MERLIN

Modelling the Economic Reactions Linking Individual Networks

# Milestone 4

## 2.01 GridOS Flexibility Market Simulation Configuration

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Scottish & Southern Electricity Networks | opus one solutions

# Contents

# 1 Introduction / Market Structure Components

For Project MERLIN, SSEN will design, simulate, and test a distribution flexibility market in the Fort William and Oxfordshire network areas, with the support of the University of Cambridge Energy Policy Research Group and Opus One Solutions. The purpose of this report is to highlight the structure and components of flexibility markets, which will be provided by Opus One's GridOS Flexibility Market Simulator (FMS) and advised by Cambridge's flexibility markets experience.

The GridOS Distribution System Platform (DSP) is Opus One's software that allows for user-created market scenarios to be evaluated based on both the physical constraints of the grid and the economic considerations of market participants. A scenario is comprised of a user-input network model, flexibility utilisation bids and offers that simulate accepted flexibility responses, system load data, and intermittent resource generation data. GridOS evaluates those inputs to determine a cost-minimising flexibility utilisation that maintains system security.

Services simulated by the software include both peer-to-peer and peer-to-DNO, and scenarios can be modified to facilitate evaluation of the physical and economic implications of the varied user participation models that may emerge.

The flexibility market in Project MERLIN will use a constraint management framework in which the DSO approves or rejects peer-to-peer transactions and makes use of peer-owned flexibility to resolve system constraints.

# 2 Market Objectives and Services

## 2.1 Objectives

A flexibility market can achieve several objectives for a DSO. Primarily, markets can achieve cost efficiency for the DSO by finding cheaper alternatives to traditional reinforcement. Markets can also contribute to system reliability by providing more power balancing options for the DSO. In longer timeframes, markets can be used to support planned outage management, while shorter timeframe markets can support unplanned outage management.

Market rules can be adjusted to emphasise other objectives such as stimulating new connections, new technology uptake (such as electric vehicles), achieving carbon neutral goals, and facilitating a competitive marketplace. Variations to payment structures, penalties, enrolment rules, or procurement periods can favour certain flexibility providers and technologies.

For Project MERLIN, market facilitation is a key objective to show competency and ability for SSEN's transition to a DSO. The learnings from this project will support Transition and add to SSEN's experience for DSO-readiness. Market rules within Project MERLIN will allow SSEN to investigate flexibility valuation mechanisms, evaluate predicted load and DER growth, and gauge SSEN data readiness and availability.

## 2.2 Simulated Services

There are three categories of services: DSO flexibility services, ESO-DSO services, and Peer to Peer (P2P) services. DSO flexibility services are procured for the DSO to manage their system. P2P services are procured and transacted between industry actors. ESO-DSO services are procured to manage energy imbalance between the ESO and DSO, these will not be trialled in Project MERLIN.

The services to be investigated for Project MERLIN are detailed in Table 5 of the Transition use cases and services report[1].

### 2.2.1 DSO Constraint Management

DSO Constraint management is a service procured by the DSO from industry actors[2] who take part in the flexibility market. The service allows the DSO to utilise flexibility in the form of reduced demand, increased generation, or dispatched storage to mitigate the impact of a network constraint. This constraint could be, for example, due to a planned outage. The DSO may make use of this service to operate their network safely.

### 2.2.2 Peak Management

Peak management is a service procured by the DSO from industry actors who take part in the flexibility market. The service allows the DSO to utilise flexibility in the form of reduced demand, increased generation, or dispatched storage to mitigate the impact of a period of peak demand on an asset in network. Reactive power services can also be procured to reduce losses or improve power factor quality. The DSO may make use of this service to operate their network safely.

[1] https://ssen-transition.com/wp-content/uploads/2020/11/TRANSITION-WP4.3-Use-Cases-and-Services-to-be-Trialled-v1.1.pdf

[2] Industry actors include the DSO, the end users who own / operate distributed energy resources (DER), as well as aggregators and the ESO.

### 2.2.3 Maximum Import and Export Capacity Trading

Maximum Import and export capacity trading is a type of P2P service in which a set of industry actors agrees to limit their import or export to enable increased import or export by another industry actor on the network. This service may be transacted in either constrained or unconstrained network states and changes the ratings of assets in the system, and allows for changes in their realised consumption beyond their initial rating. The DSO's primary responsibility is to accept or reject the transaction.

