Local Energy Oxfordshire

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Commercial MVS D4 Report

Declarations, Baselining Methodology & Settlement

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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) [1] 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.

[1] Glossary Terms Archive - Project LEO (project-leo.co.uk)

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Executive Summary

In December 2020, the TRANSITION project conducted a short study that identified 26 commercial areas which would benefit from feedback. An evaluation to rank these 26 commercial areas identified six (6) Minimum Viable System (MVS) trials that would benefit from input from LEO partners during the first six months of 2021. One of these six trials was Commercial MVS D4, which took place during June 2021 to assess three commercial areas:

- The accuracy of the partners forecasting (at month ahead, week ahead and day ahead) and how it may change over time;
- The application of the historic baseline methodology; and,
- The suitability of two potential settlement mechanisms: Option 1 has two large step changes (at 50 and 90% of the Forecasted Flexibility Delivered) and Option 2 has three straight-line representations (at 50, 85 and 95% of the Forecasted Flexibility Delivered; linearly derived).

These areas were tested via a series of flexibility events, during which each of the LEO Distributed Energy Resources (DERs) would either manually or automatically provide a pre-specified amount of flexibility for one hour. In addition to participating in these flexibility events, the partners had to submit the following for each DER (see Figure 1):

- An Initial Questionnaire before any of the scheduled flexibility events (to capture qualitative data - see Section 3.2);
- A separate Declaration of Delivery for each DER (to capture the forecasted amount of flexibility that each DER was expected to deliver at the month ahead, week ahead and the day ahead stage - see Section 3.3);
- Metering data for the 10 days prior to each flexibility event (to create a baseline - see Section 3.4);
- Metering data for each flexibility event (to be used with the metering data ahead of events to determine the flexibility delivered - see Section 3.4); and,
- A Final Questionnaire after the scheduled flexibility events (to capture learnings and qualitative data - see Section 3.2).

The volume of data collected by participants throughout each of these events was substantial and allowed the TRANSITION project to test and verify their Baseline and Settlement model ahead of Trial Period 1. The following outcomes resulted from the deliveries:

Table 1: Results of Baseline and Settlement

Organisation	DERs	Payment	Comments
EDF Energy	4 Domestic Batteries	£10.48	Fully delivered 14.4kWh during Service 1, partially delivered 14.4kWh during Events 2 & 3.
Low Carbon Hub	Rose Hill Battery	£13.50	Fully delivered 15kWh during Events 1, 2 & 3.
	Sandford Hydro	£24.00	Fully delivered 30kWh during Events 1 & 3. Fully delivered 20kW during Service 2.

Organisation	DERs	Payment	Comments
Nuvve	3 EV Chargers	£1.50	Partially Delivered 10kWh during Service 2.
University of Oxford	Westgate Library	N / A	No flexibility delivered during Events 1, 2 & 3. Unable to create reliable baseline due to insufficient meter data.

The data show that it was difficult to predict the amount of flexibility that Sandford Hydro, Westgate Library and the Nuvve chargers would be able to provide during the flexibility events, which resulted in lower payments. Origami will hold individual sessions with these organisations during the Project LEO Smoke Tests to determine what could be done to improve forecasting as it may affect the ability of some DERs to participate in the market either directly or at all.

There were a number of errors in the data uploaded to the Project LEO SharePoint site. For instance, data was not uploaded in the correct format, and scientific notation and different units were used throughout the three events. This had to be corrected before it could be used in the baselining tool. TRANSITION should create a data upload template for flexibility providers which provides guidance on its use to ensure these errors are not repeated during the TRANSITION Trials.

This report provides a summary of the flexibility events held throughout May and June. It captures the process, outcome, and learnings from the flexibility events which can be used to inform future work. The analysis and the key learnings from this MVS will be used to develop the Baseline and Settlement models and stipulate the data format to be used to be used during Trial Period 1.

1 Introduction

Project LEO (Local Energy Oxfordshire) is a sociotechnical innovation project which aims to demonstrate that a functioning Smart Local Energy Systems (SLES) in Oxfordshire can maximise economic, environmental, and social prosperity in the area. One of the objectives of Project LEO is to develop and deliver new and existing Flexibility Services using the flexibility of Distributed Energy Resources (DERs) connected to the electricity system or distribution network (Flexibility Services) in conjunction with project TRANSITION.

TRANSITION is an Ofgem Electricity Network Innovation Competition (NIC) funded project which explores the Distribution Network Operator (DNO) transition to a Distribution System Operator (DSO). The TRANSITION project is integral to Project LEO as it will deliver the network management system to facilitate the Local flexibility Market.

Project LEO has devised a Minimum Viable System (MVS) approach to develop and test Flexibility Services, business models and the multi-organisation procedure and communications required to operate a Local Flexibility Market. Each MVS trial represents the minimum set of participants and processes required to test a new process modification or DER use case. In doing so, potential value is identified and evaluated quickly at a small scale, before significant investment is committed.
Using this agile approach, the TRANSITION project designed a number of Commercial MVS trials to obtain feedback on a number of commercial areas (see Section 2) ahead of the TRANSITION Trials. Commercial MVS D4 assesses three areas: forecasting; validation and settlement.

These areas were tested via a series of flexibility events held in June, during which each of the LEO DERs would either manually or automatically provide a pre-specified amount of flexibility for one hour. Three flexibility events were scheduled for each DER.

In addition to participating in these flexibility events, the partners had to perform a number of tasks for each DER, as described in Section 3:

- Fill out an Initial and Final Questionnaire;
- Submit a Declaration of Delivery at a month ahead, week ahead and day ahead of the flexibility event;
- Collect monitoring data from 10 days prior to the flexibility event; and
- Collect monitoring data during the flexibility event.

By carrying out the above activities, Projects LEO and TRANSITION were able to: determine the accuracy of the forecasting for each DER and how this varied over time; assess the accuracy of the baseline model produced by TNEI; and determine the appropriateness of the settlement options for the LEO / TRANSITION Trials.

This report provides a summary of the flexibility events held in June. It captures the process, outcome, and learnings from the flexibility events which can be used to inform future work.

2 The Commercial MVS Trials

In December 2020, the TRANSITION project conducted a short study that identified 26 commercial areas which would benefit from feedback. An evaluation to rank these 26 commercial areas identified six (6) MVS trials that would benefit from input from LEO partners during the first six months of 2021:

Table 2: MVS Number, Subject and Status

Trial Number	*Trial Name*	*Status*
MVS 001	Assessment of DERs with Low Levels of Flexibility	Complete
MVS 002	Assessment of Reliability Index	Under Discussion at time of report
MVS 003	Assessment of Monitoring Granularity for Different DERs and Services	Report in Draft at time of report
MVS 004	Assessment of Declarations, Baselining Methodology and Settlement	Complete
MVS 005	Flexibility Service Agreement Workshops	Complete
MVS 006	Market Stimuli Package Review	Complete

Commercial MVS' 001 to 004 were originally defined using the same template to aid engagement with LEO and received very favourable feedback from discussions with the MVS Group within LEO. The template produced for Commercial MVS 004 is provided in Appendix A. This was used to develop the scope of the Commercial MVS to its final form, as defined in Section 3. Commercial MVS D4 was also re-named to align with the naming convention used by the technical MVS'.

2.1 Trial Naming

Previously the notation MVSAX.Y.Z was used; where A was used for all technical Flexibility trails (B was for Geospatial trials (i.e., the mapping work) and C was for Informing Policy trials). X then referred to an DER group (Prosumer, Generator, SFN, Aggregator, or Portfolio), Y the 'learning number' or trial number, and Z the attempt number (would increase if a previous attempt was deemed to fail or it was a direct repeat).

To keep the naming convention consistent with the above, Commercial MVS 004 was re-named to Commercial MVS D4 and the following notation was used:

- **MVSD** [Commercial] **4** [Trial Number].**Y** [DER Number] .**Z** [Service Schedule Number]

Each DER was assigned an DER Number and a different Service Schedule Number was used for each flexibility event (see Section 3.1). The specific numbers used during Commercial MVS D4 are shown in Appendix B.

3 Commercial MVS D4

Commercial MVS D4 took place during June 2021 to assess three commercial areas:

- The accuracy of the partners forecasting (at month ahead, week ahead and day ahead) and how it may change over time;
- The application of the historic baseline methodology; and,
- The suitability of two potential settlement mechanisms: Option 1 with two step changes in payment and Option 2 with three equations (see Figure 2).

These areas were tested via a series of flexibility events, during which each of the LEO DERs would either manually or automatically provide a pre-specified amount of flexibility for one hour. In addition to participating in these flexibility events, the partners had to submit the following for each DER (see Figure 1):

- An Initial Questionnaire before any of the scheduled flexibility events (to capture qualitative data - see Section 3.2);
- A separate Declaration of Delivery for each DER (to capture the forecasted amount of flexibility that each DER was expected to deliver at the month ahead, week ahead and the day ahead stage - see Section 3.3);
- Metering data for the 10 days prior to each event (to create a baseline - see Section 3.4);
- Metering data for each event (to be used with the metering data ahead of events to determine the flexibility delivered - see Section 3.4); and,
- A Final Questionnaire after the scheduled flexibility events (to capture learnings and qualitative data - see Section 3.2).

After each available DER had taken part in three flexibility events, Origami Energy and SSEN conducted analysis on the data captured and completed this Commercial MVS report, which is similar in format to Technical MVS reports produced by Project LEO[2].

3.1 MVS Flexibility Event Details

Three flexibility events were originally scheduled between 16:00 and 17:00, during which each participating DER aimed to provide a Flexibility Service for one hour as follows:

- Service 1 (S1): Tuesday 8th June
- Service 2 (S2): Wednesday 16th June
- Service 3 (S3): Thursday 24th June

After these dates were finalised, Westgate Library informed SSEN that they were unable to participate in Service 2 due to resourcing issues. An additional Flexibility Service was therefore scheduled (Service 4: Wednesday 30th June) to ensure that as much data as possible could be collected for each of the DERs.

[2] MVS Sackler Library technical report, University of Oxford, published Project LEO on 15th April 2020

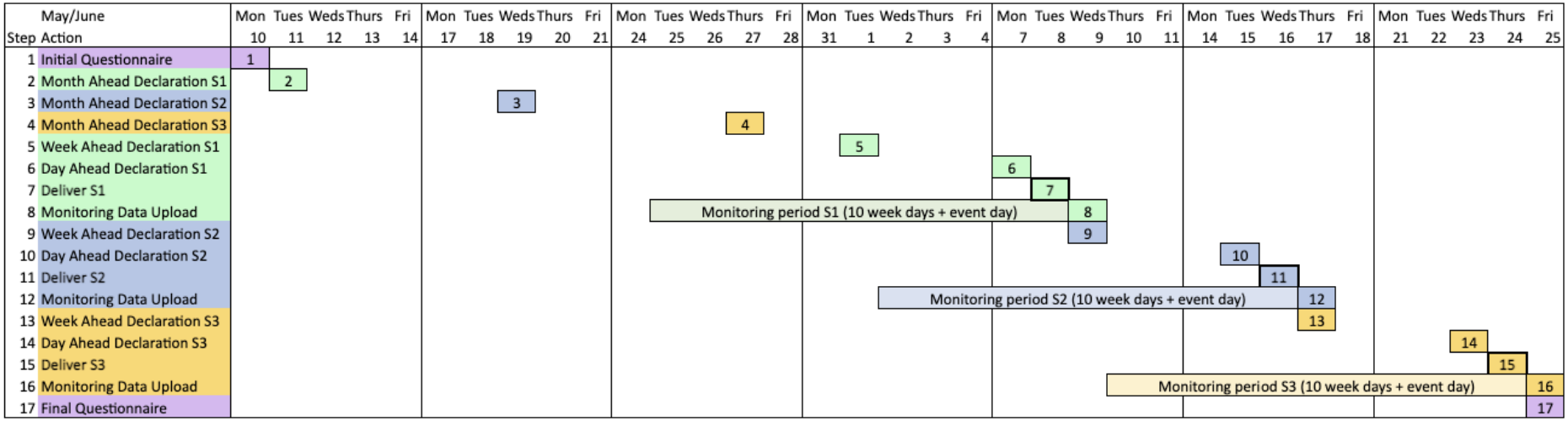


Figure 1: Programme for Commercial MVS D4

Table 3: Survey Participants and their role

LEO Partner	Role	DER	S1	S2	S3	S4
EDF Energy	Party and available DER(s) used to test the process	4 x 3.6 kW batteries	x	x	x	n/a
Low Carbon Hub	Party and available DER(s) used to test the process	Sandford Hydro	x	x	x	n/a
		Rose Hill Battery	x	x	x	n/a
Nuvve	Party and available DER(s) used to test the process	3 x V2G Charge Points at the Oxford Office Furniture Site	x	x	x	n/a
Origami Energy	Develops materials, conducts the analysis, manages the Flexibility Events and writes the report.	n/a	n/a	n/a	n/a	n/a
Oxfordshire County Council	Available DER(s) used to test the process	Westgate Library: load reduction (turn-down) flexibility via HVAC	x	n/a	x	x
SSEN	MVS owner / sponsor, conducts the analysis	n/a	n/a	n/a	n/a	n/a
University of Oxford	Party used to test the process, develop the materials, and manage the flexibility events.	n/a	n/a	n/a	n/a	n/a

3.1.1 Participants

Table 3 summarises the key participants, their role and the DERs used to provide the Flexibility Service during each of the scheduled flexibility events.

3.1.2 Data

The data generated as part of these trials were uploaded to the Project LEO Data Sharing Log using the instructions provided in Appendix B. All data can be accessed by project partners through the Project LEO Data Catalogue using the instructions in the Project LEO Data Sharing Guide available on the Project LEO SharePoint.

3.1.3 Risks

Table 4Table 4: Risk matrix for delivery summarises the risks for the delivery of this Commercial MVS.

Table 4: Risk matrix for delivery

No.	Category	Risk	Impact	Likelihood	Total	Mitigation
1	Delivery	DER not available due to weather conditions.	Partial or failed dispatch.	High	High	Multiple flexibility events scheduled during the summer months.
2	Delivery	DER not available due to the driver profiles at EV charge points.	Partial or failed dispatch.	High	High	Multiple flexibility events scheduled.
3	Declaration of Delivery	Multiple forms to be submitted per DER per flexibility event	Failure to complete and submit the forms by the agreed deadlines.	High	High	Weekly reminder emails sent to the DER owners.

3.2 MVS Questionnaires

An Initial and Final Questionnaire were completed once per organisation to capture the following qualitative information in relation to the partners available DER(s):

- Flexibility Event Details
- Forecasted flexibility (methodology, confidence, attitude to risk, unforeseen circumstances)
- Preferred Market (month ahead, week ahead, day ahead)
- Preferred Settlement Mechanism (see Section 3.5)

The Initial Questionnaire was completed before the scheduled flexibility events to capture the partners responses for all their available DERs; the Final Questionnaire was completed after the scheduled flexibility events. Both the Initial and Final questionnaires sought to draw out the learnings from Commercial MVS D4 and highlight if the partners approach had changed as a result of participating in the flexibility events. A summary of the responses given to the initial and Final Questionnaire is provided in Appendix C.

