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Plug-in Projects –Year 1 Review

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Context

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

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

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

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

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

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

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1 Executive Summary

During year 1 of Project LEO, the Low Carbon Hub (LCH) has worked with its 43 existing projects and 17 new projects to form a pipeline of 'Plug-in Projects' (PiP) for Project LEO. This pipeline would:

1. Provide the range of Plug-in Projects required to complete fully automated flexibility service market[1] trials by the end of Project LEO;
2. Test the technical, commercial and social viability of the Plug-in project exemplars in current market conditions;
3. Inform policy and regulatory processes currently on-going, eg RIIO-2 and RIIO-ED2[2], to ensure that they support the development of a mass market of flexible assets (generation, storage and demand-side reduction) at the grid edge.

1.1 Range of projects

The development of assets as initially planned has been hindered by unexpected events since the project plan was first submitted. The most severe of these have been:

1. The uncertainties caused by the outcome of Ofgem's Targeted Charging Review (TCR)
2. The emergence of the COVID-19 pandemic
3. Uncertainty over the value and availability of new long-term revenues after the end of the Feed-in Tariff that, in itself, makes the investment case for small-scale assets very challenging.

Despite these challenges, LCH has continued the development of Plug-in Projects by taking on higher risks, beyond the value of the iUK grant funding available to it through Project LEO. LCH has been able to do this because its business model produces community benefit funds that can be used to provide essentially free money as match to the grant funding. In this way, LCH has maintained the range of Plug-in Projects required to develop and test the technical aspects of delivering the five flexibility services[3]. The constraint lies in the numbers of projects of each type LCH is able to fund in this way.

1.2 Viability

In terms of **technical** viability, the LCH portfolio of existing and new projects has already provided the foundation for the development of a comprehensive programme of Minimum Viable System (MVS) trials. These projects are located in priority geographic areas defined by primary substation

[1] Flexibility services refer to a subset of the wider energy market and are either procured or facilitated by the Distribution System Operator (DSO).
[2] RIIO-ED2 is part of the overall RIIO-2 price control process. The overall RIIO-2 process covers electricity distribution as well as electricity transmission, gas distribution and ESO controls.
[3] The five flexibility services identified are: Sustain Peak Management, Secure or Dynamic Constraint Management (Pre- or Post-Fault), Secure Short-Term Operating Reserve, Exceeding MIC/MEC and Offsetting.

boundaries where full trials of new flexibility services will take place, including full integration of assets to end-to-end automated markets.

The pipeline is also generating valuable learnings about how to enable flexibility at low voltage levels of the electricity network, the grid edge. It is clear from this work that there are more technical issues to solve than were anticipated, and that these issues are about communication protocols and data management as much as about hardware, but there is confidence that these issues can be solved.

The picture on **commercial** viability is less positive, however. It is clear from work on the year 1 projects that the current market structure, particularly the lack of long-term visibility of new revenue streams, favours exceptional projects where there is a very favourable combination of factors in play, such as:

1. Large scale
2. High percentage of behind-the-meter use of on-site generation
3. The availability of long-term Power Purchase Agreements (PPAs)
4. Low-cost, and timely, availability of grid connections, and
5. Revenue streams that have the minimum of exposure to policy changes, such as the TCR.

It is almost impossible to stack up new small-scale assets for the provision of flexibility services at the grid edge. Given the projected market penetration of electric vehicles (EVs) over the coming decade, this situation will need to change if capacity at the grid edge is to be able to accommodate this major shift.

Given these realities, it is likely that the provision of flexibility services will initially just provide an upside to the financial models of existing generation and storage assets, and will not incentivise the development of new demand reduction projects.

The MVS trials have not yet addressed issues of **social** viability. A range of nine Smart and Fair Neighbourhood projects (SFNs) has been developed forming years 2 and 3 of the project pipeline that will allow us to gain understanding about the desirability of the services being trialled and the extent to which it is possible to develop social acceptance around them, creating an enabling environment for fast uptake where co-benefits are clear and available.

1.3 Policy and regulation

Small-scale assets at the edge of the network are currently not financially viable and in order to make them so, and to enable capturing the value potential in the overall energy system, some aspects must addressed, such as:

1. High transaction costs are present throughout the regulated energy sector which will require streamlined processes and widely adopted simple and standard contractual frameworks to reduce

2. The simple adaptation of current ESO/DNO model for the contracting and procurement of flexibility services also has very high built-in transaction costs making it impossible for small-scale assets to participate in the market; a solution must be found in dealing with those transaction costs too
3. Continued cost curve reductions are required, including an estimate of when PV and batteries would achieve the required price given forecast rises in energy costs; though in the long run the marginal cost of equipment, particularly PV, will rapidly tail off and have an ever-smaller impact on the overall cost of development, especially for small-scale assets
4. Embedded Benefits revenue needs to be replaced, with the assignment of monetary value that truly reflects the benefits of flexibility, such as time of use and location-specific tariffs or the ability to choose different network services levels depending on individual requirements[4]
5. Policy requirements are need that direct building owners to maximise generation/storage on-site. Alternatively, incentives could be put in place that would encourage them to do this by adding to the commercial business case for installing such assets or reducing business rates payable on buildings[5]
6. Metering and access to data must be simplified and standardised
7. Export PPAs could be developed with local/regional institutions in such a way that acknowledges the overall economic and social benefits of local generation and flexibility and assigns adequate monetary value to it.

The financial case for developing local and relatively small-scale assets is currently not stacking up. This prevents the deployment of critical flexibility at the edge of the network which is not only critical for meeting the zero-carbon target for 2050. Rather, flexibility provided by small scale assets at the edge of the network not only provides a more resilient network but also has the capacity to make a major contribution towards:

- Reducing the overall investment in infrastructure by 50%
- Reducing peak capacity by 17 GW through smart demand
- Reducing annual whole-system cost by £5.0 bn[6].

It also provides the means for the type of engagement with people that is needed to ensure an equitable system and the societal changes required for achieving the 2050 target.

The analysis and learning from year 1 of Project LEO is now providing input into a White Paper being developed by the LEO Consortium, led by Origami. This paper will discuss and propose ways to address some of the issues identified and how changes in policy and regulation could become an enabler of flexibility at the edge of the network.

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[4] Questions related to social equity must also be addressed, so people can truly select and afford the appropriate service level. That will take into account questions of tenant/landlord split of benefits, how to enable people to invest in the assets they need for their homes, etc.

[5] Currently there is a disincentive to the development of on-site renewables as such development increases the rateable value of a property and therefore the amount of Business Rates payable.

[6] "Modelling the GB Flexibility Market, Part 2: The Value of Centralised and Distributed Storage", A technical report for Piclo, co-authored by Element Energy and Graham Oakes, in partnership with Innovate UK and Project LEO.

2 Report Purpose

This report fulfils the Project LEO Deliverable 3.6.1 'Produce a Report on Progress of Year 1 Projects'.

The report covers progress to date on projects taken forward in year 1 (finance, construction and operation), taking into consideration issues and remedies.

The report draws conclusions from the work that can inform:

- the development of the Project LEO flexibility services market
- the LEO WP3 pipeline of Plug-in Projects for years 2 and 3
- the Project LEO policy and regulatory influencing programme.

3 Year 1 Pipeline: Project Status

The Low Carbon Hub has 73 potential projects identified as Plug-in Projects for LEO. Of these, 43 are operational assets which are listed in full at Appendix A. The rest of the projects form a pipeline of proposed new projects as set out at Appendix C. The WP3 PiP Board approved 16 projects from this portfolio for year 1 of Project LEO. Out of these 16 projects 6 have been completed and are operational, 9 are in progress and 1 was aborted. The list of projects and their status can be seen in the table below, grouped by categories as detailed in the current version of the Detailed Project Plan v4.0.

The status and applicability of these projects to Project LEO are continually reviewed. Where a project is unlikely to fit the criteria for a MVS trial, or is unlikely to be delivered in time, it is replaced with another project to be put forward for approval by the PIP Board.

The project identifiers (i.e PD3.XXX) are used in all aspects of LCH project management and are used here to enable ease of cross-reference with project finances.

Project ID	Project Category / Name	Status
	Oversolar Extensions & Optimisation	
PD3.258	CTG Banbury Extension	Completed, operational
PD3.294	Rose Hill Primary School battery	In progress, construction
	Oversolar Newbuild	
PD3.235	Thames Travel	Completed, operational
PD3.240	West Witney Primary School	Completed, operational
PD3.265	Langford Village Primary	Completed, operational
PD3.263	Oratory School	Discontinued – school not able to enter into contract due to Charities Act restrictions[7]

[7] Impact of The Charities Act 2011 requires a charity to demonstrate best value before granting a lease, which independent surveyors and trustees feel reluctant to sign-off even though the project will have no cost to the

	Community Microgrid / CESCO	
PD3.295	Sutton Courtenay Abbey	In progress, legals
PD3.251	Rose Hill Community Centre	In progress, construction
PD3.252	Rose Hill Advice Centre	In progress, construction
PD3.253	Elsfield Hall	In progress, legals
PD3.SFN-HN	Hook Norton Community Housing microgrid	In progress, feasibility
	Hydro Optimisation	
PD3.026	Sandford Hydro Gate Automation	In progress, construction
PD3.026	Sandford Hydro Power Output Control	In progress, construction
PD3.026	Sandford Hydro Reactive Power Control	Completed, operational
PD3.026	Sandford Hydro System Integration	In progress, development
PD3.OLH	Osney Lock Hydro Gate Automation	In progress, statutory permits
	Third-party Asset	
	Oxford Bus Company Battery Control	Completed, operational

Table 1 – Approved year 1 Plug-in Projects status

Brief descriptions of each project type are given below.

