REVIEW OF FLEXIBILITY PLATFORMS

A report prepared by Frontier Economics for ENTSO-E
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ENTSO-E MISSION STATEMENT

WHO WE ARE

ENTSO-E, the European Network of Transmission System Operators for Electricity, is the association for the cooperation of the European transmission system operators (TSOs). The 42 member TSOs, representing 35 countries, are responsible for the secure and coordinated operation of Europe's electricity system, the largest interconnected electrical grid in the world. In addition to its core, historical role in technical cooperation, ENTSO-E is also the common voice of TSOs.

ENTSO-E brings together the unique expertise of TSOs for the benefit of European citizens by keeping the lights on, enabling the energy transition, and promoting the completion and optimal functioning of the internal electricity market, including via the fulfilment of the mandates given to ENTSO-E based on EU legislation.

OUR MISSION

ENTSO-E and its members, as the European TSO community, fulfil a common mission: Ensuring the security of the inter-connected power system in all time frames at pan-European level and the optimal functioning and development of the European interconnected electricity markets, while enabling the integration of electricity generated from renewable energy sources and of emerging technologies.

OUR VISION

ENTSO-E plays a central role in enabling Europe to become the first climate-neutral continent by 2050 by creating a system that is secure, sustainable and affordable, and that integrates the expected amount of renewable energy, thereby offering an essential contribution to the European Green Deal. This endeavour requires sector integration and close cooperation among all actors.

Europe is moving towards a sustainable, digitalised, integrated and electrified energy system with a combination of centralised and distributed resources. ENTSO-E acts to ensure that this energy system keeps consumers at its centre and is operated and developed with climate objectives and social welfare in mind.

ENTSO-E is committed to use its unique expertise and system-wide view – supported by a responsibility to maintain the system's security – to deliver a comprehensive roadmap of how a climate-neutral Europe looks.

OUR VALUES

ENTSO-E acts in solidarity as a community of TSOs united by a shared responsibility.

As the professional association of independent and neutral regulated entities acting under a clear legal mandate, ENTSO-E serves the interests of society by optimising social welfare in its dimensions of safety, economy, environment, and performance.

ENTSO-E is committed to working with the highest technical rigour as well as developing sustainable and innovative responses to prepare for the future and overcoming the challenges of keeping the power system secure in a climate-neutral Europe. In all its activities, ENTSO-E acts with transparency and in a trustworthy dialogue with legislative and regulatory decision makers and stakeholders.

OUR CONTRIBUTIONS

ENTSO-E supports the cooperation among its members at European and regional levels. Over the past decades, TSOs have undertaken initiatives to increase their cooperation in network planning, operation and market integration, thereby successfully contributing to meeting EU climate and energy targets.

To carry out its legally mandated tasks, ENTSO-E's key responsibilities include the following:

- Development and implementation of standards, network codes, platforms and tools to ensure secure system and market operation as well as integration of renewable energy;
- Assessment of the adequacy of the system in different timeframes;
- Coordination of the planning and development of infrastructures at the European level (Ten-Year Network Development Plans, TYNDPs);
- Coordination of research, development and innovation activities of TSOs;
- Development of platforms to enable the transparent sharing of data with market participants.
- ENTSO-E supports its members in the implementation and monitoring of the agreed common rules.

ENTSO-E is the common voice of European TSOs and provides expert contributions and a constructive view to energy debates to support policymakers in making informed decisions.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

In the electricity system of the future, smaller scale, intermittent generation will increasingly locate at lower voltage levels of the electricity network and closer to the point of consumption. Electricity consumption levels and patterns too will change as consumers choose to self-generate and take up electric vehicles and heat pumps. This will happen against a background of increasing digitalization which is facilitating the wider penetration of distributed energy resources ('DER')[1] that can modify their generation and/or consumption patterns to provide flexibility to transmission and/or distribution system operators ('T/DSOs')[2]. These developments are encouraging T/DSOs to deploy new technological solutions and co-ordinated market processes that can provide for the optimal operation of the whole electricity system.

Against this backdrop, 'flexibility platforms' have emerged to facilitate or co-ordinate the trade, dispatch and/or settlement of energy or system services between T/DSOs and DER. This includes platforms that are self-contained marketplaces, as well as platforms that act as intermediaries to established wholesale and balancing markets. Moreover, these platforms pertain to both 'local' flexibility, where the primary focus is to resolve constraints on the distribution networks, as well as flexibility that can help with national (or cross-border) balancing of the electricity system, including the update of existing platforms to integrate DER as new resources in the provision of system services.

This report conducts an in-depth examination of the following selection of flexibility platforms identified as being at implementation stage at the time of research and covering a broad range of possible functional and design characteristics:

- DA/RE (Germany);
- The Crowd Balancing Platform[3] by the Equigy consortium (Germany, The Netherlands, Italy, Austria and Switzerland);
- GOPACS (The Netherlands);
- The Single Flexibility Platform – demo of Horizon 2020 project INTERRFACE in Latvia, Estonia and Finland (here after referred to as INTERRFACE);
- Implementation of NODES marketplace platform as part of two projects: NODES-IntraFlex (UK) and NODES-NorFlex (Norway);
- eSIOS-CECRE-CoordiNet (Spain); and
- Piclo Flex (UK).

Flexibility platforms that act as intermediaries to markets typically enable an exchange of standardised balancing and congestion management products between TSOs and aggregators (e.g., the Crowd Balancing Platform, INTERRFACE); although both operators (i.e., TSOs and DSOs) may also be active participants (e.g., GOPACS, INTERRFACE). Marketplace platforms, on the other hand, tend to focus on the localised procurement of congestion management services by DSOs (e.g., Piclo Flex, the NODES-IntraFlex project), either coordinated by TSOs (e.g., eSIOS-CECRE-CoordiNet) or by DSOs which may then offer residual flexibility to TSOs as secondary buyers (e.g., NODES-NorFlex project). Whilst industry-led standardisation of congestion management products for DSOs are emerging (e.g., as those traded via Piclo Flex[4]), non-standardised products with flexible parameterisation options are also observed on NODES (e.g., both in NODES-IntraFlex and NODES-NorFlex).

In this report, we consider the following functions performed by flexibility platforms:

- asset registration and prequalification;
- notification of flexibility requirements and submission of offers;
- coordinated grid impact assessment and priority of access;
- matching;
- price formation;
- issuing dispatching instructions and activation;

  and
- validation and settlement.

1 These include distributed generation, energy storage, and various types of dispatchable loads and demand response.
2 Note that in the rest of this report we use this term to refer to system operators that may be TSOs, DSOs, or both TSOs and DSOs.
3 NB: several figures of this report refer to Equigy instead of Crowd Balancing Platform because it was the name of the project when this report was under development.
4 Piclo note that their platform may elect to enable trade of non-standard parameterised products in the future, subject to industry requirements.

Adapting to the needs of system operators and the relevant regulatory and institutional context, flexibility platforms have varying forms of involvement in each of these procurement functions. Some offer a modularised set of complementary services that T/DSOs can select from to support different stages of the end-to-end flexibility procurement process, ranging from an advertisement-only to a fully-outsourced procurement model. These different approaches are discussed in Chapter 2 of this report and are briefly summarised below.[5]

1. ASSET REGISTRATION AND PREQUALIFICATION

- Flexibility platforms may be involved in hosting eligibility criteria for flexibility service providers (FSP) participation, collecting the relevant information for prequalification, and may take responsibility for approval.
- Intermediary platforms (the Crowd Balancing Platform) typically defer assessment of eligibility criteria and approval to the adjoining markets, whilst self-contained marketplaces host the asset-level (NODES-IntraFlex and NODES-NorFlex) as well as company-level (Piclo Flex and eSIOS-CECRE-CoordiNet) eligibility criteria requested by the procuring T/DSOs.
- Physical testing is sometimes required of FSPs prior to approval (NODES-IntraFlex).
- In some cases, platform-operated 'asset registries' store technical information of FSP resources and their location (the Crowd Balancing Platform, Piclo Flex, NODES-IntraFlex, INTERRFACE, eSIOS-CECRE-CoordiNet).
- Approval of asset prequalification may either be delegated to T/DSO, either as part of a platform-facilitated function or through a separate coordinated process (INTERRFACE, Crowd Balancing Platform), performed automatically within platform (NODES-IntraFlex, NODES-NorFlex) or by the adjoining market operator (GOPACS).

2. NOTIFICATION OF FLEXIBILITY REQUIREMENTS AND SUBMISSION OF OFFERS

- Flexibility platforms improve the visibility of market participants over transaction opportunities by way of digital communication interfaces between stakeholders.
- All platforms provide an interface for T/DSOs, with marketplace platforms enabling T/DSOs to directly upload their flexibility requirements as applicable*. Market intermediaries may either act as T/DSOs' gateway to existing markets (GOPACS) or will interact with T/DSOs once tenders are processed on adjoining marketplace platforms (the Crowd Balancing Platform).
- Whilst the information regarding T/DSO's flexibility requirements is needed for price formation, it is not necessary to initiate the market-based procurement process as FSPs may be able to provide their flexibility bid-offers without a prior request from T/DSO.
- Marketplace flexibility platforms also offer direct interfaces for FSPs to upload information regarding the availability of their asset portfolios. In some instances market intermediaries may also provide direct interfaces for submission of bids (the Crowd Balancing Platform); although this is typically conducted within the adjoining marketplace (GOPACS, INTERRFACE).
- In some cases, platform-operated 'asset registries' store technical information of FSP resources and their location (Piclo Flex, NODES-IntraFlex, INTERRFACE, the Crowd Balancing Platform, eSIOS-CECRE-CoordiNet). T/DSOs are able to use these registers to view assets that meet their flexibility requirements (whilst this information remains confidential to other market parties), or may use the data records to perform flexibility resource qualification (such as determining the location of flexibility resource within the grid for congestion management purposes).

* For the Crowd Balancing Platform, this functionality depends on the product. For example, for Redispatch, the TSO does not upload its flexibility requirement.

5 At the time of writing this report we understood that several features of the platforms were evolving. We have strived to ensure that all descriptions in the report are correct as of June 2021.

3. COORDINATED GRID IMPACT ASSESSMENT AND PRIORITY OF ACCESS

- Market intermediary platforms typically have an explicit coordination objective between TSOs and DSOs (GOPACS, INTERRFACE, DA/RE) and may support a coordinated grid assessment by T/DSOs, before bid qualification and matching of offers with requirements.
- This may either be by way of hierarchy rules between T/DSOs that ensure orders are not used if they have the potential to cause congestion in another area (GOPACS) or through an optimisation across network voltage levels accounting for the network constraints of all participating T/DSOs (DA/RE).
- Marketplace flexibility platforms are currently used by TSOs and DSOs (eSIOS-CECRE-CoordiNet) or only by DSOs (Piclo Flex, NODES-IntraFlex), where a coordination principle for grid prequalification is defined. In some cases marketplace platforms provide an information service for TSOs to enable procurement on intraday markets in response to DSO activations (NODES-NorFlex).

4. MATCHING

- Efficient matching of FSP offers to T/DSO needs requires a joint-optimisation across multiple dimensions, including: the effectiveness of the asset to satisfy the flexibility need (across both technological and locational constraints of the provider), the opportunity cost of the FSP and T/DSO, and the effects of activated flexibility on areas of the grid outside of the constraint.
- Flexibility platforms first implement a bid-qualification process that filters for bids that meet the technical and temporal requirements of the request. Flexibility platforms that provide congestion management products will also screen portfolio-orientated bids for locational criteria (NODES-IntraFlex, NODES-NorFlex).
- After bid qualification, platforms may either enable T/DSOs to filter and select flexibility offers themselves (Piclo Flex, eSIOS-CECRE-CoordiNet) or facilitate centralised matching without the direct involvement of T/DSOs (NODES-IntraFlex, NODES-NorFlex).
- GOPACS utilises a multi-transaction structure that enables T/DSOs to simultaneously execute separate buy and sell transactions with FSPs on the connected intraday market with the price difference between the buy and sell orders (intra-day congestion spread) paid by the T/DSO.

5. PRICE FORMATION

- Marketplace flexibility platforms run internal auctions either through a closed auction format (Piclo Flex) or a continuously-clearing market format (NODES-IntraFlex, NODES-NorFlex).
- In closed-auctions, T/DSOs publish a flexibility request and may be given the option to impose a maximum cap on bids. Qualifying flexibility offers are then collected from FSPs by the market operator up until the bidding deadline is reached. At this point, the T/DSO reviews qualifying bids and chooses whether to accept their preferred offer.
- In continuously-clearing market, both T/DSOs and FSPs submit requests and bids on a continuous basis that are matched under a pay-as-bid approach. A contract is established without there being direct contact between the procurer and provider.

6. ISSUING DISPATCHING INSTRUCTIONS AND ACTIVATION

- The dispatch setpoint instructions and/or activation signal that the FSP receives may be issued by the T/DSO or the flexibility platform.
- The mode of activation may either be: a) manual by the FSP (Piclo Flex); b) automatic through a closed-loop control system with the T/DSO (Crowd Balancing Platform*) or platform operator (NODES-IntraFlex, NODES-NorFlex); or both a) and b) (eSIOS-CECRE-CoordiNet).
- In some cases, for market intermediary flexibility platforms, activation may be dealt with in the adjoining markets (INTERRFACE).

* Not for all products e.g. for redispatch it is manual.

7. VALIDATION AND SETTLEMENT

- Flexibility platforms may play a role in validation of delivery against a measured baseline and settling payments.
- Baseline measurement is typically the responsibility of market participants to agree and nominate a responsible party for uploading baseline values to the platform.
- In some cases, flexibility platforms may collect baseline and metering data for validation within a 24-hour window of activation (INTERRFACE) or on a minute-by-minute basis (NODES-NorFlex, NODES-IntraFlex). In other cases, validation may be handled by the T/DSOs outside of the platform (Piclo Flex, GOPACS).
- In the case of market intermediary platforms, settlement and renumeration is handled by the relevant marketplace operator. Marketplace flexibility platforms, or measurement and settlement functions coordinating with system services platforms, settle transactions after validating delivery and may impose penalties for discrepancies (NODES-IntraFlex, NODES-NorFlex).
- Beyond validation and settlement, flexibility platforms may also deploy actions to mitigate incentives for FSPs to engage in strategic gaming behaviour. These include payment caps and longer-term contracts that better align the incentives of both sides of the market (Piclo Flex), as well as platform-operated market surveillance routines that monitor abuses of market power signalled through market prices (NODES-NorFlex).

IN THE FINAL CHAPTER OF THIS REPORT WE SET OUT POLICY ISSUES WE HAVE IDENTIFIED AS PART OF OUR STUDY, BROADLY FALLING UNDER THREE AREAS:

- **Challenges to DER integration:** DER face proportionally high entry costs and weak participation incentives, whilst T/DSOs may perceive greater levels of risk in contracting with DER than utility-scale assets.
- **Challenges to TSO-DSO coordination:** Coordination between system operators will be increasingly important as distributed FSPs are integrated in system service markets. To effectively realise the potential of distributed flexibility, both TSOs and DSOs will need to more actively manage their system processes. In this regard, technical and institutional barriers to information sharing and collaboration will need to be overcome in order to ensure T/DSOs responsibility for system stability and security of supply can be effectively delivered.
- **Challenges to market design:** As innovative flexibility marketplaces continue to take shape across Europe, issues around alignment of market arrangements and product specifications may need to be addressed.

1 INTRODUCTION

The energy system is undergoing a significant transformation driven by the trifecta of decarbonisation, decentralisation and digitalization. Historically, power generated in large power plant would flow on high voltage (transmission) networks and be stepped down to low voltage (distribution) networks before reaching the end consumer. Under the traditional system (see high level representation in Figure 1), Transmission System Operators ('TSOs') would mostly rely on centralised utility-scale generators to balance the electricity grid and Distribution System Operators ('DSOs') would ensure sufficient network capacity to meet exogenous consumer demand for electricity generated upstream.

