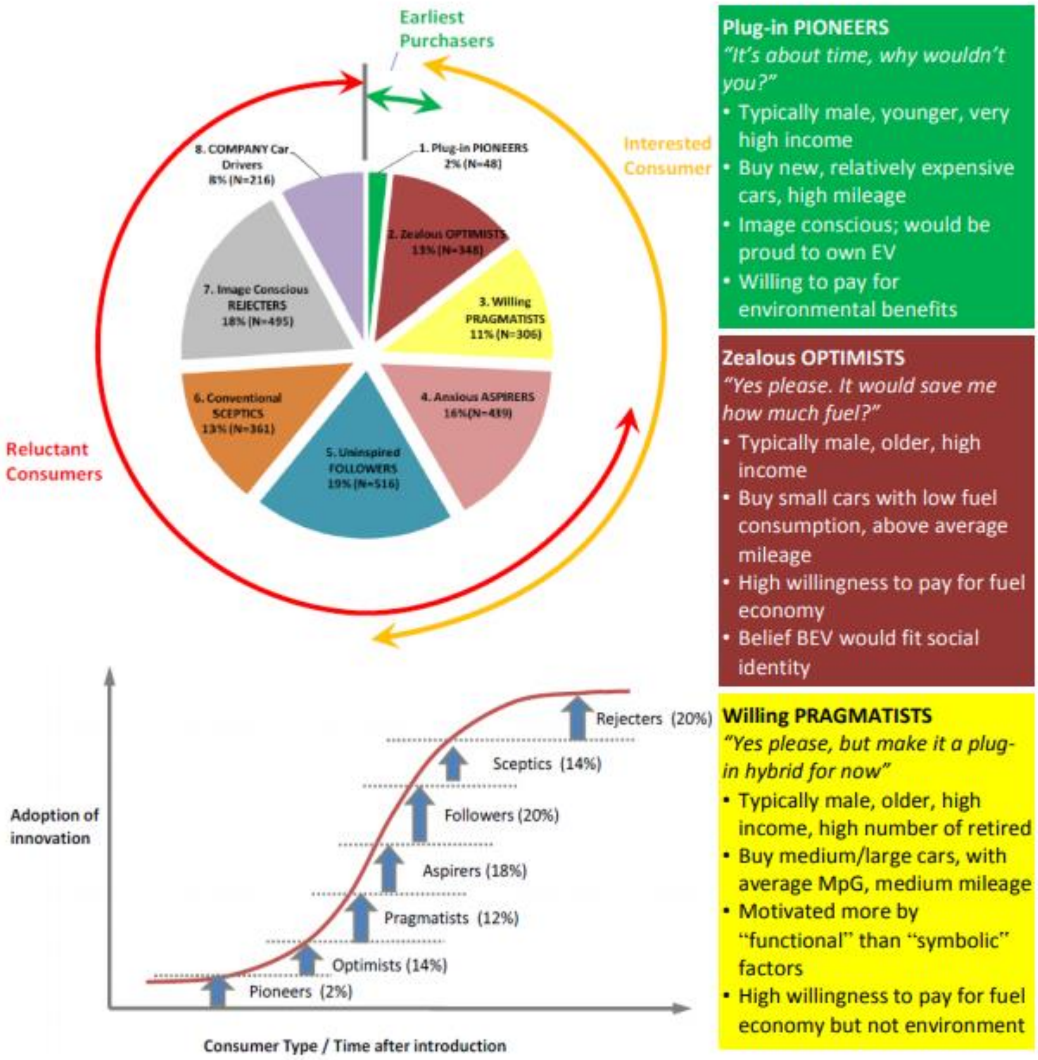


Figure 16: Segmentation of Electric Vehicles adoption.

Since this study was completed the EV market has undoubtedly shifted. For example, it is probable that "pragmatists" are now beginning to take a greater share of EV sales (but note that this group is also high income and typically older and male). The strong link between EV ownership and income level is one factor used in forecasting adoption rates of EVs at geographies (e.g. Lower Super Output

[27] Anable, J., et al (2011) Plug-in Vehicles Infrastructure Project. Consumers and Vehicles: Consumer Segmentation and Demographic Patterns. WP 1.3.5 Project Report. University of Aberdeen and Transport Research Laboratory

Area) matched to the Electricity Supply Areas on the Low Voltage network[28]. This analysis is used in SSEN's EV strategy (March 2020) to 'anticipate issues and make sure our networks can cope'.