Oversolar extensions and optimisations

The whole Low Carbon Hub portfolio of 42 existing solar rooftop PV arrays is reviewed continually as results come from MVS trials to identify opportunities for increasing capacity and installing batteries. The objective is to prove the concept for a business model around oversizing existing renewable generation and providing batteries to make generation from the whole array dispatchable, i.e. installing as much as PV as possible on a roof area irrespective of the load of the host building.

Oversolar newbuild and new solar groundmount

This project type is about moving on one stage from the oversolar extension projects and proving the concept of a post-FIT business model for installing new, oversized PV arrays with appropriately sized batteries alongside them. The business model for these will rely wholly on the stack of income from sales to the host and income from flexibility services in a way that oversolar extensions and optimisations projects do not.

Hydro optimisation

This project type is about allowing us to test the potential for using the river itself as a battery to store water for greater generation at predictable times of high demand, particularly the morning peak. Optimisation will include improved controls for reactive power and total output power. The automation of weir gates is a required safety feature to minimise flood risk and will also give the Environment Agency the added benefit of greater control in times of emergency.

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charity and they will have guaranteed savings on electricity – they cannot demonstrate best value simply because there is no other similar offer to compare against. An amendment that would exempt community energy from that property clause would resolve the issue (acknowledging that different trustees may read the same report differently).

Community Energy Service Company (CESCO) and community microgrid models
This project type is about combining on-site generation, storage and demand reduction behind the meter to deliver energy services to owners and occupiers with assets owned by LCH. Small-scale proof-of-concept models where the equipment is owned by the CESCO and the customer is charged for the provision of light and heat.

There were no projects scheduled for year 1 in the **Heat networks** and **Smart transport hub** categories. Preliminary work on projects expected to come forward in these categories, however, revealed either that the project would not be viable even with Project LEO grant funding (Hinksey Pool) or would not come forward within the timescale of Project LEO (Park+Ride projects). This project type is therefore now being included within the Smart and Fair Neighbourhood trials via a network of heat pumps at Deddington/Duns Tew and a network of EV charging points at Osney Island.

4 Technical Factors

Both existing and new projects have provided early-stage MVS trials that have tested both how to operate assets to provide flexibility services and what processes are required to run end-to-end, fully automated markets in each service. These are described in detail in the MVS trial reports: MVS A2 Sandford Hydro Technical Report; MVS A3.1 Technical Report Oxford Behind the Meter (Sackler Library); MVS A Procedural Learnings.

4.1 MVS Programme

The MVS Programme includes the “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)”[8].

The MVS programme of trials include several of LCH’s assets including those already in operation and developed before the start of Project LEO, recently completed projects and those under development.

The historical data and operational experience provided by pre-existing assets and the existing software platform developed by LCH (pre-LEO) for the monitoring of assets provide valuable information and insights that in turn fed into the MVS programme and the development of a new and improved software platform, the People’s Power Station (PPS), that will enable participation in fully automated markets for flexibility regardless of the size or technology of an asset.

[8] Source: LEO Year 1 Annual Synthesis Report

The location of assets, technical characteristics, type of commercial arrangements, stage of development and financial viability have all been important aspects in the selection of the wider areas for trials (under primary substations); they have also provided learning on how to enable and operationalise the provision of flexibility.

MVS trials have already been carried out with the Oxford Bus Company battery and Sandford Hydro. The outcomes have provided important input into the detailed definition of end-to-end processes for the trading of flexibility with Work Packages 2, 4 and 5.

Those MVS trials also provided critical learnings that have been incorporated into:

- the design and specification for new assets being developed, such as Rose Hill battery and the optimisation of Sandford Hydro
- new projects being developed in Years 2 and 3 of LEO
- the development of potential new commercial arrangements that can improve the access to market for small scale DER (Decentralised Energy Resources).

The experience of LCH in the funding, development and operation of its portfolio of assets combined with the progress of the MVS programme is also providing direct inputs into the TRANSITION[9] project led by Scottish and Southern Electricity Networks (SSEN).

Technical issues that have been identified from this work are:

It has become clear from the MVS trials that there are a number of interface issues to be solved and commoditised so that transaction costs can be kept to a minimum for small-scale assets at the grid edge. As noted, for this reason, a new project has been added to WP3, the **People's Power Station.** This is a software platform intended to enable small-scale distributed assets to participate in automated end-to-end markets. This project provides the interface between Plug-in Projects and the market platforms being developed by WP2. The technical requirement for this project has been clearly identified; the commercial model for it is, however, less clear and will be developed and tested in iteration with the MVS trial programme.

The platform design concept for the PPS is based on it being:

- Scalable and replicable
- Able to interface with multiple fully automated market platforms
- Multi-service (different applications)
- Able to provide third-party access to asset pools for energy and flexibility trading (virtual and/or network clusters).

Integral to being able to meet the design concept is the ability to:

- Provide bidirectional data comms with connected assets

[9] Led by SSEN, TRANSITION is testing the energy system architecture for the move to a smarter network supporting the UK's net-zero targets.

- Exchange real-time and high-resolution data
- Send and receive executable instructions to and from assets.

Access to markets, and revenue streams both from energy trading and flexibility services, are essential for improving the financial viability of small-scale assets and the PPS acts as a technical enabler (through its data comms and automated controls). Later phases of development will add upstream market integration and explore the addition of new services, or applications, ranging from portfolio performance management to citizen and community local area engagement.

The development of the PPS is being carried out in phases alongside the MVS programme in such a way that learnings from one can inform the development of the other. Figure 1 shows the schematic design of phase 1 development which will deliver the underlying capabilities of bidirectional data comms and automated remote control.

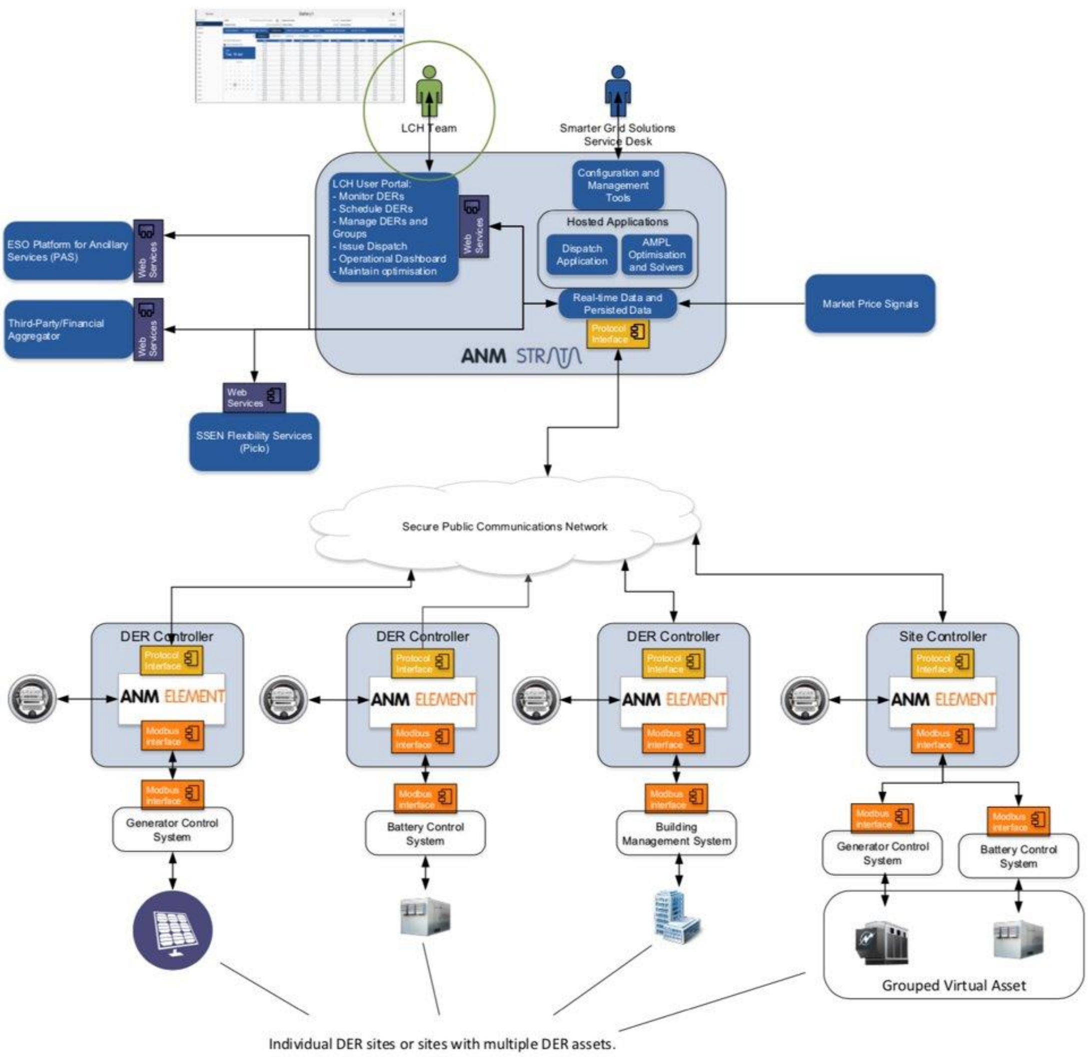

Figure 1 – People's Power Station high level technical schematic – Phase 1

Phase 2 of the People’s Power Station development includes the specific interfaces for market integration with the Piclo platform (WP2) and the Neutral Market Facilitator (NMF) platform (WP5), leading to a fully automated process for the provision of flexibility services as planned in the MVS programme.

The design specifications of the PPS also include the development of an interface to access wider markets such as ESO and energy trading through third-party market players such as suppliers and aggregators.

