Local Energy Oxfordshire

August 2021 | *Summary*

Annual Synthesis Report Year 2

Nick Banks, Sarah Darby & Vicky Grant

Summary Edition

University of Oxford · Oxford Brookes University · low carbon hub · Oxford City Council · Oxfordshire County Council · Scottish & Southern Electricity Networks · piclo® · EDF Energy · NUVVE · Origami Power Over Energy · Industrial Strategy · UK Research and Innovation

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

Version:	1	Date:	09/08/21/
Workpack:	WP6	Deliverable:	6.3.4
Reviewed by:	Project partners		
Date:	19/08/2021		
Signed off by:	Sarah Darby		
Date:	30/09/2021		

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

Executive summary

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

This report brings together lessons learned during the second year (Y2) of LEO and is based on a series of reports and interviews with project partners. The first year demonstrated the value of a flexible, modular approach to energy transition through the development of Minimum Viable Systems, designed for rapid learning. In Y2, we have made progress on the organisational, data and connectivity issues that emerged in Y1, with deeper understanding of the processes needed to gain flexibility from electric vehicles (EVs), connect new distributed resources and activate demand-side response in institutional buildings. There have also been detailed preparations in the Smart and Fair Neighbourhoods (SFNs) where much of the local community-based work is carried out. LEO is now close to the point at which larger-scale trials of DSO-procured and DSO-enabled flexibility can begin. This takes the level of complexity and challenge up a level.

We expect the work of building a shared understanding of SLES to continue throughout the project: it is very necessary for effective working. LEO is 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 is the basis for a Theory of Change[1] that sets out in detail how this can be achieved: which actors, technologies and processes are involved, how they relate to one another, and what the path dependencies are.

The project continues to show the importance of local stakeholders and infrastructure for the development of SLES, in terms of ambition, social capital, knowledge and engagement, planning challenges and network conditions. The local 'ecosystem' is very favourable to LEO but we have to remember that this is not always the case. Conversations about replication in other areas are already under way with a small number of 'Fast Followers' who are interested in developing SLES.

Work continued on access, protocols, data cleaning and other essential routine operations. Major gains in Y2 have been the development of the Oxfordshire Integrated Land Use Mapping tool, with 79 layers of data, and of the LEMAP tool (by Oxford Brookes University), which is intended to assist engagement with local stakeholders. Data used by local policy makers and planners in decision-making on energy issues continues to be a vital element of LEO.

LEO envisions a move beyond the traditional producer-consumer paradigm in electricity markets and explores how to create a market that meets network operational needs while delivering social and environmental benefits. The structure seen as best suited for this is a Local Energy Market (LEM), using assets (distributed generation, storage and demand response) within a defined geographical area. Asset owners/operators can sell flexibility locally, or as services in national markets, or both (value stacking). Especially for the latter two, they may be aggregated.

This year has seen the development of some key components of a LEM including a Whole System Coordinator that identifies network needs and feeds these through to the Neutral Market Facilitator (NMF) platform, where services to meet network needs are procured via auction. The NMF also interacts with third party Flexibility Exchange Platforms, creating another space where flexibility

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

service providers can contract for services with the DNO/DSO or with third parties in peer-to-peer (P2P) capacity trading.

A key challenge for SLES is enabling production of business models and value propositions that work for people who are unlikely to have the capabilities to participate fully in a local system. To ensure that access is as widespread as possible, there will need to be a mix of market actors operating with different value propositions, some of which will not be structured around optimising financial returns. Market solutions that are judged unfair or environmentally damaging are unlikely to gather support.

At the end of Y2 there is much greater familiarity with the nature of the market and potential ways of developing it. However, there are still gaps and uncertainties relating to end-to-end procedures for procuring and delivering flexibility. LEO remains keen on working with a large number of grid edge assets for operational, social and environmental reasons. Aggregating small-scale assets, including creation of a community-owned asset, is under investigation. The TRANSITION trials, starting in the autumn of 2021, are to explore the detail of end-to-end processes.

All the Oxfordshire local authorities have declared a Climate Emergency and shown willingness to take action. This opens doors for engagement on local policy, including two very productive events with councillors and planners in Y2. The formation of the Zero Carbon Oxford Partnership, involving several LEO partners, has been a further step forward.

At national level, there continues to be high ambition for carbon reduction and for renewable supply (mostly offshore wind), but the 2020 Energy White Paper has very little to say on local energy systems and policy/regulatory risk relating to SLES continues. As noted last year, changes to network infrastructure can only be sustained if there are corresponding changes to the structure and functioning of the electricity market. Settlement of transactions within a LEM, between local markets and between a local and a national market (e.g. the ESO balancing mechanism) still poses operational, policy and regulatory challenges.

The PFER programme aims for social as well as operational benefits. Achieving equity and inclusion through a market-based system is a challenge and LEO has developed an ethical framework in Y2 to guide the project in addressing this. The project now has a set of stakeholder engagement principles, paying special attention to building trust and productive relationships with more disadvantaged stakeholders so that they are not 'left behind' through being unable to benefit directly from owning or operating distributed energy assets.

Y2 work has continued to validate LEO's 'agile learning' approach and has brought exciting innovations, as indicated above. Y2 work has also shown the weight of path dependencies when attempting to build a new system within the constraints of the old one. Great care is needed to ensure continuous service to customers before, during and after project procedures, and LEO has shown that this is possible - that innovation can take place without disrupting the legacy system. We anticipate that Y3 will be an exciting and demanding year of flexibility market trials, establishing the first SFNs, gathering new data and putting it to work, and evaluating the outcomes.

This summary report sets out our main findings from the second year of the project. Readers who would like to learn more can find the full-length report here.

Contents

1 Origin, aims, concepts and project structure

Radical changes in how electricity is generated, distributed, traded and regulated call for system reconfiguration, not just optimisation of the current system. In 2018, the Industrial Strategy Challenge Fund (ISCF) set up *Prospering from the Energy Revolution* (PFER), a programme with £102.5m of funding to develop systems to support the move to renewable energy. Eight million pounds of the fund went to the EnergyREV research consortium, tasked with driving research and innovation for smart local energy systems (SLES) that are characterised by the 'four Ds' of decarbonisation, digitalisation, decentralisation and democratisation.

1.1 Origin and aims

Three large demonstrator programmes were also funded to run alongside EnergyREV, starting in 2019: Local Energy Oxfordshire (LEO), Energy Superhub Oxford and ReFLEX in Orkney. These are developing and demonstrating SLES approaches that can

- provide cleaner, cheaper, more desirable energy services for the end user,
- lead to more prosperous and resilient communities,
- prove new business models that are suitable for investment and that can grow and replicate in the 2020s, and
- provide evidence on the impacts and efficiency of novel energy system approaches by the early 2020s.[2]

Project LEO is at work 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 national climate targets. This will need to happen in a distribution network that was not designed for distributed generation or for changing demand patterns. LEO therefore aims to develop *a skilled community positioned to thrive and benefit from a smarter, responsive and flexible electricity network.*[3]

Towards the end of the four-year project, we will test LEO's replicability with 'fast followers' - communities and organisations with similar goals and a capacity to adopt processes that LEO has tested.

