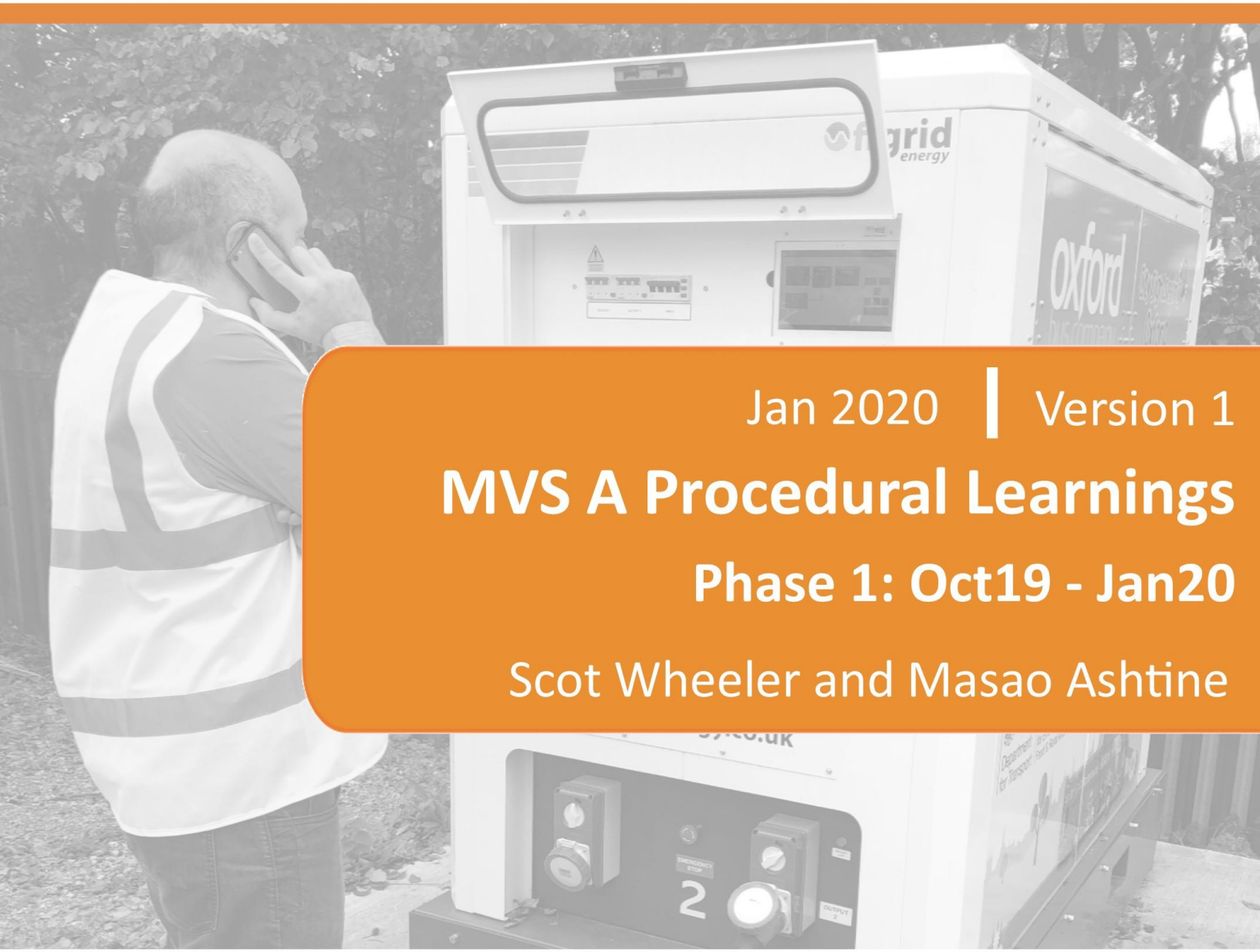
Local Energy Oxfordshire



Jan 2020 | Version 1

MVS A Procedural Learnings

Phase 1: Oct19 - Jan20

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Executive Summary

The minimum viable system (MVS) concept is used within Project LEO as an agile approach to developing and testing new flexibility services, business models and procedures required to operate a local flexibility market. Through the MVS approach, new value can be identified at a small scale before significant investment is committed; it is intended as a way to manage the risks associated with innovation in an uncertain, changing environment.

This report details the procedural issues, learnings and implemented changes arising from the 'MVS A - Flexibility Trials' which ran between October 2019 and January 2020. The service procedure for identification, delivery and validation consists of 14 steps and was initially proposed at an internal WP3 workshop held on the 30th of July (2019) at Piclo's London office.

Initially 4 different flexibility types have been identified based on currently available assets: 1) Electrical Storage, 2) Flexible Generation, 3) Demand Side Response and 4) Aggregation. Over the course of these trials, a trial implementation framework has evolved which ensures learnings are captured for each stage of the flexibility procedure. This includes an assessment of process maturity, a useful metric for accessing the value added through the increased automation of each MVS procedural step.

Despite some of the trials resulting in a 'failure to deliver, trialing the procedure itself has been successful in providing some key learnings and modifications from issues that arose. Two key themes to highlight are: 1) the need for a protocol for bi-directional communication between participants to notify changes in operational status; 2) a framework setting out the consequences for failures and/or delays to deliver, including possible penalties for service providers and the resulting dispatch of secondary services where available.

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Introduction

The purpose of this series of documents is to collate and track the key learnings specific to the Minimum Viable System (MVS) procedure used for the MVS A - Flexibility Services trials as these are tested. More detailed technical learnings, specific to each MVS trial and objective, will be published in separate reports.

The MVS concept is used within Project LEO as an agile approach to developing and testing new flexibility services, business models and the multi-organisation procedure and communications required to operate a local flexibility market. Each MVS trial should represent the minimum stress set of participants and processes which are required to test a new process modification or asset use case. In doing so, new value can be identified and confirmed at a small, quick scale, before significant investment in time, money and user relations are committed; it is intended as a way to manage the risks associated with innovation in an uncertain, changing environment. All trials within Project LEO will be in response to artificial constraints.

Each MVS will involve multiple organisations and multiple components (assets, digital platforms, users, etc) which may themselves be undergoing their own MVP (minimum viable product)[1] cycles. The LEO MVSs are intended to test new value which comes with being connected into the LEO ecosystem. Isolated product development can and should occur outside the LEO MVS system.