The value proposition underlying the business model for the People's Power Station is also under development and explores tangible financial benefits as well as intangible ones that are valued on different metrics by citizens and communities within the context of the Smart and Fair Neighbourhoods programme. While the PPS is a necessary piece in the development of the SFNs, the SFNs inform the development of its business model and new functionality.

5 Commercial factors

Project LEO objectives include the development and demonstration of viable business models for the investment and deployment of flexible assets at the edge of the network, as well as the development and testing of particular technology types and how to operate them for the provision of flexibility services.

The ongoing work on viable business models started with both an initial hypothesis and broad revenue and cost models descriptions. This initial hypothesis is that the stacking of new revenue streams from the provision of flexibility services will enable:

- Increased local installed renewable generation capacity
- Increased deployment of new storage capacity
- Participation of flexible demand assets
- Optimisation of existing asset potential (generation, storage, demand response).

This hypothesis is being tested by LCH Industrial & Provident Society using the investment criteria adopted by its Investment Committee for the deployment of its capital. These can be largely summarised as:

- Low-risk, low shareholder return
- Commercial agreements securing long term revenue to achieve:
    - Minimum nominal IRR of 7.5% (including inflation)
    - Which is broken down as 5% cost of equity and 2.5% community benefit profit.

The broad categories of revenue and cost models being explored can be summarised as:

Revenue models

1. Existing assets with revenue model based on FIT, behind-the-meter PPA, exports PPA and Embedded Benefits
2. New assets with revenue model based on behind-the-meter PPA, exports PPA and flexibility services
3. New assets with revenue model based on exports PPA and flexibility services.

Cost models

1. capital investment (CAPEX), fixed operational expenditure (OPEX), near-zero short run marginal cost[10]
2. CAPEX, mostly fixed OPEX, flexibility-driven short-run marginal cost correlated to marginal revenue[11].

These revenue and cost models are expressed in each category of LCH project as follows:

5.1 Oversolar extensions

The Low Carbon Hub has been developing rooftop PV assets under a third-party finance[12] model since 2013 and by the time Project LEO started it had an operational portfolio of 43 projects with an installed capacity of 3,530 kW.

The investment case for those assets was underpinned by long term revenue streams derived from:

- Long-term lease on the airspace above the property roof
- Long-term RPI-indexed FIT
- Long-term retail energy price-linked PPA or RPI-indexed PPA with the occupier.

These assets also generate revenue from short-term export PPAs from energy not used on site, although this represents a small proportion of the total revenue. It's important to note that export PPAs are not only short term but also significantly less in value and volatile compared to occupier PPAs. The difference in value can be up to £80/MWh.

The cost model is one of high upfront CAPEX, fixed OPEX and near-zero short-run marginal cost.

The careful dimensioning at design stage to match generation with on-site demand, along with clear visibility and long-term certainty of revenues, made these projects investable using the community benefit equity model of the Low Carbon Hub.

These assets were designed to meet a minimum risk-adjusted financial return rather than to maximise generation. As part of Project LEO therefore, these projects afford the potential to demonstrate how asset owners could increase generation capacity and add behind-the-meter battery storage based on new income streams coming from flexibility service delivery.

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[10] This applies to assets where there are no materially significant extra costs for the delivery of an extra unit of output. An example would be a rooftop PV installation where the costs remain the same whether it's producing 100% of its available output or 50%.

[11] This applies to assets where the realisation of extra revenue will have an associated and correlated input cost. An example would be a battery being charged overnight (there is the cost of buying electricity) so it can be discharged at a set time for the provision of a service.

[12] The Low Carbon Hub, as the owner-operator of the asset, provides the capital investment and generates a financial return through the sale of the energy generated.

This category of **Oversolar extension and optimisation** Plug-in Projects is intended to test the viability of increasing the already installed capacity in LCH's existing portfolio (those assets operational prior to the beginning of Project LEO, see Appendix A) with the explicit objective of maximising generation, adding storage or optimising output with new revenue streams largely deriving from:

- Short-term export PPAs
- Yet to be defined value and term of flexibility services
- And in the case of batteries behind the meter[13]:
    - Storage of excess generation for later on-site use:
        - marginal net revenue expressed as occupier PPA price minus export PPA price
    - Time of Use Tariffs (ToU):
        - marginal net revenue expressed as the difference between the sale price to occupier and import price from the grid[14].

The costs associated with the oversolar extensions are:

- deployment of further capital (CAPEX)
    - transaction costs – mainly related to commercial contracts
    - project management
    - capital items, materials and labour
- relatively small[15] increment in OPEX
    - separate metering
    - cleaning, inspections, ongoing maintenance.

LCH developed a model for analysing the potential for combined generation and storage in all 43 of its existing sites (Appendix A) as part of Deliverable D3.3.1 'Existing Assets Data Modelling'. This work showed the optimum size of a co-located battery for each existing rooftop PV project, along with the energy flows and the potential revenues from accessible markets.

The co-location of rooftop PV and battery storage can significantly reduce the overall utilisation of the local network through lower on-site peak demand, lower median on-site demand throughout the day and lower maximum on-site demand at network peak time.

[13] The use of battery storage needs to take into account the losses in the charge/discharge cycle, which for modelling assumptions were estimated at 20%.
[14] An example would be to charge a battery overnight when energy prices are low and discharge during peak price time.
[15] Fixed operating costs related to ongoing asset management, operations and maintenance management and metering have already been absorbed by the pre-existing installation. There are also economies of scale in planned maintenance, such as inspections and panel cleaning.

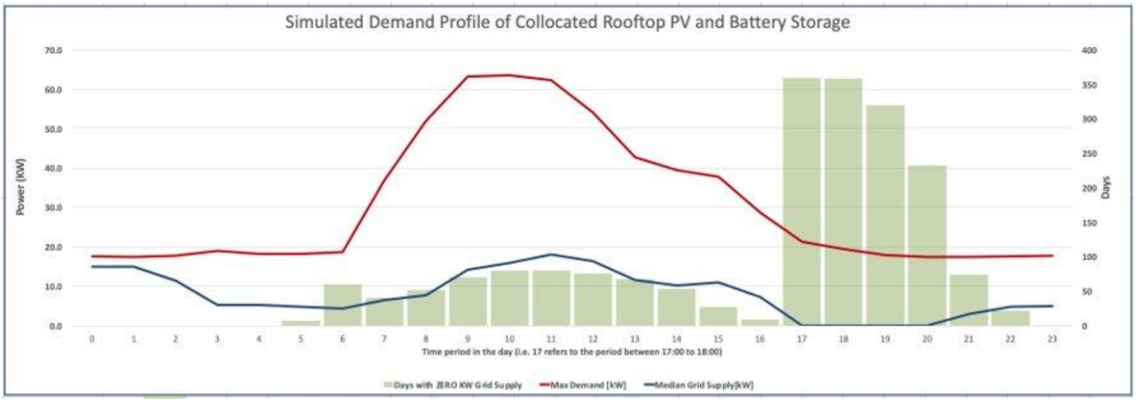

Chart 1 – Modelled reduction in network utilisation through co-located rooftop PV and battery storage at Rose Hill Primary School, showing maximum annual site demand (kW) and median network demand (kW), and number of days with no network demand. These are shown for 24 1-h periods throughout the day

Despite the overall benefit to the local network, the modelling showed that there is no current business case for the investment in battery storage in any of the 43 modelled sites. The net revenue streams arising from the battery do not make installing it an investable proposition.

With a CAPEX expenditure of circa £55k the optimum size battery at Rose Hill Primary School has forecast gross marginal revenue of less than £150/year[16] which represents a payback greater than 300 years on an asset with an estimated lifetime between 10 and 15 years. The financial viability of this asset has a net revenue gap, to meet LCH investment criteria, of circa £185/kWh-storage/year or £370/kW-capacity/year.

The decision to proceed with the deployment of the Rose Hill battery, and the provision of grant match for LEO from the LCH community benefit funds, was made to give us a real exemplar demonstrator project. We can now use it to explore in real time how to operate the asset to deliver flexibility services and understand what market conditions would need to be in place to achieve mass deployment of small-scale energy resources at the grid edge in a way that will be viable.

This project is also providing critical input into the overall MVS development programme, the development of the People's Power Station software platform, the design of the flexibility market rules and the SFN programme in general and, in particular, with the SFN under development with the local community in Rose Hill and Iffley Ward in Oxford.

5.2 Oversolar newbuild

This category of Plug-in Projects envisaged developing new rooftop PV assets dimensioned to maximise on-site generation with the potential addition of battery storage for the full provision of flexibility.

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[16] Data Modelling on Existing Assets Report, WP3 Deliverable D3.3.1, 28/11/2019. Baseline Reports PD3.181 Rose Hill Primary School

The revenues under this model would be underpinned by:

- Long-term lease on the airspace above the property roof
- Long-term index-linked PPA with the occupier
- Short-term export PPA
- Yet to be determined value and term for flexibility services
- In the case of batteries[17] behind the meter:
    - Storage of excess generation for later on-site use:
        - marginal net revenue expressed as occupier PPA price minus export PPA price
    - Different time-of-day tariffs:
        - marginal net revenue expressed as sale to occupier minus import price.

The cost model remains similar to pre-existing assets, characterised by high upfront CAPEX and fixed OPEX with near-zero short-run marginal costs.

Three assets have been developed, completed and are operational. These assets provided the basis for evaluation of the investment feasibility under current market conditions, which is unfavourable as described in the next section. These assets are listed at Appendix B, together with other projects completed in year 1.