1.2 Central concepts

Three concepts that have been central to LEO are:

- Minimum Viable System (MVS). An MVS represents the smallest set of participants and processes required to test a process or new use for an energy asset or service. Potential value can then be identified and evaluated quickly at a small scale. This offers an agile way of testing innovations and learning from them.
- Smart and Fair Neighbourhood (SFN). This is a community-based initiative with a distinctive mix of low carbon technologies and technical, economic and social capabilities. The 'fair' element calls for particular attention: can a market-based system be operated in such a way that all can benefit and no-one is left behind?
- Smart Local Energy System (SLES). A SLES connects local and national system infrastructure to create an intelligent, integrated energy system that delivers value to the community it serves by taking advantage of innovative approaches to provide, move, store, sell and use energy at a local scale. LEO is contributing to development of this concept partly through

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

[3] Project LEO website, accessed March 2020

local experimentation and partly through dialogue with sister programmes, policymakers and other stakeholders.

1.3 Project structure.

Scottish and Southern Electricity Networks (SSEN) are piloting systems needed to enable their role to evolve from being a Distribution Network Operator (DNO) to a Distribution Systems Operator (DSO)[4], through the Ofgem-funded TRANSITION project. These systems include more comprehensive data, software interfaces and commercial mechanisms, and the recruitment of distributed energy resources (DER) to offer balancing and other services to the network. Hence LEO and TRANSITION work together. TRANSITION is exploring the systems needed to monitor, coordinate and contract out network needs, whilst the systems and services to meet those needs are researched and tested in detail in LEO. TRANSITION is incorporated within LEO as Work Package 5. LEO partners include:

- The **project lead**, SSEN, [5] who are primarily responsible for project management, oversight of systems , marketing and communications.
- **Market operators** who develop and support a marketplace in energy and system flexibility so that contracted service providers can meet network operational needs. Piclo are developing a third-party flexibility exchange platform for trade of DNO procured and peer to peer services.
- **System developers**. Opus One are involved in developing the Neutral Market Facilitator (NMF) market platform according to rules set out by Origami Energy and SSEN. This interfaces with the DSO's 'Whole System Coordinator' (WSC) platform which analyses the electrical load on the network.
- **Service providers** that focus on community-led investment, community engagement, planning, mapping and governance (Low Carbon Hub, City and County Councils); working with industrial and commercial customers (EdF Energy); and working with the public sector and householders (Nuvve vehicle-to-grid innovation).
- **Flexible asset providers**. Oxford City Council, Oxfordshire County Council, Oxford Brookes University (OBU) and the University of Oxford (UoO) bring flexible load from their estates and vehicle fleets.
- **Researchers** from the UoO and OBU, consolidating data sources and analytic tools to develop local energy system mapping, conduct trials, analyse and evaluate outcomes.

These partners collaborate in seven work packages, including market platform development, 'plug-in projects', DSO TRANSITION and system learning.

[4] This means taking on a more active role in operating the system, to make the most of all resources – generation, storage and flexible demand.
[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.

1.4 Progress in the second year

In the second year of the project, there has been progress on the organisational, data and connectivity issues that emerged in Year 1, with deeper understanding of the processes needed to gain flexibility from electric vehicles (EVs), connect new distributed resources and operationalise demand-side response in institutional buildings. A major mapping exercise has expanded the quantity and quality of data available to the project. Detailed preparatory work is under way in selected sites around Oxfordshire – the Smart and Fair Neighbourhoods – where much of the community-based work will be carried out. Project LEO is now close to the point at which the TRANSITION and associated trials can begin, taking complexity and challenge up a level.

2 Building a Local Energy Market

2.1 Value

The concept of value has cropped up throughout Y2 of LEO, raising some complex questions. In economic terms, the value of flexibility in different situations can only be estimated in the absence of a functioning market and it is risky to invest in flexibility-providing assets without an assured market for the services they can provide. It is a lengthy process to build and test such a market, working simultaneously from the 'edge' (generators and electricity users) and from the 'centre' (market designers and platform operators).

At grid edge, there has been preparation for five SFNs, designed for participation and inclusion, with the development of an ethical framework and continuing engagement work. Discussions with SFN residents in Y2 have shown how value is not purely a matter of economics and brought to the fore the challenging value fairly. The main concern is that no-one is left behind in any move towards smart local systems: that services should be available and affordable to all.

Last year we noted that 'there is an open question about how far a market-based system is able to achieve equity and democratic control of energy services and assets', and this question still stands. Preparatory work with residents of the designated SFNs and the substantial progress with interactive mapping are helping our understanding of equity and the actual and potential distribution of value in a more flexible electricity system.

LEO has continued to explore how to create a local market that can meet network needs while offering social and environmental benefits. The Local Energy Market (LEM) idea has been tested in recent years in several places.[6] A LEM uses assets within a defined area that can generate or store electricity or can be used as flexible demand – for example, vehicle chargers or cooling systems that can be turned on or off according to network conditions. Asset owners can sell flexibility locally or to the national Electricity System Operator, as individuals or via an aggregator who can bring together many small-scale assets in order to trade with them.

It is a challenge to create business models and value propositions that will work for people who do not have the physical, financial, social and knowledge resources – the capability - to participate fully as individuals in a local system. However, aggregating (combining) small-scale assets, including creation of a community-owned asset, is an important part of the programme. A community may fund a community asset by selling their aggregated flexibility, an interesting possibility where the value of flexibility to each individual may be too small to be worth pursuing. This idea is being considered in relation to funding the installation and maintenance costs of a publicly accessible vehicle-to-grid (V2G) chargepoint in the Osney SFN.

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

There are also good operational reasons for flexibility at the grid edge and LEO partners remain keen to explore the conditions that enable small-scale flexibility to tackle hyper-local issues. Some network constraints at secondary substation and feeder level can only be tackled by flexing demand and generation at low voltage levels. Making better use of the network using smart technologies to create flexible demand and supply, leads to development of new value propositions.

To ensure that access is as widespread as possible, it seems that there will need to be a mix of actors who take part in a LEM for different reasons and who will gain value in different ways.

2.2 The need for flexibility

The Great Britain electricity distribution network was not designed to accommodate thousands of new sources of generation connected at the low voltage level. In addition, increases in demand from electrified heat and transport, connected at the grid edge, will at some point add to network stresses and capacity issues. Network operators can re-engineer and reinforce networks at great cost, or find new ways of getting the most out of the existing infrastructure by, for example, creating a market for energy users or generators to be rewarded for making their demand or generation ore flexible

Analysis conducted for LEO estimates that flexibility has the potential to reduce annual system cost by £4.55bn in this country, with savings from avoided network capacity, reduced peaking generation capacity and reduced curtailment of variable renewable energy sources, which in turn reduces fuel use. Widescale deployment of storage, either utility scale or distributed, has potential to extend these savings to £4.55bn per year[7]: the modelling suggests there is a great prize to be captured.

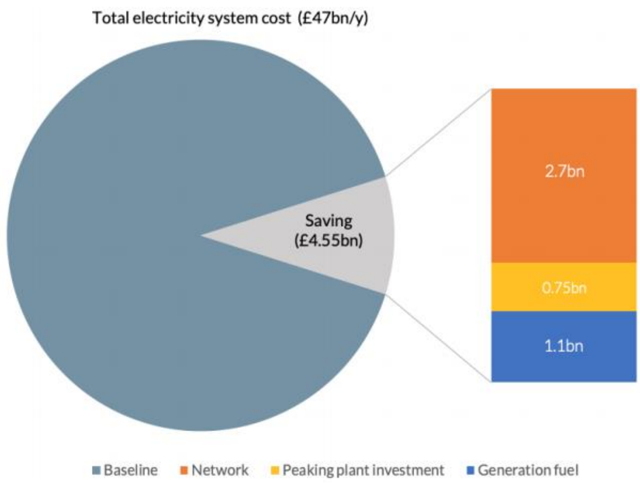

FIGURE 1: MODELLED ANNUAL SAVINGS FROM FLEXIBILITY. SOURCE: PICLO, ELEMENT ENERGY AND GRAHAM OAKES (2020)

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

2.3 Recruiting actors at the grid edge for market liquidity and competition

Having enough actors to create liquidity and competition will vary between voltage levels and locations. At secondary substation level there will be fewer flex providers to provide services than at higher levels of the network, so it may be that a flex provider can name their price depending on where in the network the service is needed, and how many others can provide a service at that point.