In the electricity system of the future, smaller scale generation will increasingly locate closer to the point of consumption on the distribution grids. Driven by ambitious policy targets at the European Union level, a majority of the electricity mix will comprise of renewable sources, increasing the variability of electricity supply. The Distributed Energy scenario of the 2018 Ten Year Network Development Plan ('TYNDP') envisions that up to 50 % of new renewable installations in 16 countries of Continental Europe will be connected to the distribution network by 2030.[6]

Electricity consumption levels and patterns will also change as more consumers may choose to self-generate and take up electric vehicles ('EVs') and heat pumps, facilitated by policies supporting the electrification of the heat and transport sectors and conversion of electricity into other energy carriers[7] through sector coupling. This will result in higher levels of future electricity demand and increase the potential for constraints to materialise on the transmission and distribution grids. The TYNDP sees electricity demand across Europe increasing by almost 20 % by 2030 driven by the uptake of EVs and heat pumps, despite significant increase in various energy efficiency measures.[8]

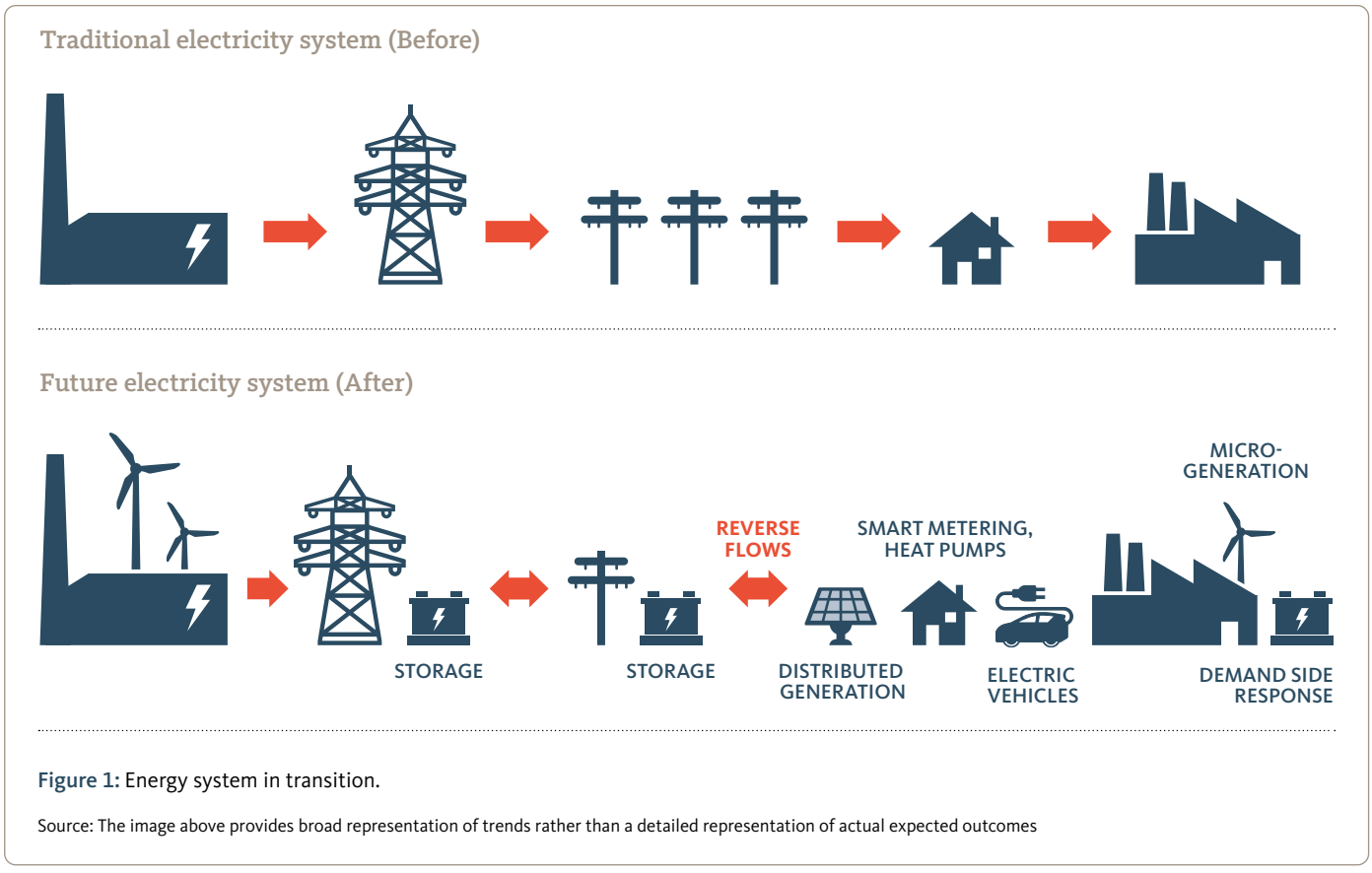


Figure 1: Energy system in transition.

Source: The image above provides broad representation of trends rather than a detailed representation of actual expected outcomes

6 ENTSO-E. Vision on market design and system operation towards 2030. November 2019. Available at: *vision2030.entsoe.eu/wp-content/uploads/2019/11/entsoe_fp_vision_2030_web.pdf*

7 For example, power-to-gas, power-to-heat, power-to-hydrogen.

8 Other studies foresee a sharp increase in electricity demand beyond 2030 and towards 2050: 53 % for the European Commission (A Clean Planet for all, 2018), 60 % for Eurelectric (Decarbonisation pathways for the European economy, 2018).

These developments are happening against a background of increasing digitalization and the emergence of a 'Digital Grid'. On the one hand, this evolution of the electricity system towards a "cyber-physical" system is helping enhance physical grid utilisation and has translated into pan-European digital platforms that foster coordination between TSOs.[9] On the other hand, these trends are helping unlock the potential of distributed flexibilities by facilitating the wider penetration of distributed energy resources[10] ('DER') – different types of distributed generation, but also dispatchable loads, electric vehicles, energy storage – and allowing them to become more price responsive. Commercial developments such as the increasing prevalence of aggregators or use of blockchain to facilitate peer-to-peer trading are increasing the extent to which small scale DER can access and participate in existing markets, and provide system services (i.e., re-dispatching services, frequency and non-frequency ancillary services and congestion management).

Matching the intermittent generation mix with higher levels of more price responsive demand will require that the future electricity system becomes more 'flexible' with respect to both how power is consumed and produced. TSOs already have many years of experience procuring flexibility to manage supply and demand on the transmission systems. In the future electricity system, DSOs will also need to "actively" manage more complex power flows and constraints that will increasingly arise on the distribution grids by engaging with DER that are able to alter their consumption/production in response to an external signal, e.g. a change in price ('flexibility resource'). Less predictable patterns of electricity supply and demand could mean that using a flexibility resource to resolve a network constraint may in some instances deliver better value to consumers than investing in traditional network reinforcement.[11]

As such, the development of initiatives that facilitate a more active role in system management will need to be an integral part of the DSO role in the future. There will be a need for greater coordination amongst DSOs and between DSOs and TSOs to make sure that resources needed to manage the grid at all voltage levels are shared efficiently across the grid under a "one system approach".[12]

It is expected that these initiatives will build on TSO-DSO cooperation that has existed for years, and is envisioned to deepen going forward. Chapter VI of Regulation 2019/943 of 5 June 2019 calls for close coordination between TSOs and DSOs[13] and is being realised through several initiatives underway, including the Bridge Horizon 2020,[14] EU smart grid task force[15] and the ENTSO-E Research, Demonstration and Innovation Roadmap 2020-2030.[16]

9 ENTSO-E. Cyber-physical grid. 2019

10 Small, geographically dispersed generation or demand resources, installed and operated on the distribution system at voltage levels below the typical bulk power system, as defined by ENTSO-E Position Paper 31 March 2021

11 Scottish and Southern Electricity Networks and Frontier Economics have developed a framework that assesses the "option value" a flexible resource can offer as an alternative to network reinforcement being considered to resolve a constraint against a background of uncertain demand growth. See here: *news.ssen.co.uk/news/all-articles/2020/july/ssen-announces-a-new-cost-effective-approach-to-delivering-a-smart,-low-carbon-energy-system*

12 Described as an approach where " ... closer coordination between TSOs and DSOs ensure that power flows, congestions, data, and market interactions with assets and consumers at distribution level are managed efficiently and effectively ...". ENTSO-E. Vision on market design and system operation towards 2030. November 2019. p. 17. Available at: *vision2030.entsoe.eu/wp-content/uploads/2019/11/entsoe_fp_vision_2030_web.pdf*

13 Article 57 highlights that DSOs and TSOs "shall cooperate with each other in order to achieve coordinated access to resources such as distributed generation, energy storage or demand response that may support particular needs of both the DSO and the TSO." Official Journal of the European Union, L158/54, 14.6.2019. In Article 59(3), demand response is identified as a key area where additional regulatory guidance may need to be developed. It is still uncertain whether this would include the development of platforms that support the provision of flexibility services from DER. Available at: *eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32019R0943&from=EN*

14 *www.h2020-bridge.eu*

15 E.DSO. Smart Grid Task Force. Available at: *www.edsoforsmartgrids.eu/policy/eu-steering-initiatives/smart-grid-task-force*

16 ENTSO-E. Research, Development & Innovation Roadmap 2020-2030. Available at: *eepublicdownloads.azureedge.net/clean-documents/Publications/RDC%20publications/entso-e-rdi_roadmap-2020-2030.pdf*

1.1 RATIONALE FOR AND SCOPE OF THIS REPORT

Against this backdrop, ENTSO-E has asked Frontier Economics to help refresh a 2018-19 review of flexibility platforms and interfaces across Europe that primarily aim at facilitating the participation of distribution grid-connected assets in markets for the provision of flexibility for grid and system services (mostly balancing and congestion management).

The review demonstrated a wide variety of local flexibility projects led by TSOs, DSOs and third parties each trialling and implementing their vision of flexibility management (see Figure 2) beyond the traditional market platforms for TSOs (e.g., procurement of balancing reserves).

This refresh includes recently implemented mechanisms and commercial solutions, insights from initiatives focused on integration of DER in various European member states and the UK,[17] recent Pan-European mappings of decentralized and digital electricity solutions[18] and interactions between TSOs and DSOs.[19] While many of these solutions have come out of TSO innovation projects, others have been developed independently by DSOs, through TSO-DSO coordination, as well as through other third parties such as power exchanges, technology developers, and suppliers.

Consistent with definitions used by EU regulatory bodies, we define flexibility as the "ability of the power system to cope with variability and uncertainty in demand, generation and grid capacity, while maintaining a satisfactory level of reliability." We use the term flexibility sources[20] to mean "assets connected either to the distribution or transmission grid which have the ability to modify their generation injection and/or consumption patterns in reaction to an external signal, in order to provide a service".

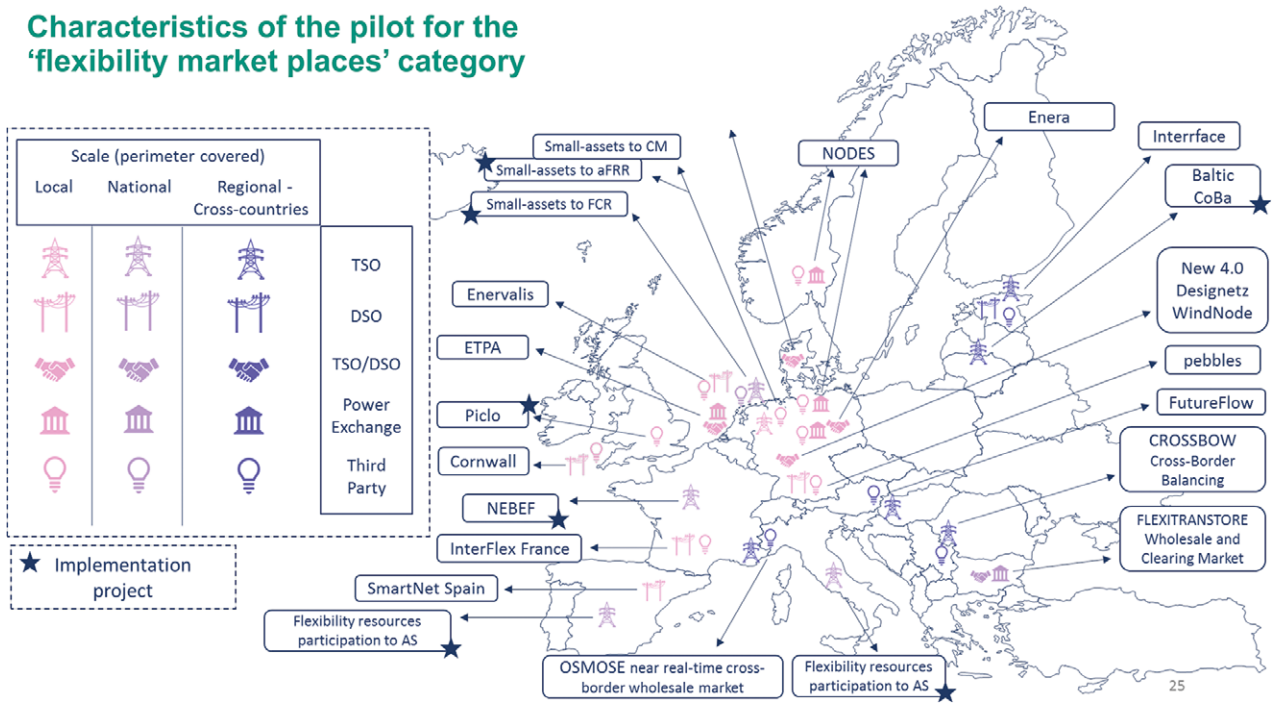


Figure 2: Emergence of flexibility platforms across EU member states

Source: ENTSO-E. Available at: *eepublicdownloads.entsoe.eu/clean-documents/events/2019/191205_Flexibility%20Framework_full_public.pdf?Web=1*

17 Other than focused examinations by Ofgem and BEIS, flexibility integration is a key workstream in the UK Electricity Network Association's Open Networks project, see here: *www.energynetworks.org/creating-tomorrows-networks/open-networks*

18 ENTSO-E. Technology Factsheet. 2021. P. 8. Available at: *eepublicdownloads.entsoe.eu/clean-documents/RDC%20documents/2021_Technology%20Factsheet.pdf*

19 For example, Bridge Horizon 2020. TSO DSO Coordination. December 2019. Available at: *www.h2020-bridge.eu/wp-content/uploads/2020/01/D3.12.f_BRIDGE-TSO-DSO-Coordination-report.pdf*

20 ENTSO-E. Technology Factsheets. 2021. Available at: *eepublicdownloads.entsoe.eu/clean-documents/RDC%20documents/2021_Technology%20Factsheet.pdf*

This review aims to identify and promote best practices, and provide a view of market and regulatory barriers faced in the procurement and management of local flexibility services. The platforms we have reviewed are summarized in Figure 3 below.[21]