5.3 Evolution of the third-party investment case for rooftop PV

The current analysis is based on historical data available from the development of rooftop PV assets since 2013 by the Low Carbon Hub, with a total installed capacity of 3,530 kWp divided into 3 portfolios referred to as FY 2014, FY 2016 and FY 2019, where the individual assets range from 20kWp to 700kWp installed capacity.

Table 2 shows the evolution of the underlying factors in determining the financial viability of individual projects and whole portfolios. Those assets developed from 2013 to 2016 counted on the availability of FIT as the main source of revenue.

The general trend is unfavourable to the extent that developing this type of portfolio, even in those cases where the system is carefully designed to maximise on-site use of generation, is not currently financially viable.

	FY 2014	FY 2016	LEO 2019[18]	LEO 2019[19]
Total CAPEX per kWp	£1,556	£1,217	£930	£919
Average capacity (kWp)	62	89	52	70

[17] Revenues derived from the use of battery storage take into account the losses occurred during the charge/discharge cycle.
[18] Modelled for maximising on-site use of generation on a portfolio of four assets, with 20% of energy generated exported to the grid.
[19] Modelled for maximising generation on a portfolio of four assets, with 40% of energy generated exported to the grid.

	FY 2014	FY 2016	LEO 2019[18]	LEO 2019[19]
REVENUES				
FIT	64.7%	52.8%	0.0%	0.0%
Behind-the-meter PPA	31.9%	36.4%	91.3%	79.5%
Exports PPA	3.4%	10.8%	8.7%	20.5%
Total	100.0%	100.0%	100.0%	100.0%
Operating surplus	77.6%	73.5%	41.5%	32.5%
IRR (real)	6.3%	5.4%	0.3%	-2.2%

Table 2: Evolution of CAPEX, relative sources of revenues, operating surplus and IRR on portfolios of rooftop PV developed, owned and operated by LCH.

CAPEX

- Total CAPEX has dropped from £1,556/kWp in 2014 to £919/kWp in 2019 and is driven by the drop in the long-run marginal cost of PV and inverters
- Transaction costs on the other hand have remained largely unchanged and have a weak correlation to the installed capacity; with the drop in the cost of equipment there's been a sharp relative increase of the proportion of costs associated with project management, project finance and commercial contracts.

Chart 2 shows current total CAPEX costs in relation to installed capacity for the development of solar PV assets, both rooftop and ground mount.

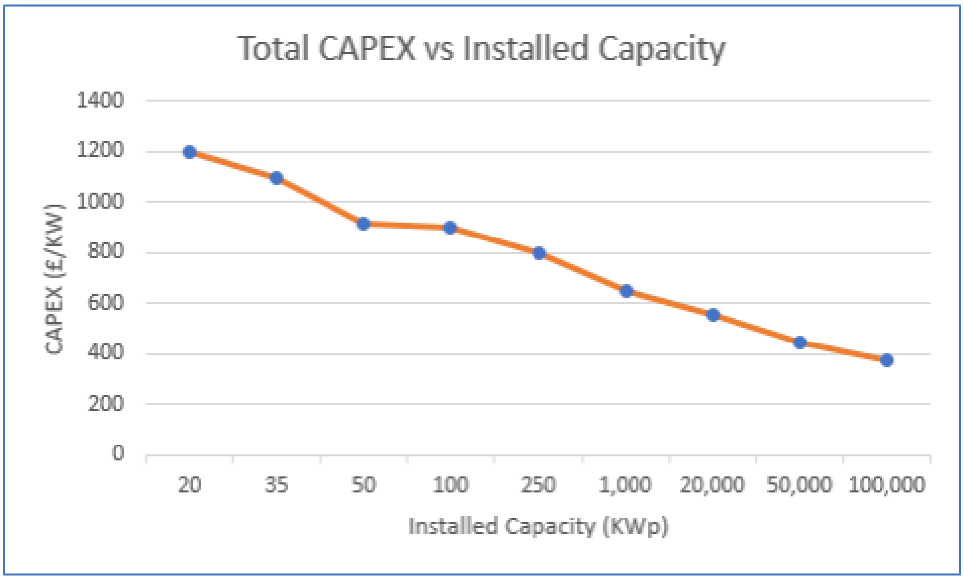

Chart 2 – Current total CAPEX in relation to installed capacity for PV assets

OPEX

- All fixed-cost OPEX have remained largely unchanged in the period from 2014 to 2019, going up from 22% to 67% of total revenue and therefore reducing the net operating profit

- These costs are mainly associated with preventive and corrective maintenance, asset management, insurance and transaction costs such as metering, data acquisition, billing and extremely cumbersome manual processes within the regulated energy markets.

Chart 3 shows current total OPEX costs in relation to installed capacity for solar PV assets, both rooftop and ground mount.

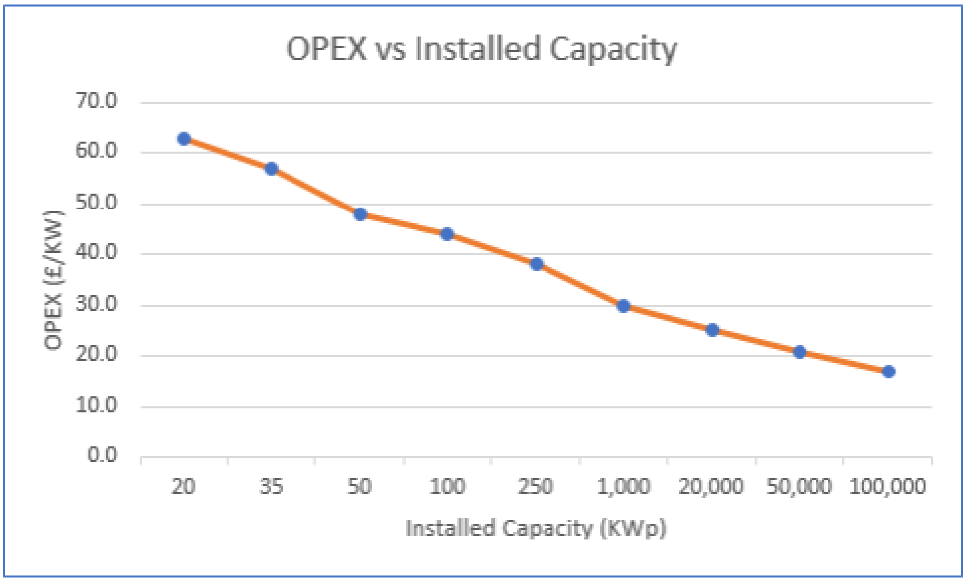

Chart 3 – Current total operating expenses in relation to installed capacity for PV assets

Transaction costs, both in CAPEX and OPEX, have a material impact on the overall financial viability of assets and they tend to be either misjudged or overlooked during policy/market or regulatory design[20].

Realising the potential available through mass participation of small-scale assets in the energy system will require all forms of transaction costs to be brought to a minimum. This could be achieved through the use of common standards, proactive default positions, simple processes, simple market structures, simple commercial documents, automation and full data transparency.

Revenues

The business case for assets developed from 2013 to 2016 was underpinned by revenues derived from FIT and long-term PPAs with occupiers, while new assets designed to maximise generation have a significantly larger proportion of revenues derived from short-term export PPAs.

[20] A case in point would be metering and the multiple parties involved: the network operator, the Meter Operator (MOP), the Data Collection and Data Aggregator (DCDA) and the site energy supplier. LCH currently has eight open cases of exports revenue not being made available for several years due to poor co-ordination between those actors in the metering chain, with the consequent impacts on revenues and costs (internal resource drain). In one extreme case, at a comprehensive school in Oxford, the solar panels became operational in mid-2014 and access to the export metering data only became available in early 2020. This was a seemingly simple task of enabling the export data channel in an existing meter with the hardware capability to do so - and it still took nearly six years and countless hours of chasing.

For projects developed until the end of FY 2016 up to 96% of revenues were underpinned by long-term, index-linked PPAs and RPI-indexed FIT. The combination of money and long-term visibility of revenue made rooftop PV projects as small as 10kW viable for investment.

Charts 4 and 5 show the current investment performance modelled over 20 years for different sizes of rooftop PV, based on 80% on-site consumption (chart 4) and 60% on-site consumption (chart 5).

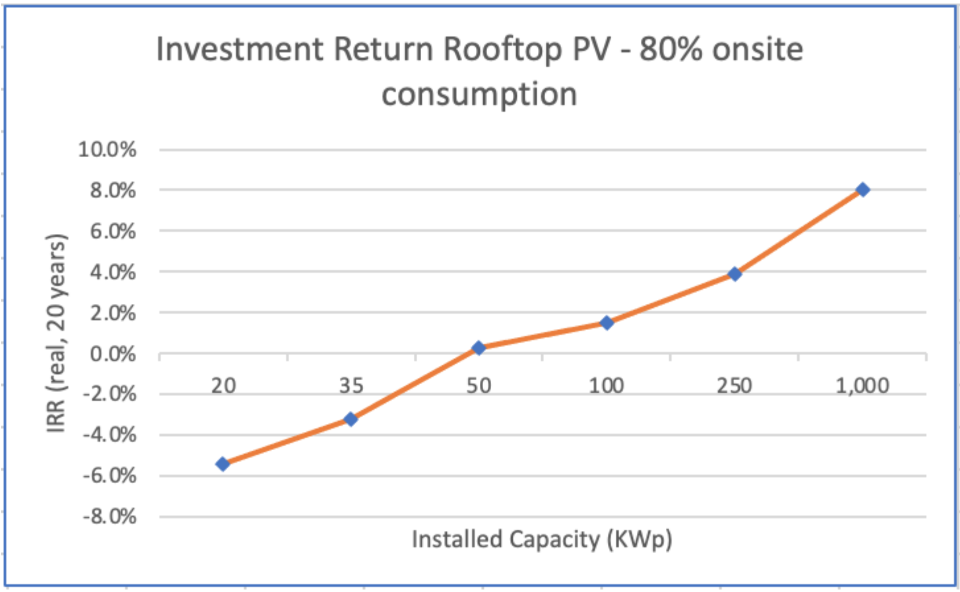

Chart 4 – Investment return for rooftop PV with 80% on-site consumption, assuming £110/MWh occupier PPA and £42/MWh export PPA