The need for liquidity is particularly important for day-ahead markets that deal with pre- and post-fault constraint scenarios. Without plenty of market actors able to provide services for tackling faults, there is a risk to security of supply. Recruiting enough actors could be particularly difficult for services requiring *increases* in (non-fossil) generation, as the business models of most generation assets are built around generating as much as possible for as long as possible, so that further increases may not be feasible.

Households have different capacities, capabilities and transaction costs from industrial and commercial organisations and each type of customer requires a different approach. When working at the grid edge, useful flexibility is only achieved if many households and small businesses can be coordinated/ aggregated. Monitoring, control and decision-making systems that allow small assets to interact automatically with a software platform with minimal transaction costs are now available, and some have been investigated within LEO in a small sub-project.

2.4 Non-domestic actors and capabilities: the example of vehicle-to-grid adoption

Non-domestic organisations have technical, financial, intellectual, cultural and social capabilities that will influence their decision-making when adopting innovative technologies and practices. This is exemplified by LEO's experience with vehicle-to-grid (V2G) technology.

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

A V2G charging system is, however, much more expensive than conventional one-way EV charging. Also, the case for investment in the technology is uncertain: no-one knows the expected value of flexibility at a site in one year's time, for example. This means that only organisations with the ability to absorb certain levels of risk are likely to adopt the technology at present – struggling SMEs are less likely to participate in a V2G offer. There are equity issues amongst organisations as well as in the domestic sector.

2.5 Paving a way to market

Energy suppliers and aggregators have the capacity to work with their customers' flexibility portfolios and to find optimal mixes. But smart energy management and playing in energy markets is not an area of focus for most Small and Medium Enterprises (SMEs), that will generally not have the skills, time, systems or human resources to engage in flex markets.

SSEN recognise a 'middle ground' of larger energy users such as universities and local authorities who employ energy managers and have staff with the skillsets to flex their demand to meet network needs. However, here too there will be different appetites for risk and energy management capabilities. At the same time, from the network point of view, some services need different levels of assurance that they will be delivered. For example, a service delivering pre-fault flexibility (to address an emerging issue that could lead to an unplanned outage) requires greater assurance than peak management and therefore a more liquid and competitive market to minimise risk.

Recognising this diversity amongst potential flex providers and the need to encourage involvement by institutions who may never have heard of the opportunity, SSEN have developed three routes to market: two types of auction and a market stimulation route specifically designed for entrants who require great simplicity and minimal transaction cost, and/or some financial support to prepare their assets to participate (e.g., to install automatic control systems).

Auctions

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

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

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

Market stimulation packages

These are aimed at recruiting new entrants who may have little time or resource to participate in markets, or appetite for risk, but wish to participate if barriers to entry can be reduced and there is minimal transaction cost. These two packages offer simplicity and financial support but may pay less than the auctioning options presented above.

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

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

2.6 Local energy market system architecture

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

Settling transactions within a LEM, between different local markets and between local and national markets will pose operational, policy and regulatory challenges, but it is critical to system operation.[8]

TRANSITION recognises the need for both ESO and DSO to have sight of flexibility assets that are registered on market platforms, and for back-end systems that can manage conflicts between transmission and distribution level needs. The LEM architecture under development in TRANSITION and in activities led by Piclo in WP2 has components as shown in Figure 2.

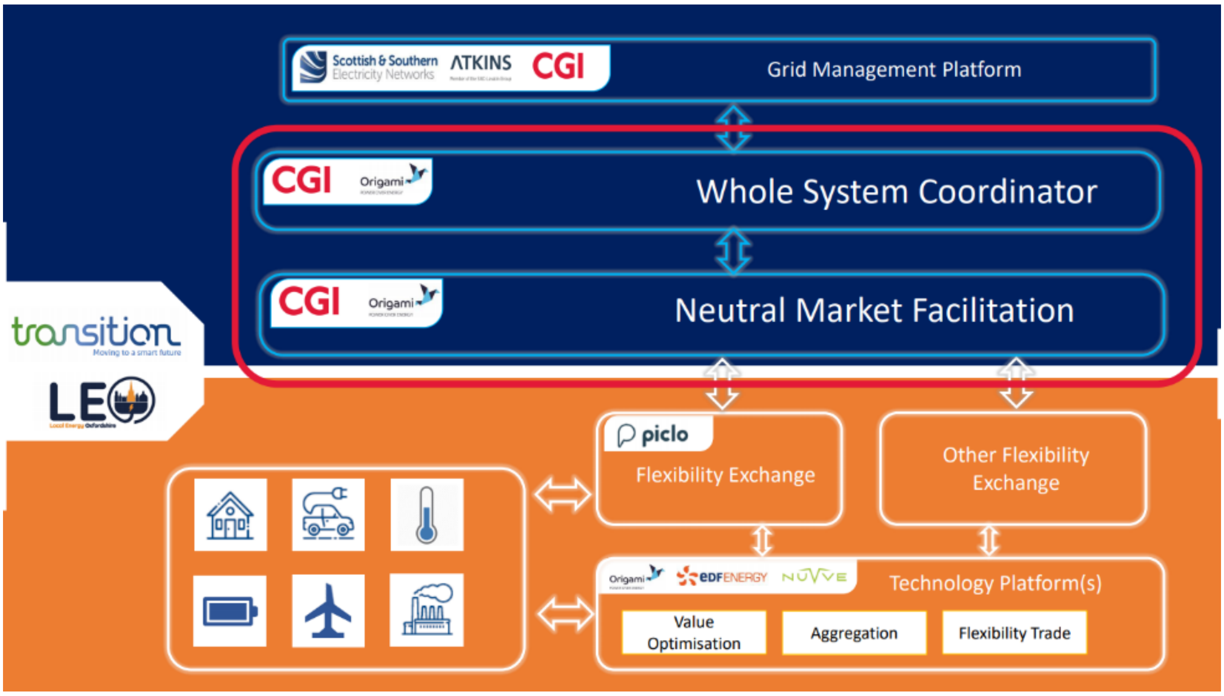

FIGURE 2: FUNDAMENTAL MARKET ARCHITECTURE

2.7 Whole System Coordinator and Neutral Market Facilitator

Developing flexibility services that can be traded on a LEM platform includes developing and testing market flexibility models for the energy system in Oxfordshire and understanding how households, businesses and communities can realise benefits from transition. Much of the learning in Y1 related to the ways in which actors connect with each other and with technologies and data. In Y2, the focus has widened and LEO developed basic rules for such a market, along with planning for trials to take place in Y3. The early-stage LEM has been set up to operate at two levels:

- a Neutral Market Facilitator (NMF) platform as part of the TRANSITION project. This is designed to send signals to flexibility providers, manage procurement and contracting, and ensure that conflicts between DSO and Electricity System Operator (ESO) do not arise. It will also allow P2P transactions. It interacts with a Whole System Coordinator (WCS), which identifies potential or actual network constraints and assesses options for mitigating them. The WSC can also coordinate with the ESO and other DSOs to enhance reliability and effectiveness of the networks as a 'whole electricity system'.[9]

[8] Energy Systems Catapult (2019) The policy and regulatory context for new Local Energy Markets, https://esc-non-prod.s3.eu-west-2.amazonaws.com/2020/11/Local-Energy-Markets-review.pdf

[9] High level descriptions of the system architecture for the WSC and the NMF are found in the TRANSITION report, *High Level Solution Design Summary 2019*

- The NMF hosts a Flexibility Exchange Platform, which allows providers to contract for services with the DNO/DSO or third parties in peer-to-peer (P2P) capacity trading.