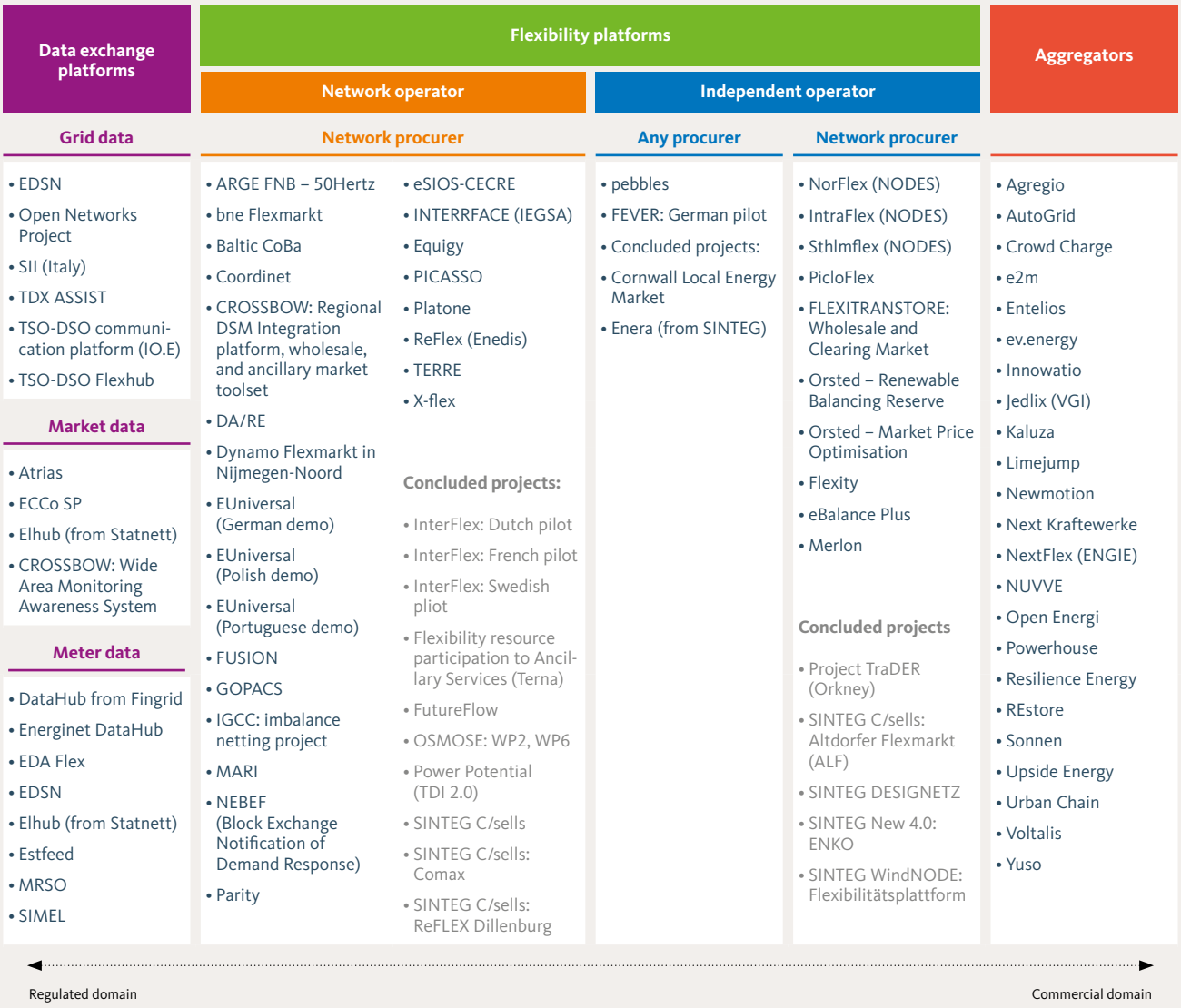


Figure 3: Overview of flexibility platforms reviewed[22]

Source: Frontier Economics

21 This list of DER platforms provided is not exhaustive.

22 The clusters of this framework are distributed across a horizontal axis to indicate closeness to regulated or commercial domains. This not perfect, and there is some project-level variation across this dimension within clusters. For example, 'EDA Flex' (under 'Data exchange platforms') is a commercially operated platform providing services to T/DSOs.

Through our review we have clustered projects within the following three categories (as reflected in Figure 3):

- **Aggregators:** Defined in Article 2(18) of Directive 2019/944 as an entity that combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market. This includes dedicated independent aggregators (i.e., a market participant engaged in aggregation who is not affiliated to the customer's supplier) as well as entities that perform an aggregation function alongside other services (e.g., energy supply).
- **Data exchange platforms:** Defined as a system architecture, or set of protocols, that facilitates the exchange of information between operationally distinct entities across the energy supply chain, but that does not by itself support market-based procurement or administrative dispatch of energy or system services requirements. We have further categorized these platforms by three types of data they exchange, i.e., grid, market or meter data.
- **Flexibility platforms:** Defined as a digital platform that facilitates or coordinates the procurement, trade, dispatch and/or settlement of energy or system services. This includes platforms that are self-contained marketplaces as well as platforms that act as an intermediary between market participants and existing system services or wholesale markets. Moreover, these include both "local" flexibility platforms where the primary focus is to resolve constraints on the distribution networks, as well as balancing platforms (e.g., TERRE).[23] Under this overarching category, we have identified sub-categories characterised by:
  - **Platform operator,** which may be either TSOs, DSOs or both (e.g., DA/RE, GOPACS); or independent operators which in turn may be power exchanges (e.g., NODES) or third parties (e.g., Piclo Flex).
  - **Procurer,** which is either the network/system operator or any buyer of energy (e.g., peer-to-peer platforms).

These flexibility platforms cover a breadth of use cases (summarised in Annex C) including frequency response, voltage control and congestion management.

ENTSO-E's initial review covered a broad range of flexibility platforms at different levels of technological readiness. For the current report, we focus on a selection of these projects that were identified as being at an implementation stage at the time of our research and cover a number of different possible design characteristics (e.g., type of procurer, platform operating model, etc) for the purposes of conducting an interesting cross-sectional analysis.[24]

23 It is noteworthy that there can be quite a bit of overlap between these two categories with local flexibility platforms offering flexibility into the balancing markets.
24 The scale of flexibility traded and number of market participants on the various platforms were additional, secondary considerations.

We focus on the following eight (8) flexibility platforms:

- **DA/RE** in Southern Germany being developed by TransnetBW and Netze BW.
- **The Crowd Balancing Platform** in The Netherlands, Italy, Austria, Germany and Switzerland, owned by a consortium of TSOs called Equigy and independently operated.
- **GOPACS** in The Netherlands, owned and operated by Dutch-German TSO (TenneT) and four DSOs (Stedin, Liander, Enexis Groep and Westland).
- **INTERRFACE** demonstration project in Latvia, Estonia and Finland owned and operated by a pan-European consortium of T/DSOs and energy exchanges.
- **NODES** originally set-up and operated by the power exchange NordPool and Agder Energi. We look at two implementations of the NODES platform:
  - **NODES-IntraFlex** in the UK, launched by DSO Western Power Distribution (WPD) and operated by independent marketplace platform NODES.
  - **NODES-NorFlex** in Norway, launched by TSO Statnett and DSOs Agder Energi, Glitre Energi, and Mørenett, and operated by independent marketplace platform NODES.
- **Piclo Flex** in the UK, owned and operated by an independent software company Piclo.
- **eSIOS-CECRE-CoordiNet** in Spain, owned and operated by TSO, Red Electrica de España (REE).

A summary of key characteristics of these platforms is provided in Annex B.

THE REMAINDER OF THIS REPORT IS STRUCTURED AS FOLLOWS:

In Section 2 we provide a deep dive on the selected platforms describing their operational model, their participants and associated products, the core functions performed and the solutions deployed to serve these functions.

In Section 3, we provide high-level discussion of key policy issues that have emerged during this study and discuss the ways in which flexibility platforms may help stakeholders overcome these challenges.

2 OVERVIEW OF FLEXIBILITY PLATFORMS

In this section we discuss the following aspects of the eight flexibility platforms reviewed in detail as part of this engagement:

- The main operational models adopted (Section 2.1);
- The procurers and providers of flexibility, as well as the flexibility products (defined in Section 2.2.2) that are exchanged between the two (Section 2.2), and;
- The core functionalities of each platform within the end-to-end flexibility procurement process (Section 2.3).

2.1 PLATFORM MODELS

Our review has identified three main operational models of flexibility platforms:

- **Administrative flexibility scheme coordinators:** This category relates to flexibility platforms that do not support a market-based allocation of flexibility, but instead provide support for a centralised cost-based allocation of flexibility, by facilitating data exchange between relevant stakeholders.
- **Market intermediaries:** This category relates to platforms that act as an intermediary to procure flexibility services through established markets. Market intermediary flexibility platforms do not perform the essential functions of marketplaces within the platform ecosystem, but instead provide enabling services (e.g., asset registration and prequalification) to T/DSOs and Flexibility Service Providers ('FSPs') that facilitates procurement.
- **Marketplaces:** This category relates to flexibility platforms that perform the essential functions of a marketplace such as running auctions, clearing transactions and settling payments between T/DSOs and FSPs.[25] In general,[26] these platforms do not rely on existing markets to support procurement but are not precluded from connecting to these markets as a complementary feature.

Figure 4 maps the eight platforms reviewed in this report under these three operational models.

Using this framework we introduce the aforementioned eight selected flexibility platforms below.

Figure 4: The operation model for the eight flexibility platform implementation projects

25 In principle, marketplace platforms may enable FSPs (with or without a balancing responsibility) to also procure flexibility, although the platforms reviewed as part of this report do not provide for this.

26 eSIOS-CECRE-CoordiNet relies to some extent on existing markets (as discussed in Section 2.1.3)

2.1.1 Platforms as administrative flexibility scheme coordination

DA/RE

DA/RE ("Datenaustausch Redispatch" – data exchange redispatch) is an IT platform that facilitates coordination between TSOs, DSOs, generating units and storage units in Baden Wuertemberg (TransnetBW control area, Germany[27]). It is presently focused on facilitating participation in the mandatory 'Redispatch 2.0' congestion management scheme from October 2021. DA/RE issues redispatch instructions based on a central optimization algorithm that analyses the reported redispatch needs of T/DSOs, cost data submitted by participating generating/storage units and redispatch availabilities. DA/RE determines the possible efficient redispatch measures and selects the relevant generating/storage units for redispatch, taking into account the network restrictions of all participating network operators. DA/RE does not currently intend to facilitate participation in markets for system services.

A significant development with the Redispatch 2.0 regulatory provision is that DSOs will be required to make use of redispatch instruments (previously this was only a TSO obligation). In order to implement these requirements, the network operators have to fulfil new coordination tasks including the implementation of the data exchanges required.

Whilst the legal and technical requirements of Redispatch 2.0 apply to all network operators in Germany, the specific IT infrastructure that implements these requirements is not mandated. Established by Netze BW and TransnetBW, thirteen other network operators have also since registered as partners in the test phase.[28] The project is open to all other interested DSOs.

2.1.2 Platforms as market intermediaries

This category of flexibility platforms capture those which facilitate the procurement of flexibility from existing markets. These platforms either facilitate the penetration of DER into existing wholesale energy and balancing markets (e.g., the Crowd Balancing Platform) or act as a single gateway for T/DSOs to procure flexibility through established wholesale energy and balancing markets (INTERRFACE and GOPACS).

THE CROWD BALANCING PLATFORM

Founded by an international consortium of TSOs ('Equigy'), the Crowd Balancing Platform is a market-intermediary platform that integrates with existing TSO system services markets and redispatch processes. The Crowd Balancing Platform is blockchain-based and acts as the gateway for FSPs (in particular, aggregators) to access national TSO markets for balancing services and congestion management.

The core functions of the Crowd Balancing Platform are to provide for secure data exchange and transaction validation between market participants, with the objective of increasing the level of assurance and reducing the levels of perceived risk that system operators have when contracting with small-scale assets.

As of March 2021, the platform has gone live for aFRR in The Netherlands (connecting a 27MW wind farm and a battery) and has run a FCR pilot project in Switzerland (connecting a 1.2MW battery storage system). Going forward, the Crowd Balancing Platform aims to contribute to redispatch in Germany, to the aFRR market in Austria and to RR in Italy. A pilot project with focus on redispatch was also successfully implemented in Germany with sonnen e-services in 2018.

Whilst currently an exclusively TSO platform, the Crowd Balancing Platform may involve markets and products for DSOs in the future.

The Equigy/Crowd Balancing Platform related topics are from Equigy European perspective. Each TSO/country can implement their own solution with their own processes and legislations. In this document, solutions/processes are mentioned that are not implemented or foreseen within TenneT TSO.

27 Expansion to other control areas is possible contingent on voluntary participation from other TSOs.

28 Partners are: TenneT TSO, Stadtwerke Schwäbisch Hall, Flughafen Stuttgart Energie, EnBW Ostwuerttemberg DonauRies, Regionalnetze Linzgau, ED Netze, FairNetz, bnNetze, MVV Netze, Stadtwerke Schwäbisch Gmünd, Stadtwerke Karlsruhe Netzservice, Stadtwerke Heidelberg and EGT Energie.

INTERRFACE

The INTERRFACE Interoperable pan-European Grid Services Architecture (IEGSA) aims to facilitate competition *between* energy markets by linking wholesale, retail, balancing and new congestion management markets. As a single gateway for T/DSOs to access markets, IEGSA aims to increase overall liquidity and allow T/DSOs to secure flexibility at the most competitive price. Bids are submitted by FSPs within the connecting markets and forwarded to the IEGSA platform where they are qualified, combined into a merit order list, and forwarded back to the market. INTERRFACE aims to improve penetration of DER in existing energy markets through standardisation of prequalification and settlement processes and adapting new congestion management products around the mFRR standard.

The INTERRFACE trial phase is due to launch in March 2021 with an expected end date of December 2022. During this phase the following operators are involved in the design, deployment and evaluation of the platform: Fingrid (Finnish TSO), Elering (Estonian TSO), AST (Latvian TSO), Elenia (Finnish DSO), Elektrilevi (Estonian DSO). A call for FSPs will target either independent aggregators or software providers that can support energy suppliers to implement a demand response program.

GOPACS

The GOPACS (Grid Operators Platform for Congestion Solutions) is a market intermediary platform owned and operated by the Dutch-German TSO (TenneT) and four DSOs (Stedin, Liander, Enexis Groep and Westland). The GOPACS platform supports coordinated market-based procurement of congestion management services via participating energy markets in the Netherlands, currently the intraday market operated by Energy Trading Platform Amsterdam (ETPA).[29]

GOPACS provides a single gateway for T/DSOs to issue a congestion notification to the connected markets.

GOPACS procures a combination of two or more orders (a buy and a sell order) from associated intraday energy markets for each congestion notification. FSPs on the intraday market that are located within the congested area are invited to submit an energy sell or buy order (depending on the nature of the congestion problem), and those located outside of the congested area are able to submit an opposite (i.e., buy or sell) order to facilitate a balanced activation.

The price difference between the buy and sell orders is called an Intraday Congestion Spread (IDCONS).

The market platform provides GOPACS with bidding and location information for the market participants. The GOPACS optimisation algorithm then matches buy orders with sell orders (based on price, volume and effectiveness of the flexibility resource). The network operator who initiated the request pays the difference between these two prices (IDCONS) to enable the transaction to take place and solve the congestion problem.

Bids submitted by FSPs to the ETPA orderbook with locational data of assets may be matched as a standard intraday product rather than IDCONS and can therefore be delivered anywhere with the usual energy trading obligations.

As of March 2021, over 90 GWh of flexibility has been procured via GOPACS by TenneT (since January 2019) with a further 110 MWh procured by Liander (since September 2020), giving an annualised figure of 45 GWh.[30]

29 There are ongoing conversations with other market platforms (EpexSpot, Nord Pool) with the aim to also connect these to GOPACS.
30 Based on data extracted from: ***idcons.nl/publicexpenses#/expenses***

2.1.3 Platforms as marketplaces

Within this final category of flexibility platforms there are two varieties: marketplace platforms that are based on a continuously-clearing market format (NODES-NorFlex and NODES-IntraFlex) and those which are based on a closed-auction format (Piclo Flex, eSIOS-CECRE-CoordiNet).[31]

Both continuously-clearing market platforms reviewed in this study are facilitated by the independent marketplace operator NODES. Under this model, FSPs can place offers on the platform when it is suitable for their own operational conditions. This contrasts with Piclo Flex, where tendering is on an auction basis and so features discrete competitions with pre-defined bidding deadlines.

PICLO FLEX

Piclo Flex is an independently operated marketplace that enables flexibility to be transacted between FSPs and DSOs, across both time and location dimensions. The platform offers grid operators a 'modularised' service, from fully outsourced procurement with in-house transaction clearing, auction facilitation, flexibility requirement visibility and advertisement, to asset and company prequalification and credential certification that in the future, may enable bidding into other markets. Across 2021/2022, Piclo is developing the platform to provide API enabled automated end-to-end services for flexibility procurement including settlement, activation and validation and secondary trading markets.