3.3 Declaration of Delivery

The partners had to submit a separate Declaration of Delivery for each DER to capture the forecasted amount of flexibility that it was expected to deliver at the month ahead, week ahead and the day ahead stage. It also helped to capture the assumptions made when determining the amount of forecasted flexibility and the metering details for the DER. The forecasted energy provided in these forms was used to determine the utilisation payment to be awarded to the participants for participating in the flexibility event (see Section 3.5).

The Declaration of Delivery also showed how the amount of forecasted energy changed at the month ahead, week ahead and the day ahead stage with a discussion on why the changes occurred.

3.4 Baselining Methodology

The ENA Open Networks Project (ENA ONP)[3] defines the baseline as the "Established level of Distributed Energy Resources base load from which a delta is measured to calculate level of service delivered". Different methodologies may be used to determine the baseline for DERs, two of which will be used during the TRANSITION Trials: Historical Baseline with Same Day Adjustment, and Nomination Baseline. Data collected during Commercial MVS D4 was used to test a baseline tool developed by TNEI which utilises the Historical Baseline with Same Day Adjustment methodology. The Nomination Baseline methodology was not used within this tool, but will be used in the TRANSITION Trials. A mathematical representation of how both baseline methodologies will be calculated is currently being drafted and will be provided on the TRANSITION website in due course[4].

In order to test this baseline tool, the partners were required to upload service meter data from 10 days prior to each flexibility event. The data were collected from either the MPAN or metering located near to or on the DER. Data were run through the baseline tool to calculate an unadjusted baseline. A same day adjustment is made to reflect any variability between the historic data and actual load profile in the two (2) hours leading up to the flexibility event start time. This is known as the adjusted baseline for the flexibility event period.

The adjusted baseline was compared to the metered data during the flexibility event to calculate the amount of energy and amount of flexibility delivered during each of the flexibility events and therefore, the amount to be paid to each of the partner in accordance with the settlement rules as seen in the following section.

[3] Baseline Methodology Assessment, Energy Networks Association, issued by DNV.GL in Dec-2020
[4] See the "Get Involved" section of the TRANSITION Website, available at: https://ssen-transition.com/

3.5 Settlement Rules

Two possible settlement mechanisms were tested during the Commercial MVS D4 to determine the potential utilisation payment to be made to the service provider for the energy delivered during the events: Option 1 has two large step changes (at 50 and 90% of the Forecasted Flexibility Delivered) and Option 2 has three straight-line representations (at 50, 85 and 95% of the Forecasted Flexibility Delivered; linearly derived).

For each mechanism, Figure 2 depicts the relationship between the percentage of the payment received vs. the percentage of forecasted flexibility delivered. The below options were used to determine the payment each partner could have received during each of the flexibility events using the Declarations of Delivery (month ahead, week ahead, day ahead) provided. For the purposes of the Commercial MVS D4, the provider was paid the maximum amount calculated using the most favourable settlement mechanism and declaration. This approach is maintained in the Flexibility Services Agreement for those who provided data within six weeks of a flexibility event or during the day before a potential stage.

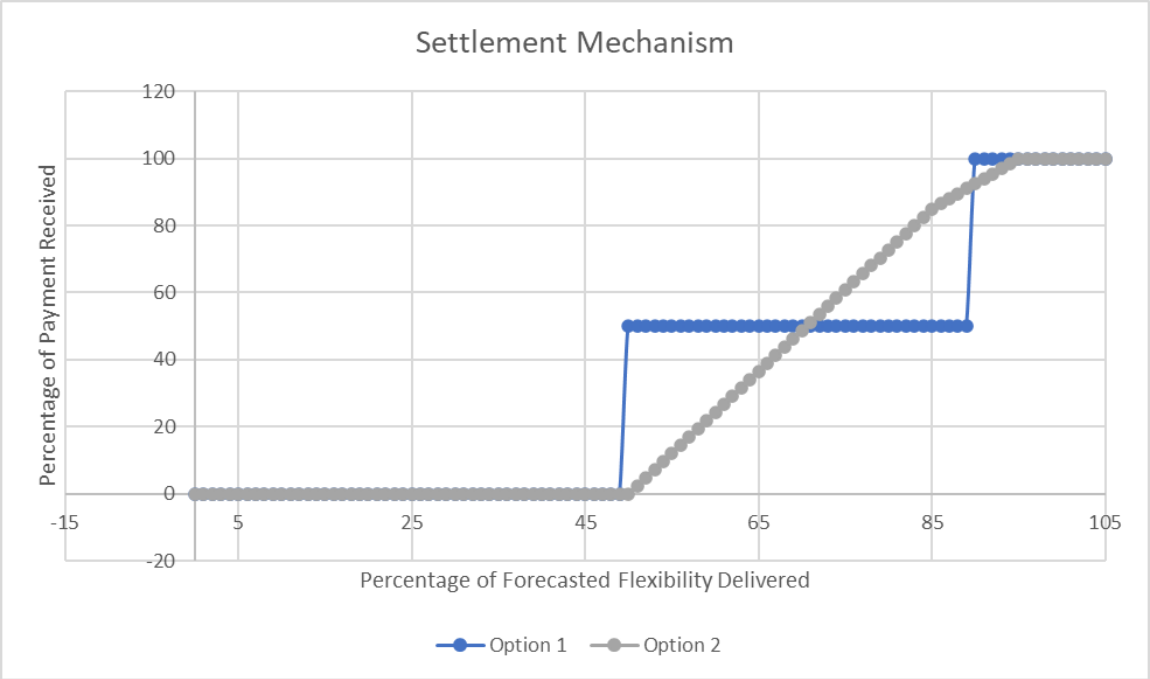


Figure 2: Illustration of Settlement Mechanisms for Option 1 and Option 2

The settlement mechanisms illustrated in Figure 2 are summarised in Table 5.

Table 5: Description of Settlement Mechanisms for Option 1 and Option 2

Option 1 (per flexibility event)	Option 2 (per flexibility event)
• If (Energy Delivered / Forecasted Energy is 90% or above), pay 100% *x* Utilisation Bid *x* Forecasted Energy • If (Energy Delivered / Forecasted Energy is equal to or more than 50% but less than 90%), pay 50% *x* Utilisation Bid *x* Forecasted Energy • If (Energy Delivered / Forecasted Energy is less than 50%), pay 0% *x* Utilisation Bid *x* Forecasted Energy	• Energy Delivered / Forecasted Energy is 95% or above), pay 100% *x* Utilisation Bid *x* Forecasted Energy • If (Energy Delivered / Forecasted Energy is equal to or more than 85% but less than 95%), pay (1 - (0.95- Energy Delivered / Forecasted Energy) x 1.50) *x* Utilisation Bid *x* Forecasted Energy • If (Energy Delivered / Forecasted Energy is equal to or more than 50% but less than 85%), pay (085 - (0.85 - (Energy Delivered / Forecasted Energy)) *x* 2.43) *x* Utilisation Bid *x* Forecasted Energy • If (Energy Delivered / Forecasted Energy is less than 50%), pay 0% *x* Utilisation Bid *x* Forecasted Energy

4 Results and Analysis

The results of the analysis conducted during Commercial MVS D4 are summarised in Table 6 below:

Table 6: Results of Baseline and Settlement

Organisation	DERs	Service	Contracted Capacity[5]	Delivered (SP1)[6]	Delivered (SP2)	Settlement[7]
EDF Energy	4 Domestic Batteries	S1	14.4kWh (M/W/D)	7.25kWh	7.09kWh	£4.32
		S2		5.50kWh	5.50kWh	£2.74
		S3		6.90kWh	5.30kWh	£3.42
Low Carbon Hub	Rose Hill Battery	S1	15.0kWh (M/W/D)	7.80kWh	7.60kWh	£4.50
		S2		7.80kWh	7.60kWh	£4.50
		S3		7.80kWh	7.60kWh	£4.50
	Sandford Hydro	S1	15.0kWh (W/D)	34.6kWh	29.0kWh	£9.00
		S2	10.0kWh (M/W/D)	34.0kWh	29.0kWh	£6.00
		S3	15.0kWh (D)	19.0kWh	24.0kWh	£9.00

[5] This value provided the most favourable settlement; (M/W/D) indicates whether this value was provided at the month ahead, week ahead or day ahead stage
[6] Baselining is conducted on half-hourly Settlement Periods (SPs)
[7] Settlement calculated using highest paying settlement options

Organisation	DERs	Service	Contracted Capacity[5]	Delivered (SP1)[6]	Delivered (SP2)	Settlement[7]
Nuvve	3 EV Chargers	S1	5.00kWh (D)	1.70kWh	2.14kWh	£0.00
		S2		1.96kWh	5.80kWh	£1.50
		S3	0.00kWh (D)	-1.50kWh	0.69kWh	£0.00
University of Oxford	Westgate Library	S1	3.34kWh(W)	0.03kWh	0.03kWh	£0.00
		S3	13.5kWh (M/W)	0.65kWh	0.65kWh	£0.00
		S4[8]	12.0kWh (W)	-0.07kWh	0.18kWh	£0.00

The detailed analysis is provided in Appendices C to F:

- Appendix C: Summary of Initial and Final Questionnaire
- Appendix D: Analysis of Commercial Baselining and Settlement Results
- Appendix E: Baselining Results Graphs
- Appendix F: Analysis of Declaration of Delivery Over Time

4.1 Appendix C: Summary of Initial and Final Questionnaire

Appendix C provides a summary of partner responses to the Initial and Final Questionnaire. The table is split in to five sections and generally follows the format of the questionnaires:

1. General Information - provides the details of the assets used in the scheduled events.

2. Forecast Flexibility – provides details of the partners' methodology for determining the forecasted flexibility for Service 1, their confidence in this and their attitude to risk. It also records any circumstances which may have affected their delivery.

3. Preferred Market – indicates the partners' preferred market (month ahead, week ahead or day ahead) and the reasons for this selection.

4. Preferred Settlement Mechanism – indicates the partners preferred Settlement Mechanism (Option 1 or Option 2, see Section 3.5) and the reasons for this selection.

5. Leanings – captures any learnings that the partners gained from participating in Commercial MVS D4.

4.2 Appendix D: Analysis of Commercial Baselining and Settlement Results

Appendix D provides a summary of the baselining and settlement results for each asset during each event window. The reference number uses the naming convention shown in Appendix B and is unique to the asset and delivery window. The Contracted Capacity was taken from declaration of

[8] Westgate Library were unable to participate in Service 2 due to resourcing issues. An additional Flexibility Service was therefore scheduled (Service 4: Wednesday 30th June), see Table 3.

delivery forms and shows the different values provided at the month ahead, week ahead and day ahead declarations.

Asset Name	Asset Owner	Number	Contracted Capacity		Baselining (first half hour; second half hour)	Settlement
Sandford Hydro	LCH	MVSD4.1.1	month ahead;	20kW	Fully delivered (346%, 34.6kWh; 290%, 29kWh)[9]	Option 1: £6
						Option 2: £6
			week & day ahead	30kW	Fully delivered (230%, 34.6kWh; 193%, 29kWh)	**Option 1: £9**[10]
						Option 2: £9
		MVSD4.1.2	20kW for all events		Fully delivered (337%, 34kWh; 296%, 29kWh)	**Option 1: £6**
						Option 2: £6
		MVSD4.1.3	month & week ahead	20kW	Fully delivered (188%, 19kWh; 242%, 24kWh)	Option 1: £6
						Option 2: £6
			day ahead	30kW	Fully delivered (125%, 19kWh; 161%, 24kWh)	**Option 1: £9**
						Option 2: £9

Figure 3: example of baselining and settlement analysis

For determining settlement, both Option 1 and Option 2 were used to calculate the amount that could be paid using the month ahead, week ahead and day ahead declarations. The final payment was determined based on the highest amount calculated across both settlement options and all three timescales. For example, Sandford Hydro delivered *ca.* 34.6kWh during the first settlement period (1601 and 1630) of Service 1 (MVSD4.1.1). This is above the amount declared at any of the month ahead, week ahead and day ahead timescales and therefore above the 90 and 95% thresholds required to receive the full payment for Option 1 and 2 respectively[9]. The calculated payments were £6 (based on the 20kWh month ahead declaration), £9 (based on the 30kWh week ahead and day ahead declarations). SSEN paid the highest of the two amounts: £9. Similarly, where Option 2 provided a higher amount than Option 1, the amount calculated using Option 2 was paid.

4.3 Appendix E: Baselining Results Graphs

Figure 4 provides the performance assessment for Sandford Hydro for Service 1 (Jun-8, 2021):

- The blue line (Baseline) depicts the baseline for Sandford Hydro for Service 1. This was generated by the baselining tool which analysed the historic data to generate a routine daily pattern. This is an average value, with the blue shadow showing the range of data points around this average.
- The green line (Measured) is the generated output for the test event day.
- The pink line is the Contracted Service Capacity specified by each partner. In this instance, it is 20kW for the month ahead declaration. A separate analysis was used for the week ahead and day ahead declarations for Contracted Service Capacity as can be seen in Appendix D.
- The purple line (Response) is the flexibility delivered, which is the Baseline minus the Measured values. The Response only considers the test window and therefore data are only shown between 16:00 – 17:00.

[9] Taking the Month Ahead value as an example, the contracted capacity is 20kWh, so the total flexibility over the 1h test window will be 20kWh. 10 kWh is to be delivered every half hour. During the first half hour, Sandford Hydro delivered total 34.6kWh which is 346% of the contracted half hour capacity (10kWh). During the second half hour, Sandford Hydro delivered 29kWh which is 290% of the contracted half hour capacity (10kWh).

- The purple line in this instance is negative, as the response is a generation. This was manually changed to a positive value to compare with the Contracted Service Capacity.