Throughout Y2 there has been development of the WSC and NMF systems. Within LEO, the NMF platform will only serve the network in Oxfordshire, but it could also work at licence area or national level. TRANSITION hopes to determine the appropriate scale and coverage for an NMF.

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

2.8 Flexibility exchange or platform

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

Some functions of the Piclo platform, such as registration of assets, replicate those in the NMF. It was known that there would likely be areas where the two systems would overlap and that it would be necessary to integrate the two systems in order to understand where the boundaries between regulated business and private sector flex exchange platform lie.

Functions of the NMF and the Flexibility Platform are shown in Table 1

TABLE 1: SUMMARY OF FUNCTIONS OF NMF AND FLEX PLATFORM AT DIFFERENT STEPS IN THE END-TO-END PROCESS OF PROCURING, DISPATCHING, VERIFYING AND SETTLING FLEXIBILITY SERVICES

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

The basic business model of the third-party platform provider is to charge the DNO when the platform is used to procure services. One option under discussion is to provide a free basic service and then charge for added-value services such as data analytics. The flexibility exchange platform is not currently set up to deliver automated control or dispatch of assets, unlike some National Grid systems. It is more of a human relationship tool than an asset control tool: notifications to dispatch flexibility may be automatically generated but the recipient will be a person rather than a machine.

2.9 Services traded in the LEM

A key activity in Y2, facilitated by Origami, has been to understand how different assets can deliver different services to the market, via the MVS programme and TRANSITION trials development;

https://ssen-transition.com/wp-content/uploads/2019/11/High-Level-Solution-Design-Summary-v1.pdf to develop the flexibility services themselves and, through the commercial programme, develop the Basic Market Rules governing operation of the flexibility market.

Under the Open Networks Project,[10] TRANSITION and other projects have been working with Origami to develop a series of flexibility services. These are:

- Sustain: scheduled delivery of flexibility to meet a forecast requirement
- Secure: scheduled real-time delivery of flexibility to meet a requirement based on system conditions
- Dynamic: flexibility to recover from / respond to an incident-driven requirement
- Restore: support for restoration of the network or system following an outage
- Trading: trading and/or sharing of energy, capacity, financial instruments and other commercial obligations for mutual benefit
- Risk Management: mitigating the effect of uncertainty on objectives, usually provided by financial or insurance products.

Work by Origami to map asset types to different services is shown in Table 2.

TABLE 2: MAPPING ASSET TYPES TO SERVICES

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

2.10 Achieving fairness

A LEM must be able to operate in a transparent and fair way, with low barriers to entry, to encourage liquidity and competition. In Y2 there has been further work in the TRANSITION work stream to develop the market rules.[11,12]

Market solutions that are judged unfair or environmentally damaging are unlikely to gather popular or political support and to succeed in the longer term. But there is a balance to be struck. If the costs of widening access become too high, value propositions may be undermined and business models become unviable. To ensure that access is as widespread as possible, there will need to be a mix of

[10] Energy Networks Association: https://www.energynetworks.org/creating-tomorrows-networks/open-networks/

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

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

actors with different value propositions, some of which will not be structured around optimising financial returns. A not-for-profit community aggregator is one such idea.[13] LEO's approach to fairness is set out in in the engagement principles and ethical framework developed in Y2.

3 Smart and Fair Neighbourhoods

SFNs are co-developing, with community groups, socio-technical energy systems that align with their needs, aspirations and capabilities. This requires careful and frequent engagement, trust and capacity-building. Social and technical dimensions are captured in specifications for each SFN.

3.1 Understanding value propositions

Co-development of value propositions is a major part of the engagement work. A starting point has been to define user groups that a value proposition could be targeted at, understanding their needs and priorities. Low Carbon Hub (LCH) are approaching this in three ways:

- System-led, starting with the flexibility needs in a neighbourhood and identifying the people or organisations best placed to deliver the sort of flexibility required. This might be most appropriate when trying to solve or pre-empt a technical issue at a known spot on the network.

- Community-led, starting with an understanding of the capabilities and motivations of community members, and the types of flex they can provide. Mapping exercises can help with identifying user groups and the size of each. There is a danger that there may be no existing or potential network constraints in a community, reducing the value of capacity to flex demand. However, even where flexibility has little economic or operational value, establishing a SFN can deliver social, financial and environmental benefits, for example via publicly-accessible EV charge points or behind-the-meter technologies linked to time-of-use tariffs.

- User-led, starting from a particular user type and their capabilities, identifying the flexibility they are able to offer, and developing a value proposition and service to facilitate that. This is the approach being taken with trials focusing on LCH's energy assets.

Overall, Y2 experience indicates that developing flexibility capability in SFNs is important in preparing an overall energy strategy for an area. SFNs are where the aim of 'nobody left behind' can be properly explored. Rose Hill, for example, has areas where owner-occupier residents have very low incomes and are highly unlikely to own EVs or solar roofs, or to have money to invest in smart technologies. Others are limited in capability by being tenants. Value-proposition-building exercises are thus designed to seek out capabilities and to consider different routes to benefits from a SLES.

3.2 Characteristics of the SFNs

Five SFNs are now developing, facilitated by LCH working with community groups, and will be taking part in trials over the remainder of the project. Each has a different mix of low carbon technologies and technical, economic and social capabilities, along with its own needs and aspirations (Table 4).

[13] Carbon Coop (2018) https://cc-site-media.s3.amazonaws.com/uploads/2019/01/ECAS-Local-Flexibility-Markets.pdf

Table 4: characteristics, assets and aims of each Smart and Fair Neighbourhood

SFN	Site Description	Aims
Osney Island	A small neighbourhood in West Oxford. It includes a 50kW hydro plant with a 9kW solar installation, owned by Osney Lock Hydro Limited, a community benefit company. Also solar installations at the community centre, on home rooftops and on the University of Oxford estate.	Examine opportunities for and benefits from battery storage and EV charging. Maximise electricity generated by the hydro and its use locally, including powering the EV fleet at the Environment Agency depot. Give residents access to an EV and explore how using it informs their readiness to adopt an EV.
Rose Hill	A largely residential neighbourhood in SE Oxford, classified as an area of multiple deprivation with mixed types of housing and tenure. Some residents experience fuel poverty. Some have solar PV and batteries. The area has been a site for previous energy studies.	Explore potential for flexibility services to help a community with areas of deprivation to progress towards its goal of becoming a net zero carbon estate, in a way that is inclusive and equitable. Understand what role domestic energy demand might play in the Rose Hill energy system. Learn about potential barriers to participating in flex service in near future, with benefits to all.
Westmill	The Westmill site at Colleymore Farm is home to the UK's first community-owned solar and wind farms. Outline planning for a battery on the site is in place.	Look at how combined solar and wind farms, with potential battery storage, could enable participation in local flexibility markets. Investigate opportunities for commercial innovation relating to community investment in a large-scale battery project and community leadership in a zero-carbon local energy system.
Deddington and Duns Tew	Deddington is a large village, partially off the gas network; Duns Tew is a much smaller community, completely off the network. Both have strong local environment and sustainability groups who are working on the challenge of what a zero-carbon future might look like for a rural community	Understand how to enable a zero-carbon future for a rural community with planning constraints, via three sub-projects: • Flexibility service trial with 15 households, to install heat pumps and monitoring. • Working with local authorities and householders to unpick barriers to energy efficiency improvements in listed buildings and conservation areas. • Communicating energy efficiency technologies and flexibility services through a plain English, community-focused guide.
Eynsham	Eynsham has 2,200 new homes planned plus a business park and Park-and-Ride north of the village. A further 1,000 homes are to be built in the West Eynsham Strategic Development Area. These developments drive a local ambition for zero carbon energy.	Develop and extend the Energy Plan for Salt Cross to cover the whole Eynsham primary substation area, creating an Eynsham Area Energy Action Plan. Develop long-term stewardship structures whereby this Energy Action Plan can reach a zero-carbon energy system in advance of 2050