DSOs in the UK currently adopt different procurement models via Piclo Flex. SPEN, ENWL and UKPN fully outsource each step of the procurement up until bidding and auctions including auction and settlement functions. WPD, SSEN and ENWL on the other hand, previously only outsourced the advertisement function of their procurement process to Piclo Flex and conducted the remaining stages of procurement using the 'Flexible Power' website by WPD. Figure 5 provides an overview of procurement activity in 2019 and 2020 through Piclo Flex.

As of June 2021, further active tenders have been opened by SPEN and ENWL for 562 MW and 182 MW of flexibility, respectively.

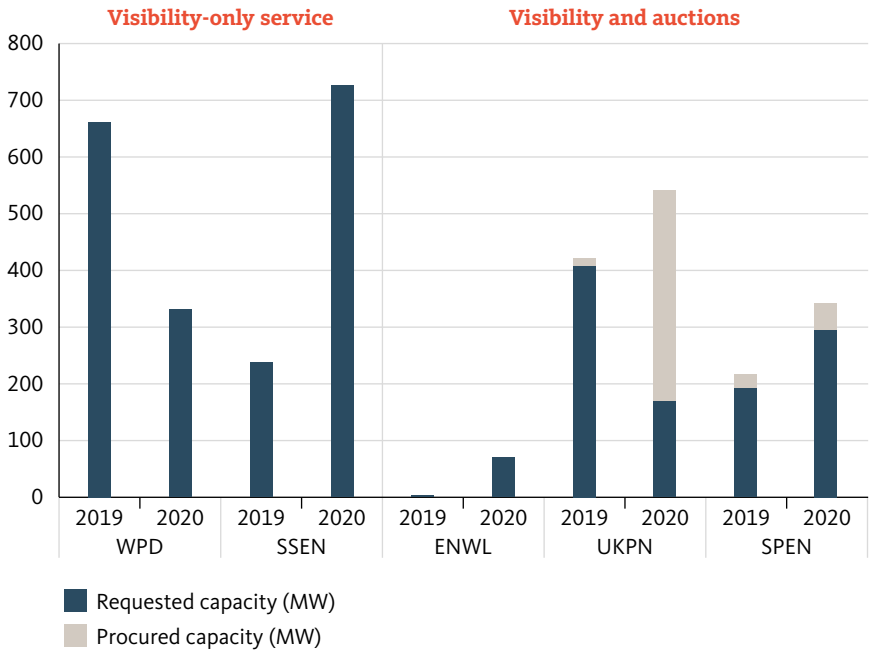


Figure 5:
Volume of flexibility requested and awarded on Piclo Flex*

Source: Piclo

Note: For DSOs using Piclo Flex's visibility-only service, the following was procured over 2019 and 2020; 457 MW (WPD**), 171 MW (SSEN***). These totals include MW procured without the use of Piclo Flex service. Data for ENWL is not available. A further procurer NPg is also active on Piclo Flex, although data is not available

* There are some methodological differences in the calculation and reporting MW of flexibility procured by DSOs across the UK. As such, there may be divergences in how individual DSOs report flexibility procurement outside of the Piclo Flex platform.

** *www.flexiblepower.co.uk/downloads/406* and *www.flexiblepower.co.uk/downloads/582*

*** *www.energynetworks.org/assets/images/ENA%20Consolodated%20Flex%20Figures%202020-PUBLISHED.xlsx*

31 A further discussion of these auction formats is provided in Section 3.5.

NODES-NORFLEX

The NODES-NorFlex project is a 3-year pilot for local flexibility procurement established by the Norwegian TSO Statnett and DSOs Agder Energi, Glitre Energi, and Mørenett, in conjunction with the independent market operator NODES and technology-provider Enfo.[32] The pilot comprises three demonstration projects[33], where partners will jointly test various technological solutions to enable local flexibility to be made available at the distribution-system-level initially, with plans to make the residual flexibility available to the existing TSO reserve market. Currently in its second year, the project is facilitating local flexibility trading at the distribution system-level.

In the first phase, the project traded 25 MWh of flexibility across the 3 month operating period with FSP assets varying between 50-250 kW in capacity. The second phase (commencing in April 2021) expects to add to this by including batteries above 200 kW.

NODES-INTRAFLEX

Launched in 2020 by Western Power Distribution (WPD), the NODES-IntraFlex project is a DSO-led trial of flexibility procurement using the independently operated NODES marketplace platform. NODES-IntraFlex is testing the use of a continuously-clearing market that operates from a few days ahead to close to real-time for the procurement of flexible generation and consumption. The NODES-IntraFlex platform implementation project is separate from WPD's primary flexibility procurement system 'Flexible Power'.

In the first phase, WPD procured approximately 50 MW of pre-fault flexibility services (similar to the UK standardised product 'Secure' described in Figure 9) across 241 trades, amounting to just over 25 MWh of activated flexibility. The assets were split between a few larger generators and some providers of flexibility from electric vehicles. WPD have stated that Phase 2 of the trial, commencing in Spring 2021, will focus on increasing flexibility volumes on the platform and improving processes to ensure scalability of the product.

32 NODES marketplace has been used in several projects, which are summarised in Annex 1.
33 Demo Møre, Demo Glitre and Demo Agder.

ESIOS-CECRE-COORDINET

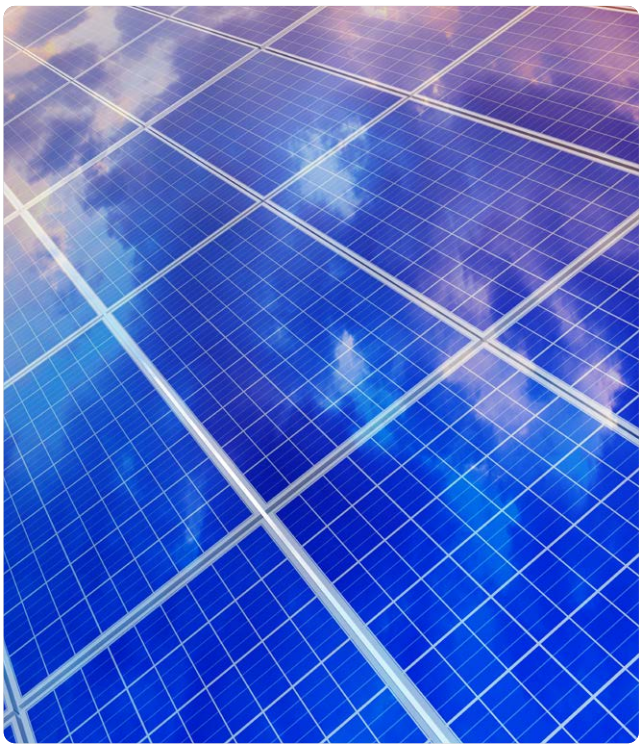
This project refers to the ecosystem of digital platforms owned and operated by TSO Red Electrica Espana ('REE'), that facilitates market-based balancing and congestion management for T/DSO in Spain. At present the platforms support flexibility procurement by REE and the following DSOs: Endesa; i-DE; UFD; EDP; and Viesgo.

eSIOS is a marketplace platform that receives bids for downwards and upwards redispatch for T/DSO congestion management purposes, whilst CECRE is an operating platform that monitors real-time production of FSPs (with a capacity >1 MW) and has control over asset activation. CoordiNet refers to the local platforms that integrate the coordinating functions that manage the interactions between FSPs, eSIOS and CECRE.

If a congestion event is identified within the day-ahead time frame, eSIOS reviews FSP schedules from the wholesale market and identifies the schedules that may be adjusted (either upwards or downwards, either by adjusting wholesale results or by specific bids to the separate congestion management market) to resolve the congestion at the lowest opportunity cost. In particular, in day-ahead time frame, downwards redispatch solutions for congestions are made by directly removing the relevant FSP transactions from the wholesale market schedule.

eSIOS operates a separate congestion management process for congestions that may only be resolved *beyond* the day-ahead gate closure time (i.e., within the intraday time frame). In these circumstances, eSIOS uses offers collected from the day-ahead market timeframe, being market participants allowed to update their offers till real-time. FSPs identified for redispatch are considered by the eSIOS platform and, in the case of upwards and downwards real-time energy redispatch, FSPs are reimbursed on a pay-as-bid basis.

Redispatch instructions are then issued to the relevant market parties. In all the cases (also in pilots leading with potential voluntary promoted local markets under exploration), the counterbalancing of redispatches and the adjustment of imbalances are made by the TSO through eSIOS-CECRE. After a redispatch instruction is issued, eSIOS coordinates with the TSO settlement system during the imbalance settlement process.



eSIOS works in conjunction with the operating unit CECRE, which monitors production in real time from facilities (or groups of facilities) with a power capacity greater than 1 MW, through 'delegated control centres' (qualified by REE) that have control, command and monitoring capacity, acting as aggregators of information. The delegated control centres provide CECRE with real-time information and also receive and distribute operational measures, issued by REE, necessary for the system to remain in a safe state.

FSPs are either mandated (i.e., for units with a capacity >1 MW) or voluntary (i.e., <1 MW) participants registered on the day-ahead market. FSPs may include any generating/storage units that have a minimum capacity (individually, or pooled-capacity in the case of aggregators) of >1 MW, with a minimum bid granularity of 0.1 MW. That means that FSPs must at least aggregate themselves above 1 MW to participate in the markets under current rules.

eSIOS also communicates the availability of resources to national balancing markets, in particular, when the resources have already been allocated a congestion management activation within the relevant time frame. Through this function, eSIOS ensures that the TSO and DSO do not issue counteracting instructions to the same units for different purposes. As part of the real-time congestion management process, balancing energy is used for counterbalancing the real-time redispatch actions.

2.2 PARTICIPANTS AND PRODUCTS

T/DSOs are the main procurers of flexibility products across the platforms reviewed. Figure 6 provides an overview of the types of flexibility products that are procured through the eight (8) selected flexibility platforms, as well as the procuring and providing entities. The following sections discuss in further detail the procurers, products and providers across each platform.

Platform	Platform type	Procurers	Product-type	Providers
DA/RE	Coordination for administrative flexibility scheme	TSO; DSO	Non-standard Congestion Management	All generating and storage units with a capacity >100 kW
The Crowd Balancing Platform	Market intermediary	TSO	Balancing	FSP
INTERRFACE	Market intermediary	DSO; TSO	Balancing; Standardised Congestion Management	FSP registered on the flexibility platform
GOPACS	Market intermediary	DSO; TSO	Standard Congestion Management	FSP registered on a participating energy exchange
Piclo Flex	Marketplace	DSO	Standard Congestion Management	Any
NODES-NorFlex	Marketplace	DSO	Non-standard Congestion Management	Any
NODES-IntraFlex	Marketplace	DSO	Non-standard Congestion Management	Any
eSIOS-CECRE-CoordiNet	Marketplace	TSO; DSO	Balancing; Non-standard Congestion Management	All generating and storage units. Demand-response participation is under development.

Figure 6: Summary platforms reviewed as part of this report

Source: Frontier Economics

Note: 'Standard' products are characterised by a pre-defined set of values across the product parameters (e.g., FCR or FRR for balancing products, and the Secure/Sustain/Dynamic/Restore standard local flexibility products agreed by the UK DSOs). 'Non-standardised' products allow the market parties to specify different combinations of parameter values for each transaction.

2.2.1 Procurers

The platforms reviewed as part of this study are used by TSOs primarily for maintaining the short-term balance between active power supply and power demand, whilst DSOs use these platforms primarily for congestion management.[34] The needs of procurers may be further characterised as a need at the overall system level (e.g., balancing) or from a local perspective (e.g., congestion management).

Flexibility products traded via these eight flexibility platforms are used by TSOs for balancing and congestion management purposes, whilst DSOs typically procure flexibility for congestion management purposes. Figure 7 provides an overview of the main procurers of flexibility through platforms selected for this study.

It is worth noting that balance responsible parties (including FSPs) could also use certain platforms to both buy and sell flexibility to manage their open positions; although they are not as yet active on the platforms reviewed as part of this report.

Platform	Procurers	Name
DA/RE	TSO, DSO	All participating generating/storage unit operators within the TransnetBW control area (from October 2021)
The Crowd Balancing Platform	TSO	SwissGrid, TenneT, Terna, APG
INTERRFACE	TSO, DSO	Fingrid (TSO), Elering (TSO), AST (TSO), Elenia (DSO), Elektrilevi (DSO)
GOPACS	TSO, DSO	TenneT (TSO), Liander (DSO)
Piclo Flex	DSO [35]	SSE, UKPN, ENWL, SPEN, NPg, WPD
NODES-IntraFlex	DSO	WPD
NODES-NorFlex	DSO	Agder Energi, Glitre Energi, Mørenett
eSIOS-CECRE-CoordiNet	TSO; DSO	REE (TSO); Endesa; i-DE; UFD; EDP; Viesgo

Figure 7: Summary of procurers

Source: Frontier Economics

34 Congestion management relates to the requirement for T/DSOs to limit or avoid exceeding network congestion driven by the need to mitigate the risks posed by overload. As defined by Commission Regulation (EU) 1222/2015 of 24 July 2015

35 All DSOs listed use the Piclo Flex flexibility platform for visibility, whilst only SSEN and UKPN use the platform for auctions (i.e. fully outsourced procurement). ENWL, SPEN, NPg and WPD have ‚visibility only' contracts, whereby the DSO uses Piclo Flex to advertise and publish their flexibility needs, but conduct the procurement process outside of Piclo Flex using separate systems.

2.2.2 Products

The units that define flexibility products are characterised through various technical, commercial and operational parameters (so-called 'dimensioning parameters'). For example, parameter values may be specified for: the amount of power modulation, the direction of modulation, the rate of change, the response time and (in the case of congestion management) the location of the asset.

'Standard' products are characterised by a pre-defined set of fixed values across the product parameters, whilst 'non-standardised' products allow the market parties to specify different combinations of parameter values for each transaction. Both standardised and non-standardised products may include locational requirements for the purposes of congestion management.

STANDARD PRODUCTS

All products that support regional system balancing are based on standard dimensioning parameters defined by the Network Code on System Operation (Commission Regulation (EU) 2017/1485),[36] as summarised in Figure 8. In addition to these products, Member States may also have standardised 'national' balancing products, e.g., Dynamic Containment (DC) procured by National Grid in Great Britain.[37]

Standard products that support local congestion management have more recently also emerged in some jurisdictions. For example, the UK Energy Networks Association (ENA) has established a set of four product-standards (Sustain, Secure, Dynamic, Restore) across multiple parameter dimensions. Figure 9 provides a summary of these products and their key characteristics.

We also observe new congestion management products that are based on the mFRR product standard[38] in the case of INTERRFACE, and TenneT's redispatch product, Reserve Power Other Purposes (ROD), in the case of GOPACS.[39] These products are supplemented with locational information on the providing units to enable T/DSOs to redispatch generation/consumption across geographically defined constraint areas.

Replacement Reserve	Replacement Reserve (RR) are the active power reserves available to restore or support the required level of FRR to be prepared for additional system imbalances, including generation reserves. RR is a standardised frequency response product that supports the required level of FRR for additional imbalances with an activation time of over 15 minutes.
Frequency Restoration Reserve	Frequency Restoration Reserve (FRR) active power reserves available to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value. FRR is a standardised frequency response product dispatched for frequency deviations that last between 30 seconds and 15 minutes. This may include both automatic (aFRR) and manual (mFRR) activation. aFRR is traded via a capacity price (and possibly also utilisation price) and is dispatched automatically by contracted flexibility provider on command of the grid operator.
Frequency Containment Reserve	Frequency Containment Reserve (FCR) refers to the active power reserves available to contain system frequency after the occurrence of an imbalance. FCR is a standardised frequency response product dispatched for frequency deviations in less than 30 seconds. This product is traded via a capacity price (and possibly also utilisation price) and is dispatched automatically by contracted flexibility provider on command of the grid operator.

