

Flexibility Markets Unlocked

Phase 2

Final Report
March 2025

Developed for:



Department for
Energy Security
& Net Zero

Executive summary (1 of 3)

Development and demonstration of Flexify, Flexibility Data Standards, and Market Rules Test Bed

Overview

To achieve a clean power system by 2030 and reach net-zero emissions by 2050, UK requires a smart and flexible energy system. While progress has been made in unlocking flexibility from distributed energy resources (DERs) such as storage, electric vehicles, and heat pumps, significant barriers persist.

The Flex Markets Unlocked (FMU) Programme is a Department for Energy Security and Net Zero (DESNZ) funded initiative under their £1b Net Zero Innovation Portfolio fund. It aims to drive the design and development of innovative technical solutions to address barriers in the flexibility sector by enabling system-wide coordination and standardisation across multiple flexibility markets, summarised through the following problem statement:

“The provision of distributed, small-scale flexibility is relatively untapped and there are challenges to realising its full system value; this value is fragmented across several markets that are not fully standardised, coordinated or fully accessible to this type of flexibility.”

Programme objectives

FMU aimed to deliver the following four key outcomes:

Better information visibility. Currently, SOs, FSPs, regulators, and investors do not have access to high fidelity flexibility market data to support their business decisions. Therefore, the solution needs to enable greater visibility of asset, product, and market operation data for all market participants.

Greater market coordination. Current flexibility markets, services, and supporting platform providers operate without any common controls or processes, leading to operational discrepancies. Therefore, the solution needs to provide mechanisms to coordinate across multiple products e.g. stacking.

Connected user experience. Many steps in the end-to-end process today are disconnected, manual and often unnecessarily repeated across different SOs. Therefore, the solution needs to enable improved access to markets via common and streamlined processes.

Fostering trust. Buyers and sellers need a common process to meet their desire for transparency, and data to evidence their operational choices, investments, and trust their assets will be protected. Therefore, the solution needs to enable transparency in decision making and governance.

Approach

Flexibility Markets Unlocked Programme is a key step in determining the value of enabling a federated flexibility ecosystem, and the ways it enables a more diverse and competitive marketplace.

To ensure its success, over 50 engagement sessions were held. Stakeholders directly affected by the project were actively involved at every milestone to shape solution development and define the value of each component. These sessions encouraged collaboration, allowing stakeholders to voice concerns, ask questions, and offer recommendations, fostering a sense of ownership and commitment to the outcomes. See [Appendix A](#) on the details of the engagements.

The programme was completed across two phases. The current phase involved the development and demonstration of a Proof-of-Concept (PoC) of the solution components, defining its value, an assessment of constraints, dependencies, enablers, how the solution fits with the wider sectoral Content, and an outline of potential pathways for future adoption.

Executive summary (2 of 3)

Solution definition of Flexify, Flexibility Data Standards, and Market Rules Test Bed

Solution overview

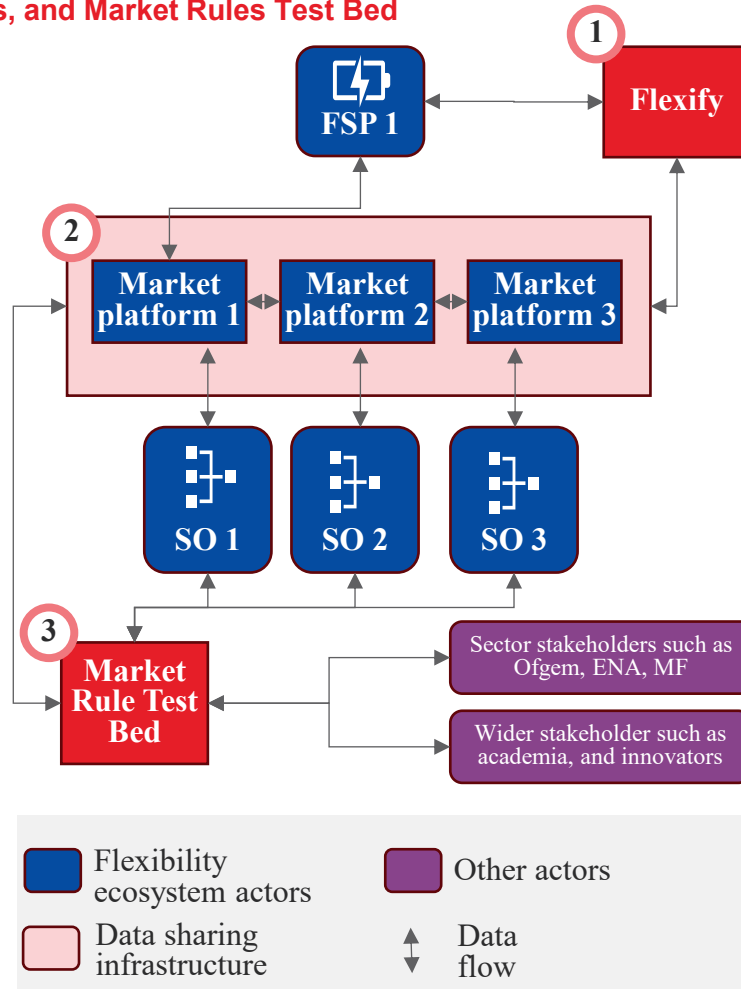
Guiding vision for the solution:

“Unlocking flexibility markets through distributed digital solutions that drive innovation through market competition, and incentives, but is centrally managed to ensure appropriate rules are determined and enforced.”

1. Flexify serves as an integration platform, seamlessly connecting disparate digital systems within the flexibility ecosystem. By streamlining the user journey for Flexibility Service Providers (FSPs), it addresses the challenge of market access.

2. Flexibility Data Standards (FDS) is an ontology specifically designed for the flexibility sector, facilitating scalable data exchange and aggregation for business intelligence. By enhancing information transparency, FDS supports more informed decision-making and market insights.

3. MRTB functions as a market optimisation tool, empowering system operators and policymakers to assess and understand the implications of different market rules before implementation. Its initial focus is on evaluating the economic benefits of stacking, including both splitting and co-delivery.



Alignment with on-going sector initiatives

All three solution components interact with on-going sector consultations, projects, and initiatives.

For Flexify, Ofgem’s Flexibility Market Asset Registration (FMAR) consultation defined 10 functional outcomes which Flexify can fully or partially meet 8 of them, placing a constraint on the component. See [page 33](#) for more details.

For FDS, development and adoption of the Information Exchange Standard (IES) by the energy sector is a key constraint, along with the high relation to the smart data scheme consultation initiated by DESNZ. FDS has the potential to be a component of the scheme and/or can inform the development of the scheme.

For MRTB, Data Sharing Infrastructure (DSI) is a key enabler to help the tool ingest the dynamic data required to fully operationalise the information in business-as-usual activities.

Lastly, the findings from Phase 2 of FMU provides a strong evidence base for policy makers to draw upon for defining the future of flexibility.

Executive summary (3 of 3)

Value & proposed next steps for Flexify, Flexibility Data Standards, and Market Rules Test Bed

Value to the sector

Through-out the development and testing, the following benefits were evidenced across each component:

Flexify as a common infrastructure can significantly contribute to unlocking flexibility by creating a connected user experience for all FSPs for accessing flexibility markets. It is estimated the solution benefits could range from £10mn to £12mn a year by 2035 by increasing the competition and market liquidity by reducing the burden associated to market access.

Benefits for FSPs include:

- Faster time to market
- Opportunity identification

Benefits for SOs include:

- Reduction in administrative costs for completing commercial and technical checks

Benefits for Market Facilitator and Regulators:

- Delivery of actionable insights and analytics
- Increase in market liquidity

FDS supports the flexibility use case for the Data Sharing Infrastructure (DSI) by providing a standardised ontology that enables seamless data exchange. Additionally, testing has demonstrated that FDS reduces the resources required for mapping and exchanging information by 60%, reducing the need for 1-2-1 mappings. Lastly, the ontology sits at system boundaries, eliminating the need for modifications to existing infrastructure. This enabling tool will support greater visibility of asset, product, and market operation data across all market participants.

MRTB has evidenced its ability to support system operators and policymakers by helping them make informed decisions about implementing common controls and processes. Starting with revenue stacking, the tool outlines a ‘win-win’ scenario for building an inclusive marketplace for all FSPs and SOs.

These tools will support all existing sector software systems, market products, and data streams, facilitate ‘competition everywhere’ while also providing the scalability and performance required for future growth in the flexibility ecosystem.

Proposed next steps

Flexify

- Move from PoC to MVP by building the missing functionalities needed for FMAR, building on the pathways defined in [Section 2.1.4](#).
- Complete an assessment to understand the system value Flexify delivers and define the features that are needed for an MVP.

Flexibility Data Standards

- Identify a sector entity to take over the ownership of the standard, and for that entity to complete the remaining development efforts
- Encourage collaboration between NPSA and NESO, as DSI operator, to establish best practices for information security management.

Market Rules Test Bed

- Complete a SiF Alpha application to further build the tool.

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Notice:

This report summarises the findings and conclusions of the Flexibility Markets Unlocked – Phase 2 Development & Demonstration, part of the Flexibility Innovation Programme, commissioned under the government’s £1 billion Net Zero Innovation Portfolio, which provides funding for low-carbon technologies and systems. Decreasing the costs of decarbonisation, the Portfolio will help enable the UK to end its contribution to climate change.

The findings are the view of the consortium and are not the views or policy of the Department for Energy Security and Net Zero.

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Delivery team

Delivery led by a consortium of domain experts

FMU Phase 2 has been led and delivered by Arup, in partnership with the Energy Systems Catapult and Electron from Phase 1, and joined by GreenSync, Piclo, and University of Edinburgh in Phase 2.

- **Arup:** An employee owned, multinational organisation with more than 15,000 specialists, with a mission to ‘shape a better world’.
- **Energy Systems Catapult (ESC):** An independent, not-for-profit centre of excellence set up to accelerate the transformation of the UK’s energy system.
- **Electron:** A leading provider of marketplace software for flexibility and distributed electricity.
- **GreenSync:** A global energy tech company, committed to digitally enabling renewable energy for a better world.
- **Piclo:** A provider of multiple software solutions that make energy networks smarter, flexible and more sustainable
- **University of Edinburgh:** A public research university based in Edinburgh, Scotland. Founded by the town council under the authority of a royal charter from King James VI in 1582.

ARUP

CATAPULT
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THE UNIVERSITY
of EDINBURGH

Approach

Stakeholder led, and value focused

Stakeholder led

Flexibility markets unlocked programme served as a crucial step in determining the value in enabling a federated flexibility ecosystem.

Therefore, to ensure success, over 50+ engagement sessions were undertaken, guided by the principles of being stakeholder-led, collaborative, and consultative.

Across every milestone and solution component, stakeholders who are directly affected were actively engaged to help shape the solution development and ensure appropriate value of the component was defined.

Throughout each engagement, stakeholders were invited to collaborate in the development of the component, instead of being solely recipients of information. Each stakeholder was given the opportunity to express their concerns, raise questions, and provide recommendations. This mindset ensured the engagement sessions fostered a sense of ownership, responsibility, and commitment to the outcomes, leading to stakeholders wanting to be part of the development of the solution.

See [Appendix A](#) for detailed overview of the engagements and findings.

Value focused

A key part of the engagements was to validate and extensively test the assumptions set out for the programme. It started with an acknowledgement that the solution components developed in this phase built on previously completed works.

Value focused mindset drove the consortium to engage with organisations and stakeholders that are not directly involved with flexibility, including NDTP, NPSA, and RECCo to ensure cross-sector alignment benefits are incorporated into the design and development of Flexify, and Flexibility Data Standards.

[Sections 2.1.2](#), [Section 2.2.1](#), and [Section 2.3.1](#), provides a view of the unique value each solution component offers, while defining each wider initiatives as a constraints, dependency, and enabler.

Developing a Proof-of-Concept

Phase one of the programme drove the conceptual design of the three solution components, leading into Phase 2, for development and demonstration of a Proof-of-Concept.

The development focused on design, iterative improvement through stakeholder engagement, and testing of the concept.

Further work is required to bring each component into production, outlined in recommendations in [Section 3.2](#).

Nomenclature & terminology

- **AAR** – Automatic Asset Registration
- **ACID** – Atomicity, Consistency, Isolation, and Durability
- **AES** – Advanced Encryption Standard
- **AI** – Artificial Intelligence
- **ANM** – Active Network Management
- **API** – Application Programming Interface
- **AWS** – Amazon Web Services
- **BAU** – Business As Usual
- **BM** – Balancing Mechanism
- **BNEF** – Bloomberg New Energy Finance
- **BSC** – Balancing & Settlement Code
- **CAF** – Cyber Assessment Framework
- **CAR** – Centralised Asset register
- **CICD** – Continuous Integration and Continuous Delivery/Deployment
- **CIM** – Common Information Model
- **CIS** – Centre for Internet Security
- **CMA** – Competition and Markets Authority
- **CMZ** – Constraint Managed Zone
- **CNI** – Critical National Infrastructure
- **CPU** – Central Processing Unit
- **CSF** – Cyber Security Framework
- **CSIP** – Common Smart Inverter Profile
- **CUSC** – Connection and Use of System Code
- **DCUSA** – Distribution Connection and Use of System Agreement
- **DDoS** – Distributed Denial-of-Service
- **DER** – Distributed Energy Resource
- **DESNZ** – Department for Energy Security and Net Zero
- **DFS** – Demand Flexibility Service
- **DNO** – Distribution Network Operator
- **DNS** – Domain Name System
- **DPN** – Data Preparation Node
- **DSI** – Data Sharing Infrastructure
- **DSO** – Distribution System Operator
- **DSR** – Demand Side Response
- **EDM** – Enterprise Data Model
- **ENA** – Energy Networks Association
- **ENWL** – Electricity North-West Limited
- **ESC** – Energy Systems Catapult
- **ETL** – Extract, Transform, Load
- **EV** – Electric Vehicle

Nomenclature & terminology

- **FDS** – Flexibility Data Standards
- **FFR** – Firm Frequency Response
- **FMAR** – Flexibility Market Asset Registration
- **FMU** – Flexibility Markets Unlocked
- **FSP** – Flexibility Service Providers
- **GDPR** – General Data Protection Regulation
- **GDS** – Government Digital Service
- **GSP** – Grid Supply Point
- **GUI** – Graphical User Interface
- **IDP** – Identity Provider
- **IEC** – International Electrotechnical Commission
- **IEEE** – Institute of Electrical and Electronics Engineers
- **IES** – Information Exchange Standard
- **IHM** – Information Handling Model
- **IMP** – Independent Market Platform
- **IP** – Intellectual Property
- **IPaaS** – Integration Platform as a Service
- **JSON** – JavaScript Object Notation
- **KYC** – Know Your Customer
- **LCM** – Locational Constraints Market
- **MF** – Market Facilitator
- **ML** – Machine Learning
- **MPAN** – Meter Point Administration Number
- **MRTB** – Market Rules Test Bed
- **MSID** – Mobile Station Identity
- **MVP** – Minimum Viable Product
- **MW** – Mega Watts
- **NCSC** – National Cyber Security Centre
- **NDTP** – National Digital Twin Project
- **NESO** – National Electricity System Operator
- **NGED** – National Grid Electricity Distribution
- **NIST** – National Institute of Standards and Technology
- **NPg** – Northern Powergrid
- **NPSA** – National Protective Security Authority
- **Ofgem** – Office of Gas and Electricity Markets
- **ONS** – Office for National Statistics
- **OWASP** – Open Web Application Security Project
- **PBAC** – Policy-Based Access Control
- **PoC** – Proof Of Concept
- **PQQ** – Pre-Qualification Questionnaire
- **RBAC** – Role-Based Access Controls
- **RDF** – Resource Description Framework

Nomenclature & terminology

- **RIIO** – Revenues and Incentives to deliver Innovation and Outputs
- **SA+OU** – Scheduled Availability and Operational Utilisation
- **SaaS** – Software as a Service
- **SDS** – Smart Data Schema
- **SHACL** – Shapes Constraint Language
- **SIEM** – Security Information and Event Management
- **SiF** – Strategic Innovation Fund
- **SMP** – Single Markets Platform
- **SO** – System Operator
- **SPEN** – Scottish Power Energy Networks
- **SSEN** – Scottish and Southern Electricity Networks
- **SSO** – Single-Sign On
- **STOR** – Short Term Operating Reserve
- **TBD** – To be Developed
- **TC** – Technical Role
- **UI** – User Interface
- **UID** – Unique Identifier
- **UKPN** – UK Power Networks
- **UMR** – Universal Market Register
- **URI** – Uniform Resource Identifier
- **UX** – User Experience
- **WM** – Wholesale Market
- **XML** – Extensible Markup Language
- **XSD** – XML Schema Definition
- **ZTA** – Zero Trust Architecture

1 — The challenge

Current state of the flexibility ecosystem

Defined through stakeholder engagement and market research

Overview

While market-based mechanisms offer significant advantages for enabling flexibility, their full potential remains unrealised due to a fragmented implementation.

The inherent complexity of this process stems from the distinct challenges and flexibility requirements faced by each System Operator. These variations are influenced by factors such as network characteristics (e.g., geographical location, connected resources, network constraints) and their individual experience in leveraging flexibility services. Consequently, each System Operator has developed bespoke business processes and enabling systems to address their specific needs.

This variety in operational and system processes introduces complexity, resulting in limited visibility of opportunities and increased barriers to participation for Flexibility Service Providers (FSPs).

Furthermore, lack of coordination among System Operators can compound these challenges, for example, restricting the ability of flexibility providers to aggregate revenue streams and hindering an optimal flexibility outcome across national and local markets due to poorly established primacy rules.

Varying types of flexibility

Moving to a decentralised energy system increases the complexity of the network as more connected assets are both consumers and producers of energy. Flexibility as a service makes better use of those assets, but scaling flexibility becomes an increasingly difficult activity as more FSPs participate and, importantly, add more assets of varying technologies.

Electrification across transport, domestic heating, and other aspects of society will diversify the energy system connecting assets with different capacities, charge rates and utilisation patterns.

The increase in types of flexibility, combined with differing requirements from system operators when it comes to providing flexibility, leads to an exponential increase in complexity when it relates to market design (e.g. market timings and payment structures), and visibility of both opportunities to provide flexibility, and the activity within various flexibility markets at both local and national level.

Increasing flexibility

Increasing flexibility market liquidity requires a holistic and simplified approach that is easy for FSPs, with minimal friction to register, access and dispatch into markets. Transparent information regarding market and service needs and value of flexibility is required across both local and national markets.

The current lack of efficient information sharing, manifested in a complex 'many-to-many' relationship between actors, creates significant obstacles to scaling infrastructure and realising the full value of flexibility in day-to-day operations. Therefore, a robust information sharing framework is required to enable comprehensive market participation and coordinated system management.

The need for flexibility

Outlining the need and gaps in the delivery of flexibility services, products, and markets

Overview

The United Kingdom has established a clear objective to achieve 12 GW of consumer-led flexibility by 2030. Realising this ambition necessitates a fourfold increase in sector capacity within the next five years, a significant acceleration compared to the seven years required to reach the current capacity level.

Insights gathered from over 50+ engagements as part of FMU Phase 2 with Flexibility Service Providers, System Operators, and Policy Makers, validates the four programme challenges that are hindering the full realisation of flexibility potential in the UK:

1. *Market Access*
2. *Market Coordination*
3. *Information Transparency*
4. *Trusted Governance*

The impact of these constraints is evidenced by the recurring discrepancy between the required and contracted levels of flexibility. For instance, analysis of tendered versus contracted DSOs flexibility, as reported by ENA, indicates a closing gap between tendered and contracted, but an overall decrease in MWs, thereby increasing the difficulty in reaching clean power 2030.

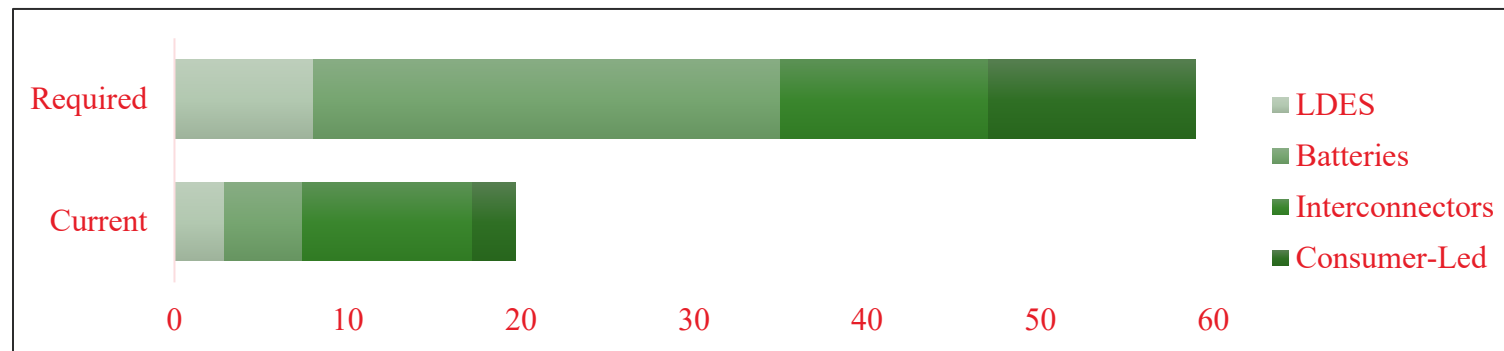


Figure 1: Outlined need for flexibility in GWs in the recent policy publications (Clean Power 2030)

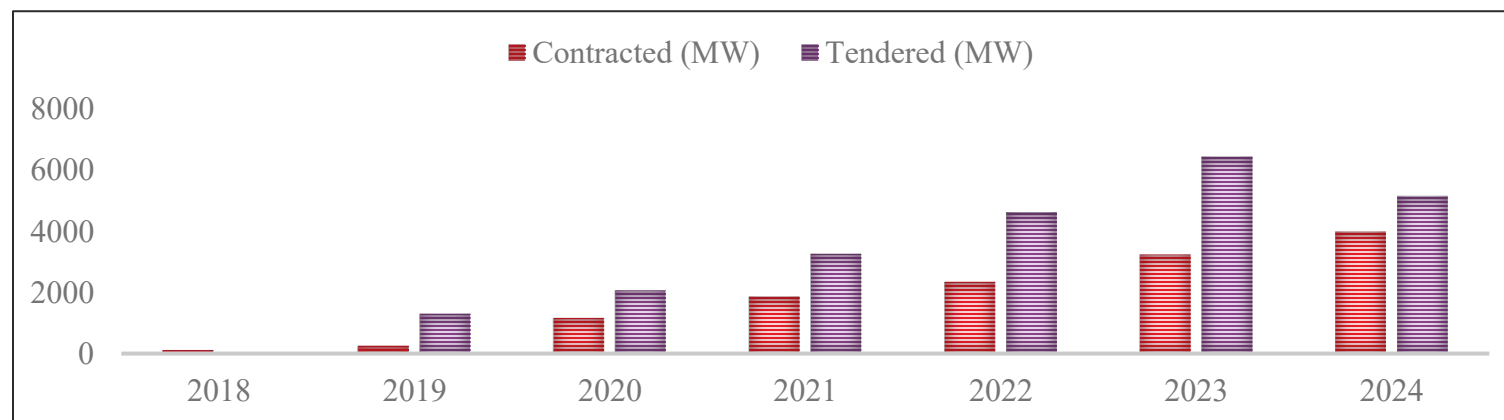


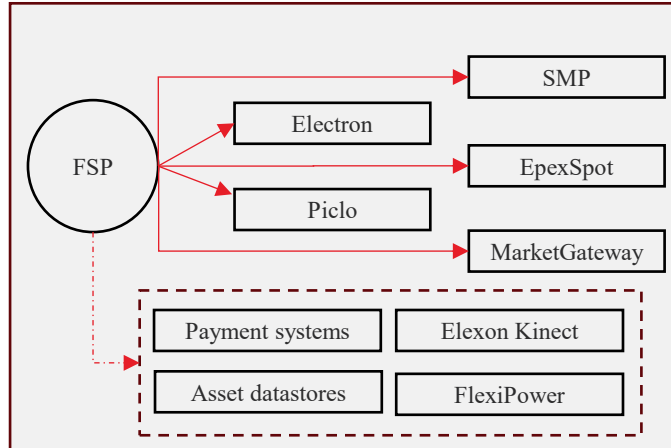
Figure 2: Showing the trend of contracted vs tendered in MWs for the local markets operated by the DSOs.

Four challenges that locks the flexibility ecosystem

Aim of FMU is to mitigate these challenges

Market access

Accessing markets and market products across various platforms is challenging FSPs due to the need to register information on multiple software platforms and understand specific qualification criteria for each market.



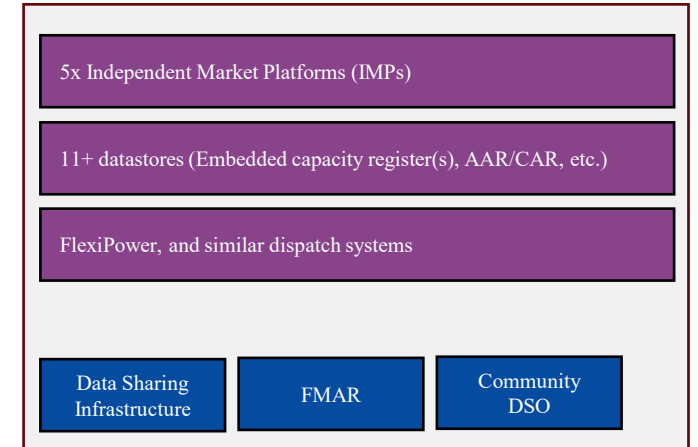
Information transparency

Information about flexibility and flexibility markets is often not interoperable, making it difficult to integrate and analyse information shared between market platforms and system operators.

Subject area	Data alignment between platforms
Commercial and Legal	
Asset	
Optimisation	
Market	
Finance	
Settlement & Reporting	

Trusted governance

High software and infrastructure diversity that makes it difficult to implement and enforce rules, causing a higher barrier to entry for FSPs, and higher costs for system operators to scale their markets, products, and services.



Market coordination

The ability to maximise the reward for flexibility providers is widely understood as being central to scaling up of flexibility, but complexity in market processes and rules inherently creates a high administrative burden for FSPs, and SOs.

National Markets	Ancillary Services	Congestion Management
Wholesale	Response	Peak Reduction
Balancing	Voltage	Scheduled Utilisation
Capacity	Thermal	Operational Utilisation
	Reserve	OU + VA
	Stability	OU + SA
Business process		
Stacking & Primacy rules		

2 — Solution

Solution overview

The solution is made of three components: Flexify, Flexibility Data Standards, and a Market Rules Test Bed

Overview

The development of the solution components was guided by the principle of supporting a federated flexibility ecosystem. This approach is designed to address user and market needs by leveraging existing technology to resolve key challenges while ensuring scalability and robustness. It also allows for seamless adaptation to market changes and the integration of future technologies efficiently.

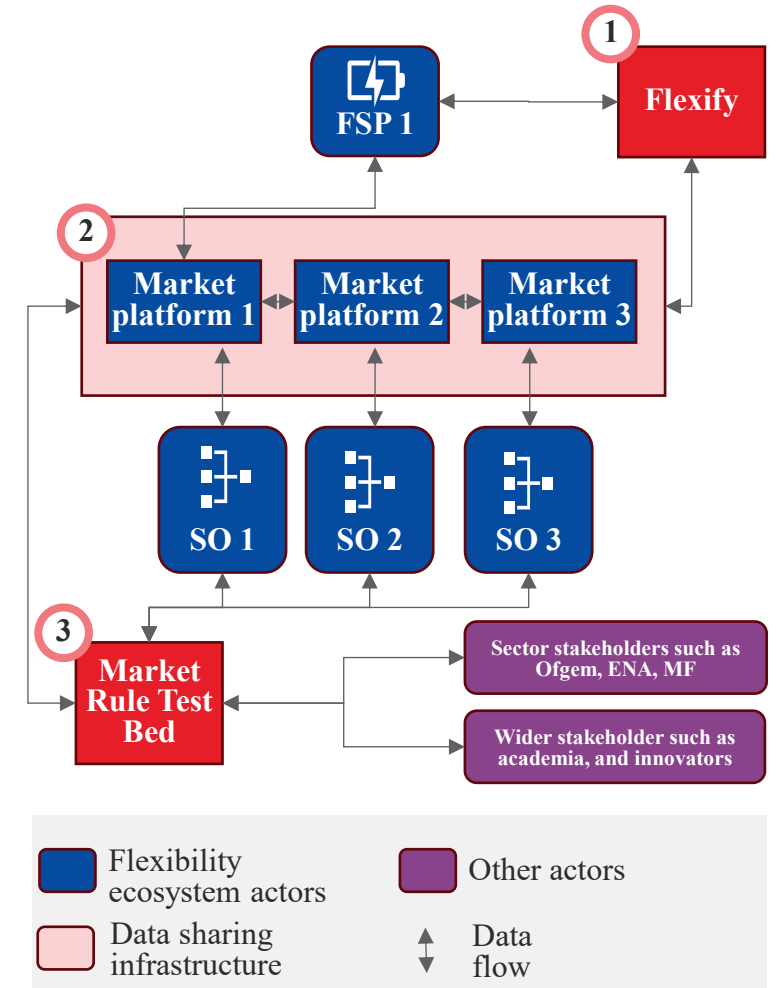
Each of the three solution components is defined by its purpose and role within the broader ecosystem, the value it delivers to users and governing bodies, the key constraints and challenges that may influence its implementation, such as regulatory requirements, adoption concerns, and technological barriers, and the potential delivery pathways for long term adoption.

For a detailed breakdown, refer to [Section 2.1](#) for Flexify, [Section 2.2](#) for Flexibility Data Standards, and [Section 2.3](#) for MRTB.

1
Flexify: an integration platform that provide a streamlined and consistent approach for FSPs to access market platforms, manage their asset across multiple platforms, guide them to new market opportunities, and provide insights both FSPs and the broader flexibility ecosystem.

2
Flexibility Data Standards (FDS): an ontology that supports scalable and assured data sharing in the flexibility ecosystem without the need to change existing system and architectures.

3
Market Rules Test Bed (MRTB): a first of it's kind market optimiser that will serve as a shared testing environment to understand the impact of proposed market rules, starting with defining economic benefits of stacking.



2.1

Flexify

Solution overview

Flexify is the response to the Universal Market Register (UMR) solution component from Phase 1

Flexify as a self-serve platform

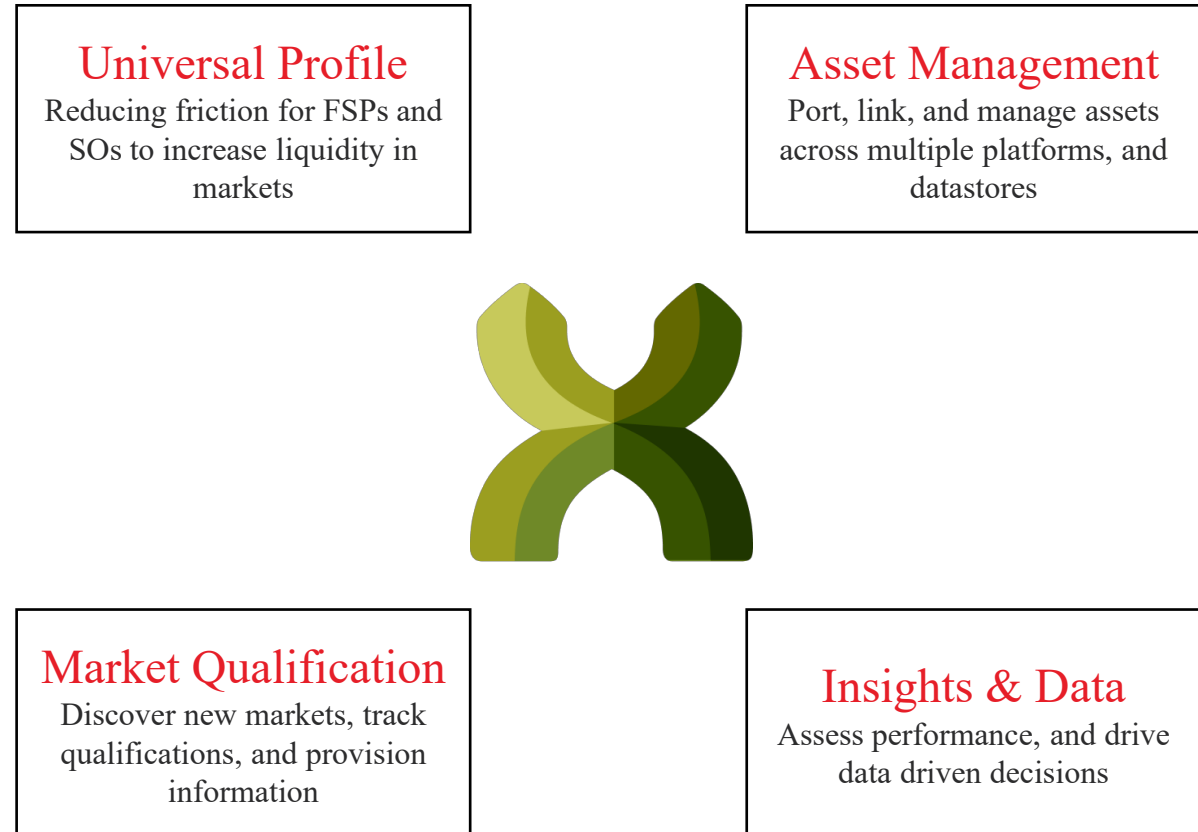
Flexify stands for '*Flexibility Simplified*'. The platform's aim is to provide a streamlined and consistent approach for Flexibility Service Providers (FSPs) to access market platforms and participate in flexibility markets. The platform lowers barriers to entry by enabling FSPs to port their commercial and technical qualification information between market platforms.

It also guides FSPs to market opportunities, highlighting the markets they could participate in and making it easy for them to qualify.

Through integrations with the market platforms and the Automatic Asset Registration (AAR) innovation project, Flexify will provide summary analytics to both FSPs and the broader flexibility ecosystem.

There are four core features to the Flexify platform which respond to the programme's identified challenges of market access, information transparency, and trust and governance, as described to the right.

For phase 2 of FMU a proof of concept of Flexify has been built with all development and platform integrations taking place in sandbox environments.



Flexify development

Developing Flexify in alignment with TOGAF and best practice design principles

Overview and principles

Flexify has been developed in line with best practice design approaches with clearly established design principles and different levels of architecture developed to express different components of the solution considering business, data, application and technology in line with TOGAF architecture development. See [Appendix B](#), for a detailed outline of the platform design process.

Architecturally, principles were established to guide the development through options assessment, ensure long term viability of the platform and ensure the platform is designed securely. A summary of the principles are set out below and can be found in [Appendix B.1.3.1](#).

General & design principles: Domain ownership, self-serve data platform, event-driven architecture, make data accessible, data as a product, alignment with data best practices.

Application & technology principles: Make applications scalable, pilot new applications and processes, use open standards and open source, use UK or EU data centre hosting.

Security principles: Zero trust architecture (ZTA), alignment with NCSC best practice and guidance, compliance with relevant legislation and regulations.

Requirements and design

A user-centred design approach has been implemented where the focus has been on understanding user requirements through identification of different personas, engagement, iteration of the design based on feedback and a focus on usability and inclusivity. The design approach has been set out in [Appendix B.1.1](#).

Process maps were used to identify the user actions that Flexify would need to support. These process maps identified the user interactions with the platform as well as the data attributes required at each step. The output of these process maps was a consolidated set of user requirements shown in [Appendix B.1.2](#) as well as the development of the information architecture.

The look and feel of the platform was also developed in parallel to the process maps and user requirements. Platform branding, name and colour palette were defined and developed into a brand kit.

The combination of the process maps, requirements, information architecture and brand kit were fundamental in developing the platform wireframe, shown from [Appendix B.1.1.1](#) onwards.

Architecture

The development of process maps and information architecture represent the business and data architectures of the solution while the application and technology architectures were represented through the logical and physical architectures.

The logical architecture represents the application components of Flexify. Three levels of architecture were developed Level 0, Level 1 and Level 2+ with each level representing a more detailed view of the architecture components and their sub-components. Each component within the architecture has a unique ID, name and description and further information can be seen in [Appendix B.1.3.2.1](#).

The physical architecture represents how the solution components are delivered through specific technologies. The physical architecture is described showing the structure of key applications and the connections between them. The technologies supporting key components are also described under the categories of infrastructure, application and storage. Further information is shown in [Appendix B.1.3.2.2](#).

Security considerations have also been developed and are shown in [Appendix B.1.3.3](#).

2.1.1

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Solution details

Universal Profile

Organisation level validated identity

Overview

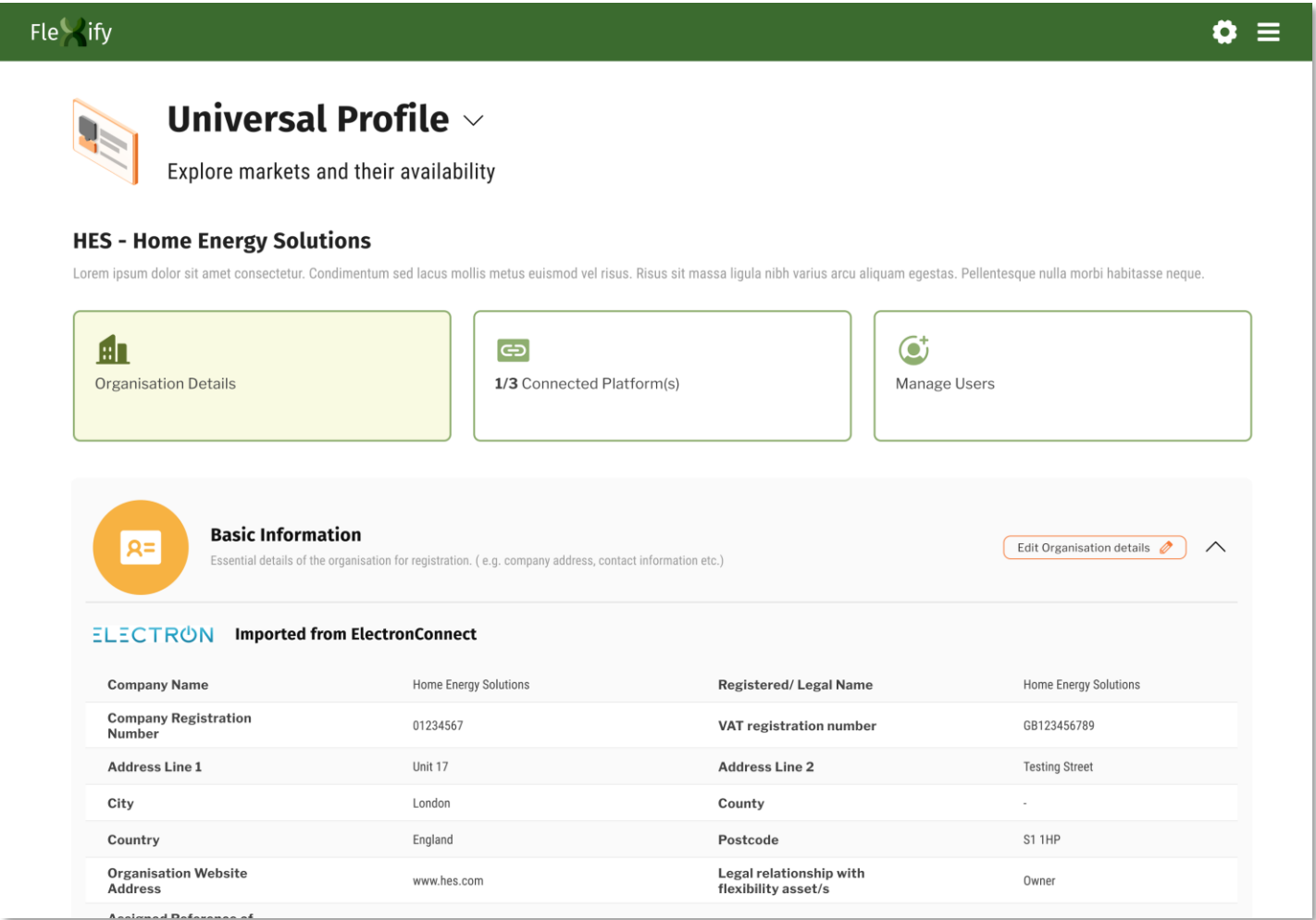
The Universal Profile provides FSPs with a streamlined approach to accessing market platforms and an ability to share information across market platforms.

In this phase integrations have been built between Flexify and Electron Connect, Piclo Max and NESO’s SMP so that a single organisation has a common profile across all platforms and can authorise the sharing of information between Flexify and the platforms, and vice versa.

This capability provides FSPs with streamlined and secure access to various digital platforms in the ecosystem and allows them to securely share their organisation and asset information between platforms.

Integration with the full suite of market platforms is a key future ambition and further development would include organisation level validation, role-based access control and multiple users/multiple organisations relationship mapping.

The user journey processes and wireframes are detailed in [Appendix B.1.1.1 Universal profile](#).



Universal Profile

Organisation level validated identity

Overview

For the proof of concept, a secure and scalable Universal Profile component for Flexify has been designed, using each platform's IDP for authentication.

While users don't have SSO across platforms, they can perform cross-platform actions through Flexify.

- We adopted a federated IDP approach to minimise disruption, utilising existing platform APIs and authentication methods.
- Platforms retain control over their permissions, with users able to map them to their Flexify accounts.
- Flexify allows users to set multiple levels of platform access per connection, for individuals or user groups within their organisation.

Design considerations

We propose two approaches for cross-platform integration: a central IDP operated by Flexify and federated IDPs managed by each platform. These approaches vary in the level of involvement required from platforms, users, and Flexify, and both allow platforms to choose which method(s) they wish to support.

Both options enable users to connect their accounts across platforms and perform cross-platform actions, such as transferring asset data between platforms, with Flexify acting as the intermediary.

Both methods utilise widely accepted authentication protocols (OAuth and OpenID Connect), ensuring security and seamless interoperability with future digital infrastructures, including the Consumer Consent Solution and Data Sharing Infrastructure.

Platforms retain full control over their role-based access controls (RBAC), with Flexify not assigning roles or permissions to users.

Built for future

Post-PoC, Flexify will authenticate users with each platform's IDP on behalf of user groups.

For platforms offering their own IDP alongside Flexify, or those not supporting Flexify for authentication, users will authenticate directly through the platform's IDP.

Platforms can integrate Flexify as an authentication option, either alongside or in place of existing methods, enabling users to sign in with their Flexify identity for a single-sign-on experience across platforms. This identity will also allow users to sign into Flexify and perform cross-platform actions.

Flexify will notify users if they lack sufficient permissions for an API call, guiding them to request the necessary access from the platform.

Additionally, Flexify admin users can configure platform connections for user groups, aligning these groups with platform-specific roles and permissions.

Asset connection service

Management of flexibility assets across platforms

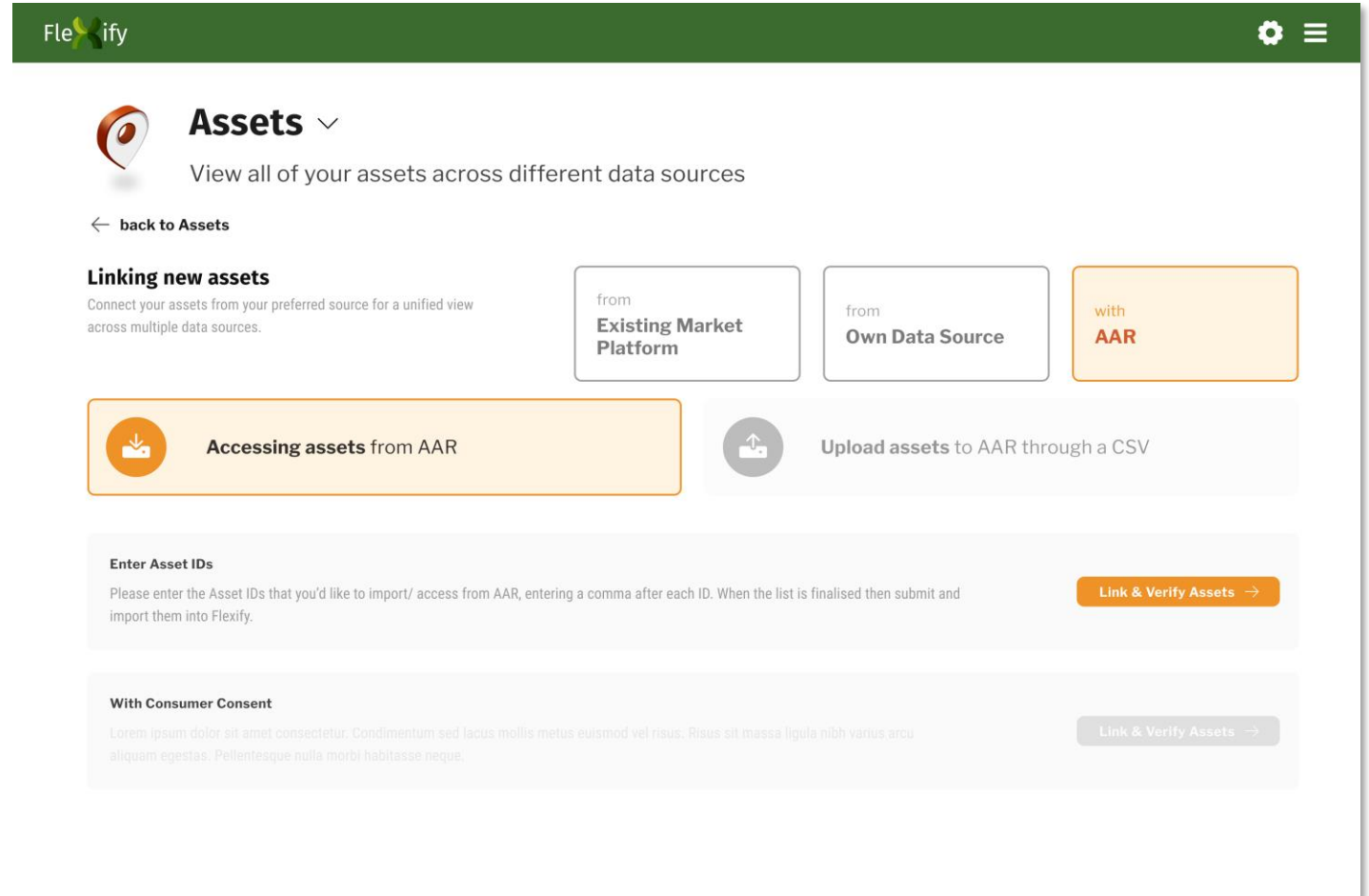
Overview

The asset connection service support FSPs in managing their asset information, allowing them to access the information from multiple sources and then “port” that information to their desired target location.

Flexify has integrated with AAR’s test environment, demonstrating how FSPs can link the assets they manage to their UP and then identify target market platforms to port their asset information to. The target platforms that have been integrated with for the proof of concept are ElectronConnect and NESO’s SMP.

Assigning a unique asset ID, Flexify develops a map of asset information that identifies where data has been sourced from and where it has been ported to. If changes are made to the asset, Flexify can support the updating of asset information across the platform ecosystem.

Future development would see integrations with the full suite of market platforms as well as FSPs’ own asset data sources. The user journey processes and wireframes are detailed in [Appendix B.1.1.2 Asset connection service](#).



Connection service

Enabling commercial and technical data exchange

Overview

To enable the Connection Service, Flexify will integrate multiple IMPs, platforms and datastores with different data schemas & requirements for organisations and assets while interacting with the Data Sharing Infrastructure.

Therefore, Flexify must:

- Connect and link data from source (IMPs, AAR, own source)
- Translate data from source to the agreed standard (based on the Flexibility Data Standards or FDS), while exposing certain attributes to the user
- Validate linked data against any existing data by conducting a duplication check as well as flagging any detected errors
- Assign a digital certificate or Unique Identifier (UID) to allow for persistency across Flexify and the relevant data sources

Design considerations

Flexify aims to maintain a source of truth across time and platforms, without relying on a monolithic database.

The connection service therefore allows users to manage their data, ensuring completeness and compliance with the FDS, but not determining data accuracy. Flexify will flag missing, duplicate, or erroneous data, while users are responsible for keeping their data updated and choosing their source of truth.

This approach enables seamless exchange of commercial and technical information, supporting trusted data governance and scalability of the flexibility ecosystem.

To achieve persistent mapping, Flexify:

1. Creates and persists organisation and asset IDs
2. Stores a subset of asset data (see page 85)
3. Maintains cross-platform mappings for other attributes without storing them centrally.

Built for future

For the Flexify proof of concept, the platform enables users to link assets from AAR, view their total asset list and port assets to the SMP platform.

In the future, Flexify will allow users to filter assets, discover asset data & insights as well as link and port assets to additional platforms.

Additional future work will include:

- Validate linked asset data against any existing asset data by conducting a duplication check as well as flagging any detected errors
- Connecting the FDS to Flexify to enable a generalised data mapping
- Two-way integrations with AAR to register assets via Flexify.
- Integrations with the future Consumer Consent solution to enable seamless evidencing of consent to operate assets
- Integrating to the DSI providing FSPs with a mechanism to share all technical information between source and target locations.

Market qualification

Supporting FSPs to access markets

Overview

The market qualification service supports FSPs in accessing markets and their opportunities by signposting which markets are available on which platforms and the qualification status of the FSP and their assets in that market.

The market list and individual market qualification pages provide FSPs with an overview of all operating flexibility markets and allows them to explore the details of the market to understand additional market entry requirements, which platform they can access that market through, the services and opportunities that the market is providing, as well as their own qualification status within that market.

The future capability of this service could support streamlined market entry processes, reusing market entry information from one market to support entry into a secondary market, FSP or Market Operator performance ratings, and management of a collection of assets into units for market qualification.

The user journey processes and wireframes are detailed in [Appendix B.1.1.3 Market Qualification](#).

The wireframe shows a user interface for the 'Flexify' platform. At the top is a green header with the 'Flexify' logo and a settings menu. The main section is titled 'Markets Qualification' with a sub-header 'Explore markets and their availability'. A 'back to Markets Qualification' link is present. The featured market is 'SSEN', with a description: 'SSEN procures flexibility services from generators, storage systems, and aggregated consumer energy to efficiently manage network constraints, optimise capacity and support a reliable electricity supply.' Two boxes show '3 Qualified Services' and '5 Total Services'. Below this is a 'Qualification Status' section with a message: 'You have qualified for 3/5 available SSEN services. Please provide outstanding details below to complete qualification.' It includes a 'Qualify through:' button for 'ELECTRON' with the text 'Enter Market Platform'. The qualification details are split into two columns. The left column contains 'Organisation Qualification' (In Progress), 'PQQ Information' (Completed), and 'Org Registration' (Please register your organisation). The right column contains 'Assets Qualification' (Not Qualified) and a box showing '25 Assets available in this market'. An 'Additional Requirements' section is at the bottom left.

Insights & data

Using Flexify data to deliver insights.

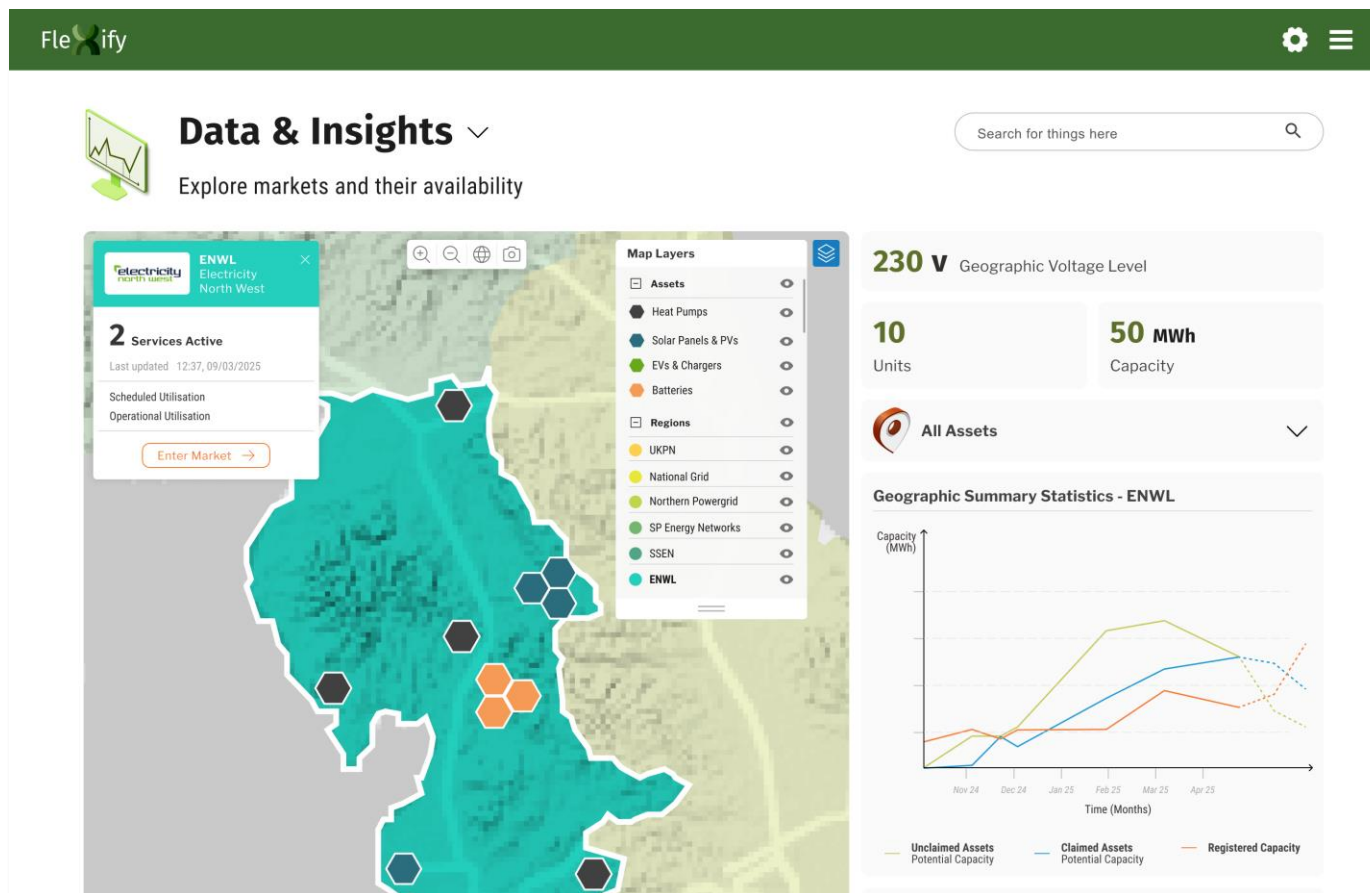
Overview

The insights and data service will make the platform's data accessible for various purposes, both within the platform and via API.

Flexify will maintain valuable data for the flexibility ecosystem, including an overview of FSPs, their market registration status, the number of assets associated with their profiles, and the market status of these assets. Integration with AAR will also provide a view of total installed assets not yet associated with an FSP.

This data can be utilised to deliver insight services to FSPs and system operators. For FSPs, analysis could include data on market share, broken down by geographic region, technology type, and voltage level. System operators could access information on total potential or upcoming capacities.

Further consultation is required to determine the granularity of the data, considering GDPR, commercial, and market operation considerations.



2.1.2

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Value assessment

Flexify as IPaaS (Integration Platform as a Service)

Summary of the value that Flexify provides as an integration platform for the whole flexibility ecosystem

Overview

IPaaS (Integration Platform as a Service) enables seamless connectivity and data exchange between disparate systems. As outlined in [Section 2.1.1](#), Flexify provides a ‘connection service’ that serves as the foundation of its value proposition. This service facilitates the definition, development, execution, and governance of integrations and data flows between various flexibility platforms and central databases.

By leveraging these integrations, Flexify delivers value to its users through a Software as a Service (SaaS) model, encompassing the four key features detailed in [Section 2.1.1](#). Each SaaS offering delivers distinct benefits to both FSPs and sector regulators and policymakers, as discussed in [page 30](#).

A key distinction to note is that while IPaaS functionalities can support additional capabilities, all SaaS features are inherently dependent on IPaaS. The delivery models for Flexify – whether as an IPaaS solution or as a combined IPaaS and SaaS offering – are further outlined in [Section 2.1.4](#).

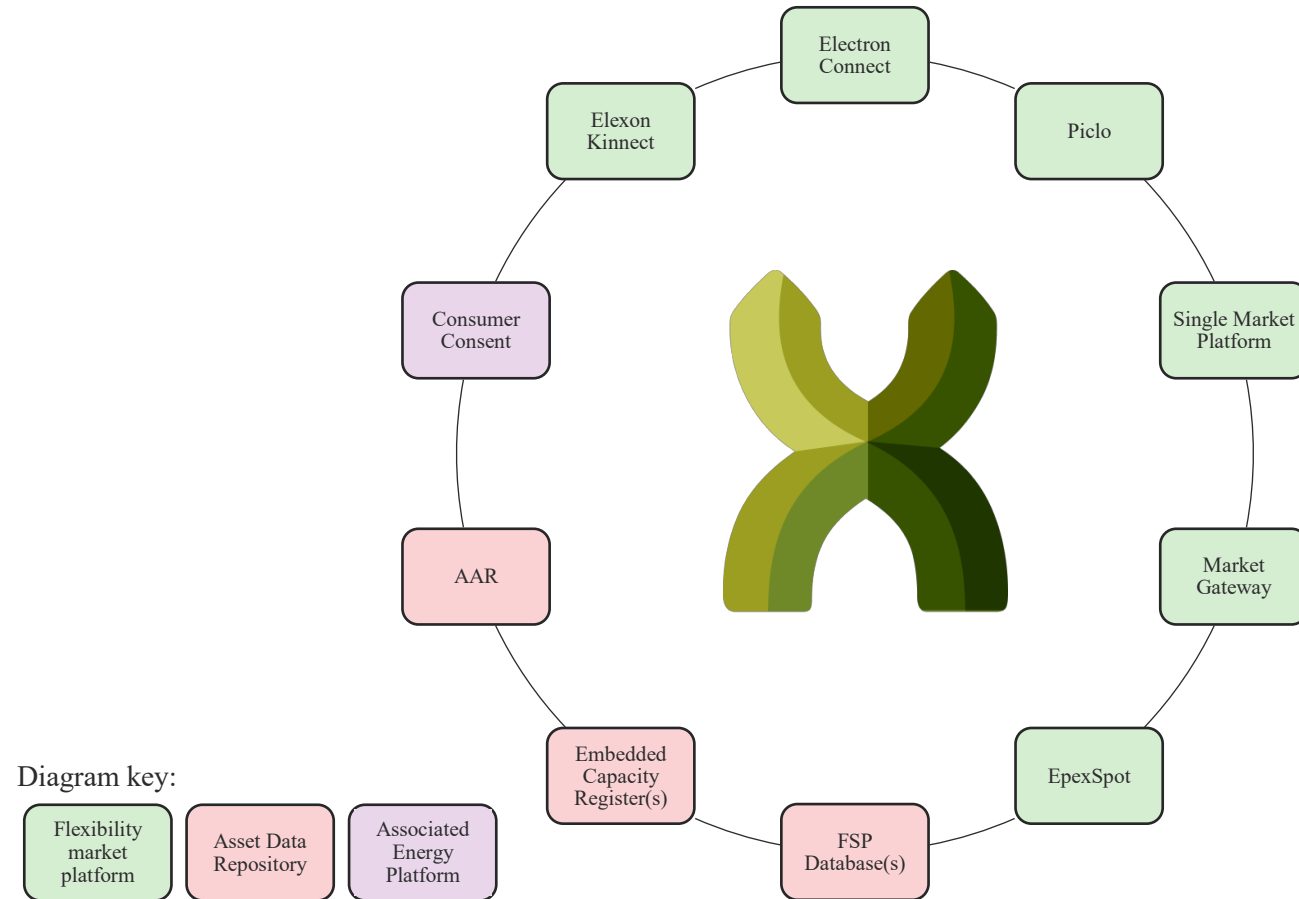


Figure 3: Future view of the integrations Flexify can undertake

Value of Flexify

Benefits for FSPs, regulators and policy makers, and the DSI

Flexibility service providers

Benefit for FSPs is delivered through three areas.

1. Time reduction and administrative costs
2. Opportunity identification
3. Faster time to market

The greatest benefit is achieved through opportunity identification as Flexify provides insights to FSPs on potential opportunities and how to leverage assets across multiple markets, which in turn should support increased competition and market liquidity.

Value is also expected through faster time to market as the platform and market registration processing time is reduced and the process is simplified.

Lastly, it was recognised that Flexify could unlock wider flexibility system benefits identified within the Smart Systems and Flexibility Plan.

Overall, it is estimated benefits could range from £10m to £12m a year by 2035 by increasing competition and market liquidity through reducing the burden on FSPs associated to market access. For a detailed breakdown of the value and benefits to FSPs, see [Appendix B.3](#).

Regulators and policy makers

For regulators and policymakers, Flexify offers a comprehensive data aggregation and mapping capability across IMPs and central datastores. This enables the delivery of actionable insights and analytics through flexibility data aggregation, facilitating qualitative decision-making and the development of whole-system business intelligence.

Notably, this intelligence is achievable within existing regulatory frameworks, leveraging current licenses, codes, and sector responsibilities, thereby mitigating the need for new agreements. A detailed evaluation of relevant sector codes, licensees, and processes is provided in [Appendix B.2.3](#).

The value of the business intelligence is shared with the next solution component, Flexibility Data Standards. While Flexify provides the essential data integration and mapping across the ecosystem, FDS establishes a standardised data language, ensuring seamless interoperability.

For a detailed breakdown of the value and benefits to System Operators, Regulators, and Policy Makers, see [Appendix B.3 Value for sector regulators, and policy makers](#).

Flexibility use case for the DSI

The Data Sharing Infrastructure (DSI) is an initiative led by NESO. As part of its development, Ofgem has identified flexibility as a key use case for building the minimum viable product (MVP) functionalities.

The DSI provides an open-source Data Preparation Node (DPN), enabling users to deploy APIs or Pub/Sub data exchange capabilities. To utilise the DPN, users must first standardise their data, treating it as a product before sharing. The Flexibility Data Standard (FDS) serves as the standardisation mechanism, ensuring consistency and interoperability across the ecosystem.

While the FDS enables the effective use of the DSI, an integration platform is required to fully support the flexibility use case. This platform processes data streams from the DSI, mapping information across the ecosystem while preventing duplication and ensuring alignment with specific use case requirements. These requirements include flexibility product definitions, market coordination, and energy optimisation.

2.1.3

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Constraints, dependencies, and enablers

Constraints, dependencies, and enablers

Overview of the current initiatives, policies, and organisations that could impact the adoption of Flexify

Constraints

Flexibility Market Asset Registration (FMAR)

FMAR is a policy area under the umbrella of the Market Facilitator, which sets out 10 functional outcomes. Initial assessments suggests Flexify can meet 5 out of 10 outcomes and can be developed further to meet all the functional outcomes. See [page 33](#) for more details.

Common sharing contracts

Flexify will require organisations to share key end user and corporate data to allow for the business and information layer interoperability across different market platforms. There are two pathways available:

- Data sharing agreements are developed by advisory groups with engagement of all parties to align on common terms and conditions.
- Data sharing is mandated by the regulator. This poses a risk of slower compliance and potentially limiting innovation in the future.

These contracts will define the extent of the business interoperability, see [Appendix B.4.2](#) for the proposed methodology for realising greater value.

Dependencies

Definition of flexibility products

The definitions of flexibility products provide the details of organisational and technical qualification information. Flexify has codified existing product information, as part of the market qualification feature. See [Appendix B.1.4.3](#) for details on local and national market qualifications.

On-going policy-developments that can affect these product definitions are a dependency because any changes to the existing design will require further development to update the features of the platform.

Data pipelines with all platforms

Flexify platform needs to integrate with all market platforms for its full value to be realised; therefore, there is a dependency on all System Operators and Market Platform providers to commit resources to build these pipelines and keep them functioning. For the next phase of the programme, other digital platforms should be integrated with Flexify including Elexon Kinnect, Market Gateway, and EpexSpot, and if required, FlexiPower.

Enablers

Automatic Asset Register (AAR)

An innovation programme that has built an asset register. This solution integrates with Flexify as the datastore for asset information. Flexify will not store the asset information itself but will only store the metadata to identify the 'source of truth' for asset information. For Flexify, the asset register is a key enabler, providing functionality that Flexify requires but does not offer as an internal feature.

Data Sharing Infrastructure (DSI)

Flexify is a user of the DSI, acting as a node that can utilise its functionalities to enable data exchange between Flexify, market platforms, central asset datastores, and consumer consent. While DSI isn't essential for operations, its use will add resilience, deliver scalable data pipelines, ensure security and allow integration with further services such as consumer consent.

Relationship to FMAR

Flexify + AAR as the tools to deliver the needs outlined in the FMAR consultation

Overview

Ofgem’s consultation on FMAR aimed to gather stakeholder input on developing a common registration system for flexibility assets with the purpose of integrating distributed assets like electric vehicles, heat pumps, and domestic battery energy storage systems into flexibility markets.

The consultation focused on establishing common processes and digital infrastructure for asset registration, ensuring seamless participation in both local and national markets. It also outlined key design principles for the platform and identified ten functional outcomes essential to its development. These outcomes have been systematically mapped to assess how Flexify and AAR can support and achieve them. See [Appendix B.2.3 – Alignment with FMAR](#) for further details.

Fully achieved through Flexify

Almost fully achieved through Flexify

Partially achieved through Flexify

Not achieved through Flexify

FMAR functional outcome	Through Flexify + AAR	Justification
1. Single master data record		Enabled by providing a continuously updated mapping of data across multiple systems, platforms, and datastores; with AAR acting as a datastore for capturing asset data that are not yet participating in markets/products.
2. Unique ID		Flexify maps unique asset ID assigned to each asset across multiple platforms, allowing it to track updates and/or changes to a specific asset across the all-digital platforms.
3. Data quality		Flexibility Data Standards implemented through Flexify support scalable and assured data sharing in the flexibility ecosystem, and AAR providing the means of checking data with OEM databases, installer records, and consumers energy management systems.
4. Appropriate collection points		Flexify supports collection of asset information from Independent Market Platforms, and AAR has features for owners and installers to share their asset information.
5. Common data access		The mapping of data across different sources provides the opportunity to enable common data access for all stakeholders, but further analysis is needed to understand the information security parameters.
6. Data exchange mechanisms		Flexify exchanges data between multiple data sources, but further analysis is necessary to understand FMAR data exchange mechanism requirements and if these align with what has been developed for Flexify.
7. User Experience		Designed to meet needs of system users, incorporating accessibility principles.
8. Consumer Consent Framework		Consumer consent has been considered within the design; however, this needs to be considered further in the MVP through engagement with ReCCo.
9. Integration with wider systems		Designed using similar principles and existing processes from energy sector initiatives; therefore, it can be integrated with DSI and Consumer Consent platforms.
Non-functional requirements		Further evaluation is required of how a trust framework would be implemented across all system operators.

2.1.4

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Delivery pathways for Flexify

Potential delivery pathways

Three possible delivery models have been explored for implementation of Flexify

Option	Description	Cost assessment	Revenue
1. Long term commercial contract (see Appendix B.2.1.1 for more details)	In this option it is presumed that the overarching direction and accountability for development and operation of Flexify is undertaken by a separate organisation/industry body (referred to as ‘The Client’), however, the Flexify service is tendered to a commercial entity through a long-term contract.	Additional costs would be required to develop Flexify to Minimum Viable Product (MVP) based on the Client’s requirements and therefore are not estimated at this point in time. Following development of the MVP, personnel, technical and operational costs would be required to deliver Flexify. Operating costs for the MVP are estimated annually to be between £1.28m and £1.32m, full details of the build up of these costs are included within Appendix B.2.1.1.	- Flexify would receive a licencing fee from the client for the duration of the contract. - For additional Flexify development beyond the MVP, additional charges would be incurred by the platform in alignment with the contract terms; these costs would be passed onto users.
2. Flexify is sold post MVP (see Appendix B.2.1.2 for more details)	Under this option, Flexify is developed to the MVP and then is sold. For Flexify to be sold there will need to be a robust business proposition, underpinned by sufficient revenue streams which will be dependent on actual and expected uptake onto the platform.	Costs associated with MVP development will be required. As this will be based on the buyer’s requirements, these costs are not estimated at this point in time	Revenue streams would be determined by the buyer but are likely to be either the revenue streams achieved under Option 1 or 2.
3. Consortium as required under the Innovation Programme (see Appendix B.2.1.3 for more details)	Under this option, Flexify is developed and operated by the existing Consortium as a commercialised offering in line with wider market and regulatory reforms.	Costs associated with MVP development will be required, these costs are not estimated at this time as further stakeholder engagement is required. Following development of the MVP, personnel, technical and operation costs would be required to deliver Flexify. Operating costs for the MVP are estimated annually to be between £1.95m and £2.02m, full details of the build up of these costs are included within Appendix B.2.1.3.	Flexify would offer licences for access to the below parties: - A license fee for System Operators (i.e. NESO/DNOs) for base access and then a separate subscription fee for the insight offering. - A license fee for FSPs for base access and then a separate subscription fee for³⁵ the insight offering.

Delivery timeline

The roadmap for further developing Flexify through alignment with on-going sector initiatives

Overview

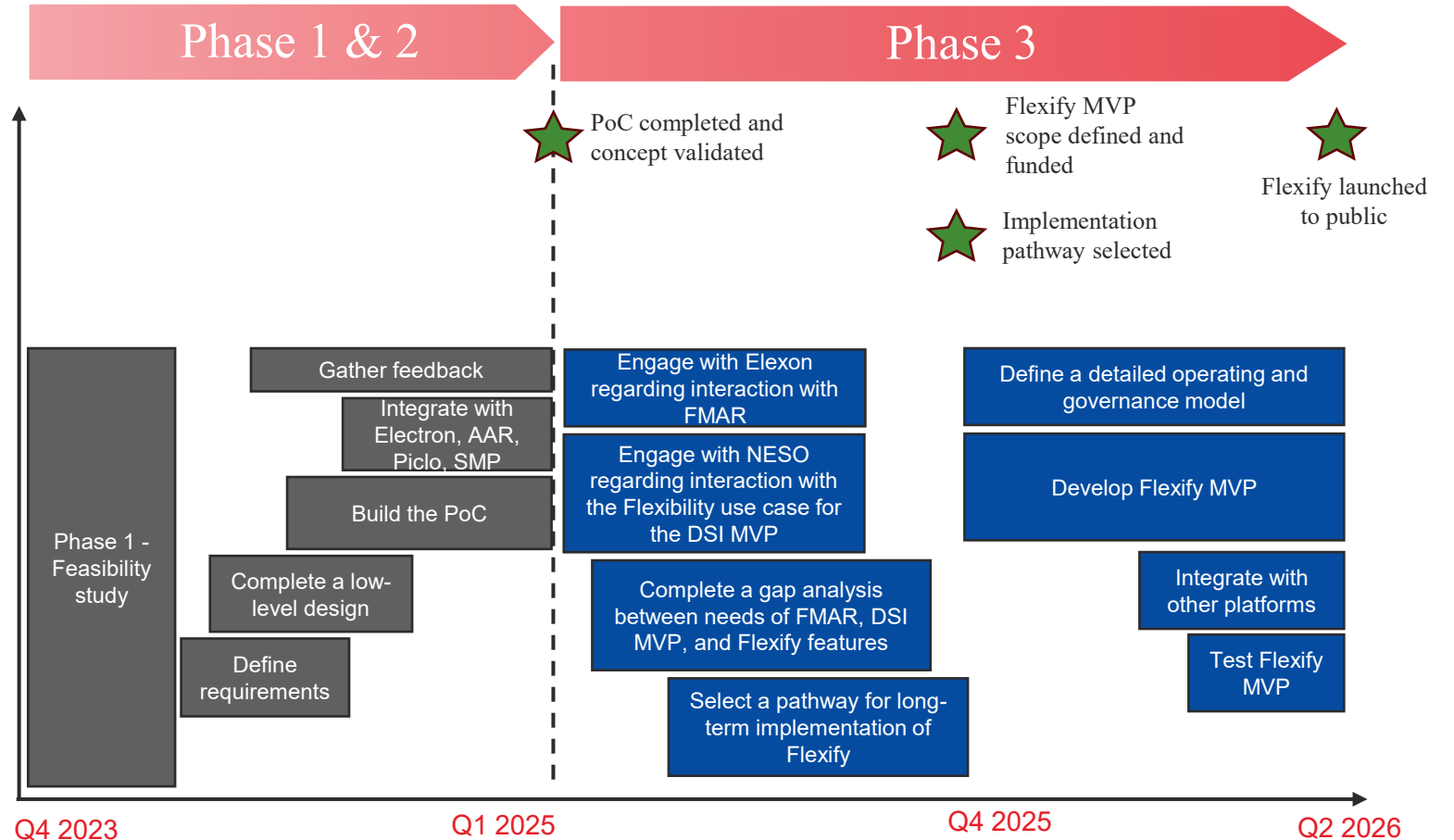
The successful delivery of Flexify is highly dependent on ongoing consultations before a definitive pathway can be established. As a result, the timeline is divided into two stages:

Stage one: Sector engagement & strategic alignment

Stage one focuses on engaging with key stakeholders to assess the alignment between Flexify, FMAR, and the Flexibility use case for the DSI MVP. These engagements will play a critical role in shaping the commercialisation strategy for Flexify. A primary area of discussion will be the scope and legal frameworks required to establish and maintain long-term integrations with Flexify, ensuring sustainability and interoperability within the broader energy ecosystem.

Stage two: MVP development & deployment

The second stage involves the development of Flexify, guided by a gap analysis conducted in stage one. At a minimum, this phase will ensure the platform is built with Critical National Infrastructure (CNI) security considerations and expanded integrations with outstanding market platforms. Stage two will conclude with the public launch of Flexify, supported by a fully funded, long-term operational model.



2.2

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Flexibility Data Standards (FDS)

Solution component overview

Standards that will support scalable data sharing across the flexibility ecosystem

Overview

Flexibility Data Standards (FDS) introduce standards for registration and market participation, promoting visibility and sharing of assets, markets, products, and settlement data, including specification for the interactions between flexibility market actors.

FDS has been logically modelled through a 4D ontology approach, extending the Information Exchange Standard 4 (IES4) with domain-specific additions to include attributes identified in the FDS logical data model.

The FDS ontology is designed to support shared vocabularies and standards that enhance data interoperability. By aligning with existing standards like IEC's (Common Information Model) CIM, the FDS ontology ensures seamless integration with industry-wide tools and datasets.

This alignment facilitates efficient data exchange and interoperability among diverse systems, allowing them to map their internal data structures to the IES format at the system boundary. This approach helps maintain business agility and reduces maintenance costs associated with point-to-point interfaces.

Implemented scope

Data Mapping

A data mapping exercise was completed to define the minimum required data products, attributes, types, and formats across markets, products, and platforms. A gap analysis of data attributes across SMP, ElectronConnect, AAR and Piclo Max platforms was conducted to identify overlaps and gaps (see [Appendix C.1.2](#)). The local and national market qualification criteria were also aligned with FDS data (see [Appendix B.1.4.3](#)).

Data Translation

A translation system was developed to facilitate the exchange of data between different parties and systems and demonstrate the FDS ontology functionality. It allows for systems to maintain their own data structures and formats while interfacing with other systems via common exchange formats (JSON, XML to RDF-compliant) (see [Appendix C.2.1.2](#)).

Data Validation

A process was developed using SHACL rules to verify data types, object relationships, and cardinality in exchanged payloads, while allowing flexibility for systems to map their internal data formats to the ontology without enforcing collection requirements (see [Appendix C.2.1.3](#)).

Partial Ontology model

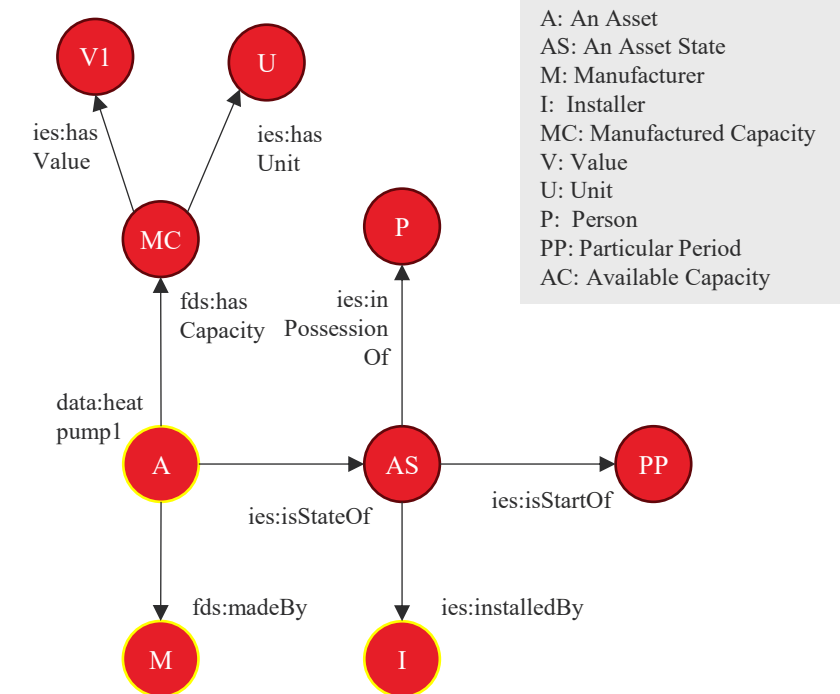


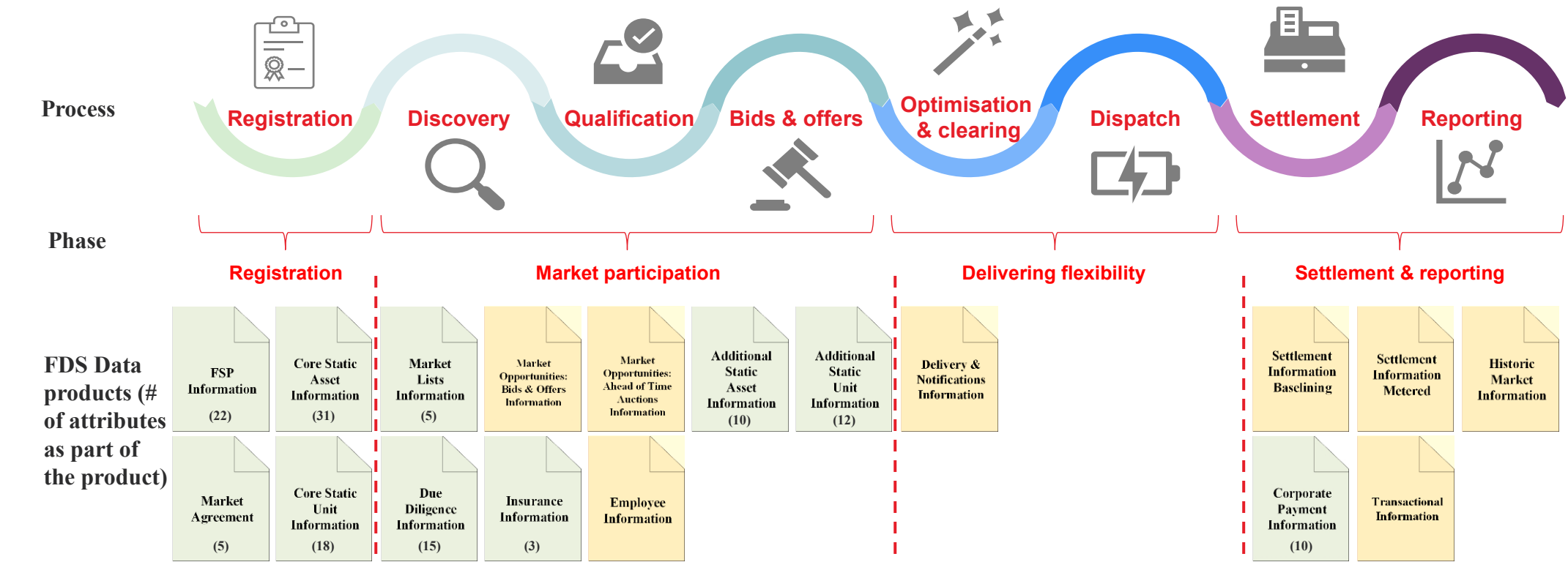
Figure 3: Ontology model indicating IES extension to include asset states and FDS data attributes

FDS data products

Identifying the FDS data products and attributes reviewed

FDS Data Products

The data products reviewed are highlighted in green below and indicate the number of attributes identified. Following a comprehensive review of AAR, ElectronConnect, SMP and Piclo Max documentation the data mapping exercise was completed and defined the total number of data attributes to be **131** (see [Appendix C.1.2](#) for further details). The data products highlighted in yellow were not included in the analysis and require further investigation to be carried out in a future phase of work from Q2 2025 onwards.