### 2.2.4 Offsetting

Offsetting is a P2P service in which two participants agree to increase load and increase generation (decrease load) at the same time period to 'offset' each other's system impact. This service contemplates increases (decreases) from a baseline and includes charge or discharge of storage assets such as battery energy storage systems (BESS) or electric vehicles (EVs) to enable increased generation or increased demand. This service may be transacted in either constrained or unconstrained network states, and results in changes to supply and demand in the network. The DSO's primary responsibility is to accept or reject the transaction.

# 3 Market Rules

## 3.1 Industry Actors

There are two main classifications of industry actors in Project MERLIN: the DSO user (i.e., the market operator) and the DER owner/operators providing and requesting flexibility services. The market operator is the entity responsible for managing and operating the market. The DER owner/operators are the entities who agree upon peer-to-peer transactions or supply peer-to-network flexibility services.

While there are many neutral parties that can facilitate a market, in Project MERLIN, the market operator will be the DSO, SSEN. SSEN will manage the overall operation of the flexibility market and will likely be the main procurer of flexibility services.

Market participants for this project include flexibility service operators or aggregators. These participants can provide flexibility services to the DSO and to each other. Refer to Section 5 in the Transition Use Cases and Services report[3] for more details on other specific industry actors.

For market participants, the expected types of technology to be enrolled in the market includes demand side responses and generation assets. For demand side responses, these could include heating or cooling loads, or EV chargers, modelled as flexible loads. Generation assets include solar panels, hydro plants, diesel generators, and batteries to list a few. Note that these technologies can exist at different sizes such as industrial, commercial, community, and residential. There can be market rules to specify the minimum flexibility service size for a participant to join the market.

## 3.2 Market Operation

The order of operations for the flexibility market in Project MERLIN will be as follows. GridOS will facilitate the second and third steps, while the rest will be performed offline in a workshop setting.

1. Request – Performed Offline

The users will post a request for flexibility services to other industry actor users participating in the simulation. The request can be for any of the peer-to-peer or peer-to-DSO services. Peer-to-DSO services will be for availability with the option to be utilized by the DSO, whereas peer-to-peer services will be for utilisation.

2. Response– Performed Offline

The posting will be visible to market participants for a defined period and open for responses. Interested market participants will submit bids and offers to the requestor to indicate their availability and willingness to provide their services and desired compensation for availability and utilisation. At the end of the defined period, no new responses (bids and offers) will be accepted.

3. Selection and award of DSO Availability Contracts – Performed Offline

[3] https://ssen-transition.com/wp-content/uploads/2020/11/TRANSITION-WP4.3-Use-Cases-and-Services-to-be-Trialled-v1.1.pdf

The flexibility requestor will be given time to review all received responses to their request, and may choose to select as many services as desired. Selected flexibility service providers will be notified of their awarded contract(s).

4. Utilisation of flexibility services

After the services are agreed upon, the DSO user will initiate the simulations of scenarios the DSO user creates. These scenarios will make use of the flexibility contracts for constraint management, as well as incorporate the peer-to-peer offsetting and MIC/MEC transactions.

a. **Peer-to-Peer:**
    a. Offsetting transactions agreed upon by participants alter the load profile at offsetter nodes within the system
    b. MIC/MEC transactions agreed upon by participants (and approved by the DSO) create a network model change.
b. **Peer-to-DSO:**
    a. DSO Constraint Management and Peak Management responses that are selected by the DSO are used by the software to mitigate the impact of network constraints.

5. Measure and verify flexibility service

Upon completion of the flexibility market analysis for a day, the administrator user may manually upload simulated measurement data to GridOS . In a field demonstration or live market, these data would be updated via meters at assets. For the market simulations, these data will be user-generated and may be identical to the utilisation schedules, or differ from them.

6. Perform Settlement

Flexibility service providers are compensated for their services (i.e. monthly). If there are any discrepancies between the commitments and actual service delivery, penalties can be applied to compensation payments. The flexibility requestors then repay all the service providers.

7. Conduct cost benefit analysis

Flexibility simulation participants should perform an analysis to understand the economic implications of their flexibility service procurements. For DSOs like SSEN, this would likely be a comparison to alternative and traditional solutions to network constraints or upgrades.