Figure 8: Standardised categorisation of EU active power balancing products

Source: Frontier Economics, based on ENTSO-E 'Electricity Balancing in Europe' November 2018

36 Whilst these products are designed for cross-border provision of balancing services, national balancing products also exist.
37 National Grid ESO. Balancing Services. Available at: *www.nationalgrideso.com/industry-information/balancing-services*
38 As described in Figure 9.
39 *www.TenneT.eu/electricity-market/ancillary-services/redispatch-documents*

Service name	Service type	Service definition
Sustain	Scheduled constraint management	The Network Operator procures, ahead of time, a pre-agreed change in input or output over a defined time period to prevent a network going beyond its firm capacity
Secure	Pre-fault	The Network Operator, procures, ahead of time, the ability to access a pre-agreed change in the Service Provider input or output based on network conditions close to real-time
Dynamic	Post-fault	The Network Operator procures, ahead of time, the ability of a Service Provider to deliver an agreed change in output following a network abnormality
Restore	Restoration	Following a loss of supply, the Network Operator instructs a provider to either remain off supply, or to reconnect with lower demand, or to reconnect and supply generation to support increased and faster load restoration under depleted network conditions

Figure 9: ENA definition of standardised local flexibility services

Source: Open Networks Project, Active Power Services Implementation Plan, December 2020

NON-STANDARDISED PRODUCTS

Certain flexibility marketplaces also enable T/DSOs to depart from fixed product standards for congestion management. In particular, NODES marketplace platform (used for both NODES-NorFlex and NODES-IntraFlex) allows flexibility providers to select combinations of different dimensioning parameters which provides a catalogue of flexibility offers for T/DSOs to filter from. Alternatively, the T/DSOs themselves may issue a template defining the parameter values that they would like. Alongside these dimensioning parameters, flexibility offers may indicate the locations at which the assets are connected.

These flexible products may either oblige the provider to adhere to a constant change in infeed or offtake of active power during a fixed time period (e.g. the 'ShortFlex' product) or establish capacity contracts in pre-defined grid locations (e.g., the 'LongFlex' product), or a combination of both.

Figure 10 provides an overview of the dimensions across which a ShortFlex product may be specified.

Product parameters	Description
Order type	Whether the flexibility is requested through a buy or a sell order.
Order quantity	The MW of generation or consumption capacity that is requested for the flexibility potential.
Time	The various time parameters, including the interval over which the flexibility is requested and the expiry time of the order.
Activation price	The price per MWh for activated deviations in energy generation/consumption from the baseline schedule.
Reservation price	The price per MW for availability of flexible generation/consumption capacity.
Location	The grid location for the flexibility order that is created by the DSO, defined by a set of spatial boundaries for the flexibility offers.
Regulation	Either 'up-regulation' (i.e. an increase in generation or reduction in consumption) or 'down-regulation' (i.e. a decrease in generation or increase in consumption).
Fill type	This parameter specifies the way in which the order is executed. The fill types used on by NODES-IntraFlex follows the definitions used on Nord Pool intraday market: 'Limit order'; 'Fill-or-Kill', and; 'Fill-and-Kill'. 'Limit order' is executed at the limit price or lower (for buy orders), or at the limit price or higher (for sell orders) and may be partially executed. 'Fill-or-Kill' is a limit order that shall be immediately matched for the whole order volume or cancelled whilst 'Fill-and-Kill' shall be immediately matched for as much of the order volume as possible and then cancelled.

Figure 10: Flexibility product parameters for the ShortFlex product

Source: WPD and Nord Pool

PAYMENT BASIS

All flexibility products (both standard and non-standard) are further defined by how they are remunerated, and may involve two main payment types:

- Activation or utilisation payments specify a price per MWh for every unit of energy that is produced (or withheld) and not consumed (or over-consumed) relative to an agreed counterfactual profile over the settlement period.
- Reservation or availability payments specify a price per MW of generating or consumption capacity that is reserved for flexibility activation over the settlement period (whether or not it is actually activated).

These payment types may either be used in isolation or combination to provide the necessary incentives to FSPs. Figure 11 provides a summary of the payment types currently adopted across the flexibility platforms reviewed.

Platform	Payments
Piclo Flex	Availability (EUR/MW/h) and/or Activation (EUR/MWh)[40] depending on the product in question
NODES-IntraFlex	Availability (EUR/MW/h) and Activation (EUR/MWh)
NODES-NorFlex	Activation (EUR/MWh) only
Crowd Balancing Platform	Depending on the trading rules of connecting marketplace platform
GOPACS	
INTERRFACE	
DA/RE	Activation (EUR/MWh) only
eSIOS-CECRE-CoordiNet	Activation (EUR/MWh) only, except for aFRR which also receives capacity payments (EUR/MW/h)

Figure 11: Summary of payment types adopted

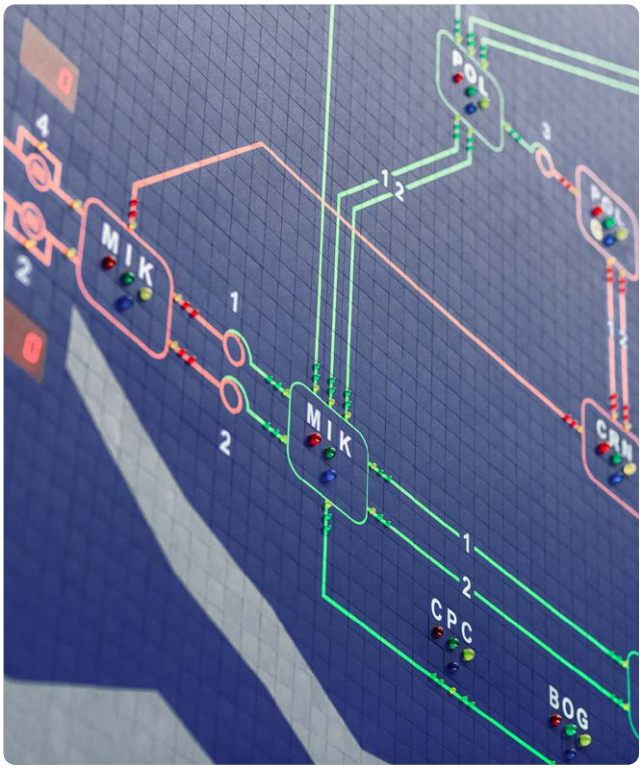
Source: Frontier Economics

40 Piclo Flex enable the trade of industry-defined product standards which determines the types of payment (Open Networks Project, Active Power Services Implementation Plan, December 2020)

2.2.3 FSPs

Providers of flexibility have traditionally been centralised utility-scale assets such as conventional power plants. In recent years, the proliferation of DER has provided opportunities for disaggregated generating, storage or consumption units to access markets for flexibility. The platforms in this study focus on increasing participation of DER that are operated by a range of different types of commercial entities, as summarised in Figure 12.

Aggregators[41] are emerging as an important stakeholder in the form of an intermediary between a broad and diverse set of potential FSPs and platform operators. Aggregators may take the form of an independent third-party that contracts directly with the DER, or an energy supplier that makes available its existing supply assets. Whilst aggregators focused on Commercial and Industrial ('C&I') segments have existed for some time, the EU directive (2019/944) encourages Member states to "foster [the] participation of demand response through aggregation' and calls for allowing 'final customers, including those offering demand response through aggregation, to participate alongside producers in a non-discriminatory manner in all electricity markets."



Platform	FSPs	DERs
DA/RE	All FSPs	Includes all storage and generation systems (including renewable energy sources and combined heat and power systems) with a capacity of more than 100 kW
Piclo Flex	All FSPs	The platform is technology agnostic. Current assets registered as flexibility providers include commercial aggregators, storage entities, and C&I[42] customers.
NODES-IntraFlex	All FSPs	Generators (C&I), Customers (C&I), Customers (Residential), Storage entities
NODES-NorFlex	All FSPs	The platform implementation project is technology agnostic. A broad range of assets are currently registered, from C&I customers (through commercial buildings) to residential customers (through EV chargers and electrical heating).
The Crowd Balancing Platform	All FSPs	The platform is asset agnostic. Assets are generally connected to the distribution grid beneath the 20 kV level, although may be higher in some circumstances. Currently, those active in the platform provide flexibility from several resources, including RES generators (specifically, wind farms), residential customers, and storage entities (via EV and household batteries), heat-pumps.
GOPACS	All FSPs that are eligible to trade on the associated intraday platform.	Both large-scale and smaller scale assets (EVs, batteries and HPs) with a minimum bid size of 100 kW, to be aggregated to 500 kW.
INTERRFACE	Aggregators	C&I generators, RES generators, C&I customers, residential customers, and storage entities.
eSIOS-CECRE-CoordiNet	All FSPs that are eligible to trade on the day-ahead wholesale market	FSPs may include any generating/storage units that have a minimum capacity (or pooled-capacity) of >1.MW[43]

Figure 12: Summary of FSPs

Source: Frontier Economics

41 Defined in Article 2(18) of Directive 2019/944 as an entity that combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market.
42 'Commercial and Industrial'.
43 Units that are smaller than 1 MW can participate but they shall aggregate themselves in such a way to ensure minimum bid of 1 MW and granularity of 0,1 MW

2.3 PLATFORM FUNCTIONS

Within the three models of platform defined in Section 2.1 above, there is considerable variation in the functions that platforms perform within the end-to-end process for accessing flexibility. The end-to-end process may be characterised as follows:

Figure 13: End-to-end process for accessing flexibility

The remainder of this section is structured along each stage of the end-to-end procurement process outlined above. Within each stage we first characterise the nature of the problem that needs solving. We next provide an overview of the role that flexibility platforms play in addressing this problem. Lastly, we follow with a discussion of the specific technological solutions that the platforms deploy to serve these purposes.

Figure 14 provides a high-level summary of the key functions that the platforms perform. ››

Platform functions	Piclo Flex	NODES-IntraFlex	NODES-NorFlex	The Crowd Balancing Pla
Prequalification	■ Within-platform Company and asset details qualified for each auction, with Dynamic Purchasing System (DPS) framework.	■ Within-platform Platform verifies assets to qualify on platform	■ Within-platform Platform verifies assets to qualify on platform	■ Off-platform Responsibility of pre-qual resources at the aggregat level remains with the TS may process resulting dat
Asset registration	■ Within-platform Flexibility register maintained by platform. Assets that qualify for an T/DSO's competitions are viewable by that T/DSO.	■ Within-platform Flexibility Register accessible for T/DSOs.	■ Within-platform Flexibility Register accessible for T/DSOs	■ Within-platform FSPs register single assets platform
Notification of requirements	■ Within-platform T/DSO requirements are directly submitted to, and publicised within, platform.	■ Within-platform T/SO requirements submitted tom and publicised within, platform.	■ Within-platform T/SO requirements submitted to, and publicised within, platform.	■ Within-platform TSOs may input requirem platform, which are then an affiliated marketplace may elect to only use plat pass through for offers.
Notification of offers	■ Within-platform FSPs submit flexibility offers directly to platform, and may post availabilities within grid areas.	■ Within-platform FSPs submit flexibility offers directly to platform.	■ Within-platform FSPs submit flexibility offers directly to platform.	■ Within-platform FSPs may submit flexibilit platform which are direct to the backend of the TSO elect to retain this functio off-platform procurement
Coordinated grid impact assessment and priority of access	■ Off-platform Currently a DSO-only platform. A support function for secondary trading of flexibility in Capacity Market is available.	■ Off-platform Currently a DSO-only platform.	■ Off-platform In the future the platform will aggregate local flexibility unused by the DSO from low voltage levels to the TSO via the existing mFRR reserve market.	■ Off-platform Currently a TSO only plat
Matching	■ Within-platform FSPs submit flexibility offers, and the T/DSO chooses which to accept either within platform or through own procurement system.	■ Within-platform Market operator matches once a request is greater than or equal to an offer. T/DSOs may filter order-book based on non-price criteria. There is no direct contact between T/DSO and FSP.	■ Within-platform Market operator matches once a request is greater than or equal to an offer-. T/DSOs may filter order-book based on non-price criteria. There is no direct contact between T/DSO and FSP.	■ Within-platform FSPs submit flexibility off are then routed to balanci where the bids selection may also elect to retain th off-platform.
Price formation	■ Within-platform Closed auction, pay-as-bid	■ Within-platform Continuously – clearing market, pay-as-bid	■ Within-platform Continuously – clearing market, pay-as-bid	■ Off-platform Prices are formed within balancing markets
Dispatch instruction and activation	■ Off-platform Manual dispatch instruction and activation by the DSO. Plans to bring automatic dispatch signals from the DSO via a marketplace API during 2021/22.	■ Within-platform Platform sends trade confirmations that the FSP can convert to activation signal. Activation is the responsibility of the FSP and may be manual or automatic.	■ Within-platform Platform sends trade confirmations that the FSP can convert to activation signal. Activation is the responsibility of the FSP and may be manual or automatic..	■ Within-platform[44] TSOs send the activation via the platform to FSPs. responsible for the activa devices via its own systen
Validation	■ Off-platform DSO-led manual validation process using FSP meter data	■ Within-platform Metering portal validates using baseline measurement methodology and metering data from FSPs.	■ Within-platform Validates using baseline measurement methodology and metering data from FSPs.	■ Off-platform TSO receives a real-time measurement and baselin platform but the validatio done outside.
Settlement	■ Off-platform Settlement is conducted by DSOs off-platform. Payments are for activation or utilisation (depending the on product).	■ Within-platform Settlement conducted within platform. Activation payments only, with performance-based penalty methodology.	■ Within-platform Settlement conducted within platform. Payments are for Activation (ShortFlex and Availability (LongFlex)	■ Off-platform Settlement is done via the market processes. The for payments are in line with

Figure 14 Summary of flexibility platform implementation projects and their functional capabilities

44 The activation itself is done in the TSO system. The signal of the activation is sent via the platform to the FSP. FSP is responsible for the activation of the devices via its own systems.

tform	GOPACS	INTERRFACE	DA/RE	eSIOS-CECRE-CoordiNet
ification of ion/pool O. Platform a records.	**Off-platform** FSPs register on a connected market platform that supports IDCONS and enter into a participation agreement with GOPACS.	**Within-platform** Assets must qualify with platform. T/DSOs and marketplaces may require parallel prequalification.	**Off-platform** Participation is mandated by criteria of Redispatch 2.0	**Within-platform** eSIOS-CECRE and DSO have a role to check requirements for participation in wholesale markets. Company and asset details qualified when starting as market participants in the Spanish market.
s on	**Off-platform** Not performed within platform	**Within-platform** Flexibility Register stores asset information, trading results and receives metering data.	**Off-platform** Assets are registered on the Connect+ platform, with description of MW capacity band that units may alter output within.	**Within-platform** All providers are registered with information of e.g. electrical location.
ents on routed to platform, or form as a	**Within-platform** T/DSOs input requirements on platform, which are then routed to an affiliated market	**Within-platform** T/DSOs input requirements on platform, which are then routed to an affiliated marketplace platform.	**Within-platform** T/DSOs submit redispatch requirements to platform, which is vertically aggregated with all T/DSO planning data.	**Within-platform** T&D system operators submit redispatch requirements to eSIOS platform, that solves the congestion and provides solution . -
y offers on ly forwarded D. TSO may on within t processes.	**Off-platform** FSPs submit flexibility offers onto an affiliated market (ETPA)which is routed through to GOPACS with FSPs bidding information.	**Off-platform** FSPs submit offers to the affiliated marketplace platforms, which are forwarded onto the platform	**N/A** FSPs do not place bids, participation is mandated and FSPs are selected based on central optimisation	**Within-platform** FSPs submit flexibility offers directly to platform (eSIOS).
form.	**Within-platform** Platform acts as TSO-DSO intermediary that facilitates coordination T/DSO that solutions provide national balance.	**Within-platform** TSO-DSO coordination module performs a grid security assessment before activating FSP bids.	**Within-platform** Platform performs regular network security assessment from T/DSO-submitted forecast and planning data	**Within-platform** TSO-DSO coordination of results of grid assessment are supported by the platform.
ers. Bids ing markets occurs. TSOs his function	**Within-platform** Platform's optimisation algorithm then matches FSP buy orders with sell orders based on price, volume and effectivity of the flexibility resource.	**Off-platform** Platform creates merit-order list for all qualified bids which is forwarded to markets	**Within-platform** A multi-dimensional optimisation is performed across all voltage levels to identify the most efficient redispatch to resolve the congestion event	**Within-platform** Platform creates merit-order list for all qualified bids
national	**Off-platform** Prices formed within wholesale markets. T/DSO pays the spread between FSP buy and sell orders.	**Off-platform** Not performed within platform	**Off-platform** FSPs submit calculated operating cost of redispatch which is the basis of reimbursement	**Within-platform** For congestion management, allocation is solved paid as bid. Downwards redispatch in D-ahead congestion process is solved by cancelling allocated schedules in DA wholesale market.
signals FSP is tion of the ns.	**Off-platform** Manual activation takes place off-platform	**Off-platform** mFRR is manually activated through the markets. Congestion management may be initiated by the platform (which forwards information to markets) or takes place directly in markets.	**Within-platform** Platform issues redispatch instruction to FSPs. Activation is manual or automatic, depending on FSP unit type.	**Within-platform** Congestion management activation can be both: manual or automatic (in the case re-dispatching request in real time process).
power e via the n itself is	**Off-platform** Validation handled by T/DSOs outside platform.	**Within-platform** FSPs upload metering data and activated volumes to platform prior to settlement.	**Within-platform** Activation measurements are required for reimbursement.	**Within-platform** CECRE validates flexibility providers deliver the service by tele-measurement.
e normal m of the the market.	**Off-platform** Settled as a regular intraday trade by market platform operator.	**Off-platform** Platform forwards validation data to markets were payments are settled.	**Off-platform** Settlement is conducted between the instructing T/DSO and the relevant FSP.	**Off-platform** Supported by specific measurement and settlement system: SIMEL-SIL

Source: Frontier Economics, based on information provided by platform operators and public sources

Notes: This table describes the capabilities of each platform, whether or not a particular functional element is implemented across all national programmes. For example, different national implementations of the Crowd Balancing Platform may adopt different combinations of the above functional elements whilst T/DSO retain particular functions outside of the platform ecosystem.