2.2.1

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Value assessment

Enabling information transparency

Integration of data from multiple systems to enable business intelligence

Overview

Greater insights and visibility of assets, products and organisation behaviour is required to enable information transparency between SOs, FSPs, regulators and investors participating in flexibility markets.

FDS ontology can enable said insights for sector regulators by:

1. Enabling interoperability using standards and data models for sharing information
2. Supporting oversight of flexibility ecosystem technology, data, and operations

This solution will define key data standards which will be used by an enabling technology, such as DSI, to facilitate interoperability between market actors.

This will provide a mechanism for unlocking data to enable whole-system business intelligence, supporting policy makers to convert the vision for flexibility markets into a market coordination delivery plan, including monitoring and advisory for all related aspects.

It starts with system information stored in multiple disparate platforms. Through the ontology, the system data is converted to an RDF (Resource Description Framework) which allows the data to be aggregate in form of a graph. The graph structure allows for business intelligence by enabling machines to understand the Content of the data, and answer questions associated to the aggregated data.

Lastly, it will allow SOs to migrate their data to different market platform providers, depending on their needs. This ability to switch could in turn increase competition in the platform market and drive the utilisation of greater innovative technologies and solutions.

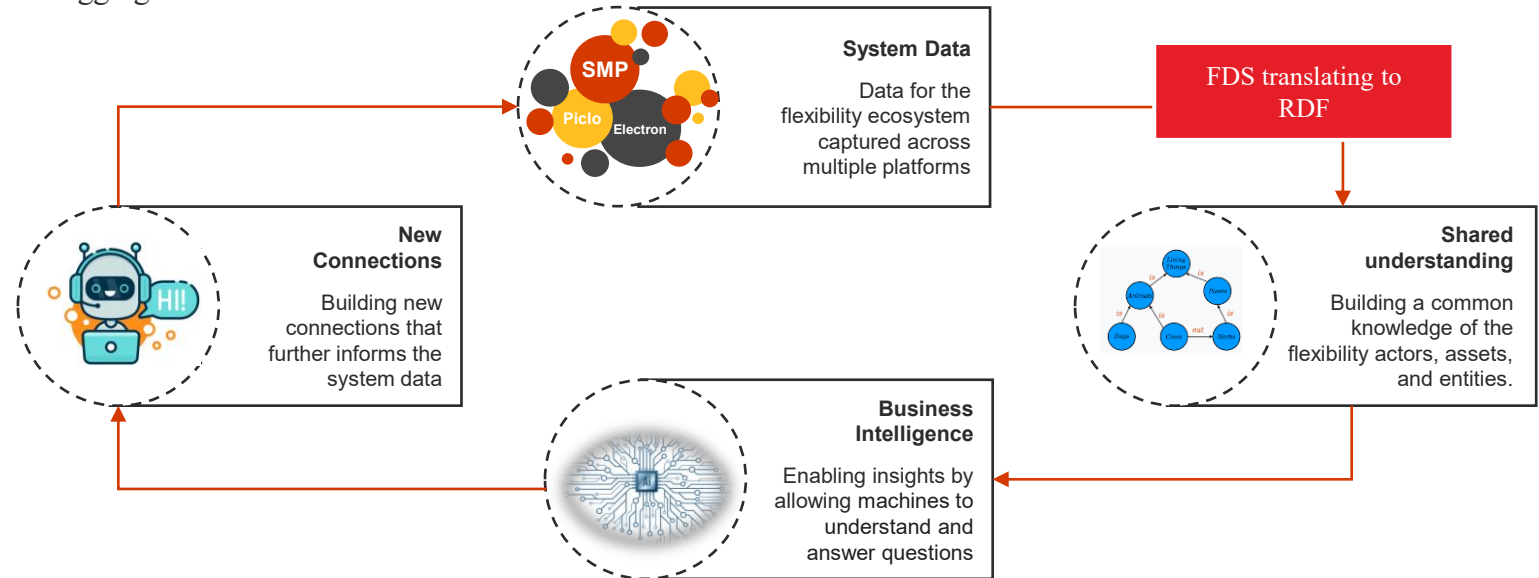


Figure 4: Virtuous cycle that will build a shared understanding of the flexibility ecosystem

Scalable exchange of data

Achieving interoperability for data exchange without the burden of updating existing system

Overview

Alongside the integration that were completed as part of Flexify, the data standard integrations were undertaken to showcase the benefits of using an ontology. Flexify acts as the first use case and defines the effort, constraints, and risks associated with Flexibility Data Standards.

Flexibility Data Standards allow for a scalable exchange of data between the market platforms. To evidence the scalable value, development team for Flexify completed two mapping scripts. One that creates 1-2-1 pipelines between AAR to Electron, and AAR to SMP.

Second that creates pipelines using AAR to FDS, Electron to FDS, and SMP to FDS. As defined in [Appendix C.2.1.3](#).

The ontology mapping evidenced the reduction in mapping effort by 3-fold. Within Flexify, without the ontology, 1-2-1 mappings development accounted for ~200+ man-hours of effort.

With the ontology the effort was reduced to 40 man-hours, showing an 80% reduction in effort. In addition, it evidenced the reduced effort in continuously updating the mapping and ontology, requiring only 1 script to be updated when new attributes were added.

Secondly, this approach does not require changes to existing systems. The data conversion sits outside the system boundary; thereby, making the adoption of the standard easier. See [Appendix C.2.1.2](#) for more details.

Lastly, this approach and technology stack aligns with the requirements of the Data Sharing Infrastructure. DSI requires an aligned ontology to support exchange of information; FDS is the ontology for the Flexibility use case.

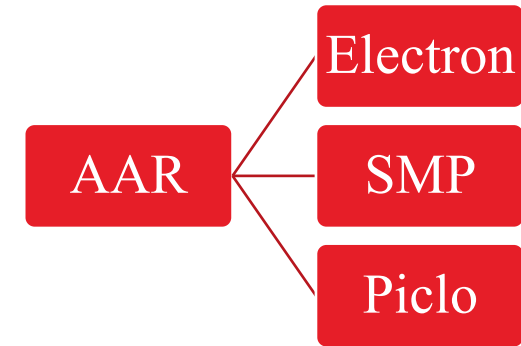


Figure 5: Representation of current ways of exchanging information

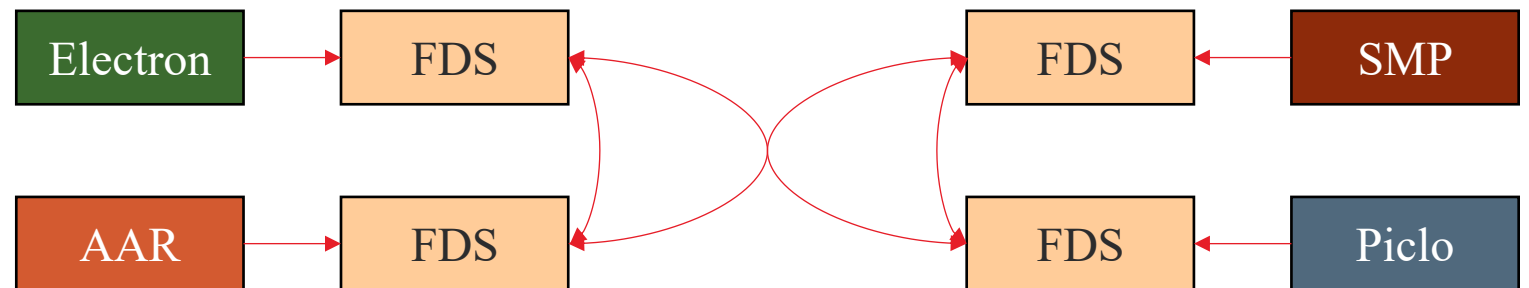


Figure 6: Representation of the ways FDS can enable scalable data exchange without changes to existing systems

2.2.2

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Constraints, dependencies, and enablers

Constraints, dependencies, and enablers

Overview of the current initiatives, policies, and organisations that could impact the adoption of the FDS ontology

Constraints

System operators and market platforms buy-in

A key constraint will be to ensure buy-in from the system operators and market platform providers to engage with the ontology. This will allow further ontology development to facilitate the FDS MVP rollout and long-term ontology operation, maintenance and further evolution.

Existing standards alignment

The ontology must align with established standards like IEC CIM and IES4, since any non-compliance could lead to fragmentation or rejection by industry stakeholders, limit adoption and create inefficiencies.

Modelling and testing of the ontology

Failure to capture the complex relationships and interdependencies between FSPs, assets, grid constraints and Independent Market Platforms could limit the ontology's operationalisation. Testing with real-world data is deemed necessary to avoid delays in the MVP rollout and adoption by stakeholders.

Dependencies

Ontology experts availability

Engaging and developing the ontology further leads to a key dependency for availability of ontology experts to validate the concepts and relationships defined.

Stakeholder engagement platform

A collaborative platform (e.g., GitHub) is essential for stakeholder engagement and transparency, to allow multiple stakeholders to view, comment and provide suggestions on the ontology design, and to develop trust.

IMPs data schema access

Operationalisation of the ontology requires access to the data schemas for IMPs to understand translation requirements.

Existing ontology tools integration

Integration with tools like Protégé is needed for efficient development, scalability, validation, and maintenance of the ontology.

See [Appendix C.3.3](#) for further details.

Enablers

Flexify

The Flexify platform will be a key enabler to evidence the value of FDS, allowing for further investment and buy-in to adopt the ontology for business-as-usual use.

Information Exchange Standard (IES)

FDS integration with IES as the 'upper' ontology ensures interoperability among diverse systems.

National Digital Twin Programme (NDTP)

Aligning with national initiatives ensures compatibility with broader digital energy strategies and adoption.

Data Sharing Infrastructure (DSI)

FDS supports the flexibility use case for DSI by providing a standardised ontology that enables seamless data exchange.

Smart data scheme consultation

DESNZ initiated a call for evidence to explore the development of a Smart Data Scheme aiming to empower consumers by facilitating secure sharing of their energy data. FDS can be part of the scheme and/or can inform the development of the scheme.

2.2.3

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Delivery pathways for FDS

Governance of the FDS ontology

Summary of the proposed future operating model for the ontology

Overview

A transparent governance framework, including defined roles, decision-making frameworks, and regular reviews, is required to facilitate initial rollout of an FDS MVP, ensure efficient use of resources, effective long-term management of the data standards and maintenance of the ontology.

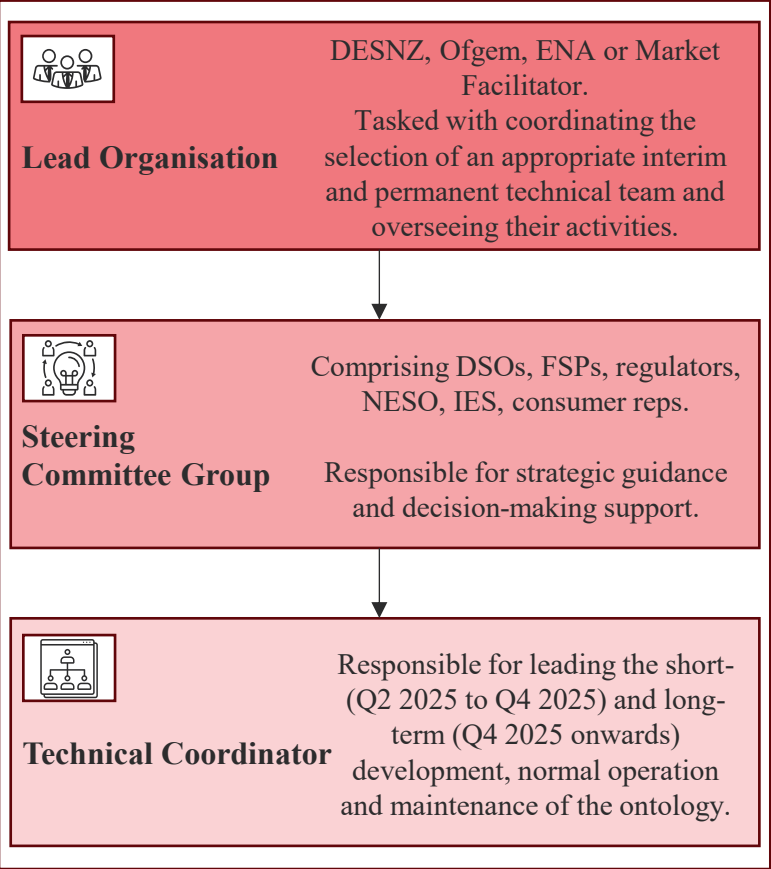
This process would ensure the standard remains relevant, interoperable, and widely applicable across domains and that they are operationalised following the FMU programme.

The key requirements to determining the governance model, except for defining the operating entity, include releasing the ontology under an open-source license and ensuring the ontology is promoted within the industry, fostering collaboration and driving adoption.

The operating entity of this ontology will need to undertake the following responsibilities: oversee updates, ensure compliance, evaluate emerging needs, and manage feedback from the community.

Details of the key challenges and the outstanding ontology work is presented in [Appendix C.3.1 What is the outstanding ontology work?](#).

Proposed governance structure



Consortium responsibilities

In Phase 2, the consortium has developed and evidenced the value of the FDS ontology.

The ontology is a common infrastructure that should be maintained and operationalised by an entity that can provide legitimacy and long-term oversight, aligning it with wider sector initiatives (e.g., Smart Data Scheme).

The key bodies for the proposed governance model are presented to the left. The options for the short- and long-term governance entities have been determined and evaluated, with recommendations on their suitability detailed in the next page.

However, the consortium, acting as the current owner of the FDS ontology, will undertake significant steps to promote the ontology, maintain development momentum, ensure the governance entities are formed and secure buy-in from the industry.

Details of the three governance entities, the recommended governance models and the actions required to be undertaken by the consortium to support the ontology development are presented in the next page.

FDS ontology governance

Optioneering of the operating model for the ontology

Optioneering of ontology governance entities

An analysis of three governance entity options has been undertaken to determine the most appropriate short and long-term operating model. The three options considered are:

- **A new sector-led open initiative:** A governance board made up of representatives from industry experts, data stewards, regulators, and end users to capture a broad range of perspectives.
- **Transferred to an existing sector entity:** Identify the most appropriate existing sector entity (e.g., ENA Data Standardisation, DESNZ or Ofgem) and transfer ownership of the ontology.
- **Under the remit of the market facilitator (MF):** Integration into the MF's existing role and structures by allocating a dedicated team responsible for the ontology maintenance and development.

The potential for each governance entity to satisfy the requirements for the technical coordinator role on an interim and permanent basis was analysed.

Further details on the entities' structure and suitability to satisfy the requirements is presented in [Appendix C.3.2](#).

Recommendations

The proposed governance options for the short and long-term ontology operation have been determined.

- The **sector-led open initiative** has been selected as the recommended governance model for the short-term FDS ontology development. The key reasons include allowing market wide participation, rapid updates without time-consuming organisation processes, and broadest inclusivity of industry representatives.
- **A sector entity**, such as the market facilitator or NESO, has been recommended as the preferred governance model for the long-term FDS ontology operation and maintenance. The key reasons include operation within an existing framework that aligns with industry standards, benefits from mature governance structure for the long-term operation, and provides cost efficiency by utilising existing infrastructure.

Further clarification on the MF's role and engagement with DESNZ is required to understand the potential for Elexon taking over the FDS ontology development.

A more detailed explanation of the reasons for the above governance model selection is provided in [Appendix E – Ontology governance entity recommendation](#).

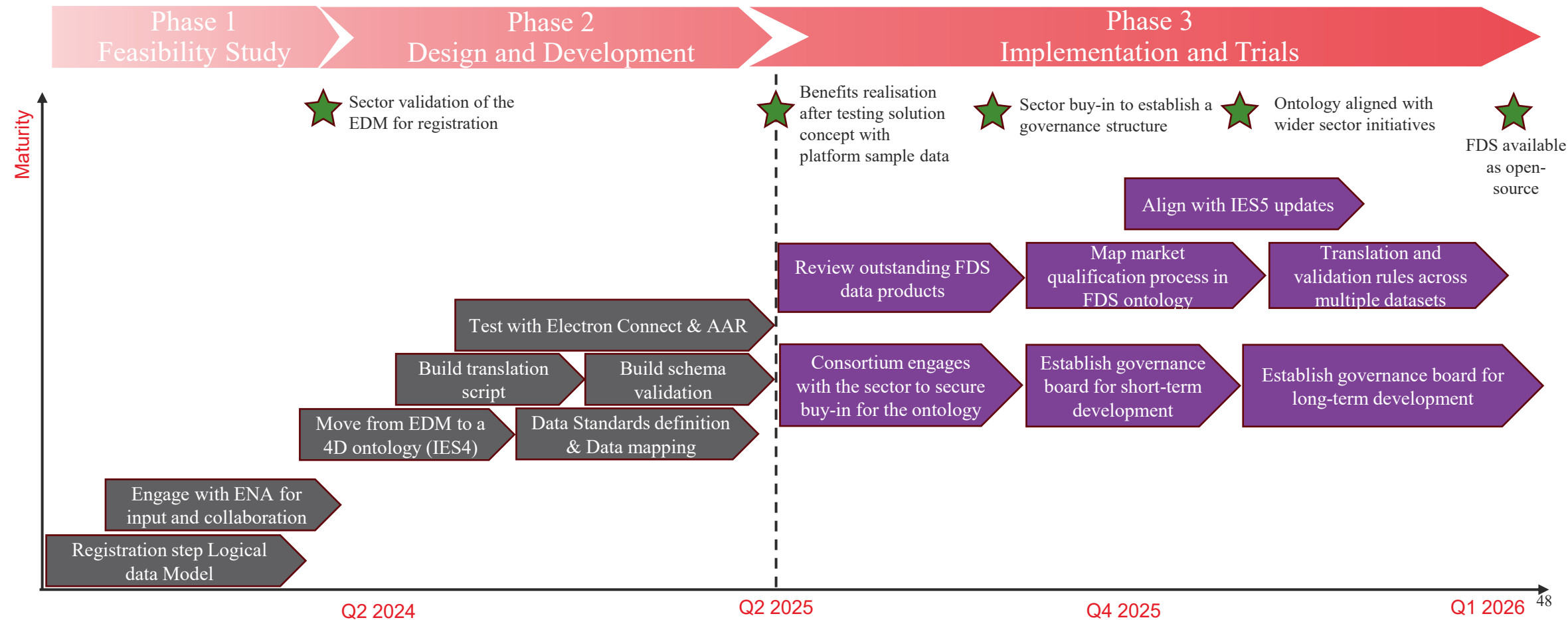
Consortium next steps

The practical next steps for the consortium include:

- Engage with the sector and government to promote the ontology and secure buy-in by realising its value.
- Socialise the ontology through industry forums to ensure readiness, scalability and interoperability.
- Continue ontology development by securing funding contributions and allocate resources to outstanding tasks.
- Operating costs for the 3-6 months MVP rollout are estimated to be **between £135k – £265k** (see [Appendix C.3.2 Personnel costs](#) for details).
- Identify lead organisation entity to structure the sector-led open initiative governance model.
- Reach out to potential members to form the steering committee (DSOs, consumer advocates, gov reps) and in coordination with the lead organisation appoint a technical coordinator to oversee MVP rollout.
- Once short-term governance is established, plan the transition to the long-term model, by hosting joint planning sessions to ensure financial sustainability, align on future ontology development and resourcing requirements, and successfully transfer FDS MVP.

FDS delivery timeline

Timeline for delivering FDS



2.3

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Market Rules Test Bed (MRTB)

Solution Overview

MRTB as a FOAK market optimiser platform for all system operators and policy makers

Challenge overview

Historically, DSOs have procured flexibility for the purpose of deferring the need for network reinforcement, particularly in locations where there has been constraints on the network. However, beyond the understanding that deferring reinforcements saves large infrastructure costs, the actual value of increased flexibility remains unanswered and complex when thinking about what this looks like for all those who participate in or benefit from the energy system.

Through engagement with FSPs, it was suggested that there were several blockers that encumbered their willingness to provide flexibility locally;

- a) The procurement timelines for DSO flexibility often happen months or years in advance of asset dispatch and FSPs don't feel as if they can accurately forecast and commit their capacities this far ahead of time.
- b) The market terms are complex and its difficult for FSPs to understand how they can move between the markets that best serve them
- c) Historically it has proven more profitable for FSPs to be riskier with their capacity, holding back from local markets to allocate to more profitable dynamic markets.

Enhancing market Efficiency

These complexities have made it increasingly difficult for DSOs to anticipate the flexibility being made available locally and so are more frequently having to fall back on costly methods of combating real-time constraints.

One way in which DSOs could increase predictability over what flexible capacity is likely to be made available within their markets is by better understanding the incentivisation metrics that would encourage FSPs to commit their capacity to local services.

Assuming here that the main incentivisation for FSPs is their revenue opportunities, then revenue stacking is a way to both maximise the revenue available, as well as maximising the amount of capacity being made available to local markets.

Revenue stacking would enable FSPs to more confidently offer their asset capacities in local markets, locking in the often-lower priced availability cost, whilst also remaining reassured that in the scenarios where their capacity is no longer required, they could trade it within alternative national markets.

Revenue stacking is currently stagnated by a lack of understanding of who reaps the rewards.

Optimising flexibility markets

To truly understand the value of flexibility, a solution is needed that is able to optimise services whilst accounting for the individual needs of all participants.

In order to solve this problem, a mathematical model is required that is able to co-optimize the outputs for both an SO and an FSP, providing an optimal cost to FSPs to elicit participation, whilst also minimising the costs that an SO is paying for the procurement of flexibility.

The algorithmic model outlined in [Appendix D.2.1.1](#) and enables a user to input key metrics such as target liquidity, FSP risk and whether stackability is enabled or prohibited to visualise the indicative capacity being made available in their markets, as well as the price that they should be making available to FSPs.

The Market Rules Testbed (MRTB) is proposed as a solution based on this modelling, able to offer SOs the ability to better understand how the complexity of their markets and services impact FSPs looking to provide flexibility and determine how these rules could be adapted to make participating in local markets more attractive to FSPs.

Wireframe

For Proof-of-Concept only

Modular design

The tool is structured into modules to facilitate various optimisation approaches and enable future extensions. A detailed overview, including post-PoC wireframes, is provided in [Appendix D.2.2.1](#).

Module one enables users to assess the impact of revenue stacking on local flexibility markets. The PoC simulates outcomes when FSPs can stack their asset capacities between the SA + OU service and the wholesale market, classified as implicitly stackable in the [Energy Networks Association's \(ENA\) stackability assessment](#). Users can compare stacking versus non-stacking scenarios to evaluate the economic benefits or drawbacks. Stacking is deemed beneficial to the system operator if it results in a lower total service cost.

Module two allows users to analyse how factors beyond stacking — such as tendered service duration and utilisation rates — affect service costs, supporting them to understand appropriate timelines to run markets, and other services.

Each optimisation output can be evaluated against the historical market data for the specific local constraint zone.

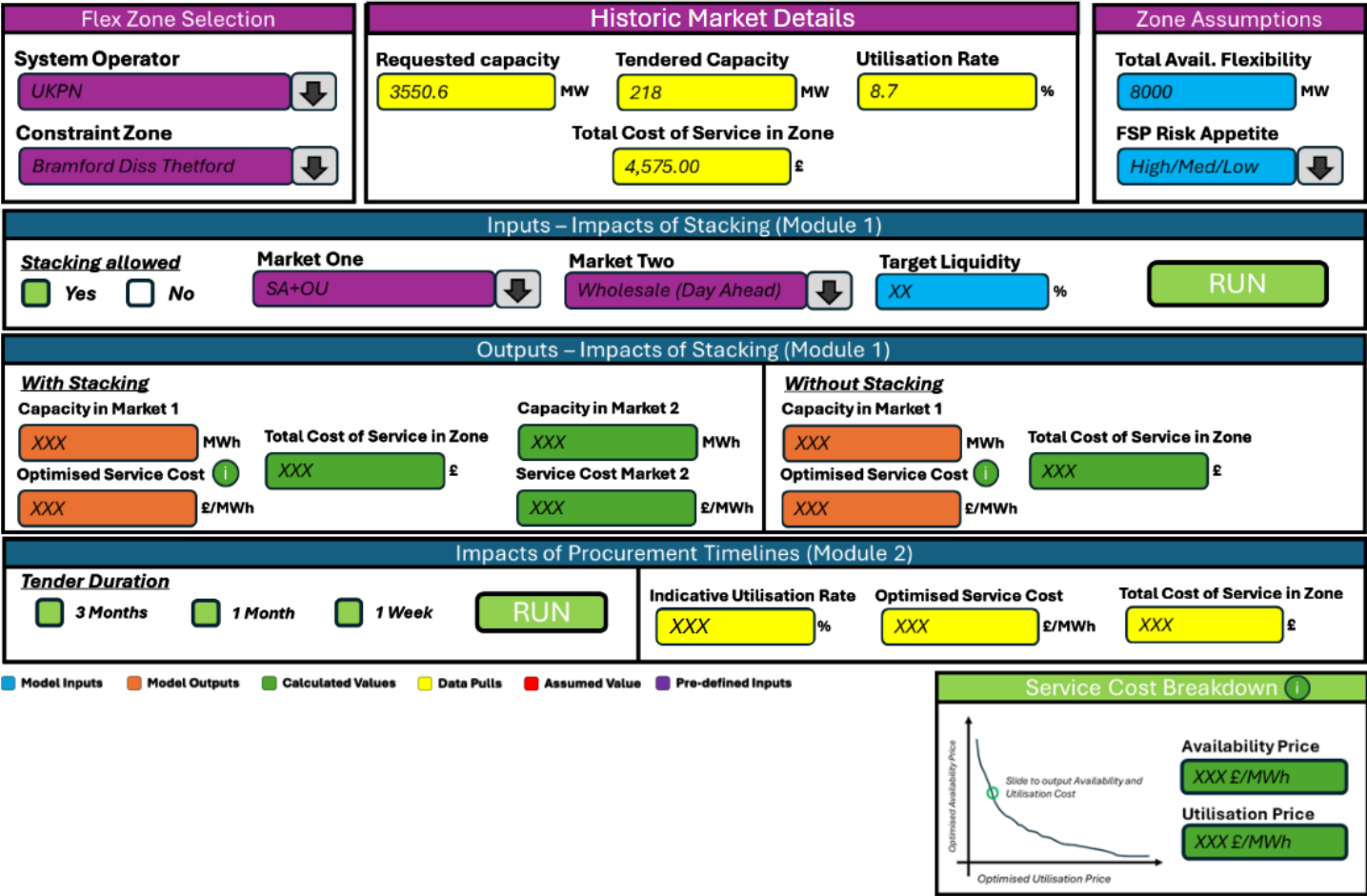


Figure 7: An initial representation of the wireframes for the Market Rules Test Bed

Algorithms underpinning the model

Balancing the needs of SOs and FSPs

Introduction to the model

Standing up the MRTB is an optimisation model designed to identify the best possible solution to a problem within a set of constraints and objectives. This model looks to optimise SOs markets in a way that maximises revenue for FSPs as they look to choose between allocating their capacities between two different markets, for the PoC this is constrained to looking between the Scheduled Availability + Operational Utilisation DSO service and the wholesale market.

The model development is split into two focus areas

- **Focus area 1** explores the behaviour of an FSP to enable an SO to understand their impact of their decisions in settling the value of flexibility, defining stackability rules and determining the procurement timelines for markets.

Focus Area 1 forms the basis of the PoC and is explored in further detail in [Appendix D.2.1.1 Focus area 1](#).

- **Focus Area 2** explores the behaviour of specific asset types that make the portfolio of an FSP. It aims to quantify the benefits of the technical capabilities of flexible assets.

Focus Area 2 is future scope and detailed in [Appendix D.2.1.1 Focus Area 2](#).

Forming the basis of the PoC model

The PoC centres around the optimisation of the SA+OU service procurement, with a bi-level optimisation problem developed to properly represent the game between a DSO and FSP.

In the bilevel optimisation problem, there are two sides simultaneously optimising their own objectives

- The DSO is looking to minimise their overall procurement costs through optimising their availability and utilisation prices, whilst also ensuring that the prices incentivise FSPs enough to want to commit their capacity enough to satisfy the capacity requirements of a constraint zone
- The FSP is seeking to maximise their own revenue for the DSO requested service window, by choosing to commit their capacity within the DSO service or the day-ahead wholesale market.

The model outputs the optimal capacity allocation between the SA+OU and wholesale markets for FSPs utilising the average and variance values of the two markets and thus the indicative cost of service procurement for DSOs.

Stacking is deemed as beneficial, where the tender cost works out cheaper with stacking than without.

PoC model input data and outputs

For the PoC, the following parameters have been edited to see the impacts on the pricing of the SA+OU service;

- DSO liquidity target – this has been varied between 25% liquidity target, through to 100% liquidity target.
- Total available flexible capacity in a zone - it is assumed within the model that there is an amount available to fulfil the capacity request made by a DSO in their competition data, but the model has been run to investigate how increasing the amount of flexible capacity in a zone would likely affect DSO costs.
- FSP Risk - It is assumed that an FSP with a higher risk appetite is less worried about the price volatility of the wholesale markets and will therefore be more likely to wait until closer to dispatch to lock in their utilisation prices.
- Utilisation rate - the historic rate for the flexibility zone tested has been varied and modelled to see how utilisation rate would affect the prices able to be offered by the DSOs to incentivise FSP participation.

The inputs and outputs of the model are explored further within [Appendix D.2.1.1 Calculation of the model parameters](#).

2.3.1

Value assessment

Benefits

Overview of the direct and indirect benefits of the Market Rules Test Bed.

System operator benefits

Increased understanding of how to price services to incentivise participation from FSPs

A user would interact with MRTB for the purposes of understanding how to optimally price their services, to be more economically attractive to FSPs who have asset capacity able to be committed to local markets. The tool allows this user to better understand how optimally pricing their services could increase competition and liquidity in their local areas, giving FSPs confidence that they are as able to achieve profits in the local markets, as well as they are within the national markets.

Faster and simpler testing of rules to understand the impacts on flexibility markets

Assessment of the qualitative benefits highlighted that the most impactful are the ability to quickly assess the effectiveness of market rules. The MRTB can provide a shared assessment and evidence to give SOs confidence in how altering their service features could provide holistic benefits to both themselves, and the wider energy sector.

Market facilitator benefits

Trust and governance: Greater system operator confidence and credibility on system

Having a market-wide view of flexibility market opportunities and their assigned rules and impacts will provide greater transparency over how stackability will reduce risk to network operations and reduce cost to consumers.

Market coordination: Easier for SO and new market platform entrants to navigate flexibility markets

The MRTB will provide an overview of market activity and the rules for the flexibility ecosystem. This includes both SOs (in terms of having confidence that they can operate the markets in the way they need to) and MF (in terms of understanding how to increase the simplicity of transversing between different markets and services for FSPs, to increase the value of flexibility to the entire energy system)

Overall benefits

Market coordination: Faster and simpler testing of rules to understand how stacking increases the overall value of flexibility and drive down the cost of electricity to end users.

The MRTB will provide a ready-made environment to assess the impact of market rules, such as stacking and procurement timelines, on the ability and willingness of FSPs to participate in local flexibility.

Alongside outputting a cost that will ultimately minimise the procurement costs for SOs, the tools' ability to optimise costs available to FSPs that would incentivise them to participate in local services is likely to increase the amount of flexible assets available in a zone, increase competition within tenders and enable a lower price point for end consumers.

Increasing the predictability of available flexible capacity is also likely to drive down the price volatility within the national markets, creating more transparency over the future costs of energy.

Whole system optimisations

MRTB as a means to accelerate towards net zero energy network

Overview

A key bottleneck for accelerating towards net zero energy network is the efficiency losses in the electricity transmission and distribution networks as energy flows through various equipment. This section discusses the long-term vision of how the power system can be coordinated across all voltage levels. It draws heavily on a previous report by the University of Edinburgh for the [Energy Systems Catapult's Cyber Physical Infrastructure programme](#).

In the long run, it is anticipated that the penetration of flexible distributed resources will grow to an extent that efficient distribution system operation is not possible without explicit coordination of such resources with distribution constraints at all voltage levels, as well as considering transmission needs.

While the number of entities with which the transmission operator directly interacts will grow, the number of resources directly connected at transmission level will remain limited, though there are other challenges such as managing stability with reduced conventional inertia. By contrast, the broad system vision is for the number of flexible resources to become comparable with the total number of meter points, i.e. in at least the millions and possible the tens of millions.

Coordinating local and national markets

MRTB in PoC is focused on specific issues of coordination in localised areas, rather than forming part of a coherent whole system framework.

Indeed, one important question is how many different products there actually are – the questions of whether to contract for services to transmission or distribution discussed in this report are largely about whether to sell the same product to a different purchaser, with variation in the timeline on which contracts are signed and options called.

Further to this, most deployment to date of coordination of different distributed flexibility services has either covered specific constraint issues within a limited area of distribution network, or involves the distributed resource selling services to transmission without consideration of distribution constraints.

By contrast, research work has typically made strong assumptions such as highly idealised forms of network optimisation models, or that very high volumes of communication between customers and network nodes are possible, making the route to practical control schemes unclear.

Enabling whole-system optimisations

The whole system optimisation on which a practical operational architecture is based is likely to be a model one can write down in principle but not solve in practice – either for computational reasons or because the data cannot all to be brought together for central optimisation.

The exercise of writing down this model might then be the basis for a decentralised scheme which could actually be deployed, with the voltage level changes at grid supply points and substations forming a natural division into operating zones. MRTB forms the basis of this model, which is deployed at a specific constraint zone, while having the ability to scale in a federated scheme.

This is somewhat in analogy to how control of other engineering networks, particularly in communications, is designed. One important point in power networks is that the network flow of interest is the same as the physics of the network, unlike e.g. data packets or phone calls where the physics has been abstracted out. This would manifest itself as consideration of ancillary services needing to be included in a whole system scheme, along with the different timelines on which decisions need to be made when some resources have a substantial lead time for start up.

2.3.2

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Constraints, dependencies and enablers

Constraints, dependencies and enablers

Overview of the current initiatives, policies, and organisations that could impact the adoption of the MRTB

Constraints

Data gaps

Inadequate data in historic tenders about market performance therefore assumptions were needed to be made which could impact on the optimisation calculations that inform the MRTB.

Real-Time data gaps

The PoC model uses historical data and could be expanded to include forecast wholesale data for optimising forward prices of DSO services. However, the optimisation model details scenarios where FSPs could reject DSO direction, based on indications that they could gain increased revenue in the other direction from alternate markets. The modelling of this decision making relies on much more dynamic, closer to dispatch data, and so to give more realistic simulations on FSP behaviour, real-time data should be included.

Fluidity in tendering regulation

Another incentivisation metric that the DSO could use to optimise FSP participation in their markets is through the altering of procurement timelines and settlement periods, bringing decision making closer to asset dispatch time. This would require likely further engagement with Ofgem and ongoing participation from the MF.

Dependencies

Asset visibility

The MRTB depends on the visibility of assets available to participate within energy markets. It is envisioned that this would come from an innovation project such as Flexify.

Data pipelines

MRTB will need to be able to pull in data from all participating SOs flexibility competition, tender and dispatch data. There is therefore a dependency on SOs to regularly update these documents to online data portals, ideally in a machine readable and standardised format.

Enablers

DSO participation

The success of MRTB rollout relies heavily on buy-in from system operators, and so it needs to be demonstrated and communicated that use of the tool would save them time and money in the form of resource, over following current procedures for defining costs.

Data sharing infrastructure

Adoption of the DSI by the system operators can provide the dynamic live stream of data needed to bring this tool into Business-as-usual operations.

2.3.3

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Delivery pathways for MRTB

Building an MVP

MRTB to be further built through a SiF Alpha

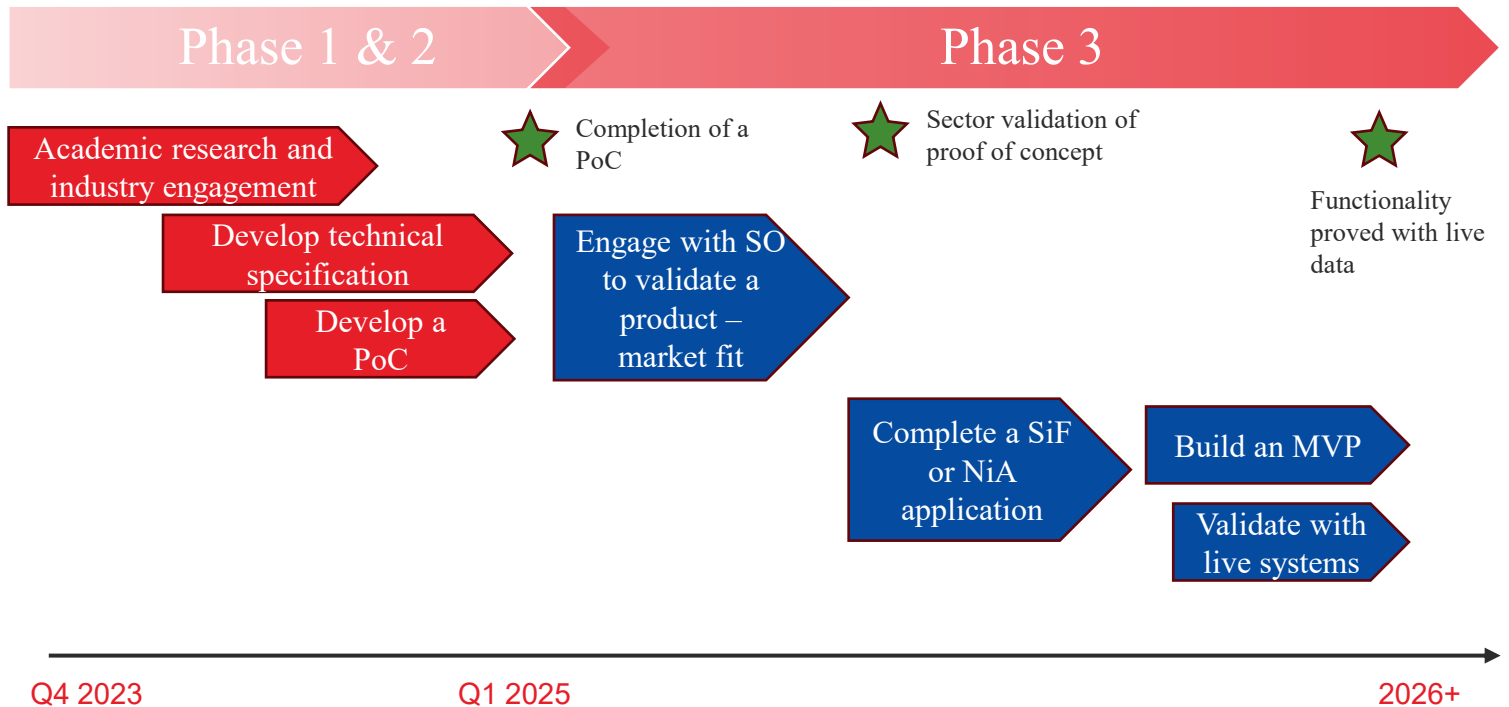
Phase 3 for MRTB

Building on the success of phase 2, the approach for phase 3 of the MRTB focuses on ensuring the tool's operationalisation and validation in a live environment. Further development is required to enhance its capabilities through partnerships with a system operator.

A critical barrier to improving overall network efficiency is the ability to perform whole-system optimisations. MRTB addresses this challenge through a federated approach, enabling individual system operators to conduct modelling and optimisation independently. This reduces both complexity and computational burden while ensuring a cohesive and efficient optimisation process.

By providing system operators with standardised principles and algorithms, MRTB facilitates federated optimisation across networks while aggregating the results for whole regional and service-level optimisations. This approach lowers costs and simplifies processes.

High level timeline for the PRTB



3

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Advancing the solution

3.1

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Alignment with on-going sector initiatives

How does it all come together?

Achieving the Flexibility Digital Infrastructure outcomes by pooling resources across the ecosystem

Overview

Our energy sector's digital transformation is being developed as a federated system, or a combination of federated and centralised systems. This approach inherently requires integration to address the question of how different systems will come together.

In a federated ecosystem, various organisations, systems, and services operate autonomously but must collaborate efficiently. Therefore, an integration architecture is essential for enabling seamless data sharing, interoperability, security, and governance across multiple independent entities.

An integration architecture is a blueprint and a set of principles, patterns, and guidelines that describe how different software applications, systems, and data sources across organisations can connect and exchange information. Think of it as the roadmap for connecting disparate parts of a digital ecosystem so they can work together effectively.

Within the flexibility ecosystem, there are numerous market platforms, data stores, and digital services used by Flexibility Service Providers and System Operators.

Interplay between the various digital systems

Data sharing infrastructure plays the central role by providing the ability to seamlessly share data between multiple organisations and can be the basis for enabling a scalable and flexible way of sharing data across multiple independent market platforms, datastores and other digital systems.

Consumer consent, while does not interact with flexibility in MVP, it can be the platform that can support with identities and providing authorisations to FSPs to act on owner's behalf, and for consumers to understand the ways their information is shared and used to enable Net Zero.

Independent market platforms are private entities that have been procured by system operators to operate flexibility markets. These system on-boards FSPs and provide services from bids/offers to settlement and reporting.

Datastores such as **Embedded Capacity Register**, and **Automatic Asset Registration** act as independent stores of asset information. **Elexon Kinnect** provides market access and organisational information management services for BSC participants.

Need for integration

To enable scalability, these platforms require a blueprint of how these systems and applications connect, Flexify provides the needed integration architecture.

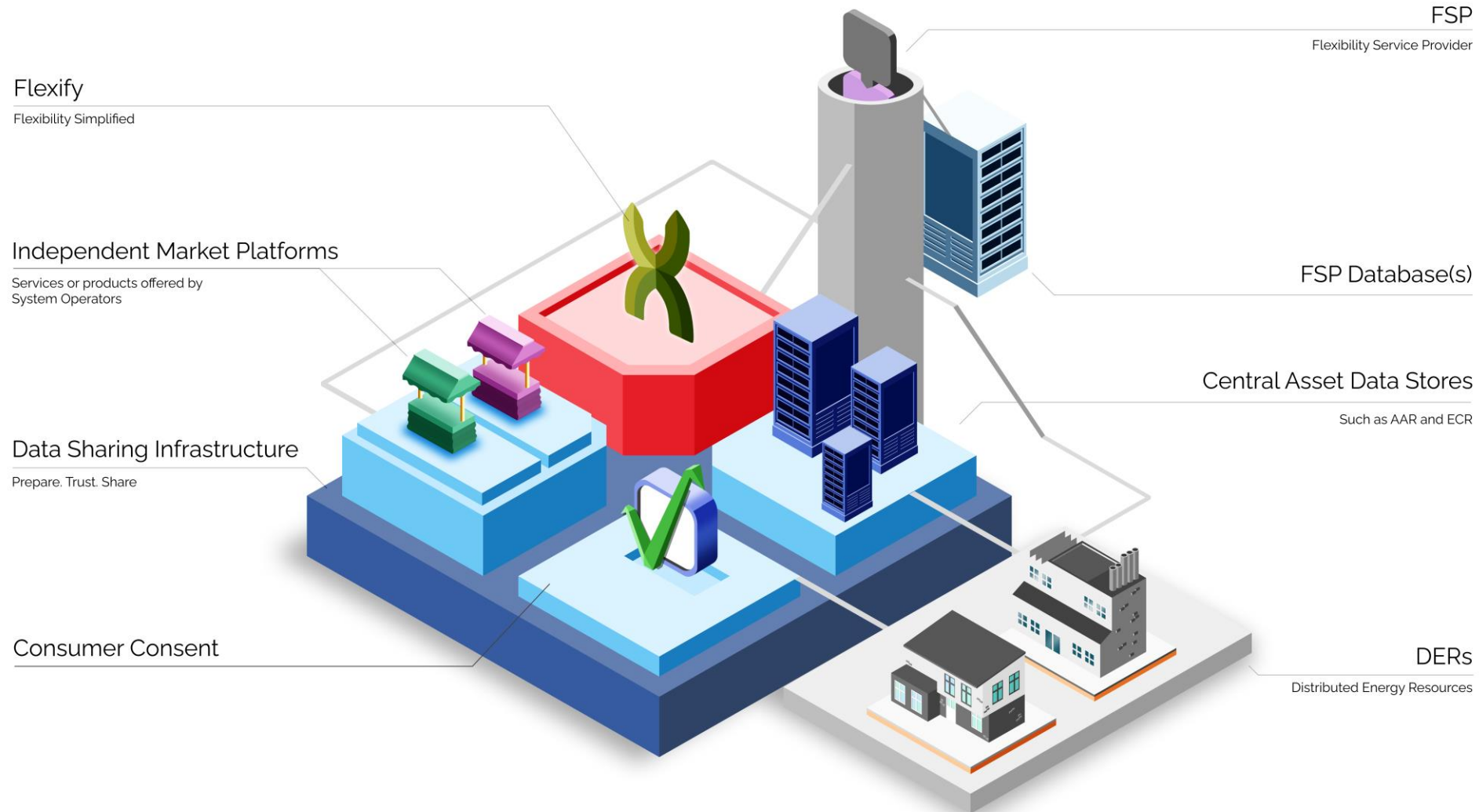
Flexify keeps the mapping of the commercial and technical information across the Independent Market Platforms, and central datastores, and can incorporate the Data Sharing Infrastructure to seamlessly exchange information, enabling a single master of data without keeping the data itself in a central store.

See [Appendix B.1.4.1](#), and [Appendix B.1.4.2](#) for how Flexify achieves this.

Flexibility Data Standards is a key component to ensure data is interoperable and exchange scalable. See [Appendix C.2](#) for how it's achieved.

All of these platforms pooling their resources together enables a trusted view of the whole flexibility system, allowing for data-based governance to support exponential scaling of the flexibility ecosystem.

System architecture of the Flexibility ecosystem



3.2

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Proposed next steps

Proposed next steps

Summarising the recommendations for phase 2 of FMU

Overview

Through the delivery of this phase and the stakeholder engagement activities undertaken, several recommendations have emerged. These will be broken down across the three solution components.

To make use of the momentum gathered through phase 2 of the programme, there are opportunities and no regrets actions that can be taken by government that will support getting optimal benefits and value from public funds.

With existing initiatives already establishing and developing technical capabilities in this space, it is important to evaluate each solution component on its value and understand how they interact with each other.

Including the findings of the programme into government's plans, noting sequencing, rough timetable and expectations for engagement, would evidence the value generated from the innovation programme.

Areas of future work

Flexify

- Move from PoC to MVP by building the missing functionalities needed for FMAR, building on the pathways defined in [Section 2.1.4](#).
- Complete an assessment to understand the system value Flexify delivers and define the features that are needed for an MVP.

Flexibility Data Standards

- Identify a sector entity to take over the ownership of the standard, and for that entity to complete the remaining development efforts
- Encourage collaboration between NPSA and NESO, as DSI operator, to establish best practices for information security management.

Market Rules Test Bed

- Complete a SiF Alpha application to further build the tool.

Accelerating the development of common infrastructure

Recommendations to collaboratively develop infrastructure that can exponentially accelerate flexibility

Flexify: Complete a gap analysis

Encourage Elexon to undertake a holistic review of the functionalities Flexify and AAR provide, and their interaction with meeting the ten functional outcomes for FMAR.

No-regret actions (0-6 months)

- Host technical meetings with Elexon to outline alignment with FMAR.
- Undertake town hall sessions to gather feedback on outcomes of technical alignment.

Other actions (0-6 months)

- Host technical alignment meetings with NESO to evaluate the need for Flexify to support development of DSI MVP.
- Host technical sessions with NPSA to define best practice for information exchange.

FDS: Link with national initiatives

Flexibility Data Standards require legitimacy and alignment with sector initiatives, such as the Smart Data Scheme. Until a legitimate body is selected to operationalise the standard, consortium will host and manage the FDS. These steps are explained in detail in [Appendix E](#).

No-regret actions (0-6 months)

- Identify a sector entity, potentially the market facilitator, to oversee and host the data standard on behalf of the flexibility ecosystem.
- Assess the feasibility of utilising IES 5 as an upper ontology to facilitate cross-sector information interoperability.

Other actions (0-6 months)

- Sponsor a Phase 3 to complete the build of the FDS data standard.

MRTB: Evaluate it's need

MRTB has taken the first step to build a co-optimisation model for the flexibility ecosystem. It's a model that can be used by each System Operator, which considers their own unique network aspects to define a 'win-win' scenario that allows for FSPs to maximise their revenues, and consumers to reduce their bills.

No-regret actions (0-6 months)

- Encourage System Operators and Elexon and consortium to engage with the consortium to provide feedback on the approach.

Other actions (0-6 months)

- SOs align on the value of the tool and sponsor a SiF Alpha application to build the model further.

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[Challenge](#)

[Flexify](#)

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Stakeholder engagement & knowledge dissemination

Stakeholder engagement

Our engagement approach

Overview

Our stakeholder engagement approach is designed to gather diverse insights and ensure alignment with project objectives through targeted, inclusive strategies.

Key stakeholders, including representatives from existing market platforms, flexibility service providers, and service operators, were identified early in the process. Engagement activities have been conducted through different approaches depending on the stakeholder group.

The approach prioritises iterative engagement, ensuring stakeholders can provide feedback throughout the entire project lifecycle. Initial sessions have focused on capturing high-level requirements, while subsequent discussions delved into refining detailed use cases, data flows, and system workflows. This iterative process ensures stakeholder input has continuously been integrated into the solution development.

Effective communication is a cornerstone of the strategy. Regular updates are shared via "show and tell" sessions, keeping stakeholders informed and engaged at every stage.

Stakeholder groups

As part of our engagement approach, stakeholders were mapped to groups representing different interests.

Client & External Design Authority: Representing the DESNZ client and the external FMU programme board. They ensure successful delivery of FMU programme objectives and attend the monthly Programme Show & Tell engagements.

Organisations: DESNZ, Ofgem, Carbon Trust, NESO, ENA

Technical Authority: This group are not directly connected to the programme but have progressed work in the flexibility ecosystem through development of data standards or flexibility markets or platforms.

Organisations: ENA, Elexon, SSEN, NGED, NESO SMP

End users & wider sector participants: These are potential end users or relevant sector entities against whom we are validating our design decisions, capturing requirements and recommendations, and aligning on different potential technical and delivery mechanisms.

Organisations: AMP Clean Energy, Modo Energy, Equiwatt, Electralink, Kaluza, Ovo, RECCo, Constantine Energy Storage, Flexitricity, EV.Energy

Engagement approaches

Direct engagement: We have engaged directly with key stakeholders and future potential users typically in groups of two to three. These engagements have been run in an open format where the solutions component is presented followed by questions in a conversational style approach.

Workshops: Workshops have been delivered where there has been value in engaging large groups of stakeholders. Workshops have been run both in person and online often in a hybrid fashion. Workshops allow for deep dives on specific solution components and bring diverse viewpoints together to resolve blockers & support design thinking.

Programme Show & Tells: The programme has delivered monthly show & tells the client and External Design Authority. These sessions have presented solution components as they pass through the design and development process allowing the project team to present their work for high level scrutiny.

External Show & Tells: To deliver against our social value deliverables and to engage the wider sector external show & tells were held, providing an update on the solution design and development.

Flexify

Stakeholder interviews conducted during this phase

Overview

The consortium have conducted both internal and external engagements through either 1-2-1 interviews or group interviews.

Externally, high-priority stakeholders were engaged on a singular basis to better capture the diversity of feedback.

Overall, during this phase, over 20 engagement sessions have been held with a diverse range of organisations.

Topics that were covered in these engagements include:

1. The four core features that make up the platform
2. Challenges with the business processes for FSPs
3. Standardisation of business processes across SOs
4. Requirements & challenges with validating asset information

Summary of the organisations engaged

External Design & Technical Authority

- NESO – Virtual Energy System & Flexibility teams
- GreenSync
- SPEN
- Elexon
- UKPN
- Scottish and Southern Electricity Networks Distribution
- Ofgem
- National Grid Electricity Distribution

End users and wider sector participants

- AMP Clean Energy
- Constantine Energy Storage
- Modo Energy
- Flexitricity
- Equiwatt
- EV.Energy
- Electralink
- Digital Catapult
- Kaluza & OVO
- RECCo

Stakeholder feedback

Stakeholder feedback

- Consideration for the roles of parent organisations, brokers, and asset operators.
- Define – what is an Asset? As it relates to various types of FSPs.
- Standardisation of business process associated to FSP on-boarding is a core challenge
- Unclear service and procurement requirements between different System Operators.
- Flexify must be able to provide access to all platforms and all markets for it to be valuable
- The platform must be seen to deliver value to FSPs and not be an additional digital platform in the flexibility space
- The data that the platform captures should be used to deliver insights to FSPs to help them determine which markets to operate in as well as where they would have good market share.

Show & tell

Overview of the sector wide show & tell to outline the Flexify platform

Participation

An external show & tell was held on the 17th December 2024, which was publicised through social media and through ESCs marketing list.

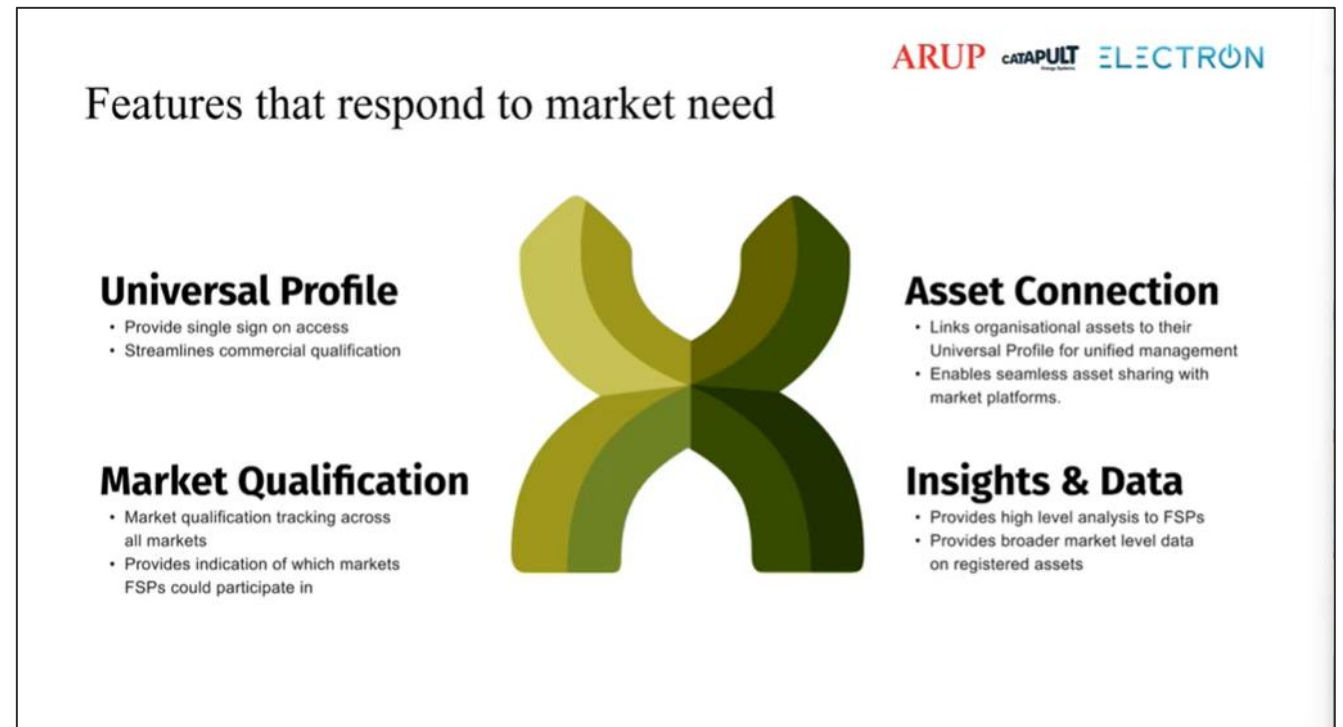
There were a total of 24 attendees to the Show & Tell, with attendance from other Consultancies, Flexibility Service Providers, and Regulators.

The session included an overview of the platform including the core features and value that the platform would provide.

Participants were asked to respond to questions on the challenges they currently face in the flexibility market and their thoughts on the functionality of the platform. Participants were also given the chance to ask questions to the product team.

A further Show & tell was conducted through Energy UK on the 20th of March and a final in person demonstration is being planned for early May.

A knowledge dissemination report will be published in advance of the final demonstration.



Flexibility Data Standards

Stakeholder interviews conducted during this phase

Overview

The consortium conducted both internal and external engagements through either 1-2-1 interviews or group interviews.

Externally, high-priority stakeholders were engaged on a singular basis to allow the team to better capture the diversity of feedback.

Overall, during this phase, over 5 engagement sessions were held with a diverse range of organisations.

Topics that were covered in these engagements, not exclusively:

- 4D Ontology representation of data
- Functional implementation of the ontology
- Information security
- Data quality and tagging

Summary of the organisations engaged

External Design & Technical Authority

- NESO
- National Digital Twin Programme
- National Protection Security Agency

End users and wider sector participants

- EpexSpot
- Jonathan Eyre, AMRC
- Digital Places Catapult
- Zuhlke
- CReDO
- Data Sharing Working Group
- Digital and Data Steering Group
- OpenADR 2.0 User Group

Key learnings

Stakeholder feedback

- Start small. Adoption of an 4D ontology can be confusing for most organisations; therefore, starting with a small use case that can articulate its benefits is needed.
- Evaluate the need for an 4D ontology, as not all systems need to adopt to this ontology.
- Information management security needs to be incorporated with any data exchange.

How was it incorporated?

- Platform operators will not be asked to change or adopt their systems to the ontology.
- Any translations will be done at the boundary of Flexify to reduce the burden on existing systems.
- Governance considered the changing landscape; thereby requiring continued engagements with relevant actors, such as NDTP.

Market Rules Test Bed

Stakeholder interviews conducted during this phase

Overview

The consortium conducted both internal and external engagements through either 1-2-1 interviews or group interviews.

Externally, high-priority stakeholders were engaged on a singular basis to allow to better capture the diversity of feedback.

To date 9 engagement sessions have been held with a diverse range of organisations.

Topics that were covered in these engagements, not exclusively:

- How primacy rules are structured and how they currently interact with the energy system
- Current perceptions of stackability for different system participants – who was likely to want more access to stacking, and who was happy with the current state of system
- How flexibility is currently procured and how could this process could be simplified?

Summary of the organisations engaged

External Design & Technical Authority

- ENA PWG
- NESO
- DESNZ

End users and wider sector participants

- Elexon
- SSEN
- SPEN
- UKPN
- NPg
- Flexitricity

Stakeholder feedback

- After speaking with the ENA PWG, the consortium pivoted our research area from the impact of primacy rules, to the impact of market rules more widely, with a focus area on how they impact stackability opportunities.
- After communicating the three shortlisted use cases to the targeted MRTB users, co-delivery use case garnered the most interest in discussions and was discussed as being the most lucrative to FSPs.
- Market variables that the test bed can consider for evaluation are:
 - Timelines for running specific markets
 - Procurement blocks alignment across various markets
 - Operational metering requirements
 - Ramp rates in relation to procurement blocks
 - Value of flexibility offered
 - Ability to use flexibility for live balancing, as it requires shorter ramp times
 - Baselining of flexibility assets for settlement
 - Ability to shift investments to other technologies

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Knowledge dissemination

Knowledge dissemination & information sharing

An overview of the approach and considerations to share information with the stakeholders after Phase 2

Overview

Knowledge sharing can be challenging, especially within a sector that involves multiple organisations with diverse teams and dispersed locations.

Therefore, knowledge dissemination and information sharing about the flexibility market unlocked, and creating a collaborative environment, will be the key to the successfully implementation of the three solution components.

There are several approaches to knowledge sharing that will be used. A combination of the approaches will be used to get maximum impact and support the stakeholders involved.

The approaches currently considered include:

- Conferences, events, and industry forums
- DESNZ sharing sessions
- Public show & tell events
- 1-2-1 demonstrations with key stakeholders

Dissemination of information

A key requirement for disseminating information will be to effectively balance of the need for openness, with confidentiality, trust, and accountability.

The default position on all outcomes and findings will be *“for the products delivered through the Government’s Net Zero Innovation Portfolio are findings, and are not official government policy”*

When considering knowledge sharing activities, the following questions will be considered and this will inform the selection of the appropriate mix of approaches.

- What can be shared, and when?
- What is the best methods of engagement?
- What level of engagement is required?
- What tools/mechanisms are required to share?

Timeline of stakeholder engagement

Proposed timeline of various engagements to demonstrate the functionality of the three components

	April Wk.1 25	April Wk.2 25	April Wk.3 25	April Wk.4 25	May Wk.1 25	May Wk.2 25	May Wk.3 25	June+
Demonstration of Flexify								
Demonstration of Flexibility Data Standard								
Demonstration of Market Rules Test Bed								

Conference, events, and industry forums

DESNZ sharing sessions

Show & Tells

Other stakeholder

Digital media (articles/blogs)

System Operators

FSPs

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Flexify

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Technical specification

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Platform design & wireframes

Design approach

A tested approach that incorporates user needs to define the technical requirements for development and testing

Personas and user journeys

To establish a clear understanding of future users and their requirements the design approach developed personas and mapped the user interactions with the platform.

User personas were developed based on stakeholder engagement with existing market platforms, FSPs and market providers. The development of these personas supported the understanding of their different needs and enabled the development of requirements that responded to diverse user groups.

User journey process maps were developed to map the interaction of users with the platform and to establish the platform response. The processes aligned to BPMN 2.0 notation. The processes identify user or system activities and supported in the definition of requirements for the platform development. In addition, these processes established the high-level need for data and the activities where data input is required.

Requirements & information architecture

To ensure a comprehensive understanding of platform requirements and develop an effective information architecture, the approach centred on aligning user needs, system objectives, and data dependencies. This was achieved through a structured process involving stakeholder engagement, iterative validation, and user-centred design principles.

Stakeholder engagement provided valuable insights into operational challenges, user expectations, and potential opportunities. Requirements were derived from these discussions, ensuring they accurately reflected real-world needs and priorities. Also, the user journey mapping clarified the relationship between platform functionalities and user interactions, laying a solid foundation for requirements definition.

The information architecture was designed to facilitate seamless navigation, efficient data flow, and intuitive user experiences. Personas and user journeys guided the design of information pathways, ensuring the architecture accommodated diverse user scenarios. A high-level data model was established to define data sources, relationships, and dependencies, ensuring consistency across the platform.

Branding & wireframes

To create a unified product and service, the outcomes of previous design stages were used to inform the design of the Flexify platform and its corresponding brand. The branding exercise centred around the exploration of the team's future vision and the understanding of the potential real-world impact the platform could bring.

Team workshops proved invaluable in informing the tone, aesthetic and visual language of Flexify, alongside being paramount in determining the service's name. A range of media, descriptions and archetypes were explored to align on the correct name for the platform, before moving to the design of wireframes.

Subsequently, wireframes were developed iteratively and were informed by feedback from the involved software engineers and project managers. Using the information architecture as a guide, low-fidelity wireframes were created, before being refined into high-fidelity and development ready screens aligned to the branding guidelines.

User personas

Establishing the potential users of the Flexify platform

Defining Flexify users

To gain a better understanding of Flexify’s future users, a list of four user profiles, or personas, were created. Each persona represents a potential Flexify user and personas have been defined based on their relationship to the assets they own or aggregate.

Flexify serves a diverse range of users, each managing different types of assets and energy sources. To accommodate these varying needs, the platform provides a holistic approach to asset management and market participation.

The user personas outlined on the grids reflect the key stakeholders within Flexify, ensuring that platform features and integrations are designed with their unique requirements in mind.

Retail Energy Companies

Retail Energy Companies operate 100,000s of small assets. They sell EV chargers and home energy systems. They have a software system that optimises the assets they operate.

Place in the Flexibility Market

Retail energy companies do not need to register to flexibility markets

Assets

They don't own assets, but manage them and optimise them with their software

Operation of assets

Their asset operations are established by consumer consent



Domestic Aggregators

Domestic aggregators operate 100,000s of small assets. They sell EV chargers and home energy systems. They have a software system that optimises the assets they operate.

Place in the Flexibility Market

Domestic aggregators do not need to register to flexibility markets

Assets

They don't own assets, but manage them and optimise them with their software

Operation of assets

Their asset operations are established by consumer consent



Asset Owners & Operators

Asset owners and operators own and manage their assets, which are typically >1MW. They work towards making their assets available to other platforms.

Place in the Flexibility Market

They will register themselves as well as their assets. Each user will be part of an organisation.

Assets

They own assets outright

Operation of assets

Operation of asset established by direct ownership



Industrial & Commercial Operators

Industrial and Commercial operators aggregate and manage assets from multiple other organisations as a service. They may be set up as one holding company with different subsidiary companies

Place in the Flexibility Market

They will need to qualify asset owner companies and assets as a service. They will also manage assets on behalf of asset owners.

Assets

They manage assets on behalf of asset owners with commercial agreements in place

Operation of assets

Their asset operations are established by consumer consent



Defining Flexify

Creating a unique and coherent brand for the Flexify platform

Defining the brand

At the start of this phase of the project, a need to brand and rename the Universal Market Register platform was identified.

A brand workshop was hosted in October with the goals of understanding the team's perception of the platform, discussing what productising the tool would look like, and exploring everyone's expectations. Activities included writing a newspaper front page to understand what is worth highlighting about the platform, selecting words from various word buckets to define the tone of voice, and looking at an art gallery made of images representing different aspects of the energy sector to be taken as inspiration.

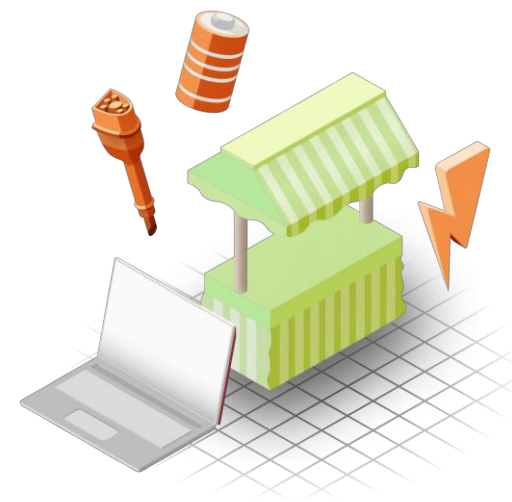
Finding a name

Following the workshop, a name needed to be found for the platform. The team got together to brainstorm ideas that would embody aspects of the platform such as flexibility, energy and exchange. After a week spent trying to find a name within the criteria of sounding right, not being associated with an existing brand, and which could be used with a ".energy" domain extension, Flexify was selected. The Flexify name is short for "Flexibility Simplified" which aligns clearly with the aims of the platform.

Associating the new name with the learnings from the workshop, multiple logo options were explored, before finally settling on a logotype showcasing the dynamism of the platform. The logo is inspired by a simple typeface showcasing the letter, "X". This letter is not only central in the brand's name (fle-x-ify), but also visually represents the exchange and exploration of data across the interconnected service providers, market operators, organisations and asset owners.

Colour Palette

To emphasise sustainability, energy and the alignment to net zero and green energy, a palette composed of greens and oranges was selected. Warm greens were chosen as primary colours as a node to enabling a greener energy sector, which the platform aims to aid in facilitating. The colours are used throughout the platform as cues for actions, to highlight important components and to illustrate sections.



Flexify's brand kit

Creating design guidelines and narrative around the Flexify brand

Using the Flexify brand

A brand kit was developed to facilitate the use of the Flexify brand on the platform as well as in any collateral documents and illustrations. It contains sections on typography and its usage for headings and body text, colours and their usage, and the tone of voice and values of Flexify.

Our Tone of Voice & values should be

Cooperative

As the platform will bring together data from multiple sources and facilitate the ease of sharing between platforms, cooperation between these parent platforms is of paramount importance and we should seek to evoke this collaborative motif within the brand's itself.

Short

We want to be concise and clear with the language that we use so as to avoid confusing our potential users.

Practical

As the platform is geared towards simplifying the process of managing assets and enabling flexibility, a practical view is required to inform our target audience of the necessary actions they need to take to make the process as easy as possible for them.

Resourceful

Resourcefulness is essential to the brand's integrity and sits at the heart of the brand's function. Being resourceful with data being shared across platforms and linked via a central register (Flexify) is one of the core issues that we aim to solve as part of the UMM's development.

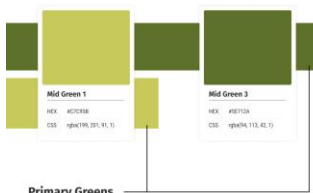
Responsible

Working to establish ourselves as a prime authority within the Energy sector, Flexify should seek to educate potential users on the best ways for them to access and navigate flexibility markets.

Our Illustrations



Our Primary Colour Palette



Primary Greens

We identified 2 accent colours for the Flexify brand that we were interested in pairing together, and the more popular of these two was the green tone displayed above - making it the perfect candidate for our brand's primary colour.

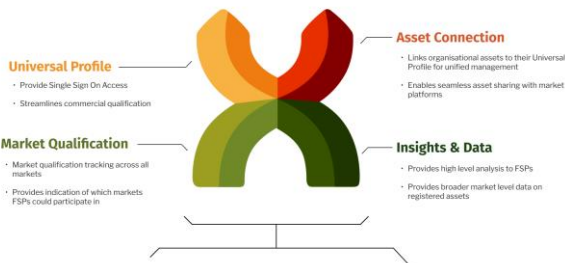
The narrative behind the green is one that emphasises sustainability and the strong alignment towards net zero and green energy. From these warm-toned greens, we extended the palette to a full range of green values (both warm and cool tones) that could be used across the platform and the branding and marketing of Flexify.



Primary Oranges

The oranges here are the two values which comprise the secondary logo/ orange alternative for Flexify. The colour orange creates a direct visual link to the energy sector and we repeated the approach of having warmer tones for the primary palette to emphasise the flexibility aspect of the platform.