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

TABLE 5 MATCHING ASSETS TO SERVICES IN THE OXFORDSHIRE SFNS

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

3.3 Understanding the role of aggregators

As Table 5 shows, nearly all the services provided through a SFN depend on an aggregator. LEO partners are discussing what might be appropriate business models for an aggregator working with slivers of flexibility at the grid edge and seeking to generate community benefit in a fair and inclusive way; also, what is needed as supporting system architecture? Automation and internet connectivity are clearly needed if thousands of small assets are to be controlled and coordinated to balance supply and demand.

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

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

4 Minimum Viable Systems

A MVS represents the smallest set of participants and processes required to test a process or new asset use-case. The aim is to identify and evaluate potential value quickly at a small scale, before significant investment is committed. Early in Y1 the 'Lean Ecosystem Transition' approach led to identification of three categories to be tested within the project: Flexibility Services (MVS A), Geospatial Planning (MVS B) and Influencing Policy (MVS C). To date, the development work on these categories has centred on MVS A. The project team has struggled to progress the Geospatial Planning and Influencing Policy categories as MVSs, though: the feedback loop in the 'lean ecosystem transition' process is less applicable as the planning and influencing cannot be re-tested within short time periods. Due to their complexity and size, the SFN trials will not be able to go through an iterative learning loop in the time available to the project.

There has been considerable progress with the Flexibility Services to ensure that full-scale trials can maximise the value of learnings and develop thinking around the requirements for a SLES.
Early in Y2, the MVS working group began to distinguish between levels of complexity, with the aim of showing progression of an asset(s) and/or service through testing stages. These terms were introduced:

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

Once assets completed these stages, they could be deemed ready to sign the necessary documents and participate in the TRANSITION trials beginning in autumn 2021.

It has been a challenge for the MVS team to ensure that all aspects of the local energy system are tested within the MVS environment: not just asset development and operation but also service context and elements such as digital platforms, communications, data exchange and user interaction. The focus has remained on iterative testing of an asset, stemming in part from IUK monitoring requirements.

In tandem with the development of the MVS levels, the MVS A asset types evolved into the following groupings:

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

4.1 Learning from Phase 2 MVS trials

4.1.1 Technical assessment of flex capabilities

Over 20 trials were run during the second phase from October 2020. Learning outcomes (from the Sandford Lock hydro plant, Rose Hill battery, HVAC[14] at the County Library and aggregated Powervault-owned residential batteries, aggregated by the EdF Powershift platform) are summarised in Table 6 of the full synthesis report.

4.1.2 Assessing commercial dimensions of asset participation

To ensure early input from LEO partners in relation to commercial (contractual and financial) decisions, a Commercial Working Group was set up in Y2, led by SSEN and attended by all partners. The purpose was to break the flexibility market into elements (e.g. business-as-usual processes, auction and bidding mechanisms, market operation, and technical requirements), to understand how they can be simplified for new flexibility providers. The group created market stimulus packages and developed commercial MVSs to test contractual and financial arrangements.

TRANSITION conducted a short study that identified 26 commercial areas that would benefit from feedback to develop the delivery of these services and six MVS trials that would benefit from input by LEO partners during 2021:

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

In January 2021, MVS 001 was conducted by Origami. The aim was to determine the suitability of TRANSITION's suggested pre-qualification questionnaire (PQQ) process for organisations with DERs with much lower levels of flexibility than are normally found in BaU flexibility markets, and that are unfamiliar with such markets. The PQQ process may be time-consuming, particularly for those not used to collating such information and providing it to a third party. It is prudent to consider giving supporting information for PQQ questions, to clarify requirements.

[14] Heating, ventilation and air-conditioning

Additional commercial MVSs ran in late spring/early summer 2021 and TRANSITION will be conducting auctions for selection and delivery of DSO-procured flexibility services through the remainder of the project.

4.2 Operational learning from the MVSs

LEO is showing that it is possible to carry out system innovation trials without disrupting service to electricity customers: to start developing a new system within the old one. The main operational lessons from Y2, recorded in the LEO learnings log, interviews with partners and project meetings, have been that:

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

4.3 Development of the MVS hypothesis framework and research questions

An MVS hypothesis framework was set up, with a hierarchy of research questions to direct and collate MVS learning outcomes. The aim is to align detailed technical/commercial/social questions answered in MVSs (on the right of the diagram in Figure 3) with higher-level questions relating to MVS categories, services, service types and (on the left of the Figure) with overarching project-wide questions that seek to understand the flexibility market as a whole.

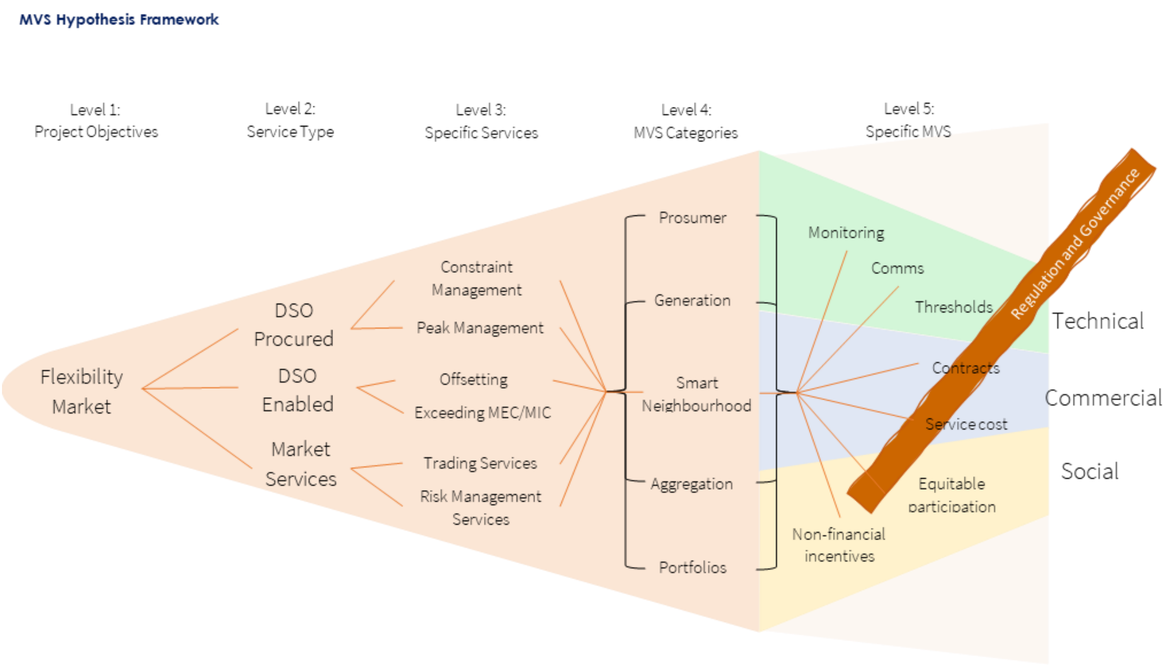

FIGURE 3: LEO MVS HYPOTHESIS FRAMEWORK

It has been a continuing challenge to identify questions from MVS trials appropriately and to feed into higher-level questions. However, we anticipate that as the project moves into the full trials period from November 2021, it will begin to answer these questions more readily.