In addition to forecasting, socio-economic characteristics of adopters of specific technologies are also invaluable for building engagement strategy – for example, in communications to encourage participation in a Vehicle to Grid aggregation scheme.

Socioeconomic analysis also indicates groups who are relatively unwilling or unable to participate in services in a local energy system. Therefore, it is vital that LEO continues to monitor and analyse trends so that it can design local energy services in which factors such as low income are not barriers to participation in some form.

6.4.3 Business Model Canvas

LEO has explored other business planning and business model development tools, including the Business Model Canvas (BMC), essentially a tool for service developers to identify and summarise the dimensions of their business models. This was used in Q4, where LEO summarised the principal commercial dimensions of each completed MVS category using a BMC.

An example of a completed Business Model Canvas is shown in Figure 17. It is arranged as follows:

Left side columns: the resources needed to create value, including partners (their motivations and services we acquire from partnership with them); suppliers and the services they perform; key services and activities; physical, intellectual and financial resources needed.

Right side columns: the means of engaging and communicating with customers, including customer relationships, communication channels, customer segments and the value created for each.

Bottom row: costs and revenue streams, including identification of most important costs, what customers are prepared to pay, what is currently paid, and how payment should be made.

(Note, the figures quoted on the Canvas are not representative.)

[28] Regen has produced analysis for SSEN forecasting adoption rates of EV's, solar roofs and heat pumps using National Grid's Future Energy Scenarios (https://www.regen.co.uk/wp-content/uploads/SSEN-South-FES-Scenarios-Final-v2.pdf).