Our Logos (a deeper look)



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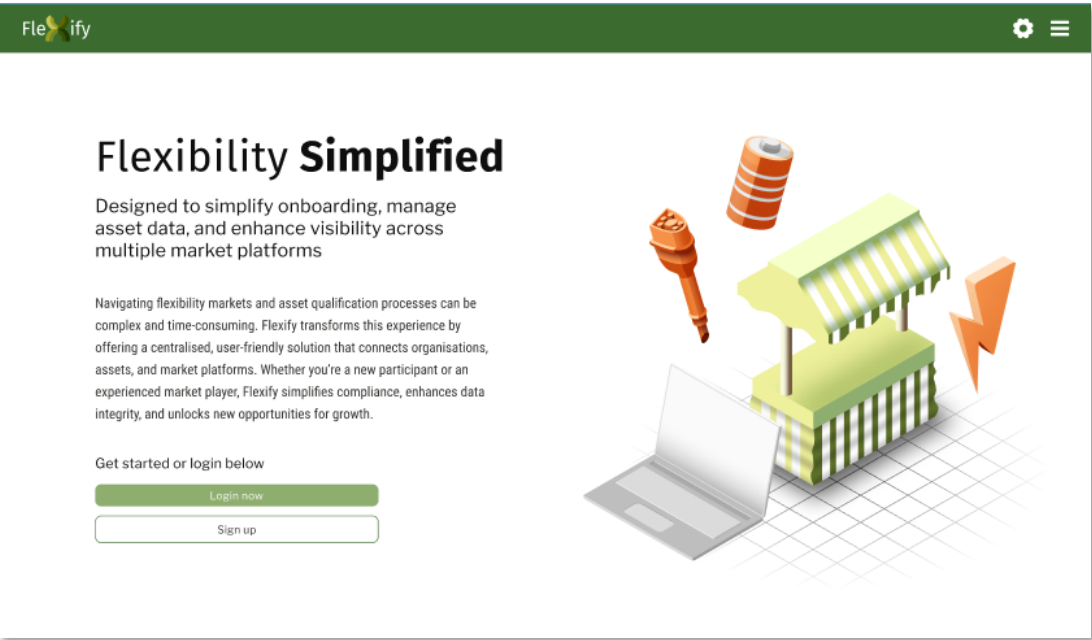
Universal Profile

Universal Profile

Creating a Universal Profile: A user journey through wireframes

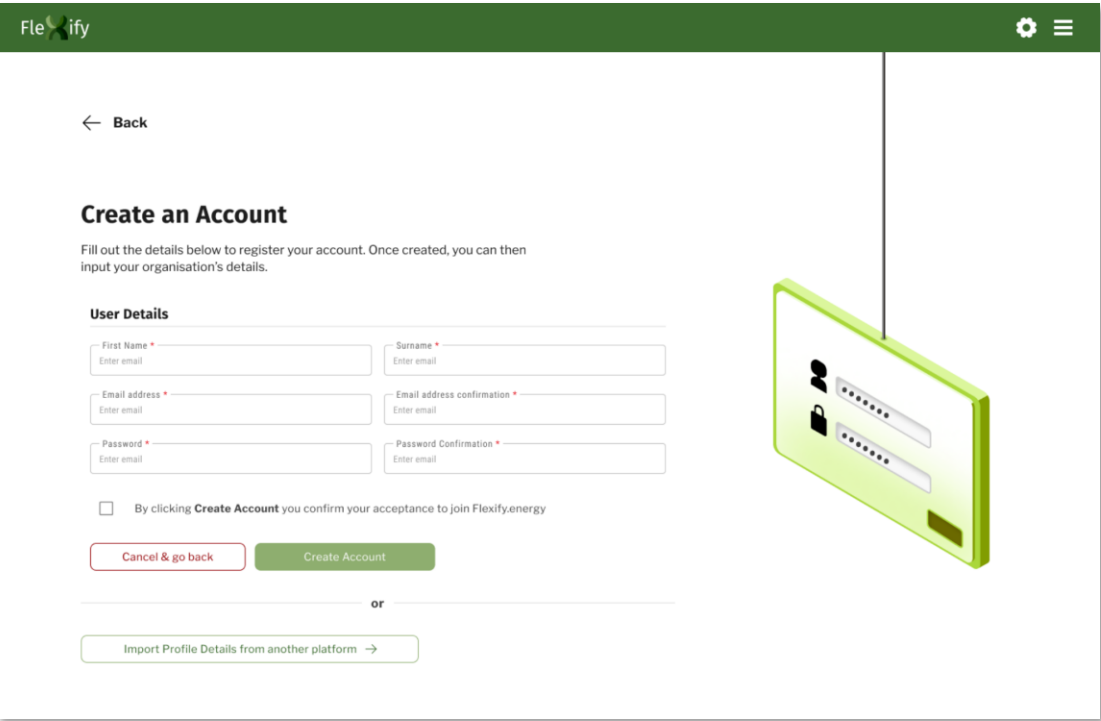
Flexify Landing Page

User navigates to Flexify



Create an Account

User navigates to Flexify, and creates a new account

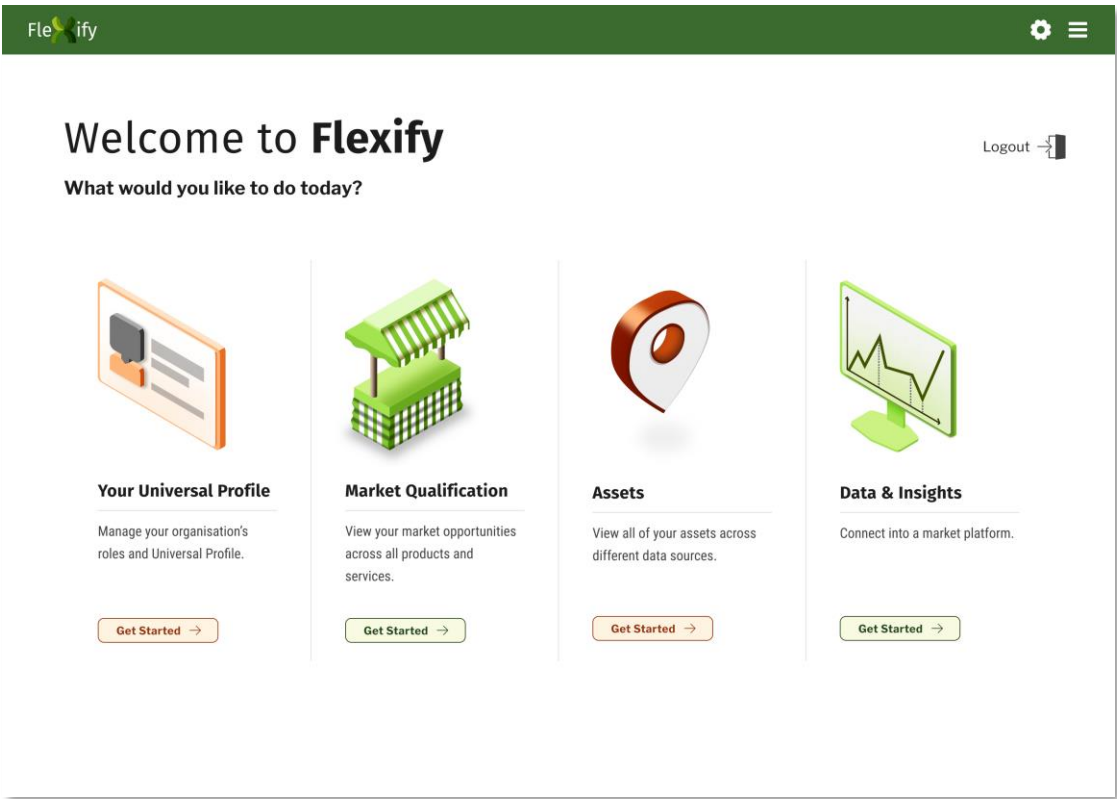


Universal Profile

Creating a Universal Profile: A user journey through wireframes

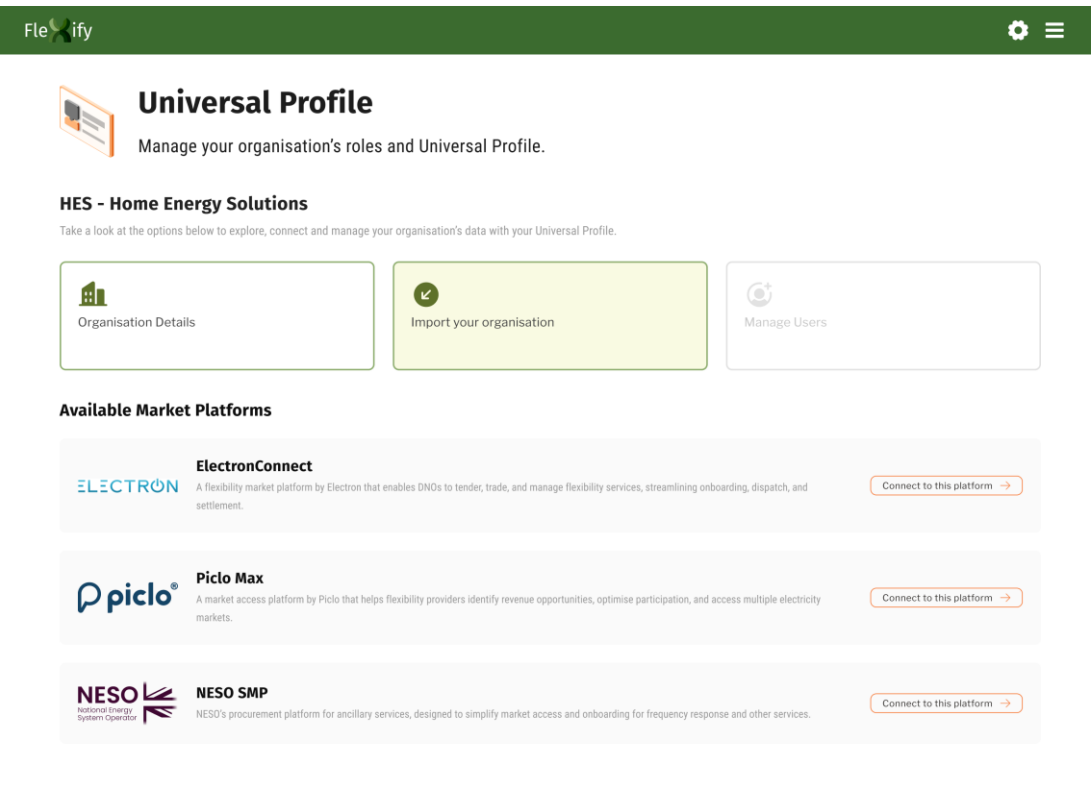
Flexify Features

User sees Flexify features



Import Account Details

User views market platform list, and select import your organisation to retrieve organisation information

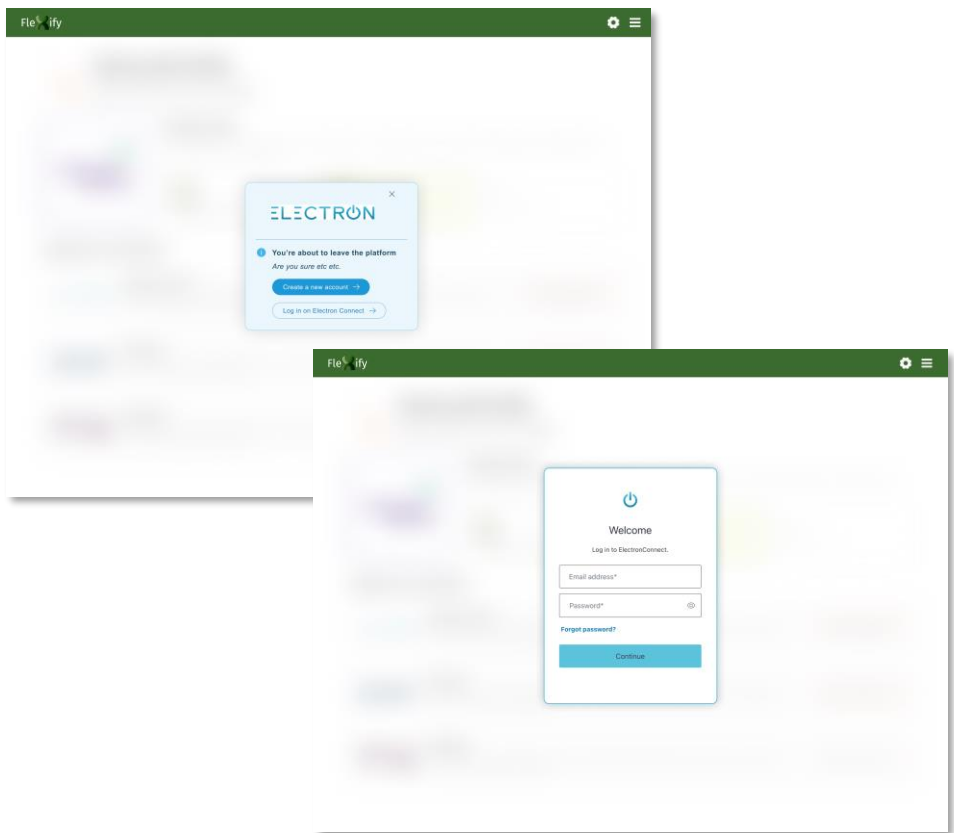


Universal Profile

Creating a Universal Profile: A user journey through wireframes

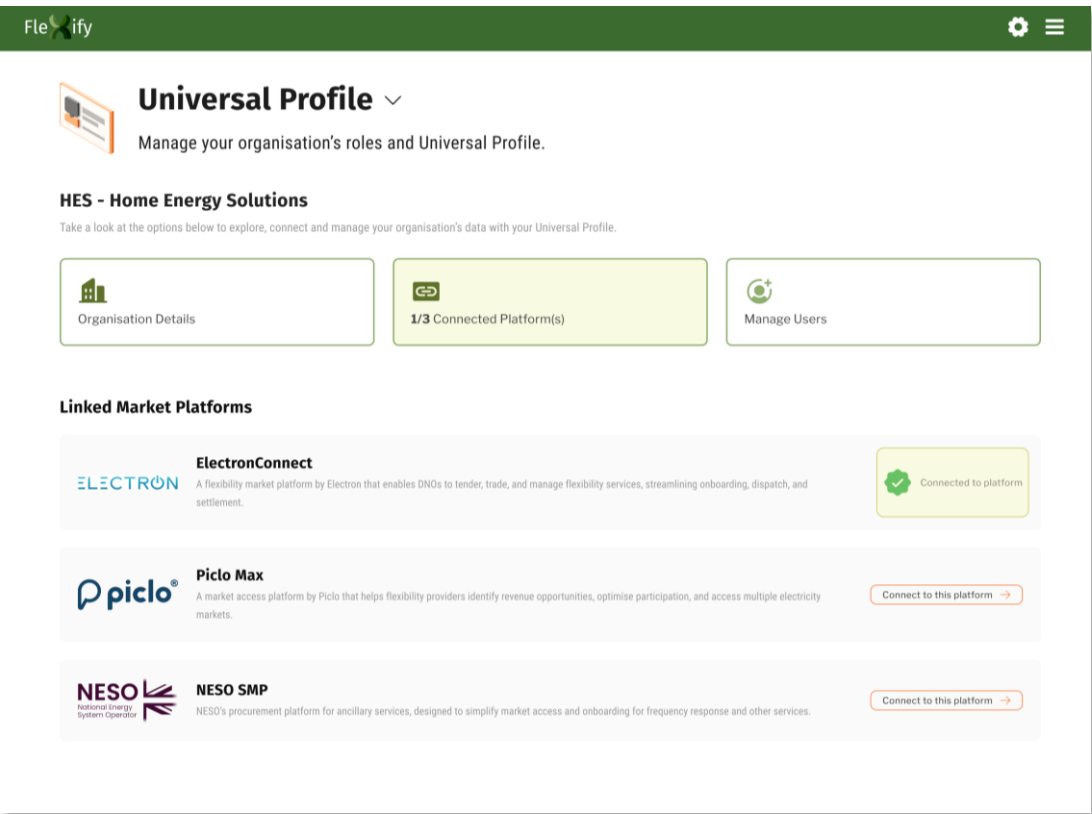
Connect to a market platform

User selects market platform to connect with (Electron) and chooses "Log in"



Link to a market platform

After successful login the user can see that the platform has been linked



Universal Profile

Creating a Universal Profile: A user journey through wireframes

View organisation details

User selects the organisation details and sees the imported information

Universal Profile Manage your organisation's roles and Universal Profile.

HES - Home Energy Solutions

Take a look at the options below to explore, connect and manage your organisation's data with your Universal Profile.

Organisation Details 1/3 Connected Platform(s) Manage Users

Basic Information Essential details of the organisation for registration (e.g. company address, contact information etc.) Edit Organisation details

Imported from ElectronConnect

Company Name	Home Energy Solutions	Registered/ Legal Name	Home Energy Solutions
Company Registration Number	01234567	VAT registration number	GB123456789
Address Line 1	004 12	Address Line 2	Testing Street
City	London	Country	-
Country	England	Postcode	E1 1HP
Organisation Website Address	www.hes.com	Legal relationship with Flexibility asset(s)	Owner
Assigned Reference of Organisation	-		

PQQ Information Commercial Requirements: These are the commercial requirements of the PQQ information that are required for you to operate within any given market. Please take the time to check the fields below for this information to be verified in the future.

Validation Documentation Additional documents to verify the organisation's identity.

Edit organisation details

User selects edit the organisation details and is able to make changes and can save/discard the details

Universal Profile Manage your organisation's roles and Universal Profile.

HES - Home Energy Solutions

Take a look at the options below to explore, connect and manage your organisation's data with your Universal Profile.

Organisation Details 1/3 Connected Platform(s) Manage Users

Basic Information Essential details of the organisation for registration (e.g. company address, contact information etc.)

PQQ Information Commercial Requirements: These are the commercial requirements of the PQQ information that are required for you to operate within any given market. Please take the time to check the fields below for this information to be verified in the future.

Validation Documentation Additional documents to verify the organisation's identity.

Document Name 1 Document 1 Name here Document Name 2 Document 2 Name here Document Name 3 Upload Document 3 Document Name 4 Upload Document 4

View PQQ information

User selects the PQQ dropdown to view completed imported information

Universal Profile Manage your organisation's roles and Universal Profile.

HES - Home Energy Solutions

Take a look at the options below to explore, connect and manage your organisation's data with your Universal Profile.

Organisation Details 1/3 Connected Platform(s) Manage Users

Basic Information Essential details of the organisation for registration (e.g. company address, contact information etc.)

PQQ Information Commercial Requirements: These are the commercial requirements of the PQQ information that are required for you to operate within any given market. Please take the time to check the fields below for this information to be verified in the future.

Terms and Conditions

Confirm you have read the applicable ENA, Standard Facility Services Agreement and understand it will be a requirement to accept this Agreement in order to form any contract for the delivery of flexibility services

Do you declare that you have the authority to submit this application and by confirming you declare that to the best of your knowledge, the information in this form is accurate?

Due Diligence

Is the contracting party a member of Flex Assure Code of Conduct?

Contracting parties Achilles UVOB Registered No. if applicable

Where Achilles UVOB registration has not been advised, you understand that the PQQ may exceed the contracting Parties must recent audited financial accounts via Companies House for the purpose of credit checks.

Is this contracting party currently, or has it ever been in administration?

Is this contracting party currently, or has it ever been unable to pay its debts as they fall due (within the meaning of Section 248 Insolvency Act 1986)?

Is this contracting party currently, or has it ever had any petition for bankruptcy (or their equivalent in the country in which the Applicant is incorporated) within the last three years?

Is this contracting party currently, or has it ever been convicted of any of the offences or has any discretionary exclusion occurred, as contained in Regulation 56 of the Utilities Contract Regulations 2016 (UCR), and listed in Regulation 57 and 57B of the Public Contracts Regulations 2015 (PCR)? (If in SCOTLAND, is this contracting party currently, or has it ever been convicted of any of the offences or has any discretionary exclusion occurred, as contained in Regulation 56 of the Utilities Contract Regulations 2016 (UCR), and listed in Regulation 58 of the Public Contracts Scotland Regulations 2015 (PCSR)?)

Is this contracting party currently, or has it ever had, in the past 3 years, any similar contracts terminated prematurely and/or had damages claims or other comparable sanctions brought against the contracting party for any significant or persistent performance in performance of a substantive requirement of the contract?

Has the contracting party been subject to any material non-compliance related litigation (pending, threatened or determined) or other legal proceedings against the contracting party within the last three years that may be relevant to your ability to deliver services?

Insurance

Does the contracting party have or consent to have Employer's liability insurance with a minimum limit of £5m?

Will the contracting party provide copies of such insurances upon request?

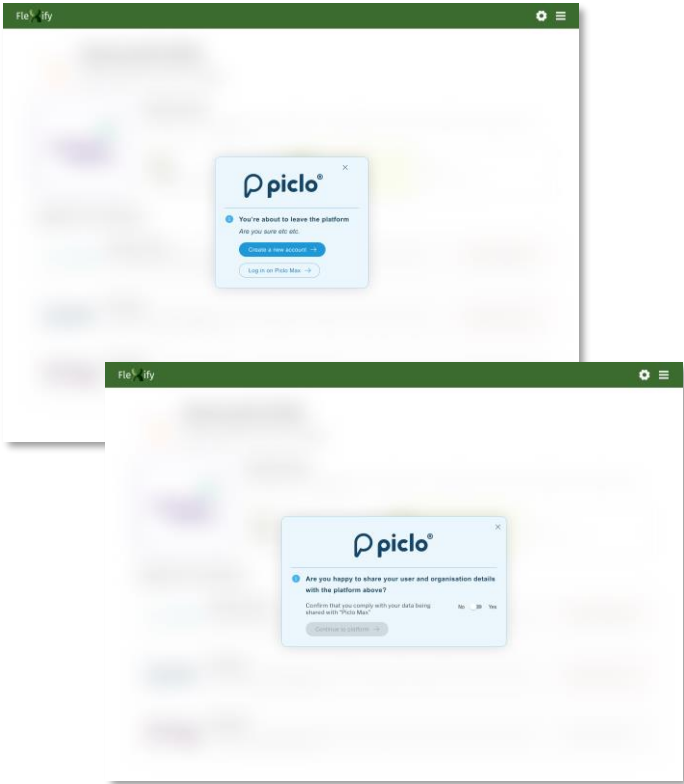
Does the contracting party have or consent to have Public liability insurance with a minimum limit of £5m?

Universal Profile

Creating a Universal Profile: A user journey through wireframes

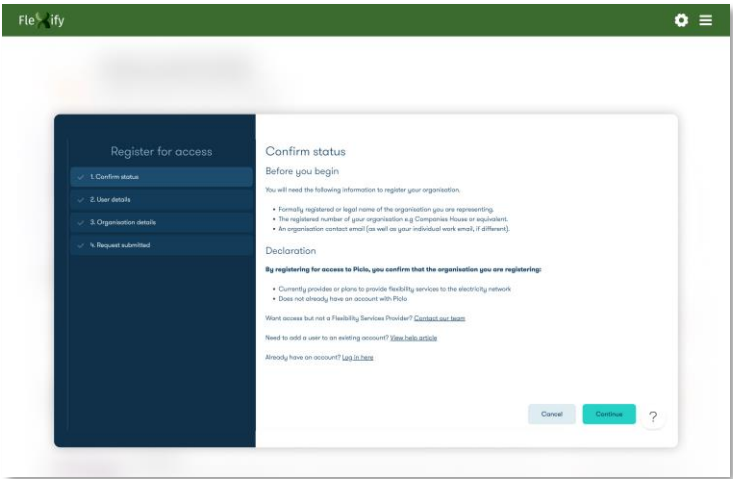
Link and additional platform

User navigates to market platform connector, selects another platform (Piclo) to initiate a connection



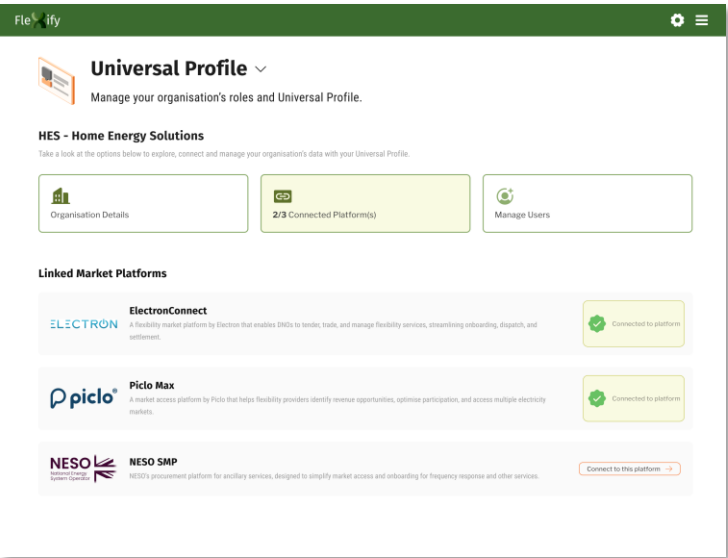
Accept platform terms and conditions

Flexify takes the user to 'Piclo' to create a new account



Linked to another market platform

After successful account creation, the user checks the platform status within the universal profile



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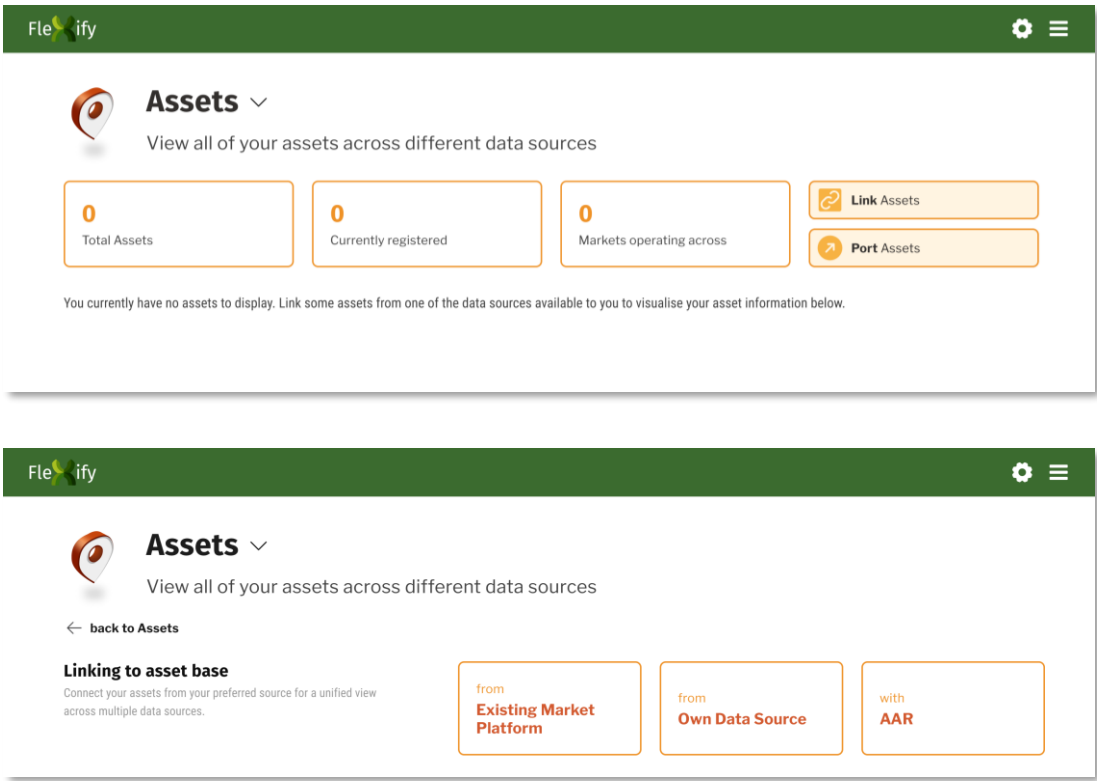
Asset connection service

Asset connection service

Connecting using the asset connection service: A user journey through wireframes

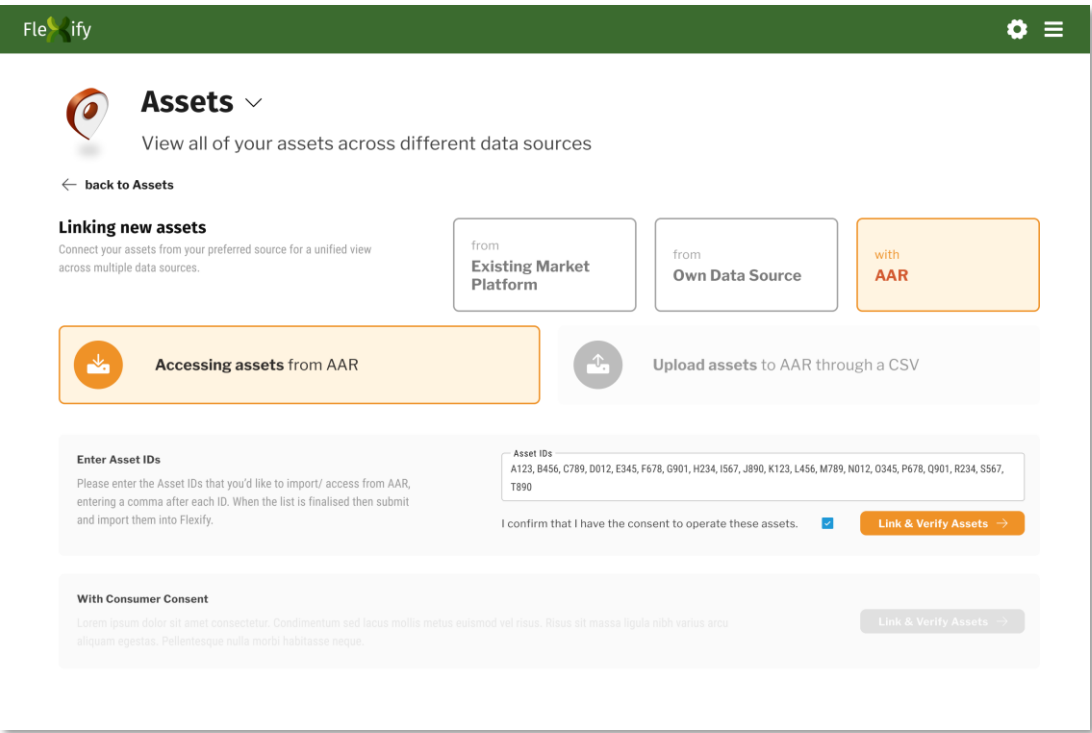
Link assets

User navigates to the 'Asset' feature, and choose “Link Assets”



Linking new assets through AAR

User submits a list of assets using the AAR Asset ID code and confirms the import of asset information from AAR

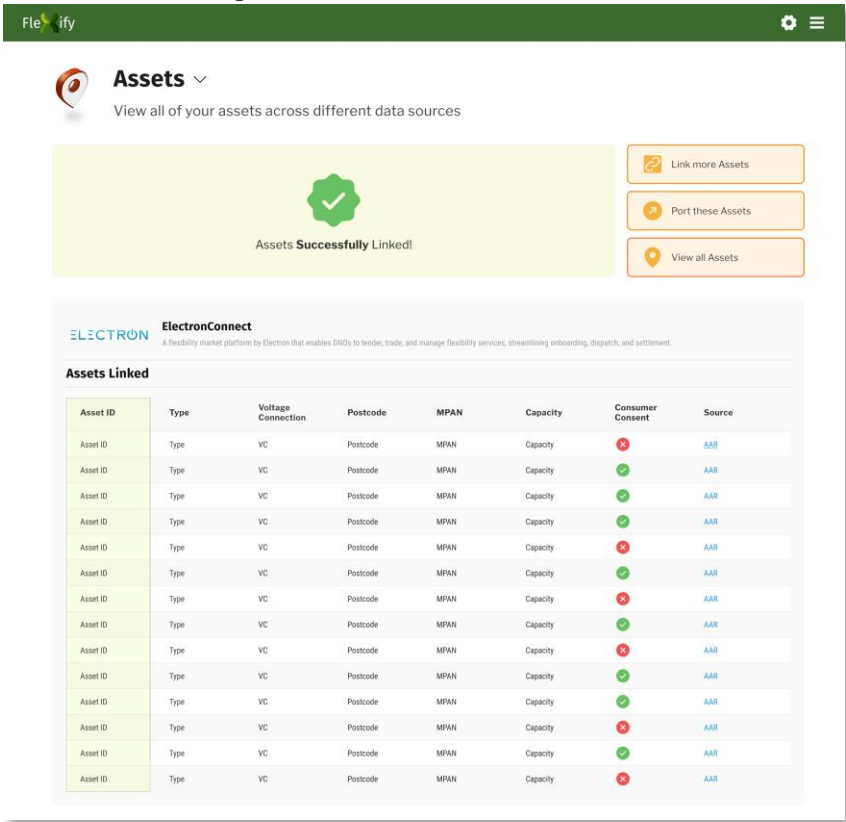


Asset connection service

Connecting using the asset connection service: A user journey through wireframes

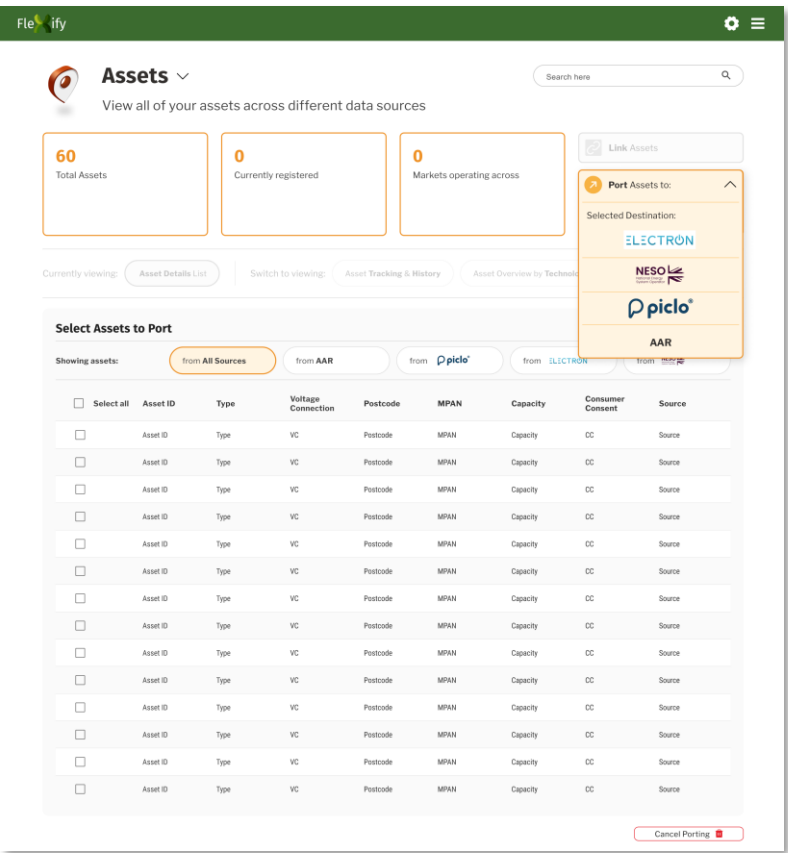
View Linked Assets

User views the imported asset list



Porting Assets

The user clicks on 'Port Assets' and selects the destination for the assets.

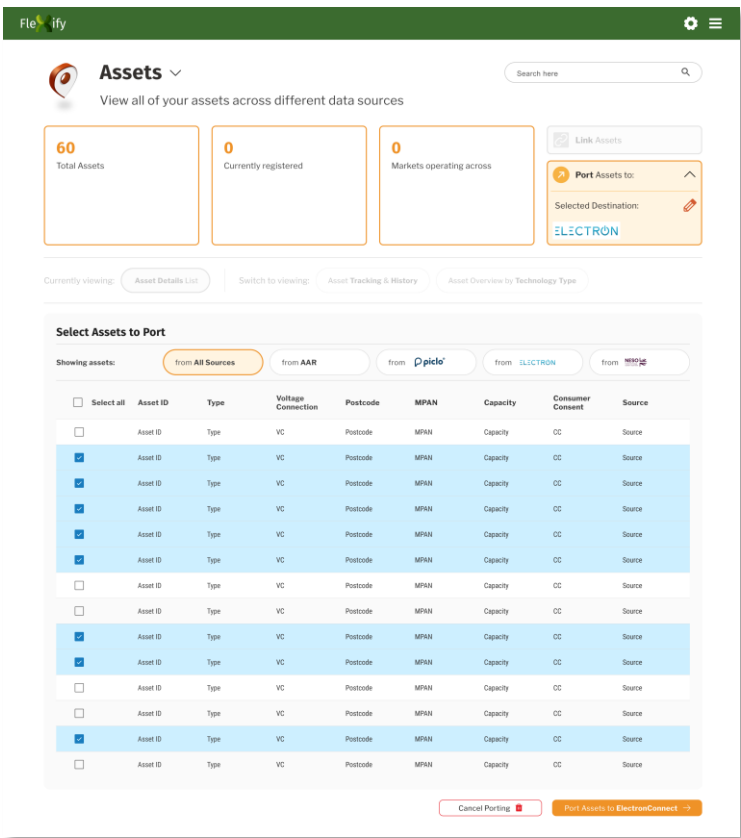


Asset connection service

Connecting using the asset connection service: A user journey through wireframes

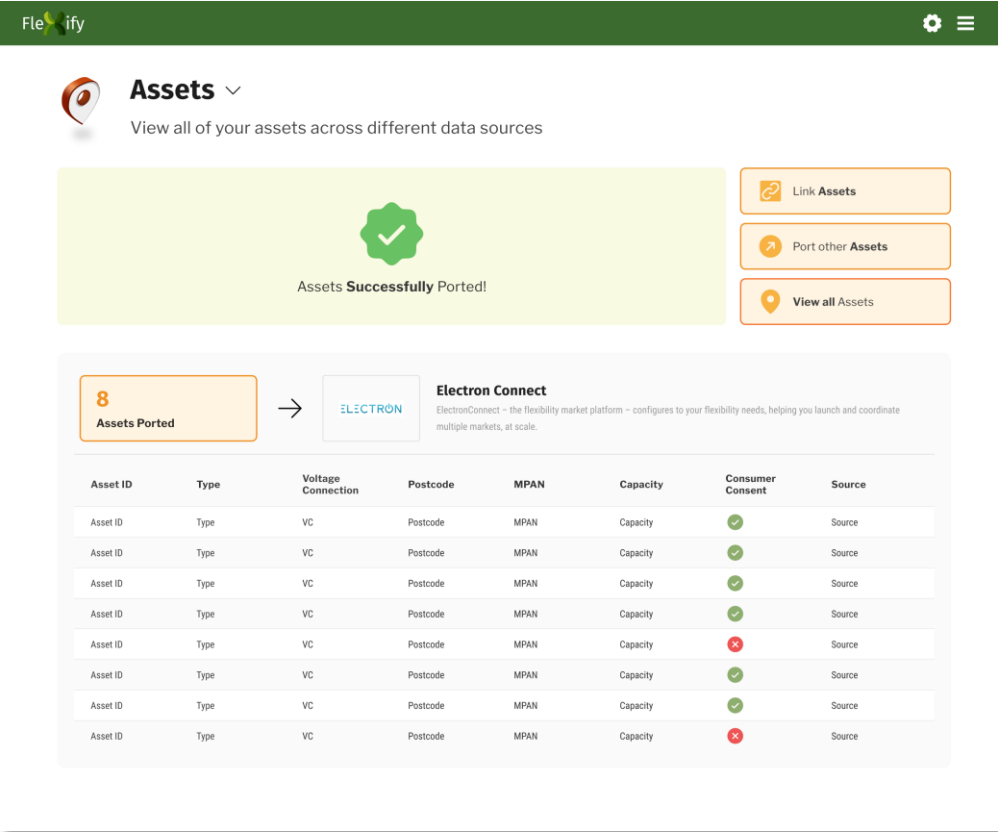
Select assets to transfer

User selects the asset information to transfer to the selected destination.



Asset transfer confirmation

User successfully transfer assets and sees it in the selected destination.



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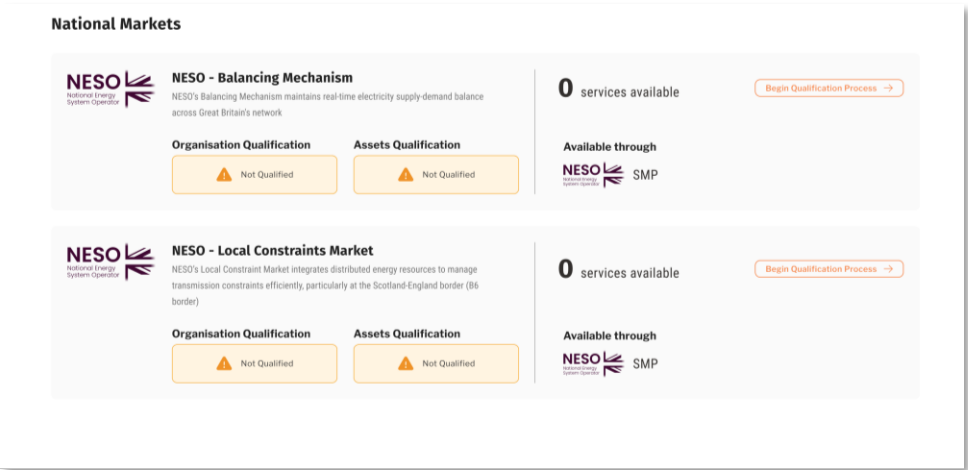
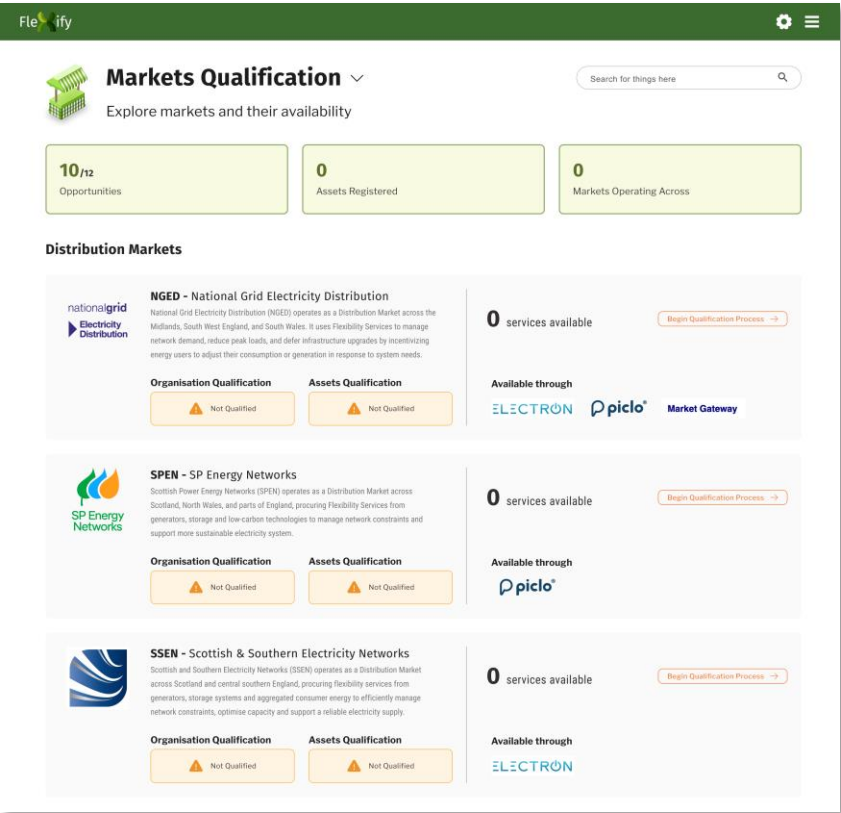
Market qualification

Market qualification

Exploring market opportunities: A user journey through wireframes

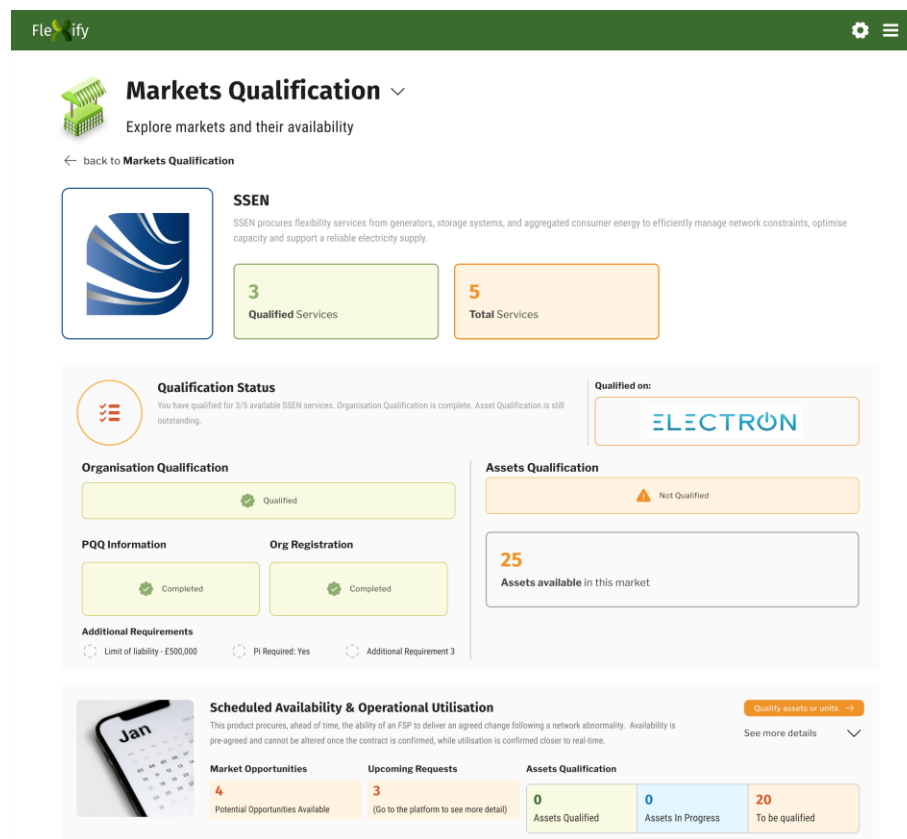
Explore markets

User navigates through the market list to explore available markets



Exploring market opportunities: A user journey through wireframes

User is notified of outstanding items and is prompted to provide further details to achieve market qualification.

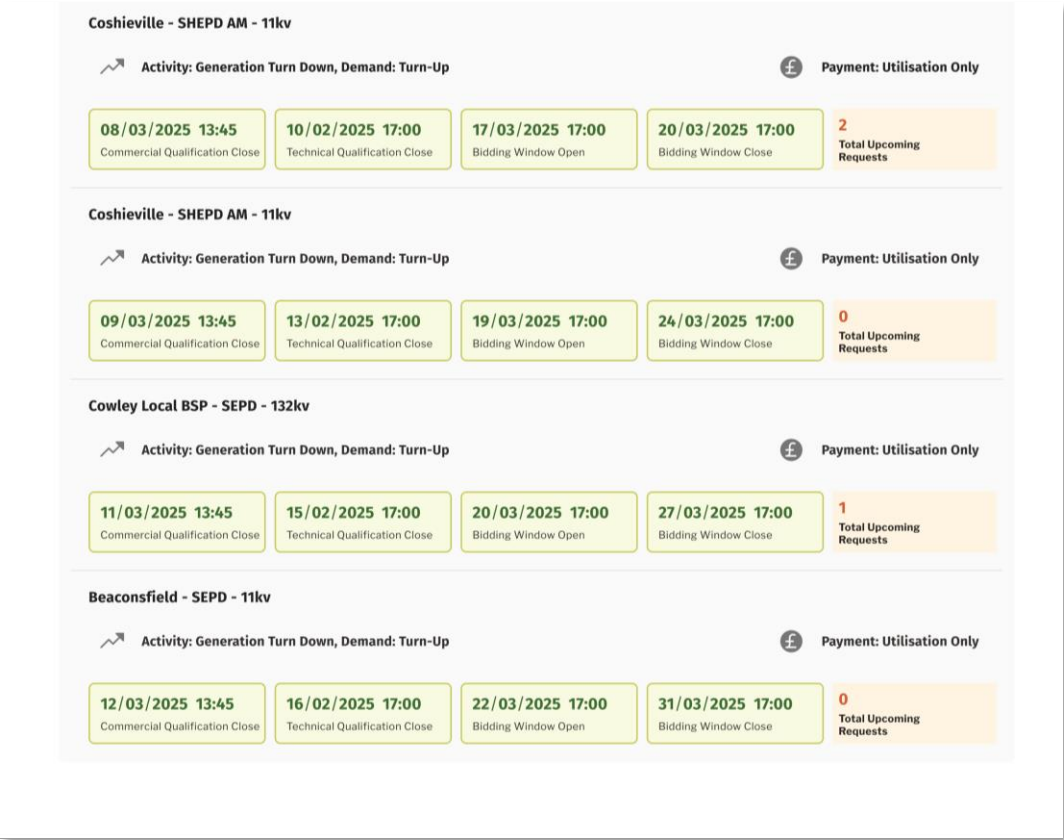
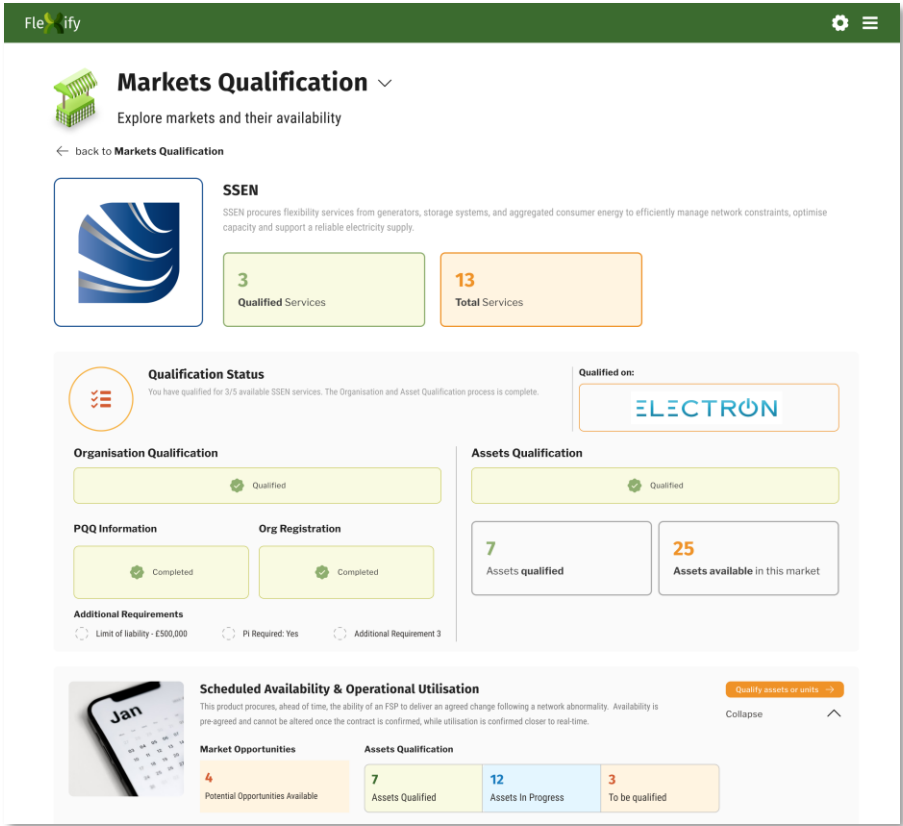


Market qualification

Exploring market opportunities: A user journey through wireframes

Track market qualification

Once all qualification items are completed, FSP receives confirmation for completed qualification process.



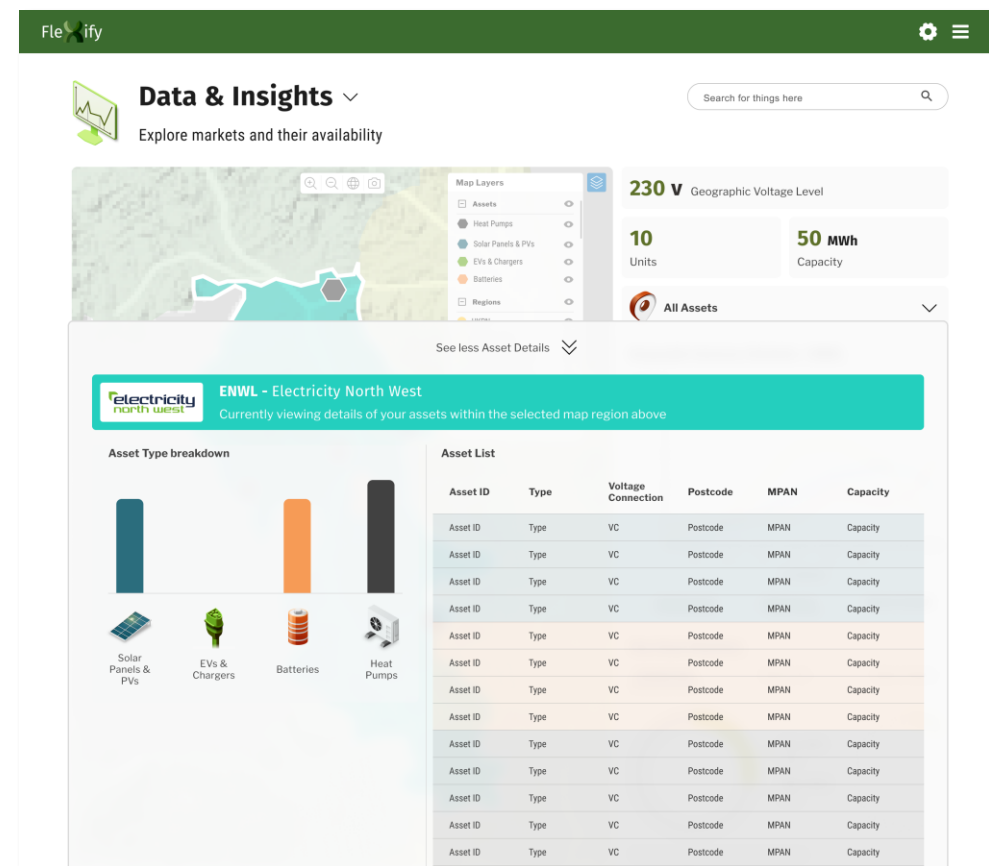
B.1.1.4

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Insights & data

Gaining insights on market data: A user journey through wireframes

Users would explore data and insights made available through Flexify



B.1.2

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Flexify requirements

B.1.2 - Flexify requirements

Theme	UX process	ID	Title	PoC priority - agreed
1. Registration	A.1.1 User sign up	A.1.1.2	Primary user signup process	Must have
1. Registration	A.1.1 User sign up	A.1.1.3	User log-in via password and email (SSO post-PoC)	Must have
1. Registration	A.1.1 User sign up	A.1.1.1	UMRweb portal	Must have
1. Registration	A.1.2 Create new primary user	A.1.2.2	User email authentication	Must have
1. Registration	A.1.2 Create new primary user	A.1.2.1	The platform creates a profile for the new user	Must have
1. Registration	A.1.3 Register a new organisation	A.1.3.1	New organisation registration	Won't have
1. Registration	A.1.3 Register a new organisation	A.1.3.2	Technical users signup process	Won't have
1. Registration	A.1.4 Transfer an existing organisation details	A.1.4.1	Transfer existing organisation process	Could have
1. Registration	A.1.5 Register and validate organisation details	A.1.5.2	A unique ID is assigned to organisations	Must have
1. Registration	A.1.5 Register and validate organisation details	A.1.5.3	Create Universal Profile	Must have
1. Registration	A.1.5 Register and validate organisation details	A.1.5.1	Know Your Company organisation check	Won't have
1. Registration	A.1.6 Transfer an existing organisation details	A.1.6.1	Access to existing market platform logins	Must have
1. Registration	A.1.6 Transfer an existing organisation details	A.1.6.2	Organisation validation confirmation	Must have
1. Registration	A.2.2 Organisation receives and stores their Digital Certificate	A.2.2.1	Enable Storage of Digital Certificate	Could have
1. Registration	A.2.3 Organisation configures their SSO and onboards users	A.2.3.1	Admin configures SSO for the first time	Must have
1. Registration	A.2.3 Organisation configures their SSO and onboards users	A.2.3.2	Admin provides access to FSP organisation users	Won't have
1. Registration	A.2.5 Organisation configures access to additional platforms	A.2.5.1	A new connection request to the selected market platform is initiated	Won't have
1. Registration	A.2.6 Organisation adds/edits corporate commercial information	A.2.6.1	The admin add new data or edits existing corporate information	Won't have
2. Connection & access	B.1.1 User imports asset information to link with Universal Profile	B.1.1.1	User adds asset data from asset source	Must have
2. Connection & access	B.1.1 User imports asset information to link with Universal Profile	B.1.1.2	User adds asset data from asset source	Must have
2. Connection & access	A.3.1 User completes organisation PQQ information	A.3.1.1	User adds commercial PQQ information to their Universal Profile	Must have
2. Connection & access	A.3.2 User navigates to and signs in to the market platform	A.3.2.1	User views available market platforms	Must have
2. Connection & access	A.3.2 User navigates to and signs in to the market platform	A.3.2.2	User requests access to market platform	Must have
2. Connection & access	A.3.3 Enable SSO access to market platform	A.3.3.1	Send Universal Profile and market qualification status to market platform	Must have
2. Connection & access	A.3.3 Enable SSO access to market platform	A.3.3.2	Wait for confirmation from market platform that Universal Profile has been registered	Should have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.1	Verify Universal Profile to import existing asset market information	Must have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.3	Provide access to AAR to import asset data	Must have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.4	Import, translate, and validate asset data	Must have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.6	Duplication Check for Assets Associated with Universal Profile	Must have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.7	Error Handling for Duplicate Assets Detected in Universal Profile	Must have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.8	Assign Unique Identifier (UID) to Assets if No Duplicates Detected	Must have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.5	Provide Data Mapping Template and Run Data Validation	Won't have
2. Connection & access	B.1.2 ETL of asset data, provide UID and run duplication checks, link to the Universal Profile	B.1.2.2	Provide connection/upload options for importing data from user environment	Won't have
2. Connection & access	B.2.1 User views asset list, sets their preferred view and checks asset status	B.2.1.1	User navigates to their asset list	Must have
2. Connection & access	B.2.1 User views asset list, sets their preferred view and checks asset status	B.2.1.2	User configures their asset list view through search or filtering	Won't have
2. Connection & access	B.2.1 User views asset list, sets their preferred view and checks asset status	B.2.1.3	User selects individual asset and views additional asset information	Could have
2. Connection & access	B.2.2 User explores market opportunities associated with assets	B.2.2.1	User views market list and available market information	Won't have
2. Connection & access	B.2.2 User explores market opportunities associated with assets	B.2.2.2	User explores market opportunities and identifies applicable assets in each market	Won't have
3. Sharing & qualification	B.3.1 Request asset data transfer to chosen market platform	B.3.1.1	User opens market platform with configured access	Must have
3. Sharing & qualification	B.3.1 Request asset data transfer to chosen market platform	B.3.1.3	User requests transfer of selected asset data to market platform	Must have
3. Sharing & qualification	B.3.1 Request asset data transfer to chosen market platform	B.3.1.4	User is notified that asset data has been transferred	Won't have
3. Sharing & qualification	B.3.1 Request asset data transfer to chosen market platform	B.3.1.2	User selects assets to be shared with market platform	Could have
3. Sharing & qualification	B.3.2 Enable transfer of asset data to preferred market platform	B.3.2.1	Configure data for transfer to selected market platform	Must have
3. Sharing & qualification	B.3.2 Enable transfer of asset data to preferred market platform	B.3.2.2	Send request to existing market platform to transfer data to target platform	Must have
3. Sharing & qualification	B.3.2 Enable transfer of asset data to preferred market platform	B.3.2.3	Transfer of asset data from UMR to the target platform	Must have
3. Sharing & qualification	B.3.2 Enable transfer of asset data to preferred market platform	B.3.2.4	Send request to 3rd party database to transfer data to target platform	Won't have
3. Sharing & qualification	B.3.2 Enable transfer of asset data to preferred market platform	B.3.2.5	Confirm data has been received by target platform	Must have
3. Sharing & qualification	C.1.1 Validate market and asset qualification statuses and associate statuses to Universal Profile and assets	C.1.1.1	UMR associates market qualification status with Universal Profile	Won't have
3. Sharing & qualification	C.1.1 Validate market and asset qualification statuses and associate statuses to Universal Profile and assets	C.1.1.2	UMR associates asset qualification status to assets	Won't have
3. Sharing & qualification	C.2.1 User views market and asset qualification dashboard	C.2.1.1	User views market qualification status	Won't have
3. Sharing & qualification	C.2.1 User views market and asset qualification dashboard	C.2.1.2	User views assets qualified in market	Won't have

B.1.3

— Flexify architecture

B.1.3.1

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Architecture principles

Architecture principles

Defining the design and architecture principles for Flexify

General & Design Principles

Design principles are used to assess options associated with meeting a specific user or a technical requirement.

As the development of the solution moves through the various lifecycle stages, and additional testing, iteration and low-level documentation is produced, then it is expected that some of these principles will evolve.

They are broken down by the following categories:

- **Domain Ownership**
- **Self-serve data platform**
- **Event-driven architecture**
- **Make data accessible**
- **Data-as-a-product**
- **Alignment with Data Best Practices Guidance**

Application & Technology Principles

Application & Technology principles ensure the long-term viability of the platform and means it can respond to future needs.

As the development of the solution moves through the various lifecycle stages, and additional testing, iteration and low-level documentation is produced, then it is expected that some of these principles will evolve.

They are broken down by the following categories:

- **Make applications scalable**
- **Pilot new applications & processes**
- **Use open standards and open source**
- **UK/ EU data centre hosting**

Security Principles

Security principles ensure the design and development of the platform places security of users and security of data at the forefront.

As the development of the solution moves through the various lifecycle stages, and additional testing, iteration and low-level documentation is produced, then it is expected that some of these principles will evolve.

They are broken down by the following categories:

- **Zero trust architecture (ZTA)**
- **Alignment with NCSC best practices and guidance**
- **Compliance with relevant legislation and regulation**

General principles

Defining the design and architecture principles for Flexify

Design Principle	Statement	Rationale	Implications
Domain ownership	Locality and management of the data will remain with the participants who are providing the data, and not in a centralised, monolithic platform.	Decentralised ownership of data leads to improved ability to scale data sharing aligned with organisational growth. Furthermore, it enhances agility by removing bottlenecks from centralised designs.	The locality and ownership of data must remain with the organisations/data owners, and not in a central platform.
Self-serve data platform	The solution will provide users with the tools to discover, access and use the data in a streamlined and secure way.	Enables an effective and useful platform for both producers (who are publishing data and setting permission controls) and for consumers (who are searching, subscribing, and ingesting datasets).	The solution must provide users with all the correct tools to exchange data securely and effectively in a self-serve federated fashion.
Event-driven architecture	The solution will adopt an event-driven architecture, where system components communicate and react to events and significant changes in state, facilitating asynchronous data processing and real-time responsiveness.	This enables high levels of decoupling between components, enhancing system scalability and flexibility. It allows different parts of the system to efficiently react to and process events as they occur, supporting a responsive and dynamic user experience.	The solution must adopt an event-driven architecture through the implementation of a robust message-brokering system. This must be carefully designed and configured to minimise event-driven chaos, particularly in error handling and data inconsistencies. This means that the system’s components must be designed to operate in a stateless fashion, optimising resource utilisation and scalability.

General design principles

Defining the design and architecture principles for Flexify

Design Principle	Statement	Rationale	Implications
Make data accessible	Data will be made easily discoverable, retrievable and reflect a single version of the truth to ensure consistency and reliability in decision-making processes.	Ensuring data originates from a single, authorised source enhances its integrity and trustworthiness, making it a reliable for analysis, reporting and operational use.	The solution must be designed with flexibility to accommodate diverse user needs, including varying access methods, ensuring that all users can effectively utilise the data regardless of their technical expertise.
Data-as-a-product	Data that is shared will adhere to a set a of usability characteristics to ensure that the data is understandable, secure, trustworthy, and interoperable.	By ensuring the value and utility of the data being shared, friction in discovering, accessing, and consuming data is minimised. This approach not only streamlines the interaction with data but also fosters a data-driven culture where data is treated as a product that can be readily shared between Market Platforms.	Participants must treat their data as a product that has value to users and ensure it has the correct characteristics and components that are required for sharing. E.g., providing appropriate metadata, assigning correct access control permissions and data licenses, and standardising the data into an interoperable standard.
Alignment with Data Best Practices Guidance	The solution will align Ofgem's Data Best Practice Guidance .	This ensures that the approach to handling energy data is compliant with industry standards, reflecting the latest in responsible data management and security.	The solution must implement established best practices as described in the Data Best Practice Guidelines, ensuring that data management and privacy controls meet or exceed the recommended standards.

Application principles

Defining the design and architecture principles for Flexify

Design Principle	Statement	Rationale	Implications
Make applications scalable	Applications will be architected and deployed with scalability in mind, ensuring they are adaptable to growing demands and increased workloads.	This approach ensures that applications remain efficient and responsive, regardless of data volume and number of users. This helps mitigate bottlenecks and supports the future growth of the solution.	Applications must incorporate strategies for scaling both vertically (enhancing the capacity of existing software) and horizontally (expanding the system with additional compute instances). This approach ensures that the solution can handle an increase in demand, maintaining high levels of service and user experience.
Pilot new applications & processes	Functionalities will be developed and iterated to test with users, gathering insights to refine the application components.	It is difficult to forecast every aspect of an application’s performance and user reception to it. By adopting a pilot-and-learn approach will confirm the viability of the solution’s usefulness, investment strategies and technologies. Obtaining early user feedback offers insight into the solution’s effectiveness, thereby enabling continuous improvement of the design.	The design process must be open to experimenting and investing in new applications and technologies on a manageable scale before broader implementation. This approach minimises risk associated with full-scale deployment or ‘big bang’ approaches by ensuring that the solution is aligned with users’ needs.

Technology principles

Defining the design and architecture principles for Flexify

Design Principle	Statement	Rationale	Implications
Use open standards and open source	The solution will adopt open standards and open-source technologies where appropriate, to ensure interoperability.	Relying on proprietary standards can hinder reuse, limit interoperability, and potentially result in vendor lock-in, potentially leading to unexpected costs. The solution should adopt the <u>HM Government Open Standards Principles</u> and <u>GOV.UK Technology code of practice (Point 5 and 6)</u> which encourages the use of open technologies and practices.	Exit, rebid and rebuild costs must be taken into consideration during procurement decisions for best value for money comparisons, between open source and proprietary solutions. Open-source software is not necessarily free to use. Many independent software vendors and value-added resellers use open-source technology within proprietary for-profit products. Therefore, the total cost of ownership must be assessed for both open-source and commercial software to ensure the most cost-effective choices are made.
UK/ EU data centre hosting	Services will be hosted in data centres located within the UK and EU to ensure efficient and secure data handling.	Hosting in UK and nearby EU data centres minimises network latency, enhancing the performance and responsiveness of the services. This also aligns with data sovereignty principles, reassuring connected partners about the handling and storage of their data compliance with UK and EU data regulations.	This hosting strategy requires careful considerations of data centres providers that comply with the UK and EU’s stringent data protection and privacy laws, such as GDPR. It may also involve implementing additional security measures to safeguard against data breaches and unauthorised access, this may include physical security of the data centres. If a cloud vendor is selected to host the data in their data centres, then this will require careful supply chain review to ensure that the vendor is trusted.

Security principles

Defining the design and architecture principles for Flexify

Design Principle	Statement	Rationale	Implications
Zero trust architecture (ZTA)	The solution will adopt a The Zero Trust Architecture (ZTA), which asserts that trust is never assumed and must be continuously verified for all users, devices, and entities attempting to access the solution. The primary objectives are to enhance security by minimising the inherent trust traditionally assigned to users within a network, irrespective of their location, and to fortify the overall resilience of the solution against evolving cyber threats.	The rationale for implementing a ZTA in the distributed nature of the solution where traditional perimeter-based security models will be insufficient. ZTA recognises the necessity to scrutinise and validate every access attempt. By doing so, it significantly diminishes the attack surface and fortifies the security posture against both external and insider threats.	Implementing a ZTA requires robust identity verification mechanisms, continuous monitoring of network traffic, and the adoption of strong encryption protocols. Access decisions must dynamically be made on real-time assessments of user behaviour and device health. The principle implies a move away from the traditional model of assuming trust once inside the network perimeter to a model where trust is earned and continuously verified throughout the user's interaction with the solution. This approach enhances security, especially in a dynamic and distributed digital environment, and ensures that potential threats are promptly identified and mitigated.
Alignment with NCSC best practices and other relevant best practice guidance	The design of the solution will adhere to the best practices and guidance issued by the National Cyber Security Centre (NCSC).	Aligning with NCSC guidelines ensures that security measures are aligned with nationally recognised standards to enhance the security posture of the solution. This also builds trust with stakeholders and users, reassuring them that their data is protected according to the highest standards.	The commitment to NCSC standards will enhance service credibility and reliability, especially in a regulated sector such as energy. Compliance with NCSC guidelines may require regular security audits and assessments for continuous improvement to cybersecurity measures.

B.1.3.2

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Solution architecture

B.1.3.2.1

— Logical architecture

Overview

Developing a structured architecture to define the design of the platform

Introduction

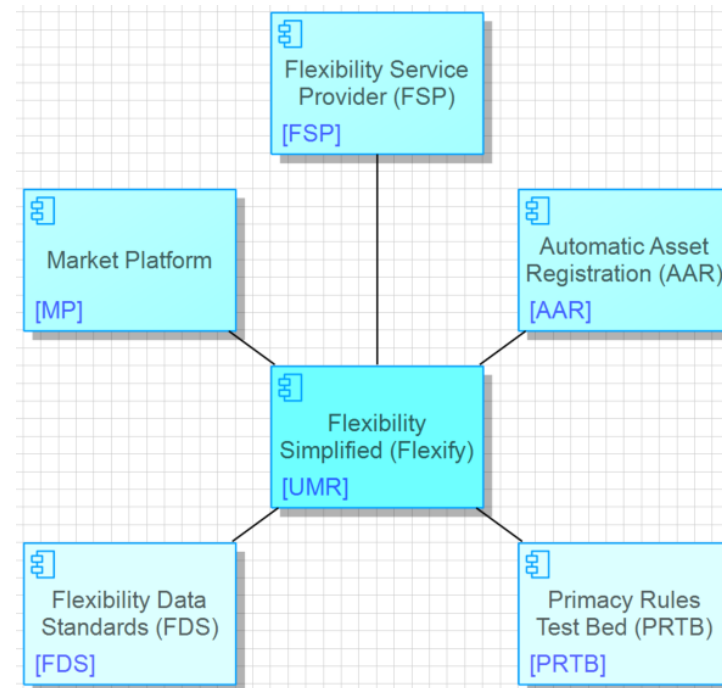
An application architecture for Flexify is presented in this section. The purpose of the application architecture is to illustrate and describe the application components required to meet the functional requirements. Throughout this section, the application components are presented, with accompanying descriptions of their functionality, including their interfaces with other components.

View levels

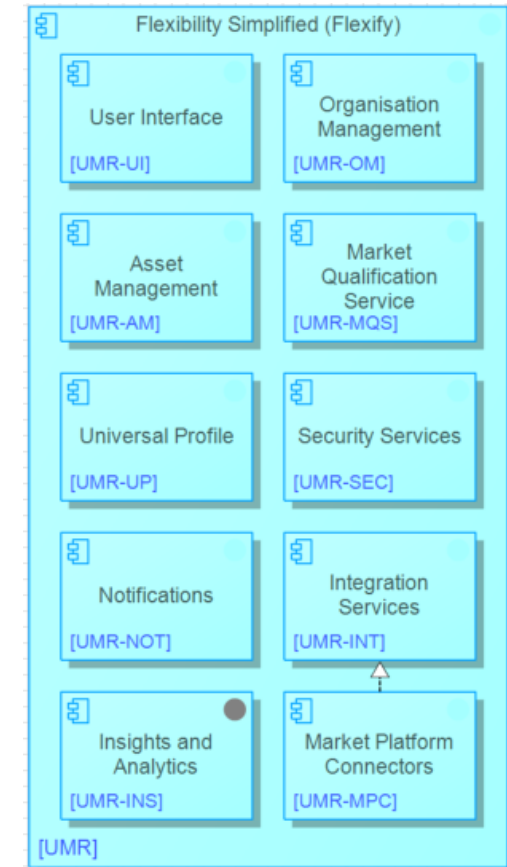
The architectural diagrams are presented through various levels, as described below:

- Level 0: Only the main systems are shown and none of the application components.
- Level 1: The high-level parent application components are shown but without the child or sub-components.
- Level 2+: The child/sub-components for each parent component is shown.

Level 0 Application Architecture Overview



Level 1 Application Architecture Overview



L2 application components

Developing a structured architecture to support the design of the platform

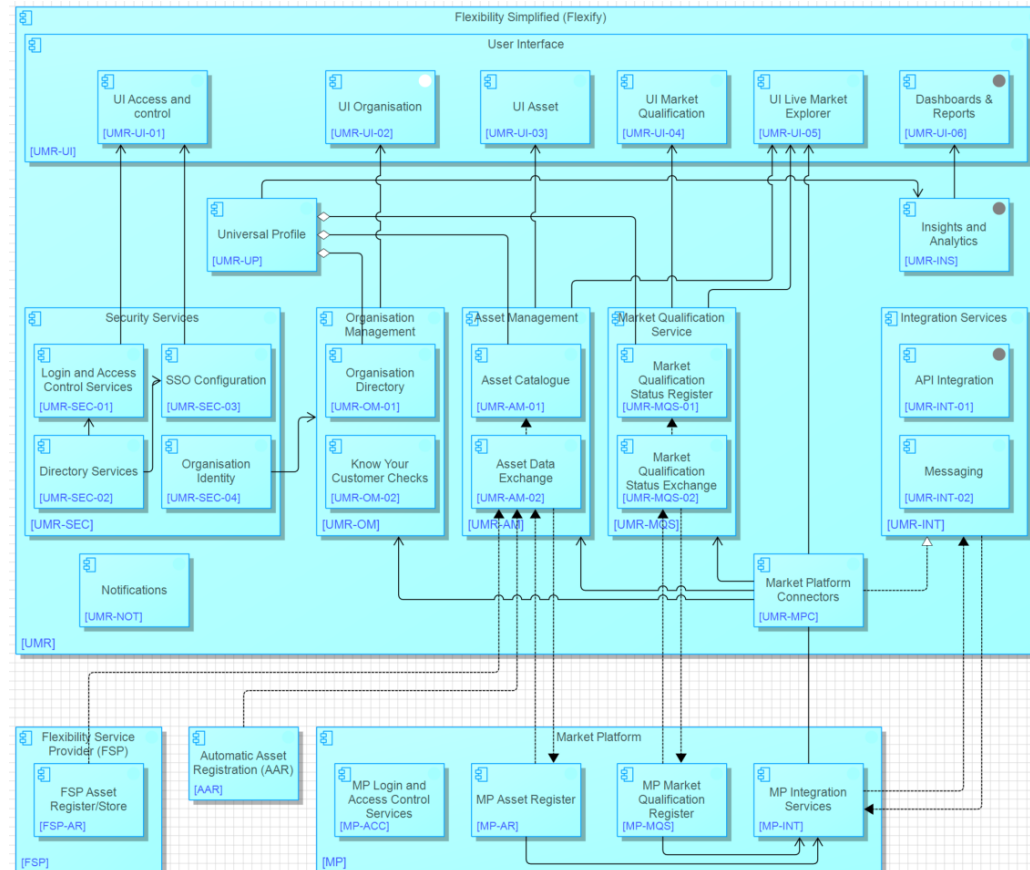
System Building Blocks

Flexify's Physical Architecture elements have been captured in the following pages; mapping to the Application Architecture components presented in the level 0-2 diagrams.

Elements marked TBD will be updated based on research and additional architectural clarifications when decisions have been made.

Note however that some product requirements marked TBD are currently considered post-POC and may not have implemented physical architecture elements.

Level 2+ Application Architecture Overview



System building blocks (1 of 4)

Definition of application components that outline the four key functions of the platform

Unique ID	Name	Description	Physical Architecture
UMR	Flexibility Simplified (Flexify)	The top-level logical component that encompasses all other Flexify components.	ASP.NET Core Web API Azure PostgreSQL Flexible Server Auth0 Azure Service Bus ASP.NET Razor Pages Postmark
- UMR-AM	Asset Management	Provides ability for FSPs to coordinate the management of their assets associated with their Universal Profile across multiple Market Platforms.	Azure PostgreSQL Flexible Server ASP.NET Core Web API
- - UMR-AM-01	Asset Catalogue	A store of data relating to the assets associated with the Universal Profile. This will not be a central database of the full asset datasets, rather the metadata for the assets, such as type of asset, unique identity reference, and Market Platforms the asset is in.	Azure PostgreSQL Flexible Server
- - UMR-AM-02	Asset Data Exchange	Provides a means to exchange asset data between Market Platforms, providing logged in users the means to select which assets will be shared with different Market Platforms.	ASP.NET Core Web API OAuth
- UMR-INS	Insights and Analytics	Provides insights and analytics against the data held within the platform, including all aspects of the Universal Profile as well as platform usage and market opportunities.	TBD [post PoC]

System building blocks (2 of 4)

Definition of the application components associated with integration services and market qualification

Unique ID	Name	Description	Physical Architecture
- UMR-INT	Integration Services	Provides the means for components within Flexify, to Flexify, and from Flexify to integrate, making requests for data and passing data between them.	ASP.NET Core Web API OAuth
- - UMR-INT-01	API Integration	Allows for synchronous web service API integration between components within Flexify, and between Flexify with external components.	ASP.NET Core Web API OAuth
- - UMR-INT02	Messaging	Allows for asynchronous messaging-based integration between components within Flexify, and between Flexify with external components.	Azure Service Bus
- UMR-MPC	Market Platform Connectors	Realised by the UMR-INT components, this logical component provides the integration between Flexify and Market Platforms.	ASP.NET Core Web API OAuth
- UMR-MQS	Market Qualification Service	Provides ability for FSPs to coordinate the management of their market qualification status associated with their Universal Profile across multiple Market Platforms.	TBD [post PoC]
- - UMR-MQS-01	Market Qualification Status Register	A store of data relating to the market qualification statuses associated with the Universal Profile.	TBD [post PoC]
- - UMR-MQS-02	Market Qualification Status Exchange	Provides a means to exchange market qualification status data between Market Platforms.	TBD [post PoC]
- UMR-NOT	Notifications	Provides the capability to send communications to users to support functionality across the platform. These communications can include confirmation emails and notifications of new market opportunities.	Postmark

System building blocks (3 of 4)

Definition of the application components that define the organisation management and security services

Unique ID	Name	Description	Physical Architecture
- UMR-OM	Organisation Management	Provides the capability to register and manage organisational details and data associated with the Universal Profile.	ASP.NET Core Web API Auth0
- - UMR-OM-01	Organisation Directory	A directory of all organisations that use the Flexify service.	Azure PostgreSQL Flexible Server
- - UMR-OM-02	Know Your Customer Checks	A capability to perform checks against organisations to validate authenticity, etc.	TBD [post PoC]
- UMR-SEC	Security Services	Provides various security-related capabilities.	Auth0
- - UMR-SEC-01	Login and Access Control Services	Capability that provides login and access control for users accessing the Flexify service.	Auth0
- - UMR-SEC-02	Directory Services	Directory of all users, linking user accounts to organisations, roles, etc.	Auth0
- - UMR-SEC-03	SSO Configuration	Capability to allow organisational administrators to manage the SSO configuration to allow users to single sign-on to the Flexify service.	Auth0
- - UMR-SEC-04	Organisation Identity	Directory of organisations that have registered and been authenticated on the Flexify service, with associated users.	Auth0

System building blocks (4 of 4)

Definition of the application components that define the user interface and the universal profile

Unique ID	Name	Description	Physical Architecture
- UMR-UI	User Interface	Provides a graphical user interface for users to interact with the Flexify service(s).	ASP.NET Razor Pages
- - UMR-UI-01	UI Access and control	UI for registering and logging into Flexify, in addition to management of user accounts.	ASP.NET Razor Pages
- - UMR-UI-02	UI Organisation	UI for management of organisation details.	ASP.NET Razor Pages
- - UMR-UI-03	UI Asset	UI for management of asset data associated with Universal Profiles.	ASP.NET Razor Pages
- - UMR-UI-04	UI Market Qualification	UI for management of market qualification data associated with Universal Profiles.	ASP.NET Razor Pages
- - UMR-UI-05	UI Live Market Explorer	UI for a consolidated view of Market Platforms available for the FSP to participate in.	ASP.NET Razor Pages
- - UMR-UI-06	Dashboards & Reports	UI for the creation and view of dashboards and reports relating to aspects of Flexify and Universal Profiles.	TBD - pending UP final design
- UMR-UP	Universal Profile	An aggregation of organisation, asset and market qualification status, allowing interoperability across different Market Platforms.	Azure PostgreSQL Flexible Server

B.1.3.2.2

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Physical architecture

Physical architecture overview

Mapping physical connections between application components

Overview

The image opposite describes the Physical Architecture, showing the structure of key applications in Flexify and the connections between them.

It provides an overview of the solution that accommodates the logical architecture as demonstrated in application architecture figures.

Development Approach

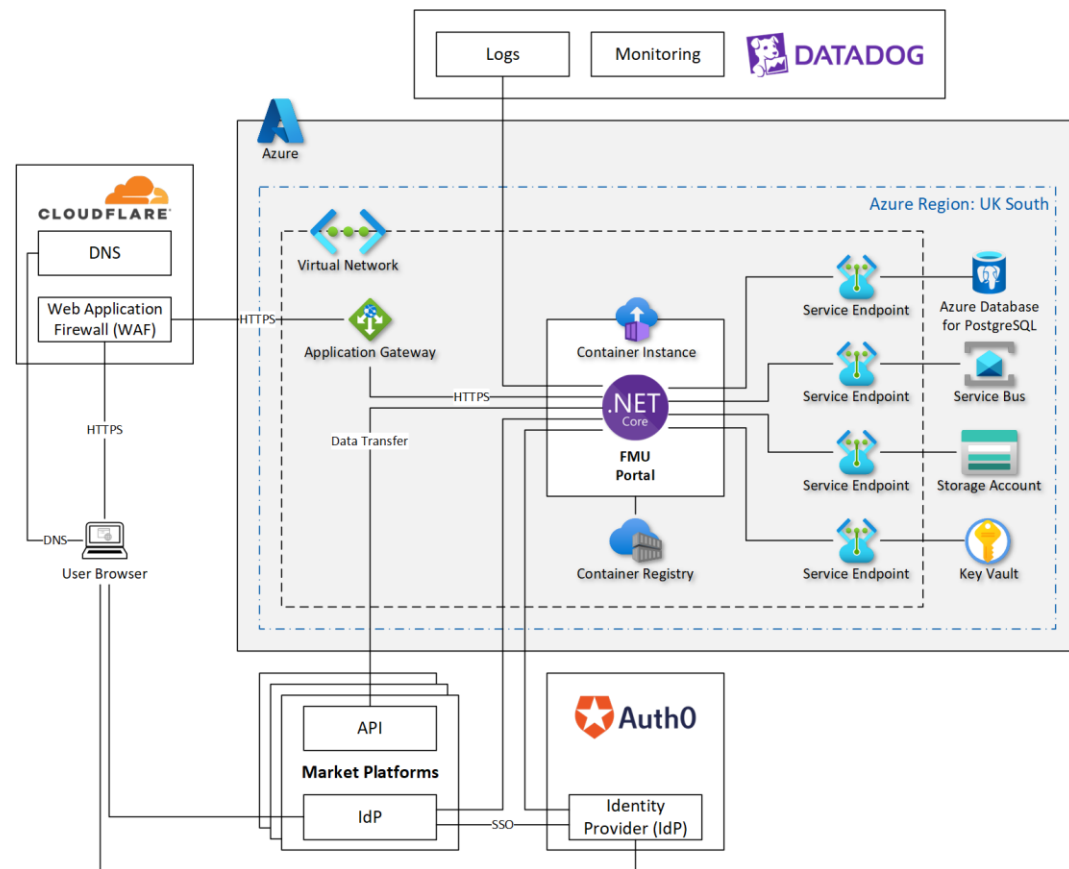
For the Proof of Concept, security, flexibility, and scalability have been prioritised while adhering to best practices such as architectural layering, separation of concerns, Restful design, and Terraform-driven automated deployments.

We implemented a single-instance portal front end with a single-instance API backend sidecar within one container, designed for easy reconfiguration to support scaling via multiple container instances behind a load balancer with minimal disruption. Similarly, while using a single-instance Postgres database, the code is built with high availability in mind.

Existing synchronous Market Platform APIs with temporal state (currently underused for passing UI element state) were leveraged, with the potential to expand in future phases to support fully asynchronous jobs or message queuing/event-driven infrastructure as needed.

The key components of the Physical Architecture are described on the following pages under the categories of Infrastructure, Application and Storage.

Physical Architecture



Physical architecture components

Defining the physical application components

Infrastructure

CICD

Terraform is used for setting up the environment.

Deployment Configuration

SUK

Network Configuration

The web portal is hosted within a virtual network and communicates with internal cloud resources via private endpoints, reducing exposure to the public internet.

The resources (such as Postgres) are configured to be inaccessible from the public internet (via the Azure Postgres firewall) but accessible to the Flexify application via a private VNET.

The Azure Application Gateway provides public access to web clients to the Flexify application by linking a front-end public IP to the back-end Azure Container Instances IP.

Cloudflare

Cloudflare is a web performance and security platform providing DDoS protection and DNS management to optimise and secure websites and applications.

Containerisation

Both the Portal and API are deployed to Azure containers. For PoC, the API is deployed as a sidecar in the same container instance.

Monitoring and Logging

Datadog is a cloud-based monitoring and analytics platform that provides comprehensive visibility into applications, infrastructure, and logs for real-time performance tracking and issue resolution.

Application

Flexify Web Portal

The main entry point for the application consisting of a containerised ASP.NET Razor pages site.

Flexify Web API

An internal API implementing the Flexify application logic. APIs summary is available via a swagger interface but is not publicly exposed.

Identity Provider

Auth0 is an identity management platform that provides secure authentication and authorisation solutions, including features like login, single sign-on (SSO), and access control across applications.

Service Bus

Azure

Email Notifications

Postmark is an email delivery service focused on reliably sending and tracking transactional emails with high deliverability and detailed analytics.

Storage

Azure Database for PostgreSQL

Postgres is single instance (No replication, daily backup with 7-day retention)

Storage Account

Two blob stores with file content are being used. One of those is public (e.g. for the use of logo on Auto0) while the other is private (for application logs and transient security/token storage)

Key Vault

1password, Azure KeyVault (for postgres secret and ssl cert).

B.1.3.3

— Security considerations

Security considerations

Defining the need to identify the risks and associated management approaches

Introduction

The Platform

Flexify is a platform with three core components that enables flexibility markets through distributed digital solutions:

- Universal Market Register
- Flexibility Data Standards (FDS)
- Market Rules Test Bed (MRTB).

Cyber Security Considerations

The following aspects should be taken into consideration when developing the cyber security programme:

- **Risk management:** Aligning with frameworks like NCSC CAF and NIST CSF to identify and mitigate risks
- **Product security:** Implementing controls, secure development practices, and assurance through testing
- **Cyber concept of operations:** Integrating Flexify into new or existing security policies, processes, and governance structures

Risk Management

Aligning with Established Frameworks

Establishing a risk management framework for the design, development, and operations of Flexify will underpin the cyber security of the platform. Aligning with existing frameworks provides a structured approach to identifying and managing risks throughout the product lifecycle.