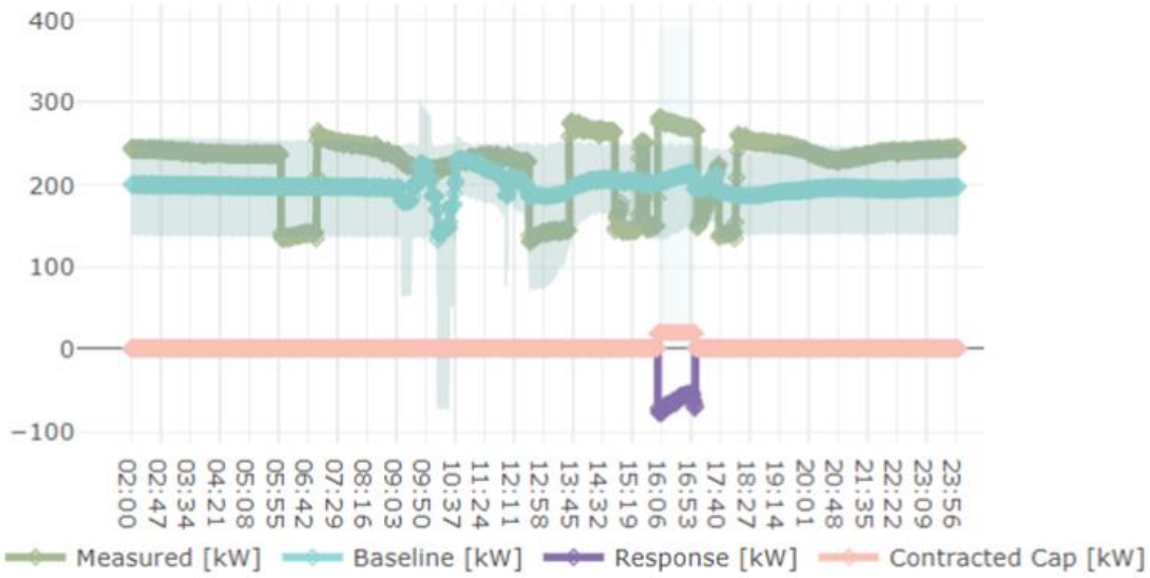


Figure 4: Baseline result for Sandford Hydro during Service 1

4.4 Appendix F: Analysis of Declaration of Delivery Over Time

Appendix F considers how the declarations varied over time from the month ahead stage to the week ahead and day ahead stages. These are compared to the flexibility delivered during each Settlement Period of the event.

The analysis for Sandford Hydro across all three Events is provided in Figure 5 to illustrate how the graphs are interpreted;

- For Service 1, Sandford Hydro declared 20kW for the month ahead declaration. This was increased to 30kW for the week ahead declaration and remained at 30kW for the day ahead declaration.
- The test window was 1 hour (16:00 – 17:00), thus the declared capacity would be 20kWh (20kW * 1 hr using the month ahead declaration) and 30kWh (using the week ahead and day ahead declarations) for the total test window period.
- SSEN uses half-hourly analysis for the final settlement analysis; the half-hour settlement for the declared month ahead will be 10kWh (20kWh/2) and for each of the week ahead and day ahead declarations it will be 15kWh (20kWh/2) (see the blue bars).
- LCH delivered 34.6kWh for the first half-hour (16:00 – 16:30) and 29kWh for the second half hour (16:30 – 17:00); this is shown by the yellow bars (Settlement Period 1 & 2 respectively).

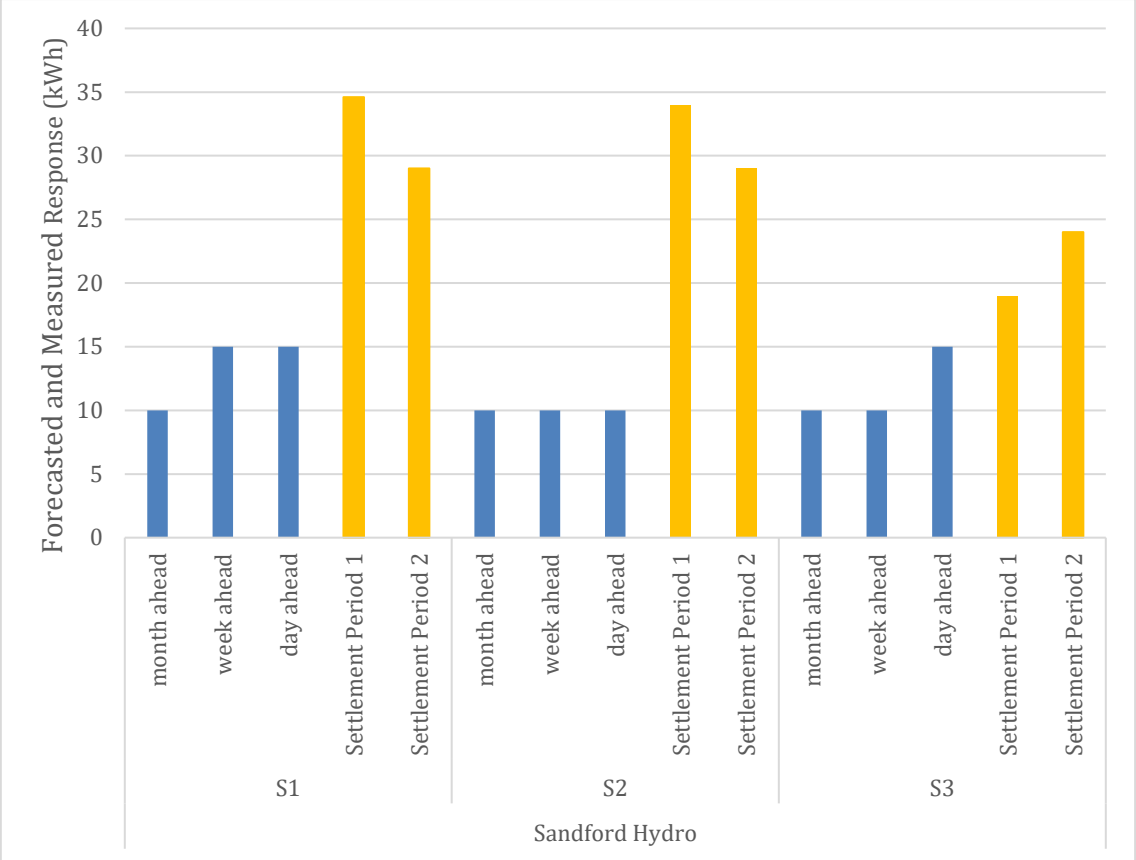


Figure 5: Declaration of Delivery of time vs. actual delivery for Sandford Hydro across all three events

5 Key Observations

The key observations from the Summary of Initial and Final Questionnaire (see Appendix C) are provided below:

- The day ahead market was favoured for all but one of LEO DERs as they found it easier to forecast their availability / flexibility levels at the day ahead stage. Rose Hill battery was the exception and favoured the month ahead market)
- There was no consensus between the partners as to the preferred settlement method:
  - In the Final Questionnaire, Nuvve (V2G chargers) and LCH (Rose Hill battery) favoured Option 1;
  - In the Final Questionnaire, EDF Energy (domestic batteries), LCH (Sandford Hydro), and the University of Oxford (Westgate Library) favoured Option 2;
  - The preferred settlement mechanism for EDF Energy (domestic batteries), Nuvve (V2G chargers) and the University of Oxford (Westgate Library) changed as a result of Commercial MVS D4;
  - For all events, Option 2 provided the partners with a higher reward (see below).
- Communication was lost with Rose Hill Battery a couple of days before Service 2. Comms was restored on the morning of 16th June, so the delivery went ahead, but data from this period was lost

The key observations from the Analysis of Commercial Baselining and Settlement Results are provided below (see Appendix D and Appendix E):

- Westgate Library;
  - could only deliver a very small amount of flexibility during Service 1 (08-Jun) due to operational issues at the site;
  - in order to gather as much data as possible from the local and MPAN metering, the DER delivered the flexibility again on 09-Jun-21;
  - local metering showed ~30kW of flexibility was delivered during Service 1, although this could not be verified as there was only one day of historic data available (at least eight previous weekdays are required to perform a robust assessment of the baseline);
  - no response was calculated using the data collected at the MPAN; and
  - the reliance on the historic data baseline meant no payment was made.
- During each flexibility event and for each DER the delivered Contracted Service Capacity for the first and last minute was far below that requested; this indicates the DERs were not dispatched in sufficient time to reach the Contracted Service Capacity for the start of the delivery period and maintained throughout of the delivery window.
- For all events, Option 2 of the settlement mechanism provided the partners with a higher reward (see Appendix D).
- The baselining results for Sandford Hydro (see Appendix E) show that at multiple points the DER was importing ~70kW of power. This could potentially indicate the maintenance work conducted during Service 1 (S1), during which the Archimedes' screws were switched on and off multiple times. However, similar patterns can be seen during the second event when no maintenance work was reported.

The key observations from the Analysis of the Declaration of Delivery Over Time are summarised below (see Appendix F):

- Generally, the partners found it difficult to accurately forecast the amount of flexibility that their DERs would be able to provide during the events ;
- LCH (Sandford Hydro), Nuvve (V2G chargers) and the UoO (Westgate Library) highlighted the need to refine their forecasting model;
- EDF Energy (domestic batteries);
  - has fully controllable DERs and flexibility is typically forecasted based on their power and energy ratings;
  - the flexibility requested was delivered in full during Service 1 and partially delivered during Service 2 and Service 3; and
  - consistently provided more than 73% of the contracted capacity throughout all Events.
- LCH (Sandford Hydro);
  - the average power output for a given month is estimated using historic river data and the power output recorded from previous technical MVSs;

    - the power output is highly dependent on the weather and the operation of the weirs upstream and the power output in the summer has historically been significantly lower than expected; and
    - the power output recorded during the Events was well above the month ahead, week ahead and day ahead forecast for all Events even though the flow was relatively low (less than 2 screws at full speed).
- LCH (Rose Hill battery);
    - the forecast flexibility is equal to the maximum power output of the battery;
    - the flexibility delivered was as forecast for each Event with the response measured at ~15.5kW.
- Nuvve (EV chargers);
    - determines the forecast flexibility of their DERs by assessing the driving patterns of their customer and the residual battery capacity at the end of their daily drives;
    - for all Events, the month ahead, week ahead and day ahead declarations forecasted a higher response than what was delivered during an Event;
    - EV chargers were newly installed and Nuvve was not confident about the driving behaviour of the customers at the site; and
    - during June, the driving profile of one of the drivers changed and one of the three cars will now be charged during the day and taken home in the evening, contrary to the expected profile of the site.
- UoO (Westgate Library);
    - determined the forecasted flexibility using two methods: (i) forecasting the electrical load as a function of external temperature and (ii) via a statistical model-based estimation;
    - for all Events, each of the month ahead, week ahead and day ahead declarations forecasted a higher response than what was delivered; and
    - the metering at this site did not provide an accurate baseline model so the forecasting may be more accurate than shown.

The following data issues were observed during Commercial MVS D4:

- The PPS2.0 DER scheduler used to dispatch the Rose Hill Battery operates in UTC (not BST). For each event it therefore appears that the Rose Hill Battery delivered the Flexibility Service between 1500-1600 (see Appendix E), an hour before the service window.
- For each event it appears that EDF Energy's domestic batteries delivered the Flexibility Service between 1700-1800 (see Appendix E), an hour after the service window. SSEN have assumed that this is due to an error with the time stamp (as above), however this has not been confirmed by EDF Energy at the time of this report.
- The sign of the metered data needs to identify whether the DER is importing (positive) or exporting (negative) when providing the Flexibility Service. This resulted in some errors when using the baselining model.
- Some of the data was uploaded to the Project LEO SharePoint site in the wrong format (e.g., scientific notation and different units were used among the three events). This had to be corrected before it could be used in the baselining tool.

The following Commercial Issues were observed during Commercial MVS D4:

- The FSA does not currently specify whether the data should be recorded in kW or kWh. However, the granularity of the collected data has been relaxed such that the partners may supply the data in 30 mins intervals. Collecting kW data at 30-minute intervals could introduce gaming or inaccuracy into the baseline, as the kW value may not be representative of what an DER has delivered if not collected much more frequently.
- During June, the driving habits of one of the Nuvve drivers changed. As stated above, one of the three cars will now be charged during the day and taken home in the evening. As charging needs to be balanced across the phases to stay in line with the G99 codes, this could reduce the amount of flexibility available from this site.

6 Key Learnings

The key learnings from the Summary of Initial and Final Questionnaire are provided below:

- All DERs should be tested and proven to deliver the flexibility offered to ensure the reliability of flexibility delivery.
- DER owners could consider buffering data locally to mitigate against a loss of comms which may affect the baseline.

The key learnings from the Analysis of Commercial Baselining and Settlement Results are provided below:

- DERs should be informed that they should be at the contracted flexibility level from the start of the delivery period through the delivery period until the end of the delivery period
- Flexibility providers should be informed they will not receive any payment for any energy provided outside of the scheduled flexibility window.
- Data can be provided at various intervals but should aggregate to 30 minutes of data within a settlement period to ensure the correct payment is provided;
    - data provided for capacity measurements should be provided in kW and at least one reading for each minute; and
    - data provided for energy measurements should be provided in kWh and can be at a variety of intervals (although not mixed), e.g. 30 x 1-minute interval data, 15 x 2-minute interval data, etc.
- Local metering can be used for a DER, but establishing a baseline requires the following data (from Flexibility Services Agreement, Schedule 5, paragraph 2);
    - data provided for capacity measurements should be provided in kW and at least one reading for each minute; and
    - within the last six weeks that contains at least ten previous weekdays (to evaluate an Event that is on a weekday); or
    - four previous weekend days (to evaluate an Event that is on a weekend).
- The baseline model for future Events should exclude any data from previous Events to avoid under reporting.

The key learnings from the Analysis of Declaration of Delivery Over Time are provided below:

- Batteries are suited to providing flexibility in the month ahead or week ahead markets as they can provide a reliable amount of flexibility (sometimes through pre-charging). This is true for both the EDF Energy and LCH batteries.
- Hydro generation is best suited to the day ahead market due to the variability of river / weir interactions which could make it difficult to reliably predict the level of flexibility available further ahead. This is true for the LCH hydro generation due to the close proximity of Environment Agency-operated weirs and the variable nature of the Thames; however, this may not be the case for other hydro generators if there has been long-term data collection with no changes to the generation model.
- V2G chargers may be suited to the month ahead or week ahead market but requires a reliable pattern of behaviour for drivers derived from long-term data capture and a larger number of DERs. This is true for the Nuvve V2G chargers and applies to other project in which they have been involved.
- DERs with low levels of flexibility that rely on weather forecast should consider restricting their focus to the day ahead market to avoid the risks associated with longer term markets (unless they have access to reliable weather forecasts for month and week ahead declarations).

The key learnings from the data observations from Commercial MVS D4 are provided below:

- A standard time stamp should be used by all DERs to reduce scope for errors and simplify the analysis during the trials.
- The data provided should correctly signify whether it was from a demand or generation source (this would also apply to the battery and EV charges).
- There should be a data template available to minimise errors, reduce administrative burden and speed up the data analysis.
- SSEN only require the data to be recorded to the nearest Watt (i.e., 0.001 for kW, 0.000001 for MW).

The key learnings from the commercial observations from Commercial MVS D4 are provided below:

- Power (kW) data should be accepted where the granularity of the data is 1 minute or less.
- Energy (kWh) data may be aggregated over the 30-minute settlement period from data collected at different time intervals.

7 Future Works

- TRANSITION to create a data upload template for flexibility providers. This template should provide guidance on its use, and address the data issues identified above to minimise the scope for errors during future events.