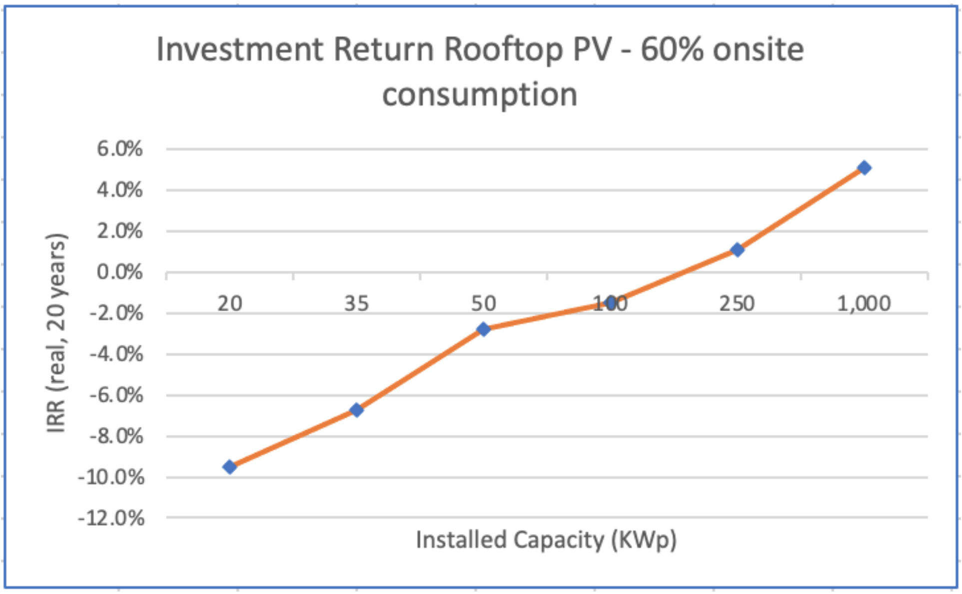

Chart 5 – Investment return for rooftop PV with 60% on-site consumption, assuming £110/MWh occupier PPA and £42/MWh export PPA

Charts 4 and 5 show that in the current market only large-scale rooftop PV on industrial buildings might provide a viable case for investment and that only if there is the right combination of high on-site use and long-term occupier index-linked PPA.

Assets designed to maximise generation on the other hand present worse financial viability as they become increasingly reliant on revenues derived from export PPAs which, as mentioned before, are short term, significantly less in value and volatile.

This is exacerbated in assets which are directly connected to the grid and export 100% of the generation as they are totally dependent on export PPAs, making them even more challenging – Ray Valley Solar, part of Project LEO, at 18 MW still requires grant funding for it to be investable.

Chart 6 shows current investment performance for ground mount solar modelled over 40 years.

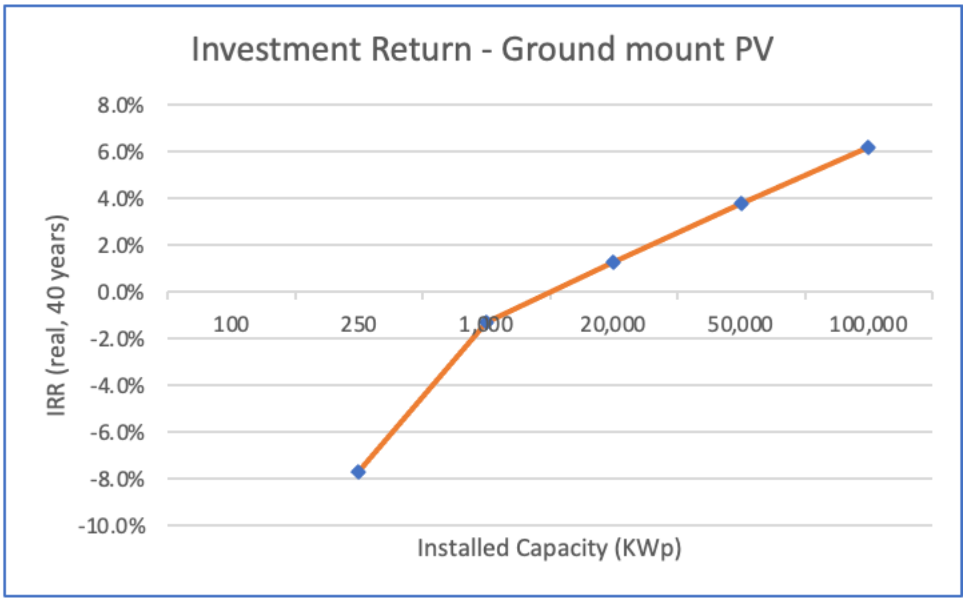

Chart 6 – Investment return for ground mount PV with 100% exports to the grid assuming a £42/MWh export PPA

The Low Carbon Hub's financial modelling shows how over the years the investment viability in small and medium-sized assets has been eroded, to the point where now only large-scale rooftop PV, with the right characteristics, and very large ground mount PV would be able to attract investment. This trend leads towards ever larger assets. It could be counter-acted through access to new revenue streams such as flexibility and fairer allocation of the total value stack towards locally produced and consumed energy.

Revenue gap

As shown in the previous section, there is currently no investment case for the development of even large-scale assets such as the 18MW Ray Valley Solar without grant funding.

The combination of the withdrawal of FITs without an adjustment to the value of local energy, like some form of contract for difference (CfD), the removal of previously available revenue streams such as Embedded Benefits, and pressures on CAPEX and OPEX from fixed costs not correlated to asset capacity, have put the development of new small to medium-scale assets on halt and paralysed local investment.

The outcome of the Targeted Charging Review and the decision to remove Embedded Benefits from the value stack for local generators is a case in point. Within LCH's portfolio Embedded Benefits range from £4.52/MWh to £6.57/MWh depending on the voltage level of the network they are connected to.

With export PPA prices currently at £42/MWh this single decision removes between 10% and 15% of revenue associated with exports, demonstrating the sensitivity of policy changes on the certainty of revenue streams.

The financial modelling for the different scales of assets has also identified the current net revenue gap for making them financially viable. This revenue gap would need to be met in future through different revenue streams including flexibility services.

Charts 7, 8 and 9 show the net revenue gap to meet a 5% IRR (real) for assets at different scales of installed capacity.

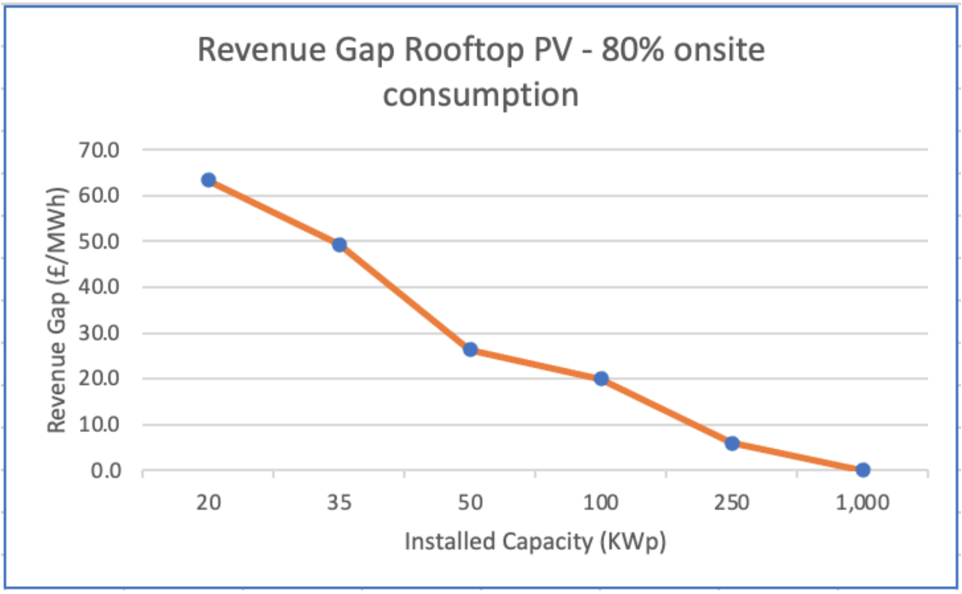

Chart 7 – Net revenue gap for achieving an IRR of 5% over 20 years, assuming £110/MWh occupier PPA and £42/MWh export PPA

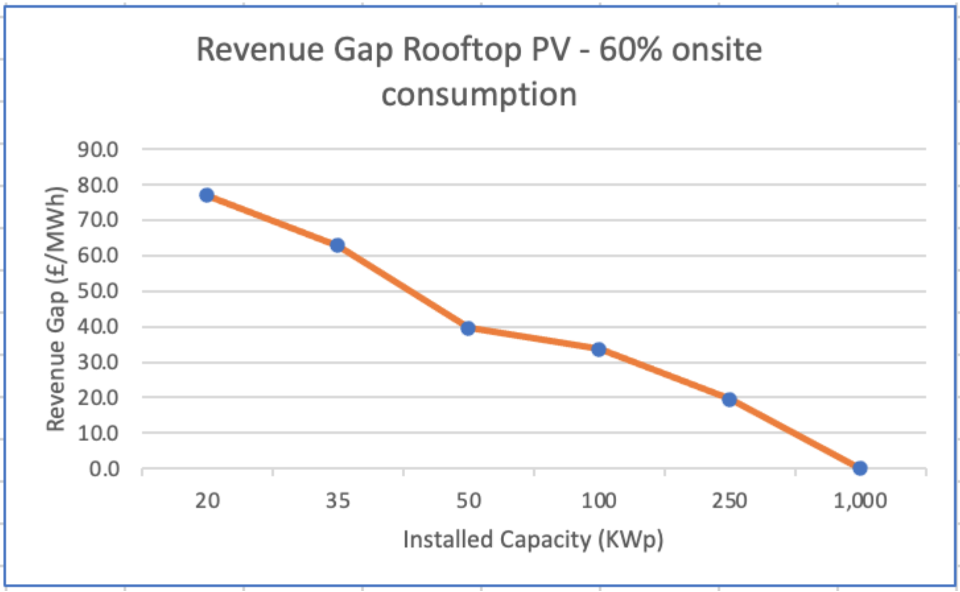

Chart 8 - Net revenue gap for achieving an IRR of 5% over 20 years, assuming £110/MWh Occupier PPA and £42/MWh Export PPA.