For example:

- **NCSC Cyber Assessment Framework (CAF):**
 - Cyber considerations across all CAF objectives will ensure the project is aligned to industry standards and best practice.
- **NIST Cyber Security Framework (CSF)**
 - Mapping platform capabilities to the five core NIST functions: Identify, Protect, Detect, Respond, Recover.

Using recognised security frameworks (or integrating the platform into existing risk management processes should they exist) will ensure that appropriate and proportional security considerations are implemented across people, process, and technology.

Risk Assessment Approach

To identify and address risks associated with Flexify, a cyber risk assessment will need to be conducted. Extending existing risk assessment methodologies and processes to understand how this new platform will influence the organisation's risk profile and provide mitigation recommendations.

Security considerations

Product security

Implementing security controls, secure development practices, and comprehensive testing creates multiple layers of security. Establishing a plan for implementing cyber security during the product development and operations should include the following:

- **Security controls framework**
 - Design and development of cyber requirements and technical controls using established frameworks and standards.
- **Secure development**
 - Security requirements defined in initial specifications, threat modelling during design and development, security testing throughout development.
- **Standards and best practices**
 - The appropriate application of standards from organisations such as NIST, OWASP, and CIS to develop technical security controls.
- **Security testing**
 - Automated security testing in CI/CD and penetration testing before deployment.

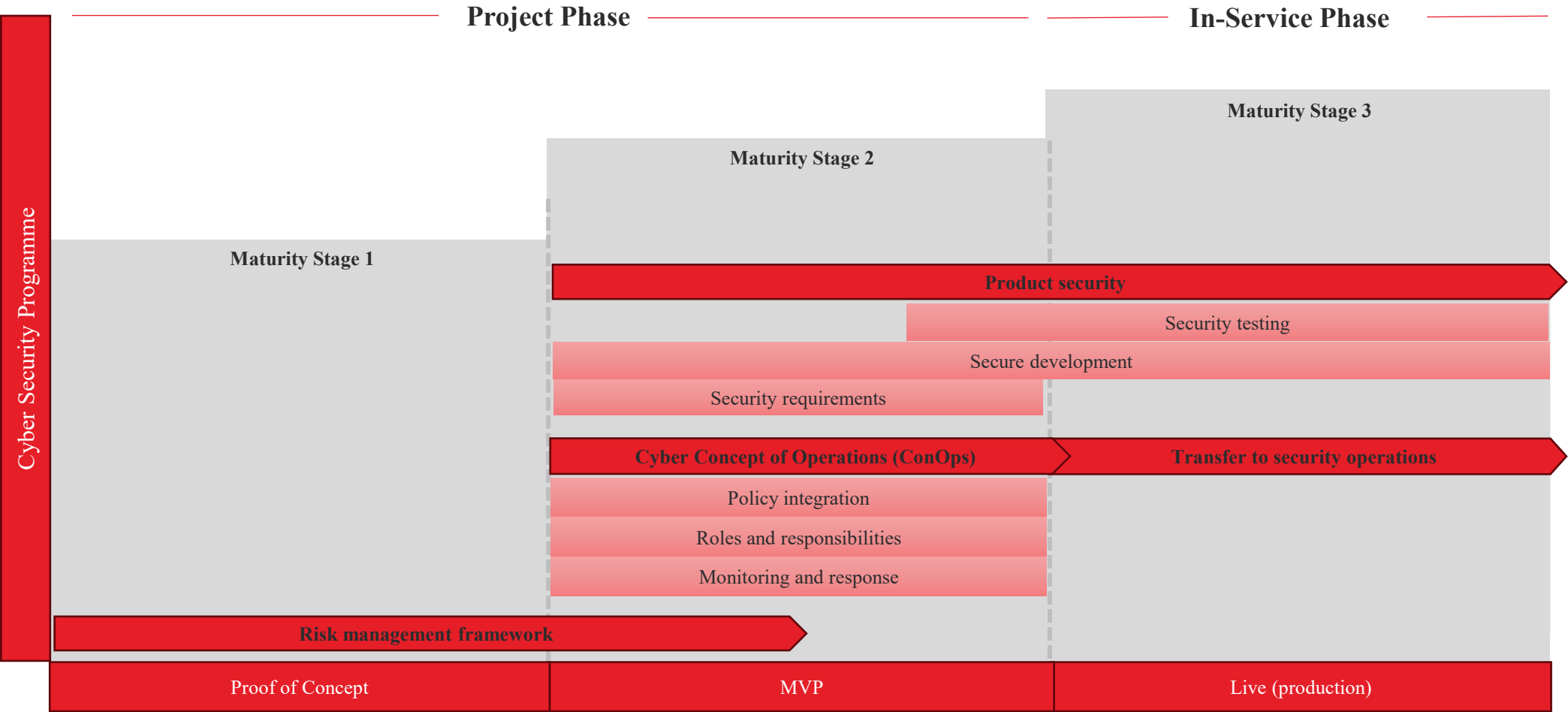
Cyber concept of operations

Cyber ConOps covers how the product will transfer from design and development to operations. This will address how the product will be integrated into existing cyber policies and processes.

- **Policy integration**
 - Integrating this platform into existing security policies ensures consistency in security posture and reduces operational friction during implementation.
- **Roles and responsibilities**
 - Define clear security responsibilities, escalation paths, and governance structure.
- **Monitoring and incident response**
 - Plan how the product will be integrated into existing operational security, including security event logging / monitoring capabilities, integrating with existing SIEM, specific incident response plans for the product, etc.

Security programme

Overview of progressive maturity and proposed security programme



B.1.4

— Design considerations

B.1.4.1

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Federated identity for Universal Profile

Cross platform authentication for the Universal Profile

Flexify design considerations between a central Identity Provider and a federated Identity Provider

Overview

To enable a Universal Profile user experience, two approaches are proposed to cross-platform integration - a central Identity Provider (IDP) operated by Flexify, and federated IDPs operated by each platform - each with differing levels of work from participating platforms, users and Flexify.

“And” not “or”

Both options can operate concurrently or independently, allowing platforms to choose which method(s) they support.

Easy to use

From a user’s point of view, both options will be similar and easy to use. The approaches differ more in their back-end implementation than in their UX.

Future ready

Both methods use accepted authentication methods (OAuth and OpenID Connect) already in use elsewhere in GB distributed energy - this makes them easier to trust and adopt. This also makes them as ready as they can be for interoperability with future digital infrastructure e.g. the Consumer Consent Solution and Data Sharing Infrastructure.

Cross-platform actions

Both options enable users to connect their accounts across platforms and programmatically perform cross-platform actions (e.g. copying asset data from a source platform to a target platform), with Flexify as the intermediary.

Authentication, not authorisation

Platforms continue to define and manage their own role-based access controls (RBAC). Flexify does not assign platform roles and permissions to Flexify users. Flexify will tell users if they have sufficient permissions to complete an API call, so that the user can go to that platform and request appropriate access.

Flexify admin users can, however, set up one or more platform connections for members of Flexify user groups, and use these groups to reflect their platform-level roles and authorisations.

One or more Flexify users can join a Flexify user group. In doing so the user gains that group’s access level in each platform. Flexify offers (and requires) a user invite flow delegating access from the Flexify user group admin to their group members.

Central IDP

Platforms add Flexify as a user authentication option, either alongside their existing options or replacing their existing options. Users can then use their Flexify identity to sign in to that platform and other platforms (i.e.. a single-sign on experience). Users can also use this identity to sign into Flexify and perform cross-platform actions.

Federated IDPs

For platforms that opt to offer their own platform-level IDP alongside Flexify, or platforms that don’t wish to offer Flexify as an authentication method, users can authenticate with that platform using the platform's IDP.

Users do not get a SSO experience across platforms, but they can perform cross-platform actions via Flexify.

Universal profile for PoC and post PoC

Universal Profile for PoC and post-PoC

Overview

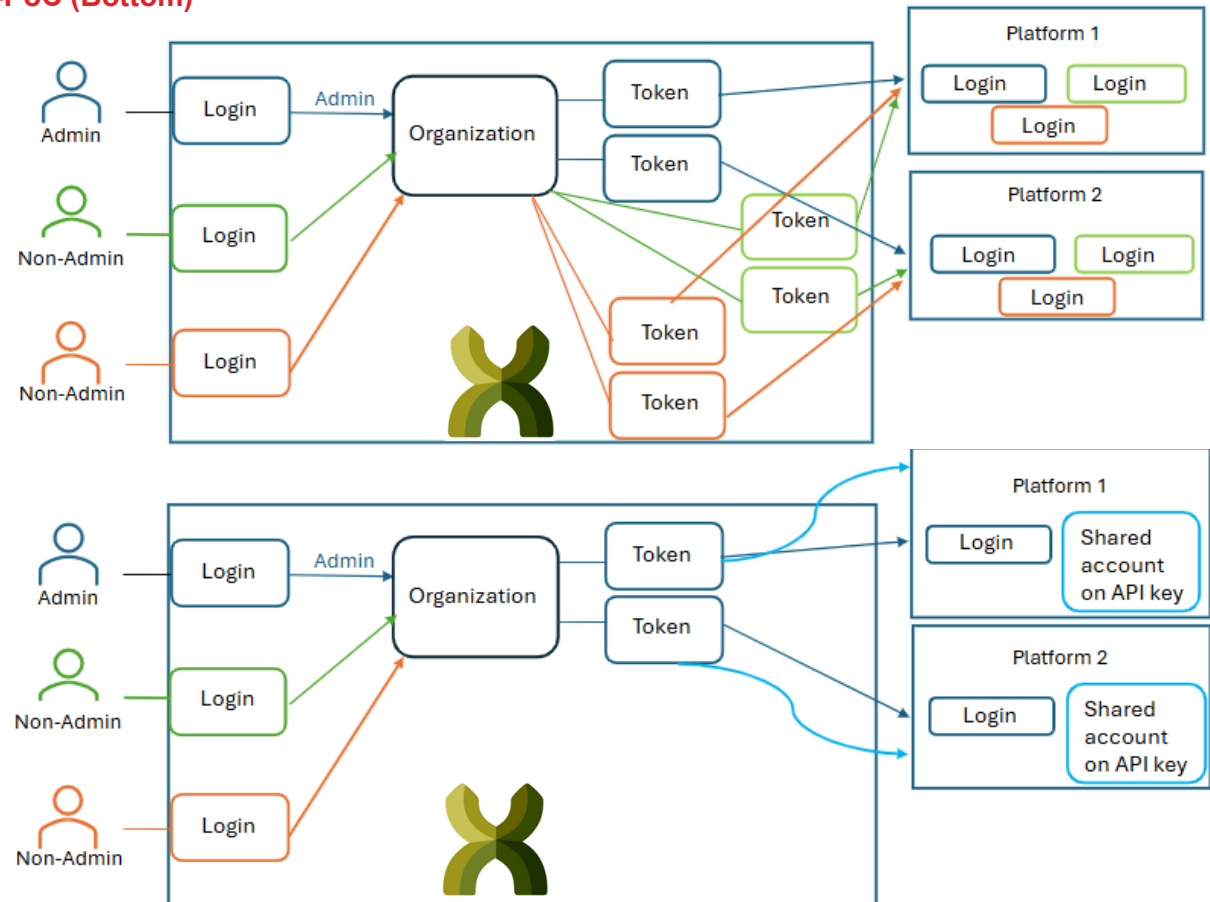
For the PoC, Flexify uses each platform's IDP to authenticate with that platform's API on behalf of **individual users**, as seen on the top diagram on the right-hand side.

- We used a federated IDP approach to be minimally invasive during PoC, using existing platform API endpoints and authentication methods

For Post-PoC, its envisioned that Flexify will use each platform's IDP to authenticate with that platform's API on behalf of **user groups**, as seen on the bottom diagram on the right-hand side.

- In that case, the Flexify user is able to set up multiple levels of platform access per platform connection, individual and / or user group associated with their organisation
- Platforms maintain control over their own permissions, and Flexify users can opt to map these to their Flexify accounts

PoC (Top) and post-PoC (Bottom)



B.1.4.2

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Connection service

Asset connection service

A source of truth for cross-platform organisation and asset data

Connection Service Overview

To enable the connection service, Flexify will integrate multiple IMPs, platforms and datastores with different data schemas & requirements for organisations and assets.

Therefore, Flexify must:

- Connect and link data from source (IMPs, AAR, own source)
- Translate data from source to the agreed standard (based on the Flexibility Data Standards or FDS), while exposing certain attributes to the user
- Validate linked data against any existing data by conducting a duplication check as well as flagging any detected errors
- Assign a digital certificate or Unique Identifier (UID) to allow for persistency across Flexify and the relevant data sources

The Connection Service allows Flexify users to manage their data; Flexify does not make decisions on data accuracy but will ensure the completeness of required data and compliance with the FDS.

Flexify will flag to users if any required data is missing or if any duplicate/ error has been detected. However, the user will be responsible for choosing their source of truth and keep their data up to date.

This approach to the Connection Service allows for seamless information exchange of commercial and technical information while enabling a single master of data without keeping the data itself in a central store. In turn, this service enables a trusted view of the flexibility system, allowing for data-based governance to support flexibility ecosystem scaling.

Persistent Mapping

Flexify aims to have a source of truth across time and across platforms, without a monolithic database.

Flexify achieves this by:

1. Creating and persisting organisation and asset IDs in Flexify
2. Persist a subset of the asset data
3. Other attributes are not persisted in Flexify, but a cross-platform mapping of those are maintained

Future Work

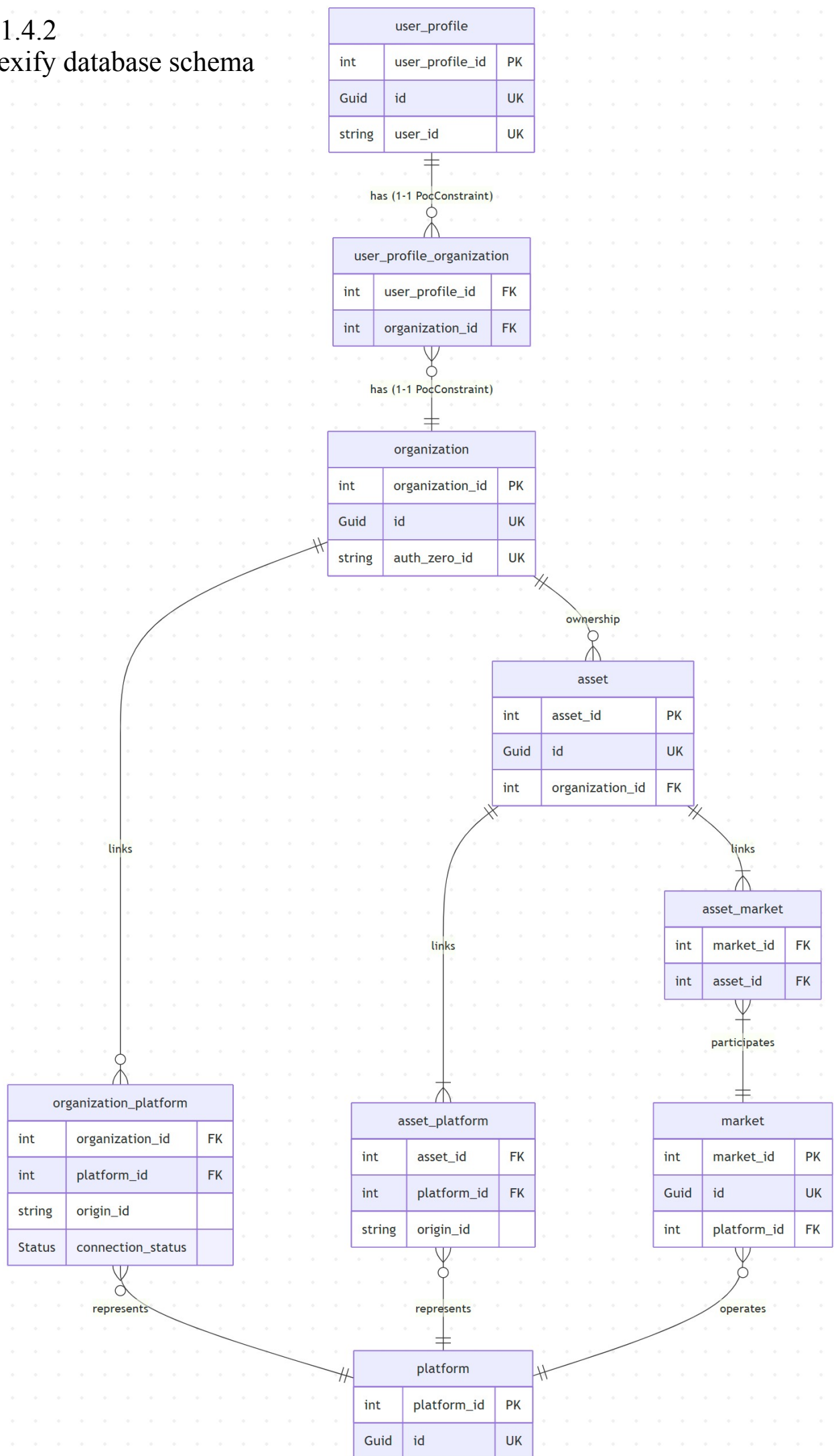
For the Flexify proof of concept, the platform enables users to link assets from AAR, view their total asset list and port assets to the SMP platform.

In the future, Flexify will allow users to filter assets, discover asset data & insights as well as link and port assets to additional platforms.

Additional future work will include:

- Validate linked asset data against any existing asset data by conducting a duplication check as well as flagging any detected errors
- Connecting the FDS to Flexify to enable a generalised mapping (see xx)

B.1.4.2 Flexify database schema



B.1.4.3

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Local and national market qualification

Market qualification analysis

Summary of approach taken to review market qualification across local (DSO) and national markets (NESO)

Purpose

The market qualification analysis has been undertaken to enhance understanding of market qualification criteria, align the FDS data attributes with the commercial and technical requirements, and identify any FDS data gaps.

This analysis will enable the mapping of market criteria-to-FDS relationships through further ontology development, ultimately empowering FSPs by automating the classification of their assets and units against both Local (DSO) and National Markets (NESO) and their respective products.

By mapping market qualification criteria with FDS data attributes in the ontology, FSPs can explore different market opportunities, understand their qualification status, and initiate the qualification process where applicable, as described in the [B.4.1 Flexify MVP section](#).

Flexify will provide clear requirements for market entry, streamlining the process for FSPs to identify where they can qualify.

This analysis aligns with the broader goal of enhancing market participation and maximising the value of flexibility service within the energy system.

Structure of review

A structured approach was employed to conduct this analysis, involving a comprehensive review of market services, technical documentation, and service requirements. Key steps included:

- Technical Requirements Review: A detailed examination of the technical requirements for market participation, listed in ‘*ENA ON - All Flexibility Product Technical Requirements (Jan 2025)*’ ([link](#)), was conducted to ensure a clear understanding of the necessary criteria FSP assets/units need to meet to qualify. This included gap identification:
 - The analysis assessed whether the collected FDS data attributes contain the necessary information to determine asset/unit eligibility for market participation.
 - Any missing data attributes were identified and incorporated into the FDS data attribute matrix (see [Section C.1.1](#) for further details).
- Commercial Requirements Review: The Commercial Qualifications Questions were analysed - standardised through ENA’s Open Network’s Project which are common across all UK DNOs - and the relevant FDS data attributes were also identified.

Market qualification matrix

The details of technical requirements review are presented in the next page providing further insights into the National Markets (NESO) and the Local Markets (DSO), along with their respective products considered in the assessment.

An analytical market qualification matrix, mapping relevant FDS data attribute to each market criterion is also presented further down. The FDS Asset Data Attribute column categorises information into three groups:

- FDS Data Attribute that directly align with the market criterion
- Criterion Realisation – Information used in the ontology development to define relationships between FSP assts/units and the market (e.g. platform used to register to enter the service)
- No FDS Data Attribute correlation (cell highlighted in grey) – Criteria that are not essential for determining asset/unit qualification for a market service and therefore fall outside Flexify’s scope

Market qualification analysis - NESO

Technical requirements of NESO market qualification services

NESO market services review

The NESO market services reviewed include:

- ESO Ancillary Services:
 - Response – including products: Static Firm Frequency Response (FFR), Dynamic Containment, Dynamic Moderation, Dynamic Regulation
 - Reserve – including products: Short Term Operating Reserve (STOR), Fast Reserve, Quick Reserve, Slow Reserve, Balancing Reserve
 - Thermal – including products: Local Constraint Market, MW Dispatch, Demand Flexibility Service (DFS)
- NESO Primary Balancing Market – with the Balancing Mechanism product

The official NESO website and its resources have been utilised to examine technical qualification criteria. NESO’s technical market requirements have been cross-referenced against existing asset data attributes in FDS.

Gaps in the existing data attribute list have been identified, with additional attributes proposed where necessary (see further details on [Section C.1.1](#)).

References

To evaluate the NESO market qualification requirements, the following websites and documents were reviewed:

- NESO - Balancing Mechanism “Wider Access” Onboarding and Registration Guidance - ([link](#))
- NESO -Increasing flexibility from small scale assets (<1 MW) in the Balancing Mechanism – Guidance Note - ([link](#))
- NESO - Capacity Market Pre-qualification - ([link](#))
- NESO - Demand Flexibility Service Participation Guidance Document (Nov 2024) - ([link](#))
- NESO - LCM Guidance Document - ([link](#))
- NG ESO - MW Dispatch service details including visibility and control requirements - ([link](#))
- NG ESO - Draft MW Dispatch Service Terms- ([link](#))
- NESO - STOR Technical Requirements - ([link](#))
- NESO - Slow Reserve Service and Procurement Design Proposal (Dec 2024) - ([link](#))

- NESO-Fast Reserve Technical Requirements - ([link](#))
- NESO- Supporting Information for the Quick Reserve Service (Phase 1) - ([link](#))
- NESO-Balancing Reserve Technical Requirements - ([link](#))
- NESO- Dynamic Services (DC/DM/DR) Technical Requirements - ([link](#))
- NESO- SFFR Technical Requirements - ([link](#))

Market qualification analysis - DSO

Technical requirements of DSO market qualification services

DSO market services review

The DSO market services reviewed include:

- DSO Flexibility Services:
 - Permanent peak reduction services – with the peak reduction product
 - Constraint Network Flexibility services – with products: Scheduled utilisation, Operational utilisation, Scheduled availability & Operational utilisation, Variable availability & Operational utilisation

The DSO market products and service requirements have been reviewed, mapping them against existing FDS asset data attributes.

The Service Term Agreement documents for each DSO and other relevant documentation have been examined to determine technical requirements for market qualification.

Gaps have been identified and new attributes introduced where required to align with the market service qualifications (see further details on [Section C.1.1](#)).

References

To assess the DSO market qualification requirements, the following documents were reviewed:

- Electricity North West Ltd (ENWL) - Flexibility Services Service Terms (July 2024) - ([link](#))
- Northern PowerGrid (NPg) - Distribution Flexibility Services Procurement Statement 2024-25 - ([link](#))
- SSEN Active Power Services -Flexibility Services Service Terms (July 2024) - ([link](#))
- SPEN - Flexibility Services Service Terms (June 2024) - ([link](#))
- NGED - Flexibility Services Service Terms (August 2024) - ([link](#))
- UKPN - Flexibility Services Service Terms (August 2023) - ([link](#))
- ENA ON - All Flexibility Product Technical Requirements (Jan 2025)- ([link](#))
- ENA- ON Flexibility Products Review and Alignment (Feb 2024)- ([link](#))

B.1.4.3 - Analysis of market qualification - technical requirements

ENA Open Networks: NESO & DSO All product technical requirements			ESO Ancillary Services										Thermal			NESO Primary Balancing Market	Permanent peak reduction		DSO Flexibility Services					FDS Asset Data Attribute
Category	Service Requirements	Requirement Description	Response				Reserve				Thermal		DFS	Balancing Mechanism	Peak Reduction	Scheduled Utilisation	Operational Utilisation	Scheduled Availability + Operational Utilisation	Variable Availability + Operational Utilisation					
User			Static FFR	Dynamic Containment	Dynamic Moderation	Dynamic Regulation	STOR	Fast Reserve	Quick Reserve	Slow Reserve	Balancing Reserve	Local Constraint Market	MW Dispatch											
Strategic Direction	Strategic Direction	The high level plan for the service in the near future. (Enduring, medium term, or non-enduring).	Enduring	Enduring	Enduring	Enduring	Non-enduring	Non-enduring	Enduring	Enduring	Enduring	Non-enduring	Enduring for NGED & UKPN Roll out to other DSOs to be decided	Medium-term	Enduring	Enduring (reviewed annually)	Enduring (reviewed annually)	Enduring (reviewed annually)	Enduring (reviewed annually)	Enduring (reviewed annually)				
Structure	Payment Structure	How the service is structured (i.e. what is the DSO asking of the FSP)	Availability Only	Availability Only	Availability Only	Availability Only	Availability, Utilisation and Optional Utilisation (Non-BM parties)	Availability (arming) and Utilisation	Availability	Availability	Availability	Utilisation Only	Utilisation Only	Utilisation Only	Utilisation Only	Utilisation Only	Utilisation Only	Availability and Utilisation	Availability and Utilisation	Availability and Utilisation				
Structure	Procurement Method	The type of mechanism used to procure the service	Pay as Clear (Capacity)	Pay as Clear (Capacity)	Pay as Clear (Capacity)	Pay as Clear (Capacity)	Pay as Clear (Capacity)	Pay as Bid (Utilisation)	Pay as Clear (Capacity) Pay as Bid (Utilisation)	Pay as Clear (Capacity) Pay as Bid (Utilisation)	Pay as Clear (Capacity) Pay as Bid (Utilisation)	Pay as Bid	Pay as Bid	Pay as bid tender	Pay as Bid	Pay as bid	Pay as bid	Pay as bid	Pay as bid	Pay as bid				
Structure	When Prices are Set	Time before use that prices are determined	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction	Day Ahead Auction (& Intra Day Auction)	Day Ahead (16:00) submission of Utilisation Rate	Within day submission of utilisation rate	Real Time	At trade	At trade	At trade	At trade	At trade				
Structure	Generation/demand turn down service or demand turn up service?	Does the service require the provider to export or import power to the grid	Export or reduce demand	BOTH	BOTH	BOTH	Export	Export	BOTH	BOTH	BOTH	Export	Generation turn down (to zero)	Demand Turn Down	BOTH	Demand Turn Down	BOTH	BOTH	BOTH	BOTH				
Pre-qualification	Required to be a Balancing and Settlement Code (BSC) Party	The rules and governance arrangements for electricity balancing and settlement in Great Britain.	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO				
Pre-qualification	Non-BM Party Accessible	Participate without being a Balancing Mechanism Party	Yes	YES (via ASDP)	YES (via ASDP)	YES (via ASDP)	YES	YES	YES	YES (Not on Day 1)	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES				
Pre-qualification	Asset Location Grouping Requirement	Requirement for where multiple assets within a unit must be located	National aggregation is permitted	GSP GROUP	GSP GROUP	GSP GROUP	GSP GROUP	GSP GROUP	GSP GROUP	GSP GROUP	GSP GROUP	PER INDIVIDUAL SCOTLAND GSP	N/A	NATIONAL	GSP GROUP	per specific CMZ	per specific CMZ	per specific CMZ	per specific CMZ	per specific CMZ				
Pre-qualification	Aggregation/Virtual Lead Party (VLP) Route Available	The option of having more than a single asset within a unit	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES	YES				
Pre-qualification	Minimum MW Delivery Required (also referred to as Minimum Aggregated Unit Size)	The minimum MW delivery rate that a unit must exceed to enter the service	1MW	1MW	1MW	1MW	3MW	25MW	1MW	1MW	1MW	NONE (1 kW)	1MW	1MW	1MW	ENWL: 10KW NGED: 0KW	NPG, UKPN, SSEN, ENWL: 10KW NGED: 0KW	SSEN: 10KW NGED: 0KW	UKPN, SSEN: 10KW NGED: 0KW	SSEN: 10KW				
Pre-qualification	Unit volume cap	Maximum amount of MW volume per unit registered in the service	N/A	100MW	50MW	50MW CAP	N/A	100MW	N/A	300MW	N/A	N/A	N/A	100MW CAP	N/A	N/A	N/A	N/A	N/A	N/A				
Pre-qualification	Open to Flexible Connections or similar?	If the asset's network connection has 'restrictions' (eg a Curtailable, Flexible or Ramped connection), can they participate?	Case by case	Case by case	Case by case	Case by case	Case by case	Case by case	Case by case	Case by case	Case by case	No	Case by case	Case by case	Case by case	Case by case	Case by case	Case by case	Case by case	Case by case				
Pre-qualification	Planned Connection	Identifying when assets must be connected to the network before participating in flexibility market.	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO	NO	SPEN, NGED: NO	UKPN, NPG, ENWL, SSEN: YES	UKPN, NPG, ENWL, SSEN: YES	UKPN, NPG, ENWL, SSEN: YES	UKPN, NPG, ENWL, SSEN: YES				
Metering	Asset metering permitted (vs boundary point metering system)	What type of metering is permitted? Some services only allow boundary meter data whilst others allow metering behind the boundary i.e. asset metering	The data is aggregated by the provider and therefore they can use asset level metering if they want to.	Asset metering permitted	Asset metering permitted	Asset metering permitted	Asset metering permitted	Asset metering permitted	Asset metering permitted	Asset metering permitted	Asset metering permitted	Boundary metering only	Asset Metering (using the DSO measurements from site)	Asset level metering permitted (but with ad hoc boundary meter checks)	Asset and boundary metering permitted	Asset and boundary metering permitted	Asset and boundary metering permitted	Asset and boundary metering permitted	Asset and boundary metering permitted	Asset and boundary metering permitted				
Metering	Operational Metering Required	A live feed to ESO control room to measure providers live service delivery	No	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	NO	YES	NO	NO	NO	NO	NO				
Metering	Operational Meter Accuracy Required	The accuracy rating required of physical meters providing operational metering	No operational metering required.	+/-1%	+/-1%	+/-1%	+/-1%	+/-1%	+/-1%	+/-1%	+/-1%	N/A	+2.5% / -3.5% (COP11 DERIVED)	+/-1%	N/A	N/A	N/A	N/A	N/A	N/A				
Metering	Operational Meter Refresh Frequency	The frequency that the physical meter captures real-time data snapshots	No operational metering required.	1Hz	1Hz	1Hz	1Hz	1Hz	1Hz	0.067 Hz (15 second refresh)	1 Hz	n/a	0.067 Hz (15 second refresh)	1Hz	N/A	N/A	N/A	N/A	N/A	N/A				
Metering	Operational Metering Latency	Operational metering data must reach the ESO Control Room within this time	No operational metering required.	5s	5s	5s	5s	5s	5s	5s	5s	n/a	Seconds	5 SECONDS	N/A	N/A	N/A	N/A	N/A	N/A				
Metering	Operational Metering Signal Type	The type of electrical data collected for operational metering	No operational metering required.	Active power and SoE	Active power and SoE	Active power and SoE	Active Power	Active Power	Active Power	Active Power	Active Power	n/a	Active Power	ACTIVE POWER	N/A	N/A	N/A	N/A	N/A	N/A				
Metering	Performance Meter Refresh Frequency	The frequency that the physical meter captures real-time data snapshots (e.g. 20Hz= 20 snapshots per second)	1Hz performance data	20Hz	20Hz	2Hz or 20Hz	Every 15 Seconds. Service Providers can submit duplicate meter reads for up to a minute.	N/A - Phase 1	1Hz (TBC) - Phase 2	1Hz (TBC)	1Hz	Half Hourly	Active Power	Half Hourly	N/A	N/A	N/A	N/A	N/A	N/A				
Platforms	Service Registration Platform	The platform used to register to enter the service	SINGLE MARKETS PLATFORM	SINGLE MARKETS PLATFORM	SINGLE MARKETS PLATFORM	SINGLE MARKETS PLATFORM	Salesforce	SINGLE MARKETS PLATFORM	SINGLE MARKETS PLATFORM	SINGLE MARKETS PLATFORM	SINGLE MARKETS PLATFORM	www.picoflex.com	SINGLE MARKETS PLATFORM (SMP)	SINGLE MARKETS PLATFORM	BM registration	ENWL: Electron, Pico NGED: Market Gateway and Pico NPG, SPEN: Pico SSEN: Electron UKPN: EPEX	ENWL: Electron, Pico NGED: Market Gateway and Pico NPG, SPEN: Pico SSEN: Electron UKPN: EPEX	ENWL: Electron, Pico NGED: Market Gateway and Pico NPG, SPEN: Pico SSEN: Electron UKPN: EPEX	ENWL: Electron, Pico NGED: Market Gateway and Pico NPG, SPEN: Pico SSEN: Electron UKPN: EPEX	ENWL: Electron, Pico NGED: Market Gateway and Pico NPG, SPEN: Pico SSEN: Electron UKPN: EPEX				
Platforms	Procurement Platform	The platform that providers use to receive instructions and bid into the service	Offline auction tool	EAC	EAC	EAC	SALESFORCE	VIA THE BM FOR BM PARTIES OR ASDP FOR ANCILLARY SERVICES FOR NON-BM PARTIES	EAC	EAC	EAC	www.picoflex.com	Ancillary Services Dispatch Platform (ASDP)	RDY solution	BM	Same as Service Registration platform	Same as Service Registration platform	Same as Service Registration platform	Same as Service Registration platform	Same as Service Registration platform				
Platforms	Settlement Registration Platform	The platform to register and submit settlement data	Via email	DAP	DAP	DAP			TBC	TBC	Automated from BM and Elexon systems	CALCULATE/REPORTING ON PICOFLEX	Calculated in Settlements BAU process / solution using Instruction and Metering data provided from ASDP and Pricing data provided from SMP	RDY SharePoint solution	Elexon	ENWL: Electron SSEN, NPG, NGED: Flexible Power Portal SPEN: Pico UKPN: EPEX	ENWL: Electron SSEN, NPG, NGED: Flexible Power Portal SPEN: Pico UKPN: EPEX	ENWL: Electron SSEN, NPG, NGED: Flexible Power Portal SPEN: Pico UKPN: EPEX	ENWL: Electron SSEN, NPG, NGED: Flexible Power Portal SPEN: Pico UKPN: EPEX	ENWL: Electron SSEN, NPG, NGED: Flexible Power Portal SPEN: Pico UKPN: EPEX				
Availability	Availability/Utilisation period	The periods in which the service is made available or utilisation is committed (e.g., settlement periods, EFA block, committed blocks, etc.)	EFA Block	EFA Block	EFA Block	EFA Block	STOR windows		Settlement Period	2 Hours	Settlement Period	N/A	Units are assumed to be available unless ESO is notified by the DSO via an unavailability / risk of conflict report ahead of time or real time availability flag update	Settlement period	N/A	N/A	N/A	N/A	Settlement Periods					
Availability	Availability Payment Unit	The units used for Availability Payments	£/MW/h	£/MW/h	£/MW/h	£/MW/h	£/MW/h	N/A	£/MW/h	£/MW/h	£/MW/h	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	£/MW/h				
Utilisation	Instruction Notice Period (also referred to as Utilisation Instruction Timing)	Notice given to providers that they will need to respond to an instruction in the immediate future	N/A (automated dispatch)	N/A (automated dispatch)	N/A (automated dispatch)	N/A (automated dispatch)	2 MINUTES	5 MINUTES for Non BM	0 MINUTE	Up to 2 MINUTES	8 hrs (6 hrs)	Real time - compliance expected within 2 minutes (NGED) and 12 minutes (UKPN - 10 minute safety window + 2 minute response time)	4+ hours	2 MINUTES	At Trade	At Trade	Real Time, or Operational- Week Ahead	Real Time, or Operational- Day Ahead, or Near time, or Operational- Week Ahead	Response time (minutes)					
Utilisation	Gate closure	Dispatched before or after gate closure	After	After	After	After	After	After	After	After	After	Before	After - price submission at 16:00 on a given day used for next day dispatch payment calculation (from 05:00)	Before	After	Before	Before or After	Before or After	Before or After					
Utilisation	Delivery Duration (also referred to as Minimum Utilisation Time)	Minimum amount of time that a provider must be able to provide its obligated delivery volume	30 MINUTES	15 MINUTES	30 MINUTES	60 MINUTES	2 HOURS +	15 MINUTES +	Up to 5 MINUTES (Min)	Up to 30 MINUTES (Min)	1 MINUTE (MIN) 89 MINUTES (MAX)	30 MINUTES (MIN) 24 HRS (MAX, NEEDS-DRIVEN)	30 MINUTES +	1 MINUTE +	30 Minutes	30 Minutes	30 Minutes	30 Minutes	30 Minutes	30 Minutes				
Utilisation	Time to respond to instruction	Time to show unit ramping has begun	up to 30 SECONDS	0.5 SECONDS	0.5 SECONDS	2 SECONDS	2 MINUTES	2 MINUTES	0 MINUTE	Up to 2 MINUTES	2 MINUTES	1hr	Acknowledgement expected within 60 seconds	4+ hours	2-89mins	N/A	N/A	N/A	N/A	N/A				
Utilisation	Max time to full delivery from instruction (also referred to as Maximum Response Time)	Time taken from utilisation instruction or triggering event to reach procured volume delivery	up to 30 SECONDS	1 SECOND	1 SECOND	10 SECONDS	20 MINUTES	2 MINUTES	1 MINUTE	15 MINUTES	10 MINUTES	(n/a - SP dependent)	2 MINUTES	N/A	As per unit parameters	N/A	N/A	N/A	2 minutes, or 15 Minutes, or N/A	2 minutes, or 15 Minutes, or N/A				
Utilisation	Ramping requirements	The specific requirements of the service in relation to ramping up or down of delivery						No maximum ramping limits for ramping up or down from instruction	No ramping greater than 50% capacity per 30s period allowed					N/A	N/A	N/A	N/A	N/A	N/A					
Utilisation	Maximum Recovery Period	Minimum time between separate instructions and providers must be ready to respond again	N/A	N/A	N/A	N/A	20 HOURS		3 MINUTES	30 MINUTES (TBC)	N/A	N/A	None	N/A	UNIT SELF DEFINE for recovery at 0MW only	N/A	N/A	N/A	N/A	N/A				
Utilisation	Instruction Trigger	What triggers a request to deliver the contracted volume	Frequency Deviation	Frequency Deviation	Frequency Deviation	Frequency Deviation	ENCC manual instruction	ENCC manual instruction	ENCC manual instruction	ENCC manual instruction	ENCC manual instruction		ENCC manual instruction in ASDP	Tender result will be seen as instruction	ENCC manual instruction	Tender result will be seen as instruction	Tender result will be seen as instruction	DSO instruction	DSO instruction	DSO instruction				
Utilisation	Auction contract length	How long the providers delivery contract lasts	4 hours	4 hours	4 hours	4 hours	STOR Window	N/A	30 minutes	2 hours	30 minutes	30 minutes	Unspecified - open ended until issue of a Cease instruction	30 minutes	N/A	Varies by DSO	Varies by DSO	Varies by DSO	Varies by DSO	Varies by DSO				
Utilisation	Utilisation Payment Unit	The units used for Utilisation payments	N/A	£/MWh	N/A	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh	£/MWh				
Settlement & Performance Monitoring	Settlement or performance monitoring required?	Identification of any service specific performance monitoring requirements.	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	SETTLEMENT AND PERFORMANCE (LCM is proposing to mirror DFS C16 conditional use of Asset metering)	Settlement process identifies any non compliance (outside 2 minute stipulation or output increase above the agreed deadband within any Settlement period)	All performance is reviewed by market monitoring team to ensure accurate payment vs delivered.	Yes (settlement of BDA) and performance monitoring via imbalance	YES Exact process differs per DSO	YES Exact process differs per DSO	YES Exact process differs per DSO	YES Exact process differs per DSO	YES Exact process differs per DSO				
Baselining	Baselining	The historical baseline data used to calculate delivery performance and inform settlement	The second immediately before the frequency event is used as the baseline.	60 minute nomination via PN or nBM equivalent	60 minute nomination via PN or nBM equivalent	60 minute nomination via PN or nBM equivalent	60 minute nomination via PN or nBM equivalent	60 minute nomination via PN or nBM equivalent	PN/ 60 MINUTE NOMINATION	PN/ 60 MINUTE NOMINATION	PN	PN/ 60 MINUTE NOMINATION	PN/ 60 MINUTE NOMINATION	PN	Real time metering output as advised to ESO via 15 second refresh used to calculate volume of MW delivered in service (assumes an immediate and constant reduction to zero)	P376 (BSC) (within-day adjustment element removed)	Varies by DSO	Varies by DSO	Varies by DSO	Varies by DSO				
Notes	Notes	Required note: who approved this info as correct?	None	None	None	None	None	None	We have recently consulted on Quick Reserve and have yet to progress to EBR Article 18 consultation	We have yet to consult on Slow Reserve and the above requirements are to be confirmed	None	None	None	Derogation expired 1 May 24.	None	None	None	None	None					

Market qualification analysis - DSO

Commercial requirements of DSO market qualification services

Commercial qualification questions

The commercial qualification questions, listed in the below reference, were assessed and the FDS data products were aligned against these criteria.

- Electricity North West Ltd (ENWL) – Commercial qualification criteria guidance (May 2024) - ([link](#))

This alignment ensures that the ontology development will support the necessary commercial requirements for market qualification, enabling FSPs to understand and meet the prerequisites for participating in flexibility markets.

Commercial checks are conducted as part of the pre-qualification process to verify that participants in flexible services tenders are genuine and reputable businesses with the required financial and technical capabilities to deliver on contracts.

This ensures that only capable and reliable companies participate the flexibility tenders, mitigating reputational risks and supply continuity issues.

Commercial qualification checks

The commercial qualification checks include:

- Organisation profile: Verification of business details and goals alignment with the tender.
- Financial records: Review of company accounts and credit checks to assess financial stability.
- Insurance verification: Confirmation of sufficient Employers Liability and Public Liability insurance.
- Due diligence: Assessment of company history, experience, and compliance with regulations.

The commercial qualification matrix mapping relevant FDS data attribute to each market criterion is presented in the next page. The FDS asset data attribute column provides the data attributes that directly align with the market criterion.

In this case, no additional data gaps were identified, and a corresponding FDS data attribute was assigned to each commercial qualification criterion.

Market qualification analysis - DSO

Commercial requirements of DSO market qualification services

Question	Description	Pass Criteria	FDS Asset Data Attribute
Company Information			
Registered or legal name of the contracting party	Full registered/legal name of the party wishing to enter into the flexibility contract	Completed	Company Name
What is this organisation's registered number?	Registered No. as shown on Companies House. Charity or Trust Registration No. is also acceptable	Completed	Company Registration Number
Registered address 1	Registered Address line 1	Completed	Address Line 1
Registered address 2	Registered Address line 2	Completed	Address Line 2
Registered address 3	Registered Address line 3	Blank / Completed	City
Registered address postcode	Registered Address Postcode	Completed	Postcode
Key contact first name	First name of main contact	Completed	Contact First Name
Key contact last name	Last name of main contact	Completed	Contact Last Name
Key contact email	Email address of main contact	Completed	Contact Email
Key contact number	Contact telephone number	Completed	Mobile number
Organisation website	Web address for contracting party	Completed	Organisation website
Legal relationship with flexibility asset/s	Declare relationship to asset/s	Completed	Legal relationship with flexibility asset/s
VAT registration number	VRN of the contracting party	Completed	VAT registration number
Terms and Conditions			
Confirm acceptance of ENA Standard Flexibility Services Agreement	Contracting party must confirm their acceptance of the ENA Standard Flexibility Agreement applicable to the DNO they are pre-qualifying for	Yes	Terms & Conditions
Declare authority to submit application	The individual completing this submission must have authority to accept the Agreement and provide the information listed	Yes	Owner
Due Diligence			
Is the contracting party a member of Flex Assure Code of Conduct?	Being a member is not required, but it speeds due diligence checks	Yes, No	Flex assure code of conduct membership
Contracting parties Achilles UVDB Registered No.	Achilles UVDB (Utilities Vendor Database) registration is not required, but it speeds credit checks	Completed, blank	Achilles UVDB registered number
Where Achilles UVDB is not advised, the DNO may access the contracting parties most recent audited financial accounts via Companies House for credit checks	Confirm understanding that the DNO may access the contracting party's most recent audited financial accounts for credit checks	Yes, N/A	Confirmation of audit requirement
Is the contracting party currently, or has it ever been in administration?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Administration check
Is this organisation currently, or has it ever been in receivership?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Receivership check
Is this contracting party currently, or has it ever been in liquidation?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Liquidation check
Has this contracting party ever been unable to pay its debts as they fall due (under Section 268 Insolvency Act 1986)?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Unable to pay debts check
Has this contracting party had any petitions for winding up (other than vexatious petitions) in the past 3 years?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Winding up
Has this contracting party had any petitions for bankruptcy (or equivalent in another country) in the past 3 years?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Bankruptcy
Has this contracting party been convicted of any offences under Regulation 80 of the Utilities Contract Regulations 2016 (UCR) or similar?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Convictions
Has this contracting party had any contracts terminated prematurely due to performance issues in the past 3 years?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Historic contracts
Has this contracting party been subject to any material non-employment-related litigation (pending, threatened, or determined) in the past 3 years?	This response will be assessed by the DNO as part of their due diligence checks	No = Pass, Yes = Further information required	Non-employment litigation
Insurance Requirements			
Employer's liability insurance	Confirm holding of insurance with a minimum limit of £5m	Yes	Employers Liability insurance (£5m)
Public liability insurance	Confirm holding of insurance with a minimum limit of £5m	Yes	Public Liability Insurance (£5m)
Will provide copies of insurance upon request	Confirm ability to provide proof of insurance if requested by the DNO	Yes	Insurance copies

B.1.4.4

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Integration with AAR, Piclo, SMP,
and Electron

Market platform, asset registries and other integrations

Flexify design approach to achieve four solution components

Approach

A blueprint of how IMPs, AARs and other platforms connect was developed. The concepts of Flexify connecting with these systems and applications were proved by collaborating with project partners to design integration concepts and test them.

In this phase integrations have been built between Flexify and ElectronConnect, Piclo Max and NESO's SMP so that a single organisation has a common profile across all platforms and can authorise the sharing of information between Flexify and the platforms and vice versa.

The extent of each integration was dependent on project time constraint and the ability of project partners to expose the relevant data (mostly using existing APIs). It was crucial to show the viability of the Flexify solution by developing various solution components for different platforms as a proof of concept.

Integration outcomes

- **ElectronConnect:** Flexify users can use an existing ElectronConnect account to create a new Flexify account and import organisation details. Additionally, users can link & port their assets from and to ElectronConnect
- **Piclo:** Users can create a new account on Piclo Max using details they hold on Flexify
- **AARs Central Asset Register (CAR):** Users can access the assets they manage which are held on that register. Core metadata on the asset is imported to Flexify while the technical asset information is maintained on the CAR.
- **SMP:** Users are now able to port information into the platform of their choice. For this phase of two-way integrations with NESOs SMP have been completed.

Future work

Future developments:

- Integrations with other IMPs & industry participants

Future capabilities:

- Flexify would allow FSPs to link assets from own data source
- Two-way integrations with AAR (read & write)
- Integrations with the future consumer consent solution to enable seamless evidencing of consent to operate assets
- Integrating to the DSI providing FSPs with a mechanism to share all technical information between source and target locations.
- Support streamlined market entry processes, reusing market entry information from one market to support entry into a secondary market, FSP or Market Operator performance ratings, and management of a collection of assets into units for market qualification
- Organisation level validations, role-based access control and user and organisation relationships

B.2

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Delivery pathways for Flexify

Delivery approaches

Summary of delivery options for the Flexify platform

Introduction

Without a clear governance framework, it would not be possible to achieve a decentralised flexibility ecosystem; therefore, a collaborative governance approach is needed to support rule setting and enforcement for flexibility markets. As part of Phase 1, the consortium determined that passthrough services of Flexify should be governed by the Market Facilitator.

As part of Phase 2, three delivery pathways for Flexify have been identified and assessed:

- Option 1. Long term commercial contract
- Option 2. Flexify is sold at the point of final MVP
- Option 3. Consortium as required under the Innovation Programme

Option	Description	Cost assessment
1. Long term commercial contract	In this option it is presumed that the overarching direction and accountability for development and operation of Flexify is undertaken by a separate organisation / industry body (referred to as ‘The Client’, however, the Flexify service is tendered to a commercial entity through a long term contract.	Additional costs would be required to develop Flexify to MVP. Following development of the MVP, personnel, technical operation and other operating costs would be required to operate Flexify.
2. Flexify is sold at the point of final MVP	Under this option, Flexify is developed to the MVP and then is sold. Flexify could be sold through a bilateral negotiation between the consortium and the buyer or through a competitive process. For Flexify to be sold there will need to be a robust business case, underpinned by sufficient revenue streams which will be dependent on actual and expected uptake onto the platform.	Costs associated with MVP development will be required.
3. Consortium as required under the Innovation Programme	Under this option, Flexify is developed and operated by the Consortium as a commercialised offering in line with wider market and regulatory reforms.	Costs associated with MVP development will be required. Following development of the MVP, personnel, technical operation and other operating costs would be required to operate Flexify.

B.2.1

— Pathway options

B.2.1.1

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Pathway 1 – Long term commercial contract

Pathway 1

Long term commercial contract

Overview

Under this option the long term overarching direction and accountability for developing and operating Flexify is undertaken by a separate organisation (referred to as ‘The Client’). However, the Flexify service is tendered to that client through a long term contract.

This would be delivered by the client appointing the Flexify owner to continue to build Flexify as part of the continued development phase; the consortium continues to own the IP of the platform following the completion of the development.

Following development completion, the client pays a license to the consortium to operate the platform through a service/license agreement.

Given the outcome of the Flexibility Market Asset Registration, the client organisation could be Elexon in its Market Facilitator role or another industry body e.g. market platform providers or NESO/DNOs.

Proof of concept to MVP costs

As Flexify is current at proof of concept stage, additional activities are required to progress the product to MVP. These include:

- In its role as responsible for national and local flexibility market asset registration, Elexon will work with industry to define the requirements to meet the Design Principles and Functional Outcomes as set out in Flexibility Market Asset Registration.
- Flexify to undertake a gap analysis of requirements under FMAR against the proof of concept to identification where additional work is required to meet requirements. This will include identification of the costs and any associated impact on the business case.
- Implementation of the requirements to finalise the MVP.

As the requirements are yet to be developed, the costs associated with developing the MVP cannot be confirmed.

MVP revenue streams

The revenue streams for Flexify under this option are as follows:

- Flexify would receive a licencing fee from the client for the duration of the contract.
- For additional Flexify development beyond the MVP, additional charges would be incurred by the platform in alignment with the contract terms.

Pathway 1 costs

A breakdown of the organisational functions required to operate Flexify

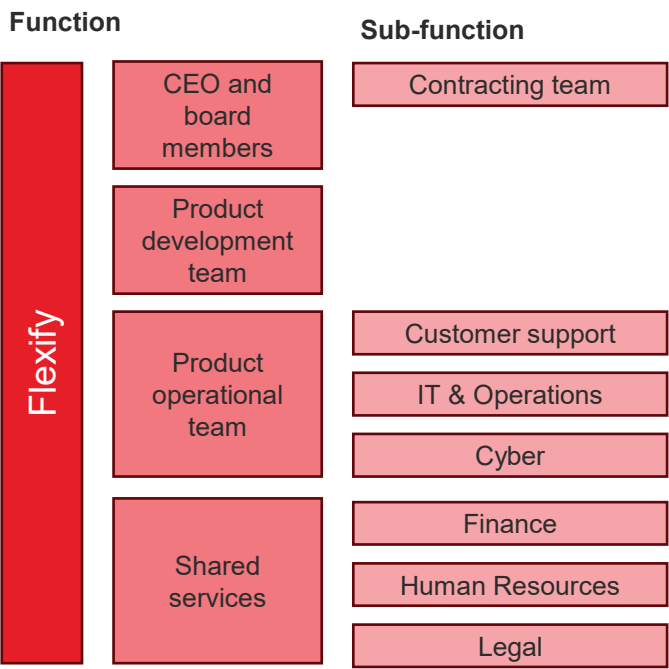
Overview

The proposed organisational functions for this pathway are presented to the right. The teams will undertake the following activities:

- **Product development team:** this team will be focussed on the future Flexify development, responding to user requirement changes and changes in the wider policy/legislative/technology landscape to ensure that Flexify continues to evolve in line with market needs.
- **Product operational team:** this team will be responsible for the day to day running of Flexify. This will incorporate providing customer service (i.e. helpdesk services) to users to either mobilise them or to provide troubleshooting. It will also provide overarching IT & operational support to maintain smooth operations as well as undertaking proactive management of cyber risks.
- **Contracting team:** this team will be responsible for engaging with long term contracting party to manage the contract and ensure that the project is meeting client requirements.

- **Shared services team:** this team will provide the fundamental services required to enable Flexify to operate effectively; this will include finance (including the management of license fees), HR and legal services.

This is a provisional structure of Flexify, which would need to be reviewed following confirmation of the requirements by the client and the gap analysis undertaken by Flexify.



Pathway 1 costs

Year 1 personnel costs

The following provides an overview of the year 1 personnel costs based on the organisation structure detailed on the previous slide.

Team	Scope	Roles	Scope of role	FTE	Full estimated cost*
Executive Team		CEO	Overarching ownership for Flexify	1	£180,000
		COO	Overarching ownership for Flexify	1	£180,000
Contract management team		Contract management	Management of the contract interface between Flexify and the client.	1	£50,000
Product team	- Further maintenance and operation of the product - Further development of the product - Provide support with integration activities with other platforms	Product Owner	Ensure overarching delivery of the product, undertaking a cross-cutting role with the operational team.	1	£75,000
		Technology Manager (CTO)	Would undertake Quality Assurance / Quality Control role for both product development and operations.	1	£100,000
		Shared Developer	Day to day design responsibilities for the platform.	2	£150,000
		Business Analyst	Responsible for tracking changes in regulatory/policy landscape and translating into product development	1	£55,000
IT operational team	- Data backup and recovery of identity data - Publishing or exporting of Flexify single dataset per user requirements	Data Architect	Ownership of the data structure and associated data management processes for Flexify, working with the operational and development teams	1	£80,000
		Cyber security Lead	Identification, management and monitoring of cyber processes across the Flexify tool and the organisation as a whole.	1	£80,000
		Operations Lead	Overarching ownership for the operations of Flexify.	1	£55,000
		Operations analyst	Day to day operational delivery	1	£80,000
Shared services	Provision of standard shared services activities	Finance officer Human resources officer Legal officer/sec	Management of company required financial processes including invoicing of Flexify users, human resources processes and legal requirements including management of user licences.	1	£70,000
Total costs					£1,155,000

* Rounded ONS Annual pay - 2024 Gross (£) UK data

Pathway 1 costs

Fixed operational costs including IT and other costs

Overview

Fixed operating costs for Flexify include IT operational costs, office space, administrative costs capturing both tools and materials as well as other costs such as legal and financial requirements.

These costs and the associated assumptions are detailed in the tables to the right.

As Flexify will be linked to other energy system platforms, costs associated with connecting Flexify to these platforms will also be incurred. It is expected that these will be a proportion of Flexify’s revenue and would need to be negotiated with individual organisations.

IT Costs

Service item	Monthly Cost
Cloud Hosting	£22 – £55
Cloud Computing	£302 - £756
API Service	£243 - £607
Dashboard Service	£8 – £21
Identify & Access Management	£106 - £266
WebApp Service	£79 - £197
Security Lake	£61 - £153
Support Chat	£41 – 101
Estimated Monthly Total	£863 - £2,157
Estimated Yearly Total	£11,000 - £26,000

Other fixed costs

Service item	Monthly Cost
Office space	£6,600 - £9,900
Administrative costs – tools & materials	£1350
Administrative costs – other	£2000
Estimated Monthly Total	£9,600-£11,900
Estimated Yearly Total	£115,200 - £142,800

Assumptions

Office space

- Office space based on 13 personnel
- Office cost is derived through Statista and based on an average UK office cost per sqm in Q4 2023.

Administrative costs

- Tools and materials includes costs associated with IT hardware/software as well as other materials. It is assumed to be £100 per FTE.
- Other administrative costs captures costs associated with legal, operating expenses for office space etc; this is assumed to be approximately £2,000/month.

B.2.1.2

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Pathway 2 – Flexify is sold post MVP

Pathway 2

Flexify is sold post MVP

Overview

Under this pathway, Flexify is taken to MVP and then is fully sold to another organisation to undertake the operation and development of Flexify. There are a range of different organisations that could taken ownership of Flexify, this includes:

- Existing regulated industry participant i.e. Market Facilitator or NESO/DSO,
- Market platform providers,
- A not-for-profit consortium,
- A commercial organisation.

Flexify could be sold through either a bilateral negotiation or through a competitive process if there were multiple parties interested. For Flexify to be sold, there will need to be a sufficient investment case, based on a robust assessment of the business plan, particularly revenue streams. As discussed in previous sections, this will be reliant on how the flexibility markets evolve and the uptake of users onto Flexify.

Proof of concept to Minimum Viable Product

As Flexify is currently at PoC stage, additional activities are required to progress the product to MVP. These include:

- Identification of a buyer to develop requirements for the Flexify
- Gap analysis of implementation, requirements gathering and cost of further build for the requirements
- Implementation of the requirements to finalise the MVP.

As the requirements are yet to be developed, the costs associated with developing the MVP cannot be confirmed.

MVP revenue streams

Revenue streams will be determined by buyer, similarly to pathway 1, these could include:

1. Flexify would receive a licencing fee from a client for the duration of the contract. For additional Flexify development beyond the MVP, additional charges would be incurred by the platform in alignment with the contract terms.
2. Licencing fee directly with industry participants such as FSPs and NESO/DNO.
3. When Flexify is sufficiently mature with high FSP uptake, industry data reports could be sold to industry at an additional rate.

B.2.1.3

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Pathway 3 - Consortium as required under the Innovation Programme

Pathway 3 costs

Consortium as required under the Innovation Programme

Overview

Under this option, Flexify is developed and operated by the Consortium as a commercialised offering in line with wider market and regulatory reforms.

Flexify would offer licences to industry parties for access to Flexify and would also be able to offer wider insights and data services to these parties. Given that different parties will have different requirement and therefore different willingness to pay, Flexify would adopt the following approach:

- A license fee for System Operators (i.e. NESO/DNOs) for base access and then a separate subscription fee for the insight offering.
- A license fee for FSPs for base access and then a separate subscription fee for the insight offering.

Proof of Concept to Minimum Viable Product

As Flexify is current at proof of concept stage, additional activities are required to progress the product to MVP.

Flexify would undertake further stakeholder engagement with expected subscribers to determine MVP requirements. As per the other pathways, Flexify would then:

- Undertake a gap analysis of implementation, requirements gathering and cost of further build for the requirements
- Implement the requirements to finalise the MVP.

As the requirements are yet to be developed, the costs associated with developing the MVP cannot be confirmed.

Revenue Streams

Arup has undertaken a review of other solutions available on the market, their licensing costs, and the services and data included. This provides insight on how Flexify could position itself within the market, and the potential costs they could charge:

- Bloomberg New Energy Finance (BNEF) provides Independent insight and analysis on commodities, clean power, transport, sustainability and cross-cutting technologies at between £15,000 - £20,000 per license.
- EnAppSys provides UK and EU-focused energy market data, offering analytics on electricity generation, demand, and interconnections at between £10,000 - £15,000 per license.

However, it is important to consider that data in these platforms is broader than what would be supplied under Flexify. Further consideration would need to be given to how the Flexify system is being used, the amount of data it provides, and the quality of that data. The ability to offer such revenues streams will be contingent on how the flexibility markets develop and the number of users on Flexify. A slower development of flexibility markets and/or uptake of users onto the platform could limit the offering of these services, at least in the near term.

Pathway 3 costs

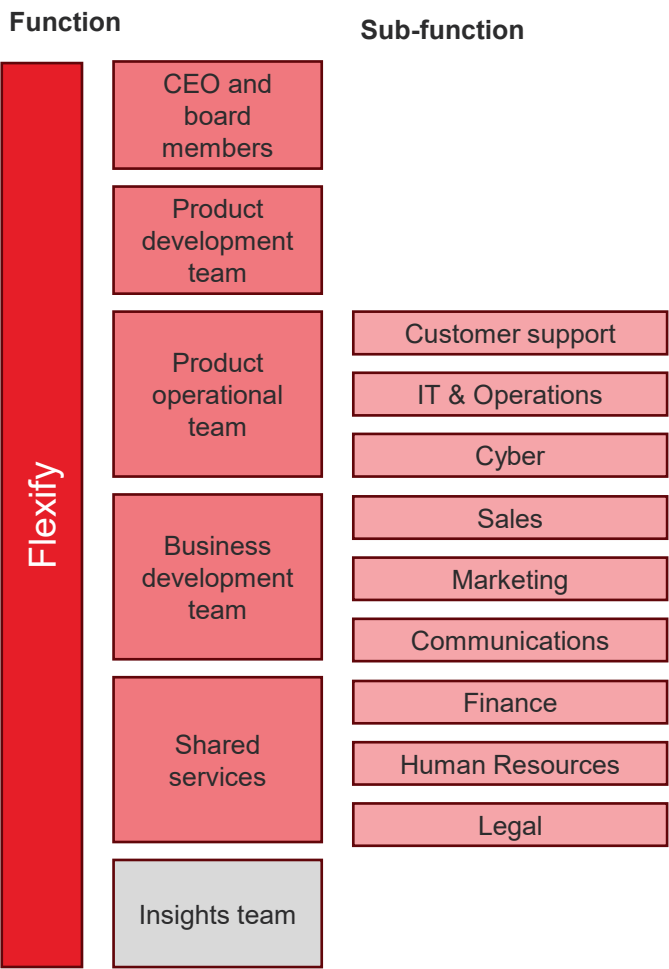
A breakdown of the organisational functions required to operate Flexify

Overview

Under Pathway 3, the proposed organisational functions are presented to the right. The teams will undertake the following activities:

- **Product development team:** this team will be focussed on the future Flexify development, responding to user requirement changes and changes in the wider policy/legislative/technology landscape to ensure that Flexify continues to evolve in line with market needs.
- **Product operational team:** this team will be responsible for the day to day running of Flexify. This will incorporate providing customer service (i.e. helpdesk services) to users to either mobilise them or to provide troubleshooting. It will also provide overarching IT & operational support to maintain smooth operations as well as undertaking proactive management of cyber risks.
- **Insights team:** this team will prepare market data insights and reports utilising the aggregated data within the Flexify that are provided as an added value offering. This team would not be introduced on Day 1

- **Business development team:** this team will be responsible for the securing of new users onto the platform through marketing and sales activities.
- **Shared services team:** this team will provide the fundamental services required to enable Flexify to operate effectively; this will include finance (including the management of license fees), HR and legal services.



Pathway 3 costs

Personnel costs (1 of 2)

*ONS Annual pay - 2024 Gross (£) UK data

Team	Scope	Roles	Scope of role	FTE	Full estimated cost*
Executive Team		CEO	Overarching ownership for Flexify	1	£180,000
		COO	Overarching ownership for Flexify	1	£180,000
		Board Members	Providing strategic direction and decision making for the Flexify product and organisation.	3	£300,000
Product team	- Further maintenance and operation of the product - Further development of the product - Provide support with integration activities with other platforms	Product Owner	Ensure overarching delivery of the product, undertaking a cross-cutting role with the operational team.	1	£75,000
		Technology Manager (CTO)	Would undertake Quality Assurance / Quality Control role for both product development and operations.	1	£100,000
		Shared Developer	Day to day design responsibilities for the platform.	2	£150,000
		Business Analyst	Responsible for tracking changes in regulatory/policy landscape and translating into product development	1	£55,000
IT operational team	- Data backup and recovery of identity data - Publishing or exporting of Flexify single dataset per user requirements	Data Architect	Ownership of the data structure and associated data management processes for Flexify, working with the operational and development teams	1	£80,000
		Cyber security Lead	Identification, management and monitoring of cyber processes across the Flexify tool and the organisation as a whole.	1	£80,000
		Operations Lead	Overarching ownership for the operations of Flexify.	1	£55,000
		Operations analyst	Day to day operational delivery	1	£80,000
Product operational team	- Know your customer data validation - Support with uploading and integrating of asset datasets into Flexify	IT Helpdesk Lead	Management of the customer support team and delivery of user-facing customer support, including issue resolution, data uploads and managing the know your customers process.	0.25	£15,000
		Customer service	Delivery of user-facing customer support, including issue resolution, data uploads and managing the know your customers process. Delivery of any necessary training and onboarding troubleshooting.	2	£70,000

Pathway 3 costs

Personnel costs (2 of 2)

*ONS Annual pay - 2024 Gross (£) UK data

Team	Scope	Roles	Scope of role	FTE	Full estimated cost*
Business development team	- Attracting new entrants onto Flexify either for core or added value activities - External communications on Flexify product development and general operational updates	Sales Lead	Overseeing the sales process to identify, engage and onboard new users onto Flexify; this will also include new user strategy development and new revenue forecasting.	1	£55,000
		Marketing & communications lead	Overseeing the development and implementation of the marketing and communication strategy for Flexify, including development of content and management of communication tools (e.g. website/ social media). Also, oversees internal communications process.	0.5	£25,000
Insights team	- Publishing or exporting of Flexify aggregated datasets per user requirements - Market data insights and analysis reports (e.g. BNEF reports)	Insights Manager	Development of the insights products strategy including development of reports, consolidation of data and incorporating customer feedback.	1	£55,000
		Insights Analysts	Production of insights products.	2-3	£90,000
Shared services	Provision of standard shared services activities	Finance officer Human resources officer Legal officer/sec	Management of company required financial processes including invoicing of Flexify users, human resources processes and legal requirements including management of user licences.	1	£70,000
Total costs					£1,715,000

Pathway 3 costs

Fixed operational costs including IT and other costs

Overview

Fixed operating costs for Flexify include IT operational costs, office space, administrative costs capturing both tools and materials as well as other costs such as legal and financial requirements.

These costs and the associated assumptions are detailed in the tables to the right.

As Flexify will be linked to other energy system platforms, costs associated with connecting Flexify to these platforms will also be incurred. It is expected that these will be a proportion of Flexify’s revenue and would need to be negotiated with individual organisations.

IT costs

Service item	Monthly Cost
Cloud Hosting	£22 – £55
Cloud Computing	£302 - £756
API Service	£243 - £607
Dashboard Service	£8 – £21
Identify & Access Management	£106 - £266
WebApp Service	£79 - £197
Security Lake	£61 - £153
Support Chat	£41 – 101
Estimated Monthly Total	£863 - £2,157
Estimated Yearly Total	£11,000 - £26,000

Other fixed costs

Service item	Monthly Cost
Office space	£14,400 - £19,800
Administrative costs – tools & materials	£2250
Administrative costs – other	£2000
Estimated Monthly Total	£18,650-£24,050
Estimated Yearly Total	£223,800 - £288,600

Assumptions

Office space

- Office space based on 22.5 personnel
- Office cost is derived through Statista and based on an average UK office cost per sqm in Q4 2023.

Administrative costs

- Tools and materials includes costs associated with IT hardware/software as well as other materials. It is assumed to be £100 per FTE.
- Other administrative costs captures costs associated with legal, operating expenses for office space etc; this is assumed to be approximately £2,000/month.

B.2.2

— Assessment of pathways

Assessment of the pathways

Assessment criteria

Overview

The following criteria have been identified for assessment of the delivery approaches. This builds on the assessment criteria identified within phase 1 with further criteria identified based on the evolving energy landscape.

Criteria	Description
Monopoly risk	This captures the dependency on a single entity during steady-state management where independent factors could cause a failure e.g., changing priorities, lack of cross industry requirement, priority considerations, resource limitations, or data monopoly.
Timeline	Ability to ensure timely delivery during steady state delivery covering: - The mobilisation period required to ensure design meets the user, governance and technical requirements. - The time to build or customise the relevant aspect of the solution components. - Integration of feedback and adaptation of technology and supporting resources.
Skills & capabilities	Availability of the correct skills to deliver the solution's functional and non-functional components, ensuring those responsible have the relevant: - Domain experience, such as cyber security, to ensure it is fit for purpose and recognises the nuances of user requirements and sector minimising dependency on government or stakeholder resource. - Sufficient relevant employee resources spanning people, process, and technology.
Cost recovery	Solution will drive to be self-sufficient to ensure it can reduce operation costs, enhance reliability by safeguarding it against external disruptions, ensuring that it can continue to support decision-making even during challenging times, and operate autonomously and adapt to changing conditions.
Meets existing regulatory / policy requirements	Several entities within the electricity sectors are regulated and licenced by Ofgem, this includes networks, suppliers and generators. The licences set the framework and the associated bounds within which existing organisations must operate as well as the associated commercialisation of their activities. The solution will need to exist within the existing regulatory and business model frameworks.
Invest-ability	The solution will need to be secure seed funding (devex and capex) for the initial delivery phase as well as being able to continue to secure funding as the solution develops and evolves. It will need to be able to do this in a sufficiently agile manner to ensure it can continue to meet user requirements.
Ability to respond to future changes	There are significant changes occurring within the energy sector, cutting across the policy landscape, regulation and technology with new organisations and responsibilities being developed as well as the development of new technology solutions. Several of these changes are currently being formalised within legislative and regulatory changes. Therefore, the organisation will need to be sufficiently structured to be able to respond to these wider changes.
Data ownership	Flexify will be storing data associated with the universal profile for domestic and non-domestic assets. Therefore consumers will need to have sufficient confidence in how their data is being used and stored.

Assessment of the three pathways

Assessment for monopoly risk, timeline and skills & capability criteria,

	Option 1. Long term commercial contract	Option 2. MVP sold	Option 3. Consortium as required under the Innovation Programme
Monopoly risk	- Organisation is centred around the delivery of Flexify and will be driven to ensure it is sufficiently aligned with industry needs and continues to respond during steady state. It is also commercially driven and therefore will be incentivised to monetise the output to protect its market position. - This approach would require robust contract management between the client and the delivery organisation, this would include KPIs for performance assessment and potential mechanisms to clawback contract value in the event of non-performance. - Long term contract may not provide sufficient incentivisation for the contracted party to provide continuous development without robust requirements within the contract.	Organisation is centred around the delivery of Flexify and will be driven to ensure it is sufficiently aligned with industry needs and continues to respond during steady state. It is also commercially driven and therefore will be incentivised to monetise the output to protect its market position.	Organisation is centred around the delivery of Flexify and will be driven to ensure it is sufficiently aligned with industry needs and continues to respond during steady state. It is also commercially driven and therefore will be incentivised to monetise the output to protect its market position.
Timeline	- As a commercially driven organisation it is likely to have agile governance arrangements that are directed to support fast delivery to meet user needs; this will be subject to sufficient certainty on the business case/revenue streams. - Potential for an extended contractual negotiation period to ensure that the contract meets the necessary requirements of both parties.	As a commercially driven organisation it is likely to have an agile governance arrangements that are directed to support fast delivery to meet user needs; this will be subject to sufficient certainty on the business case/revenue streams.	As a commercially driven organisation it is likely to have an agile governance arrangements that are directed to support fast delivery to meet user needs; this will be subject to sufficient certainty on the business case/revenue streams.
Skills & capabilities	Where there are sufficient needs cases for additional resources a commercially driven organisation would be able to recruit competitively. However, may not have access to a wider pool of resources depending on the existing remit of the organisations within the consortium.	Where there are sufficient needs cases for additional resources a commercially driven organisation would be able to recruit competitively. However, may not have access to a wider pool of resources depending on the existing remit of the organisation.	Where there are sufficient needs cases for additional resources a commercially driven organisation would be able to recruit competitively. However, may not have access to a wider pool of resources depending on the existing remit of the organisations within the consortium.

Assessment of the three pathways

Assessment for cost recovery, invest-ability, and meeting existing regulatory.

	Option 1. Long term commercial contract	Option 2. MVP sold	Option 3. Consortium as required under the Innovation Programme
Cost recovery	Fully commercial organisation that would be self-sufficient in its funding avenues, however, this would be subject to the commentary provided in the invest-able category.	Fully commercial organisation that would be self-sufficient in its funding avenues, however, this would be subject to the commentary provided in the invest-able category.	Fully commercial organisation that would be self-sufficient in its funding avenues, however, this would be subject to the commentary provided in the invest-able category.
Invest-ability	- The invest-ability of this option would be contingent on the uptake of FSPs into Flexify and the ability to therefore provide commercialised revenue streams. During the initial operational years post development, it is unlikely that Flexify would have sufficient uptake of FSPs (which is driven by wider factors around flexibility deployment). - Post high uptake onto Flexify and the development of sufficient revenue streams, this option is likely to be investable.	The invest-ability of this option would be contingent on the uptake of FSPs into Flexify and the ability to therefore provide commercialised revenue streams. During the initial operational years post development, it is unlikely that Flexify would have sufficient uptake of FSPs (which is driven by wider factors around flexibility deployment).	The invest-ability of this option would be contingent on the uptake of FSPs into Flexify and the ability to therefore provide commercialised revenue streams. During the initial operational years post development, it is unlikely that Flexify would have sufficient uptake of FSPs (which is driven by wider factors around flexibility deployment).
Meets existing regulatory / policy requirements	- Solution would sit within existing regulatory and business model frameworks, without modifications required. - Further, as Elexon will have the oversight of Flexify this would align with their overarching responsibilities under the Market Facilitator role.	Solution would sit within existing regulatory and business model frameworks, without modifications required.	Solution would sit within existing regulatory and business model frameworks, without modifications required.

Assessment of the three pathways

Assessment for ability to respond to future changes and data ownership criteria

	Option 1. Long term commercial contract	Option 2. MVP Sold	Option 3. Consortium as required under the Innovation Programme
Ability to respond to future changes	• The business model design (i.e. the development and maintaining of revenue streams) is likely to provide an incentive to continuously respond to changes. • Mechanisms would need to be included within the contract to ensure that there is sufficient mechanisms to ensure that the contracted party continues to develop the platform as new wider future changes arise.	• The business model design (i.e. the development and maintaining of revenue streams) is likely to provide an incentive to continuously respond to changes.	• The business model design (i.e. the development and maintaining of revenue streams) is likely to provide an incentive to continuously respond to changes.
Data ownership	• Under the long-term contract, the data that flows through Flexify can be used to enable trust and governance in the sector without additional contracts.	• As a commercial offering, specific data storage and exchange agreements will be required.	• As a commercial offering, specific data storage and exchange agreements will be required.

B.2.3

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Overview of regulatory landscape for Flexify

Overview of regulatory landscape for Flexify

Understanding the regulatory landscape that Flexify will operate within

Overview

To inform the delivery approaches, an assessment has been undertaken to review the existing regulatory frameworks. This focussed on identifying which of the features delivered by Flexify are already captured through the frameworks. This has included reviewing the existing licences and codes and which organisations are regulated through these frameworks.

A review of the four key licenses set out by Ofgem (NESO, Distribution, Supplier and Generator licenses) and the data requirements set out in relation to flexibility markets has been carried out. Additionally, a review of five key codes and their data requirements has been completed, the codes examined include the CUSC, BSC, DCUSA, Grid, and Distribution codes.

There are functions outside of these licenses, such as ENA standardisation initiatives and market platforms which are not specifically licenced. These platforms act as a tool for DSOs to meet their overarching DSO objectives associated with how flexibility markets should be managed and operated. Actions taken through platforms are therefore indirectly picked up by a license or code through DSO interaction.

Summary of Licences & Codes

Licences

- Licenses are specific to a licensee and provide the legal right to operate within a market and set out broad obligations using standard license conditions. Licenses also obligate compliance with codes. They are updated less frequently, and changes require a potentially prolonged regulatory process.
- With flexibility markets growing, and aggregators, which manage DER and DSR playing a larger role in the market, Ofgem is introducing the need for a new aggregator license.

Codes

- Codes provide more detailed market rules, technical standards and operational procedures that market participants must adhere to, to meet the requirements set out in licenses. They apply more broadly to all parties operating within an area of the market e.g. Generators must comply with the Grid Code.
- Recent code modifications, including the BSC allowing aggregators to operate in the wholesale market, reflect how codes are evolving to acknowledge flexibility.

Assessment outcome

- Of the data that will pass through Flexify, some is captured directly or indirectly through existing licenses, codes, and ENA standardisation initiatives; this is detailed on the following slides.
- As part of the MVP operating model and design development, consideration needs to be given to the activities of Flexify, whether these are captured under existing licenses or codes, and whether further licensing and codes or modifications are required.

Regulatory landscape

Requirements set out in licenses and codes that impact FSPs and the standardisation initiatives seeking to streamline processes. Whilst no barriers have been identified, for MVP development, a further assessment of the alignment of the solution with the regulatory landscape will be required.

Licenses

NESO
Grants the NESO the authority to coordinate the transmission system, as well as to be Code Administrator for the Grid Code and CUSC. The NESO must comply with industry codes, including the Distribution Code and be party to and comply with the DCUSA, and BSC.
Distribution
Authorises the licensee to operate, maintain, and develop the electricity distribution network. The licensee must comply with the grid and distribution codes, and be party to and comply with the CUSC, DCUSA, and BSC.
Generation
Authorises the Generators to generate electricity for the purpose of giving a supply to a premises, or enabling a supply to be given, ensuring compliance with regulatory standards and market rules. The licensee must comply with the Grid and Distribution Code, and be party to and comply with the CUSC, and BSC.
Supply
Authorises the Supplier to supply electricity to premises, ensuring compliance with regulatory requirements and fair market practices. The licensee must comply with the grid and distribution codes, and be party to and comply with the CUSC, DCUSA, and BSC.

Codes

Licensees must comply with codes

Grid Code	Distribution Code
Sets out technical requirements for the connection to, and use of, the transmission system. Compliance with the Grid Code is one of the requirements of the Connection and Use of System Code (CUSC)	Sets out the technical parameters for the connection to, and use of, the distribution system. Licensed distributors and DNOs are obliged under condition 21 of their licences to maintain a distribution code.
Connection and Use of System Code (CUSC)	Distribution Connection and Use of System Agreement (DCUSA)
Sets out the contractual framework for the connection to, and use of, the transmission system and associated charges.	Sets out the contractual framework for the connection to, and use of, the distribution system and associated charges.
Balancing and Settlement Code	
Defines the rules and governance for the balancing mechanism and imbalance settlement processes.	

ENA Standardisation Initiatives

ENA standardisation will interact with FSP processes

Prequalification
Implements standard prequalification criteria
Flexibility Contracts
Ensures NESO/DSOs use standardised contractual T&C's and common schedule headings.
Dispatch API
Ensures a common API specification for dispatching.
Settlement Process
Ensures standardised and aligned methodologies for the settlement process

Other initiatives

Wider initiatives that are shaping the flexibility landscape

Digital sharing infrastructure
Implementation of standardised data exchange (collection, storage and access) for flexibility markets, including asset registration.
Market Facilitator Implementation
Introducing requirements for DNO flex markets, NESO ancillary markets/Balancing Mechanism and in future Capacity Market and Wholesale Market

- Direct requirements on FSPs
- Indirect requirements on FSPs
- Requirements on other related bodies

Regulatory landscape

How the data to be managed by Flexify is captured within the existing licences, codes and ENA developed processes

Data requirements

The table to the right outlines where direct or indirect data requirements are placed on FSPs.