- TRANSITION to create a data import and analysis template for SSEN to speed up the analysis and allow multiple users to operate the baselining model.
- TRANSITION to reinforce the baselining methodologies to be used throughout the Trials and how they apply, e.g. without historic data the only solution is to provide day ahead nomination data.
- The FSA should be amended to stipulate when power (kW) and energy (kWh) may be submitted.[10]
- TRANSITION to consider how scheduling multiple flexibility events during a six-week period may affect the baselining model, i.e., a high number of flexibility Events may mean there is insufficient eligible days to perform a robust assessment of the baseline.
- TNEI, SSEN, or Origami to run 1-2-1 sessions with LEO partners during the Smoke Test to help them understand how to forecast using real data provided by them.
- LCH to consider the effects of turning the screws at Sandford Hydro on / off during the Trials.
- TRANSITION to engage with TNEI to develop the baselining tool so that it can convert negative numbers to positive numbers.
- The granularity of the PPS2.0 DER scheduler to be reduced from 15 to 1 minute to ensure there is no delay when starting the DER[11].
- Nuvve to consider the amount of flexibility available from the Oxford Office Furniture site ahead of the Trials.

[10] These changes were made to the 30-Jul version of FSA

[11] This change is already being explored by LCH

Appendix A: Commercial MVS D4 Template

Lead	SSEN	**MVS Identifier**	Comm 004	**Target Run Period**	15-Mar-21 to 15-Apr-21
Physical Service(s)	**Secure Peak Management**	**Sustain Constraint Management (Pre-Fault)**	**Dynamic Constraint Management (Post-Fault)**	Exceeding MIC/MEC	Offsetting

End to End process stage										
1	2	3	4	5	6	7	8	9	10	11
12	13	14	15	16	**17**	18	19	20	21	

Category	Baselining Methodology and Settlement (Penalty Assessment)
Description	Compare and contrast different baseline methodologies at portfolio, site and DER level.

How the MVS will be delivered (incl. how data collected supports LEO)	• There are two precursors:
	  - A study conducted by TNEI to compare and contrast the different baselining methodologies; and
	  - The level of granularity for the DSO-procured Flexibility Services has been determined through MVS Comm 003;
	• Deliver all Flexibility Services multiple times using a variety of DERs with MPAN and/or local metering (where available);
	• Use the most appropriate baselining methodologies to determine the flexibility delivered;
	• Compare and contrast the level of flexibility delivered by each of the following methods:
	  - The baselining methodologies;
	  - The MPAN;
	  - Local metering (where available); and
	  - flexibility provider information; and
	• Collect data for further analysis.

Parties	**DERs**	**Permission Required?**
EDF Energy	Any relevant DERs (one of each type (if available))	Yes
Low Carbon Hub	Any relevant DERs (one of each type (if available))	Yes
Nuvve	Any relevant DERs (one of each type (if available))	Yes
Origami	Not involved	No
Oxford City Council	Not involved	No

Oxfordshire County Council	Not involved	No
Piclo	Not involved	No
SSEN	Not involved	No
University of Oxford	Any relevant DERs (one of each type (if available))	Yes
Platforms	Not applicable to this MVS	
What is varied?	• The type and capacity of the DERs; • The Flexibility Service to be delivered; • The type of baselining methodology used; • The method of verifying the delivery (MPAN, local metering); and • The location of the DER.	
How will MVS be evaluated (incl. data upload)	• Analysis of the data collected and whether the baselining methodology was appropriate for the scenario ; and • Data collected will be made available for further analysis by LEO partners.	
Delivery Programme	• 29-Jan-21 – Charlie Edwards to provide Origami with the study to compare and contrast the different baselining methodologies; • 15-Feb-21 – SSEN and Origami to agree: Flexibility Services to be delivered, Flexibility Service parameters, expected granularity of data collection and the appropriate baselining methodologies to be used; • 15-Feb-21 – Origami, SSEN, EDF Energy, Low Carbon Hub, Nuvve and the University of Oxford to agree scope and timing for MVS; • 15-Feb-21 to 15-Mar-21 – Origami leads the development of a plan for this MVS; • 15-Mar-21 to 30-Mar-21 - partners conduct the MVS and provide the relevant data to Origami/SSEN; • 30-Mar-21 to 15-Apr-21 – Origami/SSEN compare and contrast the baselining methodology against the monitored output; • 15-Apr-21 – target completion date for the MVS • 22-Apr-21 – draft report on MVS available for review by all involved parties; • 29-Apr-21 – submit final MVS report to MVS working group together with all relevant data; and • Early May- SSEN to consider findings of final MVS report and how this applies DSO-procured Flexibility Services.	
Potential Risks	• Commercial: None • Financial: None • Technical: None • Delivery: None • Reputational: None	
Opportunity for Learning	Determine the optimum baselining methodology to validate the delivery of each DSO-procured Flexibility Service.	
MVS Questions addressed	**Q1.L2.A4** • what is the acceptable level of tolerance from timing and magnitude (power and energy) requirements of the Flexibility Service?	

	• what is the effect of metering accuracy on Flexibility Service delivery? **Q4.L2.A5** • what market requirements could affect fair market access and is there an alternative means to address? **Q5.L2.A3** • what are the barriers to increasing the existing level of flexibility? **Q6** • to be considered once level 3 populated
Other Comments	None
Summary of MVS Outcome	To be completed once the MVS report is substantially complete.

Appendix B: Data Upload Instructions

Naming Conventions for all DERs

Company Name	DER	Service 1 Descriptor	Service 2 Descriptor	Service 3 Descriptor	Service 4Descriptor
EDF	3 x Batteries	MVSD4.4.1	MVSD4.4.2	MVSD4.4.3	n/a
LCH	Rose Hill Battery	MVSD4.2.1	MVSD4.2.2	MVSD4.2.3	n/a
LCH	Sandford Hydro	MVSD4.1.1	MVSD4.1.2	MVSD4.1.3	n/a
Nuvve	3 x V2G Chargers	MVSD4.5.1	MVSD4.5.2	MVSD4.5.3	n/a
UoO	Westgate Library	MVSD4.3.1	MVSD4.3.2[12]	MVSD4.3.3	MVSD4.3.4

Use-case instructions for all DERs

These instructions were used by all the partners to upload their data on to the Project LEO Data Log, however the naming convention for Sandford Hydro has been used to provide an example.

Step	Date	Action
1	10-May	Initial Questionnaire • Fill in Initial Questionnaire for Flexibility Service delivery • Open the LEO Data Sharing Log. Switch account to: projectleodatashare@gmail.com (as per instructions) • After entering email proceed to next page, select "MVS data" and scroll to bottom to proceed (you can ignore everything else on that page). • Enter the MVS name as **MVSD4.1.1** • Skip to procedure "**Procedure 4 – Company Assessment**" • Follow instructions to fill out appropriate fields, using N/A where necessary. • Upload Initial Questionnaire document as "Data Upload"
2	11-May	Declaration of Delivery – month ahead - Flexibility Service 1 • Fill in declaration of delivery for month ahead availability. • Open the LEO Data Sharing Log. Switch account to: projectleodatashare@gmail.com (as per instructions) • After entering email proceed to next page, select "MVS data" and scroll to bottom to proceed (you can ignore everything else on that page). • Enter the MVS name as **MVSD4.1.1** • Skip to procedure "**Procedure 11 – Availability**" • Follow instructions to fill out appropriate fields, using N/A where necessary. • Upload Declaration of Delivery document as "Data Upload"
3 4	19-May 27-May	Repeat step 2 "Declaration of Delivery" for month ahead availability for Flexibility Service 2 and 3. Use MVSD4.1.2 for Flexibility Service 2 and "Procedure 11 – Availability" Use MVSD4.1.3 for Flexibility Service 3 and "Procedure 11 – Availability"

[12] The UoO did not participate in flexibility event 2 (S2). A month ahead Declaration of Delivery was submitted to declare the DER unavailable. No other data was collected for this flexibility event.

Step	Date	Action
5, 6	01-Jun 07-Jun	Repeat step 2 "Declaration of Delivery" for week and day ahead availability for Flexibility Service 1. Use MVSD4.1.1 and "Procedure 11 – Availability"
7	08-Jun	Deliver Flexibility Service 1
8	09-Jun	Upload Monitoring Data – Flexibility Service 1 • Obtain meter data through internal process for 10 previous days + flexibility flexibility event day as a csv document with two columns with the following headings: **datetime**; **energy (kWh)**. • Open the LEO Data Sharing Log. Switch account to: projectleodatashare@gmail.com (as per instructions) • After entering email proceed to next page, select "MVS data" and scroll to bottom to proceed (you can ignore everything else on that page). • Enter the MVS name as **MVSD4.1.1** • Skip to procedure "**Procedure 15 – Monitoring**" • Follow instructions to fill out appropriate fields, using N/A where necessary. • Upload Declaration of Delivery document as "Data Upload"
9, 10	09-Jun 15-Jun	Repeat step 2 "Declaration of Delivery" for week and day ahead availability for Flexibility Service 2. Use MVSD4.1.2 and "Procedure 11 – Availability"
11	16-Jun	Deliver Flexibility Service 2
12	17-Jun	Repeat step 8 "Upload Monitoring Data" for Flexibility Service 2. Use MVSD4.1.2 and "Procedure 15 – Monitoring"
13, 14	17-Jun 23-Jun	Repeat step 2 "Declaration of Delivery" for week and day ahead availability for Flexibility Service 3. Use MVSD4.1.3 and "Procedure 11 – Availability"
15	24-Jun	Deliver Flexibility Service 3
16	25-Jun	Repeat step 8 "Upload Monitoring Data" for Flexibility Service 3. Use MVSD4.1.3 and "Procedure 15 – Monitoring"
17	25-Jun	Final Questionnaire • Fill in Final Questionnaire • Open the LEO Data Sharing Log. Switch account to: projectleodatashare@gmail.com (as per instructions) • After entering email proceed to next page, select "MVS data" and scroll to bottom to proceed (you can ignore everything else on that page). • Enter the MVS name as **MVSD4.1.1** • Skip to procedure "**Procedure 19 – Ratings**" • Follow instructions to fill out appropriate fields, using N/A where necessary. • Upload Initial Questionnaire document as "Data Upload"

Appendix C: Summary of Initial and Final Questionnaire

<table>
<tr><th>Question</th><th colspan="4">Summary of Responses (summarised)</th></tr>
<tr><td colspan="5">1. General Information</td></tr>
<tr><td rowspan="7">1.1 Please provide the following details for your three scheduled flexibility events:</td><td>Partner</td><td>DER Name</td><td>DER Size</td><td>Services Info (see Section 3.1)</td></tr>
<tr><td>EDF</td><td>4 x Batteries</td><td>4*3.6kW (8kWh)</td><td>Took part in S1, S2 and S3</td></tr>
<tr><td>LCH</td><td>Rose Hill Battery</td><td>15 kW</td><td>Took part in S1, S2 and S3</td></tr>
<tr><td>LCH</td><td>Sandford Hydro</td><td>400 kW</td><td>Took part in S1, S2 and S3</td></tr>
<tr><td>Nuvve</td><td>3 x V2G Chargers</td><td>3*6kW (12kW?)</td><td>Took part in S1, S2 and S3</td></tr>
<tr><td>UoO</td><td>Westgate Library</td><td>140kW</td><td>Took part in S1, S3 and S4</td></tr>
<tr><td colspan="4">Additional comments
The capacity of the 3 x V2G Nuvve chargers depends on their operation. The standard operation of a “dumb” charger would be to plug in and start charging, therefore the available capacity is +6kW, if they are discharged then it would be 12kW (since its pushing back).
Westgate Library uses Load reduction (turn down) flexibility for the three trials. Delivery of flexibility during a flexibility event was subject to the HVAC system operating in cooling mode on the planned time slots.</td></tr>
<tr><td colspan="5">2. Forecast Flexibility</td></tr>
<tr><td rowspan="2">2.1 What is your methodology to determine your forecasted flexibility?</td><td colspan="2">EDF</td><td colspan="2">LCH</td></tr>
<tr><td colspan="2">The battery units are fully controllable and therefore their flexibility is typically forecasted based on their power and energy ratings.</td><td colspan="2">For Rose Hill Battery, amount of forecasted flexibility is equal to the maximum power output of the battery.
For Sandford Hydro, we can estimate the average power output for a given month based on historical river data. We can then compare that power to the conditions experienced for previous MVSs and scale the expected flexibility accordingly.</td></tr>
</table>

<table>
<tr><th>Question</th><th colspan="4">Summary of Responses (summarised)</th></tr>
<tr><td></td><td colspan="2">Nuvve</td><td colspan="2">UoO</td></tr>
<tr><td></td><td colspan="2">• Driving patterns of the customer and residual battery capacity at the end of their daily drives.</td><td colspan="2">• Forecasts are based on two methodologies:
1. Chiller electrical load as a function of external temperature. This correlation curve is estimated by regression on building electricity use vs. cooling degree days.
2. Statistical model based estimation. A thermal dynamics model for the main library hall was identified on temperature data acquired from the BMS. The model is then used to compute the building thermal energy demand for a set of external temperature samples relative to the years 2000-2020.</td></tr>
<tr><td rowspan="7">2.2 How confident are you that the forecasted flexibility will be delivered (please select)[13]?</td><td>DER</td><td>Not Very Confident</td><td>Confident</td><td>Very Confident</td></tr>
<tr><td>4 x EDF Batteries</td><td></td><td>X</td><td></td></tr>
<tr><td>Rose Hill Battery</td><td></td><td></td><td>X</td></tr>
<tr><td>Sandford Hydro</td><td>X</td><td></td><td></td></tr>
<tr><td>3 x V2G Chargers</td><td></td><td>X</td><td></td></tr>
<tr><td>Westgate Library</td><td>X</td><td></td><td></td></tr>
<tr><td colspan="4">Additional comments
• The power output of the hydro is very weather dependent. Since the hydro has been commissioned the power output of the hydro in the summer has been significantly lower than expected given historical river data.</td></tr>
</table>

[13] This question captures the partners confidence in their forecast a month ahead of Service 1 (S1),

<table>
<tr><th>Question</th><th colspan="4">Summary of Responses (summarised)</th></tr>
<tr><td></td><td colspan="4">• Asset baseline profile of the Westgate Library is strongly dependent on weather conditions and the delivery of flexibility (turn down) provision is subject to the chiller unit being operational at the time. Note: the latter is not operated continuously during the season. Forecasted flexibility will be based on 50th percentile of estimates from historic data.</td></tr>
<tr><td rowspan="7">2.3 How would you define your attitude to risk in relation to your declaration of availability to deliver Flexibility Services?[14]</td><td>DER</td><td>High Risk</td><td>Medium Risk</td><td>Low Risk</td></tr>
<tr><td>4 x EDF Batteries</td><td></td><td></td><td>X</td></tr>
<tr><td>Rose Hill Battery</td><td>X</td><td></td><td></td></tr>
<tr><td>Sandford Hydro</td><td></td><td></td><td>X</td></tr>
<tr><td>3 x V2G Chargers</td><td></td><td>X</td><td></td></tr>
<tr><td>Westgate Library</td><td></td><td>X</td><td></td></tr>
<tr><td colspan="4">Additional comments
• With the Rose Hill battery 100% LEO funded it currently has no business model, so LCH are happy to take greater risks with declaring flexibility.
• For Sandford Hydro, the priority is maximising revenue and returns for investors.
• Forecasted flexibility for the Westgate Library will be based on 50th percentile of estimates from historic data.</td></tr>
<tr><td rowspan="3">2.4 Were there any unforeseen circumstances (e.g. unplanned maintenance or adverse weather conditions) which effected your delivery during the flexibility events?</td><td>DER</td><td>S1</td><td>S2</td><td>S3</td></tr>
<tr><td>4 x EDF Batteries</td><td>n/a</td><td>n/a</td><td>n/a</td></tr>
<tr><td>Rose Hill Battery</td><td>n/a</td><td>• Communication was lost with Rose Hill Battery a couple of days before Service 2. Comms was restored on the morning of 16th June, so the delivery</td><td>n/a</td></tr>
</table>

[14] This question captures the partners attitude to risk a month ahead of Service 1 (S1)

Question	Summary of Responses (summarised)			
When did this become an issue and at what point did you become aware of this?			went ahead, but the data for the period during the comms blackout was lost.	
	Sandford Hydro	• There was site maintenance taking place during Service 1 at Sandford Hydro that meant that on the day of delivery prior to the delivery period screws were often turned on and off as and when work required. This may have impacted on the baselining but did not affect delivery.	n/a	n/a
	3 x V2G Chargers	• Chargers were relatively newly installed, so we were not as clear on the customers driving behaviour. During the month they also shifted the usage of the vehicles making forecasting difficult.		
	Westgate Library	• Delivery during Service 1 was reduced (relative to nominated baseline) due to wrong system setup.	• The DER was declared not available for Service 2 due to resourcing issues.	• The cooling system was on maintenance and the DER was declared not available.