This report presents the procedural learnings gained from the first phase of MVS trials which ran between October 2019 and January 2020. This document lays out the current MVS methodology; the key procedural learnings from each MVS trial; and finally, a brief background on the Lean Startup methodology is included in Appendix 2, from which the MVS concept was developed.

[1] See Appendix 2: MVS Background for definition

MVS A working group

The core MVS A working group during this phase is listed below. This group will adapt as necessary as further MVS trials are developed:

Malcolm McCulloch (UoO), Scot Wheeler (UoO), Victoria Grant (UoO), David Wallom (UoO), Masao Ashtine (UoO), Brian Wann (SSEN), Andrew Waterston (SSEN), Bob Hopkins (SSEN), Stevie Adams (SSEN), Adriano Figueiredo (LCH), Harry Orchard (LCH) and Kelsey Devine (Piclo).

Current MVS A Methodology

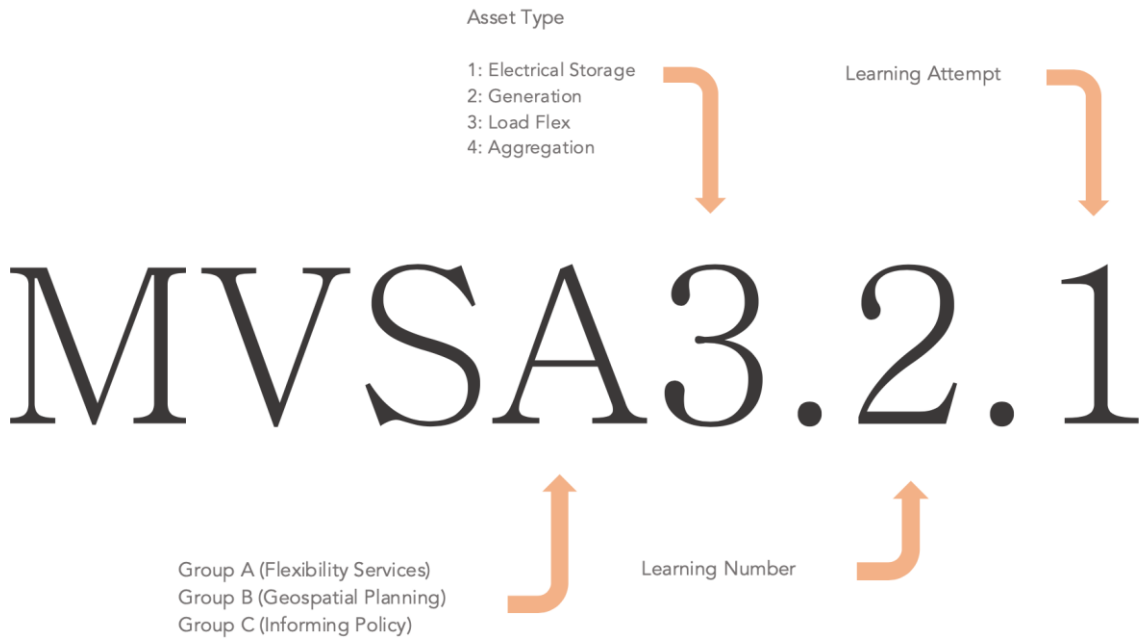
There are currently 3 different types of MVS being considered within LEO, which are denoted by the letters 'A', 'B' and 'C'.

A. Flexibility Services
B. Geospatial Planning
C. Informing Policy

This report only focuses on type 'A' - Flexibility Services.

Numbering

The MVS A numbering system is based around the 'MAJOR:MINOR:PATCH' version numbering convention common for software development.



Schematic of the MVS numbering system

The first 'service number' represents the flexibility type. Currently 4 different types have been identified for testing in the first round of MVSs as seen in the schematic above. The second 'learning number' represents a significant modification or hypothesis which is being tested. The final 'attempt number' represents the attempt at completing that MVS. This is increased if an MVS fails part way through the procedure. Once the issue has been resolved, the procedure can restart from where it failed (without requiring the whole procedure to be repeated) under a higher iteration number. Only when the full MVS procedure is completed without issues, or it is decided to drop the hypothesis and pivot to something significantly different, should the learning number be increased.

Internal MVS Administration

All MVS documentation is managed through the Project LEO Sharepoint MVS folder. When a new MVS trial is identified, the name and short description is added to the MVS Masterplan Tracker. A new MVS folder and tracking documentation will be created and labelled using the

standard MVS naming convention. The main procedure and live learnings documents are copied from the MVS templates folder (ensure the latest version of the templates are used). The procedure document should be completed (excluding the 4 procedure status columns) prior to the start of the trial and sent to all trial participants. Both documents are intended to be working documents and should be updated throughout the trial. The procedure document at time of writing is included as Appendix 1.

Participants

Every MVS must be assigned an MVS lead who is ultimately responsible for coordinating the trial, ensuring learnings are captured along the way and data is uploaded by each relevant participant.

For stage 1 of the LEO MVS A trials, 6 types of participant have been identified who may be assigned responsibility for actioning one or more of the MVS procedure steps, these are defined below:

- **Distribution System Operator (DSO)**: A party that takes on the role of system operation. A DSO securely operates and develops an active distribution system comprising networks, demand, generation and other flexible distributed energy resources (DER).

- **Flexibility Market:** The arena of commercial dealings between buyers and sellers of Flexibility Services.

- **Service Provider:** Those parties able to offer Flexibility Services.

- **Aggregator:** An aggregator is a company who acts as an intermediary between electricity end-users, DER owners and the power system participants who wish to serve these end-users or exploit the services provided by these DER. The aggregator groups

distinct agents in the electric power system (i.e. consumers, producers, prosumers, or any mix thereof) to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to system operators.

- **Technology Platform:** A market where user interactions are mediated by an intermediary, the platform provider, and are subject to network effects. As opposed to a marketplace or trading exchange, a platform intermediary must offer inherent value beyond the simple mediation process for the two sides of the market.

- **Data User:** A party or individual who requires access to some or all of the data generated as part of the MVS trial for analysis, evaluation and/or learning generation.

At planning stage, every organisation and partner coordinator(s) should be identified and recorded in the procedure document.