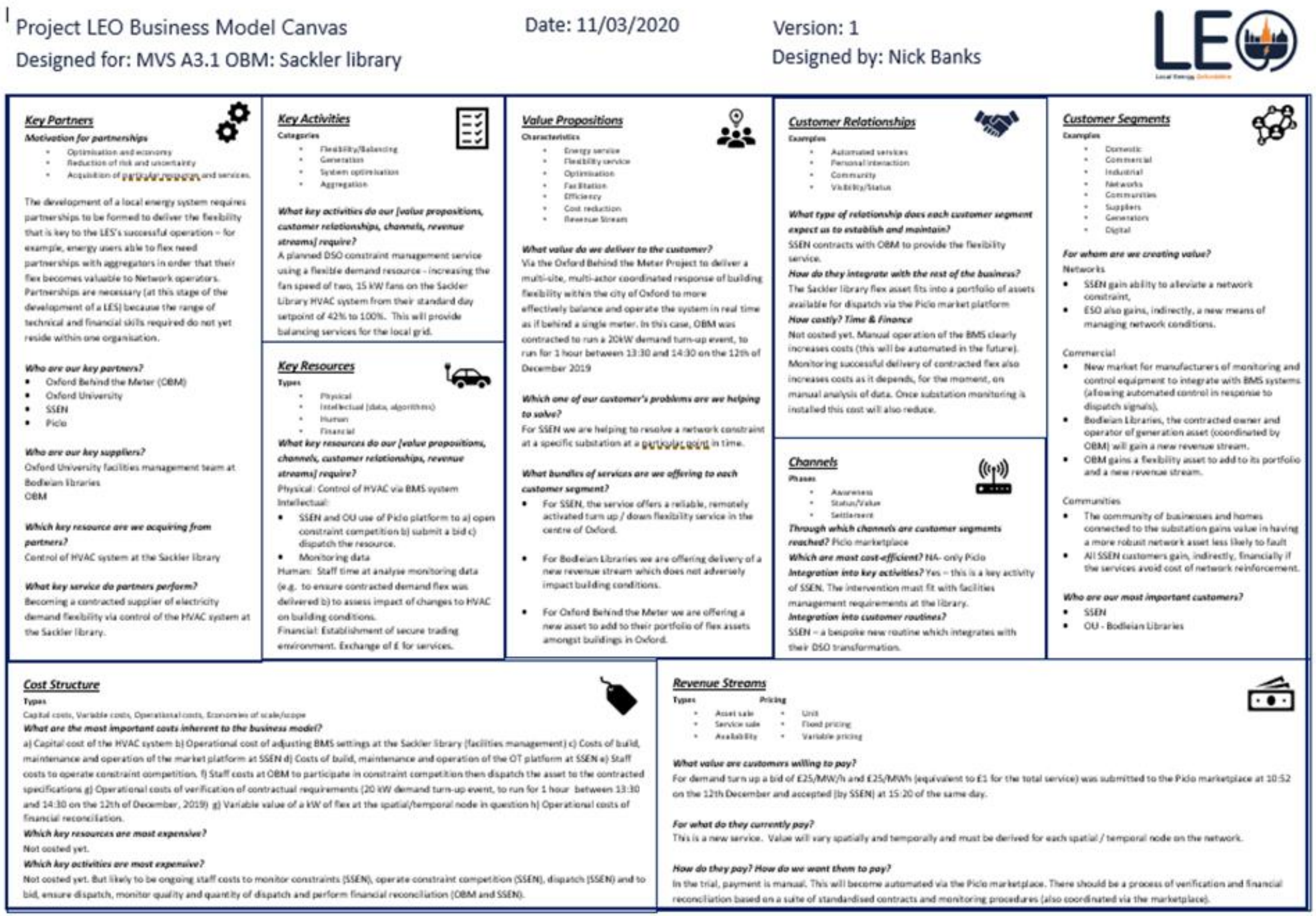


Figure 17: Example of a business model canvas

Our experience with using the BMC approach so far suggests a number of uses:

1. When designing each flexibility service, as it forces consideration of the feasibility of the service by clarifying sources of value, customers, suppliers etc.
2. In conjunction with the commercial ecosystem (see below). It allows a service developer to see if the service '"nests' within an existing network of customers, suppliers, available resources etc
3. To facilitate replication of a service, the BMC can be updated as the service is trialled. This will create a summary of the service provider's niche within the commercial ecosystem. Others can replicate this position in their own contexts.
4. A useful communications tool, summarising the information needed to judge the operation of a business model on a single page.
5. A tool to use with communities, to develop value propositions from the perspective of community groups and individuals within a community who may want to interact with any offering they develop.

6.4.4 Commercial ecosystem research

A commercial ecosystem is a network of stakeholders or 'actors' involved in the delivery of a product or service. For LEO, this means the complex network involved in the delivery of a Local Energy System (LES) in Oxfordshire. The purpose of researching the commercial ecosystem is twofold:

1. To facilitate replication and scaling of LEO. By identifying the stakeholders in a Local Energy System, along with their objectives, capacities and the relationships between them, it becomes possible to see *how* value can be created and exchanged. This is critical information for transposing LEO, or elements of LEO, to other contexts.
2. To assist with development of an engagement strategy. Once the capacities and objectives of stakeholders within a system are better understood, appropriate engagement becomes more likely, with messaging is that is relevant, interesting and effective.

Project partners held an initial commercial ecosystem workshop session as part of a meeting on 23rd Jan 2020. The workshop exercise was able to identify very quickly:

- the primary objectives of each stakeholder within a Local Energy System and how comfortably they occupy that niche in terms of their 'pains and gains' in maintaining that position, and
- the principal upstream 'suppliers' of intellectual and technological products and services to each stakeholder and the downstream 'customers' for these services.

This information was used to build a map of the stakeholders shown in Figure 18: Example map of the LEO commercial ecosystem. ** The different actors within the ecosystem are readily located by their relationships with other actors. These relationships influence the activities of each actor and hence the direction of evolution of the entire system. The more important influences and relationships of each actor are also readily identified using this approach. As an example, this is shown for SSEN in Figure 18.