2.3.1 Asset registration and prequalification

Before a flexibility provider may compete to provide flexibility it must comply with pre-determined eligibility criteria to provide assurance to potential procurers that they are capable of delivering the selected product. These eligibility criteria may either be set at the platform-level, the market-level or by individual procurers. At a minimum this typically involves technical assessment of the underlying flexibility asset(s) and may also include a company due diligence assessment.

ROLE OF PLATFORMS

The asset registration and prequalification process can lead to high transaction costs for FSPs. Flexibility platforms may play a role in reducing these transaction costs by providing streamlined and/or automated submission processes for FSPs. Flexibility platforms also play a role in providing third-party assurance of flexible assets to procurers and thereby increase up-take. Furthermore, flexibility platforms often seek to reduce the minimum thresholds for assets to participate in flexibility markets by providing or facilitating, the aggregation of assets within a single flexibility pool. In practice we observe that the platforms reviewed for this report take varying degrees of responsibility over prequalification of FSPs. We have identified three stages across which flexibility platforms may provide input.

1. Setting eligibility criteria

Eligibility criteria for FSPs to participate in flexibility markets may be at the product, asset and/or company-level. Commonly requested asset details include location, voltage, available capacity, and ramping time. Generally, eligibility criteria implemented by the platforms reflect requirements of the adjoining markets or platform participations (T/DSOs) but may, in some instances, supplement these with additional requirements.

Generally, intermediary platforms are less active in setting these requirements. For the Crowd Balancing Platform, the requirements for flexibility providers to participate in the balancing services markets are specific to each market and defined by TSOs.[45] The platform therefore implements these requirements in each market. For INTERRFACE, the qualification criteria are determined by the connecting system operator. As part of the prequalification process for NODES-IntraFlex and NODES-NorFlex, platform operator NODES requires the T/DSO to approve flexible assets by verifying in which grid area (at the lowest voltage level) the asset is located. NODES is open to all flexibility providers whether these have balance responsibility or not.

In other cases, the platforms may also implement company eligibility requirements. To provide an additional layer of assurance for procuring DSOs, Piclo Flex requires FSPs to provide prequalification data as a company, as well as in relation to the asset(s) that would provide the flexibility service. An overview of the key company pre-qualification requirements that Piclo Flex facilitates on behalf of the DSOs using the marketplace platform are provided in Figure 15.

Company pre-qualification requirements are used in tandem with asset qualification to assess and qualify FSPs.

Component	Details
Company details	Basic questions about the business that is to be the counter signing entity of the flexibility services contract with the system operator.
Asset ownership	A way to describe the relationship between the business and the assets under management.
Audit details	An independent audit document (e.g. Achilles Audit) that verifies management systems comply with the standards that have been agreed by buying organisations and demonstrates compliance against the agreed audit protocol.
Organisation questions	Questions relating to the legal status of the business and insurance details

Figure 15: Prequalification requirements for FSPs on Piclo Flex

Source: Frontier Economics, adapted from ***Support.PicloFlex.com***

Notes: The requirements outlined above may be amended or added to based on the individual requirements of the DSO.

45 The individual specifications for participation in TSO ancillary services markets can be found on their respective websites.

2. Collecting information from FSPs

Beyond hosting minimum participation criteria for FSPs, the platforms may request supporting information for registering on the platform.

Within the NODES-IntraFlex project, platform operator NODES carries out this process within the platform. When registering assets via the NODES platform, FSPs must submit technical asset details to the platform (including asset type, ramping rates in MW/minute, the Meter Point Administration Number (MPAN)[46], and location). Piclo Flex also enables asset registration for similar technical details on the platform for participation. For INTERRFACE, FSPs must complete a user registration and resource qualification with the platform before it can be forwarded to a participating market. User registration is performed by the platform administrator which requires a valid Energy Identification Code (EIC). Once an FSP has passed user registration it must register each individual asset with technical and locational information.

For GOPACS, flexibility providers need only register on a connected trading platform and enter into a participation agreement with the GOPACS platform. This process provides that any relevant data for FSPs may be sent to GOPACS and the grid operators. Likewise, for the Crowd Balancing Platform, the requirements for flexibility providers to participate in the balancing services markets are specific to each market and defined by TSOs[47] and the Crowd Balancing Platform is implemented to adhere to these requirements in each market.

3. Approval of prequalification

Any information received must be assessed against eligibility criteria, resulting in approval of prequalification (or failure to prequalify). The prequalification process as described above may either be carried out once for FSP's to be accepted onto the platform, or may be required for each individual flexibility request issued by the T/DSO.

We observe that flexibility platforms that provide self-contained markets are more directly involved in this process. These platforms serve T/DSOs who will have less experience in prequalifying assets, in comparison to platforms that are intermediaries to existing markets (the Crowd Balancing Platform, GOPACS and INTERRFACE). For example, NODES has developed a rule-book which determines a core set of requirements for the registration of assets (as summarised in Figure 16).

Prequalification Stage		Details
1	**Submit member registration form**	This includes company and asset information, including: company and user contact details, including company name, registration number, VAT number, and address, asset details, including the Metering Point Administration Number (MPAN) and flexibility volume that can be provided.
2	**Complete relevant technical build**	This involves putting the technology in place and making sure it works properly for participants – it is mandatory for the metering system API, but optional for the NODES API.
3	**Test Zero (End to End system testing)**	Participants must agree a test time with NODES and WPD. The test is carried out in an orderbook dedicated to testing, covering trade, dispatch, and validation of delivery. The trade is for a minimum of half an hour and maximum of two hours at £300 per participant.
4	**Confirm prequalification**	This confirms that the minimum participation requirements have been met.
5	**Asset approval**	Assets are submitted via the NODES portal, which requires MPAN and the unique ID given from the metering system, latitude and longitude, and ramping time in MV/minute.

Figure 16: Stages of prequalification conducted on NODES-IntraFlex

Source: Frontier Economics, adapted from Western Power Distribution[48]

Notes: The requirements outlined above may be amended or added to based on the individual requirements of the DSO.

46 MPAN is a unique reference number for all electricity supply points, including individual domestic residences, in the UK.
47 The individual specifications for participation in TSO ancillary services markets can be found on their respective websites
48 *www.westernpower.co.uk/downloads-view-reciteme/242185*

Furthermore, subject to meeting the above prequalification criteria, each FSP asset is then approved by the T/DSO into an order-book specified at the lowest possible voltage level of the grid. FSPs may then form portfolios of assets that can bid into order-books for which all assets are approved. This provides a natural incentive for portfolios to be geographically orientated. INTERRFACE may either delegate qualification of resources to the connecting T/DSO or can set preconfigured procedures that can perform automatic qualification within-platform.

TECHNICAL SOLUTIONS

Flexibility platforms are exploring a range of technical solutions to support asset registration and prequalification. Those of particular interest include NODES' asset registration interface and Piclo Flex's asset register and Dynamic Purchasing System (DPS). Moving forwards, the Crowd Balancing Platform is also exploring an automatic pre-qualification of specific device types (manufacture-model IDs) via APIs to the OEMs.

1. NODES-IntraFlex's interface for asset registration

Figure 17 displays the steps involved in asset creation via the NODES platform. Participants interact with the platform via an API. Flexibility providers must indicate whether they are registering a consumption or generation asset, the ramp-up and ramp-down rates of their asset and location information. The system operator (WPD) then checks the location of the asset before approving it to the main order book.

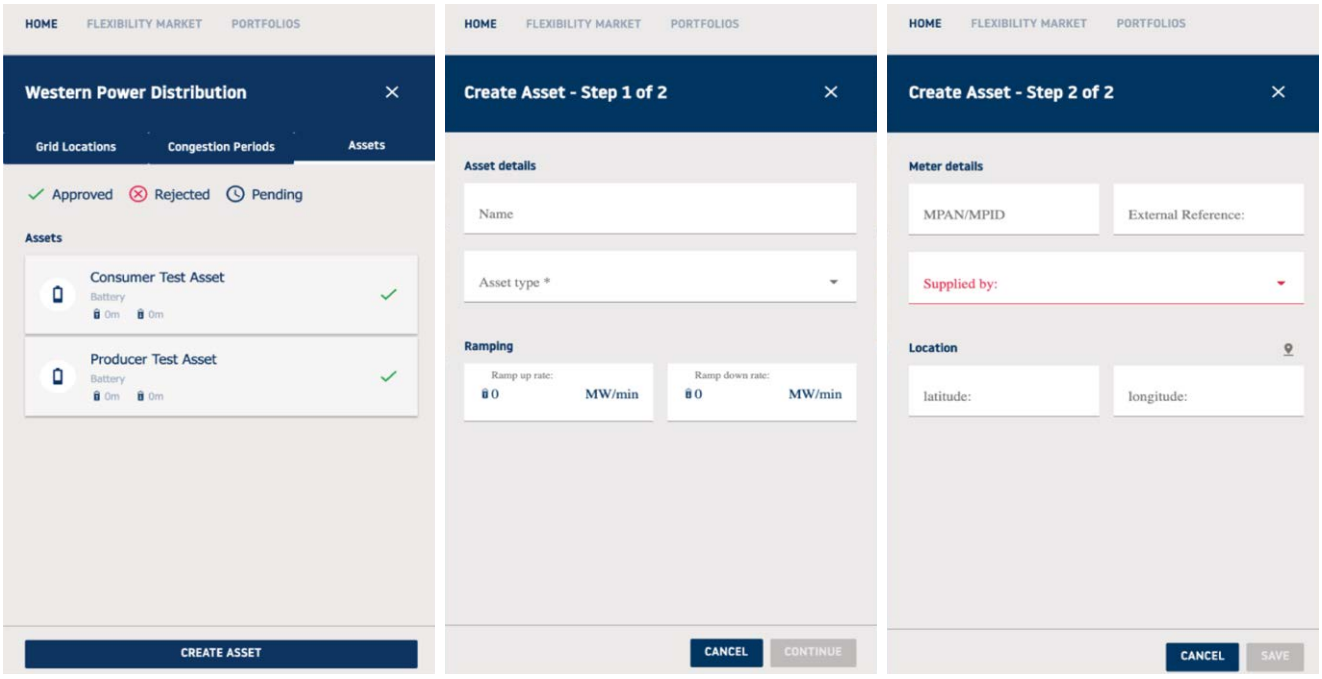


Figure 17: NODES platform asset creation

Source: Western Power Distribution[49]

49 *www.westernpower.co.uk/downloads-view-reciteme/244822*

2. Piclo Flex's Dynamic Purchasing System (DPS)

To reduce the transaction costs incurred by FSPs when qualifying registering for each competition, Piclo Flex has introduced a Dynamic Purchasing System (DPS) for company qualification. The DPS is a register that enables flexibility providers to remain qualified to bid for flexibility competitions for a set length of time determined by DSOs, thereby relaxing the requirement to re-qualify for each individual flexibility competition. Once a DPS has been established with a qualifying flexibility provider, Piclo Flex provides an automatic technical qualification of assets for every competition for the DSO, which a FSP provides and uploads to Piclo Flex via an Asset File or via Asset API.

Absent a DPS, a lengthy 'Framework Agreement' process would be required to establish the terms governing future competitions. To begin this process, the T/DSO would be required to advertise a specific time-bound opportunity. Following this, the T/DSO would undertake a consultation period, where agreements are drawn up with respondent(s). Once complete, a mini-competition is held, and a contract for flexibility services is awarded. However, if similar services are required later on, this whole process must be repeated. This process is shown in Figure 18 below[50].

Under a DPS, the system operator first advertises their needs alongside their terms and information requirements for company qualification and determines the length of time for which the DPS will remain valid. FSPs can apply to qualify in a DSO's DPS at any time, regardless of whether there are flexibility requirements signposted on Piclo Flex at that time.

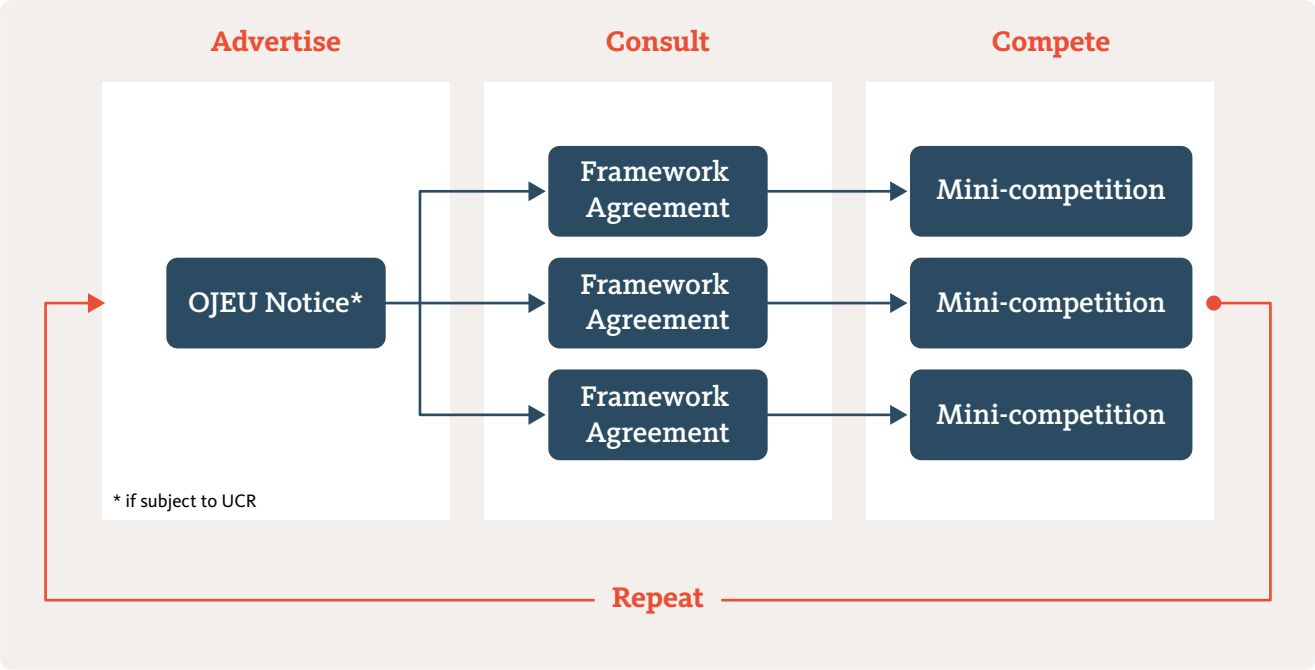


Figure 18 Traditional Framework Agreement competition process

Source: ***Piclo Flex***

50 In the figure, the DSO's advertisement is labelled as an 'OJEU notice'. This applies when the services are governed by the Utilities Contracts Regulations 2016 – in these instances, the advertisement would be placed in the Official Journal of the European Union (OJEU)

Unlike the traditional framework agreement process, the DPS advert remains active for the set time determined by the DSO. Respondents complete an online process to demonstrate eligibility, but can then proceed straight to the competition stage once their DPS application has been accepted by the DSO. All those that pass are awarded a place on the DPS, with asset eligibility being the only remaining barrier to participation. The DPS remains active for as long as the DSO determines, which can include multiple rounds of flexibility tenders. This alternative process is illustrated in Figure 19 below. After meeting the basic requirements of the DPS, assets are marked as 'qualifying' and the full details of the asset are passed on to the DSO running the competition. At this stage the DSO may perform a full technical assessment based on additional criteria (including telemetry requirements). If the asset passes the DSO assessment the FSP will receive an automatic email once bidding is open.