Flexibility Service Procedure

The current flexibility service procedure which each LEO MVS A trial follows is:

Step	Procedure Step	Description
1	DSO to identify need for flexibility services	The DSO identifies the future need for a particular flexibility service, over a given period, at a particular node of the network. While the methodology will be appropriate for real operation, trials within Project LEO will be based on artificial constraints.
2	DSO able to register their constraint requirement on the flexibility market platform	A competition is opened for a set period to advertise the DSO's need to procure flexibility to alleviate the identified constraint. The competition defines the power and energy requirements along with the service window for delivery.
3	Service provider to be able to register their flexible resource on the flexibility market platform	Flexibility service providers register their assets on the flexibility market platform with details of power and energy capacity, location etc.
4	Service provider registers company with DSO (i.e. becomes a supplier; Commercial Set Up of Service Provider is only required once)	The service provider must register with the DSO as a supplier before services can be procured.
5	Marketplace/DSO pre-qualifies the registered flexibility service	The marketplace or DSO qualifies the asset to provide flexibility services. The service provider updates asset status to 'operational' and 'dispatch ready'.
6	Service provider to bid into auction	The service provider enters an financial offer to deliver an amount of power and energy as part of the DSO request for flexibility. This can be for part or all of the advertised service request.
7	DSO to be able to select winning bids on the flexibility market platform	After the competition closes, the DSO selects the winning bid(s) through the flexibility market platform. The service provider is notified.
8	Flexibility Market platform to facilitate the communication of the dispatch signal to service provider	A dispatch signal stating the power, energy, service window and tolerances is sent to the service provider. This may or may not be facilitated by the flexibility market platform.
9	Service provider to dispatch services in accordance to agreed baseline methodology. Flexibility service delivery.	The service provider dispatches the flexibility service during the service window as defined by the dispatch request. The status of the service delivery is communicated back to the DSO.

10	Monitoring of the local substation	The local secondary substation has monitoring installed so the impact of the flexibility service on the network can be observed electrically and validated.
11	Monitoring of the flexible resource at the connection point.	The asset or site has monitoring installed at the point of connection to the network so the service delivery can be validated.
12	Settlement	Once validated, a financial transaction is made for the delivery of the flexibility service.
13	Research Evaluation of Specific MVS	Research to evaluate the financial, technical and social impact of the flexibility service is undertaken. This research helps inform the next service offering and MVS trial.
14	MVS procedure evaluation and feedback	An evaluation of the whole MVS procedure is undertaken by all participants of the trial.

Process Maturity Stages

In order to assess and demonstrate progress in efficient flexibility service delivery as MVS trials are iterated through, the concept of process maturity has been introduced. Process maturity stage is a simple measure of automation for each step of the trial procedure outlined above. Through tracking such a metric, potential rate determining steps can be identified and an assessment made of the degree to which increased automation improved the process. Each step is assigned a process maturity category listed below:

1. **Unknown** - A step has been identified, but what it entails, or how to implement it is currently unknown. E.g. Step 1: a method by which the DSO actively identifies constraints ahead of time has yet to be determined.
2. **Proxy** - The step and what it requires has been identified, but a proxy has been used as part of the MVS. E.g. Step 8: The dispatch signal is currently in the form of a personal text message.

3. **Manual** - The MVS step was completed fully, but operated entirely by a human(s). E.g.Step 5: The asset status is updated to operational by manually editing an excel document and re-uploading it to the piclo platform.
4. **Partial Automation** - The MVS step was completed fully, but involved an interaction by a human at some point (human-to-machine, machine-to-human). E.g. Step 9: During MVS A1.2, the battery was operated remotely following human translation of the dispatch signal.
5. **Full Automation** - The MVS step was completed entirely without interaction by a human. No step has reached this level of automation yet.

Risks

Any risks associated with the MVS trial should be identified and recorded in the procedure document. Any issues arising are reported in the 'Live Learnings' document, along with associated action(s) required to remedy the issue.

Key Performance Indicators (KPIs)

The set of KPIs used to report on for each MVS are

- Capacity under flexible control
- Impact on network utilisation (constraints)
- Service response time
- Levelized cost of flex event (full flex process, cost per kW and cost per kWh)
- Additional generation capacity unlocked
- Number of customers participating in the Project LEO service
- Number of vulnerable customers / 'energy poor' customers participating in the Project LEO service
- Net benefit/cost to participants
- Estimation/measurement of CO_2 impact of the Project LEO service
- Impact on non-participants

Capturing Learnings

All procedural learnings which are applicable to any MVS are captured in the MVS A Procedure Live Learnings document. Issues specific to one MVS trial type are captured in separate MVS learnings documents. Following each MVS cycle, these will be summarised by the Work Package 4 working group, any proposed methodology changes will be highlighted, and reviewed by the full MVS working group.Specific reports which include a full assessment on the technical, financial and social impact of the MVS will then follow these trials.

Data capture

In addition to time series network data which is captured as part of the delivery of the flexibility service in steps '10' and '11' of the MVS, data is naturally generated by Partners at each procedure step. During this trial phase it is important to capture as much of these data as possible. This data capture will allow us to recreate the actions taken post-trial, evaluate where potential issues arose, and generally maximise our understanding of the whole process. As an example, these data might include time-stamped copies of email exchanges/text messages which were crucial to the delivery of the service. Also, within the MVS procedure tracker, a start and end timestamp is recorded for each step.

All data generated as part of an MVS trial are considered 'Foreground' Project data and need to be uploaded to the Project LEO data archive. This data entry is currently done through the Project LEO Data Sharing Log. For further information, please consult the Project LEO Data Sharing Guide or contact Masao Ashtine.

Summary of Resolved Issues

The table below contains a summary of all closed issues relating to the general procedure which were identified during the first stage of MVS trials. It presents a description of the issue, the impact it had on the trial, and the action taken to resolve the issue.

Description	Impact	Solution
Uncertainty over who is responsible for completing the procedure document during the trial.	Procedure document/ learnings not completed.	An 'MVS coordinator' role has been added. This person has overall responsibility for ensuring the MVS procedure is correctly filled in before/during the trial.
No way of tracking if a procedure step occurred and was successful.	Difficult to identify post event exactly what happened during the trial. Required for the technical evaluation.	The completion of each procedure step should be recorded with appropriate timestamps and data to evidence the completion. The procedure template has been updated to reflect this.
Dispatch signal needs to include date of activation	Date of dispatch could be misinterpreted	A 'templates' document for MVS A communications has been added to sharepoint. The message content has been changed to include a full date timestamp for start and end of the trial.