4.4 LEO /TRANSITION trial plan

The trial plan sets out the approach for the post-MVS+ trial periods and details how this will be enabled through TRANSITION. There will be evidence on the market dynamics and requirements for DSO systems (specifically the NMF and WSC), and management of commercial arrangements. The trials will also explore the willingness of service providers to make flexibility available and establish the value of services to the DSO and market actors in a whole-system context, over three periods:

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

Following publication of the plan in February 2021, the consortium convened a Delivering Trials Steering Board and working groups beneath this to put processes in place.

5 Data

Work continued on access, protocols, data cleaning and other essential routine operations. Major gains have been the development of the Oxfordshire Integrated Land Use Mapping tool and the LEMAP tool, to assist engagement with stakeholders.

Monitoring of substations and feeders at low voltage levels has hitherto been extremely patchy. LEO has explored monitoring requirements to feed the Whole System Coordinator (WSC) systems, detect network constraints and verify the performance of flexibility assets. By January 2021, SSEN had installed 81 low-voltage monitoring sets to gather baseline data from the network, at points feeding flexibility assets which will form part of the trials due to begin in the autumn. These will provide insight into network activity and the impact of the trials[15].

Activities related to data acquisition, processing, storage and evaluation fall within the 'system learning' work package, which provides tools and data to external stakeholders and researchers:

- developing processes for capturing data to measure the effects of LEO outputs;
- gathering time series data to allow for analysis and modelling of LEO products;
- gathering spatial data to build integrated land use mapping tools to inform planning.

Y1 activities in relation to data and mapping included developing the Data Sharing agreement data protocols and storage; identification of available datasets, the first iteration of the Integrated Land Use Mapping Tool and establishment of initial key performance indicators. In Y2, these activities were developed further and a system was adopted whereby all shared datasets are linked with a data certificate. This has allowed partners and stakeholders to understand and use the complex data being shared more readily. External stakeholders have an interest in gaining access to LEO's data and LEO partners are exploring a more tailored platform service.

---

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

The project has sought to make data-cleaning tools more readily available online, and has developed an online Data Cleaning Dashboard, using Dash (by Plotly) cleaning tools; also a LEO Data Health Tool, within the dashboard, which scans the health of incoming datasets before data- cleaning. The plan is to develop these tools further in Y3.

5.1 Data collection and management

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

Reporting and data sharing for MVS trials now focus more on collecting data specific to assets at various stages, for more comprehensive trial evaluation. A significant update in Y2 to the Data Sharing Log allows users to report data in a more flexible manner, using one form for both background and foreground logging. Y2 developments in the MVS Programme mean that many of the Y1 processes were streamlined.

Various data management tools were reviewed during Y2 and Microsoft's Power BI, a data analytics platform, is seen as the option to provide the most holistic and cost-effective approach.

5.2 Spatial data and land use mapping tools

A key output has been the development of a land use mapping and energy planning tool. This is important for informing planners, policy makers and network operators who need to make decisions to prepare for SLES and associated trading platforms, and to assist replicability.

Nine categories of spatial data were identified:

Non-energy	Energy
Context – boundary layers	Network
Land use	Electricity
Buildings	Heat
Socio-economic	Transport
Lifestyle	

Of the 79 layers of data in these categories, 69 were acquired by Oxfordshire County Council or OBU and a further 10 are yet to be acquired (including aerial thermal imagery, property value information, ACORN geodemographic data and network-constrained areas).

Updating the Integrated Land Use Mapping Tool with the SSEN secondary substation areas involved the time-consuming process of acquiring datasets from different organisations and checking data quality. OBU reviewed approximately 18 platforms and 17 mapping tools in detail. Their conclusions, taken on board for the next iterations of the tool, are:

- The legacy of any tool arising from Project LEO must be carefully considered, to ensure datasets are maintained and accessible after the project comes to an end.
- To stand out from the crowd and offer the most useful insights on land use and energy from a planning perspective, there is a need to develop platforms and tools that address

electricity, heat and transport holistically, rather than as single vectors (as most current tools/platforms do).

- To engage with resident and community groups as well as planners and developers, the tool and/or platform should use publicly-available datasets as much as possible, to avoid the need for costly licences.

The aim is to develop the tool with features to enable users to view and query geospatial data, to inform strategic energy planning. This will complement the high-resolution property-level mapping being developed by OBU (see following section) for planning SFNs. The County Council have also been working with EDF-Urbanomy to trial a method for assessing pathways to net zero carbon for new developments, considering not just overall energy supply and demand but also the potential of flexibility services. The findings from this study will help inform the local area energy plan being developed by the Eynsham SFN.

5.3 Development of LEMAP

Project LEO provides a perfect testbed to develop and test an interactive community engagement tool, due to the high level of interest shown by Oxfordshire communities, particularly the emerging SFNs. OBU has been using high-resolution property-level data to develop a local area energy mapping approach (LEMAP) for planning SFNs. In contrast to the Interactive Land Use Mapping Tool discussed above, LEMAP operates at the neighbourhood and property level. It brings together public, private and crowd-sourced data on energy demand and resources, building attributes, demographics, fuel poverty and electricity networks within the ESRI ArcGIS platform.[16]

The LEMAP tool has been designed for community groups, residents and local authorities, to assist in planning, and it has been applied in the Rose Hill SFN. It has three technical elements (baselining, targeting and forecasting) and three engagement elements (participatory mapping, storymap and forum). The technical elements were targeted towards project teams (local authorities) and intermediaries (e.g., community interest companies, project managers) involved in planning SLES, while the engagement elements were designed for residents and community groups.

Feedback from the first version of LEMAP has shown interest in scaling it up to the county level and rolling out to other communities for planning and delivering smart local energy initiatives.

6 Stakeholder engagement

Engagement takes many forms throughout LEO’s work, from MVS trials through to preparatory work for the SFNs and engagement with project advisers and policymakers.

Stakeholder Engagement Principles were agreed during Y2, on the basis that:

- The energy system is understood as a socio-technical system.
- Engagement is informed by needs and priorities of stakeholders.
- Engagement is ethical and inclusive.
- The framework for engagement is evidence-based, to assist learning and replication.
- Engagement complies with statutory rules and codes of practice.

[16] https://project-leo.co.uk/reports/eceee-report-spatio-temporal-local-area-energy-mapping/

6.1 Stakeholder types

At community level, stakeholder engagement has included building support for SFNs and engaging with building managers, vehicle fleet managers, landowners and other 'middle actors' to develop demand-side response and sites for renewable generation. The project pays special attention to building relationships with more disadvantaged stakeholders who cannot benefit directly from owning or operating energy assets.