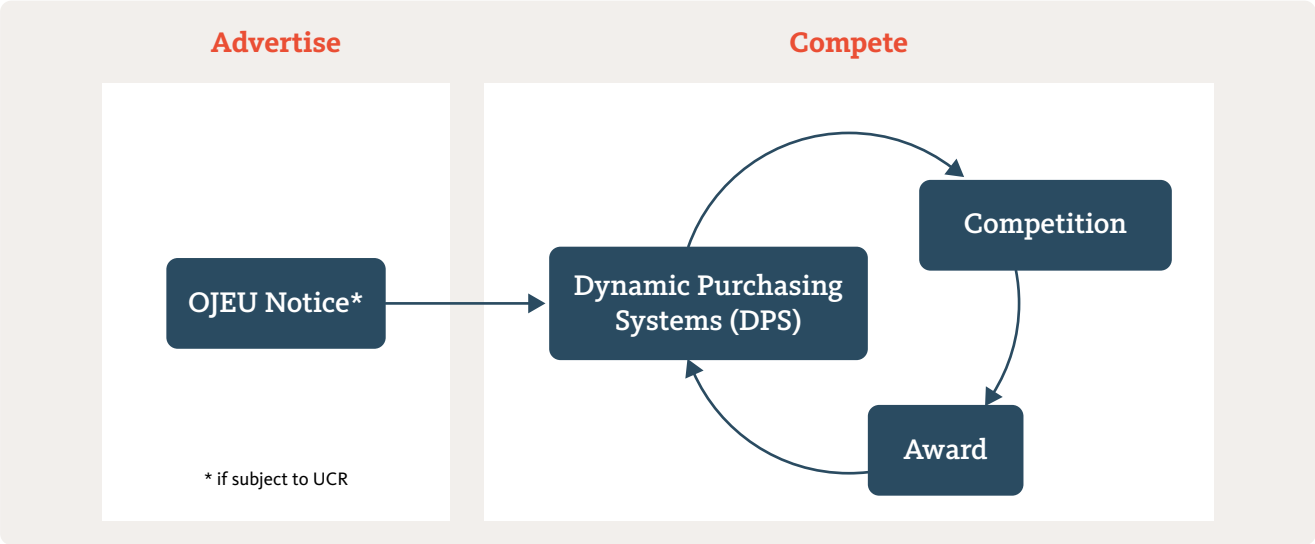


Figure 19: Piclo Flex's DPS competition process

Source: ***Piclo Flex***

3. The Crowd Balancing Platform's API for automatic prequalification

As a future development, to further reduce the transaction costs involved in registration and prequalification, the Crowd Balancing Platform is exploring the possibility of an automatic prequalification of specific device types (manufacture-model IDs) via APIs to the Original Equipment Manufacturers (OEM).[51] Under this model, once a certain device type is pre-qualified by the TSO, other devices of the same type may have the option to be directly pre-qualified ("PQ ready") on device-level, allowing for easy integration into aggregated pools.

ASSET REGISTRATION AND PREQUALIFICATION

- Flexibility platforms may be involved in setting FSPs' eligibility criteria for participation, hosting these criteria, collecting relevant information for prequalification and may take responsibility for approval.
- Intermediary platforms typically defer eligibility criteria and approval to the adjoining balancing markets (the Crowd Balancing Platform), whilst self-contained marketplaces implement asset-level (NODES-IntraFlex and NODES-NorFlex) as well as company-level (Piclo Flex and eSIOS-CECRE-CoordiNet) eligibility criteria as per the procuring T/DSOs requirements.
- Physical testing is sometimes required of FSPs prior to approval (NODES-IntraFlex).
- In some cases, platform-operated 'asset registries' store technical information of FSP resources and their location (the Crowd Balancing Platform, Piclo Flex, NODES-IntraFlex, INTERRFACE, eSIOS-CECRE-CoordiNet).
- Approval of asset prequalification may either be delegated to T/DSO (INTERRFACE, Crowd Balancing Platform), either as part of a platform-facilitated function or through a separate coordinated process (INTERRFACE, Crowd Balancing Platform), performed automatically within platform (NODES-IntraFlex, NODES-NorFlex)*, or by the adjoining market operator (GOPACS).

* INTERRFACE platform design also foresees this possibility but is not implemented

Figure 20: Summary of functions performed by flexibility platforms

51 Application Programming Interfaces (APIs) are defined as 'interfaces that define interactions between multiple software applications or mixed hardware-software intermediaries'.

2.3.2 Notification of flexibility requirements and submission of offers

The proliferation of distributed resources creates an increasingly dispersed network of stakeholders with which flexibility platforms have to interface. On the one hand, T/DSOs seek to advertise their requirements in real-time to all qualified providers and to receive offers from the market. On the other hand, pre-qualified FSPs require visibility of T/DSO requirements and a means to submit their offers. Once a manual process between a limited number of stakeholders, the procurement of flexibility increasingly calls for an automated and secure communication interface that connects multiple stakeholders and systems. Against this backdrop, flexibility platforms have adopted a range of different solutions to connect and integrate market participants.

ROLE OF PLATFORMS

The fundamental role of all flexibility platforms is to provide market participants with efficient access to, and visibility over, flexibility requirements and availabilities. Depending on the platform model in question, this may include any of the following functions.

1. A platform-interface for T/DSOs

The platform-interfaces for T/DSOs are digital portals within the flexibility platform that enable T/DSOs to specify the parameters of requests for flexibility. Once inputted into the platform, this information is then either routed to an affiliated marketplace platform (GOPACS, INTERRFACE,) or publicised within the flexibility marketplace platform itself (NODES-IntraFlex, NODES-NorFlex, Piclo Flex).

All of the platforms reviewed contain an interface for T/DSOs, with some variation in the scope of this function between platforms. Marketplace platforms (NODES-IntraFlex, NODES-NorFlex, Piclo Flex) all contain a T/DSO interface where requests for flexibility are input directly into the platform. Piclo Flex enables DSOs to directly upload network area and flexibility competition data, the maximum yearly budgets or guide prices, qualify assets and companies, auction facilitation as well as confirm the winning FSPs. Similarly, the NODES marketplace platform allows T/DSOs to input grid locations of the congested areas, the price they are willing to pay, the volume needed and the relevant time (i.e., the 'ShortFlex' product requirements). Market intermediary platforms differ. On the Crowd Balancing Platform, FSPs can submit a bid for the balancing market within the intermediary platform and TSOs interact with the platform only to confirm accepted offers. On the other hand, GOPACS acts as a T/DSOs' gateway to existing markets, enabling them to input flexibility requests that are then routed onto affiliated markets.

2. A platform-interface for FSPs

Similarly, flexibility platforms may also provide a user-interface for FSPs to input asset registration data and the parameters of flexibility offers. This functionality is core to all marketplace platforms, but not all market intermediaries.

On Piclo Flex, qualified FSPs may directly upload availability updates, company and asset data and bids with availability updates. The ability to input dispatch data and metering data is also being developed across 2021/2022. Similarly, the NODES marketplace platform allows qualified FSPs to input directly the amount of flexibility they are able to offer across their portfolios within the relevant time period and price they are willing to accept. In the future, the NODES-NorFlex project also envisions enabling a secondary market for flexibility by enabling FSPs to trade buy-orders (similar to wholesale markets). For market intermediaries there are again differences. In INTERRFACE, FSPs do not directly interact with the intermediary platform (beyond asset registration) but instead submit flexibility offers to the affiliated marketplace platforms. The market operators forward this information to the intermediary platform. The Crowd Balancing Platform, on the other hand, is the first point-of-call for FSPs which register their assets and flexibility offers. These are then routed on to a national balancing market.

3. An interface to marketplace platforms

Acting as a single gateway to existing markets, GOPACS receives standardised requests for flexibility with a locational-criteria directly from T/DSOs. This enables T/DSOs to communicate their requests for flexibility with all market parties on existing marketplaces.

4. A flexibility register of pre-qualified assets

A flexibility register is a central database operated by the flexibility platform that holds technical (and in some circumstances locational) information for all pre-qualified assets of registered FSPs.

For example, Piclo Flex's 'Shared Flexibility Asset Register' contains all the asset data uploaded by FSPs. T/DSOs are able to use the register to view only assets that are qualified for their own flexibility competitions.[52] For INTERRFACE, the flexibility register serves as an intermediary in the bid qualification process. FSPs first upload their asset information to the register, including all locational and necessary technical information. The register receives the T/DSO's requests for flexibility and issues an offer to the flexibility platform based on the requirements specified. If the offer is accepted and cleared then the register issues the activation signal to the FSP.

5. An advertisement board

Flexibility platforms can provide direct visibility over transaction opportunities to both sides of the market. Advertisement boards for T/DSO requirements provide FSPs visibility over the requests for which they qualify, including information such as time and type of flexibility requirements and, in the case of congestion management, location. This function is important in reducing the search costs associated with discovering and reviewing invitations to tender from T/DSOs.

As a tool for congestion management, Piclo Flex enables DSOs to publicise requirements for location-specific grid constraints. FSPs may also publish the location and connection-point voltage of their planned, in development, operational or mothballed assets, enabling DSOs to see qualifying assets in their constraint management zones. The platform matches active assets with new requests for flexibility as they are published, signalling transaction opportunities for congestion management purposes. For FSPs with assets distributed across multiple locations, this system identifies whether their assets are in a location that will qualify for competitions and provides data to support business cases for new assets.[53] Within NODES marketplace, the sales orders are visible to all linked grid areas (i.e., order books). Therefore, a sales bid can be active in all levels of the grid from the lowest constraint zone up to the TSO. Within the NODES-IntraFlex and NODES-NorFlex projects, platform operator NODES enables T/DSOs to publicise requirements according to a non-standardised congestion management product framework ('ShortFlex', discussed in Section 2.2.2). In ShortFlex, T/DSOs specify a spatial boundary for the flexibility offer according to the grid location of the congestion event.

52 To ensure compliance with GDPR, DSOs are only able to view asset data for FSPs that have qualified for their individual flexibility competitions (i.e. access to information is not made public)
53 *piclo.energy/publications/Piclo+Flex+-+Flexibility+and+Visibility.pdf*

TECHNICAL SOLUTIONS

Flexibility platforms typically deploy a common set of technical solutions to support interfacing functions between market participants; Application Programme Interfaces (API), and Graphical User Interfaces (GUI).

1. Application Programme Interface

An API is a digital application protocol that defines how different information communication systems retrieve data across the internet. APIs specify the format of the data, the attributes of the dataset that can be retrieved and the ways in which data may be queried. APIs can be used to connect systems together and enable automated processing of each other's data. APIs replace the need to manually transfer and format data between T/DSOs, FSPs and marketplaces. This reduces the transaction costs associated with data exchanges, improves visibility of flexibility requirements and reduces human error. Through this, APIs enable flexibility platforms to more easily scale up.

The Crowd Balancing Platform deploys an integrated infrastructure of APIs that enable qualified market parties (FSP) to communicate with TSO. It may be extended to communication from one market party to another across the individual sub-components of the flexibility procurement process. The registration of flexibility devices, creation of flexibility offers, registration of aggregated measurements and baselines, and measurement of activated energy are all communicated between the relevant parties via distinct APIs. Similarly, Piclo Flex is designed as an 'API-first' platform with the primary purpose of seamless and automatic accessing and transferring of data for dispersed systems. In this way, Piclo Flex's digital infrastructure provides a service that may be scalable to the growing needs of its users.[54]

2. Graphical User Interface

A GUI is a visual interface that enables market participants to intuitively navigate the parameters of flexibility requests or flexibility offers. GUI's use shapefile formatted data to represent icons, lines and areas across a geographic map. GUIs are most commonly deployed by marketplace platforms that serve a congestion management use case for T/DSOs. Figure 21 shows a screenshot taken from the NODES-IntraFex project, showing the relevant grid locations of FSP's assets.

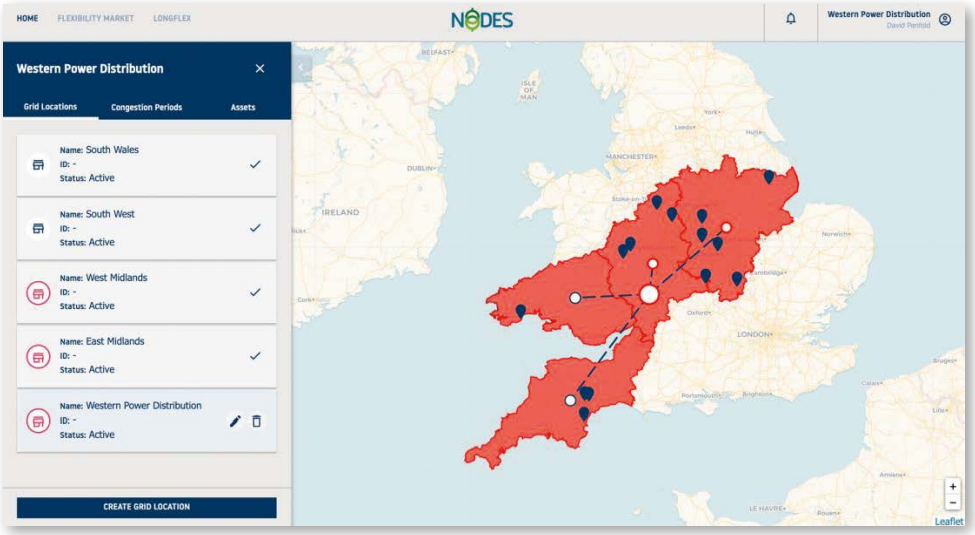


Figure 21: IntraFlex GUI

Source: Western Power Distribution

54 Piclo Flex deploys commercial solutions such as Amazon Web Services (AWS) and the open source database system PostgreSQL to support their technical offering.

NOTIFICATION OF FLEXIBILITY REQUIREMENTS AND SUBMISSION OF OFFERS

- Flexibility platforms improve market participant's visibility over transaction opportunities by way of digital communication interfaces between stakeholders.
- All platforms provide an interface for T/DSOs, with marketplace platforms enabling T/DSOs to directly upload their flexibility requirements as applicable[55]. Market intermediaries may either act as T/DSOs' gateway to existing markets (GOPACS) or will only interact with T/DSOs once tenders are processed on adjoining marketplace platforms (the Crowd Balancing Platform).
- Whilst the information regarding T/DSO's flexibility requirements is needed for price formation, it is not necessary to initiate the market-based procurement process as FSPs may be able to provide their flexibility bid-offers without a prior request from T/DSO.
- Marketplace flexibility platforms also offer direct interfaces for FSPs to upload availability information across asset portfolios. In some instances market intermediaries may also provide direct interfaces for submission of bids or asset qualification (the Crowd Balancing Platform), although this is typically conducted within the adjoining marketplace (GOPACS, INTERRFACE).
- In some cases, platform-operated 'asset registries' store technical information of FSP resources and their location (Piclo Flex, NODES-IntraFlex, INTERRFACE, the Crowd Balancing Platform, eSIOS-CECRE-CoordiNet)). T/DSOs are able to use the register to view assets that are qualified to meet their flexibility requirements (whilst this information remains confidential to other market parties), or may use the data records to perform flexibility resource qualification (such as determining the location of flexibility resource within the grid for congestion management purposes).