At an overarching level, during the license application process, Ofgem requires applicant information including company information, VAT numbers, service address and details on those in effective control. Ofgem also requires evidence of contact with industry code bodies.

The distribution license has a specific clause for flexibility markets, and the ENA sets out clear processes that FSPs Services follow. Both require an FSP to provide specific flexibility market data.

Other FSP activity is indirectly captured in other codes and licences. For example, if an FSP is providing ancillary services, the conditions for this are laid out in the grid code and BSC. The data requirements are not specific markets. Therefore, apply to all assets operating in that market.

If an FSP doesn't operate in that market e.g. Ancillary Services, then the data required through the BSC won't be captured. Therefore, the indirect data requirements are not applied consistently across FSPs, and captured data may vary per asset.

	Licenses					Codes			ENA Process
	ESO	Distribution	Supplier	Generator	CUSC	Grid Code	BSC	DCUSA	Distribution
Company Information									
Asset Data (e.g. unit ID)									
Technical Specifications (e.g. capacity, ramp up rate)									
Connection Information (e.g. DNO connection point)									
Specific Flex Market Conditions									

Key: Direct requirements on FSPs Indirect requirements on FSPs No requirements on FSPs

Regulatory landscape

How the data managed by Flexify is captured within the existing licences

Licences

The Electricity Act (1989) prohibits particular activities unless the entity carrying out the activity is licensed. Ofgem sets out standard license conditions for each licensable activity which licensees must oblige with. We have reviewed licenses in four key areas and set out the key conditions pertaining to markets in the table. In addition to the entities that are licenced there are the following entities within energy sector which are not licensed:

- Aggregator licencing – included within the 2023 Energy Bill to introduce licencing framework for third party intermediaries. It is expected that the licencing framework will be in place by the end of 2025.
- Market Facilitator – designed to coordinate a transparent and competitive market for flexibility service. The MF will set rules around flexibility markets and support the interactions between DNOs and flexibility providers.
- Platform providers e.g. Electron, Piclo - providing flex market platforms used by DNOs and FSPs to procure flexibility services.
- Data providers e.g. EnAppSys – sharing market data on volumes and prices

Licensee	Licence condition	Description
NESO	Condition C9 Procurement and use of Balancing Services	• Sets out obligations to consider price and technical differences and not discriminate on the basis of these to ensure transparency and equal treatment of market participants. • Condition C9 sets that the NESO must prepare: procurement guidelines statement, balancing principles statement, balancing services adjustment data methodology statement, system management action flagging methodology statement, applicable balancing services volume data methodology statement and a balancing services annual report
Distribution System Operator	Network operation: 2.1.1 & 2.1.3 Market development: 3.1 & 3.2	• 2.1.1 & 2.1.3: Obliges DSOs to identify and share operability constraints, including publishing this data to help avoid conflicting actions being taken by other network/ system operators. It also obliges DSOs to provide NESO with information across timescales about the DER it is planning to dispatch. • 3.1 & 3.2 set out baseline expectations for the 2 key activities DSOs must undertake in terms of market development. This includes providing accurate, user friendly and comprehensive market information and data and embedding simple, fair and transparent rules and processes for procuring distribution flexibly services
	Condition 31E Procurement and use of Distribution Flexibility service	Sets out the requirement for DSOs to procure and use Distribution Flexibility Services where it is economic and efficient to do so, procure in the most economic manner, and not discriminate in their procurement of distribution flexibility services. • 31E.1.E: When procuring flexibility services, DSOs to consider the impact actions will have in other markets and on the total system. • 31E.1.F: Establish and thereafter maintain objective, transparent, cost-reflective and non-discriminatory rules and technical requirements for participation. • 31E.1.G: Take all reasonable steps to ensure the effective participation of all undertakings participating or intending to participate in DSO markets. • 31E.15 Publish a Distribution Flexibility Services Procurement Statement and Report. Under 31E, FSPs must provide a Flexibility Procurement Statement, a Flexibility Procurement Report, and ongoing reporting on the outcomes of tender processes within 1 month of contractual agreement.
Supplier		Limited beyond standard requirement to all customers.
Generator		No explicit reference to flexibility markets.

Regulatory landscape

How the data managed by Flexify is captured within the existing codes

Codes

Codes operationalise the high-level requirements set out on licensees and provide a set of technical and commercial rules that market participants must adhere to. We have reviewed five key codes and the data requirements they set out specifically in relation to flexibility markets.

These first three codes (CUSC, Grid Code and BSC) are largely transmission focused, and are concerned with larger flexibility units, with little to no specific conditions set out for smaller units such as distributed energy resources.

However, codes are evolving to acknowledge how smaller assets and aggregators fit into the picture. For example, the Balancing and Settlement Code was modified in 2023 to allow independent aggregators to compete in the wholesale market against suppliers, by registering as a Virtual Trading Party.

As codes can take a prolonged period to update, their detail tends to be limited. Instead, codes act as high-level guides on the principles of what data needs to be published and when.

In relation to Flexify, codes will set out the details of how data sharing works and when data should be shared. In terms of markets, codes are more likely to set out what data needs to be published after the event.

Codes	Description
CUSC	No specific clauses for flexibility markets specified.
Grid Code	The Demand Response Services Code proportion of the Grid Code is concerned with Demand Response Providers who contract for the provision of Ancillary Services. Data required varies depending on the type of Demand Response Service required and is set out in the Ancillary Services agreement. The Grid Code sets out Dynamic Data Parameters which is required from each BM Unit, and is used by the NESO in the operation of the BM. These include; • Run-up rate / Run-down rate • Notice to deviate from zero • Notice to deliver offers/ bids • Minimum zero/ non-zero time • Maximum delivery volume and associated maximum delivery period • Stable export / import limit
Balancing and Settlement Code (BSC)	The BSC sets out a Dynamic Data Set which must be aligned with the Dynamic Data Parameters set out in the Grid Code.
DCUSA	The DCUSA sets out a methodology for defining a curtailable access arrangement (e.g. a curtailable connection). A curtailable connection is a non-firm access arrangement that allows a customer to connect to a distribution system while agreeing to restrictions on the use of their connection. A Curtailable Connection will only be offered where the Company has identified a requirement for Reinforcement to facilitate provision of the requested connection, and where the Curtailment will provide a network benefit. As part of this, it sets out how the exceeded curtailment price is calculated, DNOs must provide a Flexibility Market Price Statement by the fifth working day of April and October • Contracted and Tendered - Flexibility Market Import Price (£/MWh), Flexibility Market Export Price (£/MWh) determined on first working day of April and October • Exceeded Import and Export Curtailment Price (£/MWh) – demand turn down/ generation turn up • Distribution Flexibility Services contract data and tender data
Distribution Code	No specific clauses for flexibility markets specified.

Regulatory landscape

How the data managed by Flexify is captured within the existing codes

ENA Standardisation (1/2)

The ENA Open Networks programme has also introduced data requirements through standardisation across 5 key areas in relation to markets. This is set out over the following pages.

Outcome	Process	Data requirements
Standardisation of prequalification	ENA gap analysis highlighted there was signification variation in the amount of qualification criteria asked for by DNOs. ENA introduced standard prequalification criteria including 31 standard questions for commercial qualification and 35 for technical qualification. Implementation across DNOs was due to be completed by May 2024.	Commercial template is split into five key areas; 1. Reference Company information: registered legal name and number, address, key contacts name, email, and number, website, VAT number, legal relationship to asset 2. Technical 3. T&Cs: agreement with the ENA standard flexibility services agreement 4. Due Diligence: confirmation of whether the contracting party a member of flex assure code of conduct, and several contracting requirements (i.e Achilles UVDB registered/ company financial and legal history) 5. Insurance: compliance with liability insurance with minimum limit of £5m, and public liability insurance with minimum limit of £5m. Technical template is split into six key areas; 1. Reference company information 2. Connection: connection status, if awaiting energisation date, connection reference number, connection voltage level, connection offer status, target delivery date, service readiness date, recruitment status, CMZ location 3. Site/ Location: postcode, import/export MPAN, MSID, DER name/ref 4. Technology: asset scale, metering point, DER type: generation &or storage & conversion type, DER type: demand & source, technology type 5. DER parameters: installed capacity, flexible activity capacity: demand turn up/down, generation turn up/down, reactive export capacity, reactive import capacity, min/max operating duration, response time, recovery time 6. Metering: metering granularity

Regulatory landscape

How the data to be managed by Flexify is captured within ENA developed processes

ENA Standardisation (2/2)

Outcome	Process	Data requirements
Standardisation of flexibility contracts	• ENA created a standardised contract for flexibility procurement in collaboration with DNOs and the ESO who previously used separate contracts with different requirements, terms and clauses. • The standard agreement ensures DNOs and the ESO use standard contractual terms and conditions, a standard approach to service terms and common schedule headings. • They are currently working on version 3 of the agreement.	• Company: name, registered number, address • Performance monitoring: metering standards, performance report, measuring equipment, service meter data • DER: Type, location, MPAN, contact details, capacity, planned maintenance periods, notice periods for access <i>The Company is required to disclose certain information in accordance with this Agreement under obligations within its Distribution Licence or Transmission Licence (as applicable), or an Industry Code. Information shared will include but may not be limited to provider names, awarded prices, volumes, GSP and asset locations, and contract durations</i>
Standardisation of dispatch API	• ENA is reviewing options to develop a standardised dispatch API used by market platforms to instruct flexibility. • All DNOs should adopt a common API specification for dispatching, to ensure flexibility providers don't need to develop multiple interfaces. • API specification development is ongoing, and the expected implementation date is TBC.	• Key Service Parameters outlined in ON22-WS1A-P3 which set out requirements are sufficient in isolation. This includes; service provider declaration of availability – start, end, service units, min/max operating level, min/max run time, ramp time, response time, contract ID • Consultation is considering the need to provide type of energy source (hydro, battery etc), predicted amount of GHGs, confidence interval (%) that FSP can provide the service. • The working group set out communications requirements placed on FSPs to provide dispatch information to a network operator. This included: dispatch status, NO dispatch ref – unique dispatch reference, namespaced by network operator, dispatch unit – unique reference, namespaced by FSP identity, network operator ID and FSP ID
Standardisation of settlement process	• ENA seeks to standardise and align the methodologies used across DNOs for the settlement process. The services considered are turn up/down and peak reduction. • Implementation was expected in September 2024 but work is ongoing.	Metering data – unit ID, start time, end time, active power, energy (MWh)

Alignment with FMAR

How Flexify + AAR aligns with the FMAR consultation position



FMAR functional outcome	FMAR functional outcomes	Achieved through Flexify + AAR	Justification
1. Single master data record	- Data is stored as a single source of truth for asset data - Data is standardised and machine-readable with an API but with highly configurable data fields dependant on the user/asset/product needs - Data is maintained though data management services and (if necessary) synchronisation services		Enabled by providing a continuously updated mapping of data across multiple systems, platforms, and datastores; with AAR acting as a datastore for capturing asset data that are not yet participating in markets/products, and asset information provided into Flexify. Flexify will store the map of the data and metadata of the asset information, while AAR stores the entirety of the asset information.
2. Unique ID	- Unique asset ID and unique user ID, linked to master data record - Enables de-duplication of asset data records - Enables accurate and permission-based data access		Flexify maps unique asset ID assigned to each asset across multiple platforms, allowing it to track updates and/or changes to a specific asset across the all-digital platforms. This method will ensure asset information is not duplicated and consistent across multiple platforms and can track assets as they exchange owners over the course of their life.
3. Data quality	- Data quality is sufficient for users to reliably use it for their needs - Data fields are populated using trusted external data sources - Data lineage and versioning should be provided where practical		- Flexify maps the linkage between different data sources to provide that interoperability and AAR provides the validation of this into other databases. - Flexibility Data Standards implemented through Flexify supports scalable and assured data sharing in the flexibility ecosystem, solving the outcome of information transparency.
4. Appropriate collection points	- Able to collect flexibility market registration data at point of market entry - Data collection though multiple 'common client APIs' across ESO and DSO markets, which are aligned with the 'common backend API' of the single master data record, enabling 'just once' registration		- Users will register their data once and this will be transferable across all markets - Flexify can collect the assets registered and managed within the market by the FSPs; AAR provides the opportunity to collect asset information from market participants. Together they provide insights on market opportunities for flexibility assets.
5. Common data access	A 'common backend API' available for multiple ESO and DSO users, and other users as needed, to access the single master data record, enabling 'just once' registration		The mapping of data across different sources provides the opportunity to enable common data access for all stakeholders, but further analysis is needed to understand the information security parameters.

Alignment with FMAR

How Flexify + AAR aligns with the FMAR consultation position

Key

Fully achieved through Flexify

Almost fully achieved through Flexify

Partially fully achieved through Flexify

Not achieved through Flexify

FMAR functional outcome	FMAR functional outcomes	Achieved through Flexify + AAR	Justification
6. Data exchange mechanisms	- Will require machine-readable interfaces and may require user interfaces - Ability to create, read/write, search and access master data and supported by data compliance tools - All standard and secure		Flexify exchanges data between multiple data sources, but further analysis of the requirements is necessary. Greater clarity on the data exchange mechanism requirements.
7. User Experience	Modern digital and user-friendly interfaces (e.g. API and maybe GUI), and supporting documentation to provide a good user experience		Designed to meet needs of system users
8. Consumer Consent Framework	- GDPR compliant - Aligned with Ofgem’s Consumer Consent work - Easy and dynamic mechanism for asset owners to grant and manage consent with relevant parties, with that consent releasing data from the asset register in an appropriate and timely fashion		Consumer consent has been considered within the design, however, this needs to be considered further in the MVP.
9. Integration with wider systems	Integrates in a machine-readable, interoperable way with: - other FDI outcomes e.g. product register, prequalification, NESO-DSO coordination - NESO and DSO procurement systems to enable ‘just once’ registration for all flexibility markets - Consumer Consent solution as a mechanism for asset owner consent - External sources to populate data fields with trusted data - Relevant elements of the DSI		- NESO / DSO Alignment - stores the commercial qualification data associated to the organisation which is transferable to market platforms and reusable for qualifying into new markets. - DSI – the standards are based on DSI and the pipelines can incorporate DSI once available.
Non functional requirements	- Standard data models and communications protocols - Trust framework - Reference Architecture		- FDS is the standard data models and can incorporate communication protocols parameters. - Further evaluation is required of the trust framework across all system operators

Regulatory landscape

Conclusion

Conclusion

- There are some requirements today within licences, codes and standards in terms of the data that needs to be shared to register in flexibility markets. This is generally limited as 1) detailing this information within licences and codes is restrictive in how this can be modified in an agile manner 2) the flexibility markets are in their infancy and there historically hadn't been a need for widespread data to be shared. Several ENA Open Networks initiatives have introduced standardised processes.
- This is expected to grow further with the standardisation of flexibility market asset registration initiative and implementation of the Market Facilitator. Through these initiatives it is expected that the data required will be further standardised and how it will be shared will be formalised. This will be linked into the wider Data Sharing Infrastructure.
- Given this, the activities performed by Flexify will need to be defined within a standardised process; this is likely to have to interface with the ongoing work being delivered by the Market Facilitator in its overarching flexibility market design remit. But is unlikely to need to be formalised through licences and codes (although this assumes that the NESO and DNOs will have their licences updated to reflect that

they must deliver on Market Facilitator recommendations.

- As a result, the Flexify role could be performed by more than one organisation, assuming that the standardised process and Data Sharing Infrastructure is in place.

B.3

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Flexify value assessment

Introduction

Identifying the delivered value of Flexify from the perspective of FSPs, System Operators and Market Facilitator

Overview

The following chapter provides an overview of the value assessment for Flexify. This has been developed based on the approach detailed to the right.

This has been undertaken to inform the identification of possible revenue streams and the assessment of the ownership structures.

Value assessment

Approach to value assessment:

- Value opportunities have been assessed against the Flexibility Service Provider User Journey.
- For the identified value opportunities, current flexibility market information has been used to provide an estimated potential cost saving for providers. This has been developed based on a range of types of providers.

Conclusion

The assessment has identified the potential to deliver high value for flexibility providers through reducing time and cost to register in markets, wider opportunities to revenue stack and the increased competition and market liquidity through market insights. However, the delivery of this value will be contingent on the development of current flexibility markets and how future markets are developed.

Value assessment (1 of 4)

Overview of the value assessment for Flexify looking at the delivered value from the perspective of FSPs, System Operators and Market Facilitator

Flexibility market potential

The following chapter provides an overview of the value assessment for Flexify, looking at the delivered value from the perspective of FSPs, System Operators and Market Facilitator.

The value that organisations such as FSPs, aggregators and investors will receive from Flexify will be intrinsically linked to how the flexibility markets develop.

Current key flexibility markets are those developed for the distribution level. Figure 1 shows the total peak demand capacity tendered and contracted by DNOs, for their secure, sustain, dynamic, restore and reactive power products developed as part of the ENA Open Networks programme.

The amount of flexibility tendered and contracted increased between 2018 and 2023/24 as the need for flexibility increased in response to system needs, supported by the Ofgem policy of flexibility first. This trend is expected to increase and whilst the capacity looks to be decreasing from 2024/25 onwards, this reflects that the DNOs will continue to tender and contract capacity closer to real time as system needs become clearer.

Alongside a growth in these five distribution focused market products, new markets have been developed for both distribution and transmission, and the existing markets have grown in size. NESOs Clean Power 2030 report suggests as 4-5x increase in demand flexibility, increasing from 2.5GW in 2023 to 11.5GW in 2030, driven by increases in DSR, smart charging, V2G and thermal storage.

In addition to this growth in markets and capacity, there is potential for significant growth in the number of FSPs. The value of Flexify increases along with the numbers of FSPs using the platform.

The Market Facilitator is expected to be established in 2025/26, creating a more coordinated approach to flexibility markets and the development of new products, alongside the expansion of intermittent renewable technologies. This is likely to increase the need for flexibility, and the growing trend in contracted and tendered capacity is expected to continue. With this expansion of flexibility markets, there is wider value potential for FSPs to unlock, which can be supported through Flexify.

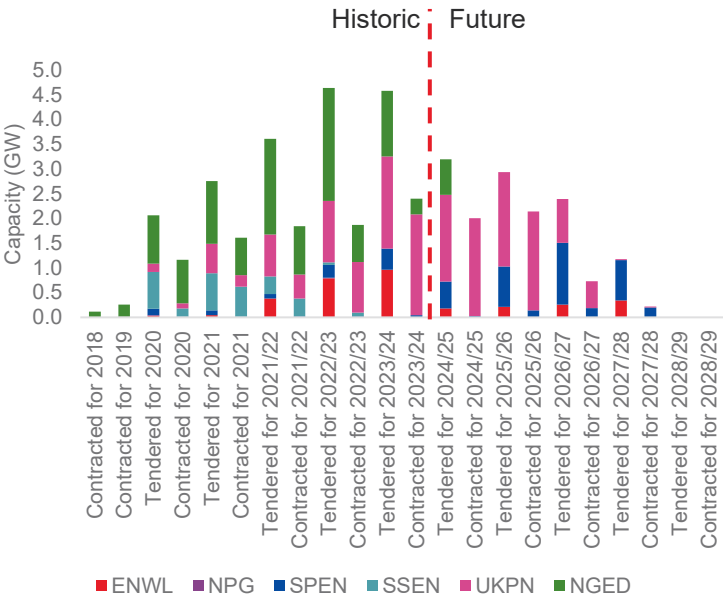


Figure 1: Total peak demand capacity tendered and contracted through flexibility markets (GW)

Source: ENA ON GB Flexibility Figures 2023/24

Value assessment (2 of 4)

Value assessment for Flexify looking at the delivered value from the perspective of FSPs

Delivering value through Flexify

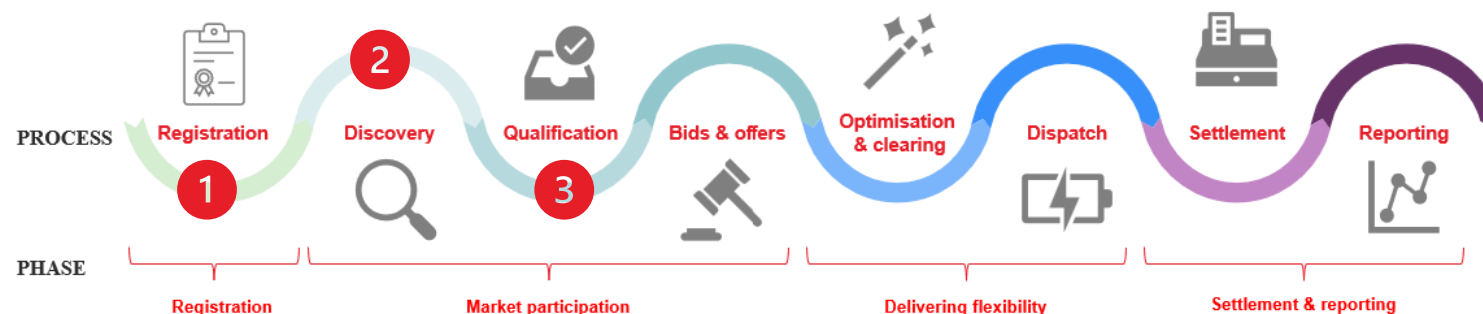
During the Flexify feasibility study, the flexibility user journey (shown opposite) was developed to explore a flexibility users' interactions with the markets; this incorporates four phases; registration, market participation, delivering flexibility and settlement and reporting. Each phase contains one or more processes that an FSP or SO would have to engage in.

By creating a control plane for FSPs to interact with multiple market platforms, Flexify aims to overcome the lack of coordination and inherent complexity associated with entering flexibility markets. By streamlining the user journey, including registration, market discovery, and highlighting opportunities for revenue stacking, Flexify could drive significant value increases for FSPs by optimising operations and profitability.

To understand the wider operating environment for Flexify in terms of ownership and revenue streams, four examples of how Flexify could create value for FSPs along the user journey have been identified. These are explored in further detail on the next slide. This is not an exhaustive list but seeks to exemplify the range of ways the platform could unlock value for FSPs.

Opportunities for Flexify to add value along the flexibility user journey

- 1 Time reduction and administrative costs
- 2 Opportunity identification
- 3 Faster time to market



Value assessment (3 of 4)

Value assessment for Flexify looking at the delivered value from the perspective of FSPs

Overview

The future cost for FSPs entering markets will have been reduced by between £10mn-£12mn by 2035.

This is based on:

- The number of FSPs participating in DNO Flexibility Markets, LCM, and as lead parties in the BM today is assumed to be 285. Sources are [BMRS](#) & [Piclo Data Hub](#).
- The forecasted need for demand side response as within National Grid's FES, assuming the number of FSPs will continue to be proportional to the number of GW needed is to be ~787.
- Benefits is an overall summation of cost savings from Flexify for FSPs, SOs, Market Facilitator, Regulators, and Policy Makers.

Benefit	Description	Potential Cost Savings on behalf of consumers
1 Time reduction and admin costs	During the registration phase, FSPs sign up to markets and register their assets. To register an asset, an FSP must collect their asset(s) and organisation data, such as registered company number, capacity and location and enter this into each operators' market platform. Today a single asset can enter multiple markets, each with varying data required across platforms. This lack of standardisation and the multiple time intensive registrations required, leads to an administrative burden which is larger for an FSP with multiple assets entering multiple markets. Using Flexify, would mean an FSP must only submit their data once and is then able to access multiple markets. Having a universal profile also lowers the administrative burden and time needed for updating market records and maintaining compliance, as an FSP doesn't need to update each different provider platform.	If it takes an FSP that can enter 5 markets, 10 hours to register with each market, Flexify could reduce this by 80%. Assuming a rate of £30 an hour, total savings for an FSP can be £240 per FSP for commercial registration. In turn, assuming, it takes 10 hours for an FSP to register their asset information, Flexify could reduce this by 80%, with total savings for both commercial and technical data provision at £480/FSP. Assuming 100 users for Flexify, the platform can provide overall benefits of £48,000, increasing as the number of FSPs grow. The real value is realised as FSPs save further time for continuous asset information management. A value difficult to quantify and requiring further analysis and engagement with FSPs. Although value was confirmed from engagements with FSPs, noting asset management as a key administrative burden.

Value assessment (4 of 4)

Value assessment for Flexify looking at the delivered value from the perspective of FSPs

Benefit	Description	Potential Cost Savings on behalf of consumers
2 Opportunity identification	During the discovery phase, system operators publish market outcomes which indicate potential market opportunities and flexibility providers review these opportunities across markets. Currently, there is not a coordinated overview of opportunities, and they may only be made available to FSPs when accessed through specific platforms. Initially, Flexify will not provide explicit insights on revenue stacking. However, in future, Flexify could provide insights on these opportunities and how an FSP can leverage the assets across multiple markets. This would drive significant value by unlocking multiple streams of income and simplifying complex market navigation. This improved visibility of stacking opportunities and revenue optimisation, will become increasingly valuable as demand for flexibility grows and more markets become available. Currently there is no centralised platform providing this insight, so Flexify will provide an innovative solution that could drive significant value for FSPs at this stage through the insights offered.	The quantification of revenue stacking benefits that are realised by FSPs through Flexify need further development and validation of the assumptions used to define the below example. If an FSP entered one industrial asset into the NESO's Local Constraints Market (LCM), with an average utilisation rate of 5% and an average utilisation payment of £200/MWh, they could potentially make £80,000 to £100,000 per year. If they can now enter the LCM and add participation in a second market, for example the Capacity Market (CM), assuming a £60/kW/yr clearing price for a 1MW asset, the revenue from the CM could add an additional £60,000 annually, leading to an 80% increase in revenue for that asset. Validation of these opportunities will require engagement with Flexibility Service Providers (FSPs) as they interact with the proof-of-concept to assess the value realisation of the feature. Additionally, Flexify can provide further insights, akin to revenue stacking, where the value of these insights can only be determined by the price users are willing to pay. As a reference, similar insights in other sectors are typically priced between £2,000 and £6,000.
3 Faster time to Market	Currently, after an FSP registers to a market platform and provides asset data, they go through a qualification process where the SO confirms their data. This process can take around 2 weeks to 1 month. If that same FSP then signed up to another market platform, they must also go through the qualification process again. Using Flexify, if an FSP registers with a market platform, their data is checked by the SO. If they then sign up to another platform, the platform knows these SO checks have been done and do not need to be repeated. The new platform has fewer processes to carry out, so rather than taking one month per platform, it may take around a day to a week for the platform to do any additional checks. This benefit becomes more valuable when the number of assets operating in the market grows, and they can be streamlined through to qualification.	The admin cost for FSPs are also reduced and potentially captured in Benefit #1. Realising value is dependent on achieving business interoperability. See Appendix B.4.2 for more details. Lastly, System Operators are the key beneficiaries of this feature, reducing significant administrative burden from their internal processes, associated with commercial and technical qualification checks.

Value for System Operators

Value assessment for Flexify looking at the delivered value from the perspective System Operators

Overview

Similarly to FSPs, Flexify is expected to deliver value for System Operators (NESO and DSOs) across three key areas:

- Ability to switch different market platform providers, depending on their needs.
- Savings in administrative costs associated with Know Your Customer (KYC) processes and asset data verifications.
- Ability to develop analytics and insights through wider aggregation and exchange of flexibility data.

Benefits

The SOs are able to switch to different flexibility market platform providers, depending on their needs. Currently, a SO is likely to use a specific platform for their flexibility markets in line with their original platform development objectives and design. Given the current development of flexibility markets and in development standardisation of processes, the administrative burden of operating these platforms is quite high as data is not standardised so each requires a slightly different set up and associated processes. This has the potential to limit the amount of competition and innovation within the platforms. As Flexify will standardise data, SOs would have the optionality to switch market platform providers to meet different needs and/or realise innovation benefits. This ability to switch could in turn increase competition in the platform market and drive the utilisation of greater innovative technologies and solutions.

Savings in administrative costs associated with KYC processes and asset data verifications. Currently, if an FSP signs up to multiple platforms, they upload the same data to each platform and each time the System Operator is required to verify it the received data. By using Flexify, the data will be verified the first time it is uploaded to Flexify, and SOs can be confident in this process. As a result, the SOs will not have to process as many applications, ultimately this saves the SOs time and the associated administrative costs as the flexibility markets develop.

Assuming a KYC check ranges from £1,500 to £3,000 per customer, SO(s) can save **£750,000 - £1,500,000**.

Ability to develop analytics and insights through wider aggregation and exchange of Flexibility Data. The data on Flexify will be standardised and accessible from one place, which will allow SOs to conduct analysis. They can gather insights on market system operation including identification of potential barriers or opportunities and be able to work with the relevant organisations under the identified delivery pathways to design better products to realise greater value within the markets.

Value for sector regulators, and policy makers

An initial view of the value assessment for the Flexify platform

Overview

For regulators and policymakers, Flexify offers a comprehensive data aggregation and mapping capability across Independent Market Platforms (IMPs) and central datastores. This enables the delivery of actionable insights and analytics through flexibility data aggregation, facilitating qualitative decision-making and the development of whole-system business intelligence.

Notably, this intelligence is achievable within existing regulatory frameworks, leveraging current licenses, codes, and sector responsibilities, thereby mitigating the need for new agreements. A detailed evaluation of relevant sector codes, licensees, and processes is provided in [Appendix B.2.3](#).

The value of the business intelligence is shared with the next solution component, Flexibility Data Standards. While Flexify provides the essential data integration and mapping across the ecosystem, FDS establishes a standardised data language, ensuring seamless interoperability.

Types of insights

Providing insights on key performance indicators, such as total number of DERs, DERs not yet participating in markets, performance of specific flexibility service providers, and much more.

Understanding Policy Implications, by understanding market interactions: As Flexify will introduce standardised data, the policy makers and market facilitator can gather this to build a dataset which will allow for detailed analysis of flexibility markets, specifically blockers and opportunities within the markets.

Increase in market liquidity

Benefits of flexibility are those described within the [SSFP 2021 plan](#), £8 billion savings by 2050. Both the Flexify and FDS are enablers that contribute to unlocking benefits. Estimated contribution in driving flexibility is as per:

- The volume of flexibility growth from ~2GW (2020 number excluding pumped hydro & interconnectors) to ~25-30 GW in 2050.
- In 2050, 40-50% of flexible capacity will be from "flexible demand and other storage" and therefore may be responsible for up to £4bn of the £8bn total benefits identified.
- The amount of flexible demand and other storage needs to increase 10 times to deliver unlock the £4bn benefits outlined in the SSFP.
- To deliver this, an increase in the number of FSPs in the markets is needed.
- Flexify is crucial to reducing barriers to enter new markets promoting greater entry of flexible assets into the networks which could account for 10% of the additional flexible capacity needed or **£400mn**.

B.4

MVP considerations

B.4.1

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MVP design & development

Universal Profile

Overview of MVP vision and options to achieve this

Vision

Flexify will extend the Universal Profile features to ensure more secure, validated, and allowing role-based access for organisations and their users across multiple platforms.

- By simplifying and automating organisation-level validation will enable businesses to establish their credentials before accessing external platforms, leveraging mechanisms such as external KYC checks, director-level validation, or regulatory database cross-referencing.
- Through role-based access control, organisations can configure user permissions within the Universal Profile, ensuring that individuals interact with the platform according to their defined responsibilities.
- Additionally, multi-user and multi-organisation management will allow businesses to operate efficiently, supporting cases where multiple users access the platform under a single organisation while also accommodating parent-child company structures

Features	Description	Options
Organisation validation for platform access	How organisations access other platforms. (not including the market qualification process).	Validation against company’s house: Verification of company details against government business registries.
		Director level validation: Cross-referencing director details with official business registries to confirm company representatives.
		External KYC: Integration with third-party KYC providers to verify company registration and financial health.
Organisation level role based access control (RBAC)	How organisations integrate with other platforms and the associated rights assigned to their users.	User role management: Flexify enables organisations to assign roles to their users, and manage what their users can view, modify and approve. (e.g. administrative, market operator role)
		Integration with external platforms: • Manual approvals • Automated permissions for some user types • API integrations
Many users, many organisations	Multiple users + parent / child orgs	Multi-User Access: Users from the same organisation access the platform with clearly defined roles and permissions.
		Parent-child organisation relationships: Data sharing and access policies are available in Flexify.
		Access control: Available cross-organisation access options.(e.g., a user to access multiple organisations with different permissions)

Asset connection service

Overview of MVP vision and options to achieve this

Vision

Flexify will act as a hub for asset registration, validation, and integration, ensuring accurate representation across multiple market platforms. By streamlining the asset connection process, users can enhance participation and data management while reducing administrative overhead and maintaining greater control over their assets.

- With two-way integration into AAR, users can register new assets and synchronise key data directly through Flexify, eliminating the need to switch between AAR and Flexify. This reduces inconsistencies and simplifies asset management.
- Additionally, Flexify will utilise standardised asset aggregation mechanisms, enabling users to group assets into market-aligned units while ensuring clear governance and traceability.
- To enhance trust and transparency, the platform supports consumer consent management, ensuring that assets are only registered and utilised with proper authorisation. This allows flexibility service providers (FSPs) and other market participants to demonstrate consent, resolve potential conflicts, and provide compliance evidence when required.

Features	Description	Options
2-way integration with AAR	Users being able to register and update assets in AAR directly from Flexify. To enhance data consistency, reduce manual duplication, and improve the traceability of asset records across multiple systems	Conflict Resolution: If an asset exists in both platforms, apply duplication resolution mechanisms.
		Integration Strategy: API-based data exchange to facilitate seamless and scalable synchronisation..
Consumer Consent	To prevent disputes, Flexify demonstrates clear evidence of consent, ensuring that any changes made are authorised and verifiable.	Customer Consent Solution: Flexify provides customer consent statement and approval.
		FSPs providing their own evidence: Upload their own documentation proving consent. (e.g. pre-approved consent contracts)
Assets to Units	Aggregated assets into units, data management to allow aggregation of the assets	Market & regulatory alignment: Sector agreement on how ownership and boundaries are determined within an aggregated unit.
		Market alignment on clear standards: Standardised rules define what constitutes a unit.

Market qualification

Overview of MVP vision and options to achieve this

Vision

Flexify market qualification service provides a summary view of flexibility markets that can be accessed by the FSP, and the status of qualification within said market. The MVP features will enable that service to offer more by:

- Enabling a clearer view of market opportunities by harnessing the view of upcoming opportunities and historic performance.
- Flexify will enable more clear requirements for market entry and will automate classification of the assets and units against flexibility services and products the FSPs can qualify for.
- Flexify will support varied procurement and onboarding models, accommodating both centralised and federated approaches based on a DSO’s integration maturity.
- Finally, by automating the asset and unit qualification process when an asset changes within a unit, Flexify enables a more optimised and efficient operation. There is also a future opportunity to embed AI-driven tools to enhance this process further by providing intelligent recommendations.

Features	Description	Options
Market Opportunities	Directing FSPs to the markets based on upcoming opportunities and historic performance	Flexify helps service providers make informed decisions on upcoming opportunities and assess historical market performance.
Market Requirements	Flexify will enable more clear requirements for market entry and will automate classification of the assets and units against flexibility services and products the FSPs can qualify for.	Mapping of the market qualification criteria with the FDS data attributes in the ontology to allow asset and unit to qualify for flexibility markets and services.
Procurement & onboarding	Different procurement and onboarding options for DSOs based on their integration maturity and level of operational autonomy.	Federated: A more decentralised approach where DSO markets maintain autonomy over their onboarding process while leveraging shared infrastructure and data.
		Central: A streamlined approach where flexibility providers complete a single onboarding process that applies across multiple flexibility markets.
Asset/ unit qualification tracking	Providing an overview of units and their qualification status.	Asset change & unit qualification automation: The unit qualifies automatically whenever an asset within it is changed.
		AI driven implementation: Asset and unit optimisation is enhanced via AI tools, ensuring the best possible solution is identified.

B.4.2

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Achieving business interoperability

Increasing the benefits of ‘Universal Profile’

Creating a trust framework through a multi-lateral agreement between all system operators

Overview

Business interoperability in the context of the Smart Grid architecture refers to the ability of different business entities, systems, and processes to work together seamlessly to achieve efficient energy distribution, improved customer service, and enhanced grid reliability.

It involves the integration and coordination of various business functions, data exchanges, and operational processes across different organisations and stakeholders within the Smart Grid ecosystem.

In the context of Flexify, it refers to two key aspects:

- Organisational information exchange that allows for interoperability between business functions such as Know Your Customer checks, credit checks, user checks, and others.
- Asset validation checks that allows sharing of validation checks completed for asset information, and operational capabilities.

Agreement between SOs

A multi-lateral agreement among UK system operators, including National Grid ESO, and Distribution System Operators (DSOs), will establish a standardised framework for exchanging and accepting business-critical information, such as asset data, and market participant details, and grid constraints.

This agreement ensures seamless collaboration, regulatory compliance, and efficient operation of the flexibility energy ecosystem, with a key focus on "Know Your Customer" (KYC) checks. The agreement will define clear governance roles, dispute resolution mechanisms, and secure data-sharing protocols to build trust among stakeholders.

The extent of this agreement will define the extent of the added benefits that can be achieved through the universal profile.

Section to the right outlines' initial considerations for the agreement.

Breakdown of initial considerations

Quick wins for the agreement

- Standard agreement to access all MPs
- Framework agreement for DSO products - Potential only alignment with data standardisations
- Credit checks up to a certain value
- Validation of organisation through company check and person to person contact/emails/phone calls.

Requires further consideration in the MVP

- Framework agreement that is common across DSO and NESO
- Credit checks for higher values for higher risk
- Approved vendor list for checks
- Sharing of banking details

Aspects that will not be part of ‘Universal Profile’

- FSP register on SOs supplier management system

Achieving business interoperability

Considerations, risks and guiding principles

Guiding principles

1. Clear objectives

A market-based data sharing ecosystem ought to be underpinned by a **strong commercial objectives** that attracts participants. Important to **align incentives** and **build trust** early on.

2. Incentivised Market Participants

For a market-based data sharing ecosystem to be sustainable, participants must be **incentivised for long-term collaboration** and **disincentivised** for [market breaches] or data mishandling.

3. Collaborative Frameworks

Collaboration among market participants with **aligned incentives** ought to be **reflected in agreements** which start from high level principles (such as Memorandum of Understandings) to more focused data sharing agreements (Heads of Terms or Multi-Party licensing agreements).

Considerations

For market participants to share data securely, they must balance **accessibility, privacy, security**, and **regulatory compliance** through:

1. Data Governance Framework:

- Clear rules on who can access data, under what conditions and for what purpose.
- Definition of rights to data, permissions and liabilities
- Agreement on data standards (e.g. ISO 27001, GDPR compliance) to ensure consistency and security.

2. Incentive and Compliance Mechanism:

- Data monetisation: Extent to which participants can commercialise the shared data.
- Regulatory compliance: data protection compliance.

Risks

Risk category	Risk description
Legal and regulatory	Perceived or actual risks of breaching data protection law, intellectual property rights, regulatory requirements, or legal contracts when collecting, using or sharing data.
Ethical	Perceived or actual risk of enabling unethical data collection or use of data or directly impacting people or communities.
Reputational	Perceived or actual risk of suffering reputational damage from sharing or using data that breaches others’ trust, or in reveals limitations in processes or analyses.
Commercial	Perceived or actual risk of losing competitive advantage in the market.

Contract and legal considerations

Enabling secure and efficient data sharing framework

Overview

To enable a secure and efficient data-sharing framework, agreements must address:

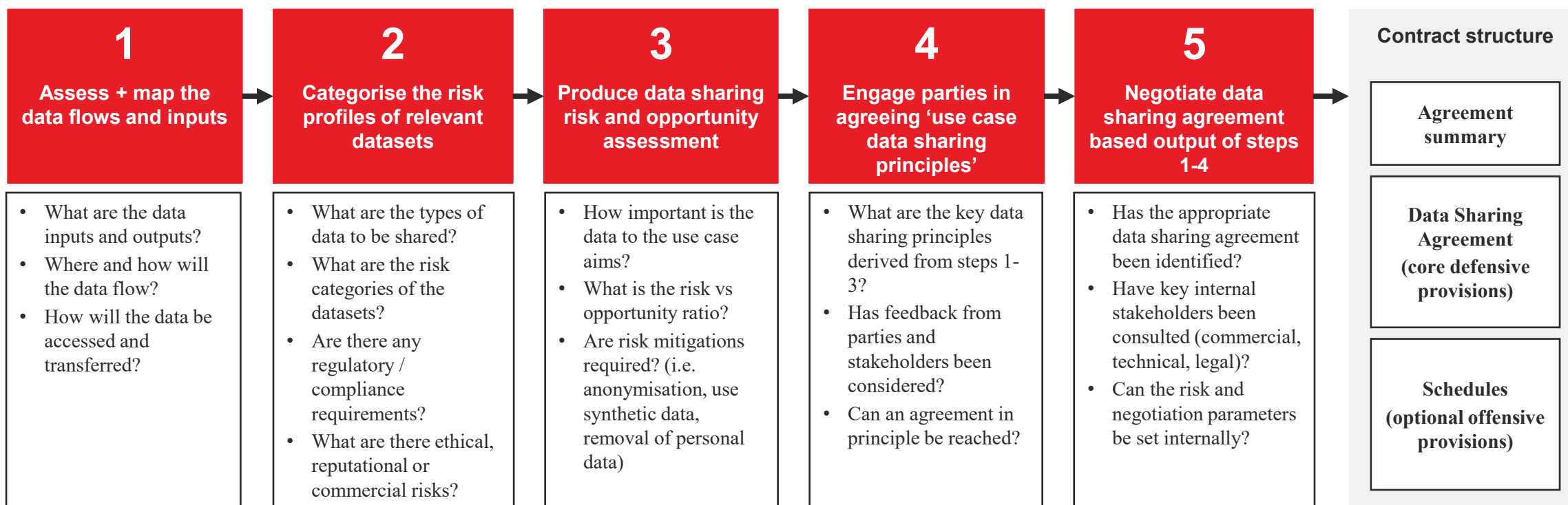
- **Ownership**
- **Access**
- **Usage rights**
- **Liabilities**
- **Compliance**

Legal issue	Description	Key considerations
Data Ownership & Usage Rights	Defines who owns the data and how it can be used.	Specify whether ownership remains with the original provider or is shared. Define permitted uses (e.g., analytics, forecasting) and restrictions (e.g., no commercial resale).
Access Rights & Control	Determines who can access data and under what conditions.	Set access levels (read-only, full access). Define whether third parties can be granted access and for how long.
Data Security & Confidentiality	Ensures data is protected from breaches and misuse.	Implement security measures (e.g., encryption, secure APIs). Include confidentiality clauses and specify how sensitive data is classified.
Regulatory Compliance	Ensures adherence to data protection and competition laws.	Comply with GDPR for personal data (lawful basis, user rights, cross-border transfers). Address energy sector regulations and anti-competition concerns.
Liability & Indemnity	Allocates responsibility for data breaches, misuse, or errors.	Define financial liability for breaches and indemnities for affected parties. Set caps on liability to manage risk exposure.
Data Accuracy & Reliability	Ensures that shared data is accurate and up to date.	Specify obligations for updating and verifying data. Define consequences of providing incorrect or delayed data.
Intellectual Property (IP) Rights	Addresses ownership of derived insights and datasets.	Define IP rights over processed or aggregated data. Prevent unauthorised monetisation of shared datasets.
Governance & Dispute Resolution	Establishes mechanisms for managing disputes and compliance.	Define regulatory oversight, arbitration mechanisms, and escalation procedures for conflicts.
Termination & Exit Provisions	Ensures smooth withdrawal from the data-sharing arrangement.	Outline how a party can exit, what happens to shared data, and obligations for data deletion or anonymisation.

Proposed data sharing framework methodology

Implementing the guiding principles

Approach to developing collaborative data sharing frameworks among market participants.



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Flexibility Data Standard

C.1

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Flexibility ecosystem data mapping

Introduction

Delivering information transparency through the development of common data standards

Background

The purpose of the Flexibility Data Standards solution is to introduce a standard to enhance visibility and sharing of assets, markets, products, and settlement data during the early stages of the customer journey.

The standards for data sharing aim to include a specification for each of the interactions between flexibility market actors. This approach will enable greater interoperability and visibility of markets, as interfaces can be reused by market actors, data can be more easily aggregated for reporting purposes, and different opportunities can be compared directly to identify conflicts.

The introduction of a flexibility ecosystem data standards will help achieve interoperability in the Information Layer of the Smart Grid Architecture.

Overview

The Flexibility Data Standards solution component focuses on developing and defining data standards that build on the existing industry and market activities. The data model covers the end-to-end user journey from organisation and asset information to current and historic market data.

The data model has been developed based on work carried out by the industry including ENA Open Networks – ElectronConnect, National Grid SMP, Piclo Max and AAR.

The solution is described at the conceptual level as well as the approach taken to developing the data model and its key components. This includes a view of the data products that will be important for Flexify, and what has been included in the data model development.

What this enables

The proposed data model brings together ongoing work from across the industry. It is introducing data standards for the registration, market participation, settlement, and reporting processes. This in turn will enable streamlining of operations for FSPs and SOs, as well as providing a template for market-wide reporting and promoting greater visibility of market activity to FSPs and SOs.

Importantly, these data standards will mean data silos are not a competitive advantage, helping to avoid monopoly ownership of data securing undue market power and promoting greater competition.

Lastly, these standards will reduce the burden on data transformations required to operate the MRTB in the long, especially when dynamic data is introduced and further use cases evaluated.

Flexible Data Standard overview

Standards that will support scalable data sharing across the flexibility ecosystem

Scope

Phase 2 has been focusing on the Registration needs for Market Access. The Flexibility Data Standards has moved away from an Enterprise Data Model (EDM) definition, as built on Phase 1, and has now been logically modelled as an ontology, extending the Information Exchange Standard 4 (IES4) with domain-specific additions to include attributes identified in the FDS logical data model.

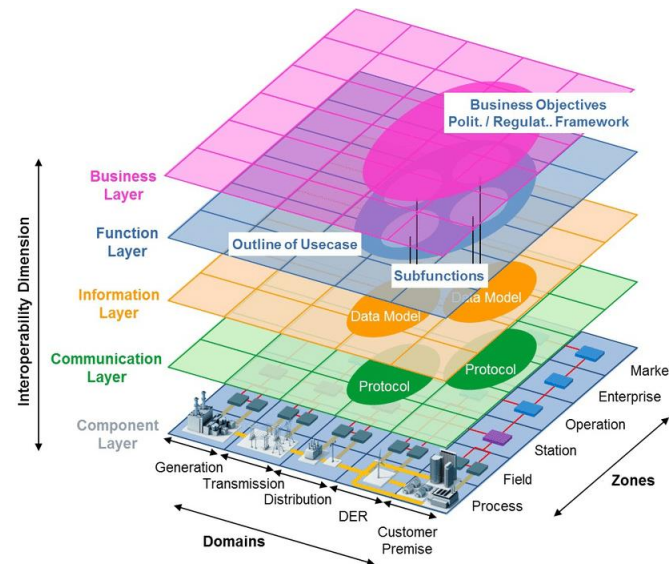
IES serves as an exchange format, providing a common exchange language so that users and systems do not need to comprehend various data formats and standards; they only need to understand how their system relates to IES.

While EDMs are often rigid and implemented with relational databases, IES4 uses a 4D ontology approach with reusable components and supports diverse storage paradigms for adaptable data modelling.

The workstream's scope included:

1. Defining the data products which were shared across the user journey.
2. Collating technical information for markets, products and platforms (data attributes, types and format).

3. Mapping of data attributes and developing the Data Schema for Flexify.
4. Defining data gaps between Flexify and AAR, ElectronConnect, SMP and Piclo.
5. Developing the Flexibility Data Standards.



How is it supporting Flexify?

1. Creation of the data model to support Flexify operation.
2. Supported the development of the user journey, wireframes, and information architecture.
3. Prompted liaison with ElectronConnect platform to enhance understanding of the parameters and integration of data standards in Flexify.
4. Laid the foundation for providing the market qualification service to FSPs via aligning the market qualification criteria against the FDS data attributes.
5. Provided the base for developing the Insights and Data service which showcases Flexify's value from the data held by the platform.
6. Encouraged the definition of governance models to identify who can take ownership of the ontology for further short-term development and long-term adoption, operation and maintenance.

Subject area model

Overview of the five areas that make up the initial definition of the data standards

Overview

In Phase 1, key subject areas and their related business entities were identified, forming a Subject Area Model that provided a conceptual view of the data, outlining key relationships and dependencies between entities.

The 5 subject areas identified were:

Organisation: Information details needed for flexibility market actors to participate in flexibility markets and users associated with actor.

Asset: Information describing an asset including the technology, its location, and how it is connected to the electricity network.

Commercial & Legal: Information related to the commercial and legal aspects within the flexibility market domain ensuring compliance with public procurement regulations and involves legal artefacts pertinent to interactions, obligations, and transactions among market actors.

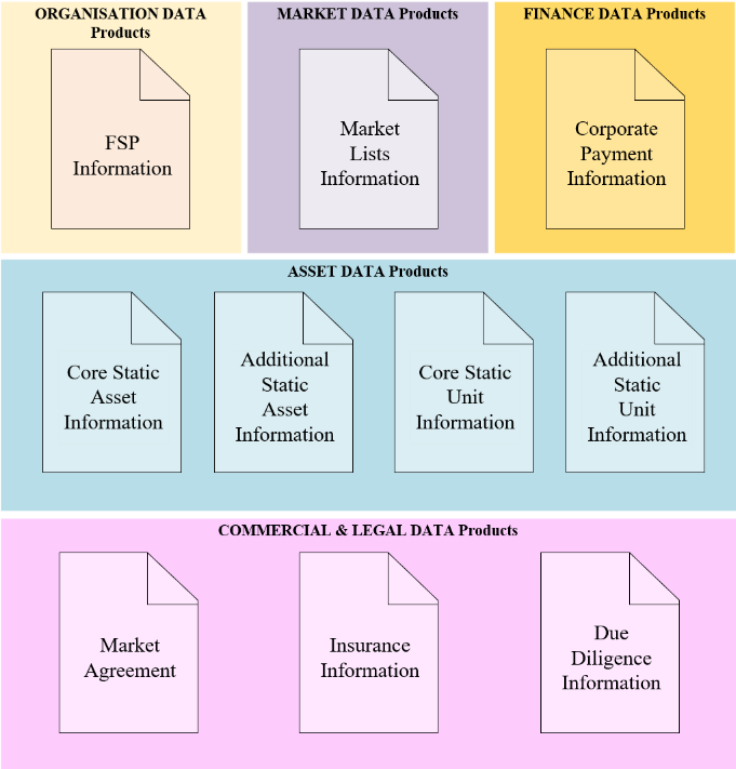
Market: Information related to the market being operated and the opportunities that are available within it.

Finance: Information related to facilitating financial transactions between two flexibility market actors.

This Subject Area Model was used to define the list of data products that constitute the Conceptual Data Model. The data products were then mapped to their corresponding entities. To support this, a metadata glossary was created, defining data attributes within each subject area.

Phase 2 expanded on this model further and fully defined the ontology, including a logical model for the entire registration journey. This was done by further defining the list of data attributes and mapping the interaction between them and developing a Data Schema for the Flexify solution.

A ‘data product’ summarises data that describe an aspect of the business, infrastructure, or operations. The term product is used to convey the notion of a managed grouping of related data assets, that deliver tangible business value and respond to a specific business requirement.



Data products categorised by subject area

Data products

Overview of the data products and associated attributes that make up the five subject areas required for the registration and market discovery steps

Phase 2 development

Building on the Conceptual Data Model defined in Phase 1 the following Data Products were developed for the Flexify registration journey:

Organisation Data Product:

- **FSP Information:** Includes data attributes relating to an organisation's details needed to participate in flexibility markets (e.g. address, VAT registration, identification information), as well as information on the users associated with that organisation:
 - Enables initial registration on Flexify and KYC checks

Asset Data Products:

- **Core Static Asset Information:** Includes the data attributes relating to the minimum information required to register an asset (e.g., type of asset, location, connection point, and capacity).
- **Additional Static Asset Information:** Includes the data attributes relating to the additional asset information required for the asset to participate in a particular flexibility market.

Core Static Unit Information: Includes the data attributes relating to the minimum information required to register a Unit (e.g., type of unit (assets), location, connection point, and capacity).

Additional Static Unit Information: Includes the data attributes relating to any additional unit information required for the asset to participate in a particular flexibility market.

- Used to identify flexible assets under operation of FSP
- Used in conjunction with Market List Data product to identify opportunities to register assets within specific markets

Commercial & Legal Products:

- **Market Agreement:** Includes data attributes relating to the commercial and legal agreements that are needed for an FSP to participate in a flexibility market. This may include terms of service for the system operator or terms of use for a market platform.
- **Insurance Information:** Includes data attributes relating to an organisation's liability or public liability insurance which is needed to participate in a flexibility market.

- **Due Diligence:** Includes data attributes relating to the Due Diligence that a system operator may carry out on a FSP looking to provide services (e.g., information on whether an organisation has previously been bankrupt).
 - Used for an organisation to pre-qualify for access to markets

Market Data Product:

- **Market List information:** Includes the data attributes relating to the market owner, market name, market description, relevant products, qualification criteria:
 - Used to identify available flexibility markets
 - Used in conjunction with Core Static Asset data product to identify opportunities to register assets within specific markets

Finance Data Product:

- **Corporate Payment Information:** Includes the data attributes relating to the banking and credit information of system operators:
 - Enables sharing of banking and credit information between system operators

C.1.1

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Overview of attributes

Data attributes analysis

Detailed representation of the FDS Data Attributes

Steps of analysis

The detailed analysis of the data attributes definition included:

- Reviewed the Phase 1 Flexibility Data Glossary and compared against SMP, ElectronConnect and AAR data attributes, to update the list of data products and glossary of data attributes.
- Carried out the data gap analysis for different market platforms, as detailed in the [C.1.2 Data mapping section](#), to determine the overlap and gaps of different data attributes.
- Determined the minimum required data attributes for an industry wide FDS and defined the specific data requirements for the Flexify platform.
- Reviewed the market qualification processes for local and national markets to identify gaps in existing data attributes and updated data products.
- Undertook a coordinated review of the ontology to determine the data format, SHACL constraints and cardinality for each of the data attributes against the summary matrix.

- Updated the user journey to reflect the Phase 2 data attributes.

The detailed data attributes per subject area are presented in the next pages. The tables show all the data attributes as reviewed from other platforms, however not all attributes were deemed necessary to be included in FDS.

Only the most necessary data attributes were incorporated to support greater interoperability between the platforms and enhance visibility of markets. Data attributes annotated with a 'Y' have been included in FDS, whereas attributes annotated with a 'N' were deemed as not required.

C.1.1-FDS data attributes

Subject Area	Data Product	Attribute Name	Definition	Data Format	FDS	AAR	SMP	ElectronConnect	Piclo
Organisation	FSP Information	Contact First Name	The first named of the FSP Contact.	STRING	Y	N	Y	Y	Y
Organisation	FSP Information	Contact Last Name	The last name of the FSP Contact	STRING	Y	N	Y	Y	Y
Organisation	FSP Information	Contact Email	The email address of the FSP Contact	STRING	Y	N	Y	Y	Y
Organisation	FSP Information	Contact Number	The mobile number of the FSP Contact	NUMERIC	Y	N	Y	Y	N
Organisation	FSP Information	Mobile number region	The mobile number region of the User	STRING	Y	N	Y	N	N
Organisation	FSP Information	Contact Role	The Role of the FSP Contact within Company	STRING	Y	N	N	N	N
Organisation	FSP Information	Company type	The category or sector to which the UK company belongs	STRING	Y	N	Y	N	Y
Organisation	FSP Information	(UK Company) Company Name	The official name of the company as registered in the United Kingdom	STRING	Y	N	Y	Y	Y
Organisation	FSP Information	(UK Company) Company registration number	The unique number assigned by Companies House upon registration of the company in the United Kingdom	STRING	Y	N	Y	Y	Y
Organisation	FSP Information	(Non-UK Company) Registration Number	The company number assigned to the relevant authority in the company's country of origin upon its registration	STRING	Y	N	Y	N	Y
Organisation	FSP Information	(Non-UK Company) Business type	The category or sector to which the non-UK company belongs	STRING	Y	N	Y	N	Y
Organisation	FSP Information	(Non-UK Company) Company Name	The official name of the company as registered in its country of origin	STRING	Y	N	Y	N	N
Organisation	FSP Information	(Non-UK Company) Address Line 1	The physical address of the non-UK company, including street name, city, and country	STRING	Y	N	Y	N	Y
Organisation	FSP Information	(Non-UK Company) Address Line 2	The physical address of the non-UK company, including street name, city, and country	STRING	Y	N	Y	Y	Y
Organisation	FSP Information	(Non-UK Company) City	The physical address of the non-UK company, including street name, city, and country	STRING	Y	N	Y	N	N
Organisation	FSP Information	(Non-UK Company) Country	The physical address of the non-UK company, including street name, city, and country	STRING	Y	N	Y	N	Y
Organisation	FSP Information	(Non-UK Company) Postcode	The physical address of the non-UK company, including street name, city, and country	STRING	Y	N	Y	N	Y
Organisation	FSP Information	(Non-UK Company) Country	The physical address of the non-UK company, including street name, city, and country	STRING	Y	N	N	N	Y
Organisation	FSP Information	(Non-UK Company) Country	The country where the non-UK company is officially registered or incorporated	STRING	Y	N	Y	N	Y
Organisation	FSP Information	Organisation Website	The website of the flexibility service provider organisation	STRING	Y	N	N	Y	Y
Organisation	FSP Information	VAT Registration number	The Value Added Tax registration number assigned to the organisation by HMRC	STRING	Y	N	N	Y	Y
Organisation	FSP Information	Assigned Reference for Organisation	Assigned Reference for Organisation	STRING	Y	N	N	Y	Y
Organisation	FSP Information	Company Phone Number	The phone number of the Company	STRING	N	N	Y	N	N
Organisation	FSP Information	Landline number	The landline number of the FSP Contact	STRING	N	N	Y	N	N
Organisation	FSP Information	Landline number region	The landline number region of the User	STRING	N	N	Y	N	Y
Organisation	FSP Information	Technical ID Contact First Name	The first name of the FSP Contact	STRING	N	N	N	N	Y
Organisation	FSP Information	Technical ID Contact Last Name	The last name of the FSP Contact	STRING	N	N	N	N	Y
Organisation	FSP Information	Technical ID Contact Email	The email address of the FSP Contact	STRING	N	N	Y	N	Y
Organisation	FSP Information	Technical ID Mobile number	The mobile number of the FSP Contact	NUMERIC	N	N	N	N	Y
Organisation	FSP Information	Organisation email	The organisation's email address	STRING	N	N	N	N	Y
Organisation	FSP Information	Year of registration	The year the organisation was registered	NUMERIC	N	N	Y	N	Y
Asset	Core static asset information	Asset Name	The name given to the asset	STRING	Y	N	Y	Y	Y
Asset	Core static asset information	Owner of the asset	The company or organisation that has ownership of the asset	STRING	Y	N	Y	Y	N
Asset	Core static asset information	Asset Scale	Identifies whether the DER is connected at a site that is domestic, or industrial and commercial.	STRING	Y	N	Y	N	Y
Asset	Core static asset information	Metering Point	Describes where the DER is metered. 'Asset Level' means behind the meter and 'Point of Connection' means the connection at the boundary to the network.	STRING	Y	N	N	N	Y
Asset	Core static asset information	Asset type	Generation asset or Storage asset or Demand asset	STRING	Y	N	Y	Y	N
Asset	Core static asset information	Effective from date	The data from which the asset is officially available to provide flexibility services	DATE	Y	N	Y	N	Y
Asset	Core static asset information	Fuel type: Energy Conversion Type (Generation or Storage)	Specifies Energy Conversion Type for Generation and/or Storage asset	STRING	Y	N	N	Y	Y
Asset	Core static asset information	Fuel type: Energy Source (Generation and/or Storage)	Specifies Energy Source for Generation and/or Storage asset	STRING	Y	N	N	Y	Y
Asset	Core static asset information	Fuel type: Technology Type (Demand)	Specifies Technology Type for Demand asset	STRING	Y	Y	Y	Y	Y
Asset	Core static asset information	Manufacturer/Service provider	The Manufacturer/Service provider of the asset	STRING	Y	N	N	Y	N
Asset	Core static asset information	Model	Commercial name and type designation of the product	STRING	Y	Y	N	Y	N
Asset	Core static asset information	Serial Number	The serial number of a device is the unique identifier assigned to that specific piece of equipment	STRING	Y	Y	N	N	N
Asset	Core static asset information	Commissioning Date	The date when the device was put into operation or service (optional)	DATE (ISO YYYYMMDD)	Y	N	N	Y	Y
Asset	Core static asset information	Assigned Reference for Asset	Assigned Reference for Asset, if known (optional)	STRING	Y	N	N	Y	Y
Asset	Core static asset information	DER Connection status	DER Connection status	STRING	Y	N	N	Y	Y
Asset	Core static asset information	Generation Capacity	The maximum power output the asset can produce measured in MW	NUMERIC	Y	N	N	Y	Y
Asset	Core static asset information	Demand Capacity	The maximum power demand the asset can consume/store measured in MW	NUMERIC	Y	N	N	N	Y
Asset	Core static asset information	Installed capacity	The full load output of the asset.	NUMERIC	Y	N	N	Y	N
Asset	Core static asset information	Connection type	Specifies if the asset has a firm or flexible grid connection	STRING	Y	N	N	Y	Y
Asset	Core static asset information	Connected to DNO	Details whether asset is connected to Distribution Network Operator or not. This is a tick box	BOOLEAN	Y	N	Y	N	N
Asset	Core static asset information	Connection voltage point	The grid voltage level the asset is connected at	STRING	Y	N	Y	Y	Y
Asset	Core static asset information	Asset Postcode	The postcode code where the asset is located	STRING	Y	N	Y	N	Y
Asset	Core static asset information	Nearest Node	The asset's nearest network grid node	DECIMAL	Y	N	Y	N	N
Asset	Core static asset information	Grid supply point	The grid supply point used by the asset	STRING	Y	N	Y	N	N
Asset	Core static asset information	OSP group ID	The unique ID of the grid supply point group used by the asset	STRING	Y	N	N	Y	N
Asset	Core static asset information	Metering granularity	Indicates if the asset has real time metering capability	BOOLEAN	Y	N	Y	Y	N
Asset	Core static asset information	MPAN import	Major Point Administration Number for the asset's import meter	STRING	Y	N	Y	Y	Y
Asset	Core static asset information	MPAN export	Major Point Administration Number for the asset's export meter	STRING	Y	N	Y	Y	Y
Asset	Core static asset information	BSC unique meter identifier (MSO)	BSC unique meter identifier associated with the DER	STRING	Y	N	Y	Y	N
Asset	Core static asset information	Consent	Consent to operate asset	BOOLEAN	Y	Y	N	N	N
Asset	Core static asset information	Consent given date	Consent given date	DATE (ISO YYYYMMDD)	Y	N	N	N	N
Asset	Core static asset information	Company Registration no. of Owner of Asset	Company Registration no. of owner (optional field)	NUMERIC	N	N	N	N	Y
Asset	Core static asset information	Subsidiary company	To specify if asset is owned by an subsidiary company	BOOLEAN	N	N	N	N	N
Asset	Core static asset information	Asset Verified	Indicates the asset has passed a verification process done by an DEM	BOOLEAN	N	N	N	N	N
Asset	Core static asset information	Asset latitude	The geographic coordinates of the asset's location	DECIMAL	N	N	Y	Y	Y
Asset	Core static asset information	Asset longitude	The geographic coordinates of the asset's location	DECIMAL	N	N	Y	Y	Y
Asset	Core static asset information	Primary Dispatch phone number	Primary contact number for directing asset dispatch	STRING	N	N	Y	N	N
Asset	Core static asset information	Secondary Dispatch phone number	Secondary contact number for directing asset dispatch	STRING	N	N	Y	N	N
Asset	Core static asset information	Dispatch Fax number	Fax number for directing asset dispatch	STRING	N	N	Y	N	N
Asset	Core static asset information	Additional MPAN import	Additional Major Point Administration Number for the asset's import meter	STRING	N	N	Y	N	N
Asset	Core static asset information	Additional MPAN export	Additional Major Point Administration Number for the asset's export meter	STRING	N	N	Y	N	N
Asset	Core static asset information	ISO assigned ID	Unit ID assigned by ISO	STRING	Y	N	N	Y	N
Asset	Core static asset information	Unit Name	The unique designated name given to identify the unit	STRING	Y	N	Y	N	N
Asset	Core static asset information	Unit type	Specifies whether type unit is Generation, Storage or Demand, this is a tick box	STRING	Y	N	Y	N	Y
Asset	Core static asset information	Generation Capacity	The maximum power output the unit can produce measured in MW	NUMERIC	Y	N	N	Y	Y
Asset	Core static asset information	Demand Capacity	The maximum power demand the unit can consume/store measured in MW	STRING	Y	N	Y	N	Y
Asset	Core static asset information	Effective from date	The data from which the unit is officially available to provide flexibility services	DATE (YYYYMMDD)	Y	N	Y	N	Y
Asset	Core static asset information	Technology Type	Specifies Technology Type for the unit	STRING	Y	N	N	Y	N
Asset	Core static asset information	Connection type	Specifies if the unit has a firm or flexible grid connection	STRING	Y	N	Y	N	Y
Asset	Core static asset information	Connected to DNO	Details whether unit is connected to Distribution Network Operator or not. This is a tick box	BOOLEAN	Y	N	Y	N	N
Asset	Core static asset information	DNO type	The Distribution Network Operator the unit is connected to (e.g. UK Power Networks, Electricity North West)	STRING	Y	N	Y	N	Y
Asset	Core static asset information	Connection voltage point	The grid voltage level the unit is connected at	STRING	Y	N	Y	Y	Y
Asset	Core static asset information	Nearest Node	The unit's nearest network grid node, if known	STRING	Y	N	Y	N	N
Asset	Core static asset information	Grid supply point	The grid supply point used by the unit	STRING	Y	N	Y	N	N
Asset	Core static asset information	OSP group ID	The unique ID of the grid supply point group used by the unit	STRING	Y	N	Y	N	N
Asset	Core static asset information	CMZ location	CMZ location	STRING	Y	N	N	Y	N
Asset	Core static asset information	Allocated MW	The maximum capacity in MW the unit can provide for the specified service	NUMERIC	N	N	N	N	Y
Asset	Core static asset information	BSC unique meter identifier (MSO)	BSC unique meter identifier associated with the DER	STRING	Y	N	N	N	N
Asset	Core static asset information	Fuel type: Energy Conversion Type (Generation or Storage)	Specifies Energy Conversion Type for Generation and/or Storage unit	STRING	N	N	N	N	N
Asset	Core static asset information	Fuel type: Energy Source (Generation or Storage)	Specifies Energy Source for Generation and/or Storage unit	STRING	N	N	N	N	N
Asset	Core static asset information	Applicable Market	Markets the unit is applicable for	STRING	N	N	Y	N	N
Asset	Core static asset information	Unit Postcode	The postcode where the unit is located	STRING	N	N	Y	Y	N
Asset	Core static asset information	Unit latitude	The geographic coordinates of the unit's location	DECIMAL	N	N	Y	Y	Y
Asset	Core static asset information	Unit longitude	The geographic coordinates of the unit's location	DECIMAL	N	N	Y	Y	Y
Asset	Core static asset information	Primary Dispatch phone number	Primary contact number for directing unit dispatch	STRING	N	N	Y	N	N
Asset	Core static asset information	Secondary dispatch phone number	Secondary contact number for directing unit dispatch	STRING	N	N	Y	N	N
Asset	Core static asset information	Dispatch Fax number	Fax number for directing unit dispatch	STRING	N	N	Y	N	N
Asset	Additional static unit information	Select Balancing Services	Select the services to pre-qualify the Unit for	STRING	N	N	Y	N	N
Asset	Additional static unit information	Response time	The time taken for the unit to reach instructed output level from idle or normal levels	NUMERIC	Y	N	N	Y	N
Asset	Additional static unit information	Recovery period	The time needed for the unit to return to normal operation level after providing response	NUMERIC	Y	N	Y	Y	N
Asset	Additional static unit information	Cease time	The time required to disconnect the unit from grid after receiving instructions	NUMERIC	Y	N	Y	N	N
Asset	Additional static unit information	Maximum utilisation	The maximum duration the unit can continuously provide response at full capacity	NUMERIC	Y	N	N	Y	N
Asset	Additional static unit information	Ramp-up rate	The rate at which the unit can increase generation measured in MW/min	NUMERIC	Y	N	Y	N	N
Asset	Additional static unit information	Minimum two-way time	The minimum time for which the unit can remain at a zero-zero output level	NUMERIC	Y	N	Y	N	N
Asset	Additional static unit information	Ramp down rate	The rate at which the unit can decrease generation measured in MW/min	NUMERIC	Y	N	Y	N	N
Asset	Additional static unit information	Service start date	Start date for the pre-qualification of a unit for particular service	DATE (YYYYMMDD)	Y	N	Y	N	N
Asset	Additional static unit information	Service end date	End date for the pre-qualification of a unit for particular service	DATE (YYYYMMDD)	Y	N	Y	N	N
Asset	Additional static unit information	Metering granularity	Indicates if the asset has real time metering capability	BOOLEAN	Y	N	Y	N	Y
Asset	Core static unit information	Tested Capacity (Date approved by TTE)	The Asset test records, MW, Date of testing by an independent Technical Engineer (TTE) which will be aligned against a service	BOOLEAN	N	N	Y	Y	N
Asset	Core static unit information	DER Connection status	DER Connection status	STRING	N	N	N	Y	Y
Asset	Core static unit information	Assigned Reference for this DER, if known	Assigned Reference for this DER, if known	STRING	Y	N	N	N	Y
Asset	Additional static unit information	Operational metering	The accuracy rating required of physical meters providing operational metering	NUMERIC	N	N	N	N	Y
Asset	Additional static unit information	Metering Frequency	The frequency that the physical meter captures real time data snapshots	NUMERIC	N	N	N	N	Y
Asset	Additional static asset information	Flexible Active Demand Turn-up (MW)	The capacity, in MW, of the asset to increase its generation output, if Zero, please respond '0'	NUMERIC	Y	N	N	Y	Y
Asset	Additional static asset information	Flexible Active Demand Turn-down (MW)	The capacity, in MW, of the asset to reduce its generation output, if Zero, please respond '0'	NUMERIC	Y	N	N	Y	Y
Asset	Additional static asset information	Flexible Active Generation Turn-up (MW)	The capacity, in MW, of the asset to increase its demand on the network, if Zero, please respond '0'	NUMERIC	Y	N	N	Y	Y
Asset	Additional static asset information	Flexible Active Generation Turn-down (MW)	The capacity, in MW, of the asset to reduce its demand on the network, if Zero, please respond '0'	NUMERIC	Y	N	N	Y	Y
Asset	Additional static asset information	Reactive Export - Generation Turn-up (MVAR)	The capacity, in MVAR, that an asset has to generate reactive power providing an inductive load and lagging effect on current with respect to the network voltage, if Zero, please respond '0'	NUMERIC	N	N	N	Y	Y
Asset	Additional static asset information	Reactive Export - Generation Turn-down	The capacity, in MVAR, that an asset has to absorb reactive power providing a capacitive load and leading effect on current with respect to the network voltage, if Zero, please respond '0'	NUMERIC	Y	N	N	Y	Y
Asset	Additional static asset information	Min Operation Duration (HH:MM)	Minimum amount of time the asset is able to provide a flexibility response. Where an asset is able to run continuously beyond 24hrs, respond 'Unlimited'	STRING	Y	N	N	Y	Y
Asset	Additional static asset information	Max Operating Duration (HH:MM)	Maximum amount of time the asset is able to provide a flexibility response. Where an asset is able to run continuously beyond 24hrs, respond 'Unlimited'	STRING	Y	N	N	Y	Y
Asset	Additional static asset information	Response Time (minutes)	The minimum time required for the asset to respond to a utilisation instruction	STRING	Y	N	N	Y	Y
Asset	Additional static asset information	Recovery Time	The time required by the asset to recover from one instruction until the next instruction can be actioned	STRING	Y	N	N	Y	Y
Asset	Additional static asset information	Previous Asset Ref	Input old Ref into this column and the new Ref in 'Asset Ref' to tell the system you want to update the Asset Ref	Alphanumeric String	N	N	N	N	N
Asset	Additional static asset information	System Operator Name	The OSO sending to they flexibility	STRING	Y	N	N	N	Y
Asset	Additional static asset information	Estimated Asset Count	The estimated count of assets in the asset plan	Numeric	N	N	N	N	N
Asset	Additional static asset information	Maximum Aggregate Technical Response Time	The maximum time required for the asset to respond to a utilisation message. If 24 hours or less, provide the duration with the number of days.	Numeric	N	N	N	N	Y
Market	Market List	Market owner	System operator and market platform responsible for operating the market	STRING	Y	N	N	N	Y
Market	Market List	Market rules	Name of the market	STRING	Y	N	N	N	Y
Market	Market List	Market description	Description of the market include the products locations and scope	STRING	Y	N	N	N	Y
Market	Market List	Relevant product	The relevant Product that is being offered within that market (e.g. Scheduled Utilisation, Operational Utilisation, Peak Reduction, Operational Utilisation + Scheduled Availability, and Operational Utilisation and variable availability)	STRING	Y	N	N	N	Y
Market	Market List	Qualification criteria	Outlines of the qualification criteria for entering into a market	BOOLEAN	Y	N	N	N	Y
Market	Market List	Recruitment Status	Recruit the status of asset recruitment for this service: not started, in progress, or complete	Text	N	N	N	N	Y
Market	Market List	Delivery Plan	State if you can submit a delivery plan on request	Text	N	N	N	N	Y
Market	Market List	Target Connection	Please enter the competition ref for which you'll be to qualify for. Competition ref is available in the competition file, available to download from the Map	Text	N	N	N	N	Y
Commercial & Legal	Due Diligence	How secure code of conduct membership	Is the contracting party a member of the How Secure code of conduct	BOOLEAN	Y	N	N	N	Y
Commercial & Legal	Due Diligence	Achilles UVOB registered number	Achilles UVOB registered number if applicable	STRING	Y	N	N	N	Y
Commercial & Legal	Due Diligence	Confirmation of asset requirement	Confirm if the Achilles UVOB - understand DNO may contact for audit	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Receivables check	Check for if the contracting party is, or has ever been in receivership?	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Administration check	Check for if the contracting party is, or has it ever been in administration?	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Liquidation check	Check for if the contracting party is, or has it ever been in liquidation?	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Unable to pay debts check	Check for if the contracting party is, has ever been unable to pay its debts?	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Winding up	Check for winding up petitions against the contracting party	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Bankruptcy	Check for if the contracting Party has been declared bankrupt	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Conventions	Check for previous conventions or 'or yes/tell'	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Historic contracts	Similar contract terminated?	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Non-employment litigation	Material non-employment litigation?	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Legal relationship with flexibility asset	Legal relationship of the flexibility service provider organisation with the assets they manage (e.g.)	STRING	Y	N	N	Y	Y
Commercial & Legal	Due Diligence	Standard flexibility services terms	The acceptance of the standard flexibility services as outlined in the requirements for participating in the market.	BOOLEAN	Y	N	N	N	Y
Commercial & Legal	Insurance	Insurance copies	Confirm you will be able to provide copies of insurances if requested by the DNO	BOOLEAN	N	N	N	Y	Y
Commercial & Legal	Due Diligence	Declaration of authority	The declaration of authority for the FSP	STRING	Y	N	N	Y	Y
Commercial & Legal	Insurance	Employers Liability Insurance (ESI)	Check that the contracting party has a minimum of ESI Employers Liability Insurance	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Insurance	Public Liability Insurance (ESI)	Check that the contracting party has a minimum of ESI Public Liability Insurance	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Insurance	Professional Indemnity Insurance	Check that the contracting party has a professional indemnity insurance	BOOLEAN	Y	N	N	Y	Y
Commercial & Legal	Market Agreement	Terms & Conditions	Terms and Conditions detailed within the Commercial (ESG/OSG) Terms & Conditions.	BOOLEAN	Y	N	Y	Y	Y
Commercial & Legal	Market Agreement	Owner	The Owner of the Commercial (ES						

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Mapping of attributes across AAR, and IMP(s)

Data mapping overview

Summary of the approach taken to map the data attributes across partner organisations

Review process overview

The steps followed in the data mapping process included:

- Initial definition of data products to be shared throughout the user journey.
- Collation of all available technical information across markets, products, and platforms, focusing on data attributes, data types, and attribute formats.
- Mapping of data attributes list against their respective sources.
- Utilisation of mapping information to update the user journey, wireframes, and architecture.
- Conducting research and analysis to identify data gaps between Flexify's data attributes and those required in the AAR, ElectronConnect, SMP and Piclo platforms, supporting further refinement and alignment.
- Developing a summary matrix to identify inclusions / exclusions of data attributes in each of the platforms.

Data gaps references

To identify the data gaps and alignment between Flexify and SMP, AAR, ElectronConnect, and Piclo, a review of the following documents was undertaken:

- NESO – Single Markets Platform - registration guidance ([link](#))
- NESO – Single Markets Platform API ([link](#))
- Energy Network Association – Pre-qualification Standardisation Report (Mar 2024) ([link](#))
- GreenSync – Data Fields and Definitions for AAR/ CAR solution
- Electron – Bulk Asset Upload Guidelines
- Piclo Max API documentation – Create a new Flex Asset ([link](#))
- Piclo Max Asset upload file template shared by Piclo
- Piclo Flex Asset and Company Qualification ([link](#))

Following the AAR, ElectronConnect, SMP and Piclo documentation review, the total number of FDS Data Attributes derived was **131**.

Data mapping summary

Summary data mapping matrix defining data gaps and alignment of AAR, SMP, Electron and Piclo with FDS

FDS data attributes

A summary matrix was developed, as presented to the right, to provide further insight on the level of alignment between FDS and the rest of the market platforms. A key was developed to colour code the level of alignment between FDS and the market platforms:

- **Green:** Data from market platforms has been aligned or mostly aligned with FDS data attributes. Minimal or no significant adjustments will be required.
- **Orange:** Data from market platforms partially aligned with FDS, with some key information missing. Platforms may require changes.
- **Pink:** Data from market platforms not aligned with FDS and missing key information. These platforms will likely require changes.
- **Grey:** FDS data not required to be provided by the platform. No changes or adjustments required.

Further coordination is required to explicitly define the requirements for flexibility space, ensuring **platform updates are informed** where required (pink cells). This includes **FDS ontology value realisation** by facilitating data exchange without requiring market system changes, to accommodate the dynamic market conditions and ongoing updates.

Subject area	Data Product	No. of Required FDS Attributes	AAR	SMP	Electron	Piclo
Organisation	FSP Information	22	Grey	Green	Orange	Orange
Asset	Core Static Asset Information	31	Orange	Orange	Orange	Orange
	Additional Static Asset Information	10	Pink	Pink	Green	Green
	Core Static Unit Information	18	Pink	Green	Pink	Orange
	Additional Static Unit Information	12	Pink	Orange	Pink	Pink
Commercial and Legal	Due Diligence	15	Grey	Grey	Green	Green
	Insurance Information	3	Grey	Grey	Green	Green
	Market Agreement	5	Grey	Grey	Pink	Green
Market	Market Lists Information	5	Grey	Pink	Pink	Green
Finance	Corporate Payment Information	10	Grey	Green	Pink	Grey

Key: Aligned Partially aligned Not aligned Not required

Data mapping with AAR

Identifying data gaps between AAR/CAR solution and FDS

Overview

To identify the data gaps between the AAR/CAR solution and FDS the following document was reviewed:

- GreenSync- Data Fields and Definitions for AAR/CAR solution

The AAR/CAR solution has focused solely on asset data attributes. While partial alignment has been observed with the Core Static Asset Information Data Product, no alignment has been found with Core Static Unit Data Products, Additional Static Asset and Additional Static Unit Information Data Products.