### 3.2.1 Market Gates

Depending on the market objectives, services can be procured at various frequencies with different lead times. In support of long-term planning, a long-term market that procures services from months to a year in advance can be used. In the short term for balancing services or depending on forecasting capabilities, markets procuring for sub-hourly to a day ahead can be used. In Project MERLIN, the long-term planning considerations will be addressed by GridOS Integrated Distribution Planning (GridOS IDP). GridOS DSP will process and simulate market transactions in a shorter timeline.

### 3.2.2 Day-Ahead Market

In operations, day-ahead energy services markets are generally evaluated for an entire day as of the prior day, generally by noon of the prior day.

For example, the market for July 1 12:00am-11:59pm utilisation offer submission may open at 5:00am on June 30 and close at 12:00pm on June 30. The markets software then evaluates the scenario for the next day and outputs a set of awards for utilisation for the next day, generally within a few hours of the market's close.

Day-Ahead utilisation will be simulated through an auction process in which participants submit a single-day set of utilisation offers and requests for the next day, and the DSO user submits a set of load and generation data for the software to evaluate.

The utilisation offers and requests will be evaluated hourly for all 24 hours of the simulated day.

The market scenario analysis can be initiated independent of the time of day, given all required inputs and prior to the end of day.

### 3.2.3 Intra-Day Market

In operations, intra-day energy services markets are generally evaluated one interval at a time, for some time within an hour in the future as of the present time.

For example, the market for July 1 11:30am-113:5am utilisation may close at 11:15am and publish results at 11:20am, giving participants 10 minutes to respond.

Intra-Day utilisation will be simulated through an auction process in which participants submit utilisation offers for a single interval, or for a set of intervals within a day and the DSO user submits a set of load and generation for that period for the software to evaluate.

The intra-day analysis will be performed for between 12 to one intervals per hour (i.e., 5-minute intervals or hourly) Services will be procured in sub-hourly intervals (5, 15, or 30 minutes), at many intervals (288, 96, or 48) in a day.

Participation in the intra-day market allows market participants to refine or change commitments made in the day-ahead market. Given any demand or generation changes in the system, intra-day market procurement can be used to correct any imbalances.

## 3.3 Auction Mechanism

There are two auction styles that could be considered for Project MERLIN: open (in which participants are aware of each other's responses) and closed (in which participants are unaware of each other's responses). The DSO issuing a request to participants is roughly analogous to a reverse auction – i.e., one in which a single user purchases a service, rather than a standard auction in which a single user buys a service. In reverse auctions, generally the lowest priced offer that clears the market wins and sets the market clearing price.

Availability auctions will be evaluated outside the tool.

Utilisation will be evaluated within the tool through participant submitted bids and offers for services.

## 3.4 Measurement and Settlement Rules

Settlement is generally performed through comparison of measured output of a resource against contracted utilisation of that resource. At a time set by the DSO user, participants must supply their measured output, or the DSO may meter those assets to measure their output.

In a live market, participants are generally expected to comply with metering requirements for settlement. The market participant must have meter capable of outputting measurements in appropriate granularity, typically half-hourly or hourly, and be able to provide the metering log to the market operator on a regular basis.

For flexibility resources that are activated by the market to inject generation, their metering logs will indicate their services. For other flexibility resources that modify their behaviour relative to a baseline performance, the market participant must either submit a baseline profile, to which their metering log is compared, or submit a meter log that indicates the net difference from their original profile. The DSO user may also calculate baselines on their own through use of the meter at the participant's site.

For the simulation, user-created measurement data may be uploaded to GridOS DSP for settlement. The settlement process within GridOS DSP will compare the committed flexibility of a resource with its uploaded measurement data. Market participants may be penalised for under or over performing based on settlement rules. In Project MERLIN, no penalties have been defined yet but GridOS DSP has previously used a linear devaluation for underperformance and capped payment for overperformance.

## 3.5 Contract Structure

There are typically three main methods of payments dictated in a flexibility service contract for market enrolment: availability, arming and utilisation payments. Availability payments serve as a retainer payment for the flexibility services in the energy market. Arming payments are paid to flexibility services to put them in a state of readiness for a period. Utilisation payments compensate flexibility services for their procured services.