External stakeholders are those who:

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

The Stakeholder Advisory Board, meeting twice a year, is a vital forum in which institutional stakeholders and LEO partners learn from each other and discuss how to use LEO findings.

6.2 Engagement lessons

Some Y2 engagement lessons have been that:

- When reaching out to new audiences, it is important to set the context. For example, explaining to community groups how engaging with LEO and with work on flexibility is relevant in global, national and local contexts.
- Consistent use of technical terms within Project LEO must be reinforced, e.g. through continued development of the shared glossary.
- Plain English versions of terms are needed for non-technical audiences.
- Where possible, LEO should focus more on benefits for the energy system, carbon reduction, and the people using energy than on the features and mechanisms underpinning services.

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

The attempt to set up value propositions that reflect what is important to potential participants is an exercise in listening as much as in design. The proposer needs to understand thoroughly the people who will be involved in providing and using a service, and any particular roles that individuals or organisations can play. One lesson from engagement to date is that financial reward alone is unlikely to motivate the owners of relatively small flexibility assets.

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

6.3 Communicating LEO

The LEO inception workshop in June 2019 achieved an early consensus on the overall project vision: a local balanced energy system, ecosystem benefits and affordable energy to meet all needs. By autumn 2020, however, the messages were becoming too complex to communicate clearly and LEO sought assistance from a marketing communications consultant. The resulting report distilled the vision to a single desired outcome:

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

The task for LEO partners is stated as:

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

… and an 'elevator pitch' is:

Project LEO is accelerating the transition to a zero-carbon electricity system. It does this by building an evidence base of the technological, market and social conditions required for a greener, more flexible and equitable electricity system, through projects that:

- *test and enable new market and service flexibility models,*
- *advance the capabilities of networks to manage smart, renewable and storage technologies,*
- *facilitate local participation in the electricity system … in a way that demonstrates how a local balanced electricity system can bring social, economic and environmental benefits for all.*

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

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

There followed an analysis of stakeholders and the communication goals for each. Following adoption of this report, a Communications Strategy team was set up and the LEO newsletter has been redesigned and published via the customer relationship management platform, Mailchimp. A web address, https://project-leo.co.uk/stay-connected/, lets any interested person find the latest newsletters, blogs and videos about the project.

Social media outreach has expanded over Y2, the website has been redesigned and communication tools including videos, animations and case studies have been developed. The aim is to increase our use of real-life exemplars to illustrate SLES concepts: for example, work with the SFNs showed that many members did not fully understand what was made by flexibility trading. A first response has been to write a user-friendly blog on the topic, but as time goes on it will be possible to point to local examples of trading in practice. This is all part of the 'learning by doing' approach, widening the circle of those who are learning.

Stakeholders have been classified according to the kind of relationship they have with the project and the effect their actions may have on progress and outcomes, as Keyholders, Amplifiers and Learner-actors. Goals were set for each type.

TABLE 3: COMMUNICATION GOALS FOR LEO STAKEHOLDER AUDIENCES

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

This segmentation can be further developed according to type of interest and levels of knowledge. For example, among the 'keyholders' are people with the power to direct change who may be baffled by competing policy initiatives or complex evidence. We therefore want to provide messages that clearly explain the scale of the challenge, solutions being sought and ways of taking action. Figure 3 shows how this may be done in such a way as to build interest and involvement as people move up the pyramid.

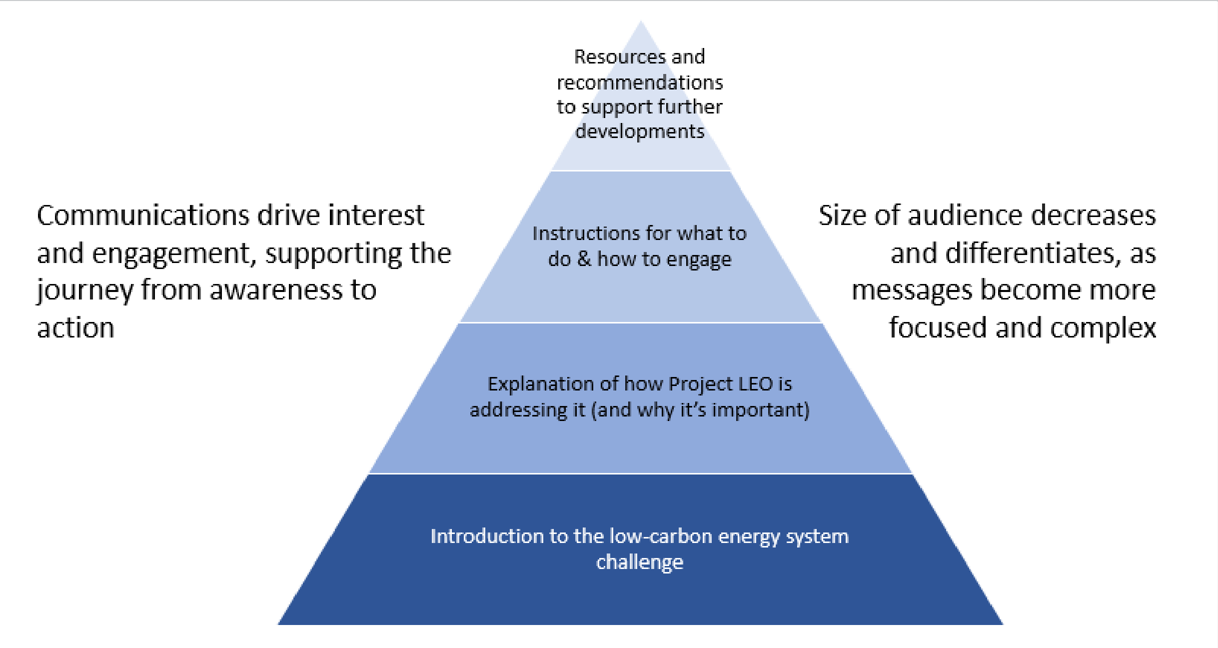

FIGURE 3: THE LEO COMMUNICATIONS PYRAMID

Communication functions are now on a more secure foundation from which to build the 'influencer' work scheduled for autumn 2021, including a presence at CoP26 in Glasgow.

7 Policy and regulatory context

All the Oxfordshire local authorities have declared a Climate Emergency, indicating cross-party support for climate action. There have been two very productive events with councillors and planners in Y2.

In February 2021 the Zero Carbon Oxford Partnership was launched with the support of major businesses, the Oxford Health NHS trust, and six LEO partners: Oxford City Council, the County Council, SSEN, Low Carbon Hub, Oxford Brookes University and the University of Oxford.
The ZCO Partnership Action Plan includes development of a joint lobbying strategy and there could be opportunities to collaborate with LEO on policy engagement.

At national level, there continues to be high ambition for carbon reduction and for renewable supply (mostly offshore wind). But the 2020 Energy White Paper[17] has very little to say about local approaches to transition, beyond a general statement of support for SLES, recognition of the role of local authorities in decarbonisation, and a commitment to assess '*what market framework changes may be required to facilitate the development and uptake of innovative tariffs and products*' during 2021, prior to a formal consultation. The 'strategic context' chapter of the White Paper recognises the need for flexible, responsive management in an increasingly decentralised system but does not mention the potential for smart local control.