Through the review, the outcome was to adopt all AAR/CAR General Data Fields and include them in the FDS asset data attribute list, including:

- Technology type
- Manufacturer/Service Provider
- Model
- Serial Number
- Commissioning Date
- Consent
- Asset Postcode

Gaps identified

Gaps identified in the **Core/Additional Asset/Unit Data Products:**

- Asset Details:** Alignment on technology type, but gaps in DER connection status, effective from date, and asset owner details.
- Capacity Details:** Missing generation and demand capacity information.
- Location & Network Details:** Asset postcode available but additional network details are missing.
- Dispatch Contact:** Dispatch contact details missing.
- Metering & MPAN Details:** MPAN details included, but metering information missing (Metering granularity, Operational metering accuracy rating and Metering Frequency)

Further engagement with AAR will be undertaken to ensure the data products identified as gaps will be incorporated into the AAR platform.

The AAR platform does not require to provide information on the rest of the subject areas, therefore they have been marked as ‘not required’ in the table.

Subject area	Data product	Alignment
Organisation	FSP Information	
Asset	Core Static asset Information	
	Additional Static Asset Information	
	Core Static Unit Information	
	Additional Static Unit Information	
Commercial and Legal	Due Diligence	
	Insurance information	
	Market Agreement	
Market	Market Lists information	
Finance	Corporate Payment Information	

Data mapping with SMP

Identifying data gaps between SMP and FDS

Overview

To identify the data gaps between the ESO's SMP and FDS the following documents were reviewed:

- NESO – Single Markets Platform - registration guidance ([link](#))
- NESO – Single Markets Platform API ([link](#))

The API documentation has been analysed to assess data types and attribute formats.

Alignment or partial alignment has been found in organisation, Core Static Asset, Core Static Unit and Additional Static Unit, and Finance Data Products, while Market Data Product and Additional Static Asset Data Product attributes are not aligned.

As a result of this analysis, the Asset Unit concept from SMP has been adopted.

Additionally, the SMP process for Commercial Prequalification differs from Flexify's, as it requires FSPs to download and upload documents, including a standardised set of questions aligned with ENA's Commercial Prequalification criteria and terms and conditions documents.

Gaps identified

Organisation data product:

FSP Information: **Mostly Aligned** (excluding FSP Contact Role, Company type and Org Website)

Asset data products:

- Core Static Asset Information: **Partial Alignment**
 - Asset Type and Fuel Type: Partial Alignment (Excludes Technology Type, Serial no., Manufacturer)
 - Capacity, Connection, Location & Network, Dispatch Contact, Metering & MPAN: Aligned
- Additional Asset Unit Information: **Not Aligned**
- Core Static Unit Information: **Mostly Aligned** (excluding CMZ Location and BSC unique meter identifier)
- Additional (Static Unit Information: **Partial Alignment** (missing some metering information required for market qualification)

Subject area	Data product	Alignment
Organisation	FSP Information	
Asset	Core Static asset Information	
	Additional Static Asset Information	
	Core Static Unit Information	
	Additional Static Unit Information	
Commercial and Legal	Due Diligence	
	Insurance information	
	Market Agreement	
Market	Market Lists information	
Finance	Corporate Payment Information	

Data mapping with Electron

Identifying data gaps between Electron and FDS

Overview

To identify the data gaps between the ElectronConnect and FDS the following documents were reviewed:

- Energy Network Association – Pre-qualification Standardisation Report (Mar 2024) ([link](#))
- Electron- Bulk Asset Upload Guidelines

Electron's Data Models follow the Commercial PQQ from ENA. There are minimal gaps in the organisation, Commercial and Legal Data Products.

Asset data attributes have been sourced from Electron’s Bulk Asset Upload Guidelines for the Technical PQQ. However, no data attributes have been identified for Finance and Market Data Products.

Gaps identified

Organisation Data Product:

- FSP Information: **Partial Alignment**
 - Includes primary user contact details (excluding phone number & contract role); some gaps were identified in non-UK company details.

Asset Data Products:

- Core Static Asset Information: **Partial Alignment**
 - Asset Details: Mostly Included but missing Technology Type, Serial Number, Manufacturer & Model
 - Fuel Type: Included
 - Generation & Capacity Info and Dispatch Contact details: Missing
 - Location & Network Info: Location details included but network details missing (e.g., Grid Supply Point, GSP Group)
 - Metering & MPAN Details: MPAN details included but metering granularity missing

- Additional Static Asset Information: **Aligned**
- Core Static Unit Information: **Not Aligned**
- Additional Static Unit Information: **Not Aligned**

Commercial & Legal Products:

- Due Diligence and Insurance Information: **Aligned**
- Market Agreement: **Not Aligned**

Subject area	Data Product	Alignment
Organisation	FSP Information	
Asset	Core Static asset Information	
	Additional Static Asset Information	
	Core Static Unit Information	
	Additional Static Unit Information	
Commercial and Legal	Due Diligence	
	Insurance information	
	Market Agreement	
Market	Market Lists information	
Finance	Corporate Payment Information	

Data mapping with Piclo

Identifying data gaps between Piclo and FDS

Overview

To identify the data gaps between the Piclo Max and FDS the following documents were reviewed:

- Piclo Max API documentation – Create a new Flex Asset ([link](#))
- Piclo Max Asset upload file template shared by Piclo
- Piclo Flex Asset and Company Qualification ([link](#))

The API documentation has been analysed to assess data types and attribute formats. The Piclo Max Asset upload file was focused mainly on asset data attributes. Alignment or partial alignment has been found in Core Static Asset, Core Static Unit and Additional Static Asset Data Products, while Additional Static Unit Data Products were not aligned.

The Commercial Qualification application is completed on Piclo to help SOs pre-qualify FSPs before bidding. This requires company documentation, insurance information, and a standardised set of questions to be filled in, aligned to Flexify. It also may require uploading a signed Framework Agreement by the SO.

Payments are typically managed by SOs and only performance assessments and invoices for payments are managed by Piclo, excluding finance data attributes.

Gaps identified

Organisation Data Product:

- FSP Information: **Partial Alignment**
 - Includes primary user contact details (excluding phone number & contract role).

Asset Data Products:

- Core Static Asset Information: **Partial Alignment**
 - Includes asset details, location/connection details and operational/fuel type info
 - Missing some asset ownership, manufacturing and some metering information
- Additional Static Asset Information: **Aligned**
- Core Static Unit Information: **Partial Alignment**
 - Includes some unit details, capacity information, and some connection and operational information
 - Missing technology type and network and location attributes (e.g., CMZ Location, GSP, etc.)
- Additional Static Unit Information: **Not Aligned**

Subject area	Data Product	Alignment
Organisation	FSP Information	
Asset	Core Static asset Information	
	Additional Static Asset Information	
	Core Static Unit Information	
	Additional Static Unit Information	
Commercial and Legal	Due Diligence	
	Insurance information	
	Market Agreement	
Market	Market Lists information	
Finance	Corporate Payment Information	

C.2

Technical specification

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As an ontology

FDS as an ontology

Overview of the benefits and opportunities associated with modelling FDS as an ontology

Technical solution

The Flexibility Data Standards (FDS) has been logically modelled as an ontology, extending the Information Exchange Standard 4 (IES4) with domain-specific additions to include attributes identified in the FDS logical data model.

IES is a UK Government exchange standard and much of the ontology is a ready fit for FDS. IES was developed in recognition of the number of point-to-point interfaces that were being developed, few of which conformed to any official data standards.

The FDS ontology is designed to support shared vocabularies and standards that enhance data interoperability. By aligning with existing standards like IEC CIM, the FDS ontology ensures seamless integration with industry-wide tools and datasets.

This alignment facilitates efficient data exchange and interoperability among diverse systems, allowing them to map their internal data structures to the IES format at the system boundary. This approach helps maintain business agility and reduces maintenance costs associated with point-to-point interfaces.

Flexibility and scalability

Ontologies are inherently flexible and extensible, capable of adapting to changes in domain knowledge, business rules, or technology without breaking the model. This flexibility is crucial for accommodating future developments and ensuring the ontology remains relevant over time.

Additionally, ontologies are machine-readable, which supports future machine learning (ML) or artificial intelligence (AI) initiatives, enabling advanced data analysis and decision-making processes.

Implementing the FDS ontology involves several costs, including the development of the ontology to meet data exchange needs, procuring software to socialise the FDS, and translating data from source systems into IES-compliant formats.

These translation steps are initially undertaken centrally to demonstrate viability but will eventually be managed by individual organisations participating in the markets. The ontology also requires ongoing maintenance to ensure it remains up-to-date and widely applicable.

IES elements

Entities in the FDS ontology represent tangible things like devices, people, and organisations. Events represent activities involving one or more participating entities, such as an organisation participating in a market. States refer to the temporal state of an entity, like the employment of a person at an organisation.

The FDS identifies nearly 200 necessary data attributes, most of which have a match in IES. For attributes without an IES analogue, new classes are created following IES guidelines. This detailed modelling ensures comprehensive coverage of data attributes and supports the ontology's flexibility and extensibility.

Information Exchange Standard (1 of 3)

Overview of the IES

Overview

IES is a UK Government exchange standard and much of the ontology is a ready fit for FDS.

It was developed in recognition of the number of point-to-point interfaces that were being developed, few of which conformed to any official data standards. These interfaces tended to be fragile, restricted business agility and were costly to maintain. The IES is a data standard for structured business data, intended to de-couple applications and simplify the application infrastructure.

IES is not like a traditional data model. It is made up of a few re-usable components that you put together in different ways to make your model. It's like Lego™ not Airfix™ - the model might not exactly as you expected, but the parts move, and you can always change and extend it easily. You can also change small parts without breaking the rest of the model.



Information Exchange Standard (2 of 3)

An overview of the benefits associated with using IES

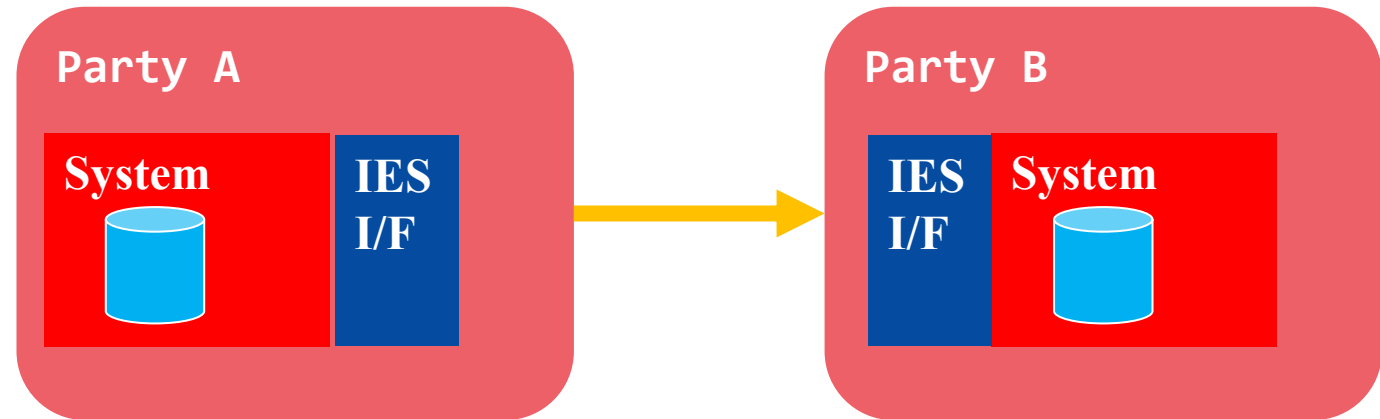
Why use IES?

In this Content, IES is defined as the 'upper' ontology, which establishes the general ontological principles into which FDS is integrated. This standardised exchange format ensures interoperability among diverse systems, thereby facilitating efficient data exchange.

Systems continue to use their own internal data structures, but map to/from the IES format at the system boundary. For example, Party B does not need to do anything if Party A makes a change to their system.

The data model can be updated in-flight: Party A adds a new entity to their system and can alert receiving systems as part of the payload. Receiving systems can then choose if to ingest it.

The ontology has been developed in Protégé an open-source ontology modelling tool and can be shared in any standard serialisation format (RDF-JSON, JSON-LD, RDF-XML).



Information Exchange Standard (3 of 3)

To develop the ontology key IES elements were identified that can be used for FDS

Entities

Entities represent tangible things like a person or a device. Examples of entities include:

- Devices or assets such as a heat pump.
- People and organisations.
- A special form of entity called “actor” covers people, organisations, and assets. Actors are entities that have agency (either direct or derived) and can participate in events. For example, an asset participating in a market is an actor as it is a participant in that market.
- Locations, with relationships used to join entities such as heat pumps to the locations they are stored in.

States

States: The temporal state of an entity. Examples of states include:

- The employment of a person at an organisation, which is time-bound and will have a start and end date (although this may not be known).
- The installation of a device at a location; the device can exist before it was installed in the location and could exist after, making it a ‘state’ of the device to be in that location.

Events

Events: Representing an activity or involving one or more participating entities. Examples of events include:

- An organisation participating in a market, as both the market and organisation are entities.
- The ability of an individual to act on behalf of an organisation, which can be modelled as a special form of event called an “Authorised Event Class” where the active event is also accompanied by an authorisation event.

C.2.1.1

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Building an ontology

Development process

The FDS identifies data products and data attributes which are mapped to IES, extending where necessary

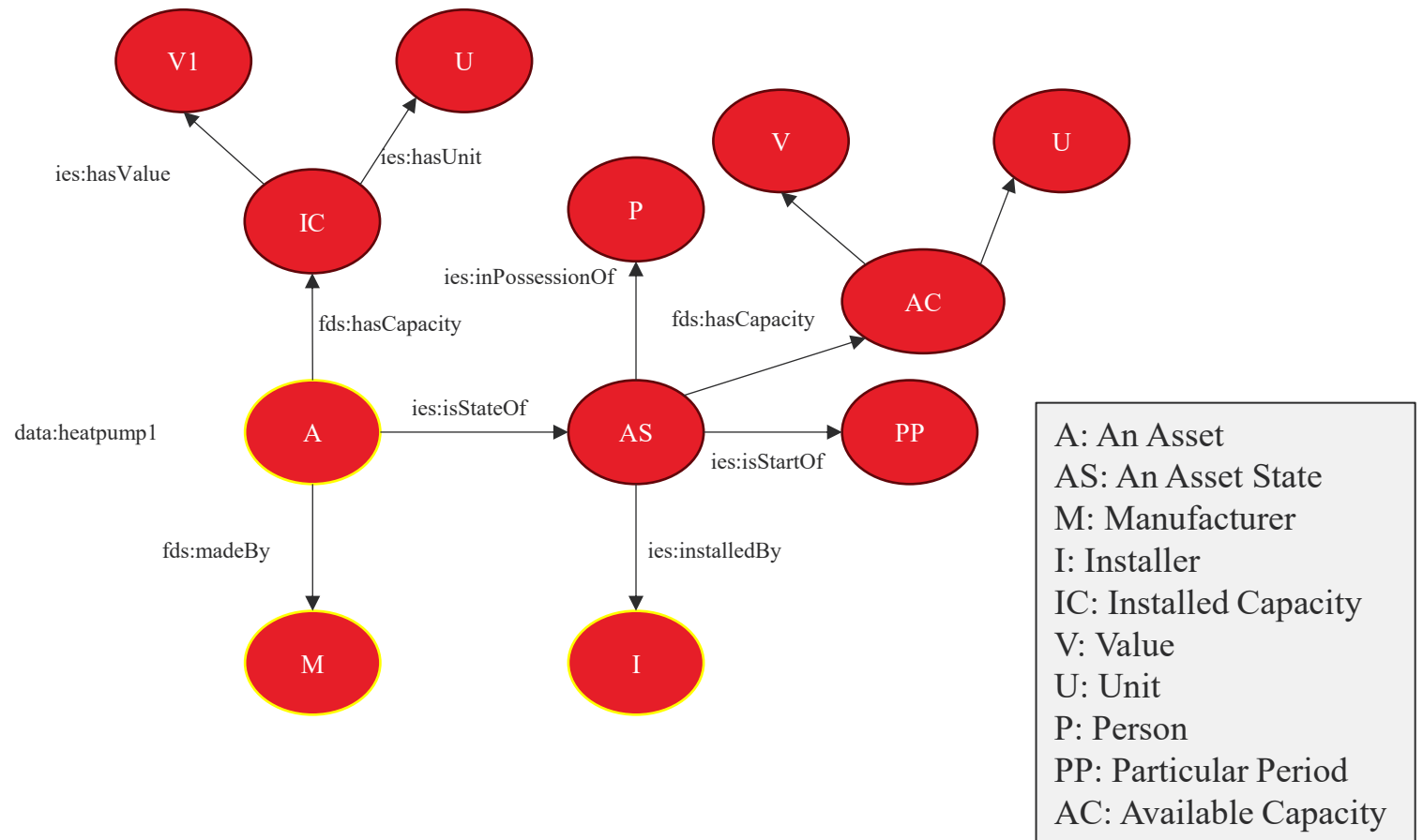
Overview

The FDS identifies nearly 200 necessary data attributes, many of these have a readily identifiable match in IES and in these cases no additional classes need to be created.

For an attribute with no IES analogue a new class is created following the IES guidelines that the tree be extended at the lowest branch. In FDS a new class of device has been created for “Air Source Heat Pumps” extending out from the “class of device” that already existed in IES.

There are other situations where an extension has been made to the meaning associated with terms– IES already has the concept of a “commercial organisation” adding a sub-class of “Flexibility Service Provider” below ensures that FSP’s both inherit from “commercial organisation” and aid expressiveness. URI’s prefixed “fds:” denote those which have been created for FDS, while “ies:” identifies which already existed in IES.

Dummy data has been created to test the FDS ontology and for demonstration purposes.



FDS data products (1 of 7)

FDS identifies data products and data attributes which are mapped to IES, extending where necessary

Overview

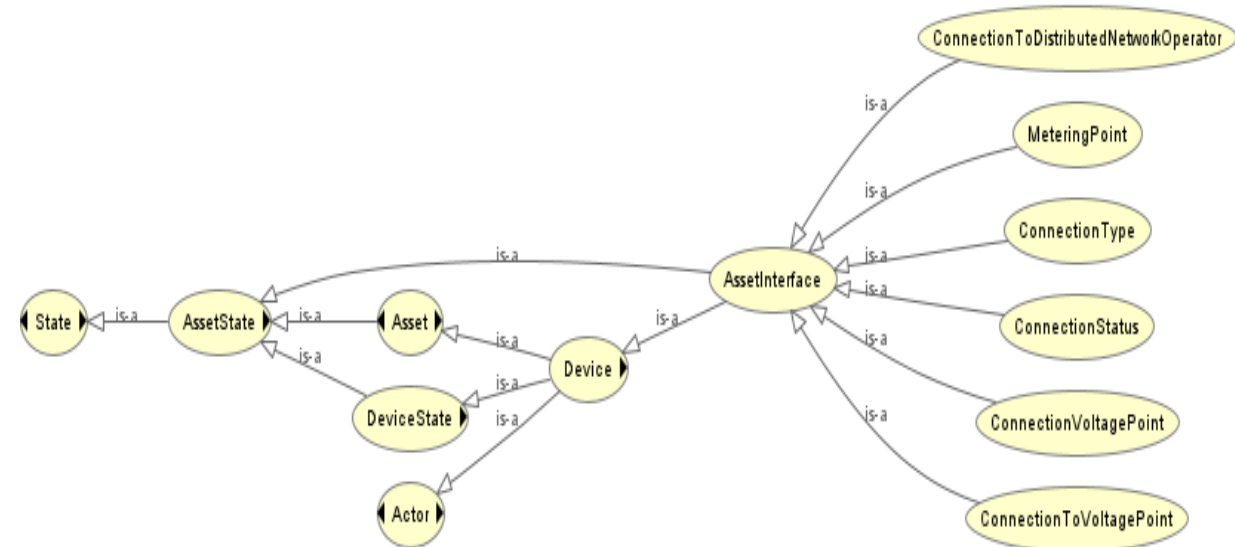
The data attributes defined were mapped with the attributes available in IES. The outstanding attributes, ones specific to the use case such as Assets, were extended.

Assets are a class of entity defined as 'An Entity that is either person-made or whose extent is defined in such a way as to specify ownership.

IES has been extended to include classes of assets such as Generation, Demand, and Storage, with smaller subclasses beneath them and models of devices at a further level down.

Additional properties have been created to model the interface between an asset and the grid, they are not fundamental properties of the asset but rather an interface (which is potentially, if not actually changeable) between the asset and the grid. To model these, states of the asset interface are created and attached to the asset with properties that apply if the asset is in this state.

The connection entities are both a sub-class of the asset (they are assets in themselves) but also a sub-class of the asset state in that they can be time bound.



Asset data products (2 of 7)

The FDS identifies data products and data attributes which are mapped to IES, extending where necessary

Implementation of the asset data standard

The examples shown are dummy examples and used to demonstrate the design of the ontology not the real world or any particular asset.

An instance of a heat pump is created, and it belongs to the HeatPump0001A class. All heat pumps of this type share the property of being an air source heat pump (this isn't shown as it is asserted based on the class that this instance belongs to) and this model has an installed capacity (the measure and the unit are defined separately) and manufacturer the properties associated with these classes can be automatically inferred for our instance without needing to be explicitly asserted.

HeatPump1 — http://data.gov.uk/testdata#HeatPump1

AnnotationsUsage

Usage: HeatPump1

Show: ☒ this ☐ different

Found 20 uses of HeatPump1

Connection State

ConnectionState isStateOf HeatPump1

HeatPump1

HeatPump1 inPossessionOf Fred

HeatPump1 hasConnectionStatus Firm

HeatPump1 Type Device

HeatPump1 Type HeatPump0001A

HeatPump1 hasName FredsHeatPump

HeatPump1 inLocation FredsHouse

HeatPump1 Type Asset

HeatPumps2U

HeatPumps2U owns HeatPump1

Installation State

InstallationState isStateOf HeatPump1

Property assertions: HeatPump1

Object property assertions +

inPossessionOf Fred

hasConnectionStatus Firm

hasName FredsHeatPump

inLocation FredsHouse

?@XO

?@XO

?@XO

?@XO

FDS data products (3 of 7)

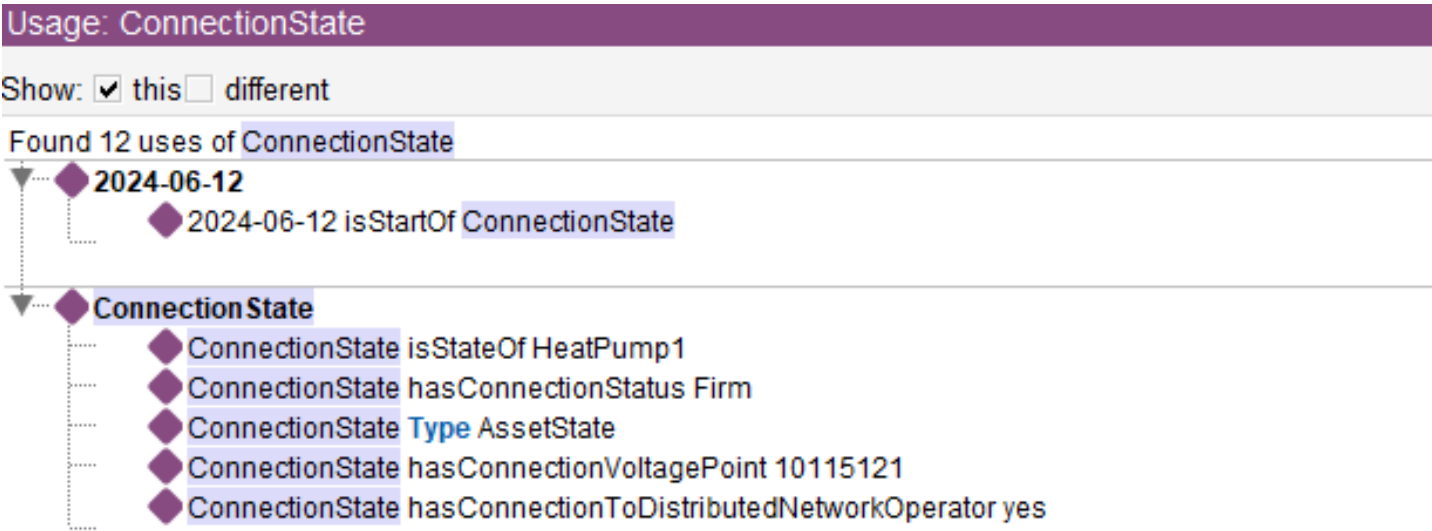
The FDS identifies data products and data attributes which are mapped to IES, extending where necessary

Implementation of the asset data standard

The example heat pump is assigned with various properties; ownership, possession (which can be different from ownership), location, and identifiers such as serial number. States of the asset are also applied; there is the installation state which commences with the date of installation and can be ended if the device is removed.

A connection state is also created to denote the status of the devices' connection to the grid and the dates which apply to this connection.

These states can be both spatially and temporally defined, in this case it is temporally defined with a start date but the end date can be left undefined.



FDS data products (4 of 7)

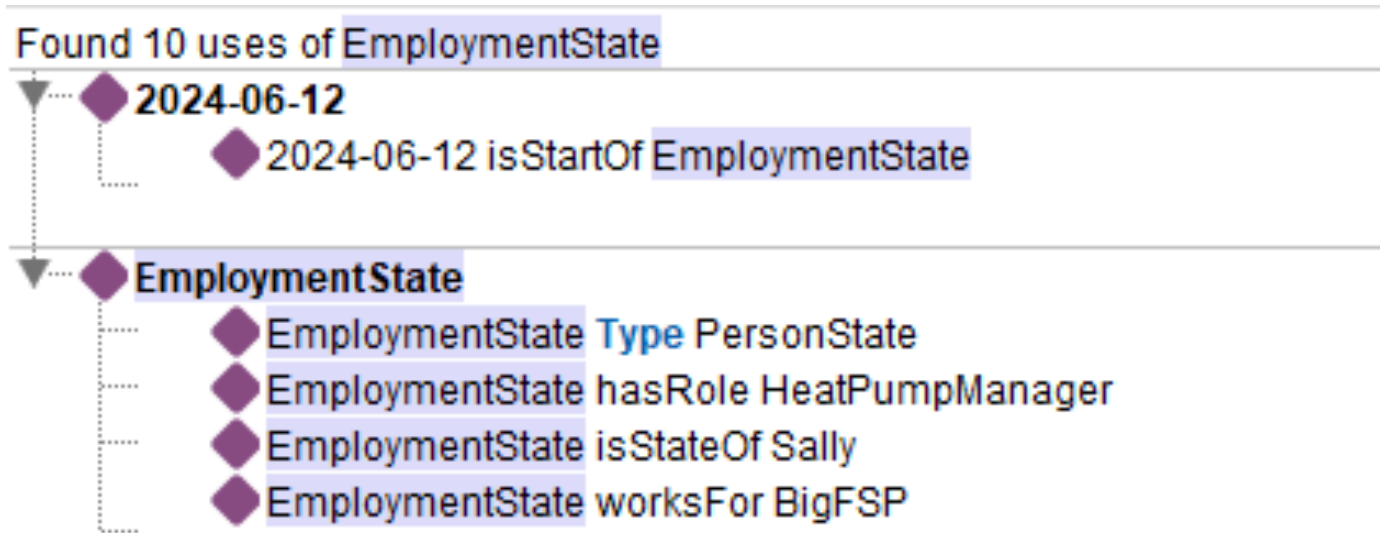
The FDS identifies data products and data attributes which are mapped to IES, extending where necessary

Implementation of the organisation data standard

As with the asset data product, the organisation data product was modelled using the IES classes and entities where appropriate and extended where necessary. We created a new class called “Flexibility System Provider” under the “commercial organisation” class, and another new class called “System Operator.”

A key component of modelling organisations is authorisation. Organisations themselves do not perform activities; people do. These people are granted time-bound authorisation to perform activities through their positions within the organisation. To model this, a responsible actor instance has been created for both a person (e.g., Sally) and an FSP (e.g., BigFSP).

The organisation can be identified by identifiers such as the country of registration, VAT number, and Company Registration Number. The FSP has roles associated with it, one of which is currently occupied by Sally (meaning it is a state of Sally).



FDS data products (5 of 7)

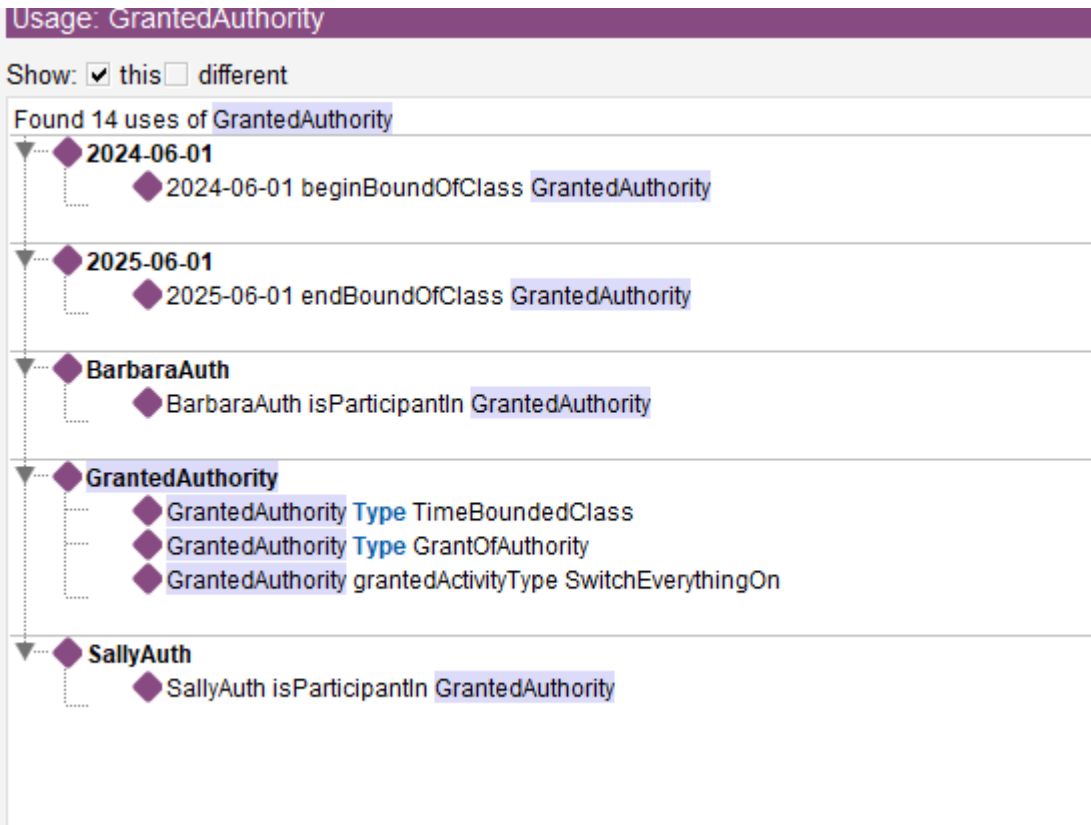
The FDS identifies data products and data attributes which are mapped to IES, extending where necessary

Implementation of the organisation data standard

To model authorisation a special event type called an authorised event is created and the authority to carry this out is passed from the organisation to people who work for it. Authority can be direct (i.e. Sally requires no other authority to conduct the activity other than occupation of a role) or the activity requires a “Grant of Authority” to be approved which then gives her authority.

The image shows a granted authority from Barbara (who occupies the role of Heat Pump Director) giving authority to Sally to conduct activities on behalf of the FSP between June 2024 and 2025 (grants of authority are rarely perpetual).

The same modelling approach is applied to subsidiary companies. A second FSP (small FSP) is a subsidiary of the first, this can be modelled explicitly using an isSubsidiaryOf relationship and grants of authority can be specified to denote that they apply not only to Sally in her role at the parent company but also at any or all subsidiaries.



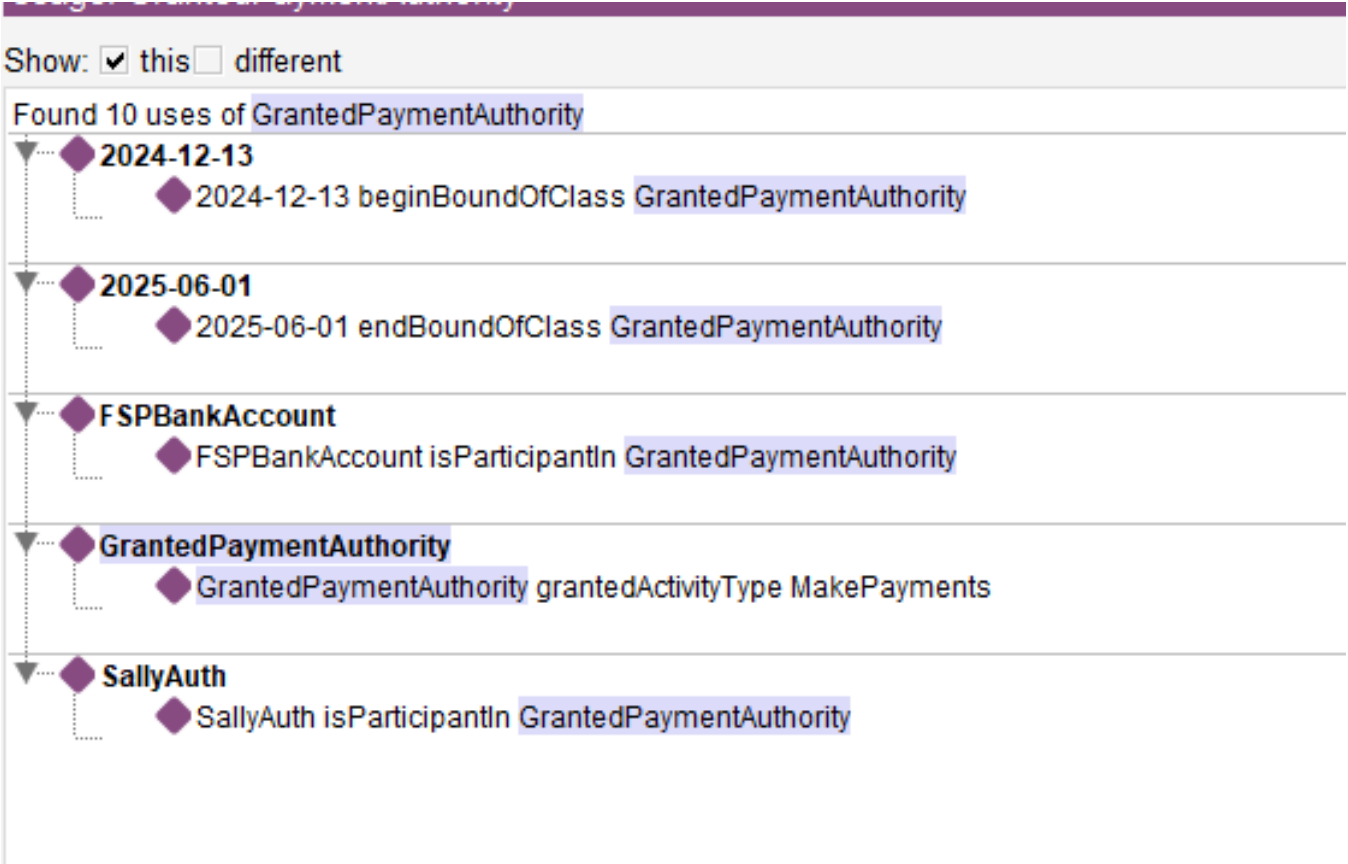
FDS data products (6 of 7)

The FDS identifies data products and data attributes which are mapped to IES, extending where necessary

Communications and finance

The data model makes a distinction between a thing that a person has access to and something they have. It is accepted practice to say that a person “has” an email address, however, this isn’t strictly true; there is an email account (with an email address an identifier that identifies it) and a responsible actor (a person, or not in the case of an automated mailbox) “has access to” the email account. In the case of Sally if she were to leave the employment of her FSP then she will no longer have access to the email account. The data model accounts for this by modelling employment as a state and making access to an email account a part of this state.

Financial information can be similarly modelled; organisations have bank accounts but actions such as making payments from the bank will be made by individuals who have access to the account and who have a grant of authority to make payments. Here “SallyAuth” - Sally and her granted authority – has been authorised to make payments on behalf of her employer from this bank account between these dates.



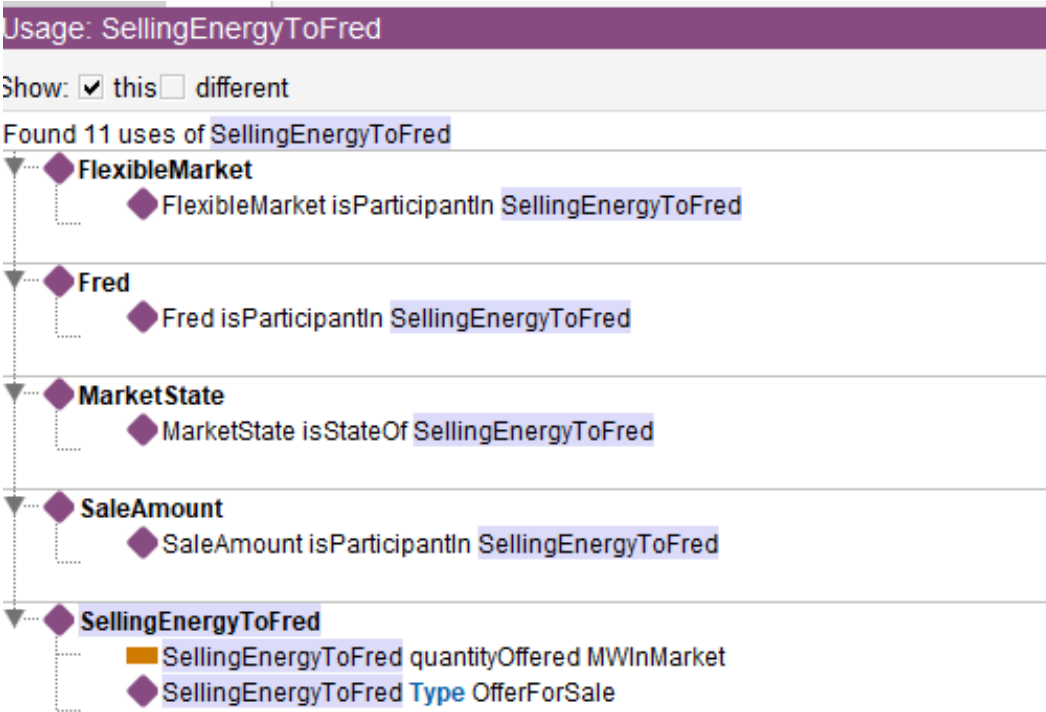
FDS data products (7 of 7)

The FDS identifies data products and data attributes which are mapped to IES, extending where necessary

Markets

Markets are entities which participate in trade ‘events’ that actors and assets can also participate in. These events can be offers for sale, offers for purchase, and encompass the full payment cycle such as raising invoices and making payments.

Markets can also be represented as states so there can be properties of a market which are fixed and those which vary depending on the state. In this highly simplified and theoretical example⁴ there is market which exists solely to sell energy to Fred, it has two participants a “Flexible Market” which is offering an asset (in this case) 2 MW for sale at a price of £100, there is a state of this market which means that this offer for sale is time bound.



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Translating system data across platforms

Translating system data

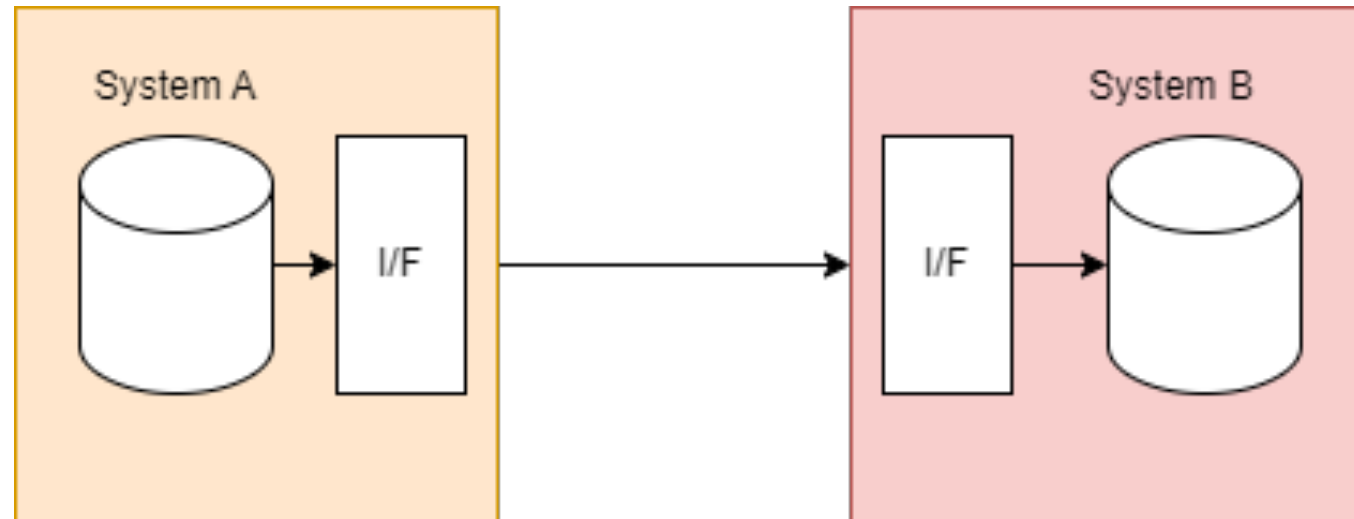
The purpose of the FDS is to enable frictionless data exchange across different platforms

Introduction

The Flexibility Data Standards (FDS) ontology provides a conceptual and logical framework for defining how data should be exchanged between participants in Flexibility Markets.

To make FDS relevant to exchanging parties and to demonstrate its functionality a translation step is required which can take data in common exchange formats (JSON, XML) and convert them to RDF-compliant formats (ttl, JSON-LD).

The fundamental purpose of the ontology is to facilitate the exchange of data between different parties and systems, it does not require parties to make any changes to their systems and is only utilised at system boundaries.



Role of the interchange format between sending and receiving systems.

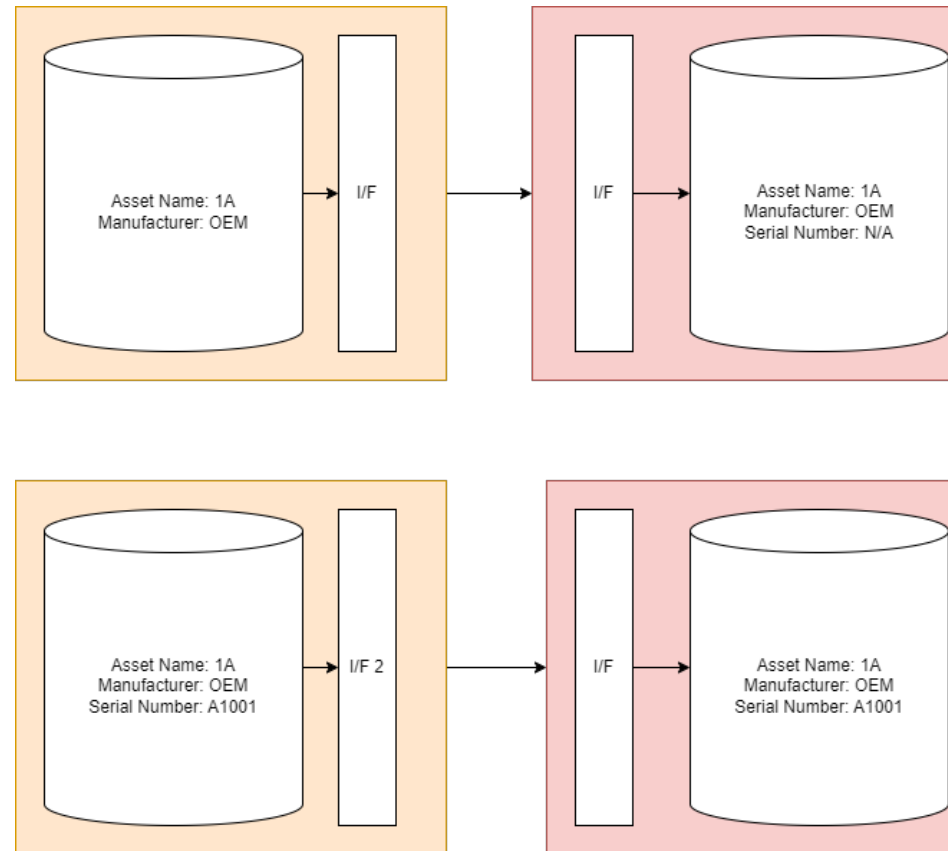
Translating system data

The purpose of the FDS is to enable frictionless data exchange across different platforms

Role of translation between systems

Both system A and system B continue to maintain their own data systems and formats but when transferring data from system A the translation script is utilised to create the common exchange format which can then be transferred to system B. Ultimately each system will manage its own interchange format as it sits within their system boundary, so if system A updates its schema or adds a new attribute the responsibility for updating the interchange lies with them. For example, system A only records Asset Name and Manufacturer in their system and the interchange file only contains this information, system B will look for serial number in the payload but will not receive it.

An update to system A adds serial number to their database, to share this new attribute system A needs to update their interchange format to include this field. Receiving systems do not need to do anything, if their system is set up to receive serial numbers this will already be included in their mapping from interchange format and now that it is included in the payload this can be read by system B. The absence of serial number from system A in the first instance does not prevent data exchange.



Translating system data

The purpose of the FDS is to enable frictionless data exchange across different platforms

Example exchanged data

As a starting point, dummy data is used to develop the translation script, so the current translation is based on the assumption that JSON will be used as the system exchange format. JSON is a lightweight format commonly used to exchange data between systems. It is versatile, and human readable and structured in key and value pairs and can be nested to indicate simple hierarchies. Dummy JSON files were been created to demonstrate the type of information that may be exchanged and how a robust translation process may operate. The example JSON is nested, and the payloads contains data relating to:

- A person who is registering an asset.
- An organisation who the person is employed by and has authority to act on behalf of. This is the information that needs to be parsed and translated to create the interchange format. The translation process has been demonstrated in python using:
 - JSON - a python library for encoding and decoding JSON.
 - rdflib - a python library for working with RDF.

```
},  
  "organisation": {  
    "(UK Company) Company Name": "Energy Solutions Ltd",  
    "(UK Company) Company registration number": "12345678",  
    "(Non-UK Company) Company Registration Number": "",  
    "(Non-UK Company) Business type": "",  
    "(Non-UK Company) Company Name": "",  
    "(Non-UK Company) Address Line 1": "",  
    "(Non-UK Company) Address Line 2": "",  
    "(Non-UK Company) City": "",  
    "(Non-UK Company) County": "",  
    "(Non-UK Company) Postcode": "",  
    "(Non-UK Company) Country": "",  
    "(Non-UK Company) Country of incorporation": "",  
    "Organisation Website": "www.energysolutions.example.com",  
    "VAT Registration number": "GB123456789",  
    "Assigned Reference for Organisation": "ESL001"  
  },  
  "contact": {  
    "Contact First Name": "John",  
    "Contact Last Name": "Doe",  
    "Contact Email": "john.doe@example.com",  
    "Mobile number": "07700 900123",  
    "Mobile number region": "44",  
    "Contact Role": "Asset Manager",  
    "Company Type": "UK Limited Company"  
  },  
}
```

Translating system data

The purpose of the FDS is to enable frictionless data exchange across different platforms

The translation process for dummy data

To translate the payload, an RDF graph is instantiated using the `rdflib` package. Each element in the graph will be uniquely referenced by a Uniform Resource Identifier (URI) these URI's will be prefaced by a namespace which denotes the source from which the element derives. In this graph the namespaces include:

- `ies`: any element in the graph which corresponds to a core IES class
- `fds`: any element in the graph which has been added to the FDS extension to IES.
- `data`: An element in the graph which represents actual data being exchanged.
- `rdfs`: the resource description framework schema which is used to denote the “types” that elements have

Uniform Resource Identifiers

Uniform Resource Identifiers are a unique way to reference ‘things’ in an RDF graph. In the core IES ontology URIs are prefixed with the IES namespace (<http://ies.data.gov.uk/ontology/ies4#>) and each class, sub-class and relationship has a suffix which uniquely identifies it. The FDS ontology follows a similar pattern of namespace ("<http://example.com/fds#>") and a unique suffix. Classes within both ontologies are represented in PascalCase with relationships represented in snakeCase.

Instances of classes, that is the data that will be exchanged, also need to ensure that URIs are unique and that this uniqueness is maintained across multiple systems, in the example script URIs were constructed using a Globally Unique ID (guid), and while this is an approach which meets the absolute requirements it can make data harder to interpret for humans. In these examples a hybrid approach of guid plus human-readable label has been implemented to both ensure uniqueness and aid comprehension.

Mapping JSON key to FDS classes

To add items from a payload to the graph a JSON dictionary is used for mapping the payload keys to ontology keys, this is a flexible and reusable approach to mapping as the dictionary can be updated when there is a change to source system, and the same dictionary can be used for multiple payloads from different systems. The dictionary will be maintained within organisations and can be updated when source systems change.

For example, different systems may refer to a person's first name in different ways and these can all be mapped to equivalent classes in IES. A JSON which contains any of “Contact First Name”, “FirstName” or “Contact Name” as keys can map the associated value to the IES concept of “Given Name”, this process can be repeated across the whole of the incoming payload data to generate an RDF and FDS compliant representation of the payload.

The process was designed to be functional and extendable, that is it could be applied across a diverse range of exchanged data while using the same code base just requiring an update to the mapping dictionary.

Translating system data

The purpose of the FDS is to enable frictionless data exchange across different platforms

Data schema from ElectronConnect

For the purposes of the Proof-of-Concept the translation script will sit within Flexify and Flexify will perform the translation from JSON to an RDF format and FDS compliant “Exchanged Item”. A data extract was received from Electron Connect which covered both assets and organisations. The sample was small, but the schema provided enough information to produce a working example of the process.

The approach developed for the dummy data example was broadly applicable to real-world data and the development process was similar. For each key in the incoming data, map this to the applicable class in FDS.

The ID key present in the Electron Connect JSON response maps directly to the IES class of “Asset” and the “providerId” key maps to the FDS created class of a “Flexibility Service Provider”. More complex JSON keys need to be mapped to ‘states’ of an asset and these are handled in much the same way but do require extra code to:

- Create a state
- Apply the state to the entity which is ‘in’ the state.

Difficulties with functional translation

While the ideal state for a translation process would be for a fully functional, repeatable codebase which could be deployed across multiple organisations and payloads the reality is that there is significant diversity in even the small samples of data collected from ElectronConnect and AAR and it proved very difficult to achieve this.

The codebase from the ElectronConnect translation became very complex and, in turn, would prove to be difficult to maintain and update and likely rely on a small number of individuals with prior knowledge of the code.

On receiving the data schema from AAR it was decided that a new approach would be trialled to see if this worked more efficiently, balancing the costs of requiring a new translation process for every new supplier and dataset against the ability to federate the translation process.

Data schema from AAR

The core process is similar for AAR as it was for ElectronConnect. Each of the keys from the AAR response is mapped to the equivalent class in the FDS ontology. Within the mapped keys the required relationships and more complex states of assets are also identified and mapped.

In contrast to the ElectronConnect translation the AAR translation script is purely procedural. Each key in the dictionary is iterated over, added as a class to the dictionary and any additional representations of the key are also added. The script is longer but was straightforward to debug and adding to it was also easier than in the ElectronConnect example as it was clearly organised and logical in its flow.

C.2.1.3

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Validating the data

Validating the data

Validation of exchanged data ensures that organisations can both understand data and have their data understood

Why validate exchanged data

Translation is the process which occurs at the boundary of system A to enable system A to transmit data to other parties, the verification process occurs either centrally or by receiving systems and authenticates the quality of data, that the correct data types are being transmitted and that the data conforms to the rules developed in FDS. By ensuring conformity of exchanged data the FDS can verify that participants are able to share data knowing that recipients will be able to use it and that they will be able to use data exchanged by other participants.

How validation is performed

Validation will primarily focus on the correct application of relationships between objects in data payloads, the cardinality of objects, and that data payloads conform to the correct datatypes. The Shapes Constraints Language (SHACL) is a W3C standard for describing and validating RDF graphs. SHACL constraints are defined in terms of constraints on the content, structure and meaning of a graph and it includes features to express conditions that constrain the number of values that a property may have, the type of such values, numeric ranges, string matching patterns, and logical combinations of such constraints.

Limits of validation

The translation step will map keys from source systems to the ontology, for example, the key “contact.FirstName” is mapped to the ontology class of “Given Name”, validation does not check these mappings as it is assumed that the mapping has been carried out correctly by sending systems.

The ontology does not, and should not, make demands of participating systems on what data they must collect and in which format they should store it.

The FDS specifies that people can be identified by a given and surname, however, if a participating system does not record this information, then it does not preclude them from participation in the exchange of data it is just that their payload will be missing this information.

Validating the data

Validation of exchanged data ensures that organisations can both understand data and have their data understood

Data type validation

Data type validation enables seamless integration between systems and, where applicable, logical tests on values. For example, if a numeric value is stored as a string then tests for equality or ranges of values will fail. XML Schema Definition (XSD) is a language for defining the structure, data types, and constraints of XML documents. It is used to enforce rules on XML data and by SHACL, ensuring consistency and validation. XSD includes primitive datatypes (like numbers, strings, and dates) and derived datatypes (like restricted ranges or lists). Each item in the FDS data glossary has been mapped to an XSD datatype and these have been translated into SHACL rules to verify incoming data against the ontology.

Relationship and allowed values validation

IES enforces allowed relationships through a SHACL file and this has been extended to include the new classes and developed for FDS. These rules work by identifying the domain and range associated with a predicate. Every item in an RDF graph is made up of three parts (triples), the subject, predicate and object (the two nodes and the edge that connects them). The domain is the subject and the range is the object. Through the translation script the predicates relevant to the Electron data schema were identified along with the domains and ranges to which they applied. For example, the predicate “hasOperatorOfAsset” has a domain of “Asset” and a range of “FlexibilityServiceProvider”. A python script has been developed which can generate a valid SHACL file from these lists and which can be used to validate predicates.

A small number of FDS elements have identified allowed values which can be associated with certain fields. For example, the “Asset Scale” item should have a value of Domestic, Commercial, or Industrial, this does not mean that all source systems must record this value just that in the process of exchange if a key in their system is mapped to “Asset Scale” then the value should be Domestic, Commercial, or Industrial.

Next steps

The validation steps outlined have been developed using some manual rules and automated generation in Python and tested against the translated sample of Electron data using Protege. The sample of data from Electron was small and therefore will not represent the likely diversity of provider responses both in terms of keys (for translation) and values (for validation), as data from more suppliers is acquired the validation framework will need to evolve iteratively. This involves several steps:

- Expansion of Rules: Additional translation and validation rules will be developed to account for newly encountered keys and the likely diversity of values used by different suppliers.
- Feedback Loop: Any discrepancies or errors identified during testing should be used to refine both the ontology and validation rules. Collaborative feedback from data providers and users will be essential in identifying gaps or inconsistencies.

By following this iterative process, the validation framework will become more robust, adaptable, and capable of handling the increasing diversity and complexity of supplier responses over time.

C.2.2

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Information security

Setting the scene

Outlining the context needed to understand information security

Overview

This section investigates security policy and data sensitivities that will need to be considered when utilising this standard for data exchange and insights. It defines the common data policy definitions and an approach for incorporating information security to enable trusted and assured exchange and use of data.

There are two technical ways for controlling data access which a platform, such as Flexify, can incorporate when integrating & exchanging data:

1. Role-based access control (**RBAC**)
2. Policy-based access control (**PBAC**)

These access controls support the codification of technical and non-technical rules for exchanging data. Therefore, they need to be combined with relevant processes and governance structures to ensure both technical and non-technical rules are defined ahead of implementation.

Role-based access control

RBAC restricts system access to authorised users, based on their roles within an organisation. Its components are:

- **Roles** – Created for specific job functions within the organisation(s) that are using the system. System roles should be defined as a logical collection of permissions which reflect the organisational structure. For example, a role might be called ‘administrator’ and contain full access permissions to use the system.
- **Permissions** – The specific set of access rights which will be granted over aspects of the system. For example, administrator can remove add or remove users associated with an organisation.
- **User-role relationships** – Users acquire permissions through being assigned to a role by a system administrator. Permissions cannot be granted through a different mechanism or assigned directly to a user.
- **Role hierarchy** – Roles can be combined in a hierarchy, wherein lower-level roles can inherit permissions from higher-lever roles. Users can hold multiple roles.

Policy-based access control

PBAC defines access control policies to manage user access to fine grain data. Policies are linked to data attributes and requests to access the said data are evaluated based on the criteria of the policies assigned to that data attribute.

The components of PBAC are:

- **User attributes** – Detail the roles, responsibilities or functions of users within an organisation.
- **Policies** – Specific criteria which describe (1) the user attributes that must be held to access the data and (2) the conditions or constraints placed upon users when accessing, processing or sharing the data.
- **Access Control Decision** – A ‘Yes/No’ decision based on evaluating policies against user attributes.

Approach for defining the rules

Creating an Information Security Management

Overview

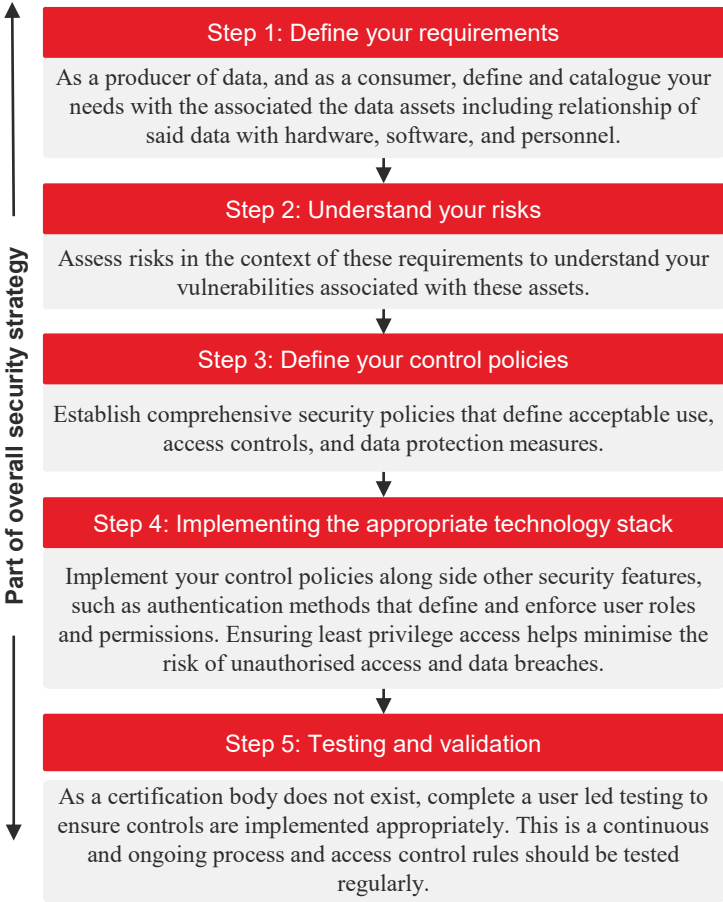
As technology has improved, certain standards have not kept pace with the evolving technology stack. Ontologies are one such technology that has evolved faster than current security standards, such as ISO 27001. Security for ontologies requires an information security architecture, an aspect considered in existing standards through infrastructure, development, and operations security. However, these standards do not incorporate the fine-grain data access controls required for ontologies.

Ontologies enable the integration and insights of data from multiple sources, allowing the creation of a 'whole-energy system' web of information. This functionality necessitates fine-grain access controls to ensure that only relevant information is shared and aggregated for the user, incorporating the context of the data and the user's needs.

Approach

A comprehensive approach to information security management must address both current and emerging threats effectively. By implementing a structured approach to ontology integration, organisations can safeguard their assets, ensure regulatory compliance, and maintain the trust of their stakeholders.

The following approach considers current best practices and can inform the development of a peer-reviewed standard. It is recommended that this program engage with the National Protective Security Authority (NPSA) and other peers, such as NESO and NDTP. These collaborations can help define a sector-approved standard for incorporating information management security related to integration infrastructure. Additionally, establishing a certification body to ensure organisations have implemented robust mechanisms for information security is advised.



Considerations for information management

Outline of findings from complimentary initiatives

XML data encoding specification

The XML data encoding specification was developed to address the growing need for a standardised, machine-processable format for exchanging data within the Intelligence Community.

The specification was designed to ensure consistent representation of data elements, attributes, and structures, facilitating secure and efficient data sharing across various systems and agencies. It incorporates detailed implementation guidance for encoding data using XML, including mandatory requirements, permissible values, and relationships between data concepts.

NESO's initiative to build a data sharing infrastructure for the energy sector use the Information Handling Model specification (IHM), which is a UK government implementation of the [XML Data Encoding Specification through the Enterprise Data Header \(EDH\)](#).

Data sensitivity classes

The following data sensitivity classifications are defined by the Open Data Institute for data sharing. They include:

Open: Data is made available for all to use, modify and distribute with no restrictions. It can be used by anyone, for anything, for free.

Public: 'Data is made publicly available but with some restrictions on usage. It has a pre-emptive license for limited usage.

Shared: 'Data is made available to a limited group of participants, possibly with some restrictions on usage. It has a pre-emptive license for limited usage.

Closed: Data is only available within a single organisation, shared through bespoke contracts between intra-organisational participants or not shared at all.

These classifications represent a 'protective marking' on the data products, and all data access control policies will have a data sensitivity classification attribute.

Organisations and data agreements

Data sharing agreements play a crucial role in mitigating risks associated with data exchange by legally obligating data producers to ensure the accuracy, completeness, and currency of the data. These agreements clarify the conditions under which data is shared and consumed, benefiting both data consumers and producers.

Additionally, they establish essential guidelines for data privacy, security, and ownership, which are critical when handling sensitive information. These agreements should be integrated into the broader governance framework of the flexible data standards, helping to define policies for data assets and incorporating the specific requirements and needs related to these assets.

C.3



Governance

C.3.1

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Governance structure

Operating considerations

An initial view of the adoption requirements, benefits and costs associated with the ontology

How can the ontology be adopted?

- Engagement is needed across the sector to socialise the ontology and promote the wider benefits of its adoption.
- To test the logical design of the ontology real data examples are required. Dummy data has been created and used to demonstrate the purpose of the ontology but only with real data and real examples of data exchange will value be realised.
- A platform to allow multiple stakeholders to view, comment and make suggestions on the ontology design will be required and platforms are being investigated to enable this.

What are the benefits of the FDS ontology?

- Modelling FDS as an ontology supports shared vocabularies and standards that improve data interoperability.
- Aligning the ontology with existing standards (e.g., IEC CIM) allows seamless integration with industry-wide tools and datasets.
- Ontologies are designed to be flexible and extensible and can adapt to changes in domain knowledge, business rules, or technology without breaking the model.
- Ontologies are machine-readable and support future ML or AI initiatives.

What costs will be involved?

- Implementation costs to further develop the ontology to meet the needs of exchanged data.
- The costs of procuring software to socialise FDS and open it up for wider discussion.
- The costs of translating data from source systems and the variety they may have into IES compliant formats should not be underestimated. Ultimately, the translation steps will be undertaken by individual organisations who wish to take part in markets but initially this will likely need to be undertaken centrally to demonstrate viability.
- The ontology will need an ongoing maintenance and governance board which will require funding.

Vision of the ontology governance

Which are the parameters used to determine the governance model?

Why is the governance model needed?

- A governance framework is required to undertake outstanding ontology development to facilitate initial rollout of a Flexify MVP, ensure efficient use of resources, effective long-term management of the data standards and maintenance of the ontology.
- A governance board should be established to oversee updates, ensure compliance, evaluate emerging needs, and manage feedback from the community.
- A transparent governance process, including defined roles, decision-making frameworks, and regular reviews, would ensure the standard remains relevant, interoperable, and widely applicable across domains.
- The proposed governance model presented here outlines the framework, controls, processes and structures that govern how the ontology would be managed, controlled and regulated within the FDS ecosystem.
- The roles, responsibilities, decision-making mechanisms and accountability mechanisms of stakeholders are determined.

What are the key challenges?

The key challenges to determine a governance board include:

- Establishing the governance rules, roles and mechanisms to facilitate initial rollout of a FDS MVP compared to regular operation and maintenance.
- Identifying costing mechanisms and revenue streams for the governance board operation (sponsor contributions or membership fees may not be viable long-term options).
- Identifying members to act as a steering committee which will be responsible for the strategic guidance for the ontology.
- Maintain technical expertise and information connectivity to avoid delays in developing, maintaining and evolving the ontology.
- Driving adoption amongst participants in the Flexibility ecosystem where they may already have point-to-point interfaces with other providers.

What is the outstanding ontology work?

Outstanding ontology development comprises:

- Mapping of the market qualification criteria with the FDS data attributes to allow asset and unit to qualify for flexibility markets and services.
- Scope definition of short- and long-term ontology development.
- Quality assurance across the flexibility ecosystem to ensure that all classes are mapped correctly and align with data collected.
- Translation and verification scripts to be demonstrated across multiple providers datasets which represent the true variability in data collected.
- Adoption within the current Information Exchange Standard.
- Alignment with the Information Exchange Standard 5, due to released in 2026.

Vision of the ontology governance

Which are the parameters used to determine the governance model?

Open-source requirements

- Further to the governance operating entity selection, releasing the ontology under an open-source license would further encourage widespread adoption, collaboration, and innovation.
- Open-sourcing would allow contributors from diverse industries and disciplines to refine, validate, and adapt the ontology to meet evolving requirements.
- The selected governance operating entity would oversee contributions to ensure they meet established quality and consistency standards while fostering a collaborative ecosystem.

Delivery requirements

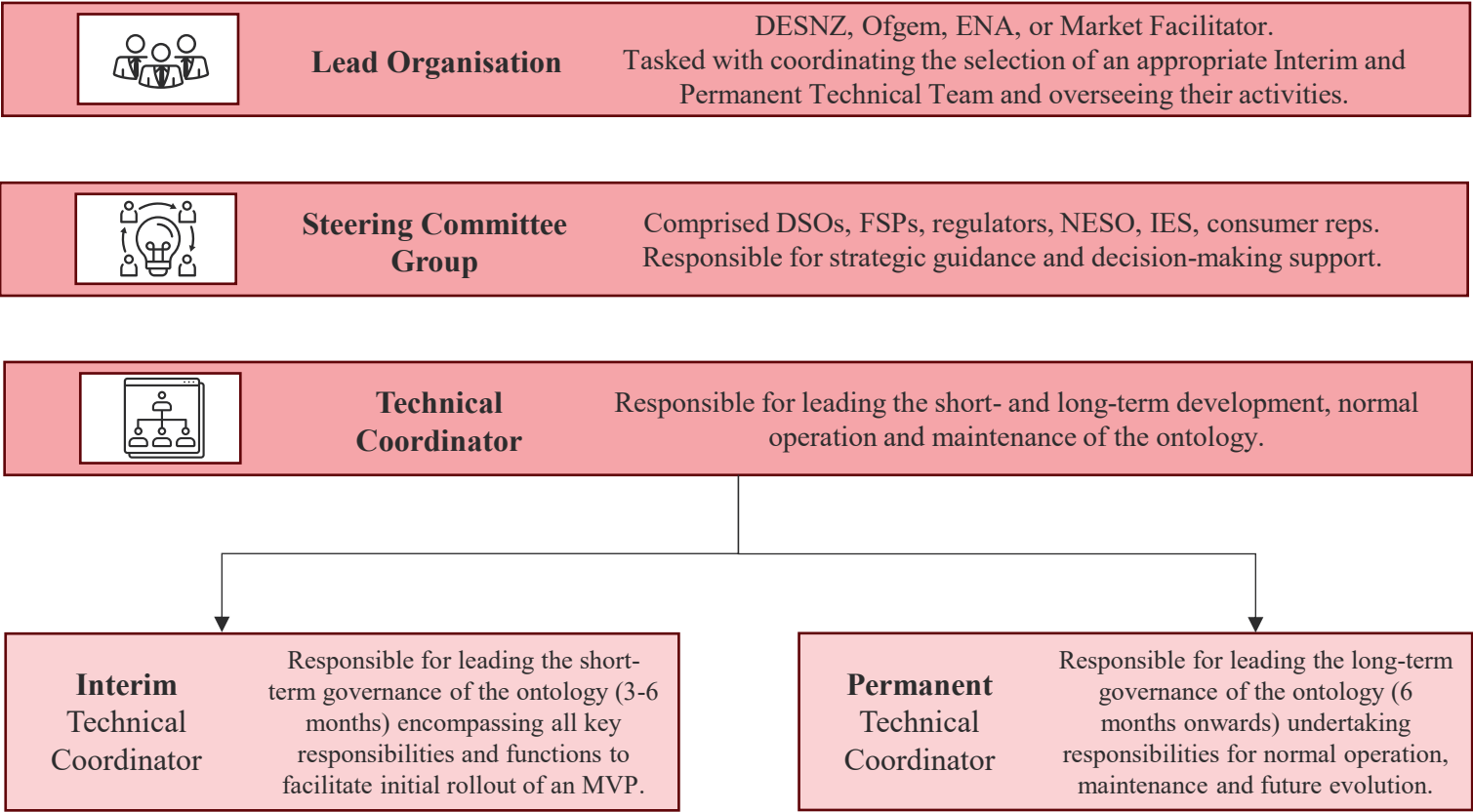
- To support implementation, the ontology should be hosted on a centralised repository (e.g., GitHub) with comprehensive documentation, example use cases, and tools for integration, such as APIs and libraries.
- An accompanying outreach program would help drive adoption and support ongoing development.
- Engaging key stakeholders early on to pilot and validate the standard in real-world use cases is also significant.
- Partnerships with organisations, industry groups, and academia can promote adoption and ensure the solution addresses practical needs, while a phased rollout plan with measurable milestones can provide a roadmap for growth and iterative improvement.

Ontology governance organisation teams and roles

A breakdown of the proposed organisation roles required to operate the ontology

Proposed approach to operating entity selection

- The introduction of a governance entity providing the core skills and capabilities required to operate the ontology in the short- and long-term is proposed. The key bodies involved in the governance selection are presented to the right.
- The purpose of the Technical Coordinator (TC) role is to offer trust that the ontology will be developed appropriately to support the FDS MVP role out and will also lay the foundation for the on-going support, maintenance and future evolution of the ontology.
- The Technical Coordinator (TC) role is therefore proposed to be divided to an **‘Interim’** and a **‘Permanent’** role.
 - The intention for the Interim Technical Coordinator (3-6 months) is to (i) maintain momentum and industry engagement, (ii) report, inform and undertake the evolution of the FDS architecture from PoC to MVP state and (iii) handover the ontology to the Permanent Technical Coordinator at regular operation.
 - The Permanent Technical Coordinator will adopt the existing ontology and integrate the operation and maintenance activities into their BAU plan.

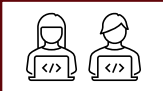
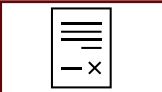
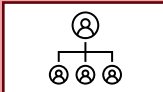


Ontology governance organisation teams and roles

Key roles and responsibilities of the Technical Coordinator role

Technical Coordinator - Roles and responsibilities

- The Technical Coordinator (TC) role is the key differentiator in the selection of a governance entity.
- All the required core functions, roles and responsibilities for the TC role are presented to the right.
- Further definition of the core functions and a breakdown of the job functions per team are presented in the next page.
- The core and job functions required for the Interim (I) and Permanent (P) TC are also specified in the next page.
- The core and job functions listed below can vary depending on the type of governance entity which will be adopted.
- The job functions from the National Digital Twin Programme (NDTP) have been used as a benchmark to determine these roles.

	Ontology Development	Will be focused on the future ontology development and maintenance, resolving conflicts between IES/CIM/FDS models, and responding to user requirements changes decided by the Steering Committee Group.
	Outreach	Will be responsible for securing funding and maintaining compliance with funding structures and rules.
	PMO	Will oversee operations, lead working groups, undertake public engagement and implement decision making required to enable the ontology to operate effectively and remain relevant.
	Security	Will ensure cybersecurity of data and systems is adhered to, and relevant security measures are being considered. Will need to work with NPSA to review information requirements and demonstrate compliance.

Ontology governance organisation teams and roles

A breakdown of the proposed Technical Coordinator roles required to operate the ontology

Core function	Function scope	TC	Job function	TC	Role scope
Ontology Development	- Ontology development, maintenance and technical evolution - Semantic modelling and version control - IES integration	I&P	Junior ontologist	I	Day to day responsibility for ontology and integrations
			Lead ontologist	I&P	Overarching responsibility for Ontology development and representative on steering committee group
			Quality assurance lead	I&P	Responsible for quality of updates to ontology and ensuring compatibility
			Software developer	I	Manages platform through which ontology is disseminated, and responsible for development pipelines and ontology integration
Outreach	- Funding and ecosystem management - Funding rules compliance	I	Community manager	I	Overseeing community of participants in steering committee group
			Formal review committee	I	Formal committee which meets periodically to review updates
			Partnerships lead	I	Overseeing funding structures, responsible for liaison with partners (IEC, CIM) and driving adoption of IES4 in DNO communities
PMO	- Progress review meetings - Working group - Public engagement - Decision making	I&P	Product owner	I&P	Roadmap alignment with development cycles, oversee delivery of the product and cross-cutting role with the ontology development team
			Programme director	I	Oversees the overall strategic direction and dissemination of the ontology
			Programme manager	I	Day to day responsibility for the direction of ontology development
Security	- Law and regulations compliance - Cybersecurity of data and systems	I	Compliance lead	I&P	Responsible for ensuring all activities adhere to relevant laws and regulations (NPSA review)
			Cyber security analyst	I	Monitors security threats to ensure the safety of data and systems and the correct application of security markings
			Cyber security lead	I	Develops and implements the programme's cybersecurity strategy
			Data sharing lead	I	Facilitates and promotes the secure sharing of data between stakeholders

• TC = Technical Coordinator • I = Interim • P = Permanent

C.3.2

Optioneering

Proposed governance entities of the ontology

Governance process and details of the ontology operation

Overview of options

Three potential options for the governance entity operating the ontology have been considered. A high-level overview of each governance option is provided to the right.

- A new Sector-Led Open Initiative
- Transferred to an Existing Sector Entity
- Under the remit of the Market Facilitator

The potential for each governance entity to satisfy the Technical Coordinator Interim or Permanent requirements is also identified in the table to the right.

Governance Entity	Description	TC potential	TC rationale
Sector-Led Open Initiative	A governance board made up of representatives from industry experts, data stewards, regulators, and end users to capture a broad range of perspectives. This would be a voluntary body made up of stakeholders that have a vested interest in the development and implementation of this ontology within the sector.	Interim	Interim only as it can be assembled in a short period of time and can support the FDS MVP development with voluntary contributions. Key challenge with Permanent requirements is securing long-term funding.
Existing Sector Entity (ENA, DESNZ, Ofgem)	Identify the most appropriate Existing Sector Entity (e.g., ENA Data Standardisation, DESNZ or Ofgem) and transfer ownership of the ontology. This would require integration of the ontology into the existing entity’s scope and activities, and formation of a subgroup or task force specifically focused on the ontology.	Interim & Permanent	Can operate both as Interim or Permanent, since a dedicated team and appropriate funding can be allocated for the ontology operation. Key challenge with Interim TC would be speed of assembly due to process-heavy environment.
Led by Market Facilitator	Integration into the MF’s existing role and structures by allocating a dedicated team responsible for the ontology maintenance and development. This would be an advisory group comprising industry stakeholders to provide input and guidance into the ontology.	Permanent	Permanent only as the MF’s role is dedicated to flexibility markets and can be integrated to BAU activities. Key challenge with Interim TC is MF’s role still being developed in the flexibility market.

Detailed description of the governance entity options

Summary of the structure, operational details & key features of the governance entities options

Sector-led Open Initiative (Interim)

A voluntary, collaborative approach where industry stakeholders form a dedicated governance board and working groups to develop and maintain the ontology. This option emphasises broad representation and transparent decision-making.

Governance Structure

- Lead Organisation: DESNZ / Ofgem
- Steering Committee Group: 15 members comprising:
 - 6 DSO/DNO representatives
 - 1 flexibility aggregator
 - 1 academic institution (e.g. ESC)
 - 1 consumer advocacy group (citizens advice, energy consumers commission)
 - 1 regulator/government body representative (e.g. DESNZ, Ofgem, CMA)
 - 5 rotating industry seats (manufacturers, tech providers, energy providers)
- Technical Coordinator: Interim TC roles, as defined earlier, provided by industry consortium / working groups undertaking the short-term ontology development to facilitate FDS MVP rollout.

Operational Framework

- Meetings:
 - Steering Committee: Monthly (hybrid)
 - Working groups: Fortnightly
- Representative Selection:
 - Nominations from stakeholder groups, ratified by majority vote
 - Term limits: 3-6 months
- Version Control: Automated dependency checks against CIM/OpenEI standards
- Public Engagement:
 - Mandatory open consultations for major updates
 - GitHub repo for issue tracking and pull requests
- Decision Hierarchy:
 - Steering committee approves ontology changes via 2/3 majority vote
 - Quarterly transparency reports on contribution metrics

Revenue Streams & Costs

- Revenue Streams:
 - Membership fees / contributions
 - Grants Funding (DESNZ / Ofgem)
- Costs:
 - Short-term TC ontology development and operation (Interim TC costs breakdown provided further down)
 - Lead Organisation and Steering Committee Group volunteering work so no fees

Detailed description of the governance entity options

Summary of the structure, operational details & key features of the governance entities options

Existing Sector Entity (Interim & Permanent)

Incorporating the ontology into an established industry Sector Entity's scope, such as DESNZ, Ofgem, ENA Data Standardisation. This option utilises existing expertise and processes while potentially accelerating adoption within current industry initiatives.

Governance Structure

- Lead Organisation: DESNZ / Ofgem / ENA
- Steering Committee Group: 15 voting members (Sector Entity rep, DSOs, FSPs, regulators, NESO, IES, consumer reps) with 2/yr term limits
- Technical Coordinator: Interim and/or Permanent roles are embedded in the Sector Entity's Directorate

Operational Framework

- Meetings:
 - Steering Committee: Monthly (Interim) or Bi-monthly (Permanent)
 - Subgroups: Fortnightly (Interim) or Monthly (Permanent)

- Representative Selection: Dependent on Sector Entity's resourcing plans
- Decision Protocol:
 - 80% steering committee supermajority for ontology version changes with guidance from Lead Organisation
 - Binding arbitration for scope disputes
- Stakeholder Input:
 - Open observer seats for startups/NGOs
 - Annual roadmap workshop
- Compliance Testing:
 - Version Control: Automated dependency checks against CIM/OpenEI standards
 - Quarterly plugfests with reference implementations
 - Certified test harness available on GitHub

Revenue Streams & Costs

- Revenue Streams:
 - DESNZ / Ofgem / ENA funding
 - FDS Ontology commercialisation
- Costs:
 - No direct user fees
 - Short-term TC ontology development and operation (Interim TC costs breakdown provided further down)
 - Long-term TC fees difficult to estimate due to multiple unknowns (dependence on Sector Entity's working structure, scope, development and operation requirements, etc)

Detailed description of the governance entity options

Summary of the structure, operational details & key features of the governance entities options

Market Facilitator (Permanent)

Leveraging Elexon's newly appointed role as market facilitator, this option integrates ontology governance into existing market structures. It provides a centralised, regulated approach with established industry connections.