Question	Summary of Responses (summarised)			
		The chiller (flexible load) was only serving the demand coming from a part of the building (one out of five air handling units). • We became aware of this at the start of the flexibility period. • We amended this by running an additional trial on the following day (June 9), for which data was also provided.	• This event was rescheduled as Service 4, on June 30. On this event, flexibility was reduced to zero due to weather too cold to allow the delivery of cooling-based flexibility service. • This was specified on the day-ahead declaration.	• Maintenance on the DER began on June 14 and ended on June 28. • However, maintenance end-date was still unknown at the time of submitting the week-ahead declaration, so unavailability of DER was only declared on the day-ahead form.
2.5 Please provide any details if your forecasting methodology changed as a result of this MVS?	**DER**	**Reason**		
	4 x EDF Batteries	• Not particularly, however there are various aspects on the Baselining methodology (derived from the forecasting methodology) that should be discussed and potentially taken into consideration.		
	Rose Hill Battery	• N/A		
	Sandford Hydro	• These events gave us a better understanding of the capabilities of the hydro, particularly under relatively low flows. A more advanced analytical model is required to predict the flex capacity with any certainty.		

<table>
<tr><th>Question</th><th colspan="4">Summary of Responses (summarised)</th></tr>
<tr><td></td><td>3 x V2G Chargers</td><td colspan="3">• Highlighted the need to refine our method with new customers and small aggregations, specifically at times that are during a change in the customers behaviour.</td></tr>
<tr><td></td><td>Westgate Library</td><td colspan="3">• Two methodologies were used for these events: month ahead forecast was based on historical data analysis, whereas weather forecasts were utilised for both week- and day-ahead declarations.
• The methodology was not changed across the events. However, this turned out to be an important opportunity to know the challenges related to achieving reliable data for mid- to short-term flexibility forecast, in the case of weather-dependent flexibility. Future work will address the refinement of the forecasting methodology.</td></tr>
<tr><td colspan="5">3. Preferred Market</td></tr>
<tr><td rowspan="7">3.1. Please highlight which (if any) is your preferred market?[15]</td><td>DER</td><td>Month Ahead</td><td>Week Ahead</td><td>Day Ahead</td></tr>
<tr><td>4 x EDF Batteries</td><td></td><td>X (Initial Questionnaire)</td><td>X (Final Questionnaire)</td></tr>
<tr><td>Rose Hill Battery</td><td>X</td><td></td><td></td></tr>
<tr><td>Sandford Hydro</td><td></td><td></td><td>X</td></tr>
<tr><td>3 x V2G Chargers</td><td></td><td></td><td>X</td></tr>
<tr><td>Westgate Library</td><td></td><td></td><td>X</td></tr>
<tr><td colspan="4">• The preferred marked for the 4 x EDF Batteries changed from Week Ahead to Day Ahead as a result of Commercial MVS D4</td></tr>
<tr><td></td><td>DER</td><td colspan="3">Reason</td></tr>
</table>

[15] This question was asked in both the Initial and Final Questionnaire to highlight if the partners preference had changed as a result of participating in Commercial MVS D4. For each DER, the name of the questionnaire in which the preference was stated is shown where a preference has changed.

Question	Summary of Responses (summarised)	
3.2. Please indicate why this is your preferred market?	4 x EDF Batteries	• In the Initial Questionnaire, EDF responded that their preferred market would be the week ahead as it offered lower risk with regards to opportunity cost (when participating in other markets / Flexibility Services). • On reflection, in the Final Questionnaire EDF responded that it was easier to forecast availability / flexibility levels at the day ahead stage.
	Rose Hill Battery	• There is high confidence that Rose Hill battery will be able to deliver the desired amount of flexibility so can participate in long-term markets.
	Sandford Hydro	• Given that the hydro's ability to provide flexibility is so dependent on the river conditions, day ahead is the most preferable. We have seen that the river conditions can change dramatically in just a few hours, so the closer to the day/time of delivery, the higher the confidence of a successful delivery.
	3 x V2G Chargers	• Day ahead to start, have better viability closer to the date.
	Westgate Library	• Certainty of delivery increases with updated short-term weather forecast and building use. Weather observations could be used in combination with historical data to improve reliability on short term markets.
	Additional comments • Nuvve will have more confidence in longer markets once a larger aggregation and more historical data on availability is available. • The UoO made the following observations in the Final Questionnaire: – The flexibility service of thermostatically controlled buildings is heavily affected by weather conditions. For this reason, reliable flexibility forecasts can only be provided in the short-term.	

<table>
<tr><th>Question</th><th>Summary of Responses (summarised)</th></tr>
<tr><td></td><td>– For week- and month-ahead forecasting, we are working on refined probabilistic prediction methods that are compatible with the proposed market mechanism.
– The reliability of the submitted flexibility forecasts will depend on that of the available weather forecasts.</td></tr>
<tr><td colspan="2">4. Preferred Settlement Mechanism</td></tr>
<tr><td>4.1. As shown in Section 3.5, there are two possible settlement mechanisms available. Please highlight which settlement mechanism you would prefer?</td><td>
<table>
<tr><th>DER</th><th>Option 1</th><th>Option 2</th></tr>
<tr><td>4 x EDF Batteries</td><td>X (Initial Questionnaire)</td><td>X (Final Questionnaire)</td></tr>
<tr><td>Rose Hill Battery</td><td>X</td><td></td></tr>
<tr><td>Sandford Hydro</td><td></td><td>X</td></tr>
<tr><td>3 x V2G Chargers</td><td>X (Final Questionnaire)</td><td>X (Initial Questionnaire)</td></tr>
<tr><td>Westgate Library</td><td>X (Initial Questionnaire)</td><td>X (Final Questionnaire)</td></tr>
</table>
• The preferred settlement mechanism for the 4 x EDF batteries changed as a result of Commercial MVS D4.
• The preferred settlement mechanism for the 3 x V2G chargers changed as a result of Commercial MVS D4.
• The preferred settlement mechanism for Westgate Library changed as a result of Commercial MVS D4.
</td></tr>
<tr><td>4.2. Please indicate why you have selected the above as your preferred settlement mechanism?</td><td>
<table>
<tr><th>DER</th><th>Reason</th></tr>
<tr><td>4 x EDF Batteries</td><td>• In the Initial Questionnaire, EDF preferred Option 1 as it was seen as a more straightforward / easier settlement mechanism to validate the percentage of payment received and provides a more tolerant non-delivery for full payment (i.e. 90%, compared to 95% on Option 2).
• On reflection, in the Final Questionnaire EDF responded that Option 2 seems to be a fairer method to determine ratio of energy delivered / forecasted.</td></tr>
</table>
</td></tr>
</table>

Question	Summary of Responses (summarised)	
	Rose Hill Battery	Rose Hill Battery: There is high confidence that the battery can deliver a given amount of flexibility, so there is little difference between the two options.
	Sandford Hydro	• Sandford Hydro: There is a relatively high likelihood that the hydro will not be able to deliver the full amount of flexibility, depending on the conditions. Option 2 provides higher returns for the DER if it falls short by approximately 30% or less.
	3 x V2G Chargers	• I am very curious to see how these different options work in reality, I like the idea of a choice and evaluating different settlement methods. This option was chosen based of a hedge of what we think gives the greatest potential for the highest rev based on drivers' profiles and available battery capacity for V2G. • No clarification was provided as to why the preferred settlement mechanism for the 3 x V2G chargers changed as a result of Commercial MVS D4.
	Westgate Library	• In the Initial Questionnaire, UoO preferred Option 1 due to a medium risk approach in forecasted capacity, in the event we underdeliver, the under delivery will be a larger percentage of forecasted delivery than if we had taken a riskier approach to forecasted capacity. The blue line is more beneficial for higher under delivery percentages in the range 50-75%. • On reflection, in the Final Questionnaire UoO responded that numerical simulations have shown that there is no significant difference between either option for our DER. Moreover, Option 2 showed more convenient analytical properties (e.g., smoother expected reward curve), which facilitated the numerical procedures we used to produce the bid values.
5. Learnings		
	DER	**Learning**

Question	Summary of Responses (summarised)	
5.1. Please indicate any learnings you gained from participating in this MVS?	4 x EDF Batteries	• Difficulty with forecasting as well as unfairness associated with method to calculate baselining methodology.
	Rose Hill Battery	• n/a
	Sandford Hydro	• Even at day ahead, it is not necessarily easy to predict what the hydro's power output will be in the future. In particularly dry spells the river flows can decrease quite rapidly, leading to a substantial drop in power output over a single day. There is also the effect of the weirs upstream to consider as in previous MVSs this has been shown to have had an impact on the power output of the plant that has lasted several hours. • Despite the variability, the power output increase gained in conditions where the flow was relatively low (less than 2 screws at full speed) was higher than expected, well above the predicted 20 or 30 kW declared in the day ahead declaration.
	3 x V2G Chargers	• Forecasting the availability with a small aggregation is very difficult, especially at the hours called. Ex: we would have better accuracy for mid-day or middle of the night since most vehicles were returning or departing during the hour of the event.
	Westgate Library	• Organizational aspects: DER energy management not tailored for the provision of flexibility (flexible operation requires a different level of attention to system parameters than standard permanent setpoint-based operation), and possibly not technologically equipped (hardware/software, connectivity, etc.) • First time delivering flexibility can require substantially more debugging than initially expected • Weather-dependent uncertainty on delivery (and availability) • Difficult (potentially costly) to source reliable weather forecasts for month- and week-ahead declaration

Appendix D: Analysis of Commercial Baselining and Settlement Results

The baseline result states whether the asset has fully / partially / minorly / not delivered the contracted flexibility. SSEN analysed the test window (1601 - 1700) for each half-hour settlement period (1601-1630 & 1630-1700). For each settlement period, the number in the bracket shows how much flexibility is delivered as a percentage of the contracted capacity, and the exact amount delivered.

Taking Sandford Hydro as an example, the contracted capacity for Service 1 was 20kWh at the month ahead stage, so 10 kWh is to be delivered every half hour. During the first half hour, Sandford Hydro delivered total 34.6kWh which is 346% of the contracted half hour capacity (10kWh). During the second half hour, Sandford Hydro delivered 29kWh which is 290% of the contracted 10kWh.

Asset Name	Asset Owner	Number	Contracted Capacity		Baselining (first half hour; second half hour)	Settlement
Sandford Hydro	LCH	MVSD4.1.1	month ahead;	20kW	Fully delivered (346%, 34.6kWh; 290%, 29kWh)[16]	Option 1: £6
						Option 2: £6
			week & day ahead	30kW	Fully delivered (230%, 34.6kWh; 193%, 29kWh)	**Option 1: £9[17]**
						Option 2: £9
		MVSD4.1.2	20kW for all events		Fully delivered (337%, 34kWh; 296%, 29kWh)	**Option 1: £6**
						Option 2: £6
		MVSD4.1.3	month & week ahead	20kW	Fully delivered (188%, 19kWh; 242%, 24kWh)	Option 1: £6
						Option 2: £6
			day ahead	30kW	Fully delivered (125%, 19kWh; 161%, 24kWh)	**Option 1: £9**
						Option 2: £9
Rose Hill Battery	LCH	MVSD4.2.1	15kW for all events		Fully delivered (104%, 7.8kWh; 101%, 7.6kWh)	**Option 1: £4.5**
						Option 2: £4.5

[16] Result show the percentage delivery compared to the contracted capacity during settlement period 33 (1600 to 1630) and settlement period 34 (1630 to 1700)

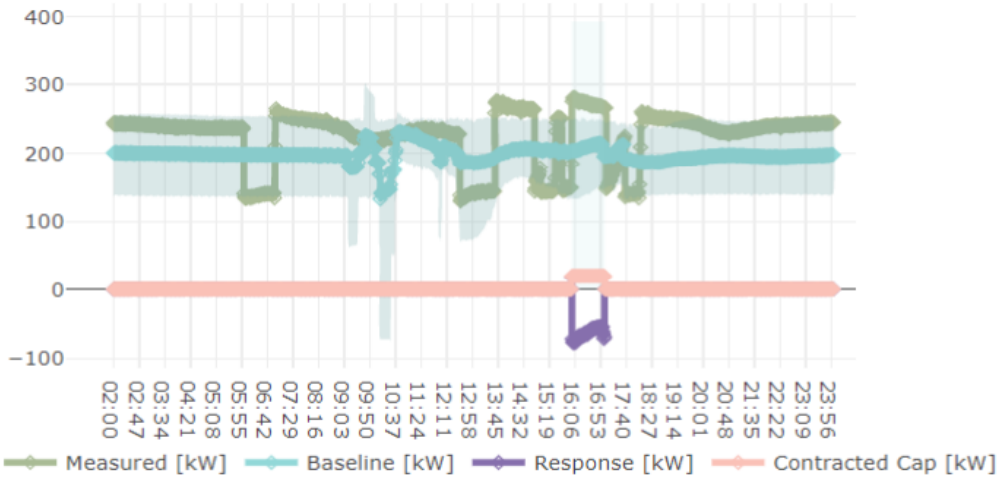
[17] The highlighted cells indicate the payment rewarded to each partner for each event. Both options are highlighted if option 1 and 2 offers the same amount.