The Transition project will investigate contract structures in more detail. The Transition Commercial Arrangements report[4] details the contract structure that will be practiced. In Project MERLIN, the software will evaluate participation based on utilisation offers. Market participants will have market contracts that can include availability payments.

Payment for services will be calculated based on valuation mechanisms described in the 1.06 Flexibility Valuation Mechanism report[5], as well as the resources' utilisation offers. These valuation mechanisms assign a cost to flexibility services based on avoided costs and earned benefits by considering traditional and novel DNO, societal, and alternative valuations methods.

For the utilisation payments, participants will be compensated in one of two ways per utilisation instance: either at their bid or offer ("pay as bid"), or at the market clearing utilisation payment ("pay as clear").

For market intervals in which multiple resources are procured:

- A pay as bid market configuration would see all market participants get paid by their offer or bid amount if they are called upon.
- A pay as clear market configuration would pay all market participants that are called upon with the highest offer required to clear the market. Table 1 below shows an example of the two configurations.

[4] https://ssen-transition.com/wp-content/uploads/2020/07/Transition-Commercial-Arrangements_final.pdf
[5] https://project-merlin.co.uk/library/milestone-2/

*Table 1: Pay as bid vs pay as clear example*

| Service Provider | Bid | Cleared? | Pay as Bid Payment Rate | Pay as Clear Payment Rate |
|---|---|---|---|---|
| A | £10/MW | Y | £10/MW | £20/MW |
| B | £20/MW | Y | £20/MW | £20/MW |
| C | £30/MW | N | N/A | N/A |

## 3.6 Load Growth Scenarios

The market structure will be used to evaluate two load growth scenarios identified by Regen's Future Energy Scenarios (FES) report[6] for SSEN North and South Networks. Consumer Evolution and Community Renewables growth scenarios were selected because they predict greater levels of decentralisation, enabling SSEN to evaluate the effectiveness of an energy market in supporting distribution system operations. These two scenarios predict different levels of decarbonisation in the UK. Table 2 from the same Regen FES report shows a comparison between the two scenarios. More information on the two scenarios are available in from the Regen report.

### 3.6.1 Community Renewables

This scenario explores how the 2045 decarbonisation target can be achieved through a more decentralised energy landscape with high levels of smaller scale, local and domestic activity. This scenario tends to have the highest levels of new generation and demand connected at distribution level. In Project MERLIN, there will be numerous EV chargers, PV, and flexible load installations on the network over the period of ten years.

### 3.6.2 Consumer Evolution

This is a decentralised scenario that makes progress towards the decarbonisation target but fails to achieve it. Deployment is focused on smaller scale, local and domestic projects. There will be some EV chargers, PV, and flexible load installations on the network over the period of ten years.

*Table 2: FES comparison*

| | **Consumer Evolution** | **Community Renewables** |
|---|---|---|
| Electricity demand | Moderate-high demand: high for electric vehicles (EVs) and moderate efficiency gains | Highest demand: high for EVs, high for heating and good efficiency gains |
| Transport | Most cars are EVs by 2040: some gas used in commercial vehicles | Most cars are EVs by 2033; greatest use of gas in commercial vehicles but superseded from mid 2040s by hydrogen (from electrolysis) |
| Heat | Gas boilers dominate; moderate levels of thermal efficiency | Heat pumps dominate; high levels of thermal efficiency |
| Electricity supply | Small scale renewables and gas; small modular reactors from 2030s | Highest solar and onshore wind |
| Gas supply | Highest shale gas, developing strongly from 2020s | Highest green gas development form 2030s |

[6] https://www.regen.co.uk/wp-content/uploads/SSEN-South-FES-Scenarios-Final-v2.pdf

# 4 Next Steps: Flexibility Market Simulations

This report has highlighted flexibility markets configurations and considerations within Project MERLIN. For SSEN to perform market simulations in the Fort William and Oxfordshire regions with GridOS DSP, the project team will next collaborate on a document explaining how to implement the aforementioned market considerations through GridOS DSP. Further design discussions will be held to determine how to implement and test the market configurations.

It is important to note that there are other market considerations that can be further explored and implemented such as market processes for over procurement and specific market timelines and mechanisms. These considerations will continue to be discussed and incorporated in the flexibility market simulations as resolved.

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