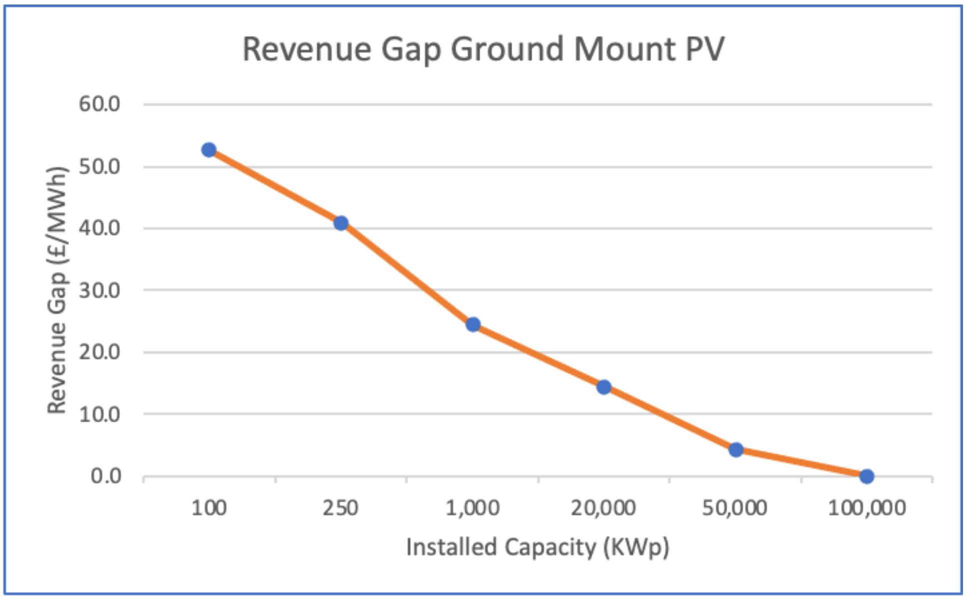

Chart 9 - Net revenue gap for achieving an IRR of 5% over 40 years, assuming a £42/MWh Export PPA

These charts suggest that Flexibility Services would need to be valued a long way above what is currently being envisaged by the DNOs and Ofgem. This would suggest that, with no other policy changes, flexibility services are likely to be used mainly as an upside to existing projects rather than as a way of bringing on new projects.

With the projected market penetration of EV vehicles already envisaged, this situation needs to change so that the combined impact of large numbers of these small assets on the grid edge can be effectively and efficiently managed. Doing this will also pave the way for the societal change needed to reach net zero carbon under all current FES scenarios where a mass flexibility services market needs to develop which is accessible to the very large numbers of small generation, storage, demand-side reduction assets and EVs.

The investment case for co-located rooftop PV and battery storage

As described in the previous section the business case for rooftop PV is currently only viable for large installed capacity in industrial buildings with the combination of high on-site use and long-term indexed-linked occupier PPA.

The business case for the deployment of behind-the-meter batteries is yet to be made and will require a positive combination of drop in CAPEX, adoption of ToU by occupiers as well as the availability of new revenue streams from flexibility services and local energy trading. Chart 10 shows the estimated revenue gap for the investment in co-located battery storage.

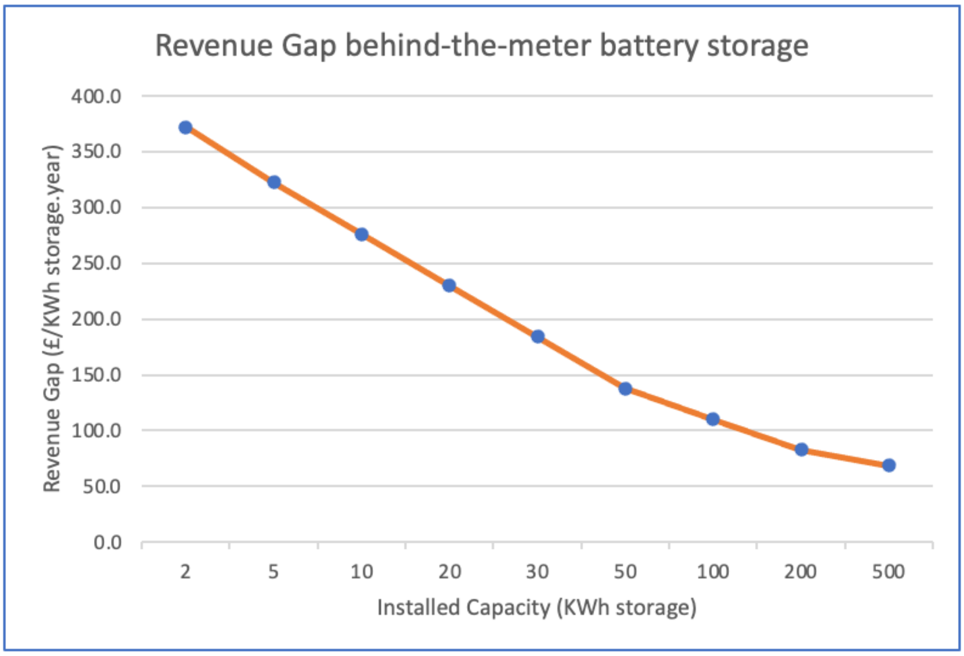

Chart 10 – estimated revenue gap for behind-the-meter battery storage

Long-term export PPAs, as currently available, mitigate part of the risk associated with revenue uncertainty. However, they might prevent the addition of new stacks of potential revenue derived from flexibility services unless they are designed to be 'flex-ready'. This would ensure that PPAs are designed to leave open the option for those new revenue streams to be enabled at any point during the lifetime of the PPA. LCH is working with local large energy consumers (institutions such as the Local Authorities) to develop such innovative commercial arrangements.

5.4 Hydro optimisation

Two low-head hydro projects on the Thames are being upgraded to enable the dispatchability of generation, the use of the river as storage and the provision of flexibility services. These are Sandford Hydro (440kW) and Osney Lock Hydro (48kW).

New revenue streams would be largely associated with:

- Use of export PPAs with time-of-day pricing[21]
- Local energy trading tariffs
- Yet to be determined value and term for flexibility services.

The costs associated with the extensions:

- deployment of further capital (CAPEX)
    - transaction costs - statutory consents and commercial arrangements
    - project management
    - capital items, materials and labour
- relatively small increment in OPEX
    - extra maintenance requirements.

Chart 11 shows the net annual marginal revenue required to make flexibility-enabling works, such as those being done at Sandford Hydro, an investable proposition.

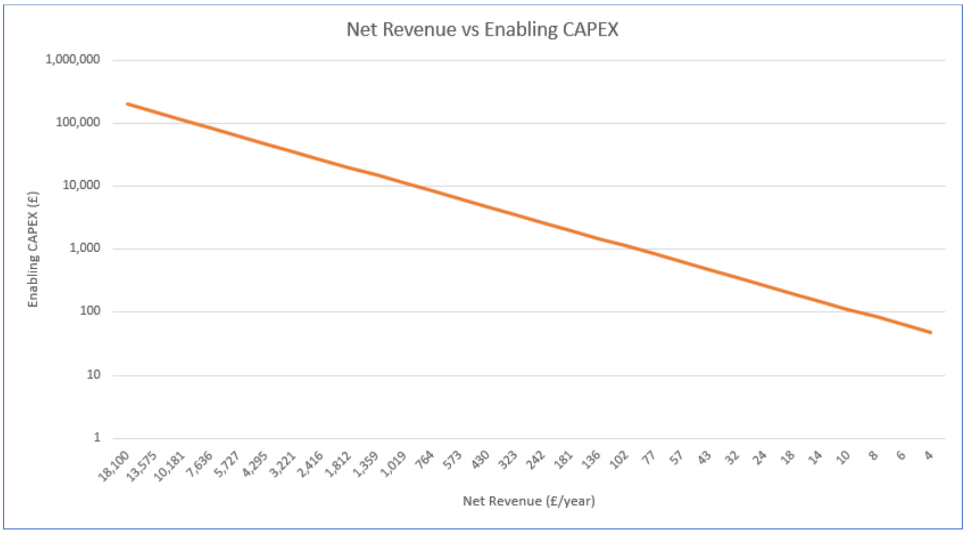

Chart 11 – Net annual marginal revenue required for investment in flexibility-enabling works at hydros

In the case of Sandford Hydro the total CAPEX for the optimisation works is circa £183,000 with no certainty over future revenue streams derived from the investment. This makes it not possible to raise investment capital and, for the purpose of the trials being run as part of Project LEO, they require 100% funding through a combination of iUK grant and match from LCH's community benefit fund.