Governance Structure

- Lead Organisation: Market Facilitator (Elexon) & Ofgem
- Steering Committee: 15 members with DNOs, FSPs, Ofgem, NESO and consumer group representatives
- Technical Coordinator: Permanent TC roles only embedded in Elexon's Markets Directorate

Operational Framework

- Meetings:
 - Steering Committee: Monthly (Permanent) progress reviews with Ofgem
 - Subgroups: Monthly (Permanent)
- Version Control: Automated dependency checks against CIM/OpenEI standards

- Representative Selection: Dependent on Elexon's and Ofgem's resourcing plans
- Performance Monitoring:
 - Ofgem monitors KPIs including market liquidity and dispute resolution time Quarterly Ofgem audits with public scorecards
- Stakeholder Engagement:
 - Rotating regional workshops (8/yr) with travel subsidies
 - Open API sandbox with synthetic market data
- Market Coordination:
 - Central registry for flexibility assets (FMAR system)
 - Standardised primacy rules across 700+ use cases

Revenue Streams & Costs

- Revenue Streams:
 - BSC cost recovery model: Proportional charges to market participants
 - No user fees for baseline services
 - £/kWh levy on flexibility transactions
 - Annual cap from any single market participant
- Costs:
 - Market facilitator fees embedded in BSC imbalance charges (£/MWh)
 - Long-term TC fees difficult to estimate due to multiple unknowns (dependence on Elexon's working structure, scope, development and operation requirements, etc)

Proposed governance entities of the ontology

Required Technical Coordinator roles for each proposed governance entity

Core and job functions against governance entities

Combining the core and job functions required for the governance entity, as listed previously, a comparison has been undertaken to define the required TC roles for each of the proposed governance entities. In more detail:

- **Sector-Led Open Initiative:** This governance entity would need to be set up for the purposes of an Interim TC without relying on a pre-existing entity. Therefore, the majority of the defined job functions would need to be resourced. The *Formal Review Committee* is only not required, since the governance entity would not need to adhere to any pre-existing processes.
- **Existing Sector Entity:** Providing a combination of Interim and Permanent TC, the majority of the roles are required, except for the (i) *Community Manager*: the participants in the steering group would belong to the existing entity, and the (ii) *Programme Manager & Director*: the Lead Organisation could provide.
- **Market Facilitator:** Only the Permanent TC roles required, which could be provided as part of the pre-existing entity's BAU.

Core function	Job function	Sector-Led Open Initiative	Existing Sector Entity	Market Facilitator
Ontology Development	Junior ontologist	✓	✓	✗
	Lead ontologist	✓	✓	✓
	Quality assurance lead	✓	✓	✓
	Software developer	✓	✓	✗
Outreach	Community manager	✓	✗	✗
	Formal review committee	✗	✓	✗
	Partnerships lead	✓	✓	✗
PMO	Product owner	✓	✓	✓
	Programme director	✓	✗	✗
	Programme manager	✓	✗	✗
Security	Compliance lead	✓	✓	✓
	Cyber security analyst	✓	✓	✗
	Cyber security lead	✓	✓	✗
	Data sharing lead	✓	✓	✗

✓ Required ✗ Not Required

Breakdown of costs for the Technical Coordinator role

Personnel costs

Overview

- An indicative breakdown of the short-term costs for resourcing the Interim Technical Coordinator role is presented in the table to the right. The key assumptions for this table include:
 - A period of 3-6 months was assumed for the completion of the outstanding work listed earlier.
 - The costs intend to provide only an indication of the expected costs and are not exhaustive.
 - ONS Annual pay 2024 Gross (£) data was used.
 - Fully loaded cost (salary & benefits & overheads) multiplier of 1.3x was used (ONS recommends 1.25-1.4x for total employment costs).
 - Fixed operating costs, which are not included in the table, comprise: (i) Annual IT operational costs: ~£6k-£12k (including GitHub enterprise 1 user, penetration testing, data storage, etc); (ii) Tools & Materials: Protégé license £3k, CIMTool Enterprise license £5k, Backup server £8k, Allowance per FTE £1k.
- Long-term TC fees are difficult to estimate due to multiple unknowns (entity's working structure, scope, development and operation requirements, etc).

*ONS Annual pay – 2024 Gross (£) UK data

Core function	Job function	FTEs	Cost range (£ annual)*
Ontology Development	Junior ontologist	1	£35,000
	Lead ontologist	1	£78,704
	Quality assurance lead	0.5	£26,611
	Software developer	1	£72,022
Total			£251,689
Outreach	Community manager	0.5	£26,000
	Formal review committee	0.25	£19,500
	Partnerships lead	0.5	£32,500
Total			£78,000
PMO	Product owner	0.5	£36,011
	Programme director	0.25	£25,000
	Programme manager	1	£56,547
Total			£117,558
Security	Compliance lead	0.5	£26,610
	Cyber security analyst	0.5	£28,273
	Cyber security lead	0.25	£19,676
	Data sharing lead	0.25	£13,305
Total			£87,865
Total Annual Cost Range			£535,112
Total Cost Range (3-6 months)			£133,778 – £267,556

Ontology governance operating principles

Governance process and details of the ontology operation

Governance operating principles definition

The selection of the preferred governance entity will be based on the principles which set a guiding approach for the ontology operation.

These operating principles establish an evaluation framework, ensuring alignment with regulatory standards and industry best practices. They also enable the ontology to achieve its strategic objectives and outcomes, meeting the necessary standards of accountability and probity.

This operating framework provides the structures and processes required to ensure the ontology is managed in the most efficient and effective manner.

The details of the governance operating principles are presented in the table to the right.

Operating principle	Description
Delivery mechanism	The ontology delivery mechanism should align with Flexify’s requirements, leverage market representation and allow public engagement. It should comply with best practice Corporate Governance including the UK Corporate Governance Code.
Technical development	The governance entity should provide the required technical support and roles to implement changes, maintain and operate the ontology.
Accountability and ownership	Clear lines of accountability and ownership of responsibilities across the governance structure should be provided.
Transparency	The governance entity should be supported by the sector, assured by other sectors & deliver to the public interest using a presumed open methodology to work.
Stakeholder representation	The governance entity should involve a diverse group of stakeholders, including DSO representatives, domain experts, end-users, consumers, hold regular meetings and workshops to gather input and ensure voices are heard.
Adaptability	The governance entity should ensure the ontology design remains flexible in future development cycles, adapting to IES modifications, changing requirements and advancements in technology with relevant version control system.
Scalability	The ontology should be able to manage increasing amounts of data and complexity without compromising integrity, clarity and performance.
Cost-effectiveness	The ontology should maintain a lean approach to governance and be created and operated at appropriate cost. There should be regular review and assess the cost-benefit ratio of the governance and operation of the ontology.
Future-proofing	The governance entity should establish a long-term vision for the ontology to ensure its relevance, interoperability and sustainability. It should anticipate and plan for future technological advancements and changes in requirements.
Supporting processes	There should be an effective and efficient system and processes in place to enable timely decision making at all layers of governance and delivery.

Ontology governance operating principles

Governance process and details of the ontology operation

Alignment to operating principles

The level of alignment of each governance entity option against the operating principles is presented to the right using the following colour coding system:

- **Green:** High alignment
- **Orange:** Moderate alignment
- **Pink:** Low alignment

Each governance entity’s strengths and weaknesses are presented to the next page before providing recommendations on the proposed approach for the short- and long-term governance entity selection.

Operating principles	Sector-led Open Initiative	Existing Sector Entity	Market Facilitator
Delivery mechanism			
Technical development			
Accountability and ownership			
Transparency			
Stakeholder representation			
Adaptability			
Scalability			
Cost-effectiveness			
Future-proofing			
Supporting processes			

Key:
 High
 Moderate
 Low

Comparison of governance options

Strengths and weaknesses of each governance entity option

	Strengths	Weaknesses
Sector-Led Open Initiative	- Quick setup: Can be formed in a short-period of time and continue the ontology development. - Results-oriented: Can provide quick results and achieve FDS MVP for an operational ontology model that supports Flexify MVP development in parallel. - Credibility: High level of trust and recognition. - Transparency: Open nature invites for public interest and sector engagement.	- Cost efficiency: Requires members contributions or grant funding, which hinders long-term utilisation of the governance model. - Coordination Challenges: Managing contributions from a large, diverse group can be complex. - Consistency: Ensuring uniform standards and practices might be difficult. - Resource Allocation: Requires effective resource management to support ongoing participation and engagement.
Existing Sector Entity	- Established Framework: Leverages an existing structure, reducing the need to build from scratch. - Short- and Long-term availability: Provides potential for undertaking both Interim and Permanent TC role, which would benefit the continuity of the ontology development from one phase to the other. - Efficiency: Can be more efficient in terms of time and resources. - Credibility: Benefits from the credibility and recognition of the existing sector entity.	- Alignment: Ensuring the new initiative aligns with the goals and practices of the existing entity could be challenging. - Process-heavy environment: Existing entity's processes could hinder swift development of the ontology and could cause delays in facilitating the MVP delivery for both FDS and Flexify. - Influence: Risk of the new initiative being overshadowed by the existing group's priorities. - Adaptability: May be less flexible in adapting to new needs or changes.
Market Facilitator	- Industry Alignment: Closely aligned with market needs. - Dedicated Flexibility: MF's role is dedicated to flexibility which can support further development and investment of FDS and Flexify. - Agility: Quick to respond to market changes. - Engagement: Strong buy-in from key players.	- Bias: Potential for bias towards the coordinator's interests. - Short-term focus: With MF's new role still being developed in the flexibility market undertaking the Interim TC role for the ontology development could clash with the governance entity's priorities. - Consistency: Maintaining uniform standards can be challenging. - Sustainability: Reliance on a single coordinator.

Summary of existing related codes & standards

Enabling the interfaces of a common digital energy infrastructure

Industry data exchange standards - Ofgem

Standards for enabling the interfaces of a common digital energy infrastructure were identified from the offerings of SDOs, such as the IEC and the IEEE, as well as from associations like the OASIS and the ebIX.

Five potential viable candidate standards were identified and evaluated against a framework determining the variety of existing market implementations, market platforms and market research initiatives for their use of standards-based data exchanges:

- IEC Common Information Model (CIM)
- ebIX
- OpenADR
- IEC 61850-7-420
- IEEE 2030.5

The IEC CIM has been recommended as the preferred standard, since it is the only standard that has defined data exchanges supporting all eight identified data domains. It has a single, cohesive underlying semantic model supporting all of its data exchange profiles. Its development is supported by a well-respected SDO. And the depth and breadth of its coverage in many of the data domains is substantial.

Common Smart Inverter Profile (CSIP) - Australia

CSIP-Aus is focused on the visibility - both static and near-real-time - of Distributed Energy Resources (DER) and their active management through the provision of dynamic (real power) import and export limits.

It heavily leverages the communications IEEE 2030.5 standards, along with California's Common Smart Inverter Profile (CSIP), adding extensions where necessary to meet Australian needs.

Like IEEE 2030.5 and CSIP, CSIP-Aus primarily supports communication directly with DER devices themselves, though it can also be used to communicate regarding aggregations of devices via a third party such as an aggregator, generating facility or microgrid.

This will enable a consistent approach to the active management of DER relevant to the Australian context, by ensuring DER, DER operators and related parties operate in a consistent and understood manner that is essential for network management and that will enable the integration across different Australian jurisdictions as seamlessly as possible, as well as making operations in other countries possible with minimal alteration.

Smart inverter interoperability standards - California

DERs paired with smart inverters have vast potential as a controllable resource for the grid. The framework for deploying and integrating California Rule 21-compliant smart inverters into the grid has been developed. This demonstrated that smart inverters could achieve more than 100 percent DER penetration of peak distribution circuit load, enabling high photovoltaic penetration beyond the 15% peak-feeder-load IEEE guideline.

Kitu Systems, a project subcontractor and system integrator, provided IEEE 2030.5/CSIP network software, a communications aggregation platform (SunSpec Modbus), saving utilities from micro-managing thousands of residential DERs, and enabling DER providers to easily onboard their installations and comply with Rule 21 requirements. This capability improves grid stability and DER participation in ancillary-services energy markets.

The financial analysis of smart inverters shows a value of \$640 million to \$1.4 billion per year of smart inverters' benefits, in addition to showing improvements in the areas of reliability, power quality, energy delivery efficiency, dispatchable resources, and avoided or deferred transmission and distribution upgrades.

Summary of existing related codes & standards

Enabling the interfaces of a common digital energy infrastructure

Smart data scheme

Ongoing policy consultation aimed at enabling better data sharing across sectors, particularly focusing on consumer data. Key points of relevance to the ontology governance include:

- **Alignment with consumer-centric data sharing:** The smart data scheme emphasises empowering consumers by enabling secure and standardised access to their data across providers. The FDS ontology could play a critical role in standardising the representation of consumer energy data, enabling seamless integration with smart data frameworks.
 - Flexibility service providers could use the ontology to provide consumers with insights into their energy usage and flexibility contributions.
 - The ontology could facilitate interoperability between energy systems and other sectors (e.g., financial services, telecoms) under the Smart Data Scheme.
- **Interoperability across sectors:** The ontology's alignment with standards like IEC CIM and IES4 ensures interoperability within the energy sector, enabling data sharing across industries, which could be extended to other sectors under the smart data

scheme (e.g. integration of energy data with financial systems for billing or payment reconciliation, or smart home integration utilising flexibility data to inform consumer decision-making).

- **Governance:** Compliance of the ontology governance model with GDPR and consumer protection laws, by aligning with smart data scheme principles by incorporating consumer advocacy groups and ensuring transparency in data usage.
- **Supporting innovation:** The smart data scheme aims to foster innovation by enabling new services that leverage shared data, with the ontology enabling new business models (e.g. dynamic pricing). It can act as a foundational layer for developing APIs or platforms that integrate energy flexibility data into broader smart systems.
- **Scalability and future-proofing:** Similar to the FDS ontology, scalability is a core focus of the smart data scheme, ensuring that frameworks can handle increasing complexity as more sectors adopt smart data practices.

C.3.3

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Constraints, enablers, and dependencies

Constraints, Dependencies, and Enablers

Overview of key aspects that may impact the FDS ontology

Constraints

- Testing of the logical design of the ontology using real data to realise value:
 - Testing requires access to high-quality, real-world data, which may not always be available due to privacy or commercial concerns. Without this testing, validating the ontology's practical utility is challenging.
 - Delays in testing could hinder the MVP rollout and adoption by stakeholders.
- Ensuring compatibility and interoperability with existing energy domain ontologies and standards:
 - The ontology must align with established standards like IEC CIM and IES4. Misalignment could lead to fragmentation or rejection by industry stakeholders.
 - Non-compliance risks limiting adoption and creating inefficiencies in cross-platform data exchanges.
- The design parameters of DSI to ensure it can be used when DSI is in operations:
 - The ontology must be designed to support DSI once operational. This requires ensuring that the ontology's data models and interfaces are compatible with DSI's data exchange protocols and standards. Any misalignment could limit the ontology's utility in real-world data sharing scenarios.
 - Misaligned design parameters could render the ontology unusable in DSI operations, hindering data-driven decision-making and market efficiency. This could lead to delays in integrating the ontology with broader data ecosystems, affecting its adoption and scalability.
- Capturing the complex relationships and interdependencies in energy flexibility concepts:
 - Flexibility markets involve intricate relationships between participants, assets, and grid constraints. Accurately modelling these complexities is challenging.
 - Failure to capture these relationships could limit the ontology's ability to support market functions like bidding, dispatch, and settlement.

Dependencies

- Platform identification to allow multiple stakeholders to view, comment and provide suggestions on the ontology design:
 - A collaborative platform (e.g., GitHub) is essential for stakeholder engagement and transparency. Without it, gathering feedback becomes fragmented.
 - Lack of a centralised platform could slow development and reduce stakeholder trust.
- Access to the data schemas for the MPs to understand the translation requirements to operationalise the ontology:
 - Clear data schemas are required to implement the ontology in MP's systems. Without this access, operationalisation would be delayed.
 - Miscommunication or lack of clarity could lead to incorrect implementations.
- Alignment with relevant energy standards, protocols and data models:
 - Domain experts are critical for ensuring that the ontology accurately reflects industry practices and technical requirements.

Constraints, Dependencies, and Enablers

Overview of key aspects that impact the ontology

Dependencies

- Limited availability of experts could delay validation processes.
- Availability of domain experts to validate ontology concepts and relationships:
 - Domain experts are critical for ensuring that the ontology accurately reflects industry practices and technical requirements.
 - Limited availability of experts could delay validation processes.
- Integration with existing ontology management tools:
 - Tool like Protégé is needed for efficient development, validation, and maintenance of the ontology.
 - Lack of integration would increase manual effort and reduce scalability.
- Clear documentation of ontology concepts, relationships and usage guidelines:
 - Comprehensive documentation is essential for onboarding new users and ensuring consistent implementation across stakeholders.
 - Poor documentation could lead to misinterpretation or incorrect usage.

Enablers

- Data Sharing Infrastructure:
 - A robust infrastructure facilitates secure and efficient sharing of data between stakeholders, which is critical for testing, validation, and operationalisation.
 - Accelerates development by providing access to real-world data for testing.
- National Digital Twin Programme's development of the Information Exchange Standard v5:
 - Aligning with national initiatives ensures compatibility with broader digital energy strategies.
 - Increases adoption by integrating with existing digital twin ecosystems.
- Engagement with stakeholders and asset registries (AAR, SMP, Electro, Piclo):
 - Collaboration with registries ensures that the ontology supports real-world use cases like asset registration and tracking.
 - Builds trust among stakeholders by demonstrating practical applications.
- Engagement with the Market Facilitator to ensure alignment with flexibility markets and leverage existing industry relationships/processes:
 - The Market Facilitator has established processes that can be leveraged for faster adoption.
 - Reduces duplication of effort by building on existing infrastructure.
- Collaborative development approach involving industry experts, regulators, and end-users:
 - Collaboration ensures that diverse perspectives are incorporated into the ontology design.
 - Increases stakeholder buy-in and ensures the ontology meets broad industry needs.
- Modular and scalable ontology design to allow for future updates and domain-specific customisations:
 - A modular approach makes it easier to adapt the ontology as requirements evolve.
 - Future-proofs the ontology against technological advancements.

Constraints, Dependencies, and Enablers

Overview of key aspects that impact the ontology

Enablers

- Demonstration of practical use cases and applications of the ontology:
 - Showcasing real-world applications builds confidence in the ontology's value proposition.
 - Encourages adoption by proving its relevance and utility.
- IES Umbrella:
 - Integration under initiatives like the IES ensures alignment with overarching energy system goals.
 - Positions the ontology as part of a broader ecosystem supporting digital energy transformation.

D — Market Rules Test Bed

D.1

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Definition of MRTB

Solution overview

MRTB to be used as a tool to assess how the structure of market rules impact those participating in energy flexibility provision

Introduction

The Market Rules Testbed (MRTB) will offer SOs and the MF the ability to better understand how the complexity of their markets and services impact FSPs looking to provide flexibility and determine how these rules could be adapted to make participating in local markets more attractive to FSPs.

The initial focus of the solution design was geared to understanding how primacy impacts those running and participating in flexibility markets and proposed a testbed that would model the implications of both static and dynamic primacy rules and the response from FSPs in how they assess the impact of these rules on their operations.

After engagement with the Primacy Rules working group ran by the ENA it was suggested that focus was given to investigate market rules more broadly and the mechanism of revenue stacking.

It was the view of the working group that stacking could provide FSPs with not only the opportunity to more seamlessly navigate through the differing energy markets and services, but to increase their confidence in offering their capacity more widely and readily.

What is revenue stacking?

Revenue stacking refers to an FSPs ability to utilise their asset capacity across multiple services and markets, with the aim of increasing their own revenue streams, but also providing the energy system with more options for flexibility.

As defined by the ENA stackability working group, there are three primary types of stackability:

Jumping: Enabling an asset owner to ‘jump’ between different markets, offering their assets capacity in multiple markets at different, but adjacent times.

Splitting: Enabling an asset owner to ‘split’ their assets capacity over multiple markets in the same direction, at the same time. For example, a battery operator may split their 10MW of capacity into 2, offering 5MW to one market and 4MW to another market, whilst retaining 1MW of capacity in reserve.

Co-delivery: Co-delivery is the least explored of the three stackability types but speaks to an asset owner’s ability to offer up their asset’s capacity in multiple markets, in the same direction, at the same time.

Aims

Revenue stacking would enable SOs to more confidently offer their asset capacities in local markets, locking in the scheduled availability cost, whilst also remaining reassured that in the scenarios where their capacity is no longer required, they could trade it within alternative national markets.

The main aim of the tool is to provide an open and transparent method for FSPs and SOs to see and assess the impact of market rules on their operations, and how market liquidity could increase from greater transparency for FSPs on how they could more optimally interact with local markets.

MRTB will do this by:

- Collecting, storing and analysing market opportunities data from flexibility market participants
- Providing a common data environment for trialling different scenarios associated to the market rule, assessing the costs and benefits to the FSP, and the impact to the network, as well as testing any assumptions made

Solution overview

MRTB use cases overview

Key research questions

To define the technical boundaries of MRTB and to define the use cases, stakeholder engagement and market research will be undertaken to understand the following:

- Form the perspectives of those running markets and those participating in flexibility markets, where do industry and markets need clarity regarding stackability rules
- How do market rules impact the decisions for an FSP to stack their assets?
- What's the right criteria for assessing the commercial and technical impact of market rules?

Use case 1: Impacts of splittable stackability

Split stacking should provide FSPs with the opportunity to earn revenue from multiple markets at the same time by splitting their asset capacity, meaning that they are able to participate in the transmission level markets and distribution level markets simultaneously.

The ability to revenue stack has been historically under-utilised by FSPs, with them unwilling to commit capacity to local level markets for two main reasons;

- a) They are unable to accurately commit their forecasted available capacity in the tender windows of the SO services (for this use case the SA+OU service which tenders up to a year ahead of dispatch)
- b) Despite the wholesale market displaying high levels of volatility in prices, it has shown to frequently pay more than the local level services.

This use case seeks to investigate how altering market rules could incentivise FSPs to participate in local-level markets, through the shortening of procurement timelines closer to that of dispatch and the optimisation of SO service cost. It is the view that increasing participation in local markets would increase liquidity and the opportunities for competition between providers.

Use case 2: Opportunities for co-delivery

The historic hesitancy of exploring co-delivery opportunities has stemmed from affiliated coordination complication and a lack of understanding of a) how would co-delivery benefit the whole system and those acting within it, and b) a real-time understanding of how to optimise flexibility.

This use case will identify and forecast the benefit of scenarios, where enabling an FSP to take part in two markets at once would be beneficial to the system. An example of this could be incentivising investment in building capacity in highly constrained areas, or increasing liquidity in related markets, by providing capacity in an ancillary service and a local market over the wholesale market.

The first steps will be the evaluation of relevant NESO ancillary services that are explicitly stackable and jumpable with DSO products. It will lead to an evaluation of economic benefits that can arise from an increase in FSP revenue, i.e. stimulation of investments in constrained areas.

Lastly, this use case will aim to understand the benefits of increasing the value of flexibility and the risk for over payments for a service by an FSP.

Solution Overview

MRTB use cases overview

Use Case 3: Opportunities for stacking with the LCM market

The Local Constraint Market (LCM) is a trial market being ran by NESO, which seeks to reduce curtailment of wind energy generation by encouraging consumers to increase their demand. Currently, stacking opportunities with the LCM market are heavily restricted, with contracts outlining opportunities only available within distinct, pre-determined settlement periods.

This use case will aim to identify scenarios where the LCM market becomes stackable with markets that can release their capacities to be included in LCM, for example, capacity in ANM released for use in LCM. This is potentially a form of co-delivery because the FSP is generating revenue from two markets for the same capacity and time interval.

Another key component of this use case, is understanding the repercussions of artificially increasing domestic demand for network reinforcement and the implications that this could cause with variability in network voltage and stability.

PoC solution overview

As recommended by the [ENAs stackability working group](#), this project engaged with various FSPs to help better understand the challenges that they experienced when interacting with the various flexibility markets and the reasons which they may not actively choose to participate in local flexibility services. It was communicated that FSPs are deterred from providing their available capacity to local markets for two main reasons;

- They are unable to accurately commit their forecasted available capacity in the tender windows of the SO services (for this use case the SA+OU service which tenders greater than 6 months ahead of dispatch)
- Despite the wholesale market displaying high levels of volatility in prices, it has shown to frequently pay more than the local level services.

Split stacking should provide FSPs with the opportunity to earn revenue from multiple markets at the same time by splitting their asset capacity, meaning that they are able to participate in the transmission level markets and distribution level markets simultaneously.

The PoC has been built around an algorithmic model that is able to demonstrate how to optimise FSP participation in local flexibility services with the tweaking of key market metrics.

The model uses historic market details, such as historic wholesale price, accepted bid capacity and asset utilisation rates to output not only an optimised price for SOs to offer FSPs, in order to incentivise participation in the markets, but it also seeks to indicate altered market liquidity, wholesale price volatility and the overall cost of flexibility to SOs.

Whilst the PoC is built off static, historic data, future scope for the MRTB would look to use dynamic data, giving a much more realistic viewpoint of the decision points of FSPs. Utilising increased, closer to dispatch time data would also allow for the expansion of scope to include all currently available flexibility markets in stackability assessments, as well as opening stacking optioneering to include co-delivery between markets.

Most importantly, the future scope would seek to understand how changes in service costs to SOs would impact on the energy cost to the end-consumer.

D.2

Technical specification

D.2.1

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Design of the test bed

D.2.1.1

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Algorithms for the test bed

Algorithms to underpin the models

Considerations for balancing the needs of FSPs and SOs

Overview

The analysis to define ‘what a good market rule is’ will need to quantify the impact of a rule change for all actors, ensuring a whole-system approach; therefore, MRTB will need to consider variables and needs of both FSPs, SOs and end consumers.

Flexibility service providers

The algorithms have been written to simulate the decisions an FSP would take in the presence of different market rules. Using data from previous tenders, the model outputs what the optimal service price should have been to incentivise FSPs to commit their capacity to the DSO service and how much capacity they likely would have been willing to commit.

System operators

For SOs, the key driver when looking to increase flexibility options in their local areas is ensuring grid stability and value for money to the end consumer. Their assessments for market design, procurement timelines and costs assigned to their flexibility services will be the core variables that MRTB will look to optimise.

Optimisation model

An optimisation model is a mathematical framework designed to identify the best possible solution to a problem within a set of constraints and objectives. It involves defining an objective function to maximise or minimise (such as profit, efficiency, or cost), and decision variables that can be adjusted to achieve the optimal outcome. Constraints are the limitations or requirements that the solution must satisfy.

Optimisation model for an FSP example:

Objective function: Maximise revenue generated from local and national markets, for PoC this is from the SA+OU and the wholesale market.

Decision variables: These could include (1) quantity of energy to buy/sell in each market, (2) prices to bid for a stated capacity, and (3) times for submitting specific trades.

Constraints: These could include (1) stackability rules i.e. whether stackability is allowed or not, (2) technical specifications for a particular market, and (3) overall capacity requirements.

Optimisation model for an SO example:

Objective function: Minimise the cost of procuring local flexibility

Decision variables: These could include (1) when to carry out tenders, (2) cost of individual SO services, and (3) the utilisation rate within flexibility zones

Constraints: These could include (1) policy constraints on market rules, (2) licensing requirements from the regulator, and (3) isolated, unpredictable events.

Algorithms to underpin the models

Outlining the focus areas and scenarios

Focus areas

The model currently has two distinct focus areas which are further broken down into different scenarios where an FSPs behaviour changes may alter.

Through the perspective of six scenarios, MRTB aims to define a model that allows System Operators to optimise their market rules and evaluate their benefits by forecasting the decisions an FSP can take.

Focus area 1: Optimisation of DSO service procurement

This section explores the behaviour of an FSP to enable a SO to understand the impact of their decisions in setting the value for flexibility, defining stackability rules, and determining the procurement timelines for their markets.

Focus area 2: Modelling specific FSP and asset types

This section explore the behaviour of specific asset types that make the portfolio of an FSP. It aims to quantify the benefits of the technical capabilities of flexible assets.

Modelling assumptions

- Each local location is unique; therefore, they need to be evaluated separately when determining the economic benefits of stackability and other market rules.
- The model will be limited in the markets it evaluates and only consider the Wholesale Market and Scheduled Availability and Operational Utilisation markets for the PoC.
- FSPs will only be motivated by revenue generation, and other factors will not be considered.
- For the PoC the model will use only historical information.
- The model needs to co-optimize to balance the benefits for FSPs, SOs, and consumers.
- Whilst the PoC is built off static, historic data, the future scope for the MRTB would look to use dynamic data, providing a more realistic viewpoint of the decision points of FSPs. Utilising increased, closer to dispatch time data would also allow for the expansion of scope to include all currently available flexibility markets in stackability assessments, as well as opening stacking optioneering to include co-delivery between markets.

Focus area 1: Optimisation of DSO service procurement

• Scenario 1: No revenue splitting allowed

This scenario is a linear optimisation model that outlines the FSP decisions where they are choosing either to commit all their assets capacity into **either** the DSO SA+OU market, or the wholesale market. There is no ability for them to split their capacity within each market.

It provides a view to the SO for the minimum value to offer to attract more liquidity to their markets.

• Scenario 2: Modelling FSP decision making when revenue splitting is allowed between SA+OU and wholesale.

This scenario is based on a mean variance framework model, where an FSP wants to maximise their revenue across both markets, while considering their ability to sell the reserved but not utilised capacity by SA+OU market in day-ahead wholesale markets if they do not get utilisation notification from DSO.

Algorithms to underpin the models (2 of 2)

Considerations for balancing the needs of FSPs and SOs

- **Scenario 3: Modelling FSP decision-making under uncertainty**

Building on the first two scenarios, The model allows an SO to evaluate the risks associated with utilisation payments. It shows the SO the impact of low utilisation and how it can impact FSP behaviour by understanding future costs to their operations.

- **Scenario 4: Co-optimisation of the SA+OU service procurement**

This scenario runs a co-optimisation model that is designed to help SOs and FSPs reach a win-win scenario. It will help SOs define availability and utilisation fees for SA+OU product across time, and targets to minimise the overall SA+OU procurement costs, while ensuring that these prices are high enough to incentivise FSPs in the flexibility zone to sell in SA+OU market.

The PoC is formed from Scenario 4 and has been run with the input of historic datasets from past tender documentation.

- **Focus area 2: Modelling specific FSP and asset types**

These scenarios have models derived within this section, but to run them would fall under future development and require more datasets than was accessible at this stage.

- **Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation**

FSPs come in a variety of types, depending on the type of flexible asset they operate; hence, there are different costs and profits profiles that can be considered for optimising revenue for an FSP. A unit price of availability and utilisation for SA+OU service, which is attractive to demand response units, may not be incentivising enough for generators or batteries.

In this scenario, a model is defined based on the assumption that prices for generation, demand response and battery responses could be different in the wholesale market.

- **Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO**

This model outlines the optimisation problem when an FSP chooses to act in the opposite direction to a DSO directional request. The FSP should consider price signals coming from all directions and will likely only respond to a DSO request if it is more profitable to do so than moving in the opposite direction of this request.

This model will help a SO understand the cases where an FSP is incentivised to act opposite to their needs. It helps forecast such scenarios and help them establish future rules and policies to mitigate this scenario from occurring.

Models that make up Section 2 are not included in the PoC. These models are defined but testing them requires further evaluation.

Algorithms to underpin the models

Considerations for balancing the needs of FSPs and SOs

Model assumptions

Through the perspective of the Use Cases, MRTB will aim to define a model that allows System Operators to optimise their market rules and evaluate their benefits by forecasting the decisions an FSP can take.

Our assumptions for the model:

- The model will be limited in the markets it evaluates and only consider the Wholesale market and Scheduled Availability and Operational Utilisation market.
- FSPs will only be driven by revenue generation, and other factors will not be considered.
- For the PoC the model will use only historical information.
- The model will consider the value for FSPs, DSOs, NESO, asset owners, and consumers.
- The model assumes that for a flexibility zone, there is a liquidity of 100%, that is there is enough capacity available to satisfy the requirements of a DSO.

- The model assumes an asset has a maximum run time that aligns with the run time required within a tender.

The definitions of the optimisation model is still under development; therefore, not included in this document.

The PoC for MRTB is to showcase how the altering of market rules and the ability of FSPs to revenue stack would affect the prices that DSOs are currently paying for their flexibility services. The model takes inputs from a hypothetical FSP and simulates how DSO market metrics would influence their decision making when choosing to participate in local flexibility markets.

Introduction

Introduction to the optimisation model used for MRTB

Introduction

The MRTB will offer SOs and the MF the ability to better explore and analyse the complexity of markets, determining where market rules could be adapted to reduce their expenses, and in turn, the end consumer.

The way in which it will do this, is by modelling the different decision processes available to be taken by a FSP. For this PoC, use case 1 has been modelled, where an FSP is weighing up the financial benefits of operating within either the local distribution level markets (in this case the Scheduled Availability + Operational Utilisation Market (SA+OU)), or the wholesale market (WM).

In this chapter, the mathematical models developed to (1) simulate the choices of FSPs, in response to differing price signals coming from the DSO's SA+OU service and the wholesale market; (2) find the DSO's optimal pricing strategy for SA+OU service are presented.

The mathematical models have been split into six scenarios across 2 key focus areas:

- **Focus area 1: Optimisation of DSO service procurement**
 - Scenario 1: Modelling FSP decision-making when revenue splitting is not allowed between SA+OU and WM
 - Scenario 2: Modelling FSP decision-making when revenue splitting is allowed between SA+OU and WM
 - Scenario 3: Modelling FSP decision-making under uncertainty
 - Scenario 4: Optimisation of the SA+OU service procurement
- **Focus area 2: Advanced future scope optimisation model scenarios**
 - Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation
 - Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

Option 1 for FSP – Bidding in the DSO service

Process for FSPs looking to bid within a DSO service, in this case **Scheduled Availability + Operational Utilisation**

DSO SA+OU service (UKPN example)

UKPN tender for SA+OU service procurement from FSPs in two separate windows yearly: summer and autumn (sometimes referred to as ‘winter’ in historical tender document data). An example of key tender dates from summer procurement in 2024 is given below.

Stage	Activity	Dates
Stage 1 Visibility and pre-qualification	PQ opens, and - Flexibility zones signposted on Localflex ; - Tender documentation published on our DSO website ;	Wed, 15 May 2024
	PQ close	Thurs, 27 June 2024
	PQ results	Wed, 10 Jul 2024 5pm
	PQ results appeal deadline	Fri, 12 Jul 2024 5pm
Stage 2 Competition	Competition open	Tues, 16 Jul 2024
	Competition close	Thurs, 25 Jul 2024 5pm
	Competition results	Mon, 30 Sep 2024
Stage 3 Onboarding	Solutions prepared for delivery in accordance with Post Tender Milestones (includes Proving Test)	In accordance with PQ submission and contract

Stage 1

FSP will check whether there is any tender available in the zone(s) in which their assets are connected. Flexibility needs are locational, and so FSP can only participate in a tender if flexible capacity is required in the same area as their assets.

If FSP in a flexibility zone tendering for SA+OU service meets the requirements of the request, they can bid for the service. There is no option to partially bid at this time.

Upon participation in the tender, the FSP is committing to the amount of capacity bid being available between the stated dates and hours.

Bidding does not guarantee that the bid is accepted by UKPN.

Stage 2

Competition data provides an indicative value for the hours of utilisation based on historic data.

At present, for the SA+OU service, it is not certain whether the capacity committed will actually be utilised until the day before, meaning that FSPs could miss out on the utilisation payment.

The actual prices awarded to FSPs is market driven and is predominantly driven by competition, as the DSO seeks the minimum cost combined.

Option 2 for an FSP – Bidding in the wholesale market

Process for FSPs looking to big in the wholesale market

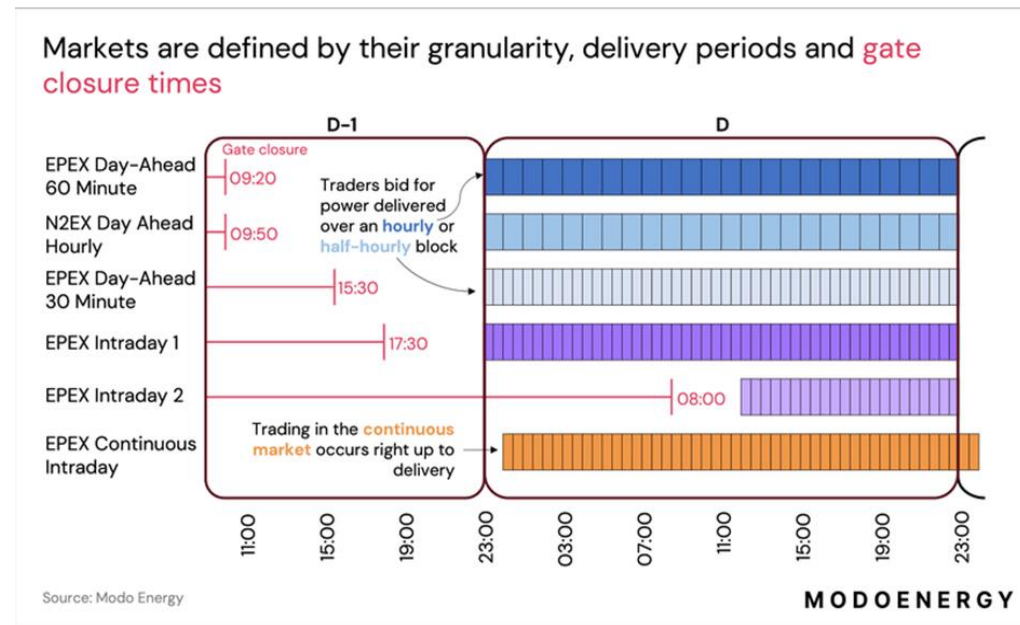
Wholesale market

In the Day-Ahead and Intraday auctions, participants submit bids and offers - an option to buy or sell power for a defined period - to the auction until gate closure. Following this, the exchange calculates a single clearing price and executes the trades which satisfy this price.

Day-Ahead auctions allow buyers and sellers to trade electricity across hourly or half-hourly blocks for delivery the following day. The second intraday auction provides an opportunity to trade on the day of delivery.

The auctions available to trade power, in order of when they run, are:

- EPEX Day-Ahead 60 Minute - runs at 09:20 day-ahead of delivery
- N2EX Day Ahead Hourly - runs at 09:50 day-ahead of delivery
- EPEX Day-Ahead 30 Minute - runs at 15:30 day-ahead of delivery
- EPEX Intraday 1 - runs at 17:30 day-ahead of delivery
- EPEX Intraday 2 - runs at 08:00 on the day of delivery



Focus area 1: Optimisation of DSO procurement

Model assumptions and inputs for scenario 1 and scenario 2

Assumptions

The model assumes the following definition of FSP;

FSP has asset(s) in a flexibility zone. There is at most one SA+OU tender for a flexibility zone for each season in the next 2-3 years. FSPs should decide:

- Whether to bid for a tender in the relevant flexibility zone for the duration and time window given
- How much capacity to bid
- Availability price
- Utilisation price
- How much capacity they want to sell in the wholesale market for the exact time window and duration of the tender

Provided that the FSP is informed of :

- The expected wholesale price for the exact time window and duration of the tender
- Upper and lower limits for bidding prices in SA+OU market
- Indicative hours of utilisation

Model parameters and decision variables

SA+OU market parameters

N_a = Total hours of availability required in the tender (Number of days x hours per day) (h)

N_u = Indicative hours of utilisation (h)

U_r = Utilisation rate = $\frac{N_u}{N_a}$

P_a^U = Upper range for availability price (£/MW /h)

P_a^L = Lower range for availability price (£/MW/h)

P_u^U = Upper range for utilisation price (£/MWh)

P_u^L = Lower range for utilisation price (£/MWh)

Wholesale market parameters

P_{WM} = Expected average wholesale price (£/MWh) for the tender period & time window

FSP parameters

Q = Total flexible capacity of FSP for SA + OU and Wholesale markets per hour (MW)

Decision variables of FSP

q_{SA} = Capacity bid or offered to SA + OU per hour (MW)

p_a = Price of availability in the SA + OU bid (£/MW /h)

p_u = Price of utilisation in the SA + OU bid (£/MWh)

q_{WM} = Flexible capacity traded in the wholesale market per hour during the term periods and duration of the tender (MW)

Focus area 1: Optimisation of DSO service procurement

Scenario 1: Modelling FSP decision-making when revenue splitting is not allowed between SA+OU and WM

Model introduction

This model serves as a baseline to measure the impact of the ability to revenue stack to FSPs in general. It can be suitable when revenue is not splittable, due to practices of both markets (e.g. SA+OU (2 mins) and Wholesale Market)

The decision-making process of an FSP can be modelled as a non-linear revenue optimisation model where an FSP tries to maximise the total revenue during the duration and time window of the SA+OU tender by selecting either bidding for SA+OU service or trading in the wholesale market.

$$\max N_a [q_{SA}(p_a + U_r p_u) + q_{WM}(p_{WM})] \quad (1)$$

$$\text{s.t. } q_{SA} + q_{WM} \leq Q \quad (2)$$

$$P_a^L \leq p_a \leq P_a^U \quad (3)$$

$$P_u^L \leq p_u \leq P_u^U \quad (4)$$

$$q_{SA}, q_{WM} \geq 0 \quad (5)$$

Optimal solution

In the objective function (1), total revenue from SA+OU and wholesale market is maximised. Constraint (2) ensures that total delivery cannot be bigger than the asset's entire flexible capacity. Constraint (3) and (4) limit the availability price and utilisation price to be inside the lower and upper range indicated by DSO. Constraint (5) the decision variables of FSP can take only non-negative values.

The optimal solution of this optimisation problem is the capacity allocation of an FSP generating the maximum revenue. Although this model does not contain any binary decision variables in the form of either; sell for SA+OU service, or sell in the wholesale market, it can generate optimal solutions for when revenue splitting is not allowed.

In the optimal solution of this deterministic model, optimal price bids for the SA+OU tender would be:

$$p_{a^*} = P_a^U \text{ and } p_{u^*} = P_u^U.$$

The best strategies are;

- Bid all of the capacity in the SA+OU market if $p_{a^*} + U_r p_{u^*} > p_{WM}$.
- Trade all the capacity in the wholesale market if $p_{a^*} + U_r p_{u^*} < p_{WM}$.
- Allocate the whole capacity as desired, like in (a) and (b) if $p_{a^*} + U_r p_{u^*} = p_{WM}$.

Focus area 1: Optimisation of DSO service procurement

Scenario 1: Modelling FSP decision-making when revenue splitting is not allowed between SA+OU and WM

Pros of the model

- It is easy to understand the reasoning behind each strategy, where the optimal solutions are driven by prices in SA+OU and wholesale markets
- It is proper to use when predictions for wholesale prices are either known through bilateral contracts between seller and the buyer or predicted with a high accuracy
- The model is suitable when two revenue streams are not stackable by splitting.

Further improvements

- Bids/offers for availability and utilisation prices are not guaranteed to be accepted by DSO. As the bid/offered availability and utilisation prices increase, the probability of being rejected might be increased. To make the model more realistic, an uncertainty factor can be added for being accepted in SA+OU tender of DSO.
- Taking every parameter as deterministic or known in advance leads to all-or-nothing solutions. SA+OU service is a more secure revenue stream where availability payments are fixed, and utilisation payments are conditional. On the other hand, wholesale market prices are more volatile and uncertain. This issue will be addressed further throughout the document.

Consideration

- Modelling of the wholesale market as a whole is a black box, since FSPs make bilateral contracts with their buyers, and they can agree on a wholesale trade at any time between years prior, until the start of a settlement period.
- The model spans a 3-month period (typical period of SA+OU), using a forecast for the average wholesale market price, made sense as forecast accuracy over long terms is better. At present, we do not have enough insight into the wholesale agreement to precisely model it.
- Wholesale price, p_{WM} , can be a forecast for a future period, or it could be already a defined number, as per previous contracts. It can be defined as a function of time also.

Focus area 1: Optimisation of DSO service procurement

Scenario 2: Modelling FSP decision-making when revenue splitting is allowed between SA+OU and WM

Introduction to scenario 2

In this model, it is assumed that an FSP is allowed to split its revenue between multiple markets, but it ensures that the revenue splitting is not going to have a negative effect on the ability to commit delivery to the SA+OU service.

This model is suitable for scenarios where revenue splitting has been deemed as either implicitly or explicitly stackable (as outlined in the ENA stackability working group outputs [1]). For this scenario, split stacking is considered between the day ahead SA+OU market and the wholesale market.

In this scenario, FSP can sell the reserved but not utilised capacity by SA+OU market in day-ahead wholesale markets if they do not get utilisation notification from DSO. Therefore, the revenue obtained by selling the not utilised capacity in the wholesale markets are added to the equation so as to illustrate how total revenue could be maximised for FSPs if revenue splitting is possible.

Optimal solution

Since the decision to split revenue is made at the point of SA+OU tendering, forecasted wholesale price is used within the additional revenue term.

$$\max N_a [q_{SA}(p_a + U_r p_u + (1 - U_r)p_{WM}) + q_{WM}(p_{WM})] \quad (6)$$

$$\text{s. t. } q_{SA} + q_{WM} \leq Q \quad (7)$$

$$P_a^L \leq p_a \leq P_a^U \quad (8)$$

$$P_u^U \quad (9)$$

$$P_u^L \leq p_u \leq$$

$$q_{SA}, q_{WM} \geq 0 \quad (10)$$

In the objective function (6), total revenue made from SA+OU service, in the wholesale market and by trading the unutilised capacity reserved for SA+OU services in the day ahead wholesale markets are maximised. Constraint(7) ensures that total delivery cannot be bigger than the FSP's entire flexible capacity. Constraint (8) and (9) limit the availability price and utilisation price to be inside the lower and upper range indicated by DSO.

In Constraint (10), the decision variables of FSP can take only non-negative values.

In an optimal solution, the optimal price bids for the SA+OU tenders become

$$p_a^* = P_a^U \text{ and } p_u^* = P_u^U.$$

For FSPs, the best strategies are;

- Bid all of the capacity in SA + OU market if $p_a^* + U_r p_u^* > U_r p_{WM}$
- Trade all capacity in the wholesale market $p_a^* + U_r p_u^* < U_r p_{WM}$
- Allocate the whole capacity as desired, like in (a) and (b) $p_a^* + U_r p_u^* < U_r p_{WM}$

Focus area 1: Optimisation of DSO service procurement

Scenario 2: Modelling FSP decision-making when revenue splitting is allowed between SA+OU and WM

Comparison of scenario 1 & scenario 2 results

- FSP is incentivised to offer/bid lower prices for availability and utilisation at in Scenario 2 where revenue splitting is allowed than in Scenario 1 where revenue splitting is not allowed.
- For the same utilisation and availability price, FSPs can make more revenue by selling its un-utilised capacity in the wholesale market (in Scenario 2), as the SA+OU service notifies FSPs a day ahead of need for utilisation, and so it could then trade its availability to the wholesale market.
- Utilisation rate, $U_r \in (0,1]$, is the probability of getting utilised by DSO. The optimal solution of Scenario 2 suggests that when revenue splitting between SA+OU and wholesale market is possible, FSPs are willing to bid or offer lower availability and utilisation prices in SA+OU market as the utilisation rate decreases.
- In Scenario 1, the value of utilisation rate does not have an effect on the offered/bid prices in SA+OU market by FSPs.

Pros of the model

- It is easy to understand the reasoning behind each strategy, where the optimal solutions are driven by prices in SA+OU and wholesale markets and extra revenue from stackability of both markets.
- It is proper to use when predictions for wholesale prices are either known through bilateral contracts between seller and the buyer or predicted with a high accuracy.
- The model is suitable when two revenue streams are stackable by splitting where the unutilised capacity by DSO can be traded in day-ahead or intraday wholesale markets.

Further improvements

- Taking every parameter as deterministic or known in advance leads to all-or-nothing solutions. SA+OU service is a more secure revenue stream where availability payments are fixed, and utilisation payments are conditional. On the other hand, wholesale market prices are more volatile and uncertain. This issue will be addressed further throughout the document.

Focus Area 1: Optimisation of DSO service procurement

Scenario 3: Modelling FSP decision-making under uncertainty

Introduction to scenario 3

Optimisation models with deterministic inputs give useful insights. SA+OU is a relatively more stable revenue stream where availability and utilisation payments are fixed well ahead of time, but the utilisation rate is uncertain at tenders. On the other hand, wholesale prices change constantly due to various reasons in the energy market. It is necessary to model the uncertainty of wholesale prices and the utilisation rate of SA+OU service to understand its effect on the FSP's choice of markets to sell its flexibility.

One way of modelling uncertainty between the two markets is to use **Markowitz's Mean-Variance Framework** from the field of portfolio optimisation [2]. In this instance, an FSP is not only interested in maximising their total revenue, but also in minimising their risks, due to the volatility of the wholesale market [3]. For this new model, the asset of new parameters are included:

Model parameters and decision variables

Model parameters

μ_1 : Mean revenue per unit of capacity in SA + OU market (£/MWh)

μ_2 : Mean revenue per unit of capacity in the wholesale market (£/MWh)

σ_1^2 : Variance of the revenue in SA + OU market (£²/MWh²)

σ_2^2 : Variance of the revenue in the wholesale market (£²/MWh²)

$\sigma_{12} = \sigma_{21}$ = Covariance of the revenues in the SA + OU and wholesale market (£²/MWh²)

γ = Risk aversion factor of the FSP ($\gamma > 0$ – Higher γ means less risk prone)

Matrix representation of model parameters

$$\mu = \begin{bmatrix} \mu_1 \\ \mu_2 \end{bmatrix} , \quad V = \begin{bmatrix} \sigma_1^2 & \sigma_{12} \\ \sigma_{21} & \sigma_2^2 \end{bmatrix}$$

Decision variables of FSP

x_1 : Percentage of flexible capacity sold in SA + OU market

x_2 : Percentage of flexible capacity in the wholesale market

Matrix representation of decision variables

$$x = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} ,$$

Focus Area 1: Optimisation of DSO service procurement

Scenario 3: Modelling FSP decision-making under uncertainty

Mathematical model

Below are the matrix notation which are used in the mathematical representation of the optimisation model:

1: One in bold represents a vector of ones

$$\mathbf{1} = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

μ^T, V^T : Transpose of matrices

$$\mu^T = [\mu_1 \quad \mu_2], V^T = \begin{bmatrix} \sigma_1^2 & \sigma_{21} \\ \sigma_{12} & \sigma_2^2 \end{bmatrix}$$

V^{-1} : Inverse of the matrix

$$V^{-1} = \frac{1}{\sigma_1^2 \sigma_2^2 - \sigma_{12} \sigma_{21}} \begin{bmatrix} \sigma_2^2 & -\sigma_{21} \\ -\sigma_{12} & \sigma_1^2 \end{bmatrix}$$

In this model, there are some differences from the first two scenarios. First, FSP decides on what fraction of flexible capacity should be traded at SA+OU and wholesale markets instead of actual capacity during the period that SA+OU tender covers. Second, availability and utilisation prices are assumed to have been determined prior to optimisation (e.g., taken as equal to the upper bound of the price range given by DSO).

The decision-making process of an FSP can be modelled as a quadratic revenue mean-variance optimisation model where FSP tries to maximise the total revenue and minimising the risk associated with their selection of capacity split

$$\max \quad \mu^T x - \frac{1}{2} \gamma x^T V x \quad (11)$$

$$\text{s. t.} \quad \mathbf{1}^T x = \mathbf{1} \quad (12)$$

$$x > \mathbf{0} \quad (13)$$

In the objective function (11), total revenue from SA+OU and wholesale market is maximised and the total risk or uncertainty of the capacity splitting decision into those two markets are minimised. Each FSP has a different response to an existing risk. As the risk aversion factor, γ , gets lower, FSP takes more risks and vice versa. In constraint (12), capacity percentages allocated to each market sums up to one and constraint (13) ensures that these fractions can only be nonnegative values.

Focus area 1: Optimisation of DSO service procurement

Scenario 3: Modelling FSP decision-making under uncertainty

Optimal solution

There are three possibilities to consider in the optimal solution:

1. If an FSP is willing to take the maximum risk possible, then

$$\mathbf{x}^* = \frac{1}{\mathbf{1}^T \mathbf{V}^{-1} \boldsymbol{\mu}} \mathbf{V}^{-1} \boldsymbol{\mu}$$

2. If an FSP is wanting to minimise their risk

$$\mathbf{x}^* = \frac{1}{\mathbf{1}^T \mathbf{V}^{-1} \mathbf{1}} \mathbf{V}^{-1} \mathbf{1}$$

3. For each risk level, the highest revenue return is obtained by combining (1) and (2)

$$\mathbf{x}^* = \lambda \frac{1}{\mathbf{1}^T \mathbf{V}^{-1} \boldsymbol{\mu}} \mathbf{V}^{-1} \boldsymbol{\mu} + (1 - \lambda) \frac{1}{\mathbf{1}^T \mathbf{V}^{-1} \mathbf{1}} \mathbf{V}^{-1} \mathbf{1}$$

where $\lambda \in [0,1]$

For an optimal splitting decision $\mathbf{x}^*$:

$$\boldsymbol{\mu}^T \mathbf{x}^*$$

gives the expected revenue from this decision

$$\sqrt{\mathbf{x}^{*T} \mathbf{V} \mathbf{x}^*}$$

gives the expected standard deviation of the revenue as an indicator of the risk

If a graph is plotted where $\boldsymbol{\mu}^T \mathbf{x}^*$ are $\sqrt{\mathbf{x}^{*T} \mathbf{V} \mathbf{x}^*}$ on the y-axis and x-axis respectively, over different $\mathbf{x}^*$ vectors, then the efficient frontier which includes only optimal solutions for different risk levels can be visualised.

Focus Area 1: Optimisation of DSO service procurement

Scenario 3: Modelling FSP decision-making under uncertainty

Calculation of the model parameters

Two datasets (historical or a forecast of a future state) are needed:

1. For time periods and dates when SA+OU service is requested by the DSO, day-ahead wholesale prices for each settlement period
2. For time periods and dates when SA+OU service is requested by the DSO, whether capacity is reserved for SA+OU capacity is utilised in the flexibility zone of an FSP

Additional parameters

T : set of time periods when SA+OU service is requested

$|T|$: Number of time periods in set T

Every $t \in T$ is a half-hour settlement period and a date, e.g., 28.02.2025 between 17:00 – 17.30

I_{RS} : Is the binary parameter indicating whether revenue splitting is possible

$$I_{RS} = \begin{cases} 1, & \text{if SA + OU and WM is stackable} \\ 0, & \text{otherwise} \end{cases}$$

Time periods	Wholesale price	SA+OU utilised or not (0 or 1)
t_1	$P_{wm}(t_1)$	$U_r(t_1)$
t_2	$P_{wm}(t_2)$	$U_r(t_2)$
...	...	...
...	...	...
...	...	...
$t_{ T }$	$P_{wm}(t_{ T })$	$U_r(t_{ T })$
Average	$\bar{P}_{wm}$	$\bar{U}_r$

From this, the expected revenue an FSP can make with a percentage split of capacity allocated to SA+OU market and the wholesale can be calculated.

When capacity is allocated to the wholesale market, an FSPs revenue is based solely on the prices available from the wholesale market. On the other hand, when capacity is allocated to the SA+OU market, an FSP can make their money as a combination of the scheduled availability payment, and if utilised, the utilisation payment. If stacking is permitted, and capacity goes unutilised in the SA+OU market, an FSP can gain revenue from the wholesale market.

Using this information, the following table can be obtained:

Time periods	Wholesale revenue	SA+OU revenue (Includes revenue from stacking)
t_1	$P_{wm}(t_1)$	$P_a + P_u U_r(t_1) + I_{RS}(1 - U_r(t_1))P_{wm}(t_1)$
t_2	$P_{wm}(t_2)$	$P_a + P_u U_r(t_2) + I_{RS}(1 - U_r(t_2))P_{wm}(t_2)$
...	...	...
...	...	...
...	...	...
$t_{ T }$	$P_{wm}(t_{ T })$	$P_a + P_u U_r(t_{ T }) + I_{RS}(1 - U_r(t_{ T }))P_{wm}(t_{ T })$
Average	$\bar{P}_{wm}$	Average $(P_a + P_u U_r(t) + I_{RS}(1 - U_r(t))P_{wm}(t))$

The model parameters can be computed as:

$$\mu_1 = \text{Average } (P_a + P_u U_r(t) + I_{RS}(1 - U_r(t))P_{wm}(t))$$

$$\mu_2 = \bar{P}_{wm}$$

$$\sigma_1^2 = \text{Variance (SA + OU revenue column)}$$

$$\sigma_1^2 = \text{Variance (Wholesale revenue column)}$$

$$\sigma_{12} = \sigma_{21} = \text{Covariance of SA + OU revenue and wholesale revenue columns}$$

Focus area 1: Optimisation of DSO service procurement

Scenario 3: Modelling FSP decision-making under uncertainty

Scenario 3 conclusions

- The optimisation approach in Scenario 3 is suitable to assess how the optimal capacity splitting decision between two markets are affected by the volatility of the prices in both markets
- FSP can choose the optimal capacity splitting decision and the maximum revenue it brings for each risk level the FSP is willing to take.
- The impact of stackability on the optimal capacity splitting decision and the maximum revenue the FSP makes associated to the same risk level can be measured through experiments with real datasets.
- This model is useful to quantify the impact of procurement timeline of SA+OU tenders as the forecasts for wholesale price and utilisation rates can become more accurate or the risk level FSP is willing to take might change closer to SA+OU service period.

Focus area 1: Optimisation of DSO service procurement

Scenario 4: Optimisation of the SA+OU service procurement

Introduction to scenario 4

DSO covers a region that is made up of a collection of flexibility zones. Each flexibility zone is unique, in that it does not overlap locationally with any other flexibility zone. The DSO makes predictions on both the demand and generation requirements of each flexibility zone based on electricity demand forecast, weather forecasts, contracts of connected generators etc. Periods of higher demand (such as winter teatime or isolated events such as EURO 2024) as well as higher generation (such as heightened wind generation or longer sunny days in the summer) could result in outages if not addressed appropriately.

If the supply or demand is predicted to cause an overload on the system in a flexibility zone, it can be solved by using the flexible capacity of assets in the same zone. The DSO can minimise the balancing costs of each flexibility zone separately, as assets can only provide capacity to their unique flexibility zone.

This scenario is designed to understand how DSO would determine the availability and utilisation fees if DSO was to set SA+OU service payments centrally and targets to minimise its total SA+OU service procurement cost while ensuring that these prices are high enough to incentivise FSPs in the flexibility zone to sell in SA+OU market.

Central pricing problem of the SA+OU service by DSO is an example of a two-player game where the DSO is in the leader role and makes the first move by deciding the prices of the SA+OU service and the FSP reacts to the centrally set prices by determining how much capacity to allocate for SA+OU service. If this was a continuous game, DSO would update the prices with lower values and see if the same level of liquidity in SA+OU market is achieved with lower prices or with higher prices to see if liquidity can be increased. As a response FSP would change its level of flexible capacity to be bid/offered in SA+OU market.

The game would end when neither player is willing to make another move, because they reach an equilibrium point that's optimal to both sides and there is no better option which improves both players at the same time.

Bi-level optimisation problem

Here, a bi-level optimisation model [4] is developed to properly represent the game between a DSO and FSP. This model serves as a decision support tool for the DSO, who want to minimise their total SA+OU service procurement cost, while targeting a liquidity level where DSO anticipates the response, capacity to bid in the SA+OU market, of FSP(s) which seek to maximise their own revenue.

The condition and the needs of the distribution network in each flexibility zone are different. The capacity necessary to balance supply and demand, and the utilisation rate of the available capacity can vary across these zones.

Focus area 1: Optimisation of DSO service procurement

Scenario 4: Optimisation of the SA+OU service procurement

Decision points

In this scenario, the DSO solves an optimisation problem for each flexibility zone. For this purpose, following decisions are made:

Decisions of a DSO

- Availability Price
- Utilisation Price

Decisions of an FSP

- Capacity amount to (MW/h) to bid in the SA+OU
- Capacity amount (MW/h) to trade in wholesale

There are usually multiple FSPs in the flexibility zone participating in DSO tenders. These FSPs are eligible ones which can pass pre-qualification steps of DSO. So, they comply with the rules such as maximum connection voltage, minimum capacity requirement etc.

Model parameters and decision variables

Sets and subsets

T = Set of settlement periods that DSO plans to regulate in the flexibility zone

DSO Parameters

D = Capacity request of DSO (MW/h) in flexibility zone

C = Total flexible capacity (MW/h) in the flexibility zone

L = Liquidity target (%), percentage of DSO request to be met

$\bar{U}_r$ = Expected utilisation rate of the available capacity in the flexibility zone

z^{MAX} = Upper bound on the cost procured flexibility in the flexibility zone

Stackability Parameter

I_{RS} : Is the binary parameter indicating whether revenue splitting is possible

$$I_{RS} = \begin{cases} 1, & \text{if revenue can be split between SA + OU} \\ & \text{and WM as in SA + OU (day-ahead)} \\ 0, & \text{if revenue cannot be split between} \\ & \text{SA + OU and WM as in SA + OU (2-min)} \end{cases}$$

FSP parameters

Same as the model parameters in Scenario 3

DSO Decision Variables

P_a = Price of availability centrally set by DSO (€/MW /h) in the flexibility zone

P_u = Price of utilization centrally set by DSO (€/MWh) in the flexibility zone

z = Cost of overall flexibility procured in the flexibility zone (€)

FSP Decision Variables

x_{SA} = Percentage of the FSP's hourly flexible capacity allocated to SA + OU market ($x_{SA} = x_1$ in scenario 3)

x_{WM} = Percentage of the FSP's hourly flexible capacity allocated to wholesale market ($x_{WM} = x_2$ in scenario 3)

$[x_{SA}^* x_{WM}^*]$ = Optimal percentage allocation as a response to DSO's to SA + OU centrally set prices

Focus area 1: Optimisation of DSO service procurement

Scenario 4: Optimisation of the SA+OU service procurement

Bilevel model

In the bilevel optimisation problem, there are two sides simultaneously optimising their own objectives.

DSO is in the search of optimal availability and utilisation prices that enable them to minimise their overall procurement costs, whilst also incentivising FSPs in the flexibility zone to provide enough capacity to satisfy the requested amount by the DSO.

FSPs in the flexibility zones respond to SA+OU prices set by DSO and then seek to maximise their total revenue for the period when a DSO has requested flexibility through their SA+OU tenders.

Based on these objectives, the optimisation model becomes:

$$\min \quad z = \frac{1}{2} \sum_{t \in T} C \cdot x_{SA}^* \cdot [P_a + \bar{U}_r P_u] \quad (14)$$

$$s. t. \quad C \cdot x_{SA}^* \geq L \cdot D \quad (15)$$

$$z \leq z^{MAX} \quad (16)$$

$$[x_{SA}^* \ x_{WM}^*]^T = \arg \max_x \{ \mu^T x - \frac{1}{2} \gamma x^T V x : \mathbf{1}^T x = \mathbf{1}, x > \mathbf{0} \} \quad (17)$$

$$P_a, P_u, z > 0 \quad (18)$$

The expressions (14) - (18) give the optimisation model of the two player-game between DSO and FSP for a single flexibility zone. The objective function of DSO, (14), is to minimise the total procurement cost of SA+OU service over the service period as requested by DSO. Constraint (15) allows the DSO to set a liquidity target for each tender and the flexible capacity procured must satisfy it. Constraint (16) forces the total cost to be less than an upper bound for procurement cost, which is defined as the present value of the deferred reinforcement cost in the flexibility zone.

If flexibility procurement costs more than this upper bound, DSO evaluates that investing in reinforcement must be preferred rather than delaying it and balance their network through flexibility market. The expression states that FSPs in the flexibility zone respond by optimally allocating their capacity to the SA+OU and wholesale markets to maximise their own revenue and based on the price signals coming from both markets. Last constraint (18), points out the decision variables of DSO which are all nonnegative.

Focus area 1: Optimisation of DSO service procurement

Scenario 4: Optimisation of the SA+OU service procurement

Optimal capacity allocation for FSP

From Scenario 3, it is determined that the optimal allocation of an FSP can be written in analytical form. Then, expression (17) can be replaced by:

$$[x_{SA}^* \ x_{WM}^*]^T = \lambda \frac{1}{1^T V^{-1} \mu} V^{-1} \mu + (1 - \lambda) \frac{1}{1^T V^{-1} \mathbf{1}} V^{-1} \mathbf{1}$$

Since the allocated capacity to the wholesale market x_{WM}^* not used anywhere else in the optimisation model, it can be removed permanently. After carrying out the matrix calculation, optimal capacity allocation to SA+OU, , becomes x_{SA}^*

$$x_{SA}^* = \lambda \frac{\mu_1 \sigma_2^2 - \mu_2 \sigma_{12}}{\mu_1 \sigma_2^2 + \mu_2 \sigma_1^2 - (\mu_1 + \mu_2) \sigma_{12}} + (1 - \lambda) \frac{\sigma_2^2 - \sigma_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}}$$

Recall, that in Scenario 3, all prices have been given values and the mean and variance of the revenues from different streams can be calculated from available data. However, in this scenario, SA+OU prices are decision variables of the DSO. Hence, mean and variance should be written down as a function of availability and utilisation prices.

The datasets in Scenario 3 are used to calculate mean and variance of SA+OU and wholesale revenue of FSPs.

Mean revenue calculation

The datasets presented in scenario 3 are used to calculate mean and variance of SA+OU and wholesale revenue of FSPs.

Mean Revenue from SA+OU service, as a function of SA+OU fees:

$$\mu_1 = \frac{1}{|T|} \sum_{t \in T} P_a + U_r(t) \cdot P_u + I_{RS}(1 - U_r(t)) P_{WM}(t)$$

$$\mu_1 = P_a + \overline{U_r} \cdot P_u + \frac{1}{|T|} \sum_{t \in T} I_{RS}(1 - U_r(t)) P_{WM}(t)$$

Mean Revenue from Wholesale Market

$$\mu_2 = \frac{1}{|T|} \sum_{t \in T} P_{WM}(t) \Rightarrow \mu_2 = \bar{P}_{WM}$$

Variance of revenues

Variance of SA+OU revenue as a function of SA+OU fees:

$$\sigma_1^2 = \text{Var}[P_a + U_r P_u + I_{RS}(1 - U_r) P_{WM}]$$

$$\sigma_1^2 = \text{Var}[U_r P_u + I_{RS}(1 - U_r) P_{WM}]$$

$$\sigma_1^2 = \text{Var}[U_r P_u] + \text{Var}[I_{RS}(1 - U_r) P_{WM}]$$

$$+ 2 \text{Cov}[U_r P_u, I_{RS}(1 - U_r) P_{WM}]$$

$$\sigma_1^2 = P_u^2 \cdot \text{Var}[U_r] + \text{Var}[I_{RS}(1 - U_r) P_{WM}]$$

$$+ 2 P_u \text{Cov}[U_r, I_{RS}(1 - U_r) P_{WM}]$$

✓ $\text{Var}[U_r]$ is the variance of the data $U_r(t)$ for $t \in |T|$

✓ $\text{Var}[I_{RS}(1 - U_r) P_{WM}]$ is the variance of the elementwise multiplied column which contains $I_{RS}(1 - U_r(t)) P_{WM}(t)$ values over $t \in |T|$.

Variance of Wholesale Revenue

$$\sigma_2^2 = \text{Var}[P_{WM}]$$

✓ $\text{Var}[U_r]$ is the variance of the data $P_{WM}(t)$ for $t \in |T|$

Focus area 1: Optimisation of DSO service procurement

Scenario 4: Optimisation of the SA+OU service procurement

Covariance of revenues

Covariance of SA+OU and Wholesale Revenue

$$\sigma_{12} = \sigma_{21} = \text{Cov}[P_a + U_r P_u + I_{RS}(1 - U_r)P_{WM}, P_{WM}]$$

$$\sigma_{12} = \sigma_{21} = \text{Cov}[U_r P_u + I_{RS}(1 - U_r)P_{WM}, P_{WM}]$$

$$\sigma_{12} = \sigma_{21} = \text{Cov}[U_r P_u, P_{WM}] + \text{Cov}[I_{RS}(1 - U_r)P_{WM}, P_{WM}]$$

$$\sigma_{12} = \sigma_{21} = P_u \text{Cov}[U_r, P_{WM}] + \text{Cov}[I_{RS}(1 - U_r)P_{WM}, P_{WM}]$$

✓ $\text{Cov}[U_r, P_{WM}]$ is the covariance of the data columns

$U_r(t)$ and $P_{WM}(t)$ for $t \in |T|$

✓ $\text{Cov}[I_{RS}(1 - U_r)P_{WM}, P_{WM}]$ is the covariance of the

data columns $I_{RS}(1 - U_r(t))P_{WM}(t)$ and $P_{WM}(t)$ for $t \in |T|$

Equivalent single level nonlinear model

Based on the previous information, the overall formulation becomes:

$$\min \quad z = \frac{1}{2} \sum_{t \in T} C \cdot x_{SA}^* \cdot [P_a + \bar{U}_r P_u] \quad (19)$$

$$s. t. \quad C \cdot x_{SA}^* \geq L \cdot D \quad (20)$$

$$z \leq z^{MAX} \quad (21)$$

$$x_{SA}^* = \lambda S_1 + (1 - \lambda) S_2 \quad (22)$$

$$S_1 = \frac{\mu_1 \sigma_2^2 - \mu_2 \sigma_{12}}{\mu_1 \sigma_2^2 + \mu_2 \sigma_1^2 - (\mu_1 + \mu_2) \sigma_{12}} \quad (23)$$

$$S_2 = \frac{\sigma_2^2 - \sigma_{12}}{\sigma_1^2 + \sigma_2^2 - 2\sigma_{12}} \quad (24)$$

$$\mu_1 = P_a + k_1 P_u + c_1 \quad (25)$$

$$\mu_2 = c_2 \quad (26)$$

$$\sigma_1^2 = k_2 (P_u)^2 + 2k_3 P_u + c_3 \quad (27)$$

$$\sigma_2^2 = c_4 \quad (28)$$

$$\sigma_{12} = k_4 P_u + c_5 \quad (29)$$

$$P_a, P_u, z, S_1, S_2 > 0 \quad (30)$$

where;

$$c_1 \quad \text{Average}(I_{RS}(1 - U_r(t))P_{WM}(t))$$

$$c_2 \quad \text{Average}(P_{WM}(t))$$

$$c_3 \quad \text{Variance}(I_{RS}(1 - U_r(t))P_{WM}(t))$$

$$c_4 \quad \text{Variance}(P_{WM}(t))$$

$$c_5 \quad \text{Covariance}(I_{RS}(1 - U_r(t))P_{WM}(t), P_{WM}(t))$$

$$k_1 \quad \text{Average}(U_r(t))$$

$$k_2 \quad \text{Variance}(U_r(t))$$

$$k_3 \quad \text{Covariance}(U_r(t), I_{RS}(1 - U_r(t))P_{WM}(t))$$

$$k_4 \quad \text{Covariance}(U_r(t), P_{WM}(t))$$

The proposed bilevel optimisation model is transformed into a single level nonlinear optimisation model by replacing the optimisation problem in expression (17) by the analytical form of the optimal solution for FSPs revenue maximisation problem in Scenario 3. The single level formulation (19)-(30) can be solved by nonlinear optimisation solvers.

Focus area 1: Optimisation of DSO service procurement

Scenario 4: Optimisation of the SA+OU service procurement

Scenario conclusions

- The optimisation approach is developed to find the optimal availability and utilisation fees which gives the minimum SA+OU procurement cost, whilst satisfying a targeted liquidity in the SA+OU market.
- The model is proposed to support DSOs to make pricing decisions, taking into account the FSPs optimal response who seek to maximise their own revenues by splitting their capacity into two markets.
- This model returns SA+OU fees at equilibrium, i.e. minimum DSO costs and maximum FSP revenue

Model pros: Uncertainty modelling included

- This model serves as a basis to measure the impact of expected/ forecasted revenues from both the SA+OU and wholesale markets, as well as the volatility of both revenue streams on the pricing strategy of the DSO.
- This model is useful to quantify the impact of procurement timelines of the SA+OU tenders, as the forecasts for wholesale price and utilisation rates can become more accurate, or the risk level an FSP is willing to take might change closer to the SA+OU service period.

Focus area 2: Modelling specific FSPs and asset types

How FSPs can choose to respond to directional requirements from DSOs in flexibility zones

Introduction to section 2

Throughout section 2, there are three types of FSP considered:

- **FSP1:** A demand response unit/load unit, e.g. warehouse with freezers, a fleet of EVs, etc.
- **FSP2:** A generator (must be dispatchable, as intermittent generation is not suitable in the SA+OU market)
- **FSP3:** A storage unit or a battery

It should also be noted that the flexibility required for each zone can be described as either upward regulated or downward regulated.

- **Upward Regulated:** Where demand is likely to exceed supply locally within a flexibility zone. A DSO needs responses from FSPs by reducing demand or turning up generation.
- **Downward Regulated:** Where demand is likely to be lower than supply within a flexibility zone. A DSO needs responses from FSPs by increasing demand or turning down or turning off generation.

In this section, it's considered that an FSP located in a flexibility zone where DSO regulation is, is looking to maximise their revenue using a deterministic approach, as in Section 1: Scenario 1 and Scenario 2.

There is an assumption that an FSP may sell some of their flexibility capacity in the forward wholesale markets, and that they can sell their reserved, but not utilised, flexible capacity from the SA+OU market within the day-ahead wholesale markets.

An FSP can decide whether or not to bid/ offer in the DSO SA+OU tenders, based on the historic wholesale market price predictions when an SA+OU tender is live.

During the SA+OU service window, a DSO can request flexible capacity from an FSP, the same amount per hour which should be available during the dates and time windows specified within the SA+OU tender.

For better illustration, it is assumed that DSO needs regulation **at 28th February between the hours of 6 and 7pm.**

At the time of SA+OU tender, assume FSP already has a forecasted state for the date 28th February between the hours of 6 and 7pm.

For FSP1 – A demand response unit

Denoting the FSPs forecasted consumption as L_f between 6 and 7 pm. It's able to use L_f^{MAX} , as outlined in connection agreements.

Based on the above, an FSP therefore has an amount of flexible capacity, which can be denoted as:

- Equal to L_f if an up-regulation is requested by the DSO.
- Equal to $L_f^{MAX} - L_f$ if a down-regulation is requested by the DSO

Here, FSP can respond to an up-regulation by scheduling more generation in a specific time window.

An FSP can respond to down-regulation by shifting its demand to alternative time windows, such as postponing EV charging, or switching off freezers in a warehouse.

Note: FSP is also available to sell its flexible capacity in the wholesale market.

Focus area 2: Modelling specific FSPs and asset types

How FSPs can choose to respond to directional requirements from DSOs in flexibility zones

For FSP2 – A generator

Denoting the FSPs baseline electricity generation as BL_f between 6 and 7pm. It also has a maximum amount of generation it can provide as C^{MAX} .

Therefore, FSP has an amount of flexible capacity, equal to or less than C^{MAX} , which can be denoted as;

- $C^{MAX} - BL_f$ if an up-regulation is requested by DSO.
- Equal to BL_f if down-regulation is requested by DSO.

However, in this use case, BL_f amount could vary across different DSOs, and it may not accurately represent the actual production levels if this FSP has not committed to the SA+OU market.

In the event of an FSP responding to an up-regulation by the DSO, BL_f will be considered as 0 by the DSO. In this instance, the DSO will pay the FSP the amount of generation that deviates from 0.

In the event of FSP responding to a down-regulation by the DSO, the BL_f will be denoted as C^{MAX} . In this instance, the DSO will pay the FSP the amount of generation which has deviated from its maximum generation capacity

Note: Currently FSP can commit a flexible capacity C_f less than C^{MAX} , considering other commitments of the generator in other markets, but it could also deliver up to C^{MAX} during a stated period, as over-delivery does not at present create a network constraints problem on distribution network. This means that the FSP can generate more than what it has committed to a DSO service, in order to sell surplus capacity in alternative markets. However, the DSO will not pay for the over-delivery.

For FSP3 – A battery owner

This FSP is able to real-time respond to both upwards and downward regulations. Its baseline electricity generation, BL_f , is assumed to be its maximum export ME_F where there is upwards regulation and maximum import MI_F where there is downward regulation.

- BL_f as zero if a battery is charging to respond a down-regulation requested by DSO.
- BL_f as maximum storage capacity if a battery is discharging to respond an up-regulation requested by DSO.

Note: FSPs flexible capacity C_f can be set to any amount as $C_f \leq ME_f$ in an upward regulation request and $C_f \leq MI_f$ in a downward regulation request based on the other commitments of the battery in the same time window. A battery can provide its flexible capacity, C_f , but it will only get paid for capacity committed through services.

Focus area 2: Modelling specific FSPs and asset types

Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation

Modelling directional decisions

Different FSP types have different production technologies, hence there are different costs and profits from the same revenue. A unit price of availability and utilisation for SA+OU service, which is attractive to demand response units, may not be incentivising enough for generators or batteries.

In this scenario, a model is developed based on the assumption that prices for generation, demand response and battery responses could be different in the wholesale market.

Additional notation is given as:

$P_{WM,D}^F$ = average predicted forward price for wholesale market demand

$P_{WM,D}^{DA}$ = average predicted day-ahead price for wholesale market demand

$P_{WM,G}^F$ = average predicted forward price for wholesale market generation

$P_{WM,G}^{DA}$ = average predicted day-ahead price for wholesale market generation

$P_{WM,B}^F$ = average predicted forward price for battery responses

$P_{WM,B}^{DA}$ = average predicted day-ahead price for battery responses

ϵ = a very small non-negative value (e.g., 0.0001) defined for computational purposes.

There are two cases to consider in this scenario;

- A DSO requests an upward regulation from an FSP
- A DSO requests a downward regulation from an FSP

Case A: A DSO requests an upwards regulation

An FSP has a choice of three options when receiving an upwards regulation from a DSO:

- Demand Decrease

At the time of an SA+OU tender being held, $p_{WM,D}^F$ and $p_{WM,D}^{DA}$ sell are forecasts for the prices an FSP can sell its demand decrease response in the wholesale market during the period when DSO requests a demand decrease response through SA+OU.

- Generation Increase

At the time of the SA+OU tender being held, $p_{WM,G}^F$ and $p_{WM,G}^{DA}$ are forecasts for the prices an FSP can sell its generation in the wholesale market, during the period when DSO requests a generation increase through SA+OU.

- Battery Discharge

At the time of the SA+OU tender being held, $p_{WM,B}^F$ and $p_{WM,B}^{DA}$ are forecasts for the prices an FSP can sell its battery discharge (generation in this case) in the wholesale market during the period when DSO requests a generation increase through SA+OU.

Note, here (b) and (c) could be the same price.