Need to agree if complete MVS Procedure needs to be rerun for each MVS iteration	How to maximise learning without wasting team time.	Partial procedure to be completed – run from last successful procedure step. The attempt number should increase by 1 (Z in MVS AX.Y.Z). To progress to the next MVS learning (Y in MVS AX.Y.Z), the full procedure should be completed without issue, or a decision to abandon the previous learning made.
There needs to be a way to track the end/start of a new learning attempt which resulted from failure part way through the procedure.	Difficult to track/recreate where the issue happened.	To highlight this in the procedure documents, a red row spanning the procedure table should be inserted. Then a duplicate of the procedure document made, MVS id updated to reflect the next iteration, and a blue row is used to identify where this continues from.
Where a screenshot has been taken to prove data upload/sharing within an MVS, is this supplementary to the data shared, or data in its own right?	How the data sharing form is completed.	Agreed that screenshots are supplementary unless raw data not possible to upload (I.e. a text message).
Need to ensure the procedure is maturing with each MVS cycle. We're not tracking current procedural step maturity.	Uninformed future iterations, bottlenecks in the procedure.	Track the maturity (automation) of each procedural step. A scale consisting of Unknown, Proxy, Manual, Partial Automation and Full Automation.

We need to track person hours required to run an MVS to do a full cost benefit analysis.	Does administration of a step make the service provided unviable? Does automation improve this?	Track person hours required to run each step at the same time as defining Process maturity.

Unresolved Issues

Issues and questions raised which remain open or unanswered are as follows:

Identified by	Description	Impact	Solution	Next steps
AF	Dispatch signal needs to specify tolerance for power over the period of service provision	Energy requirement met during period but missing power requirement	Dispatch signal to include +/- power tolerance in % of nominal requirement.	SSEN to approve dispatch signal template.
AF	Verification of meeting power tolerance in service provision need to be relative to a baseline and agreed measurement and verification standard.	Service provider penalized for not meeting dispatch requirements due to disagreement on how to verify	Agree standard for measurement and verification	SSEN to approve dispatch signal template.
AF	Need to agree/record common terminology: dispatch, activation, service provision etc	Misunderstandings and miscommunication	Add to Comms protocols document	
MM	What interactions are required to acquire permission from asset owner/operator (if	Barrier to replication outside of core LEO Partners.	Stakeholder mapping and interactions tracking	Developed in line with pip board stakeholder

	different from service provider).			mapping. See below.
SW	If potential for failure to deliver is known prior to the event but after bid submission/acceptance, what is the method for notifying the DSO and 'cancelling' the bid?	Unnecessary failure to deliver could be prevented at or before the bid acceptance stage.	Service status message templates from service provider to DSO.	Working group to agree on service status messages and add to communicatio ns template.
SW	If there is a delay in delivery but the service is still delivered for the full period.	Delay could lead to network fault. How big a delay is important? What is the process for notifying the DSO?	Service status message templates from service provider to DSO. Penalties for delay/failure to deliver.	Working group to agree on service status messages and proxy penalties.
RH	There is a separate stakeholder mapping process for MVSs which has been developed via the PiP Board and is currently being completed retrospectively, rather than as part of the MVS Development.	Stakeholders not being fully considered at the start of MVS development, potentially leading to missed permissions/ opportunities.	Integrate the mapping process with the MVS procedure in a way which doesn't cause excessive paperwork for MVS co-ordinators	MVS working group (with pip board input) to integrate this into the MVS planning procedure before next phase.

MVS History

MVS A1.1 - Oxford Bus Company Battery: Export to Grid

Context

MVS A1.1 was the first trial within Project LEO and results from the MVS concept and flexibility service procedure proposed at a WP3 workshop held on the 30th of July, 2019. The aim of MVS A1.1 was to test this proposed procedure through trialing the dispatch of a flexible storage asset in response to an SSEN advertised flex request through the Piclo platform. Following the event, an assessment of the technical, financial and social impact of the service would be undertaken to understand the value of the service and viability to progress further within LEO.

The flexibility service and assets chosen for MVS A1.1 were a planned DSO constraint management service using electrical storage. A 30 kVA, 90 kWh battery system, co-located with a 140 kWp solar array at the Oxford Bus Company (OBC) depot on Watlington Road, Cowley, was trialed; it is connected at the 400V LV level. The Low Carbon Hub (LCH) own the solar array while OBC own the battery storage. The battery storage was originally installed as a buffer for the site's 220 kVA supply connection limit, necessary when charging electric busses. As the battery's original design didn't require power to be exported back to the grid, the manufacturer, Off Grid Energy, were consulted to re-engineer the assets to enable this functionality.

Trial Summary

The trial consisted of a 30 kW export (demand reduction equivalent) for 1 hour between 13:00 and 14:00 on the 18th of November, 2019. A competition was registered on the Piclo LEO platform for the proxy flexibility service.

The LCH updated their assets to operational, and made a proxy bid of £1 to deliver the service. This was accepted by SSEN, and a dispatch request from SSEN to LCH was sent via text. The

battery assets were operated manually with the help of the manufacturer, Off Grid Energy. Current and voltage monitoring was present on the feeder at the secondary substation feeding the site, and at the common connection point on-site.

Procedural Learnings

The most notable learning stemming from the running of MVS A1.1 was the inappropriateness of the battery's design for purpose-of-use within the MVS itself. The battery, which was meant to act as a flex asset for the Oxford Bus Company (OBC), was only configured to import power from the grid and was unable to feed power back to the grid. However, it was determined that this was software rather than hardware related, and was fixed through the reprogramming of the battery management system, allowing the battery to be 'MVS functional' on the 12th of November, 2019.

Questions were raised regarding metering requirements both on and off the site. Temporary metering had to be installed at the secondary substation, but this didn't have the ability to provide real-time information. On-site metering consists of typical non-domestic half hourly metering, which is also not capable of providing live data and was deemed too low a resolution for the desired full technical analysis. Monitoring was installed at the site's common connection point by the battery manufacturer Off Grid Energy. Regarding substation monitoring, SSEN are due to receive 100 substation monitoring kits by the end of 2019, which will be installed at strategic substations for future LEO trials and provide remote data logging. Another question raised through metering discussions is how validation of service delivery is managed. For instance, what metering infrastructure is required for the DSO or service provider to be able to validate that the correct service was delivered by a particular asset (within background network behaviour).

Other learnings revolved around procedural steps and the recording of data on the Piclo platform. Procedurally, the MVS A1.1 trial revealed some ambiguity in the MVS Procedure document and further details were required to better guide those involved, including the

identification of an MVS coordinator. The Piclo platform had a few issues and although minor and quickly rectified, led to the service provider and DSO having difficulties in making and accepting successful bids (the platform required the format of £0.02999/MW instead of £0.03/MW for instance).