Asset Name	Asset Owner	Number	Contracted Capacity		Baselining (first half hour; second half hour)	Settlement
		MVSD4.2.2	15kW for all events		Fully delivered (104%, 7.8kWh; 101%, 7.6kWh)	**Option 1: £4.5** **Option 2: £4.5**
		MVSD4.2.3	15kW for all events		Fully delivered (104%, 7.8kWh; 101%, 7.6kWh)	**Option 1: £4.5** **Option 2: £4.5**
Westgate Library	UoO	MVSD4.3.1	month ahead	14.75kW	Minor delivered (0%, 0.03kWh; 4%, 0.3kWh)	£0
			week ahead	6.68kW	Minor delivered (1%, 0.03kWh; 9%, 0.3kWh)	Option 1: £0 **Option 2: £0**
			day ahead	20.05kW	Minor delivered (0%, 0.03kWh; 3%, 0.3kWh)	£0
		MVSD4.3.2	Not participate in.			
		MVSD4.3.3	month ahead	27kW	Minor delivered (5%, 0.65kWh; 5%, 0.65kWh)	Option 1: £0 **Option 2: £0**
			week ahead	27kW	Minor delivered (5%, 0.65kWh; 5%, 0.65kWh)	£0
			day ahead	N/A	N/A	£0
		MVSD4.3.4	month ahead	24.85kW	No flexibility delivered.	£0
			week ahead	24kW	No flexibility delivered. (-0.5%, -0.068kWh; 1%, 0.178kWh)	Option 1: £0 **Option 2: £0**
			day ahead	0	0	£0
4x 8kWh battery energy storage	EDF	MVSD4.4.1	14.4 kW for all events		Fully delivered (101%, 7.254kWh; 98%, 7.09kWh)	**Option 1: £4.32** **Option 2: £4.32**
		MVSD4.4.2	14.4 kW for all events		Partly delivered (76%, 5.5kWh; 76%, 5.5kWh)	Option 1: £2.16 **Option 2: £2.74**
		MVSD4.4.3	14.4 kW for all events		Partly delivered (96%, 6.9kWh; 74%, 5.3kWh)	Option 1: £3.24 **Option 2: £3.42**

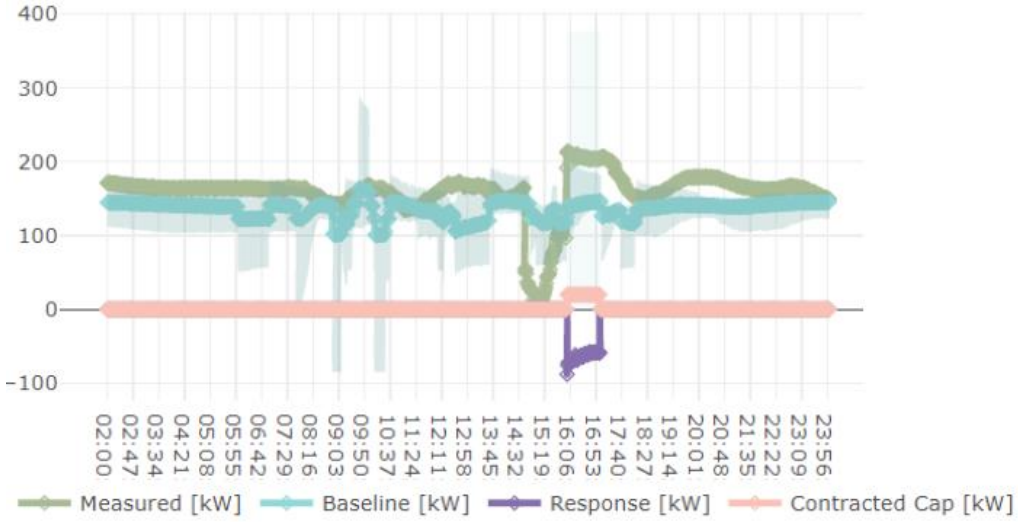
Asset Name	Asset Owner	Number	Contracted Capacity		Baselining (first half hour; second half hour)	Settlement
3 x V2G Chargers	Nuvve	MVSD4.5.1	week ahead	30kWh	Minor delivered (11.3%, 1.695kWh; 14.3%, 2.142kWh)	Option 1: £0 Option 2: £0
			day ahead	10kWh	Minor delivered (33.9%, 1.695kWh; 42.8%, 2.142kWh)	Option 1: £0 **Option 2: £0**
		MVSD4.5.2	week ahead	15kWh	Partly delivered (26.1%, 1.955kWh; 77.4%, 5.802kWh)	Option 1: £1.13 **Option 2: £1.5**
			day ahead	10kWh	Partly delivered (39.1%, 1.955kWh; 116.0%, 5.802kWh)	**Option 1: £1.5** **Option 2: £1.5**
		MVSD4.5.3	week ahead	30kWh	Minor delivered (-10%, -1.5kWh; 4.6%, 0.69kWh)	Option 1: £0 **Option 2: £0**
			day ahead	0kWh	0	0