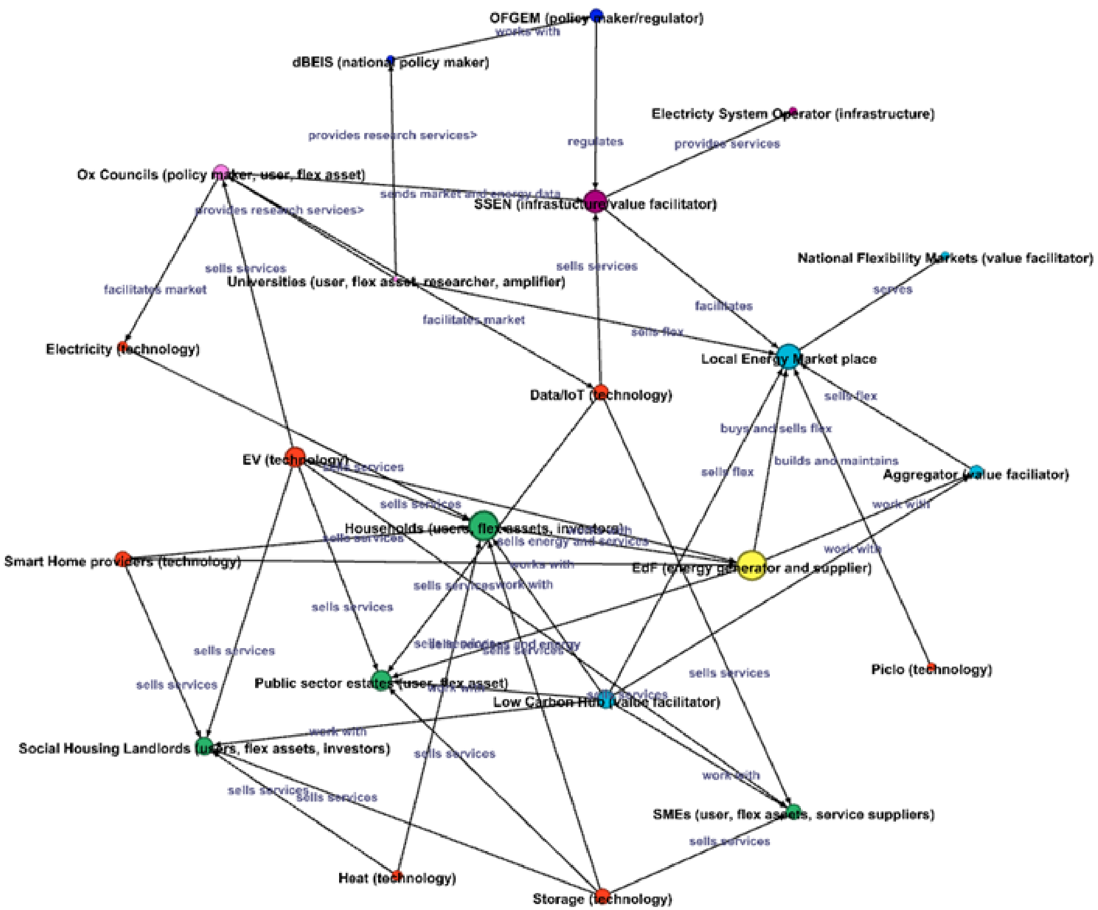


Figure 18: Example map of the LEO commercial ecosystem

The different actors within the ecosystem are readily located by their relationships with other actors. These relationships influence the activities of each actor and hence the direction of evolution of the entire system. The more important influences and relationships of each actor are also readily identified using this approach. As an example, this is shown for SSEN in Figure 19.