Finally, the MVS trial also showed that more details in data collection need to be considered. Not only were energy data required to improve learnings from the MVS, but all associated procedural streams and events (email and text confirmation etc) are needed to best understand and improve future MVS attempts and trials. Thus, the MVS Procedure Template document was edited to ensure that the responsible parties could not begin an MVS trial without properly documenting the required data.

A full technical analysis of MVS A1.1 will follow.

MVS A2.1 - Sandford Lock Hydro: Generation Increase

Context

The flexibility service and assets chosen for MVS A2.1 were a planned DSO constraint management service using a flexible generation resource. Sandford Lock Hydro, a 440 kVA micro-hydro, situated on the River Thames south of Oxford at Sandford Lock, was used for the trial. Sandford Hydro is owned and operated by the Low Carbon Hub (LCH). The hydro consists of 3 archimedes screws; 2 of which are either on/off, with a 3rd variable screw which when controlled as a set, allows a full range of power variability up to 440 kVA. The hydro is connected to the 11 kV network via a private substation, fed from the Kennington Primary substation. The site has an export connection capacity limit of 400 kVA.

Sandford Hydro is a key plug-in project for Project LEO. Generating 1.6GWh annually, roughly 450 homes and the size of neighbouring Sandford village, it offers an excellent opportunity to test how a local generation asset can operate in a flexible way for the direct benefit of local

prosumers. The generation flexibility along with some storage potential within the river, may allow coordinated balancing services for the local grid and community. Also, as generation from the hydro is seasonal, there is also an opportunity to look at complementary generation technologies which could make use of the export capacity when the hydro isn't generating; an example of 'Authorised Supply Capacity Trading' identified in Transition's 'Services in a facilitated market' report.[2] In addition to the learnings around market operation, technical grid impact and financial viability which are applicable to every MVS, additional understanding is required around the response of the river asset to flex operations, and how river conditions influence the availability of flexibility services. These questions are the objectives of MVS A2.

Trial Summary

The trial was planned as a 100 kW increase in generation event at Sandford Secondary Substation, for 1 hour between 11:00 and 12:00 on the 28th of November, 2019. A competition was registered on the Piclo LEO platform for the proxy flexibility service. The LCH updated the asset status to operational, and made a proxy bid of £1/MWh of dispatched energy. This was accepted by SSEN, and a dispatch request (a negative power indicates reduction in load / increase in generation) from SSEN to LCH was sent via a personal text message. The Environment Agency (EA) was notified of the trial taking place, then a control signal was romotely sent to the asset for screw 1 to ramp up. Care was taken to ensure the asset didn't breach the contracted export capacity and power factor tolerances (0.95-1.05). There was no additional network monitoring by the DSO other than hourly current monitoring of the primary feeder. Three phase current, voltage, power, and power factor were measured at the hydro meter at 3-second intervals. Upstream and downstream river level, screw speed and temperature of the generators are monitored at the hydro, along with upstream and downstream river levels at Sandford Lock as measured by the EA. During preparations immediately prior to delivery, a fault was detected with one of the screws, not the generator itself but with the sluice gate. While delivery was attempted, there was only a partial delivery.

[2] *Services in a Facilitated Market; SSEN, Origami Energy; 2019; https://ssen-transition.com/library/ accessed: 10/01/2020.*

Procedural Learnings

MVS A2.1 allowed further refinements of the Piclo platform as a few technical issues were raised when registering the asset and delivering the subsequent service. Besides some minor formatting tweaks (the input spreadsheet for the platform had discrepancies with date formats which led to upload failures), improvements to the Piclo service included the handling of power values (adding clarity to the units of kW/MW) and the definition of output/demand reduction tolerances at the competition stage to ensure that energy is reduced/delivered exactly as the DNO requires over the service period.

Although the delivery of the Sandford Hydro service failed (compared to the procured 100 kWh) due to a failure with one of the sluice gates, important questions were raised for the DSO, SSEN on delivery failures. This should encourage further consideration to protocols that will guide parties around the penalties, notice periods and the secondary bid process associated with assets and services that fail to deliver.

Despite MVS A2.1 being a 'failure to deliver', any technical learnings from the events that still occurred will be attempted and will follow in a separate report.

MVS A1.2 - Oxford Bus Company Battery: Remote Dispatch

Context

MVS A1.2 is the second round of MVS A1 trials looking at electrical storage for flexibility services. As with MVS A1.1, it utilised the 30 kW, 90 kWh battery system installed at Oxford Bus Company's Cowley depot. The new learning objective was to demonstrate remote activation for asset control following the dispatch signal from the DSO. Learnings from the trial are intended to inform the design of automated control software being developed as part of Work Package 3.

Trial Summary

The trial consisted of a 30 kW increase in export power (reduction in net demand), scheduled for the 5th of December 2019 for 1 hour between 11:00 and 12:00. SSEN registered the constraint competition on the Piclo platform on the 2nd of December to close at 12:00 on the 3rd of December. The asset was already registered on the Piclo platform from the previous MVS trial. A bid totalling £1 for the service was made and was broken down as separate bid prices for power, £33.00/MW/h, and energy, £33.00/MWh. SSEN selected the service as the winning bid at 15:35 on the 3rd of December. The dispatch request shortly followed at 15:54 via personal text message and read: "Instruction to dispatch; OBC Cowley; Start Time: 05/12/2019 11:00; Duration: 01:00h; Power: -30 kW;". The LCH then passed on the request to Off Grid Energy, who controlled the asset remotely. Asset monitoring was done via the asset management system.

Procedural Learnings

Learnings from the MVS A1.2 trial largely centred around the use of the Piclo platform for the registration of an asset and within the bidding process. For instance, there was a lack of clarity on the registration of constraints on the platform, where the 'deficit' / 'surplus' meanings were unclear, and needed to be amended. Other issues involved the platform listing old versions of registered constraints with the incorrect service being available for the bidding process (users need to log off and log back into the platform to see updated registrations). With respect to the bids themselves, some troubleshooting was needed for viewing bids and selecting winning bids whereby some features in the platform are still under development and users needed to be guided through this process.

Measures for optimising the process of running an MVS trial were gained within MVS A1.2 as well. Piclo suggested that the service period for an asset can be set for longer durations so that service delivery from the same MVS trial (future attempts) can be more streamlined. Before this, competitions were set up individually each time, creating some inflexibility in running future MVS attempts for the same trial.