[21] Where export sale price varies depending on the time of day and is significantly higher at peak demand times

5.5 Community microgrids / CESCO (Community Energy Services Company)

These projects were envisaged with the objective to develop and demonstrate alternative business models for end users (domestic and SMEs). This category has now been incorporated into the Smart and Fair Neighbourhoods being developed from Year 2 onwards, including Hook Norton Community Housing microgrid.

Value for the end user(s) would be derived from handing the management of all its energy needs to a CESCO which would in turn manage all energy purchasing contracts, optimise the potential for on-site generation, storage, demand response and energy efficiency and share the financial benefits with the end user(s).

There would be value for the network derived from reduced net demand on the grid and the provision of flexibility services.

The revenues are underpinned by long-term service contracts between the building owner/occupier and the CESCO. This model has the potential to enable and rapidly increase the participation of diverse small-scale assets in new markets.

6 Conclusions

We draw the following conclusions from this review of the experience in developing and deploying the Plug-in Project pipeline for Project LEO during year 1.

As things stand, is unlikely that small-scale assets will be able to participate in flexibility markets in the numbers required to achieve net zero carbon scenarios.

Multiple factors prevent the deployment and wide participation of small-scale assets at the edge of the electricity network. It will be necessary to develop and connect very large numbers of these if we are to:

- use existing infrastructure optimally
- minimise the need for further network investment and
- create the conditions for wide engagement, participation and societal change required for achieving net zero by 2050.

Transaction costs are an increasing drag on project viability, both in terms of CAPEX and OPEX.

The total capital investment (CAPEX) required for the deployment of new assets goes beyond the cost of the equipment and installation as the total cost is heavily influenced by transaction costs throughout the development phase. OPEX transaction costs, such as metering or data acquisition, also have a material impact on net revenues of an asset.

While the long-run marginal cost of renewable generation and storage has been decreasing rapidly and consistently over the years, this is not happening to transaction costs which are poorly correlated to asset capacity[22] and have also remained largely unchanged[23] in quantum. Transaction costs are akin to a non-revenue-generating overhead. This largely unchanged quantum erodes the investment case even further as it becomes a relatively greater proportion of costs.

In the specific case of flexibility services the compliance requirements or procurement and contractual processes for any asset, regardless of size, remain the same and lead to a trend that favours ever larger ones. In the event that large-scale assets come to dominate the market, this will prevent the system from realising the benefit of using small-scale assets in lower voltage levels of the network, which in turn leads to more investment in network infrastructure.[24]

High transaction costs experienced by LCH, and the wider renewables industry, generally arise from:

- The need to secure long-term revenue streams through complicated and bespoke commercial contracts, such as roof leases and site-specific PPAs
- Time-consuming and protracted processes within the regulated energy sector, such as the example mentioned previously with regards to enabling export metering which in this case also denies revenue to the asset
- Long timeframes[25] for approvals with statutory bodies or Local Authorities, such as obtaining permits to automate gates at Sandford Hydro and Osney Lock Hydro, or sign the contracts for Rose Hill Apartment Blocks[26]
- Long timeframes for energising grid connections, such as Duns Tew solar park with earliest availability planned for September 2022, though the grid application was made in January 2020
- Abortive costs[27] arriving late in the development process, such as in the examples of an independent school, where last minute concerns raised by trustees in reference to the Charities Act 2011 could not be overcome[28]; or where buyers in apartment blocks for shared

[22] Transaction costs tend to be to a large extent fixed regardless of the installed capacity of an asset. As an example the statutory, project management or legal costs of developing a 20kWp or a 1,000kWp rooftop PV are largely the same. Other examples would be the cost of raising project debt finance or the commercial and technical compliance requirements for the provision of flexibility services to the National Grid (ESO).

[23] Some significant transaction costs, such as legal costs, might have represented 2% of the total cost of a rooftop PV installation 10 years ago and now represent 8% of an installation of the same size.

[24] "Modelling the GB Flexibility Market, Part 2: The Value of Centralised and Distributed Storage", A technical report for Piclo, co-authored by Element Energy and Graham Oakes, in partnership with Innovate UK and Project LEO.

[25] The uncertainty of getting approvals and the length of time to complete a project have a direct impact on resource planning for the pre-development phase of new projects. This has a knock-on impact on the cost of servicing capital raised ahead of need, which reduces the financial return of the whole portfolio.

[26] Negotiations with Oxford City Council started in June 2018 and as of October 2020 there was no signed contract between the parties.

[27] Abortive costs are expensed in LCH's P&L account and reduce the overall return on investment of the whole portfolio.

[28] This is an example where the Charities Act 2011 requires a charity to demonstrate best value before granting a lease, which independent surveyors and trustees feel reluctant to sign off even though the project will have no cost to the charity and they will have guaranteed savings on electricity – they cannot demonstrate best value simply because there is no other similar offer to compare against.

ownership would not be able to obtain a mortgage[29] if there were LCH-owned PV on the common roof.

The wide participation in the market of small-scale assets all the way down to domestic appliances is critically dependent on very low transaction costs which in turn requires simple and standard contracts and streamlined processes.

Recent policy decisions increase uncertainty and also provide a drag on new investment.

Long-term visibility and certainty over the policy framework are critical in providing signals to the market on the trajectory being adopted and therefore reduce overall risks and cost of capital, which in turn create the conditions for increased deployment of capacity.

It is not only energy policy decisions that contribute to this climate of uncertainty. Having an effective interface between energy policy, planning policy, local government funding policy and environmental policy is becoming increasingly important if we are to create and maintain momentum in deploying large numbers of assets at the grid edge.

Examples of policy uncertainty with direct impact on LCH's ability to finance new projects:

- **TCR** and its actual impact on lost revenues (up to 15%) for assets connected at lower voltage levels of the electricity network (all new LCH assets are impacted)
- Inconsistent treatment of renewable generation assets in the valuation for **business rates** purpose – different Local Authorities apply different rules, charitable purpos of Community Benefit Societies more difficult to evidence following the Charities Act 2011; all LCH assets are impacted
- Rules applied to the provision of **social housing** via a Community Land Trust (CLT) that do not account for **total lifetime costs** of a building; impact on Hook Norton Community Housing Development
- The lack of clarity over the need for and incentives to encourage the wide deployment of energy efficiency measures; this might mean that the role of small-scale DSR (Demand Side Response) in achieving net zero is not realised to the extent needed to provide a fully flexible electricity system.

Inconsistency or misalignment in the policy framework also risks favouring particular types of technology thus distorting the market and preventing the deployment of an efficient transition to zero carbon. Such inconsistency and misalignment of policies are experienced at all levels of government, for example from standards for energy efficiency in new buildings to the refurbishment or operation of a Local Authority-owned property. A particular example pertinent to Project LEO is

[29] The largest mortgage provider in the UK will not contemplate an offer of a mortgage if there are PV owned by a third party on the common roof of the apartment block in question, but they will allow landlord-owned PV.

the Hinksey Pool Heat Network[30], where misalignment of objectives and incentives within Oxford City Council and the pool operator prevented the project from being developed.

A decentralised, environmentally sustainable and equitable energy system able to meet the net zero target set for 2050 requires the joined-up construction of a new policy and regulatory environment and not simply the adaptation of the status quo.

The regulatory framework is currently designed to value the provision of new infrastructure much more highly that the deployment of new assets delivering flexibility services.

Project LEO is a demonstrator of how a local energy system built up from the edge of the network can create the conditions to optimise the existing network infrastructure, minimise the costly investment in new infrastructure and enable the societal changes required to achieve net zero through wide citizen participation.

The current regulatory framework for network and system operators at both the transmission and distribution levels is based on a centralised model that favours large scale assets.

In the RIO-II budgeting process the National Grid has argued that its real cost of equity (excluding inflation) should be set at 6.5%. As a reference the nominal cost of equity (including inflation) for LCH's Community Energy Fund is 5.0%. A larger pool of investors would most likely invest in new assets at lower thresholds than the National Grid, given the same certainty of revenue.

Changes in the market structure would not only create the incentives for greater investment in flexibility in general, and at the edge of the network in particular, but would also reduce the total investment required for a successful transition.

Apart from the very high transaction costs currently in place and required to enable access and participation in the existing network services market there is also a distortion created by how capital investment is rewarded.

In the particular case of investment in network infrastructure versus flexibility, the regulatory framework skews the market towards investment in the former. The deployment of zero-carbon, renewable energy based flexible assets a near zero short-run marginal cost in the same way that assets in the network do. However, those assets in the network will have a guaranteed long-term revenue stream approved by the market regulator through the operator's budgeting process and socialised among all users. Private investment in flexible assets does not have a comparable guarantee of long-term revenue streams and the investors are expected to bear that risk. In the

[30] Hinksey Pool is an open air swimming pool owned by Oxford City Council and operated by a contracted third party. The pool is heated using natural gas from March to October and has the largest emissions of CO_2 within the Council's real estate portfolio. A combination of a water-source heat pump, the use of an insulated cover overnight and a CESCO contract would enable LCH to make the investment in the project and provide immediate and significant reduction in CO_2 emissions and the provision of flexibility services. Lack of internal agreement within the Council with regards to the risk posed by the use of the cover and lack of aligned incentives with the operator prevented the project from continuing.

current model, therefore, a new transformer or extra wires will always outcompete investment in flexibility.

Even though private investors would be prepared to accept a lower return on investment than the current operators given the same certainty of revenue, that option is not available.