Appendix E: Baselining Results Graphs

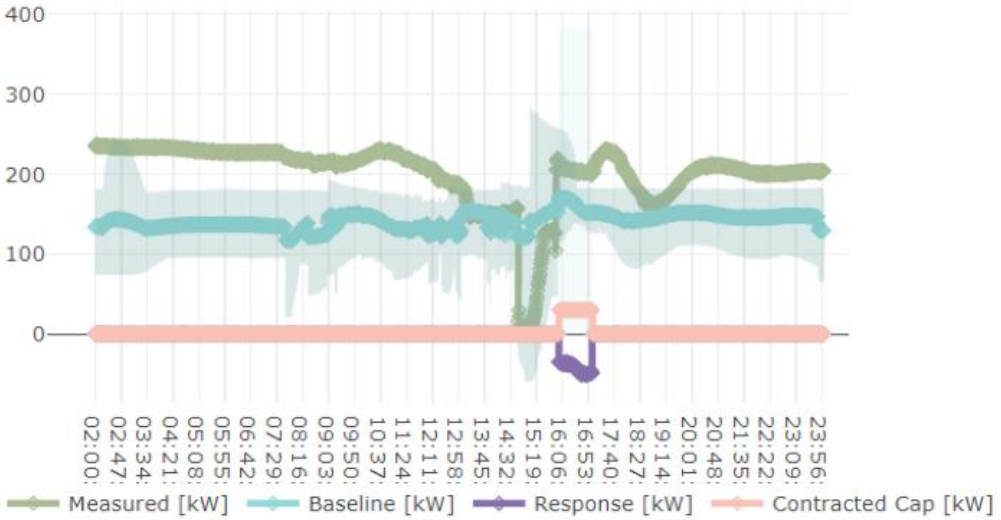
Sandford Hydro: MVSD4.1.1 – 20kW



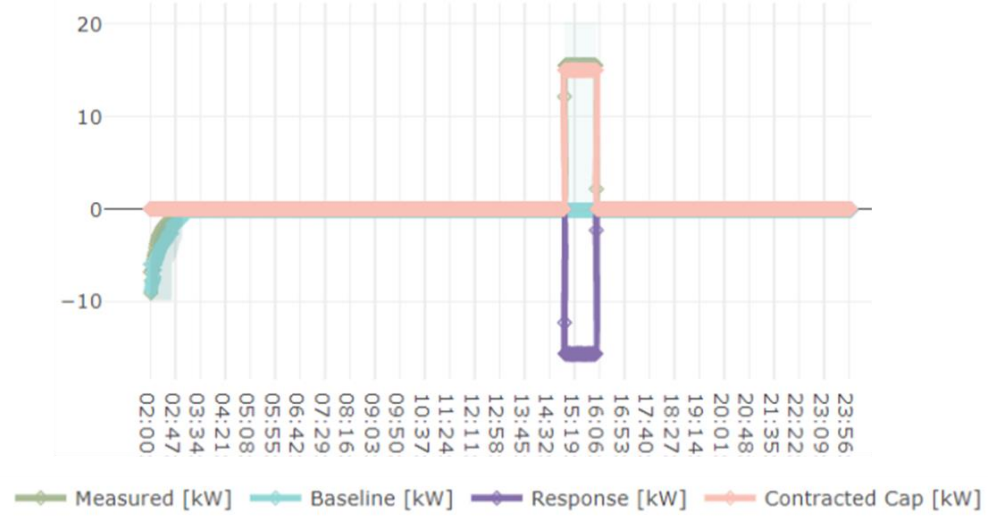
Sandford Hydro: MVSD4.1.2 – 20kW



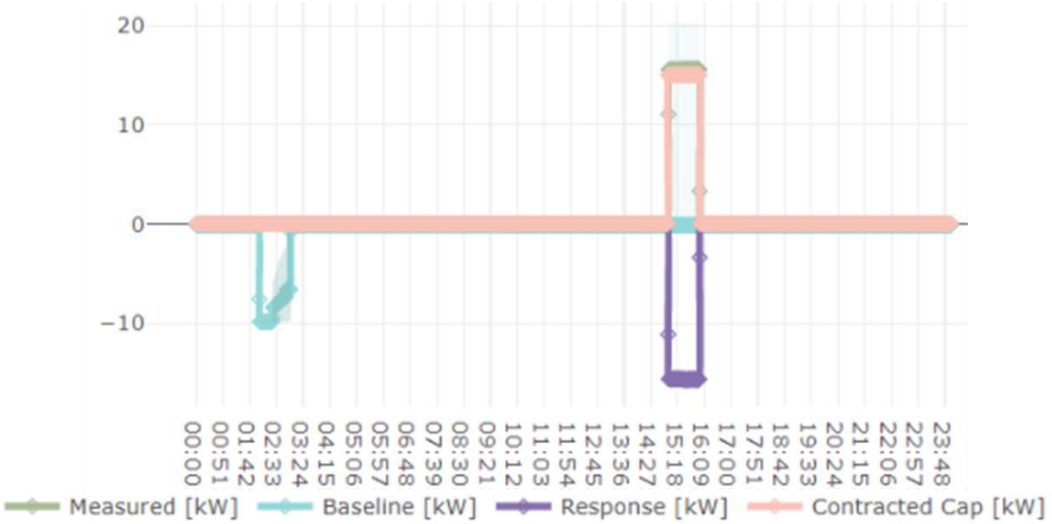
Sandford Hydro: MVSD4.1.3 – 30kW



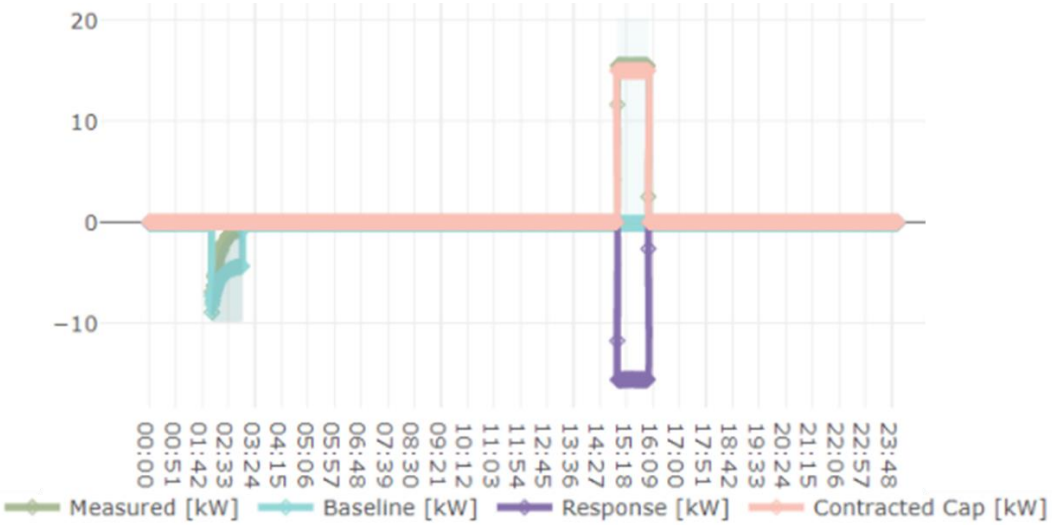
Rose Hill Battery: MVSD4.2.1 – 15kW



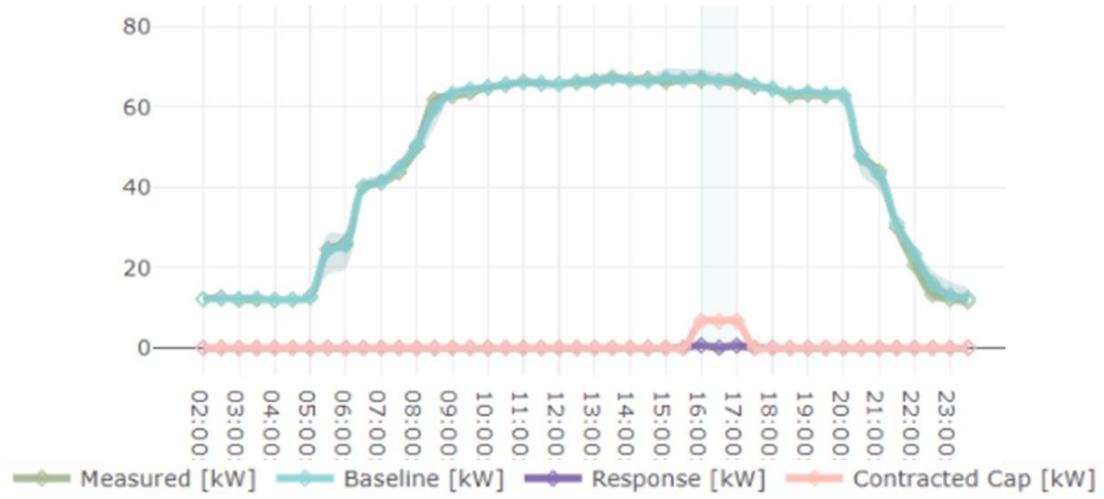
Rose Hill Battery: MVSD4.2.2 – 15kW



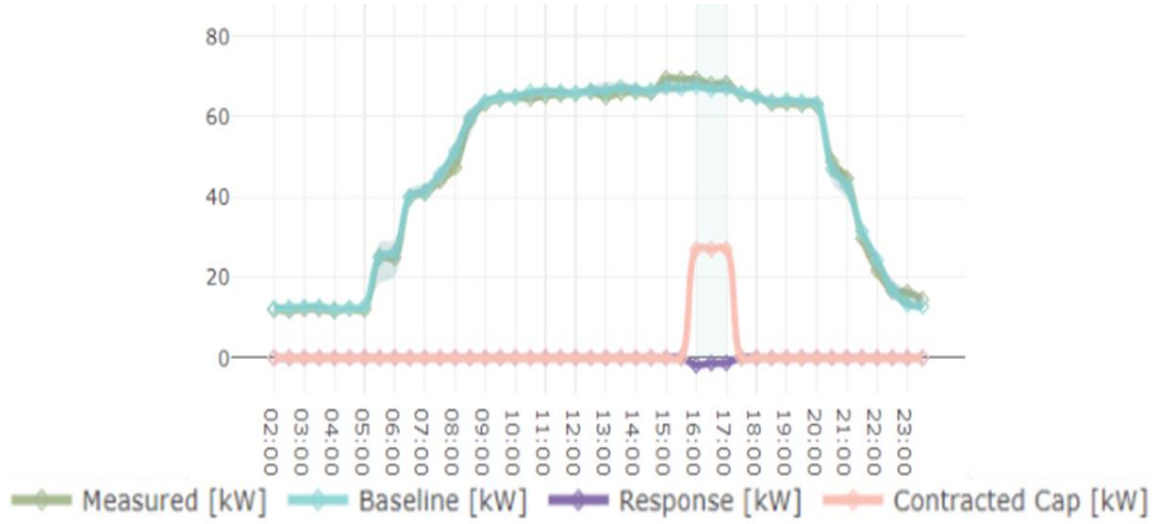
Rose Hill Battery: MVSD4.2.3 – 15kW



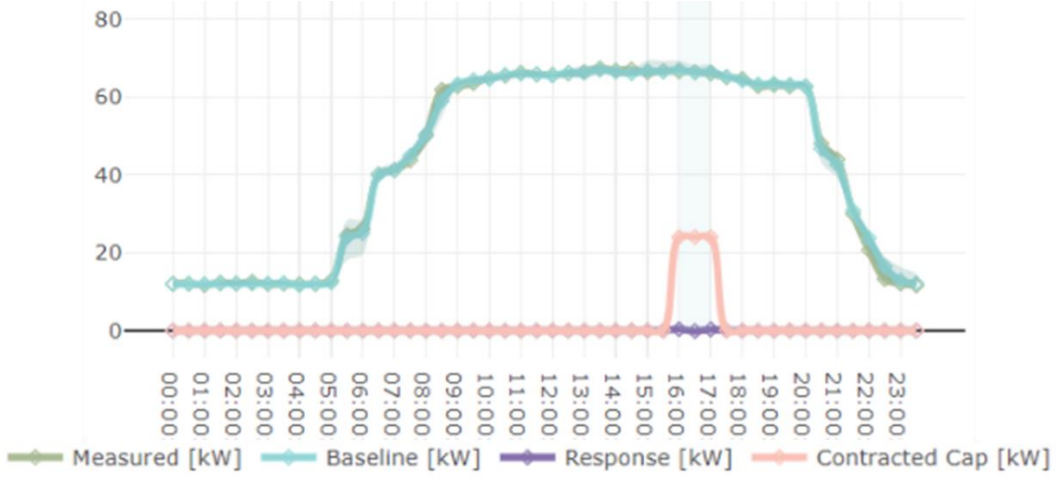
Westgate Library: MVSD4.3.1[18] (MPAN)) – 6.68kW



Westgate Library: MVSD4.3.3 (MPAN) – 27kW

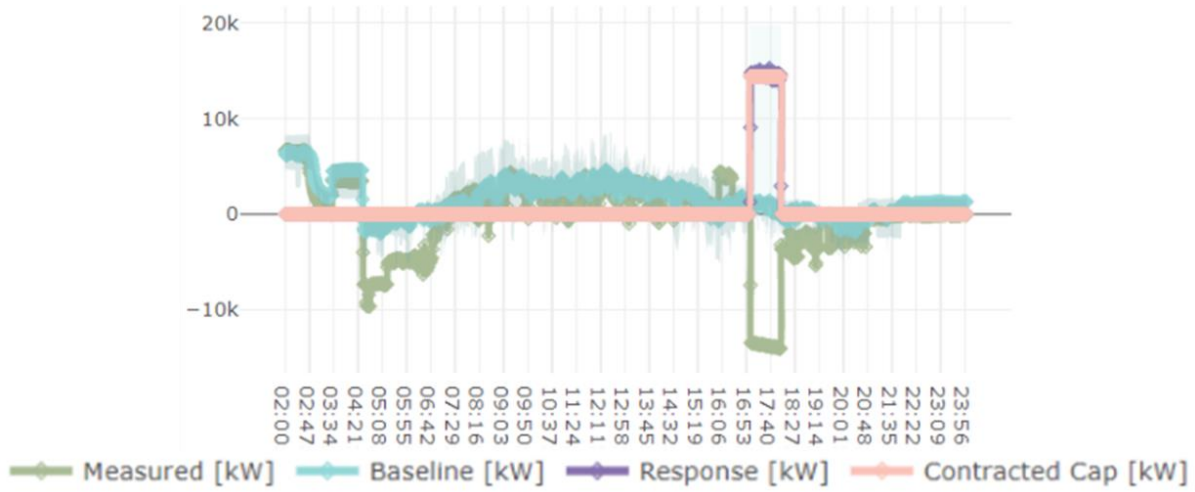


Westgate Library: MVSD4.3.4 (MPAN)– 24kW

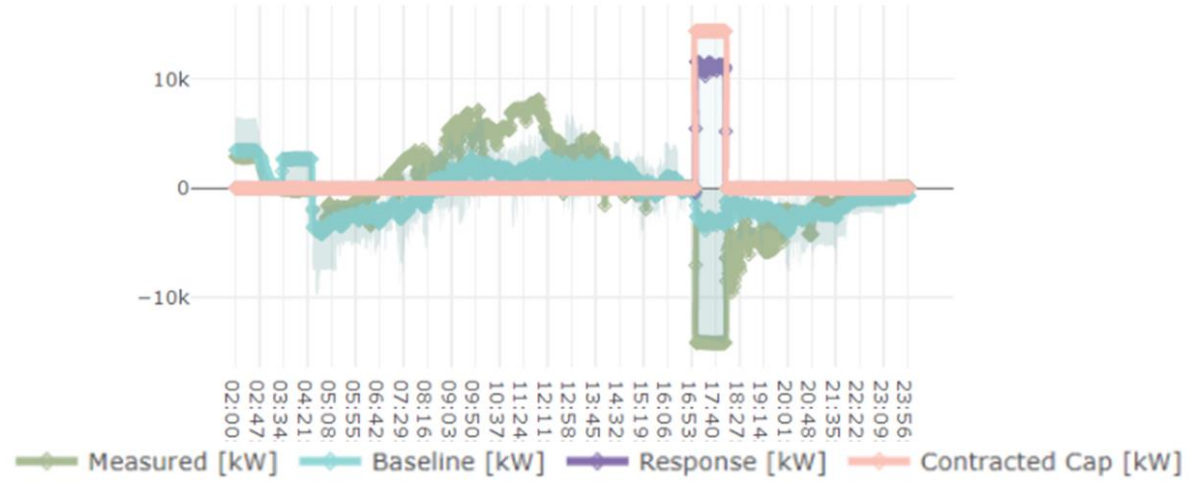


[18] Service 4.3.1 was scheduled for 08 Jun but delivered on 09 Jun, result is based on 09 Jun using MPAN data.