Figure 19

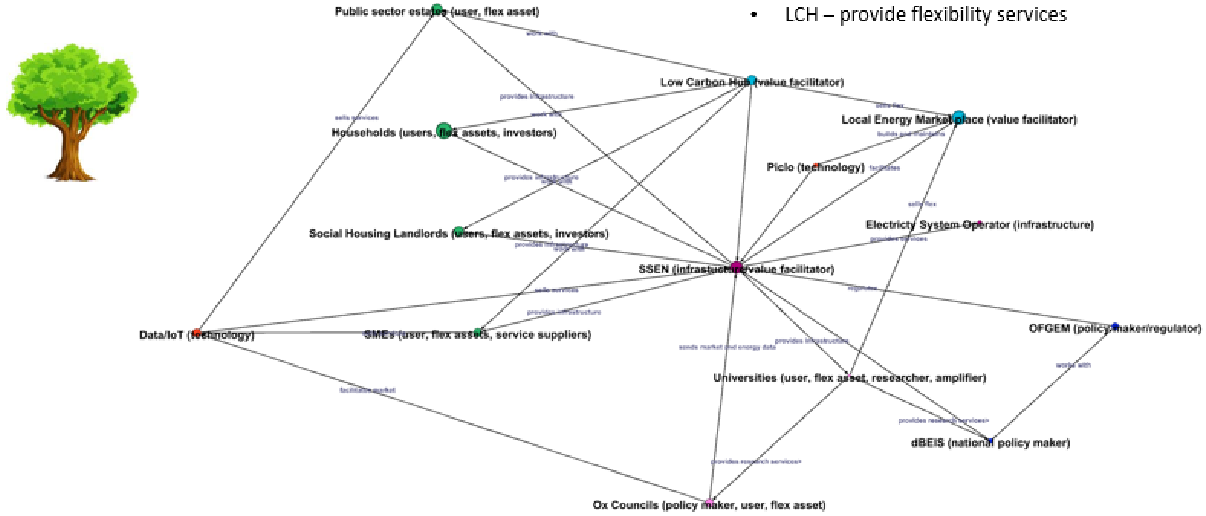
SSEN – Infrastructure provider / Value facilitator

Purpose (animal/vegetable nature)

- To grow the business
- To maintain safe reliable operation of the network whilst accommodating low carbon technologies including EVs.
- Facilitate use of the network for "wider DNO customers" using ICT systems.

Providers of services to SSEN (value required)

- SSEN (internal services) – processes to understand how SSEN should change its business to transition to DSO
- dBEIS – create, in partnership, clear policy framework
- Oxford City and County Councils – providers of planning and infrastructure data. Providers of policy steer
- Ofgem - create rules of the jungle
- Piclo – build market platform
- Origami – supporting commercial development of DSO services
- LCH – provide flexibility services



Gains and pains (services needed by SSEN)

- Understanding of new commercial, regulatory and policy environment
- Change management – e.g. new skill sets required in transition to DSO
- Ability for SSEN to more accurately monitor the cost of operation of the network
- Development of robust systems and processes allowing connection of LCTs avoiding increased cost to customers
- Help with understanding data and monitoring needs – new IT and OT systems

Services provided by SSEN (value delivered)

- Stable, safe, balanced network for households, Public sector, Private sector, Social Housing and businesses
- Balancing services to ESO
- Local Energy Marketplace

Figure 19: SSEN's niche in the LEO ecosystem

From this approach it is possible to see the creation and distribution of value in the LEO ecosystem. Importantly, it also suggests where actors and services are needed to help a local energy system thrive who are not yet represented in the ecosystem. For example, SSEN has a need to monitor the cost of operation of the network more accurately but there is not yet a service provider capable of doing this.

This approach gives clues for how LEO can be replicated and scaled in the future. However, it is necessary to explore sources of value in more detail in order to make the commercial ecosystem exercise “actionable”. Therefore, the initial workshop report will be used as the starting point for a more thorough and actionable description of the commercial ecosystem that will be updated and refined as the project progresses.

7 Conclusions

7.1 The LEO narrative

Current consensus within the project is that LEO is engaged in setting up and testing 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 narrative can be seen as a development of that in the bid, that LEO 'delivers a transformative integrated smart local energy system to maximise prosperity… and demonstrate new value creation opportunities', while addressing the pressing need to manage a stressed network by developing a local energy market place. Both sit within the wider PFER narrative of implementing an energy revolution from which people can prosper.

7.2 Concepts

Stakeholder diversity and project complexity have meant that not everyone uses the same terms in the same way. We have made progress on bringing together different sets of definitions (for example, those in use in the Open Networks Project led by the ENA along with those developed by LEO partners to describe stakeholders). The process is not complete and at this stage, the main conclusion relates to the need to continue work on developing a common language for SLES. It will need to convey meaning very precisely where operational issues are concerned, and also to recognise and reflect the many roles which people play in energy systems - not just as consumers but as as investors, operators of distributed generation, storage and demand-side assets, and practitioners in engagement and governance.[20]

The concept of a Minimum Viable System (MVS), developed from the early idea of a Minimum Viable Product, is proving its worth to describe LEO initiatives, to identify potential gaps in system services and solutions, and as a potentially replicable unit of future Local Energy Systems.