The LEO vision is consistent with each of the White Paper commitments to consumers (affordability and fairness, smart meter rollout, facilitating competition and switching, removing market

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

distortions, and protecting consumers as new 'smart' services evolve). Hence the urgent need to develop and communicate the vision and the practical case for SLES through experiment and engagement with people 'behind the meter', in practitioner roles, and in policy-making bodies.

While Ofgem are committed to energy transition and to the incorporation of distributed supply- and demand-side resources, they are still working with a highly complex regulatory framework that was designed for a centralised system. SLES innovation thus still faces policy and regulatory risks. The outcome of the Targeted Charging Review has made many potential renewables-based projects unviable that could, in more favourable conditions, develop into elements of a SLES. As noted last year, necessary changes to network infrastructure can only be sustained if there are corresponding changes to the structure and functioning of the electricity market. For example, there are still many uncertainties about the value of flexibility in different places and at different times. Settling transactions within a LEM, between local markets and between a local and a national market still poses operational and regulatory challenges. A review of the Significant Code Review of Access and Forward-looking Charging is still under way.

There is national policy support for some of the technologies investigated in LEO. For example, in the '10-point Plan for a Green Industrial Revolution',[18] major investment is promised for electric vehicle charging infrastructure (£1.3bn) and the manufacturing of EVs. Heat pumps are also supported through a market-led demonstration programme and changes to regulations, with the aim of creating a market where 600,000 heat pumps are installed per year by 2028. However, the flagship Green Homes Grant was closed to new applications from March 2021. This had funding provision for heat pumps and insulation measures. Heat pumps are still subsidised by the Renewable Heat Incentive but this scheme too closes to new applications from 31st March 2022.[19] This leaves the UK with no programme to support low carbon and energy efficient retrofit for UK householders other than the Energy Company Obligation, which is solely targeted at improving standards for householders on very low incomes and at risk of fuel poverty.

Local authorities have a critical role in fostering take-up of low carbon technologies and creating societal benefits via the planning framework. The general policy direction shaped by declarations of climate emergency and carbon reduction plans is helpful but not yet sufficient. Some Local Plans to drive development in particular directions were published years before the need for wholesale energy transition was fully recognised, so their policies may only weakly support the types of technology and approaches required in a SLES. Assessment of the Oxfordshire local plans reveals that they are largely focussed on setting out policy for new development, rather than policies to encourage retrofitting of existing buildings. Approaches to Local Area Energy Planning, under development by the Centre for Sustainable Energy and the Energy Systems Catapult, offers much-needed methods to plug gaps in local authority policy and strategy.

8 Learning and evaluation

As a demonstration project, LEO promotes what proves effective in term of energy transition and SLES. The learn/evaluate remit operates in five main ways:

- Synthesising learnings from the project, to address fundamental questions. For example, are SLES technically, economically and socially feasible? What are the environmental, economic and social benefits of a SLES? Who are the winners and losers in an energy transition that

[18] https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution
[19] https://www.ofgem.gov.uk/environmental-programmes/domestic-rhi/applicants

deploys the approaches and processes demonstrated by LEO? How do we make the journey to a new system which ensures nobody is left behind and benefits are shared fairly?

- Evaluating project learnings through contextualisation and comparison: placing them in the regulatory and policy landscape, assessing value propositions and capabilities to participate in and benefit from SLES.

- Research into the SLES and LEM ecosystems – actors and their interrelationships.

- Continued development of a Theory of Change that explains *how* change can happen in the course of transition to a renewables-based SLES.

- Informing design of tools and approaches for use by others – guidance and reports.

Our approach to understanding and evaluating LEO is based on an understanding that a SLES emerges from stakeholder interactions with people and with things: it needs social, economic, political, communications and material infrastructures and processes.

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

- Regulatory and policy context: a report on this is pending.
- Aspects of capability to participate, engage, and benefit from Smart Local Energy Systems: a review supplemented with interviews with partners and other stakeholders, to explore household, business, neighbourhood and system capability to participate in a SLES or LEM - technical, economic, social and lifestyle. As preparation, in Y2 we produced a conference paper on this topic.[20]
- Value propositions in SLES, to understand the principles of existing and potential business models.
- Actor networks in a local energy ecosystem, to identify key actors in a SLES and characterise the relationships between them. Actors will include householders, SMEs, technology companies, local authorities, public sector buildings estates teams, the DNO, energy companies and aggregators.

Processes for documenting and learning have been streamlined. There is a Central Learnings Log where lessons from all aspects of the project are recorded, along with comments on why they are important. The main sources are:

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

[20] https://project-leo.co.uk/wp-content/uploads/2021/06/ECEEE21-Banks-and-Darby_140521_final-1.pdf

8.1 The LEO Theory of Change

All these processes feed into a theory of change (ToC) that can show the processes and actors needed to achieve project goals: seeking answers to the 'How? What? Where? When? Who?' questions[21] that can be applied to the development of local energy systems. The ToC is periodically reviewed by project partners and revised, and the most recent version is illustrated in an Appendix to the full Y2 synthesis report. Note that it is a work in progress, reflecting partners' current thinking, and by no means a blueprint. LEO findings are evidence for or against the viability of processes proposed in the ToC, which needs to be modified in line with new evidence. In this way, the theory becomes an increasingly useful account of how the project is achieving its objectives. Developing the ToC also helps us to assess how far LEO approaches can be adopted elsewhere.

8.2 Key Performance Indicators and monitoring

KPIs require good sources of data and a framework of aims and objectives. They have been revised during Y2 and the new, more concise, arrangement classifies them under the headings of:

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

Innovate UK requirements have guided monitoring and recording, and LEO may still be required to report against further KPIs, developed by Innovate UK and the Energy Revolution Integration Service (ERIS). These are designed to measure overall project impacts and the degree to which LEO is meeting PFER objectives. There is ongoing work within EnergyRev to identify indicators to measure 'co-benefits' of smart local energy systems.[22] LEO, EnergyREV and ERIS will need to stay in touch regarding approaches to evaluation.

8.3 Can LEO be copied elsewhere?

The project continues to show the importance of local factors for the development of a SLES – for example, local ambitions, knowledge and skills, planning challenges and network conditions. The more actors and technologies are involved in a new system, and the more it relies on specific local conditions, the harder it will become to repeat precisely in another place. We therefore need to test and record processes in such a way that others can judge whether and how to adapt them to their own situations. Conversations about replication are already under way with a small number of 'Fast Followers' who are interested in developing SLES in their areas.

The major mapping exercise carried out in Y2 is expected to have influence well beyond LEO. It is already showing its value as a tool for engagement with stakeholders and for identifying sites that may be suitable for renewables and could be incorporated in the Oxfordshire Plan 2050.

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

[22] See p6 of Framework for Smart Local Energy Systems https://www.energyrev.org.uk/media/1273/energyrev_paper_framework-for-sles_20191021_isbn_final.pdf

9 Conclusion: building on the foundations, looking ahead

Given the delays and strains arising from the Covid19 pandemic over the past year, the funded extension to the project for a further year (to March 2023), is very welcome.

Y2 has shown some of the challenges and path dependencies when attempting to build a new system for almost 700,000 people within the regulatory, physical and organisational constraints of the old one. These will continue to need addressing at the appropriate levels. However, Y2 work on the project has continued to validate the 'agile learning' approach and has brought exciting innovations such as the mapping work in WP4, elaboration of flexibility trading processes and development of the SFN programme. It has also produced the preparatory work for full-scale trials. We anticipate that Y3 will be an exciting and demanding year of flexibility market trials, establishing the first SFNs, gathering new data and putting it to work, and evaluating the outcomes.