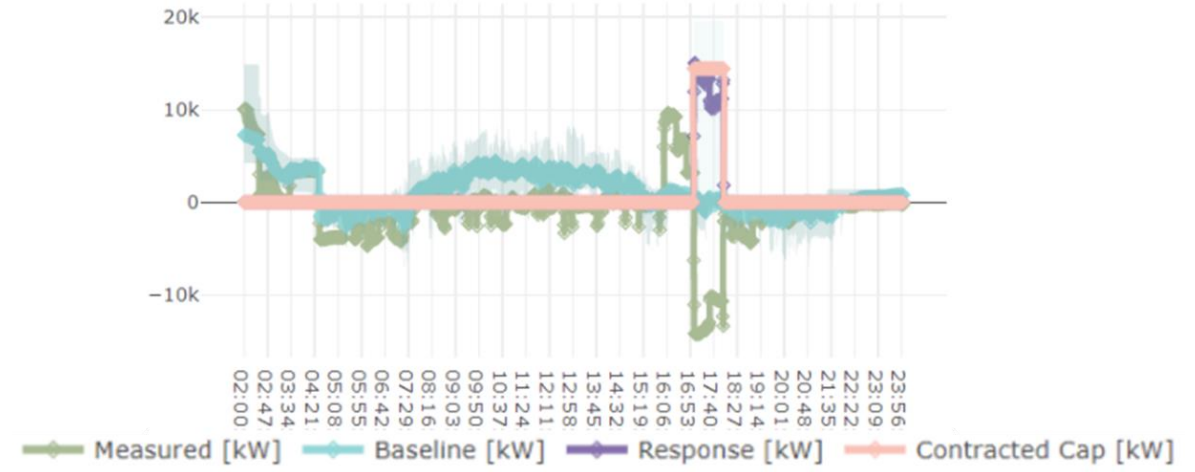
4 x EDF Battery: MVSD4.4.1 – 14.4kW



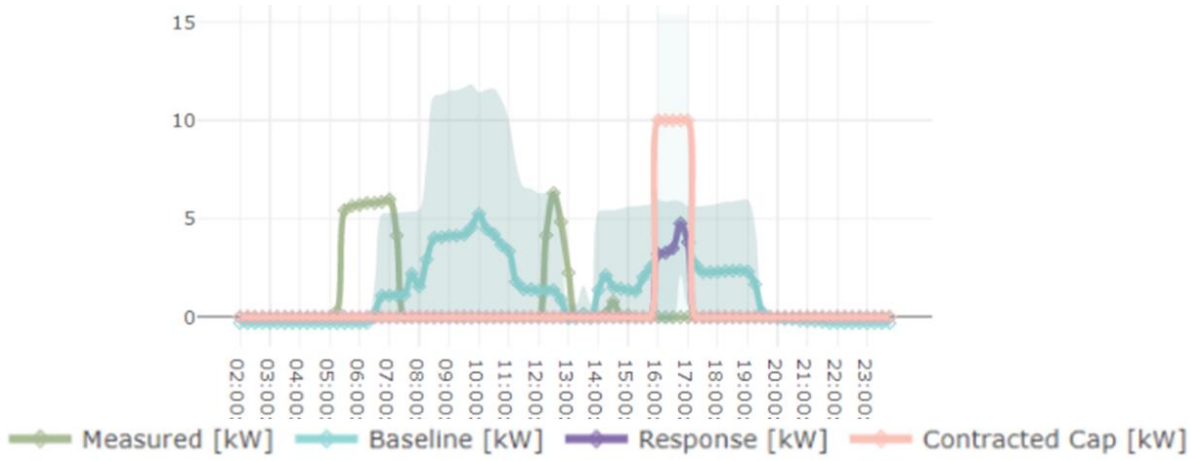
4 x EDF Battery: MVSD4.4.2– 14.4kW



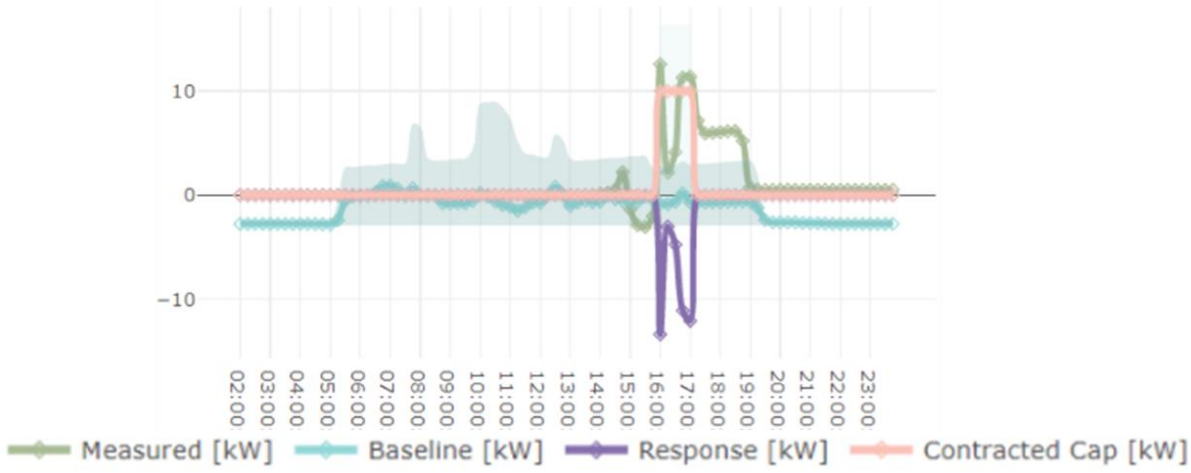
4 x EDF Battery: MVSD4.4.3 – 14.4kW



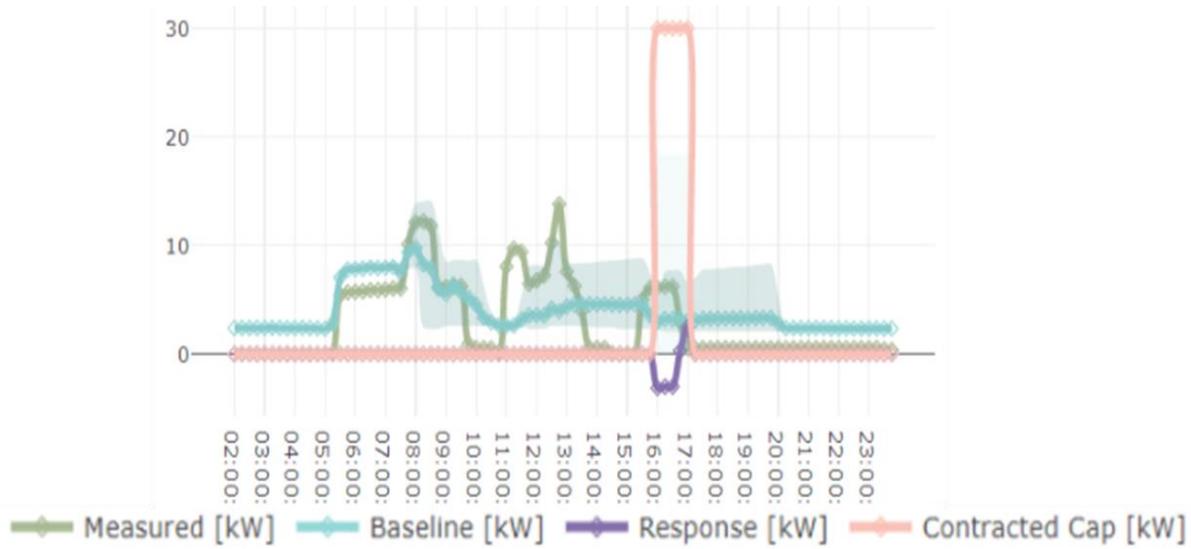
3 x V2G Chargers: MVSD4.5.1 – 10kWh



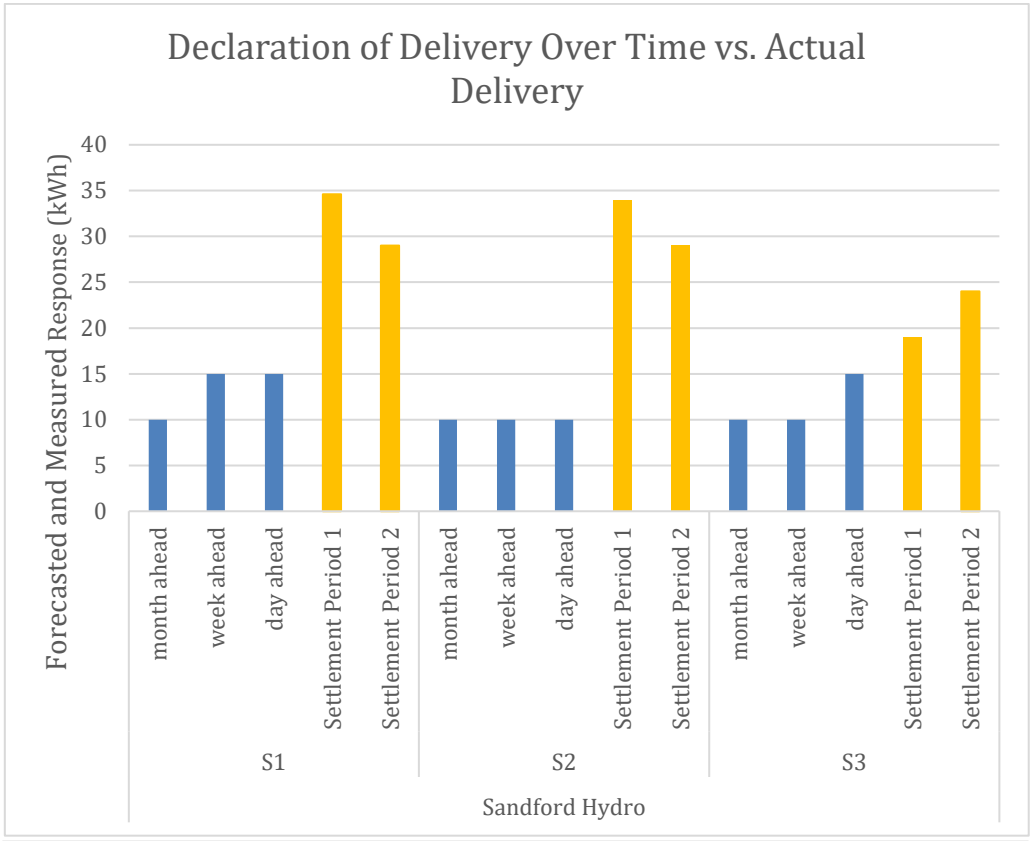
3 x V2G Chargers: MVSD4.5.2– 10kWh

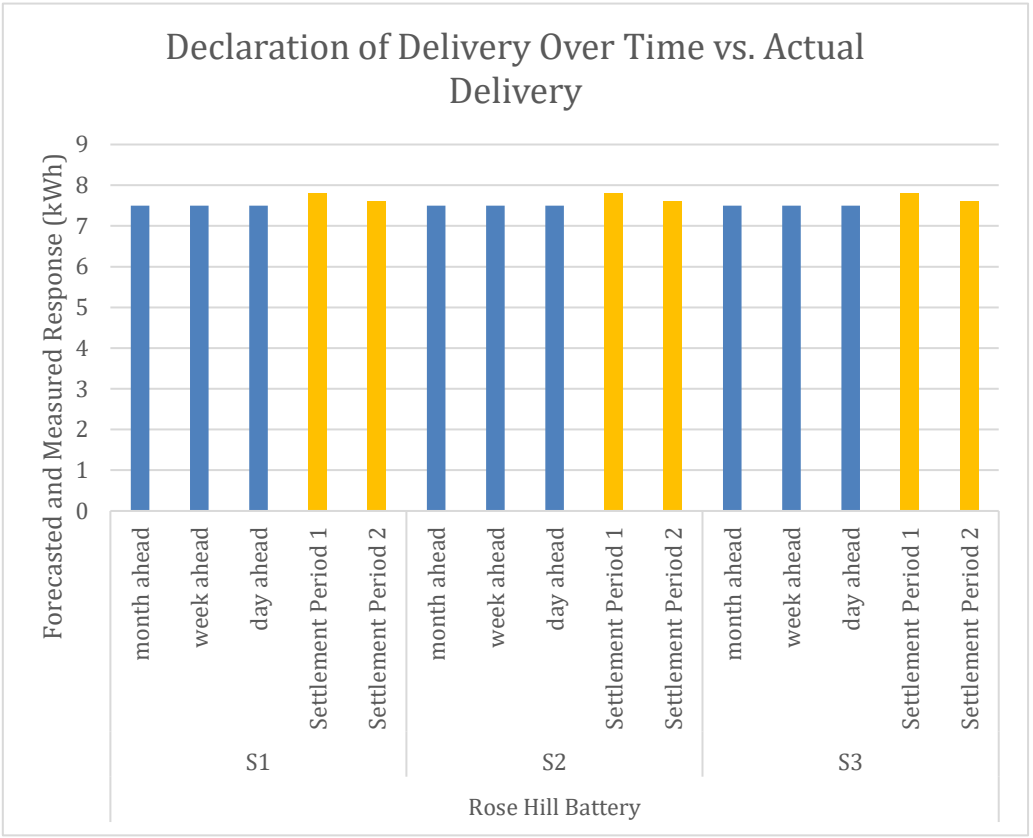


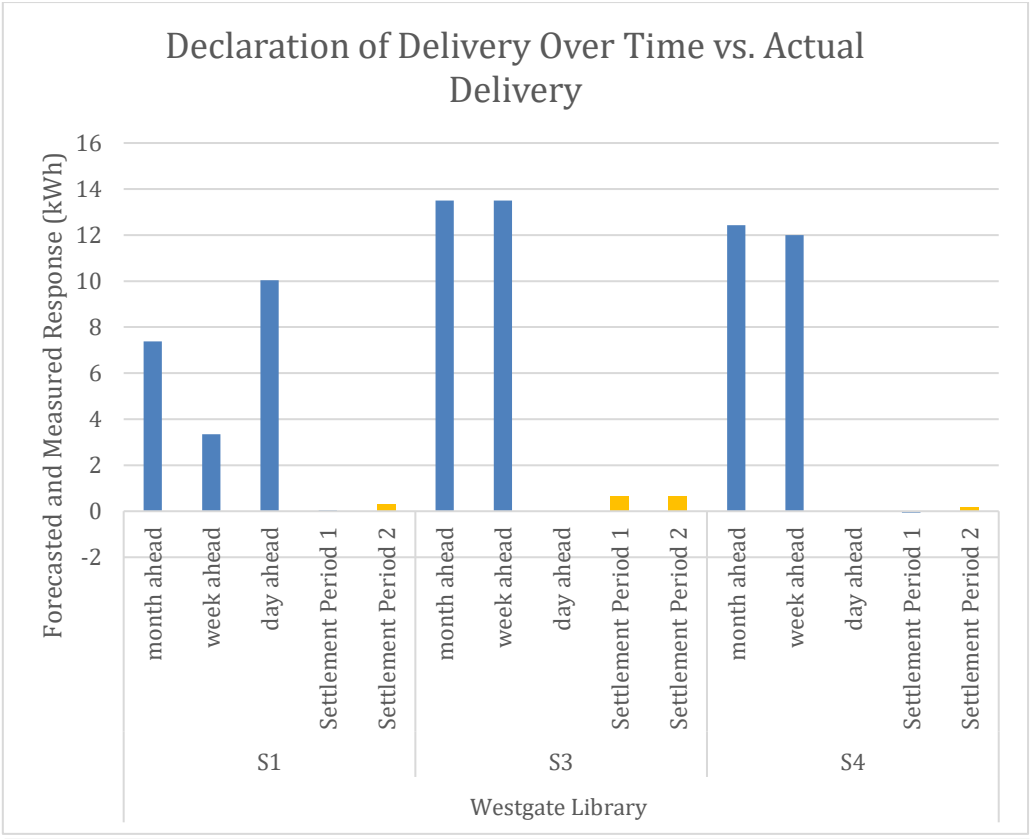
3 x V2G Chargers: MVSD4.5.3 – 30kWh

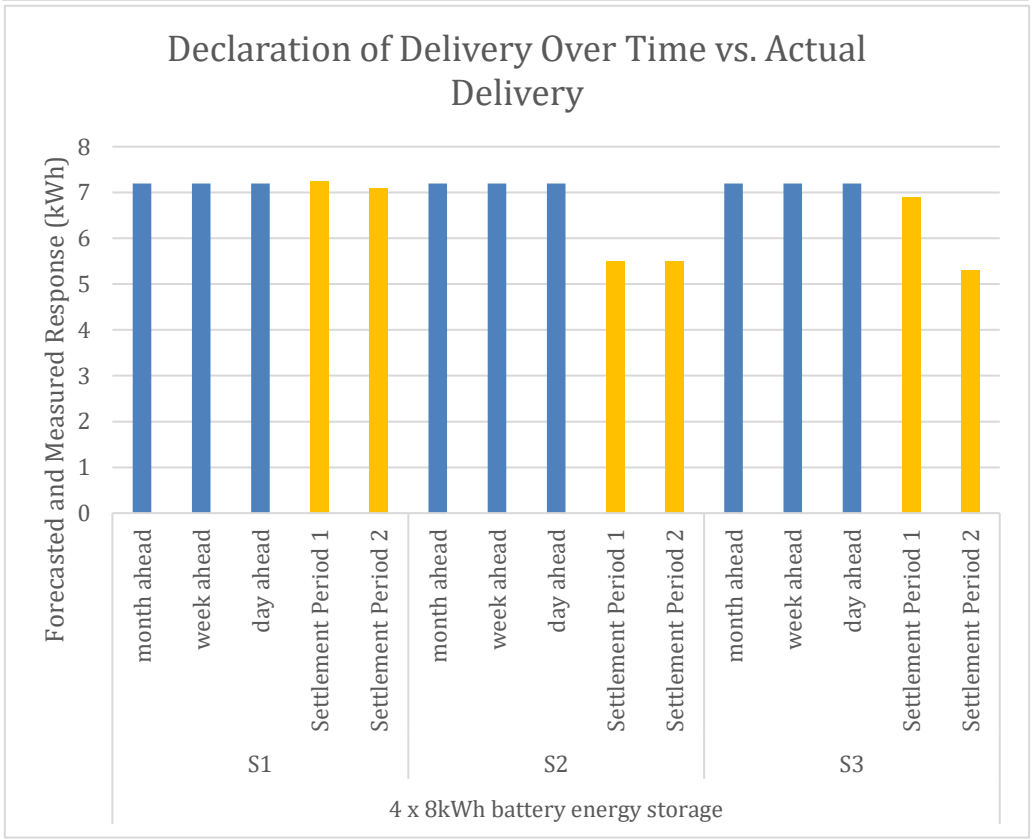


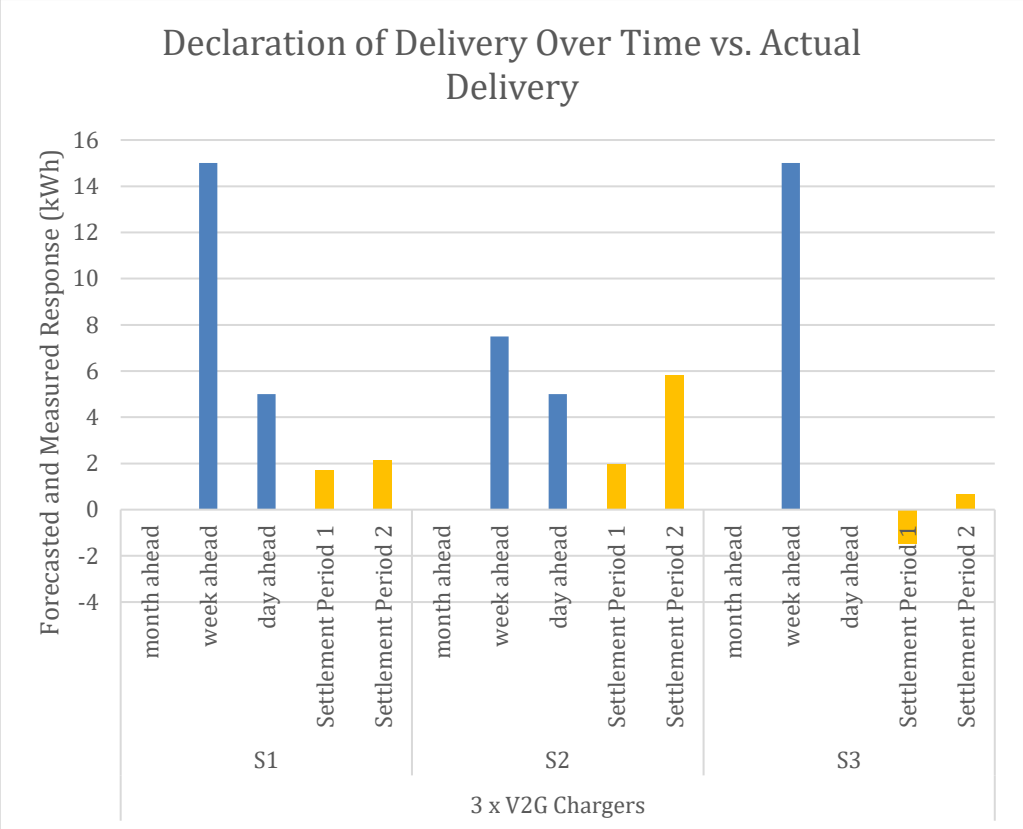
Appendix F: Analysis: of Declaration of Delivery Over Time






Declaration of Delivery Over Time vs. Actual Delivery
Forecasted and Measured Response (kWh)
16
14
12
10
8
6
4
2
0
-2
month ahead
week ahead
day ahead
Settlement Period 1
Settlement Period 2
month ahead
week ahead
day ahead
Settlement Period 1
Settlement Period 2
month ahead
week ahead
day ahead
Settlement Period 1
Settlement Period 2
S1
S3
S4
Westgate Library


Declaration of Delivery Over Time vs. Actual Delivery
Forecasted and Measured Response (kWh)
8
7
6
5
4
3
2
1
0
month ahead
week ahead
day ahead
Settlement Period 1
Settlement Period 2
month ahead
week ahead
day ahead
Settlement Period 1
Settlement Period 2
month ahead
week ahead
day ahead
Settlement Period 1
Settlement Period 2
S1
S2
S3
4 x 8kWh battery energy storage


Declaration of Delivery Over Time vs. Actual Delivery
Forecasted and Measured Response (kWh)
16
14
12
10
8
6
4
2
0
-2
-4
month ahead
week ahead
day ahead
Settlement Period 1
Settlement Period 2
S1
S2
S3
3 x V2G Chargers

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