One more outcome of inquiry into project concepts relates to the concept of local energy. This is usually thought of in relatively techno-economic terms, and contrasts with the more people-based concept of community energy. LEO straddles the boundary between these, with origins in community energy initiatives but relying on new market arrangements to deliver energy services to individuals and systems.

7.3 Characterising the local ecosystem

Local Energy Systems must operate within the national framework of regulation and planning requirements but local planning rules and policies arguably have greater influence on the design and operation of local energy systems and Distributed Energy Systems than the large scale systems connected to the transmission network. Therefore, the data and information used by local policy makers and planners in decision-making on energy issues is an important feature of the ecosystem.

7.4 Project management for a diverse consortium

A diverse consortium has been needed to address the complexity of setting up a new system while operating the old one. Workshops on market rule simulation, site selection, business model canvases and stakeholder mapping have been valuable, bringing together partners from all work packages and building knowledge and understanding. However, the time and effort needed to manage the diverse partners and their many activities is considerable. Information and coordination activities have to be carried out within tight time constraints, while meeting multiple requirements for monitoring and evaluation.

7.5 Market development

The structure identified as best suited to delivering outcomes consistent with PFER objectives is a Local Energy Market (LEM), where only assets within a defined geographical area can participate. These resources can sell their energy or services locally (e.g. in peer to peer (P2P) trading or to the DSO), or as services on national markets managed by the Electricity System Operator). Especially for the latter, they may be aggregated.

The embryonic Local Energy Market in LEO has been set up to operate at two levels:

- The Neutral Market Facilitation Platform (NMFP), under construction as part of the TRANSITION project. The NMFP interacts with a Whole System Coordinator, which assesses options for mitigating network constraints.
- The NMFP hosts a Flexibility Exchange Platform, under construction by Piclo. This allows flexibility service providers to contract for requested services, either from the DSO or from third parties in P2P arrangements.

The flexibility market must address operational needs resulting from changes in energy demand and supply, supplying constraint management, peak management, Short Term Operating Reserve (STOR), authorised capacity trading and offsetting. The second phase of MVS trials will be developed to align with these services, to be coordinated using the Flexibility Exchange Platform.

7.6 Operational learning

Year 1 of LEO has led to valuable learning on baseline conditions in the network and how to plan and manage prototype network services in the form of Minimum Viable Systems. Network operation must continue as normal throughout the network region, so great care is needed to ensure continuous service to customers before, during and after project procedures. The project has shown that this is possible while testing MVSs. Key learnings from the first phase of MVS are:

- each MVS needs an 'owner' who will take responsibility for trialing it and for communicating with all partners in the system beforehand, to ensure readiness to deploy,
- consistent, agreed terminology is needed for items of equipment and procedures, for MVS actors to understand each other and ensure reliable operation,

- not all assets can provide flexibility services readily; they may need additional work to connect them to the system reliably,
- detailed procurement standards are needed for flexible assets,
- battery management systems can be very valuable for site flexibility,
- protocols for two-way communication between flexibility assets and network are needed, to notify changes in operational status,
- a SLES needs a framework to cope with failures to supply agreed services, or delays. This should include agreed penalties and arrangements to fall back on other services.

The 'live learnings' document for each MVS is working well as a way of documenting the MVSs and capturing any issues that arise during testing.

7.7 Data

There have been considerable data-related challenges, including the finalisation of a data-sharing agreement between consortium partners. It has been important to identify, as early as possible, what data needs to be shared and with whom; also to make sure associated metadata are collected and stored in a way that makes sense of each dataset.

7.8 Achieving fairness

There are no explicit objectives relating to equity in either PFER or in the LEO bid document, apart from an aim in the latter to highlight 'any unintended consequences of the new market, including regulatory issues, impacts on system resilience and consumer protection, including affordability and data security.'

There are however issues to address such as how household and business energy costs will be affected by factors such as building energy efficiency or by ownership of distributed assets such as solar PV panels, electric vehicles or appliances suited to demand response. All of these relate to equity. They also show how the concept of energy poverty is changing over time: it is now more than an inability to afford adequate fuel and electricity for a specified standard of comfort. A more realistic definition needs to take into account a person's ability to participate in system operation (for example, through micro-generation and demand response) and in governance[1].