MVS A3.1 - OBM: Sackler Library DSR

Context

MVS A3 concerns building demand-side response (DSR) for flexibility services and initially, it will focus on buildings within the city of Oxford through the Oxford Behind the Meter (OBM) plug-in project. The objective of OBM is to demonstrate a multi-site, multi-actor coordinated response of building flexibility within the city of Oxford to more effectively balance and operate the system in real time as if behind a single meter.

The Sackler Library was chosen as the first trial building for OBM and MVS A3.1. The library is part of the Bodleian libraries, and is located on St John Street behind the Ashmolean Museum in Oxford City Centre. The demand response would come from changing the speed of HVAC (heating, ventilation, and air conditioning) fans on the air handling units which feed the central library rotunda. The aim of MVS A3.1 is to demonstrate demand side response control within the University of Oxford estate in response to a DSO flexibility service request, and secondly assess the impact of such a response on the internal state of the building which will inform future building modelling and optimisation.

Trial Summary

The trial was originally planned as a 20 kW demand turn-up event, to run for 1 hour between 13:30 and 14:30 on the 12th of December, 2019. The increase in demand would be achieved by increasing the fan speed of two, 15 kW fans from their standard day setpoint of 42% to 100%. The trial was to be preceded by a shorter 30-minute test at 8:00 on the same day, outside of building opening hours, to ensure the trial didn't negatively impact the internal conditions of the building.

Prior to the trial date, the building BMS (building management system) experienced communication problems as a result of an upgrade to the Ashmolean BMS gateway through which the Sackler Library is connected. As this would limit the ability to remotely control the

asset, or to collect internal building condition data, it was decided to postpone the trial to the following week. SSEN still registered the constraint competition with a service period from the 12th of December until the 20th of December, so that if the trial was postponed, the service window would remain open the following week. A bid of £25/MW/h and £25/MWh (equivalent to £1 for the total service) was submitted at 10:52 on the 12th December and accepted at 15:20 of the same day. The early 8:00 test still went ahead as planned with manual control of fan speed and was deemed a success. This concluded the first failed iteration of MVS A3.1.1.

The rescheduled trial occurred on the 17th of December during the same time window with label MVS A3.1.2 to highlight it is the second attempt. To minimise unnecessary time for other Partners in rerunning the full procedure, MVS A3.1.2 continues from the point at which MVS A3.1.1 failed. SSEN sent the dispatch request on the 16th of December. As BMS communications with the building were still an issue, the asset was operated manually. There was no monitoring in place at the local secondary substation as the monitoring equipment was still to arrive for the Project, and time constraints didn't allow the sourcing and installation of temporary equipment. Data from the University of Oxford electricity metering at the building common connection point was used.

Procedural Learnings

The key procedural learning which came from MVS A3.1 highlighted the need for an established two-way communication strategy between the DSO and service provider, particularly relating to failure or delay in service delivery. The trial saw a failure to deliver on the original scheduled date. What processes need to be in place for the DSO to be notified of this, and what is the mechanism that follows to procure reserve services if this failure happens after bid acceptance but before dispatch requests. The MVS trial itself also saw a delay of 10 minutes in delivering the service as a result of human error during manual control. How strict are the windows for dispatch, and what penalties, if any, might apply, are questions stemming from this MVS trial.

Summary

This report details learnings relating to the procedure for delivering DSO flexibility services as part of Project LEO. These learnings are based on phase 1 of Project LEO's MVS A trials which ran between October 2019 and January 2020. The MVS concept has been widely accepted by Project Partners, and external collaborators, as an agile, low risk approach to trial new concepts in an otherwise complex energy system. This has allowed the planning and running of numerous trials in a short space of time. The learnings captured here represent the first step in evaluating the successes and failures of the procedure to inform future iterations of the trials.

A detailed trial framework has evolved over phase 1 which has been established to ensure learnings from the MVS trials are captured. This involves tracking when each procedure step is completed with associated timestamps. Data to prove the step has been completed are also required, and the processes for uploading this data through the Project LEO data log are now in place. There has been partial success with the process. This is due in part to the continued delay in signing of the Project's data sharing agreement, which impacted data upload, and time constraints of trial coordinators.

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

Some of the trials resulted in a 'failure to deliver' which highlighted some important issues to address for future trials. Two key themes are: 1) the need for a protocol for bi-directional communication between participants to notify changes in operational status; 2) a framework setting out the consequences for failures and/or delays to deliver, including possible penalties for service providers and the resulting dispatch of secondary services where available.

To help track improvement, particularly around operational efficiency, the process maturity of each procedure step has been classified between 1 - Unknown and 5 - Fully Automated. The table below summarises the current process maturity for each MVS trial as of January 2020.

	Process Maturity Stage														
MVS	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**Average**
MVS A1.1	1	3	3	1	3	3	3	2	3	3	3	2	1	3	**2.4**
MVS A1.2	1	3	3	1	3	3	3	2	4	3	1	1	1	3	**2.3**
MVS A2.1	1	3	3	1	3	3	3	2	4	3	4	1	1	3	**2.5**
MVS A3.1	1	3	3	1	3	3	3	2	3	1	3	1	1	3	**2.2**

Process maturity ratings for the completed MVS trials.

Steps 1 and 4 have been marked as 'Unknown' due to the fact a methodology for constraint identification and commercial arrangements between DSO and service provider, still need to be established. 'Unknown' has also been assigned to later steps where official settlement (step 12) and a full research evaluation (step 13) are still to be completed. The majority of other procedure steps have been ranked 'manual' due to the high degree of human involvement in each process. This can be improved with better digital communications infrastructure between the different platforms and technologies involved. For MVS A1.2, despite remote control of the asset (step 9) improving the PMS to 'partial automation', the average PMS has decreased from MVS A1.1 due to the temporary on-site monitoring being removed.

Next Steps

Firstly, there is still one outstanding 'technology' type identified within the first phase of MVS A trials to test, that of aggregated service delivery. It is hopeful this will be able to be trialled in the near future once enough aggregate resource has been identified.

With regards to the MVS A trials discussed here, more detailed technical and financial evaluations (step 13) will be undertaken to better understand the technical benefits of the service to the network, and financial implications of offering the service to the service providers or asset owners; this will help to inform future need for flexibility and the business models around offering flexibility services. There are also solutions to be actioned to correct issues which led to 'failure to deliver' in some cases. This may require future iterations of the current MVS trials; particularly for Sandford Hydro, the river conditions in spring will allow greater flexibility in operation. The 'failure to deliver' raised a number of questions around the rules, tolerances, possible penalties and backup plan in such circumstances. These will continue to be developed alongside the work of SSEN's TRANSITION Project[3].