Focus area 2: Modelling specific FSPs and asset types

Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation

Case B: A DSO requests a downwards regulation

An FSP has a choice of three options when receiving a downwards regulation from a DSO:

- Demand Increase

At the time of SA+OU tender being held, $p_{WM,D}^F$ and $p_{WM,D}^{DA}$ are forecasts for the prices FSP is paid for increasing its demand in the forward and day-ahead wholesale markets during SA+OU service period.

- Generation Decrease

At the time of the SA+OU tender being held, $p_{WM,G}^F$ and $p_{WM,G}^{DA}$ are forecasts for the prices an FSP is paid to reduce its generation in the wholesale market, during the period when DSO requests a generation increase through SA+OU.

- Battery Charge

At the time of the SA+OU tender being held, $p_{WM,B}^F$ and $p_{WM,B}^{DA}$ are forecasts for the prices an FSP is paid to charge its battery in the wholesale market during the period when DSO requests a generation increase through SA+OU.

Note: Here, demand increase, and battery charge could be paid the same price.

Modelling next steps

- If FSP chooses to sell its flexibility only in the day-ahead markets, all prices for forward markets are replaced by the day-ahead price.
- Although the assumption that the DSO utilisation rate, day-ahead market prices and forecasted forward wholesale market values are uncertain, a deterministic case can give increased insights when the forecasts have high accuracy, or the forecasts have low variance and low bias.
- For this deterministic case, every FSPs optimal capacity allocation to the SA+OU service is based on the revenue that it can earn from the SA+OU and wholesale markets. This can be written as a collection of piecewise linear functions.

Focus area 2: Modelling specific FSPs and asset types

Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation

Scenario 5: Introducing the model parameters and decision variables

This scenario defines a bilevel optimisation model to simulate the decision pathways an FSP has when a DSO requests a directional regulation.

Sets and subsets

- $T =$ Set of settlement periods that DSO plans to regulate
- $B =$ Set of storage units (batteries) indexed by $b \in B$
- $G =$ Set of generators indexed, by $g \in G$
- $K =$ Set of demand response units, flexible loads, $k \in K$
- $F =$ Set of all flexibility providers in the flexibility zone, $f \in F, F = B \cup G \cup K$.

DSO parameters

- $D =$ Capacity request of DSO (MW/h) in the flexibility zone
- $L =$ Liquidity target (%) – percentage of DSO request to be met.
- $U_r =$ Expected utilisation rate of the available capacity in the flexibility zone.
- $z^{MAX} =$ Upper bound on the cost of procured flexibility in the flexibility zone (£)

FSP parameters

- $C_f =$ Flexible capacity of FSP f in the flexibility zone (MW/h)
- $q^{MAX} =$ Maximum capacity FSP can provide per tender, set by DSO (MW/h)
- $I_{RS} =$ Binary parameter indicating whether revenue splitting is possible
- $I_{RS} = \begin{cases} 1, & \text{if revenue can be split between SA + OU and WM as in SA + OU (day – ahead)} \\ 0, & \text{if revenue cannot be split between SA + OU and WM as in SA + OU (2 – min)} \end{cases}$

Wholesale Market Parameters

- $P_{WM}^F =$ Average forward markets wholesale price prediction for periods in T (£/MWh)
- $P_{WM}^{DA} =$ Average day ahead market wholesale price prediction for periods in T (£/MWh)

DSO Decision Variables

- $P_a =$ Price of availability centrally set by DSO (£/MW /h) in the flexibility zone
- $P_u =$ Price of utilization centrally set by DSO (£ MWh) in the flexibility zone
- $z =$ Cost of overall flexibility procured in the flexibility zone (£)

FSP Decision Variables

- $q_f =$ Fixed hourly available capacity offered or bid for SA + OU by flexibility provider $f \in F$

Focus area 2: Modelling specific FSPs and asset types

Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation

Bilevel optimisation model

In this scenario, the optimisation problem is considered a bilevel optimisation problem (as in Scenario 4), where DSO and FSPs simultaneously optimise their own decisions towards their objective functions.

DSOs seek the optimal availability and utilisation prices that enable them to minimise their overall procurement costs, whilst also incentivising FSPs in the flexibility zone to provide enough capacity to satisfy the requested amount by the DSO and taking into account how much capacity FSPs would bid/offer as a response to SA+OU prices

FSPs in the flexibility zones respond to the set prices by DSO and then seek to maximise their total revenue for the SA+OU period.

The bilevel optimisation model becomes:

$$\min \quad z = \frac{1}{2} \sum_{t \in T} \sum_{f \in F} q_f^* [P_a + U_r P_u] \quad (31)$$

$$s. t. \quad \sum_{f \in F} q_f^* \geq L \cdot D \quad (32)$$

$$z \leq z^{MAX} \quad (33)$$

$$q_f^* = \arg \max_x \left\{ \frac{1}{2} \sum_{t \in T} q_f [P_a + U_r P_u] + (C_f - q_f) P_{WM}^F + I_{RS} \cdot (1 - U_r) \cdot q_f \cdot P_{WM}^{DA} \right\}:$$

$$q_f \leq \min(C_f, D), q_f \geq 0 \quad \forall f \in F \quad (34)$$

$$P_a, P_u, z > 0 \quad (35)$$

The expressions (31)-(35) give the optimisation model of the two player-game between DSO and FSP for a single flexibility zone. The objective function of DSO, (31), is to minimise the total SA+OU procurement cost.

Constraint (32) enforces that the capacity offered/bid must be at least at the targeted liquidity level and total procurement cost must be less than the present value of the deferred reinforcement cost as implied by Constraint (33). The expression (34) states that every FSP in the flexibility zone respond to the centrally set SA+OU prices by maximising their own revenue in a deterministic setting as in Scenario 1 or Scenario 2.

In the optimisation problem, an FSP stated in expression (34), the objective function is composed of 3 terms, where;

- $q_f [P_a + U_r P_u]$ is the hourly revenue from the SA+OU market
- $(C_f - q_f)$ is the average revenue per hour from the wholesale market through contracts ahead of dispatch time
- $I_{RS} \cdot (1 - U_r) \cdot q_f \cdot P_{WM}^{DA}$ is the average hourly revenue from the wholesale day-ahead and intra day markets. This revenue measures the impact of splitting between the SA+OU market of a DSO and the wholesale markets. This is possible when the FSP knows they are not to be utilised in the DSO market.

Focus area 2: Modelling specific FSPs and asset types

Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation

Maximum revenue function of FSPs

The optimal capacity allocation of FSPs which are represented as piecewise linear function mentioned previously can be written as below;

$$q_f^* = \begin{cases} \min(C_f, D, q^{MAX}), & \text{if } P_a + U \cdot P_u \geq P_{WM,D}^F - I_{RS}(1-U)P_{WM,D}^{DA} + \epsilon \\ 0, & \text{otherwise} \end{cases} \quad f \in K \subseteq F$$

$$q_f^* = \begin{cases} \min(C_f, D, q^{MAX}), & \text{if } P_a + U \cdot P_u \geq P_{WM,G}^F - I_{RS}(1-U)P_{WM,G}^{DA} + \epsilon \\ 0, & \text{otherwise} \end{cases} \quad f \in G \subseteq F$$

$$q_f^* = \begin{cases} \min(C_f, D, q^{MAX}), & \text{if } P_a + U \cdot P_u \geq P_{WM,B}^F - I_{RS}(1-U)P_{WM,B}^{DA} + \epsilon \\ 0, & \text{otherwise} \end{cases} \quad f \in B \subseteq F$$

This then makes the overall formulation of the optimisation problem of a DSO as:

$$\min z = z = \frac{1}{2} \sum_{t \in T} \sum_{f \in F} q_f^* [P_a + U_r P_u]$$

$$\text{s. t. } \sum_{f \in F} q_f^* \geq L \cdot D$$

$$z \leq z^{MAX}$$

$$P_a, P_u, z > 0 > 0$$

$$q_f^* = \begin{cases} \min(C_f, D, q^{MAX}), & \text{if } P_a + U \cdot P_u \geq P_{WM,D}^F - I_{RS}(1-U)P_{WM,D}^{DA} + \epsilon \\ 0, & \text{otherwise} \end{cases} \quad f \in K \subseteq F$$

$$q_f^* = \begin{cases} \min(C_f, D, q^{MAX}), & \text{if } P_a + U \cdot P_u \geq P_{WM,G}^F - I_{RS}(1-U)P_{WM,G}^{DA} + \epsilon \\ 0, & \text{otherwise} \end{cases} \quad f \in G \subseteq F$$

$$q_f^* = \begin{cases} \min(C_f, D, q^{MAX}), & \text{if } P_a + U \cdot P_u \geq P_{WM,B}^F - I_{RS}(1-U)P_{WM,B}^{DA} + \epsilon \\ 0, & \text{otherwise} \end{cases} \quad f \in B \subseteq F$$

$$q_f^* \geq 0, \quad f \in F$$

Calculating the optimal price for the SA+OU service

Assuming there are distinct prices for wholesale demand and generation, as well as the battery response, there are three break-even points for the value offered for;

$$P_a + U_r P_u$$

$$\text{a) } P_{WM,D}^F - I_{RS}(1-U)P_{WM,D}^{DA}$$

$$\text{b) } P_{WM,G}^F - I_{RS}(1-U)P_{WM,G}^{DA}$$

$$\text{c) } P_{WM,B}^F - I_{RS}(1-U)P_{WM,B}^{DA}$$

Assume that $c > b > a$, and so $P_a + U_r P_u$ must be at least equal to;

1. The value given in (a), so as to attract demand responses
2. The value given in (b), so as to attract both demand and generation responses
3. The value given in (c), so as to attract demand, generation and battery responses

Depending on instruction from a DSO, in the form of upward-regulation or downward-regulation, a battery response can be equal to that demand or generation response. This means that there will be two break-even points to attract demand and generation responses.

Focus area 2: Modelling specific FSPs and asset types

Scenario 5: Optimisation of SA+OU service procurement considering different types of FSPs and their response under directional regulation

Optimal pricing strategies for DSO

Pros

In this scenario, the optimisation model returns three optimal SA+OU fees at the equilibrium : Minimum DSO costs and maximum FSP revenue when FSPs are categorised into 3 main groups and the minimum SA+OU price which is attractive to each category is different. The participation level in SA+OU tenders hence the liquidity of the market will be different at different choices for SA+OU prices.

Cons

In this scenario, all input data is treated as deterministic leading to all-or-nothing solutions. In other words, FSP either puts all its capacity int SA+OU market or not depending on SA+OU and wholesale price signals.

Future Steps

Developing more complex models where wholesale price forecasts and SA+OU utilisation rates are uncertain parameters and the risk averseness of specific FSPs are incorporated to picture a more realistic setting.

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

Introduction to scenario 6

This model now outlines the optimisation problem when an FSP chooses to act in the opposite direction to a DSO directional request. The FSP should consider price signals coming from all directions and will likely only respond to a DSO request if it is more profitable to do so than moving in the opposite direction of this request.

Assumption: The FSP is choosing to sell its flexibility in the day-ahead markets, so all prices for forward markets p_{WM}^F are replaced by the day-ahead prices p_{WM}^{DA} .

Assumption: The DSO is requesting an upwards-regulation

FSP1 – Demand response unit

Referring back to Section 2, Scenario 5 where the FSPs forecast usage is denoted as L_f between 6 and 7pm and is allowed to use up to L_f^{MAX} , which is imposed by connection agreements and denoted as the maximum import capacity for electricity demand sites.

The FSP has **FOUR** options for this time period:

- Option 1: Decrease its demand for this period and sell its flexibility in the SA+OU market
- Option 2: Decrease its demand for this period and sell its flexibility in the wholesale market
- Option 3: Increase its demand for this period and sell its flexibility in the wholesale market
- Option 4: Do nothing and keep demand at planned level L_f

Model variables

Denoting the following

C_f^{up} : Flexible capacity an FSP can provide by decreasing its demand ($C_f^{up} = L_f$)

C_f^{down} : Flexible capacity an FSP can provide by decreasing its demand ($C_f^{down} = L_f^{MAX} - L_f$)

p_1 : profit per unit of capacity (£/MWh) by choosing option 1

p_2 : profit per unit of capacity (£/MWh) by choosing option 2

p_3 : profit per unit of capacity (£/MWh) by choosing option 3

Decision Variables

x_1 = fraction of flexible capacity C_f^{up} sold in SA+OU

x_{up} = 1 if an FSP decides to decrease its demand, 0 if not

x_{down} = 1 if an FSP decides to increase its demand, 0 otherwise

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

Optimisation model to maximise it's profit

$$\begin{aligned}
 \max \quad & p_1 C_f^{up} x_1 + p_2 C_f^{up} (x_{up} - x_1) + p_3 C_f^{down} (x_{down}) \\
 \text{s.t.} \quad & x_1 - x_{up} \leq 0 \\
 & x_{up} + x_{down} \leq 1 \\
 & x_1 \geq 0 \\
 & x_{up}, x_{down} \in \{0,1\}
 \end{aligned}$$

Note that $x_1 \in [0,1]$ ion. However, there is no need to put the upper bound of 1 for x_1 , as that bound is already implied by other constraints. Linear programming (LP) relaxation of this optimisation model is obtained by relaxing the integrality constraints on decision variables x_{up} and x_{down} :

$$\begin{aligned}
 \max \quad & p_1 C_f^{up} x_1 + p_2 C_f^{up} (x_{up} - x_1) + p_3 C_f^{down} (x_{down}) \\
 \text{s.t.} \quad & x_1 - x_{up} \leq 0 \\
 & x_{up} + x_{down} \leq 1 \\
 & x_1, x_{up}, x_{down} \geq 0
 \end{aligned}$$

LP relaxation allows all integer variables to take continuous values between 0 and 1. Since, the constraint matrix of LP relaxation is totally unimodular and the right-hand side is an integer, LP generates always integer optimal solutions. Hence LP relaxation can be used instead of the original formulation.

There are 4 possible optimal solutions:

$$[x_1 \ x_{up} \ x_{down}] = \{[1 \ 1 \ 0], [0 \ 1 \ 0], [0 \ 0 \ 1], [0 \ 0 \ 0]\}$$

- $[1 \ 1 \ 0]$ is optimal if $p_1 \geq \max\{p_2, \frac{p_3 C_f^{down}}{C_f^{up}}\}$ **Optimality Condition to offer/bid in SA/OU market**
- $[0 \ 1 \ 0]$ is optimal if $p_2 \geq \max\{p_1, \frac{p_3 C_f^{down}}{C_f^{up}}\}$
- $[0 \ 0 \ 1]$ is optimal if $p_3 \geq \frac{C_f^{up}}{C_f^{down}} \max\{p_1, p_2\}$
- $[0 \ 0 \ 0]$ is optimal if $p_1, p_2, p_3 \geq 0$

Interpretation of the parameters

$$p_1 = p_a + U \cdot p_u + I_{RS}(1 - U)p_{WM,D-}^{DA} - h_f^{d-}$$

$$p_2 = p_{WM,D-}^{DA} - h_f^{d-}$$

$$p_3 = p_{WM,D+}^{DA} - h_f^{d+}$$

Where;

$p_{WM,D+}^{DA}$: unit price of demand increase in the wholesale market (£/MWh)

$p_{WM,D-}^{DA}$: unit price of demand decrease in the wholesale market (£/MWh)

h_f^{d+} : unit cost of increasing electricity demand for flexibility provider $f \subseteq K$ (£/MWh)

h_f^{d-} : unit cost of decreasing electricity demand for flexibility provider $f \subseteq K$ (£/MWh)

Based on these interpretations, if there are opportunities in the wholesale market in both directions for FSPs, the optimal capacity FSP f offers to the SA+OU service can be derived from the optimality condition given above and written overleaf.

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

Optimal capacity provided to SA+OU service

$$q_f^* = \begin{cases} \min(C_f, D^{DSO}, q^{MAX}), & \text{if } p_a + U \cdot p_u \geq \max\{p_{WM,D-}^{DA} - h_f^{d-}, \frac{(p_{WM,D+}^{DA} - h_f^{d+}) \cdot C_f^{down}}{C_f^{up}}\} - I_{RS}(1-U)p_{WM,D-}^{DA} + h_f^{d-} + \epsilon \\ 0, & \text{otherwise} \end{cases}$$

for $f \subseteq K \subseteq F$

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

FSP2: Generator

Denoting the FSPs baseline electricity production as W_f between 6 and 7pm and the maximum generation it can provide as C^{MAX} .

An FSP has three options for this period:

- Option 1: Increase its generation and sell its flexibility in the SA+OU market
- Option 2: Increase its generation and sell its flexibility in the wholesale market
- Option 3: Keep its generation at planned production level W_f and sell this downward flexibility (by keeping its production at reduced level) in the wholesale market

Model variables

Denoting the following

C_f : Flexible capacity an FSP can provide by downwards or upwards

p_1 : profit per unit of capacity (£/MWh) by choosing option 1

p_2 : profit per unit of capacity (£/MWh) by choosing option 2

p_3 : profit per unit of capacity (£/MWh) by choosing option 3

Decision Variables

x_1 = fraction of flexible capacity C_f^{up} sold in SA+OU

x_{up} = 1 if an FSP decides to increase its generation, 0 otherwise

Optimisation model to maximise profit

$$\begin{aligned} \max \quad & p_1 C_f x_1 + p_2 C_f (x_{up} - x_1) + p_3 C_f (1 - x_{up}) \\ \text{s.t.} \quad & x_1 - x_{up} \leq 0 \\ & x_1, x_{up} \in \{0, 1\} \end{aligned}$$

Note that $x_1 \in [0, 1]$ by definition. However, there is no need to put the upper bound of 1 for x_1 , as that bound is already implied by other constraints. Linear programming (LP) relaxation of this optimisation model is obtained by relaxing the integrality constraints on decision variables x_{up} :

$$\begin{aligned} \max \quad & p_1 C_f x_1 + p_2 C_f (x_{up} - x_1) + p_3 C_f (1 - x_{up}) \\ \text{s.t.} \quad & x_1 - x_{up} \leq 0 \\ & x_{up} \leq 1 \\ & x_1, x_{up} \geq 0 \end{aligned}$$

LP relaxation allows all integer variables to take continuous values between 0 and 1. Since the constraint matrix of LP relaxation is totally unimodular and the right-hand side is in integer, LP generates always integer optimal solutions. Hence, LP relaxation can be used instead of the original formulation.

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

Interpretation of the parameters

There are three optimal possible solutions:

$$[x_1 \ x_{up}] = \{[1 \ 1], [0 \ 1], [0 \ 0]\}$$

- [1 1] is optimal if $p_1 \geq \max\{p_2, p_3\}$ **Optimality Condition to offer/bid in SA/OU market**
- [0 1] is optimal if $p_2 \geq \max\{p_1, p_3\}$
- [0 0] is optimal if $p_3 \geq \max\{p_1, p_2\}$

$$p_1 = p_a + U \cdot p_u + I_{RS}(1 - U)p_{WM,G+}^{DA} - h_f^{g+}$$

$$p_2 = p_{WM,G+}^{DA} - h_f^{g+}$$

$$p_3 = p_{WM,G-}^{DA} - h_f^{g-}$$

Where,

$p_{WM,G+}^{DA}$: unit price of demand increase in the wholesale market (£/MWh)

$p_{WM,G-}^{DA}$: unit price of demand decrease in the wholesale market (£/MWh)

h_f^{g+} : unit cost of increasing electricity demand for flexibility provider $f \subseteq K$ (£/MWh)

h_f^{g-} : unit cost of decreasing electricity demand for flexibility provider $f \subseteq K$ (£/MWh)

Optimal capacity provided to SA+OU service

Based on these interpretations, if there are opportunities in the wholesale market in both directions for FSPs, the optimal capacity FSP f offers to the SA+OU service can be derived from the optimality condition given above and written as follows

$$q_f^* = \begin{cases} \min(C_f, D^{DSO}, q^{MAX}), & \text{if } p_a + U \cdot p_u \geq \max\{p_{WM,D-}^{DA} - h_f^{d-}, p_{WM,D+}^{DA} - h_f^{d+}\} - I_{RS}(1 - U)p_{WM,D-}^{DA} + h_f^{d-} + \epsilon \\ 0, & \text{otherwise} \end{cases}$$

for $f \subseteq G \subseteq F$

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

FSP2: Battery owner

If FSP has a battery asset, FSP makes charging or discharging decisions not only considering not only the time window DSO requests the upward or downward regulation but also the time periods before and after that time window. Battery can discharge a maximum export amount denoted as ME_f and charge a minimum export amount denoted as MI_f per hour (MW/h).

Denoting the following:

p_t^{in} = unit price of charging battery in period t (£/MWh)

p_t^{out} = unit profit of discharging battery in period t (£/MWh)

p_{SA} = expected profit by selling in the SA+OU market (£/MWh)

e_f^{in} = round trip efficiency of battery when charging

e_f^{out} = round trip efficiency of battery when discharging

C_f = flexible capacity of flexibility provider f (MWh)

Note: Profits can be negative if there are only costs associated to charging/discharging

Model variables

Where,

$$\text{Round Trip Efficiency} = \frac{\text{Energy output}}{\text{Energy input}} \times 100$$

Planning horizon of FSP

$$t \in \{t_1, t_2, t_3\}$$

t_2 is the time period when DSO requests upward regulation. Assume that it consists of n consecutive settlement periods.

Then t_1 is the time period that must be ending at the start point of t_2 and contain at least n_1 consecutive settlement periods.

Similarly, t_3 is the time period starting at the end of period t_2 and contain at least n_1 consecutive settlement periods.

How is the value of n_1 determined?

In the time period t_2 , the battery can discharge $\frac{ME_f}{2} \cdot n \cdot \frac{1}{e_f^{out}}$

In the previous period, the battery needs n_1 settlement periods to charge the same amount of energy, considering the roundtrip efficiency of the battery. Then,

$$\frac{ME_f}{2} \cdot n \cdot \frac{1}{e_f^{out}} = \frac{MI_f}{2} \cdot n_1 \cdot \frac{1}{e_f^{in}} \quad n_1 = \left\lceil \frac{ME_f}{MI_f} \cdot n \cdot \frac{e_f^{in}}{e_f^{out}} \right\rceil$$

Assumption: Battery charges first and pay for it, then discharges and gets paid for it. Sometimes, the battery can get paid while charging, if it charges as a flex response.

Decision variables

FSP has three options:

- Option 1: Battery charges in period t_1 and discharges in period t_2
- Option 2: Battery charges in period t_1 and does nothing in period t_2 and discharges in period t_3 .
- Option 3: Battery charges in period t_2 and discharges in period t_3

Decision Variables

x_1 = battery chooses option 1

x_2 = battery chooses option 2

x_3 = battery chooses option 3

x_{SA} = fraction of flexible capacity sold at SA+OU market

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

FSP optimisation for maximising profit

$$\begin{aligned}
 \max \quad & p_{t_1}^{in} \cdot C_f \cdot \frac{1}{e_f^{out} \cdot e_f^{in}} \cdot x_1 - p_{t_2}^{out} \cdot C_f (1 - x_{SA}) - p_{SA} \cdot C_f (x_{SA}) \\
 & + \\
 & (p_{t_1}^{in} \cdot C_f \cdot \frac{1}{e_f^{out} \cdot e_f^{in}} - p_{t_2}^{out} \cdot C_f) \cdot x_2 \\
 & + \\
 & (p_{t_2}^{in} \cdot C_f \cdot \frac{1}{e_f^{out} \cdot e_f^{in}} - p_{t_2}^{out} \cdot C_f) \cdot x_3 \\
 \text{s.t.} \quad & x_1 + x_2 + x_3 = 1 \\
 & x_{SA} \leq x_1 \\
 & x_1, x_2, x_3 \in \{0,1\}
 \end{aligned}$$

There are 4 possible optimal solutions:

$$[x_1 x_2 x_3 x_{SA}] = \{[1 \ 0 \ 0 \ 0], [0 \ 1 \ 0 \ 0], [0 \ 0 \ 1 \ 0]\}$$

We are only interested in the optimal solution where battery discharging for SA+OU is more attractive than other options. For SA+OU market to be more attractive than others, in other words $[1 \ 0 \ 0 \ 1]$ is optimal when 3 conditions hold:

In other words, optimality conditions to bid/offer in the SA+OU market are:

- $p_{SA} > p_{t_2}^{out}$ (SA+OU market pays more than MW at period t_2)
- $p_{SA} > \frac{1}{e_f^{out} \cdot e_f^{in}} (p_{t_2}^{in} - p_{t_1}^{in}) + p_{t_3}^{out}$ (battery discharging for SA+OU pays more than battery charging at period t_2)
- $p_{SA} > p_{t_3}^{out}$ (SA+OU market pays more than WM at the next period, namely period t_3 . Or, SA+OU payments disincentivises to wait for a while and sell in the wholesale market in the later periods for higher prices.)

Interpretation of parameters

$$p_{SA} = p_a + U \cdot p_u + I_{RS}(1 - U)p_{WM,B-}^{DA}(t_2) - h_f^{b-}$$

$$p_t^{out} = p_{WM,B-}^{DA}(t) - h_f^{b-}$$

$$p_t^{in} = p_{WM,B+}^{DA}(t) - h_f^{b+}(t)$$

Decision variables

where,

$h_f^{b+}(t)$: unit cost of charging battery $f \subseteq B$ (£/MWh) at time t

h_f^{b-} : unit cost of discharging battery $f \subseteq B$ (£/MWh)

$p_{WM,B+}^{DA}(t)$: unit price of storing energy as a flex response in the wholesale market (£/MWh) at time period t .

$p_{WM,B-}^{DA}(t)$: unit price of electricity supplied by battery in the wholesale market (£/MWh) at time period t .

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

Optimal capacity FSP to offer SA+OU service

Based on these interpretations, if there are opportunities in the wholesale market in both directions for FSPs, the optimal capacity FSP f offers to the SA+OU service can be derived from the optimality condition provided above and be written as following:

$$q_f^* = \begin{cases} \min(C_f, D^{DSO}, q^{MAX}), & \text{if } p_a + U \cdot p_u \geq \max\{p_{WM,B-}^{DA}(t_2) - h_f^{b-}, p_{WM,B-}^{DA}(t_2) - h_f^{b-} \\ & , \frac{1}{e_f^{out} \cdot e_f^{in}} (p_{WM,B+}^{DA}(t_2) - h_f^{b+}(t_2) - p_{WM,B+}^{DA}(t_1) + h_f^{b+}(t_1))\} \\ & - I_{RS}(1 - U)p_{WM,B-}^{DA}(t_2) + h_f^{b-} + \epsilon \\ 0, & \text{otherwise} \end{cases}$$

for $f \subseteq B \subseteq F$

Scenario conclusion

If FSP has the option to use its flexible capacity at the opposite direction of DSO request, the equilibrium price for SA +OU availability and utilisation price will be different as the optimal response of FSPs will change in the existence of price signals in the opposite direction.

If the expected revenue of moving in the opposite direction is not attractive than moving in line with DSO request the optimal decision of FSPs remain unchanged.

The overall mathematical optimisation model of DSO help determine the centrally set equilibrium price of availability and utilisation fees of SA+OU services in the existence of price signals coming from both directions. Assuming that all forward wholesale prices are replaced by day-ahead prices, the overall mathematical optimisation model is dictated overleaf:

Focus area 2: Modelling specific FSPs and asset types

Scenario 6: Optimisation of SA+OU service procurement when FSPs has an option to respond in the opposite direction of the directional regulation of DSO

Overall mathematical optimisation model

$$\min z = \frac{1}{2} N \sum_{f \in F} q_f^* [p_a + U \cdot p_u]$$

$$\text{s. t. } \sum_{f \in F} q_f^* \geq D^{DSO}$$

$$z \leq z^{MAX}$$

$$p_a, p_u, z > 0$$

$$q_f^* = \begin{cases} \min(C_f, D^{DSO}, q^{MAX}), & \text{if } p_a + U \cdot p_u \geq \max\{p_{WM,D-}^{DA} - h_f^{d-}, \frac{(p_{WM,D+}^{DA} - h_f^{d+}) \cdot C_f^{down}}{C_f^{up}}\} \\ -I_{RS}(1-U)p_{WM,D-}^{DA} + h_f^{d-} + \epsilon & \\ 0, & \text{otherwise} \end{cases}, f \in K \subseteq F$$

$$q_f^* = \begin{cases} \min(C_f, D^{DSO}, q^{MAX}), & \text{if } p_a + U \cdot p_u \geq \max\{p_{WM,D-}^{DA} - h_f^{d-}, p_{WM,D+}^{DA} - h_f^{d+}\} \\ -I_{RS}(1-U)p_{WM,D-}^{DA} + h_f^{d-} + \epsilon & \\ 0, & \text{otherwise} \end{cases}, f \in G \subseteq F$$

$$q_f^* = \begin{cases} \min(C_f, D^{DSO}, q^{MAX}), & \text{if } p_a + U \cdot p_u \geq \max\{p_{WM,B-}^{DA}(t_2) - h_f^{b-}, p_{WM,B-}^{DA}(t_3) - h_f^{b-}, \\ \frac{1}{e_f^{out} \cdot e_f^{in}} (p_{WM,B+}^{DA}(t_2) - h_f^{b+}(t_2) - p_{WM,B+}^{DA}(t_1) + h_f^{b+}(t_1))\} \\ -I_{RS}(1-U)p_{WM,B-}^{DA}(t_2) + h_f^{b-} + \epsilon & \\ 0, & \text{otherwise} \end{cases}, f \in B \subseteq F$$

$$q_f^* \geq 0, f \in F$$

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D.2.1.2

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Detailed design

Detailed designs of the MRTB

The MRTB is an application to enable the testing of markets and forecast suppliers' responses to change in market rules

Requirements for the MRTB

The requirements for the delivery of the MRTB were that:

- It should enable data sharing across multiple stakeholders.
- It should be able to provide scalable compute to match different workloads.
- It should support different patterns of data ingestion.
- It should offer a centralised interface for managing and accessing data across different sources and stakeholders.
- The solution should enable tracking of data lineage to support evidencing outputs.
- The platform should be flexible enough to handle both streaming and batch processing workloads.

Logical components

The MRTB architecture is made up of five components:

- **Ingestion** – tools to support the process of obtaining external data and bringing it within the MRTB platform.
- **Processing** – tools to process raw data, generate metadata and make data available for downstream use.
- **Storage** – centralised ingested data with data layered to indicate readiness (e.g. raw, cleansed and curated layers).
- **Consumption** – tools to run MRTB scenarios and generate scenario outputs.
- **Presentation** – tools to support the presentation and dissemination of scenario results.

Physical components

The MRTB platform will use the Arup Azure tenant with:

- Azure Storage Containers to enable authorised users to manually upload data.
- Azure Data Factory to enable the automated ingestion of data retrieved via API.
- Azure Databrick as the compute platform for cleansing data and running optimisation workloads.
- Delta Lake for data storage organised into raw, cleansed and curated layers to classify data readiness.
- Unity Catalogue for the management and governance of Delta Lake.
- Entra ID to control Role Based Access Controls (RBAC).
- Azure Key Vault to store secrets and authorisation across the infrastructure.

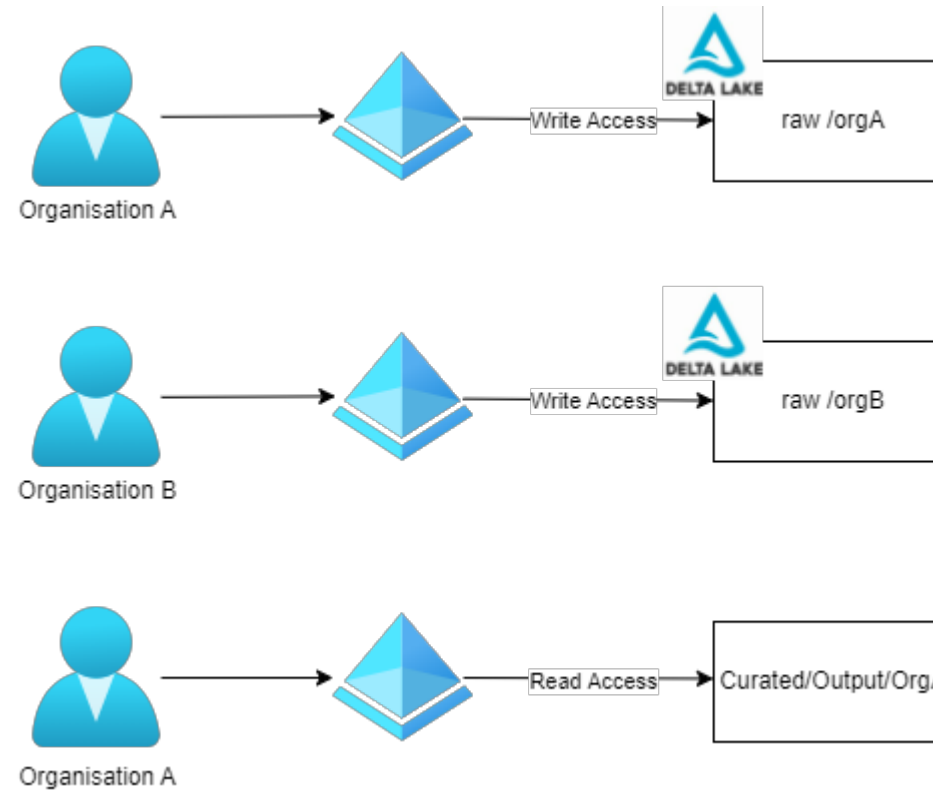
Detailed design of the MRTB

The Market Rules Test Bed (MRTB) is an application to enable the testing of markets and forecast suppliers' responses to changes in market rules.

Ingestion and processing

- The ingestion and processing stages involve taking (via API) or receiving (via manual upload) the core data required for the development of the primacy rules.
- Storage containers will be used for manual upload with physical separation of containers for different organisations and access enforced via RBAC.
- Azure Data Factory will be used to retrieve data from API with data landed in the raw layer of the Delta Lake.
- The processing steps will be undertaken in Azure Databricks and will move data from storage containers to the raw layer and cleansing of data in the raw layer and subsequently written to the cleansed layer.
- At each stage transactions will be written to a metadata catalogue (JSON) to maintain data lineage and processing steps.

Access view



Detailed design of the MRTB

The Market Rules Test Bed (MRTB) is an application to enable the testing of markets and forecast suppliers' responses to changes in market rules.

Storage

- Delta Lake will be utilised for data management, providing ACID transactions, schema enforcement, and data versioning for all datasets.
- The Delta Lake will be structured into three layers to enforce physical separation of data at different stages:
- Raw for raw, ingested data prior to any cleaning or transformation.
- Cleansed for cleansed, processed and enriched data.
- Curated for aggregated and business-ready data, data ready for analysis will be stored in this layer as will the outputs from analysis (curated/output/).
- The role-based restrictions enforced in the input layers will also be applied to the output layers, for example, users from OrgA will only upload data to their storage area and only be able to see outputs stored within the output storage layer to which they have access.
- Unity Catalog will be leveraged to manage permissions and governance across these layers, ensuring secure and consistent access.

```

1  /staging/
2    /orgA/
3      - file1.csv
4      - file2.csv
5    /orgB/
6      - file1.csv
7      - file2.csv
8    /scenarios/
9      - scenario1.csv
10     - scenario2.csv
11
12 /raw/
13   - orgAfile1.csv
14   - orgAfile2.csv
15   - orgBfile1.csv
16   - orgBfile2.csv
17   - scenario1.csv
18   - scenario2.csv
19
20 /cleansed/
21   - orgA-file1-cleansed.csv
22   - orgA-file2-cleansed.csv
23   - orgB-file1-cleansed.csv
24   - orgB-file2-cleansed.csv
25
26
27 /curated/
28   /orgA/
29     - summary_report_orgA-scenario1.parquet
30     - summary_report_orgA-scenario2.parquet
31   /orgB/
32     - summary_report_orgB-scenario1.parquet
33     - summary_report_orgB-scenario2.parquet
34

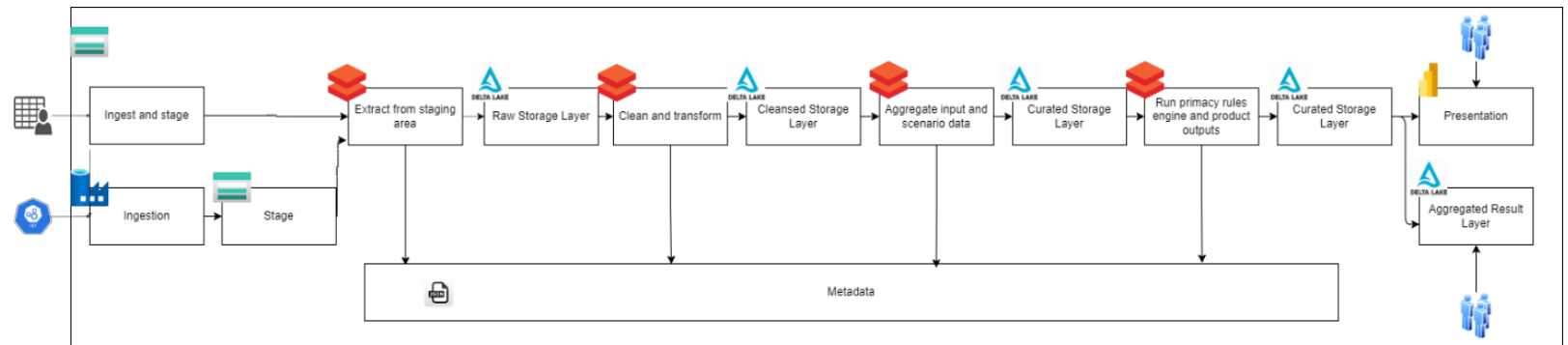
```

Detailed design of the MRTB

The Market Rules Test Bed (MRTB) is an application to enable the testing of markets and forecast suppliers' responses to changes in market rules.

Consumption and presentation

- Azure Databricks will be the core computational element of the MRTB, ingesting data from the curated layer and running optimisation.
- Databricks offers flexible access to compute families including memory optimised CPU and High-Performance Compute to suit the chosen scenario.
- Primacy outputs will be written to the output/ sub-folder of the curated layer and partitioned by organisation to enforce access requirements. These outputs will be tabular outputs and will be available for detailed interrogation of results.
- A Power BI report will ingest the analytical outputs and present findings in a high-level way to enable easier interrogation of scenarios and their results. Row-Level Security (RLS) will ensure that viewers of the report only have access to visuals which correspond to the data they have access to.



D.2.1.3

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Data products

Data products

Data Products associate with the MRTB PoC

Overview

The PoC model seeks to simulate an FSPs decision making when looking to maximise their revenue by committing their assets capacity to flexibility markets. This has been constrained to either being able or unable to stack between the SO SA+OU service and the day-ahead wholesale market. Because of the constraints of the PoC, the model hinges on only two key data products:

- **Historic tender competition data** – In this case, Summer 2023 tender competition details
- **Historic Flexibility Post Tender Report** – In this case, the Summer 2023 tender from UKPN.
- **Flexibility dispatches** – Provided by UKPN
- **Historic Wholesale prices** – For a discrete date determined from the summer 2023 tender dataset.

Historical tender competition data

The Historic Tender Competition dataset outlines the indicative values that an FSP can expect from the tender process, outlining for each flexibility zone; the total MW requirement, hours of required availability, indicative hours of utilisation and expected revenue ranges in £/MW/h that an FSP for both availability and utilisation

Historic flexibility post tender report

The Historic Flexibility Post Tender Report details both the accepted and rejected bids made by FSPs, outlining for each asset owner in each flexibility zone their committed assets capacity, agreed upon availability and utilisation fees, asset maximum run time, service start and end date and service window times.

Both the scheduled availability and operational utilisation fee are determined on completion of the tender process, but whether an assets capacity is required to be utilised is not confirmed until the day-before.

These reports are released in line with the running of the tenders, with historically two reports being published annually, reflecting the two seasonal tendering processes, spring/summer and autumn/winter.

Flexibility dispatches

The Flexibility Dispatches data provides all the operational utilisation occurrences alongside the volume requested by UKPN and the delivery price for each asset owner in each flexibility zone.

Historic wholesale prices

Historic Wholesale prices can either be purchased from EPEX or NordPool, with both allowing either a specific pull from a defined year, or a subscription to dynamic updated wholesale pricing.

Future tool

The PoC tool has been built around ingesting static datasets, but the future tool will need to ingest much dynamic and closer to real-time data, particularly for price signals, but to give a more accurate depiction on the behaviour of FSPs, it will need to incorporate forecast wholesale pricing to visualise what the prices are more likely to be closer to dispatch time.

Details of future datasets are outlined in [Section 7: Future Scope](#)

Data products

Down selection of data requirements for MRTB

Data selection process

Data	Description	Example Source	Link	Update Frequency	Licence	PoC/ Future Tool Use
Flexibility dispatches	Report on DSO use of paid flexibility services	DSOs reporting PoC – UKPN	UKPN Flex Dispatches	Monthly	CC BY 4.0	PoC
Tender documents (live and past)	Reports and datasets about tendered flex services	DSO reporting PoC – UKPN	UKPN Tender Hub	On Tender Release	Open Data Licence	PoC
Competition Data	Information on what will be put into future trades	DSO reporting PoC – UKPN	UKPN Competition Data	On Tender Release	Open Data Licence	PoC
Wholesale Prices and Volumes Day-Ahead	Subscription to prices given to capacity participating in wholesale market	EPEX/ NordPool	EPEX Wholesale Prices	-	-	PoC
Bilateral contracts tab – Flexibility services contact register	File containing the bilateral contracts from the flexibility service register	SSEN	SSEN Data	-	CC BY 4.0	Future Tool
Long and short term Bidding Activity	Collection of monthly tenders for short- and long-term tenders	SSEN	SSEN Bidding Activity	-	-	Future Tool
Embedded Capacity Register	Register of generation and storage ≥50kW connected to NG distribution network	All DSOs	National Grid Embedded Capacity Register	Monthly	CC BY 4.0	Future Tool

D.2.2

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How to use the test bed?

D.2.2.1

Wireframes

Wireframes

Overview of the wireframe output sections

Wireframes

The wireframes depict the way in which the MRTB is envisioned to work, giving a visual of how users would be able to interact with the tool and exploring the ways in which tweaking market rules would economically impact them.

One of the main aims of the MRTB is to be as intuitive as possible, incentivising use of the tool over what is perceived to be a laborious and timely process that SOs currently use to price their service.

The wireframing sections are detailed as below:

1. **Historic tender information** – This output comes from the input of previous tender information, allowing SOs to see historic market liquidity, utilisation rate and the cost of running the tender. This provides a baseline to any further details and can help to clearly outline areas where there has been historically low market liquidity.
2. **Economic Benefits of Stacking** – This part of the tool allows users to see the economic impacts that either enabling or prohibiting stacking between markets has on their services. Here users can investigate previous tenders and see how

key features of this service would've altered based on the ability to split stack with the wholesale energy market. For the PoC model, these details are given when looking at FSPs choosing between operating within the SA+OU market or the Day Ahead Wholesale market.

Within this section, users can also tweak FSP risk, tender end date and the utilisation rate to see how each of these variables would affect optimised service costs that SOs should pay FSPs to incentivise participation in their services over wholesale, market liquidity, overall tender cost and price volatility of the wholesale market.

3. **Increasing stackability opportunities impacts** – This section looks to expand on the PoC, exploring how enabling stacking opportunities between an increased number of markets would impact on SOs operations, giving visibility on where this has both positive, and negative impacts on SOs. This section also brings in the ability to co-deliver capacity and in doing so would enable the user to explore splitting with the dynamic and closer to real-time ancillary services.

4. **Asset Impacts on Stacking** – This fourth section allows a user to investigate how different asset types affect an FSPs ability to revenue stack between the different markets and outlines the specific markets in which they can stack within.

This section will also output what an SOs carbon saving would be when allowing for stacking from low carbon assets, especially when comparing to the circumstances when emergency flexibility has had to be procured from fossil fuel-based generators.

Wireframes

Visual outputs from the wireframes – PoC View

PoC Level View – Historic Tender Details and Economic Benefits of Stacking

Flex Zone Selection

System Operator
UKPN

Constraint Zone
West Letchworth

Flex Zone Selection

Requested capacity
1353.3 MWh

Tendered Capacity
5.22 MWh

Utilisation Rate
16.42 %

Total Cost of Service in Zone
4,575.00 £

Zone Assumptions

Total Avail. Flexibility
1353.3 MW

FSP Risk Appetite
High

Inputs – Impacts of Stacking (Module 1)

Stacking allowed
☒ Yes ☐ No

Market One
SA+OU

Market Two
Wholesale (Day Ahead)

Target Liquidity
60 %

RUN

Outputs – Impacts of Stacking (Module 1)

With Stacking

Capacity in Market 1
811.98 MWh

Optimised Service Cost
8.93 £/MWh

Total Cost of Service in Zone
7248.54 £

Without Stacking

Capacity in Market 1
811.98 MWh

Optimised Service Cost
72.96 £/MWh

Total Cost of Service in Zone
59,241.45 £

Service Cost Breakdown

Availability Price
3.31 £/MWh

Utilisation Price
34.19 £/MWh

Using the MRTB in it's PoC format allows a user to explore the impacts that the ability to revenue stack would have on their local flexibility services, in this case the SA+OU service. The PoC simulates outputs when FSPs can stack their asset capacities between the SA+OU service and the wholesale market, defined as implicitly stackable in the [ENAs stackability assessment](#).

First, the user defines if stacking is allowed between the two markets the target liquidity looking to be achieved within their local market. They are also able to make assumptions based on the total available flexibility within a constraint zone and the risk that an FSP is willing to take regarding their asset revenue earnings.

Running the scenario outputs the capacity likely to be made available within the local market under the assumptions and previous inputs. The optimised service price is also output, as a sum of the scheduled availability price and likely utilisation price paid to the FSP, considering the utilisation rate given in historic market details.

Finally, the user can explore how the tender date would likely impact the service price. The PoC assumes that utilisation rate increases as tender date reduces, as capacity requirements are better understood at shorter time windows

Wireframes

Visual outputs from the wireframes – Future Tool View

Future Tool View – Increasing stackability opportunity impacts

Flex Zone Selection		Historic Market Information		Zone Assumptions	
System Operator UKPN		Requested capacity 3550.6 MW	Tendered Capacity 218 MW	Utilisation Rate 8.7 %	
Constraint Zone Bramford Diss Thetford		Total Cost of Service in Zone 4,575.00 £		Total Avail. Flexibility 8000 MW	
				FSP Risk Appetite High/Med/Low	
User Inputs					
Stacking allowed ☒ Yes ☐ No ☐ Splitting ☐ Co-delivery		Market Selection ☐ DSO Markets ☐ DSO Services ☐ Scheduled Utilisation ☐ Operational Utilisation ☐ Scheduled Availability + Operational Utilisation ☐ Variable Availability + Operational Utilisation ☐ ANM Services ☐ TSO Markets ☐ Wholesale Markets ☐ Ancillary Services ☐ Balancing Market ☐ Capacity Market ☐ Demand Response Market		Operator Needs ☐ Fast Response ☐ Short Dispatch Duration ☐ Quick Reserve ☐ Low Carbon Emission ☐ Quick Ramp-up/ Ramp-down Target Liquidity XX %	
				RUN	
Outputs – Impacts of Stacking (Module 1)					
With Stacking Capacity in Market 1 XXX MWh Optimised Service Cost XXX £/MWh		Capacity in Market 2 XXX MWh Service Cost Market 2 XXX £/MWh		Without Stacking Capacity in Market 1 XXX MWh Optimised Service Cost XXX £/MWh	
Total Cost of Service in Zone XXX £				Total Cost of Service in Zone XXX £	
				Stacking Beneficial	
Impacts of Procurement Timelines (Module 2)					
Tender Duration ☒ 3 Months ☐ 1 Month ☐ 1 Week		Indicative Utilisation Rate XXX %		Optimised Service Cost XXX £/MWh	
				Total Cost of Service in Zone XXX £	



The second viewpoint on the wireframes gives a future view, with a view to explore the wider impacts of stacking between flexibility markets.

Here, a user can define the type of stacking they wish to explore, opening co-delivery as an option and a full view of the differing energy markets available for participation.

Similarly to PoC, the user has access to historic market details, offering a baseline to the outputs, but a user can now explore how enabling stacking opportunities between increased markets would impact on SOs operations, giving visibility on where this has both positive, and negative impacts on SOs. This section also brings in the ability to co-deliver capacity and in doing so would enable the user to explore splitting with the dynamic and closer to real-time ancillary services.

This viewpoint would also use much more dynamic data, where the PoC is based on historic only. Bringing in forecast wholesale price, an SO can much more accurately forecast their future service prices and understand where stacking would have positive or negative implications on their local areas.

Wireframes

Potential view of the future version of the tool

Future Tool View – Assets linked to stackability opportunities

Flex Zone Selection

System Operator
UKPN

Constraint Zone
Bramford Diss Thetford

Historic Market Information

Requested capacity
3550.6 MW

Tendered Capacity
218 MW

Utilisation Rate
8.7 %

Total Cost of Service in Zone
4,575.00 £

Zone Assumptions

Total Avail. Flexibility
8000 MW

FSP Risk Appetite
High/Med/Low

Stacking allowed
☒ Yes ☐ No
☐ Splitting
☐ Co-delivery

Market Selection

☐ DSO Markets
☐ DSO Services
☐ Scheduled Utilisation
☐ Operational Utilisation
☐ Scheduled Availability + Operational Utilisation
☐ Variable Availability + Operational Utilisation
☐ ANM Services

☐ TSO Markets
☐ Wholesale Markets
☐ Ancillary Services
☐ Balancing Market
☐ Capacity Market
☐ Demand Response Market

Operator Needs

☐ Fast Response
☐ Short Dispatch Duration
☐ Quick Reserve
☐ Low Carbon Emission
☐ Quick Ramp-up/ Ramp-down

Target Liquidity
XX %

RUN

Outputs – Impacts of Stacking (Module 1)

With Stacking

Capacity in Market 1
XXX MWh

Total Cost of Service in Zone
XXX £

Optimised Service Cost
XXX £/MWh

Capacity in Market 2
XXX MWh

Service Cost Market 2
XXX £/MWh

Without Stacking

Capacity in Market 1
XXX MWh

Total Cost of Service in Zone
XXX £

Optimised Service Cost
XXX £/MWh

Stacking Beneficial

Impacts of Procurement Timelines (Module 2)

Tender Duration

☒ 3 Months ☐ 1 Month ☐ 1 Week

RUN

Indicative Utilisation Rate
XXX %

Optimised Service Cost
XXX £/MWh

Total Cost of Service in Zone
XXX £

Asset Outputs

Technologies in Flexibility Zone

X Technology
No. Installed
Total available capacity (MW)

Y Technology
No. Installed
Total available capacity (MW)

Z Technology
No. Installed
Total available capacity (MW)

Asset Option from flexify
Drop down available Assets

Carbon Saving
BESS

Coal fired plant

XXX CO₂e



The third viewpoint is the envisioned third iteration of the MRTB tool, where asset types are directly aligned with the stacking opportunities within markets and users can better understand how specific assets within constraint zones can help to fulfil the individual SO and area requirements.

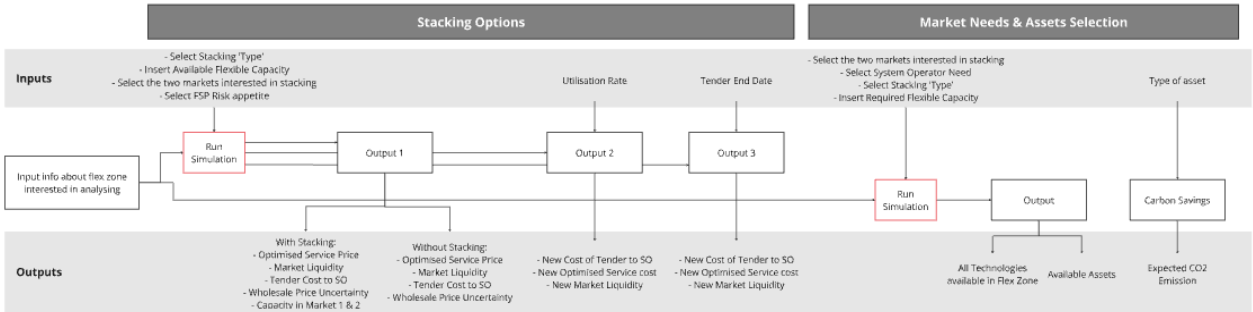
On engagement with SOs, it was expressed that there was a need to better communicate the benefits of being able to procure flexibility from low carbon assets, as opposed to having to acquire it from costly fossil-fuel based assets.

Firstly, in the lower module of the wireframe, a user is able to see the intensity breakdown of assets available in the selected constraint zone, as well as getting an output of the assets that are readily available to utilise flexify and the location, markets, stacking option and system operator need. It is envisioned that this information will be pulled from flexify and so will contain up to date and accurate data on asset capabilities and ability to provide flexible generation.

Finally, a user can see how selecting these locally available, low carbon assets can reduce carbon emissions comparatively to fossil fuelled assets, which as the target date for CP30 gets closer, becomes more crucial in ensuring.

User journeys

From the perspective of DSO & Market Facilitator



 DSO Pricing Team Member	Allows the user to understand the optimal service price they can offer to the FSPs ensuring it's a competitive price	Allows the user to understand how the pricing and liquidity changes by varying the utilisation rate	Allows the user to understand how the pricing and liquidity changes by varying the tender end date		
 DSO Policy Maker	Allows the user to understand the impact of allowing/prohibiting stacking on the market	Allows the user to understand how allowing for different staking types can increase market liquidity locally	Allows the user to understand how by varying the tender end date and so by changing market rules they can increase stackability		
 DSO Competition Administrator		Allows the user to view liquidity and optimal pricing which can be used for developing more competitive tenders		Allows the user to view all the assets available in a flex zone that can satisfy their service requirement	Allows the user to identify which asset are available to be utilised in a given flex zone
 Market Facilitator		Allows the user to understand how by varying the different parameters they can improve market rules			Provides the user an overview of the current state of assets in each flex zone and develop methods to drive up flexibility

D.2.2.2

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Model outputs

How to use the model – Model inputs

Required MRTB User Inputs

Discrete inputs

For the MRTB, the input options of the tool are outlined below. This section covers both PoC and future tool, but future tool is indicated where appropriate.

Historic Market Details Inputs

- **System Operator** – This model uses UKPN tendering datasets, but a future tool would allow a user to pick between all six SOs.
- **Flexibility Zone** – The postcode polygon area.
- **Historic Tender** – This model uses the UKPN Summer 2023 flexibility services procurement data, but a future tool would be a free text box with a look up, that would allow a user to select any previous tender.

Options for Stacking Inputs

- **Stacking Allowed** – Yes or No.
- **Market Down Selection (Future Tool)** – Whether choosing to allow stacking or not, a user can down-select to compare between two different markets to understand optimal pricing of their services. For PoC, the market options are pre-determined as the SO SA+OU service and the day-ahead wholesale market.

- **FSP Risk** – Here a user can select between static values of high, medium or low risk for FSPs. This will help determine how risky an SO can afford to be with their service pricing, knowing that low risk FSPs will want to lock in a price earlier than a high risk FSP will be willing to.
- **Available Flexible Capacity** – Here an SO can input a capacity amount available within a constraint zone
- **Type of Stacking (Future Tool)** – Co-delivery or Split Stacking.
- **System Operator Need (Future Tool)** - This allows for a SO to select their immediate need when looking to tender in a specific flexibility zone, this allows them to understand the assets that can best fulfil this requirement
- **Target Liquidity** – The Liquidity figure looking to be achieved within a constraint zone

Variable inputs

Options for Stacking Outputs

- **Availability and Utilisation Cost (Future Tool)** – The tool outputs an overall optimised service price, which is made up by combinations of the sum of the Scheduled Availability and the Utilisation Price. Due to the output being an optimised total price, a user will be able to explore a combination of these prices to help define those individual prices.

Impact of Procurement Timelines

- **Tender Duration** – A user will be able to explore how altering their procurement times, particularly moving tender end dates closer to real-time, would impact on the overall cost of the tender, optimised service cost and market liquidity.

MRTB outputs

Outputs from the algorithmic model and data pulls from market data

Discrete outputs

For the MRTB, the outputs of the tool are outlined below, with PoC algorithmic model outputs specified.

Historic market details

- **Requested Capacity** - The amount of capacity a DSO is looking to contract, as outlined in the competition data accompanying tenders
- **Tendered Capacity** – The amount of capacity that was made available by FSPs within the tender outlined
- **Tender Utilisation Rate**, as defined by the amount of capacity utilised as a percentage of the total amount of capacity tendered for by an FSP.
- **Cost of Tender to SO**, as defined by the sum of payments to FSPs, with payments being the scheduled availability cost + utilisation cost.

Outputs – Impacts of Stacking

- **Optimised Service Price**, as defined by the total cost offered by the SO to the FSP (**MODEL OUTPUT**).

- **Tender Cost to SO**, as defined by the sum of the total payments to FSPs within a flexibility zone for a tender.
- **Capacity in markets**, for instances of stacking being enabled, this will be the optimal amount of capacity being made available by the FSP for each of the two markets – in the PoC, this will be the amount of capacity to maximise revenue through participation in each of the wholesale and SA+OU markets. For instances where stacking is not allowed, the FSP will put all their capacity into the one singular market offering them the most revenue (**MODEL OUTPUT**)
- **Service Price Broken Down into Availability and Utilisation (Future Tool)** - A user would be able to explore the combinations of availability and utilisation costs that would sum to the optimised service price.
- **Stacking Beneficial vs Not Beneficial** – Defined as when the total cost of service in zone is cheaper with stacking vs without

Impacts of Procurement Timelines

- **Indicative utilisation rate** – A determination of how the utilisation rate would be impacted by the tender duration
- **Optimised service cost** – As previously defined
- **Total cost of service in zone** – As previously defined

Asset outputs

- **Technology intensity in flex zone**, pulled from flexify
- **Asset Option**, determined by the immediate SO need selected in previous section, pulled from flexify
- **Carbon Saving**, the carbon saved using the selected asset vs fossil fuelled generation

Sample outputs of the model (1 of 2)

A typical view of the model outputs when comparing the SA+OU markets and Wholesale market for a particular flexibility zone

Overview – impacts of stacking on service prices

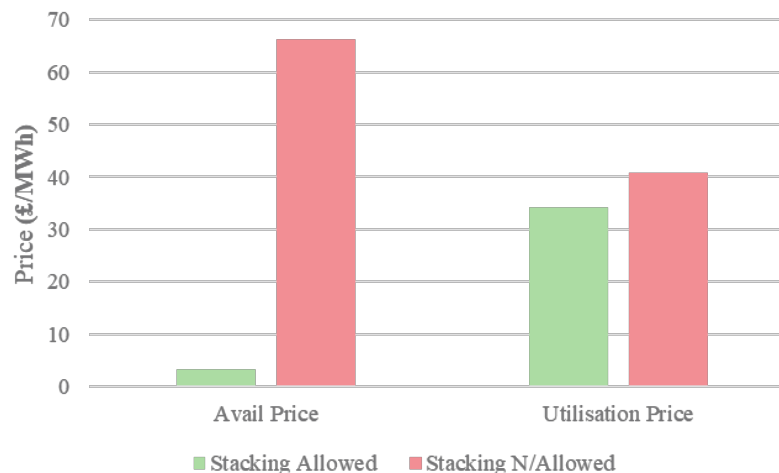
The Scenario 4 model has been run 7,500 times with different configurations of total available flexible capacity in a zone, FSP risk, target liquidity, utilisation rate and whether stacking is enabled or prohibited between the SA+OU and wholesale market. All price outputs have been generated using historic wholesale market data from EPEX.

Looking at the previous SA+OU service tender for the Winter 23/24 period in West Letchworth, the model has output the details displayed in Graph 1 and Graph 2 on the right, based on the following assumptions;

- Total available capacity = Capacity request
- FSP risk = medium risk adversity
- Liquidity target = 60%

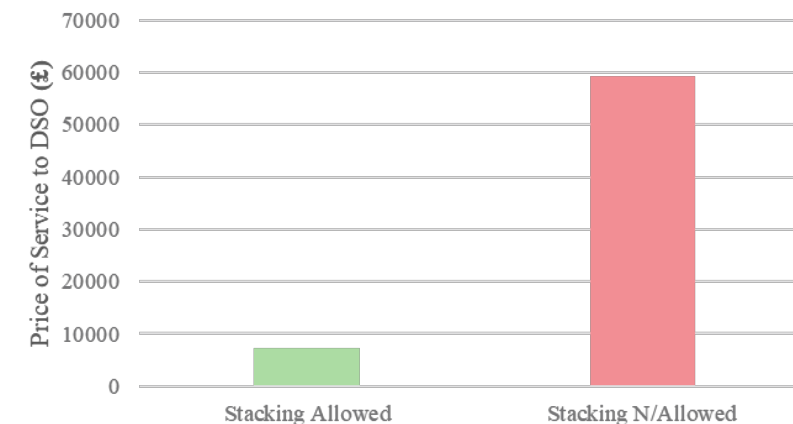
As can be seen from the graphs, the ability to stack or not stack between the SA+OU service and wholesale has a large bearing on the optimised broken-down service prices, as well as the total service cost to DSOs.

It is explored in remainder of this section how the utilisation rate, risk, liquidity targets and available flexibility impact on these costs.



Graph 1: Indicative optimised availability and utilisation prices for West Letchworth area, based on stacking being allowed or not allowed

Graph 2: Indicative total service cost to DSO for West Letchworth area, based on stacking being allowed or not allowed



Sample outputs of the model (2 of 3)

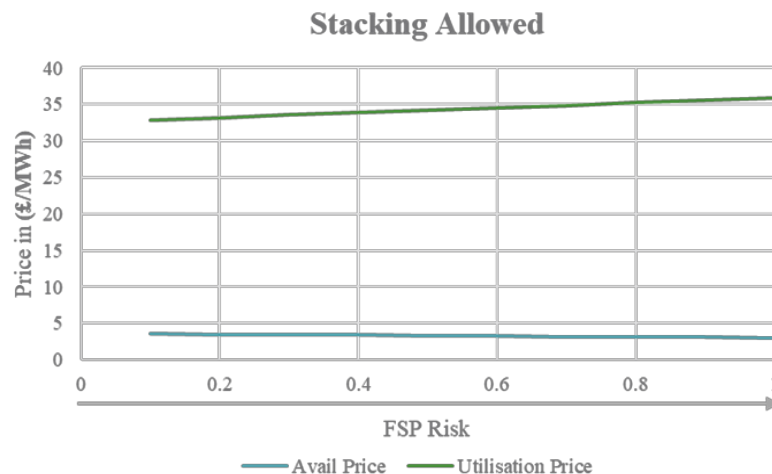
A typical view of the model outputs when comparing the SA+OU markets and Wholesale market for a particular flexibility zone

Impacts on service pricing under changing zone variables

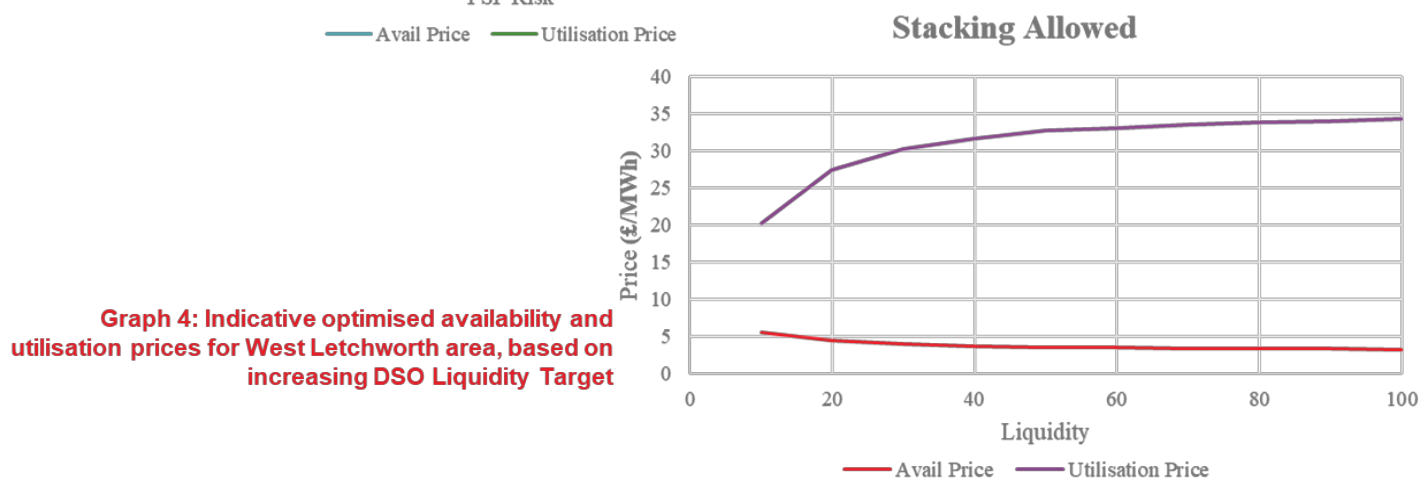
Continuing to look at the West Letchworth constraint zone, with the total available flexible capacity equal to that of the capacity request, the following outputs are gathered when varying FSP risk and Liquidity targets.

Graph 3 shows how considering FSPs with higher risk appetite would likely affect the prices required for DSOs to offer FSPs. Here, FSP risk has been described as where an FSP has an increased risk appetite, they will have a tendency to wait until much closer to dispatch time to lock in their capacity prices. The graph demonstrates this, showing how a higher utilisation price is required to lock in FSPs with higher risk appetites, whereas availability prices can remain low.

Graph 4 shows how a desire to increase liquidity in a zone requires a much higher utilisation price, to incentivise FSPs to commit their capacity, typically far ahead of the dispatch times that an SA+OU service tenders for. From engagement with FSPs and looking at the literature, the outputs provide evidence that FSPs have been typically unwilling to participate in local markets, because of the more lucrative revenues available in the wholesale market. Directly, one of the ways that DSOs can combat this is by allocating increased utilisation payments to FSPs, especially in areas of low utilisation.



Graph 3: Indicative optimised availability and utilisation prices for West Letchworth area, based on increasing FSP risk appetite



Graph 4: Indicative optimised availability and utilisation prices for West Letchworth area, based on increasing DSO Liquidity Target

Sample outputs of the model (3 of 3)

A typical view of the model outputs when comparing the SA+OU markets and Wholesale market for a particular flexibility zone

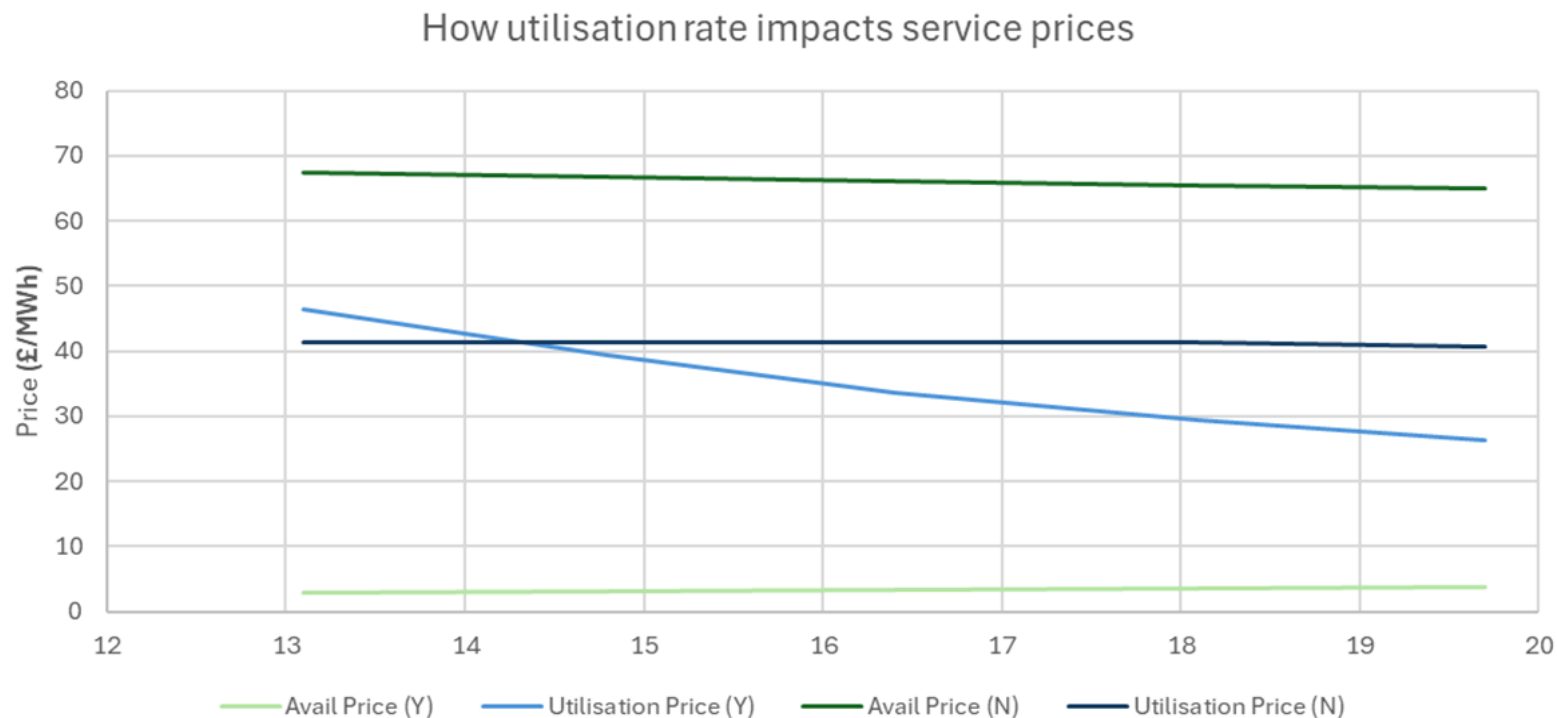
Impacts of utilisation rates on service pricing

One of the key metrics modelled through the PoC is looking at how increasing the utilisation rate within a constraint zone would likely impact broken-down services prices DSOs should make available for FSPs.

Looking at the data available for previous tenders, it was seen that in regions where utilisation rates have been historically low, there has been a large discrepancy between the amount of capacity requested and the amount being made available by FSPs.

This variability is particularly important in scenarios where stacking is prohibited, as FSPs may be put off from committing capacity in low utilisation rate zones, knowing that there is a strong likelihood they'll either get a very low, or zero utilisation payment for their capacity. Therefore, to counteract this, DSOs would need to pay much larger utilisation, or availability payments to incentivise FSP participation.

Graph 5 demonstrates how utilisation rates play an impact on the SA+OU prices, particularly where stacking is enabled with the wholesale market. Where utilisation rate increases, the indicative utilisation price decreases significantly, evidencing where FSPs have more certainty over being utilised, they will likely accept lower utilisation prices.



Graph 5: Demonstrating the impacts that increasing utilisation rate has on indicative availability and utilisation prices for West Letchworth zone.

D.3

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Future developments

Future scope

Near term development

Background

The body of the report has already described a number of specific planned developments to the tool, to the interface (Chapter 2) and the optimisation model (Chapter 3), including enhancements considering the effects of other factors on FSP decisions: (1) type of FSP, (2) price signals coming from both directions of flexibility provision.

More broadly, it will be necessary to expand all of market modelling capability, uncertainty treatment, and ability to handle multiple FSPs. Across all aspect of model formulation, one area for development will be as general a formulation of market and FSP models as possible, so that it is not necessary to produce a large number of model specifications for individual circumstances to which network operators may wish to customise analysis (as opposed to specifying bespoke datasets through the tool's interface).

In addition to the further development in the model structures for consideration of uncertainty in revenue forecasts on the part of the FSPs, it will be necessary to make the required quantifications of uncertainty within these structures.

Uncertainty specification

This must be done from the perspective of the tool user, i.e. reflecting the knowledge the DSO or market operator has about the commercial judgments made by the FSPs. Understanding such perspectives will be a key part of interaction with potential tool users in the next phase.

The wholesale market price projection might be quite generic across different organisations. However, the assessment of the probability of an offer being accepted in the local market will be specific to the individual location and market – this will depend on published guide prices, the number of FSPs in the zone, the procurement timeline, and the detail of market rules.

The acceptance probability will naturally decrease with increasing offer price, and in particular can be expected to decrease substantially above the upper guide price. The form of this function may result in a harder class of optimisation problem, as this dependence of probability on price will certainly be nonlinear, and any steep change at the upper guide price may also result in a more challenging class of optimisation problem.

Co-optimisation of services and locations

The modelling framework should also be developed to consider procuring multiple flexibility services simultaneously within a flexibility zone. This will divide into two cases of optimising procurement given offer volumes and prices from providers (for this the GB wholesale market is not relevant), and understanding through the bilevel model (where the DSO optimises subject to the FSPs' offers which are optimised from their perspectives) what FSPs' bidding strategy may be.

In general, it is to be expected that the ability to procure multiple services in a single allocation, or to optimise simultaneously across a wider geographical area, will increase liquidity through linking different markets and thus increase competition. If there are few potential providers for a service, it is naturally likely that offer prices will have to be regulated, for instance through the guide ranges already described in this report – the bilevel model may thus be used to study the degree to which providers can determine the price at which a given market clears.

E — Recommendations

Flexify recommendations

Proposed operating entity and next steps

Recommendations

Through phase two of FMU the consortium has built a proof of concept of the Flexify platform that responds to the competition challenge of market access. The platform has been designed to respond to the user need to simplify entry of both an organisation and their assets into flexibility markets.

In parallel to FMU, Ofgem released a consultation on the development of FMAR. There is clear overlap between the functional outcomes of FMAR, as stated by Ofgem, and what Flexify achieves as has been shown in [2.1.3 Relationship to FMAR](#). Furthermore, the design principles that underpin the approach taken to developing Flexify strongly align with those set out in the FMAR consultation.

There are two routes forward for Flexify, separate to the delivery pathways previously outlined, which are that Flexify forms a component part of the FMAR solution or that Flexify is not considered as part of FMAR but that it still delivers broad system value and should be considered as common infrastructure to support the flexibility ecosystem.

Flexify as a common infrastructure (FMAR)

Considering the overlap between Flexify and FMAR the following recommendations are put forward:

- A technical alignment meeting should be held with key stakeholders (Elexon & Ofgem) and the consortium to demonstrate the platform's capability and provide learnings from the programme.
- Requirements for FMAR will be developed by Elexon. Upon completion of this a holistic review and gap analysis should be carried out between these requirements and the Flexify platform.
- If Flexify is considered as a platform to meet the needs fully or in part of FMAR, then consortium requests Elexon to expedite procurement processes to ensure faster delivery of common infrastructure.
- A decision should be made by Ofgem on whether the capabilities provided by Flexify deliver inherent system value and should be supported through an MVP development stage.

Flexify as a commercial service

In parallel to undertaking the evaluation of Flexify as a common infrastructure, the consortium will pursue an option to commercialise this service. A risk to this option is the requirement of the pipelines with other digital platforms, such as SMP, Piclo, Epex, who might not be want to prioritise it as part of their product roadmap.

- Consortium to engage with other platforms to evaluate their buy-in for this proposition
- Engage with FSPs to understand their need for such a platform.
- Build a proposition for external investors to get funding to build out Flexify.

Ontology governance entity recommendation

Proposed operating entity and next steps

Recommendations

Each governance option, as presented in [Appendix C.3.2](#), balances between strengths and weaknesses against the evaluation principles and the opportunity to deliver the Interim and Permanent TC role. Based on the scoring system a combination of options would be recommended to take the ontology development forward.

Short-term Governance Entity: The Sector-Led Open Initiative is the recommended governance model for the short-term FDS ontology development. This ensures alignment with Flexify by enabling market-wide participation while maintaining agility through a dedicated steering committee, allowing for rapid updates. It promotes transparency with public consultations, ensuring broad inclusivity across DNOs, FSPs, and consumer advocates to minimise bias.

Long-term Governance Entity: The Existing Sector Entity is the recommended governance model for the long-term FDS ontology operation and maintenance. This approach leverages an existing framework aligning with industry standards and regulatory requirements while benefiting from mature governance structures, ensuring accountability through formalised ontology update processes.

With established influence across diverse stakeholders it enables balanced decision-making and FDS value realisation. Additionally, it offers cost efficiency by utilising existing infrastructure, tools, and expertise, while being equipped to manage increasing complexity and data volumes without compromising performance.

Next steps

The focus will move to transferring the ontology governance to the preferred operating entity and creating a roadmap to support Flexify operation and further ontology development.

Short-term Governance: A funding strategy is required to coordinate with the Lead Organisation and agree on development timeline, costs, and scope, while securing member contributions for the short-term development. Establishing the governance includes forming a Steering Committee and appointing a Technical Coordinator to oversee MVP rollout, engaging early with industry stakeholders to onboard founding governance board members. Key steps include hosting stakeholder workshops, leveraging industry forums like ENA Open Networks and Ofgem working groups for input, defining governance roles and decision-making processes.

Technical development will focus on ensuring ontology readiness and future scalability through gap analysis against CIM/IES4 standards, establishing a public GitHub repository for version control, and mapping FDS-specific extensions to CIM profiles to ensure interoperability. These efforts will enable a smooth transition to the short-term governance entity while maintaining development momentum and Flexify integration.

Long-term Governance: Transition planning will establish a clear roadmap for shifting from the Sector-Led Open Initiative to the new governance model, ensuring key deliverables, such as the MVP ontology and supporting documentation, are successfully transferred. This will involve joint planning sessions between the Sector-Led Steering Committee and representatives from the Existing Sector Entity. A long-term funding strategy will be developed to ensure financial sustainability, with funding planning sessions held as the short-term scope nears completion, leveraging spend-to-date insights. Additionally, stakeholder representation will be expanded during the transition period to align with future ontology development and application needs.

Information security recommendations

Define information sensitivity

To ensure the secure and effective exchange of data, it is essential to establish clear information ownership. This involves identifying the composition of the data and obtaining permissions from all relevant information owners before any publication or sharing occurs. Defining the scope of the triage process is crucial. This includes describing the proposed information, assessing its sensitivity—whether it contains personal, commercially sensitive, or security-sensitive data—and codifying how sensitivity is applied. Attempting to codify sensitivity rules ensures that consistent standards can be applied across different organisations. By implementing predefined sensitivity classifications (Open, Public, Shared, Closed) and protective marking, organisations can consistently manage data based on its sensitivity.

Care must also be taken when data has the potential to be joined to other sources, thus increasing its sensitivity and this should form part of the codification of security markings and guidance.

Define access controls

Implementing robust access controls is vital for safeguarding data. Role-Based Access Control (RBAC) should be established to define roles and permissions within the organisation. This involves creating specific roles that reflect the organisational structure, assigning users to these roles, and establishing a role hierarchy where lower-level roles can inherit permissions from higher-level roles. In addition to RBAC, Policy-Based Access Control (PBAC) should be implemented to provide fine-grain control over data access. PBAC defines user attributes and policies that describe the criteria for accessing data, ensuring that access decisions are made based on evaluating these policies against user attributes.

Processes and certification

A comprehensive governance framework is necessary to manage the publication and maintenance of information. This includes establishing governance arrangements, ensuring compliance with relevant standards, and conducting regular audits to verify adherence to sensitivity policies. Collaboration with relevant authorities including the NPSA and NESO, is also recommended to define sector-approved standards for information management security. Furthermore, establishing a certification body will ensure that organisations have implemented robust mechanisms for information security, providing an additional layer of assurance and trust.

By following these structured recommendations, organisations can effectively manage data sensitivities, implement robust access controls, and establish processes and certification mechanisms to ensure the secure and trusted exchange of data and ensure that policies are being applied across organisations.

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