Seeing that 'no-one is left behind' was identified as an important issue for LEO in stakeholder interviews and is a key aspect of the PFER programme. At this point, 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.

7.9 Policy

We identify three policy-relevant lessons. The first highlights the significance of local factors 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. Development of market

[1] See Bouzarovski and Petrova (2015) A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary. Energy Research & Social Science 10, 31-50.

platforms is typically at national scale but must be adaptable to a range of local conditions. Local factors may limit the replicability of LEO as a whole, but early experience with three modular MVSs shows their promise for replication now that they are thoroughly documented in terms of technologies, actors, data requirements, procedures and potential challenges.

The second area of learning concerns the policy/regulatory risk that attends SLES, with uncertainties over the direction that Ofgem codes will take. Regulatory uncertainty is a major factor in uncertainty about the value propositions and financial viability of many 'plug-in projects' that could develop into elements of a SLES.

Third, 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 the value of DSO flexibility. Settlement of transactions within a LEM, between local markets and between a local market and national markets (e.g. the ESO balancing mechanism) will pose operational, policy and regulatory challenges. The establishment of new processes for reconciling and settling transactions at multiple levels between markets is an issue that should be considered at an early design stage by parties at all levels.

7.10 KPIs and monitoring in Year 2

KPIs require good sources of data and an intelligible framework of aims and objectives. A risk was identified in the bid that some KPIs may become irrelevant as changes take place in the energy industry and this remains a possibility. They are kept under constant review.

Current KPIs are almost entirely quantitative, as might be expected. They relate primarily to network status and development, e.g. levels of demand and carbon emissions, connected low-carbon generation, status of planned and tested flexibility services, number and type of system participants, number of monitored substations and number of jobs created within LEO and the wider energy sector in Oxfordshire. For the project itself, there are metrics for engagement activities, and for new skills acquired; also for the number of presentations and publications to develop and consolidate knowledge.

This range of KPIs will need some extension in Y2 of the project, when multi-participant MVSs – for example, aggregating EV batteries – will be tested. There will also be spatial mapping activity. Preparation for smart neighbourhoods will require substantial engagement effort and we arguably need to develop one or more indicators of progress for that. Other areas for consideration could be data collection and management metrics/indicators; policy stakeholder engagement, specifically; and issues arising from the Covid19 pandemic.

Findings from stakeholder workshops with County and City councillors will begin to map out the information environment of planners and local politicians and consider what guidance, policy and data they use and need in decision-making. These findings will inform the design of MVS C projects and also the monitoring arrangements.

Equity in access to energy services, or 'affordable services for all' has been highlighted as a project objective and this calls for the development of one or more KPIs to assess how the social costs and benefits of an emerging SLES are distributed. These costs and benefits could be estimated in financial terms and also in terms of knowledge, access to shared services and participation in decision-making.

7.11 Ethical framework for project design, monitoring and evaluation

As LEO activities become more complex and involve more stakeholders, including citizens and businesses, it will become even more important to manage expectations and plan carefully, well in advance of trials. In particular, community-level engagement, especially in areas with a high proportion of disadvantaged households, should start as early as possible and must be perceived to be conducted by a trustworthy, reliable and competent organisation sharing the same interests as the community. To support this, LCH, with contributions from other partners, is developing an ethical framework of principles for project design. This will ensure the design, monitoring, evaluation and engagement components of the plug-in projects and other MVS have the best chance of galvanising the interest and support of local communities.

8 Appendices

8.1 Appendix A: Inventory of activities, learnings and challenges

Available as a separate file.

8.2 Appendix B: Inventory of events

Available as a separate file

8.3 Appendix C: Publications

The following documents have been published by TRANSITION and are available for viewing on the TRANSITION website.

- Neutral Market Facilitator Requirements Specification
- Neutral Market Facilitator Data Exchange and Governance
- Best Practice Report –Market Facilitation for DSO
- Services in a Facilitated Market
- Analysis of Relevant International Experience Of DSO Flexibility Markets
- Whole System Coordination Requirement Specification