Finally the next phase of MVS A trials are being developed, with a workshop planned for the 20th March 2020. These trials will consider operational and near-term plug-in projects in the Project LEO pipeline and recent work undertaken on site selection and network areas of interest. They will also be aligned with the 'services' which have been identified for trial by Origami as part of the TRANSITION Project. These services include: Peak Management, Constrain Management, Short Term Operating Reserve, Authorised Capacity (MIC/MEC) Trading, and Offsetting. Further details can be found in the 'Services in a Facilitated Market' document, available on the TRANSITION website.[4]

[3] www.ssen-transition.com

[4] *Services in a Facilitated Market; SSEN, Origami; 2019; https://ssen-transition.com/library//; Accessed: 13/02/2020*

Appendix 1: MVS Procedure Tracker V5

MVS Coordinator: [INSERT NAME AND ORGANISATION]
Decided based on prime objective of MVS, it is this persons responsibility to ensure the procedure document is completed before and during the trial, and any learnings are reported. They are not responsible for ensuring each step happens, just that it is reported.

MVS Trial Date:

Asset and Service Description:
[EXAMPLE DESCRIPTION: The HVAC DSR response will be provided by two 15 kW fans with variable speed drives, controlled manually through the University of Oxford's BMS system].

Objective of Minimum Viable System (MVS)
[Insert objective description which best describes the purpose of the particular MVS Trial]

[EXAMPLE to be deleted] To demonstrate a proposed additional or modified process or asset (via the Lean Ecosystem Transition methodology) within the LEO ecosystem by trialing and deploying the minimal version of the proposed change within a pseudo grid problem and to identify the potential value of doing so. Learnings from the trial will then inform the next iteration of the MVS.

Participants
[Delete participant description and replace with LEO Partner Name and partner coordinator]
Distribution System Operator (DSO): A DSO securely operates and develops an active distribution system comprising networks, demand, generation and other flexible distributed energy resources (DER).
Flexibility Market: The arena of commercial dealings between buyers and sellers of Flexibility Services.
Service Provider: Those parties able to offer Flexibility Services.
Aggregator: An aggregator is a company who acts as an intermediary between electricity end-users, DER owners and the power system participants who wish to serve these end-users or exploit the services provided by these DER. The aggregator groups distinct agents in the electric power system (i.e. consumers, producers, prosumers, or any mix thereof) to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to system operators.
Technology Platform: A market where user interactions are mediated by an intermediary, the platform provider, and are subject to network effects. As opposed to a marketplace or trading exchange, a platform intermediary must offer inherent value beyond the simple mediation process for the two sides of the market.

Data User: A party or individual who requires access to some or all of the data generated as part of the MVS trial for analysis, evaluation and/or learning generation.

Technical Specification

[Complete technical specification as relevant to the asset and provide any additional information as required]

Address	
Location (Lat, Long)	
Solar Generation Capacity (kW)	
Other Generation Capacity (kW)	
Storage Type	
Storage Asset Model	
Storage Capacity (kWh)	
Storage Power (kW)	
Flexibility Type	
Flexibility Capacity (kW)	
Supply Connection Capacity (KVA)	
Export Connection Capacity (kW)	
Voltage Connection (V)	
Connection Offer Reference (SSEN)	
MPAN (Import)	
MPAN (Export)	
Secondary Substation Name	
Secondary Substation Code	
Primary Substation Name	
Primary Substation Code	
HV Feeder Name	
Other Information	

Data

The person identified as 'Partner Coordinator' is responsible for uploading the data requirements as identified for each step. Data should be uploaded through the Project LEO Data Log. Please contact University of Oxford Data Coordinator (Masao Ashtine) for further information masao.ashtine@eng.ox.ac.uk.

MVSAX Procedure

[Blue text should remain the same. Underlying sub-steps to the main prodecure step should be included in orange within the 'Sub-Step' column. This should be detailed for each blue step of the MVS procedure. Data requirements for each step need to be

identified and should identify foreground and background data. Status column to be used to show when complete, use green.to be identified and should identify foreground and background data. Status column to include]

Procedure Ref.	Procedure Step	Sub-Step	Data Requirements	Status (Green for complete)	Data status (Green for uploaded)	Start Date Stamp (DD/MM/YYYY HH:MM:SS)	End Date Stamp (DD/MM/YYYY HH:MM:SS)
1	DSO to identify need for flexibility services						
2	DSO able to register their constraint requirement on the flexibility market platform						
3	Service provider to be able to register their flexible resource on the flexibility market platform						
4	Service provider registers company with DSO (i.e. becomes a supplier; Commercial Set Up of Service Provider is only required once)						
5	Marketplace/DSO pre-qualifies the registered flexibility service						
6	Service provider to bid into auction						
7	DSO to be able to select winning bids on the flexibility market platform						
8	Flexibility Market platform to facilitate the communication of the dispatch signal to service provider						
9	Service provider to dispatch services in accordance to agreed baseline methodology. Flexibility service delivery.						
10	Monitoring of the local substation						
11	Monitoring of the flexible resource at the connection point.						
12	Settlement						

13	Research Evaluation of Specific MVS						
14	MVS procedure evaluation and feedback						

Risks

Risk	Associated step	Partner responsible	Impact	Likelihood	Total	Mitigation

Appendix 2: MVS Background

The Lean Startup methodology provides an agile framework to develop new products and associated business models capable of disrupting existing markets and unlocking new value potential. The approach is analytic and hypothesis driven and follows a build-measure-learn methodology. A vision is translated into hypotheses which are built into the first version of the business model or product. These hypotheses are then tested through a series of minimum viable products (MVPs) which represent, 'the smallest set of activities needed to disprove a hypothesis'. MVPs are validated quantitatively. Following on from MVP validation, innovators are faced with three options, (i) persevere with the proposed business model; (ii) modify or pivot to a revised business model; (iii) or drop the proposal entirely (fail fast). This process is repeated until the value proposition is proven. This fast, iterative approach is particularly useful for innovation in dynamic and uncertain digital contexts, where technology, regulation and market conditions are changeable. Within Project LEO, we plan to build on this Lean Startup approach and apply it to whole system innovation.