Market structure and dynamics currently favour utility-scale generation and storage assets but all FES scenarios require the grid to accommodate very large numbers of small-scale assets.

The latest published Future Energy Scenarios (FES 2020) identifies possible pathways to meeting the net zero-carbon target set for 2050. The three scenarios that meet that goal are mapped against the level of societal change required and the speed of decarbonisation.

All of those scenarios require a high degree of societal change alongside decentralisation of the energy system. The main differences are in where the emphasis lies in terms of the required assets, where those assets are deployed in the network and the design of the overall market structure.

A scenario where total energy generation and demand is the greatest might imply greater investment in infrastructure and capital-intensive assets as opposed to investment focused on large numbers of small-scale assets and energy efficiency measures.

As noted in LEO Year 1 Synthesis Report "[n]ecessary 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"[31].

The current market structure "favours centralised storage over distributed because ESO and energy trading value streams are well developed while DSO value streams are still nascent. Coupled with the fact that the energy system is more accustomed to exploiting the scale economies of a small number of large assets rather than the standardisation economies offered by large numbers of small assets, this creates a significant barrier to distributed storage. This in turn means that there is significant risk that utility-scale storage will dominate the market, stifling optimal deployment of distributed storage"[32] as well as other forms of flexible demand and generation.

Seeking a net zero carbon outcome will require a very different market structure, based on high penetration of EV vehicles located at the grid edge, where investment in very high numbers of very small assets is needed.

Co-benefits of this change in market structure can include: much less investment in infrastructure, end-user benefits such as comfort, well-being and local economic development benefits. In contrast,

[31] LEO Year 1 Annual Synthesis Report
[32] "Modelling the GB Flexibility Market, Part 2: The Value of Centralised and Distributed Storage", A technical report for Piclo, co-authored by Element Energy and Graham Oakes, in partnership with Innovate UK and Project LEO.

maintaining the status-quo could bring "[a]s well as the economic consequences of converging on a non-optimal solution, this may have social consequences – distributed assets engage consumers and citizens directly, in a way that centralised ones don't, and so support greater engagement in the energy transition"[33].

The Project LEO pipeline has been impacted by all of these issues but the team continues to work creatively to develop the pipeline despite policy constraints and economic headwinds.

The development of assets as initially planned has been hindered by unexpected events since the project plan was first submitted, with the most severe impacts being attributed to uncertainty over TCR, the emergence of the COVID-19 Pandemic and the uncertainty over the value and availability of new long-term revenues making the investment case for small-scale assets very challenging.

Despite the unfavourable investment climate, LCH has continued the development of Plug-in Projects by taking on higher risks due to the strategic importance of Project LEO in demonstrating the future value of a local energy system. The experience gained is providing not only learning but also inputs into policy and the development of market structures based on factual information.

With the current market structure and lack of long-term visibility the financial feasibility of new assets is restricted to exceptional sites with a very favourable combination of factors such as large scale, high percentage of on-site use of generation, the availability of long-term PPAs, low cost and timely availability of grid connections and revenue streams with minimum exposure to policy changes such as the TCR.

LCH's portfolio provided the foundation for the development of a comprehensive programme of MVS trials where the process itself is continually iterated and refined with the use of operational assets; it has also generated valuable learnings on how to enable flexibility at the edge of the network.

All of LCH assets, pre-existing and newly developed, continue to contribute towards the modelling and better understanding of how small-scale assets can participate in markets for flexibility services. They have also informed the process for identifying new asstes to be developed in years 2 and 3 of the overall LEO programme.

As Project LEO matures and the work being developed by all the Work Packages converges towards system-wide change including the interfaces with TRANSITION, the WP3 Plug-in Project Board has approved a set of new projects that comprehensively address the component blocks for the delivery of both a flexible network from the grid edge and an equitable system for citizens and end users.

[33] "Modelling the GB Flexibility Market, Part 2: The Value of Centralised and Distributed Storage", A technical report for Piclo, co-authored by Element Energy and Graham Oakes, in partnership with Innovate UK and Project LEO.

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Those new projects being developed are located at priority geographic areas within a set of primary substations and will be trialling the provision of the five flexibility services identified by Transition as well as the integration to end-to-end automated markets.

Alongside the development of the technical building blocks described, LCH is also developing nine **Smart and Fair Neighbourhoods** projects that seek to address both the engagement and active participation of local communities in creating an equitable system (see 1.2). They also look to address the societal changes required for meeting the net zero carbon targets by 2050, as well as provide trials of multiple assets being connected to the grid edge.

The analysis and learning from year 1 of Project LEO is now providing input into a White Paper being developed by the Project LEO consortium. This will discuss and propose ways to address some of the issues identified and how changes in policy and regulation could become an enabler of flexibility at the edge of the network.

7 Appendices

A: Pre-existing LCH assets brought into Project LEO

Project ID	Site Name	Generation Capacity (kWp)	Annual Generation (kWh)	Commissioning Date
8	Botley School	42.64	45,593	29/10/2015
9	Brookside Primary School	40.425	34,779	01/03/2019
10	Bure Park Primary School	60	53,400	05/06/2015
11	Charlbury Primary School	24	21,534	29/08/2014
12	Cheney School	90.5	81,225	27/08/2014
14	Chilton County Primary	29.9	26,338	20/08/2015
16	Crompton Technology Group Ltd	712.25	593,304	11/11/2016
17	Didcot Girls' School	49.92	42,082.56	20/09/2016
18	Edward Feild School	16	15,024	29/07/2014
22	Eynsham GreenTEA	12.65	10,545	28/07/2012
24	Eynsham GreenTEA	3.99	3,326	21/03/2012
127	Fir Tree Junior School	34.5	28,014	20/02/2015
128	Langtree School	103.68	84,810	31/03/2016
132	Long Furlong Primary School	29.64	26,130	07/08/2016
135	Longfields County Primary School	48.4	42,199	17/12/2018
137	Middle Barton Primary School	10.4	10,025	30/10/2015
139	Nettlebed Community School	29.9	25,295	30/10/2015
140	Norbar Torque Tools	250	206,430	26/03/2015
141	Orchard Fields School	99.84	85,079	17/11/2015
143	Owen Mumford	19.76	18,100	12/01/2016
144	Owen Mumford	41.08	33,930	04/03/2016
145	Owen Mumford	49.92	45,727	15/01/2016
146	Owen Mumford	30	25,500	01/02/2016
147	Oxford Bus Company	140.4	123,000	04/10/2013
148	Prodrive	635.96	526,575	21/09/2016
150	River Trust Learning Larkrise	19.5	18,310.50	15/08/2014
151	Rose Hill Primary School	28.08	20,568	10/08/2016
26	Sandford Hydro	440	1,540,000	24/08/2017
153	Sir William Ramsay School	49.92	44,478.72	26/09/2016
154	Sonning Common Primary School	22.68	20,321.28	24/10/2017
161	St. Barnabas School	27.5	24,750	10/04/2014
164	Stonesfield School	34.32	33,531	26/08/2015
170	Thames Travel	50	44,303	29/09/2019
171	The Cherwell School	35	28,840	26/08/2014
174	The Cherwell School	46.44	38,712	07/12/2011
181	The Warriner School	106	91,056.30	21/08/2014

186	Thomas Reade Primary School	48.62	40,994	23/07/2015
190	West Kidlington Primary School	22.5	18,090	03/03/2015
208	Wheatley Park school	18.75	15,994	08/08/2014
217	Wheatley Park school	30	25,590	08/08/2014
228	Windmill Primary	26	21,110	03/06/2016
232	Wood Green School	50	40,669	16/08/2016
235	Wykham Park Academy	99.75	83,391	15/08/2014
242	Wykham Park Academy	49.47	41,948	30/06/2015

B: Y1 projects installed

Project ID	**Project Category / Name**	**Status**
	Oversolar Extensions & Optimisation	
PD3.258	CTG Banbury Extension	Completed, operational
	Oversolar Newbuild	
PD3.235	Thames Travel	Completed, operational
PD3.240	West Witney Primary School	Completed, operational
PD3.265	Langford Village Primary	Completed, operational
PD3.263	Oratory School	Discontinued – school not able to enter into contract due to Charities Act restrictions[34]
	Hydro Optimisation	
PD3.026	Sandford Hydro Reactive Power Control	Completed, operational
	Third-party Asset	
	Oxford Bus Company Battery Control	Completed, operational

C: Project pipeline

Project Name	**Type**	**Status**
Sandford Hydro Gate Automation	Hydro Optimisation	In Progress
Sandford Hydro Power Output Control	Hydro Optimisation	In Progress
Sandford Hydro System Integration	Hydro Optimisation	In Progress

[34] Impact of The Charities Act 2011 requires a charity to demonstrate best value before granting a lease, which independent surveyors and trustees feel reluctant to sign-off even though the project will have no cost to the charity and they will have guaranteed savings on electricity – they cannot demonstrate best value simply because there is no other similar offer to compare against. An amendment that would exempt community energy from that property clause would resolve the issue (acknowledging that different trustees may read the same report differently).

LEO Year 1 Plug-in Projects Review

Sutton Courtenay CESCO	CESCO	In Progress
Ray Valley Solar	New Solar Ground Mount	In Progress
Rose Hill SFN	SFN	In Progress
Kennington and Sandford SFN	SFN	In Progress
Osney Island SFN	SFN	In Progress
Westmill SFN	SFN	In Progress
Eynsham SFN	SFN	In Progress
Deddington SFN	SFN	In Progress
Hook Norton SFN	SFN	In Progress
Arncott SFN	SFN	In Progress
HOPE SFN	SFN	In Progress
Oxford Behind the Meter SFN	SFN	In Progress
People’s Power Station	People’s Power Station	In Progress