The lean ecosystem process developed for Project LEO, shown in Figure A1, is:

1. Identification of the Societal Need: Group of stakeholders identify and agree on the core societal values which should be generated by the emerging ecosystem.

2. Key steps to meet societal value identified through Theory of Change (TOC) process: A strategy for achieving the identified societal values is defined by backcasting to the present, to form a TOC. This backcasting exercise identifies the key steps envisioned to meet the societal value and informs the Lean Ecosystem Methodology which is iterative. From the TOC, Key Performance Indicators (KPIs) are used to discover where one is in the process, in addition to testing its effectiveness.

3. Creation of Minimum Viable Systems (MVSs): From the TOC, a minimum stress set of participants and processes are identified and tested. This is likely to include multiple connected Minimum Viable Products (MVPs) undergoing their own iterative sub-development cycles.

4. Measurement of ecosystem effectiveness via Processes and KPIs: The effectiveness of each step within the ecosystem, along with the KPIs, are measured to understand if the societal values are being generated/met.

5. Understanding the need to adapt and/or pivot through Learning: Analysis of the KPIs informs the TOC. TOC is updated (adapt) as necessary for the next iteration. If required, the core ecosystem values are also updated (pivot). From understanding the challenges of the process implementation (and careful consideration of the KPIs), a new MVS is developed and operationalized, thus completing the loop.

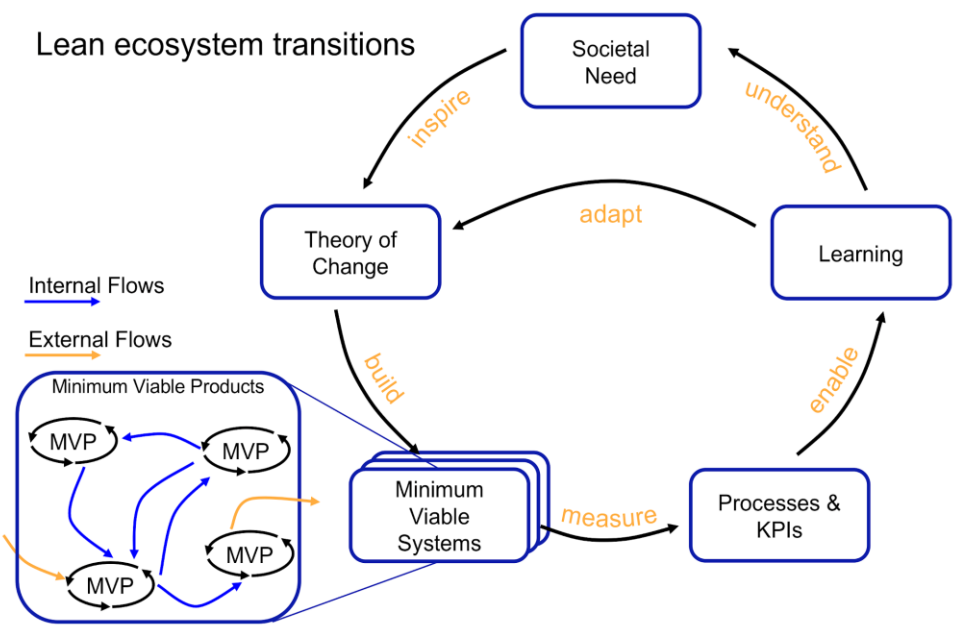


Figure A1 - Lean ecosystem transitions

Appendix 3: Glossary

Best efforts have been made throughout the document to use accepted terminology common to the UK electricity industry and DSO industry. For clarity, some key terms used in this document are defined below.

Term	Definition
Aggregator	An aggregator is a company who acts as an intermediary between electricity end-users, **DER owners** and the power system participants who wish to serve these end-users or exploit the services provided by these **DER**. The aggregator groups distinct agents in the electric power system (i.e. consumers, producers, prosumers, or any mix thereof) to act as a single entity when engaging in power system markets (both wholesale and retail) or selling services to system operators.
DER (asset) Owner	The legal owner of a **DER** (asset).
BMS	Building Management System
Data User	A party or individual who requires access to some or all of the data generated as part of the **MVS** trial for analysis, evaluation and/or learning generation.
Delivery	The fulfilment of the **flexibility service** as per the **dispatch** instruction.
DER (Asset)	Distributed Energy Resource connected at distribution level.
Dispatch	Instruction sent by the **DSO** to the **Service Provider** to initiate the flexibility service.
DNO	Distribution Netowork Operator.
DSO	Distibution System Operator. A party that takes on the role of system operation. A DSO securely operates and develops an active distribution system comprising networks, demand, generation and other flexible **DER**s.
DSR	Demand Side Response. Varying the demand of a **DER**, such as a building, to offer flexibility.
EA	Environment Agency
Flexibility Market	The arena of commercial dealings between buyers and sellers of **Flexibility Services**.
Flexibility Service	The offer of modifying generation and/or consumption patterns in reaction to an external signal (such as a change in price) to provide a Service within the energy system
Grid	The electricity distribution network.

HVAC	Heating, Ventilation and Air Conditioning
KPI	Key Performance Indicator
LCH	Low Carbon Hub
LEO	Local Energy Oxfordshire.
MPAN	Meter Point Administration Number
MVS	Minimum Viable System. A minimum stress set of participants, technology and processes required to trial new system innovation.
MVS Coordinator	A single person taking on the responsibility of 'Project Manager' for the specific **MVS** trial, they are responsible for coordinating other Partner coordinators to ensure the **MVS** documentation gets completed .
OBC	Oxford Bus Company
Partner Coordinator	The lead person from each organisation involved in the **MVS** trial that coordinates the activity of that organisation in the trial, and has responsibility for completing the **MVS** documentation relevent to their organisations role.
Plug-in Project	A **flexibility asset** or system being developed as part of LEO which is capable of 'plugging-in' to the flexibility market.
PMS	Process Maturity Stages. A metric measuring automation of a process.
Service Provider	Those parties able to offer **Flexibility Services**. Not necessarily the **Asset Owner**.
Settlement	A financial transfer to the **Service Provider** following the succesful delivery of the instructed **Flexibility Service**.
SSEN	Scottish and Southern Electricity Networks
Technology Platform	A market where user interactions are mediated by an intermediary, the platform provider, and are subject to network effects. As opposed to a marketplace or trading exchange, a platform intermediary must offer inherent value beyond the simple mediation process for the two sides of the market.