55 For the Crowd Balancing Platform, this functionality depends on the product. For example, for redispatch, the TSO does not upload its flexibility requirement.

Figure 22: Summary of functions performed by flexibility platforms

2.3.3 Coordinated grid impact assessment and priority of access

The penetration of DERs connected to the distribution grid provides opportunities for both DSOs and TSOs to procure flexibility, whilst also creating new dependencies. In particular, the reservation and/or activation of distributed flexibility by one T/DSO has the potential to effect the other's ability to maintain grid security. A coordination scheme that defines the roles and responsibilities between T/DSOs in the procurement of distributed flexibility has the potential to improve whole-system functioning.

ROLE OF PLATFORM

Whilst TSO-DSO coordination may not be outsourced to an independent platform, platforms do offer the possibility for an interfacing structure between stakeholders located across all voltage levels of the grid. We have identified several common elements currently supporting TSO-DSO coordination on the flexibility platforms we have reviewed.

1. Coordinated grid impact assessments

GOPACS, INTERRFACE and DA/RE are set up with an explicit coordination objective between TSO and DSOs, with both types of entities procuring flexibility on these platforms. A core function within the scope of these platforms is a coordinated grid impact assessment of flexibility offers submitted by FSPs.

GOPACS is the sole congestion management platform for all congestion related actions from DSOs and the TSO in The Netherlands. By ensuring every active grid connection has a unique locational ID within the congested area, GOPACS' objective is to adopt solutions that resolve the local congestion without creating another local congestion or national imbalance.

GOPACS defines hierarchy rules between the network operators. An order can be used only if it does not cause congestion in another area and does not disturb the balance at the national level. In that way, counter actions in one area of the system do not create an issue somewhere else.

An explicit objective of INTERRFACE is closer cooperation between TSOs and DSOs, and the IEGSA platform contains a dedicated TSO-DSO coordination module. Bids submitted by FSPs on affiliated markets are forwarded to the platform's single market interface and, after gate closure and bid qualification, the platform issues a merit-order list to the marketplace as well as the TSO-DSO coordination module. The TSO-DSO coordination platform ensures that the flexibility that is activated by the DSO does not exceed the maximum level that is set by the TSO. The platform does this by estimating the maximum potential upwards/downwards power modulation at each TSO substation and receives the DSO information connected to those points. If the TSO's maximum power modulation exceeds the flexibility bid value (in MW) then the flexibility register issues a capacity activation signal to the flexibility register.

DA/RE jointly optimises across all network voltage levels and therefore takes into account how a new redispatch call interacts with the existing network restrictions constraints of all network operators in Baden Wuerttemberg (DSOs and TSO). This aims to avoid some actions exacerbating congestion issues in other parts of the network and to make use of potential synergies to optimise redispatch across different types of flexibility potentials.

2. Priority of access rules

NODES-IntraFlex, NODES-NorFlex and Piclo Flex are currently only used by DSOs to procure flexibility for congestion management purposes. Whilst these marketplace platforms may open up to TSOs in the future, there is currently no defined coordination scheme in place nor a facility for whole-system impact assessment. However, both platforms have signalled future developments to include a priority of access hierarchy.

Currently, within the NODES-NorFlex project there are separate models for congestion management at the transmission and distribution levels and there is currently limited oversight between operators. Sufficient time before gate closure, NODES-NorFlex provides TSOs with an information service allowing them to take actions on the intraday market in response to DSO activations.[56] However, the project is working towards a combined balancing and congestion management model that defines the roles and responsibilities of DSOs and TSOs (expected in the autumn 2021).

Further to this, in the future NODES-NorFlex will expand to offer residual flexibility to the mFRR market, thus including the TSO as a secondary procurer. Under this new arrangement, DSOs will remain the primary buyers, and as such will be given priority as well as the opportunity to raise a red flag preventing any up or down regulation that is going in the wrong direction for the local grid.

Piclo Flex expects that the need for coordination in UK flexibility services procurement will grow over the next 1-2 years. To this end, Piclo Flex expects it will start developing measures to improve visibility of contracts and procurement between TSOs and DSOs.[57] In the more immediate term, Piclo Flex is due to launch a procurement support function for National Grid (TSO) to bring distributed flexibility into secondary trading for the GB capacity market, in collaboration with National Grid ESO (TSO).

COORDINATED GRID IMPACT ASSESSMENT AND PRIORITY OF ACCESS

- Market intermediary flexibility platforms typically have an explicit coordination objective between TSO and DSOs (GOPACS, INTERRFACE, DA/RE) and may support coordinated grid impact assessment by T/DSOs, before bid qualification and matching of offers with requirements.
- This may either be by way of hierarchy rules between T/DSOs that ensures orders are not used if they cause congestion in another area (GOPACS) or may jointly optimise across all network voltages levels thereby accounting for existing network restrictions of all T/DSOs (DA/RE).
- Marketplace flexibility platforms are currently used by TSOs and DSOs (eSIOS-CECRE-CoordiNet) or only by DSOs (Piclo Flex, NODES-IntraFlex), where a coordination principle for grid prequalification is defined. In some cases marketplace platforms provide an information service for TSOs to enable procurement on intraday markets in response to DSO activations (NODES-NorFlex).

Figure 23 Summary of functions performed by flexibility platforms

56 NODES explored an automatic rebalancing function for DSOs/FSPs in the intraday market but this was descoped in favour of an information service to support manual portfolio management.
57 Piclo is a partner in the EU OneNet Project, exploring this topic in more detail. *onenet-project.eu/launching-onenet-one-network-for-europe*

2.3.4 Matching

Efficient matching of FSP offers to T/DSO needs requires a joint-optimisation across multiple dimensions and participants (including indirect stakeholders) often at short-notice. These dimensions include: the effectiveness of the asset to satisfy the flexibility need (across both technological and locational constraints of the provider), the opportunity cost of the FSP and T/DSO, and negative effects of activated energy in other areas of the grid.

ROLE OF PLATFORM

At this stage of the procurement process flexibility platforms implement a bid qualification process and, in some cases, a matching criteria, in order to achieve an optimisation objective. A platform's optimisation objective may be based on whole-system needs (i.e. at all voltage levels of the transmission and distribution system jointly) or for individual system needs (i.e. at level of distribution system or transmission system).

1. Bid qualification

Matching begins after a T/DSO submits a flexibility request bid on the platform that specifies technical and temporal requirements. For market-based platforms, pre-qualified FSPs are invited to submit corresponding flexibility offers to the platform. The platform then conducts a bid qualification process that screens flexibility offers against the T/DSO's requirements.

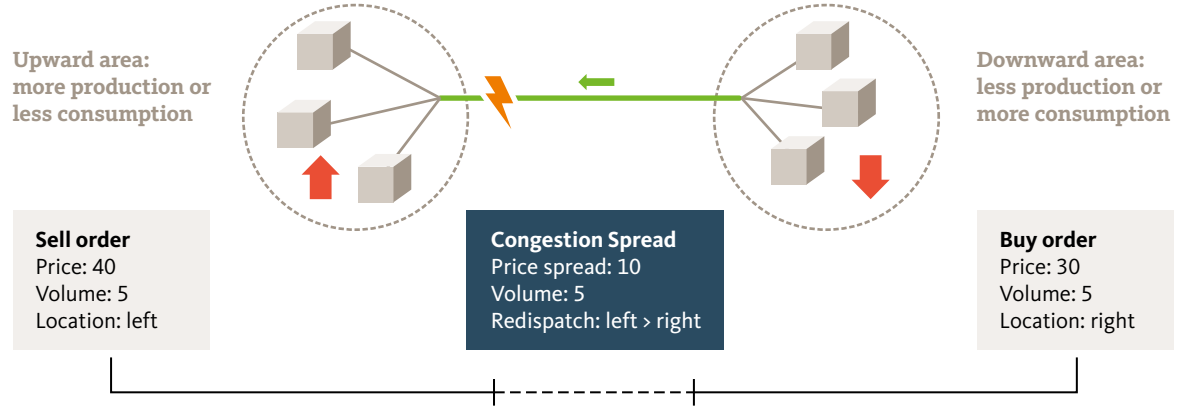
Platforms that provide congestion management products from an aggregated pool of assets will also have their portfolio-orientated bids based on locational criteria relevant to the congestion zone. Through NODES, assets are approved into an order book defined at the lowest possible grid level and automatically added into any other relevant order books in the grid hierarchy. Portfolio-bids will only qualify into orderbooks for which all assets are approved. If there is a single asset within the portfolio from a neighbouring order book then the portfolio may only bid into the grid level which is common to both order books. After bid qualification, the flexibility platform will either enable the T/DSOs to filter and select flexibility offers themselves (i.e. closed-auction platforms, such as Piclo Flex) or will facilitate a centralised matching process without the involvement of a T/DSO (e.g. continuously-clearing market platforms, such as NODES in the NODES-NorFlex and NODES-IntraFlex projects).

2. Matching criteria

Platforms that perform a centralised matching function implement predefined matching criteria which specify the dimensions (and their respective weighting) across which the FSPs' offers are assessed.

A fundamental criteria underpinning flexibility transactions between a T/DSO and FSP (as with any market-based transaction) is that the willingness to pay (WTP) of the T/DSO for the flexibility service, reflecting the opportunity cost of procuring flexibility to the T/DSO (e.g. network reinforcement costs), is greater than or equal to the willingness to accept (WTA) of the FSP, reflecting the corresponding opportunity cost to the FSP (e.g., revenue associated with alternative to flexibility provision). Market-based platforms use price signals from the participants to reveal their WTP and WTA and provide matches between FSPs and T/DSOs where the WTP and WTA overlap. Non market-based platforms (i.e. DA/RE), on the other hand, use calculated operating costs of the FSP's generating/storage units as a proxy for the FSP's WTA.[58]

The market-based platform GOPACS uses price signals to match participants through a transaction structure involving at least two trades. GOPACS procures a combination of at least two or more orders (a buy and a sell order) from associated intraday energy market. For each congestion notification issued on GOPACS, FSPs on the intraday market that are located within the congested area are invited to submit an energy sell or buy order (depending on the nature of the congestion problem), and FSPs located outside of the congested area are able to submit an opposite (i.e., buy or sell) order. The price difference between the buy and sell orders (intra-day congestion spread or IDCONS) is paid by the grid operator to enable the transaction to take place and solve the congestion problem. The process is illustrated by way of a stylised example in Figure 24.



A connection within a congestion zone has planned to produce 5 kW between 14:00 and 15:00 (equivalent to 5 kWh) and issues a sell-order for EUR 40. A market party outside of the congestion zone places a buy-order of 5 kW for the same period on the trading platform, including the EAN code of that connection. However, the buy-order is set for EUR 30 and therefore the intraday market is unable to facilitate a transaction. Instead, an IDCONS offer is created and the grid operator is issued a spread price (EUR 10) that, if accepted, enables a transaction to take place and the redispatch solves the congestion problem.

Figure 24: The IDCONS concept (a stylised example)

Source: Frontier Economics, adapted from GOPACS

58 The overall principle for reimbursement under Redispatch 2.0 is that the plant operators should be economically neutral towards the redispatch intervention. The expenses that are reimbursed include those directly related to the actual adjustments of the feed-in (such as fuel costs). Indirect 'opportunity costs' are also taken into account at the reimbursement stage, such as foregone revenue opportunities and costs associated with postponing regular operations.

Another aspect of matching criteria applied by flexibility platforms involves ordering the FSP bids. For instance, NODES marketplace platform creates a merit order stack from flexibility offers, allowing the T/DSO to buy the flexibility it needs at the lowest price. Whilst price and time are the primary matching criteria within this merit order, there may be other ordering dimensions based on buyers' preferences (such as asset type, sensitivity or proximity to congestion event).

GOPACS applies additional matching criteria related to whole-system security before activating the most cost-efficient match. This ensures that a match does not aggravate congestion elsewhere in the electricity grid (say at a different voltage level or for another T/DSO) and that the grid balance is maintained.

DA/RE matches based on a whole-system security criteria, allocating available flexibility based on the greatest need to reduce whole system costs. DA/RE optimises over the estimated operating cost of participating generating/storage units and the effectiveness of the redispatch in resolving the congestion event.

MATCHING

- Efficient matching of FSP offers to T/DSO needs requires a joint-optimisation across dimensions such as: the effectiveness of the asset to satisfy the flexibility need (across both technological and locational constraints of the provider), the opportunity cost of the FSP and T/DSO, the WTP of the T/DSO and the WTA of the FSP, and; the effects of activated flexibility on areas of the grid outside of the constraint.
- Flexibility platforms first implement a bid-qualification process that filters for bids that meet the technical and temporal requirements of the request. Flexibility platforms that provide congestion management products will also screen portfolio-orientated bids for locational criteria (NODES-IntraFlex, NODES-NorFlex).
- After bid qualification, platforms may either enable T/DSOs to filter and select flexibility offers themselves (Piclo Flex, eSIOS-CECRE-CoordiNet) or facilitate centralised matching without direct involvement of T/DSOs (NODES-IntraFlex, NODES-NorFlex).
- GOPACS utilises a multi-transaction structure that enables T/DSOs to simultaneously execute separate buy and sell transactions with FSPs on the connected intraday market with the price difference between the buy and sell orders (intra-day congestion spread) paid by the T/DSO.

Figure 25: Summary of functions performed by flexibility platforms

2.3.5 Price formation

Marketplace platforms offer internal auctions or continuously-clearing markets that clear transactions within their own ecosystem. The design of these auctions determines how prices are formed. These are discussed below.

1. Closed auctions

Piclo Flex operates a closed-auction format. In this set-up, the T/DSO publishes a flexibility need (characterised by technical and locational requirements). T/DSOs are given the option to cap bids at the maximum budget that they can spend on these contracts – reflecting their WTP. Qualifying flexibility offers are then collected by the market operator up until the bidding deadline is reached. At this point, the T/DSO reviews the qualifying flexibility offers and then chooses whether to accept their preferred offer.

2. Continuously-clearing market

NODES-NorFlex and NODES-IntraFlex projects both adopt NODES' 'continuously-clearing' market formats. In this set-up, both FSPs and T/DSOs submit their offers and requests for flexibility (respectively) on a continuous basis under a pay-as-bid approach. A contract is established without there being direct contact between the procurer and provider.[59]

For continuously-clearing market platforms, there is the potential for variation in the sequencing of price signals between the T/DSO and FSP.

In NODES-NorFlex, participating DSOs may first publicise their flexibility requirements (i.e. terms of grid location, volume required and relevant time frame) alongside their WTP. The buy order is then made available for eligible FSPs to submit corresponding flexibility offers for their asset portfolios. Alternatively, any qualified FSPs may also publish the amount of flexibility it is able to offer in the relevant time period, and their WTA for this sell offer.[60]

A further model is being tested in Phase 2 of the UK-based NODES-IntraFlex trial. Under this set-up, the T/DSO (Western Power Distribution) will first place a nominal "guide" price and invite FSPs to respond with their offers until such time that the T/DSO adds a final bid.

PRICE FORMATION

- Marketplace flexibility platforms run internal auctions either through closed auction format (Piclo Flex) or continuously-clearing market format (NODES-IntraFlex, NODES-NorFlex).
- In closed-auctions, T/DSOs publish a flexibility request and may be given the option to impose maximum cap on bids. Qualifying flexibility offers are then collected from FSPs by the market operator up until the bidding deadline is reached. At this point, the T/DSO reviews qualifying bids and chooses whether to accept its preferred offer.
- In continuously-clearing market, both T/DSOs and FSPs submit requests and bids on a continuous basis under a pay-as-bid approach. A contract is established without there being direct contact between the procurer and provider.

Figure 26 Summary of functions performed by flexibility platforms

59 This is in contrast to Piclo Flex's closed auction format where, after the a match has been made, the buyer and seller interact directly with one another to enter into a contract.

60 Irrespective of how price signals are initiated, NODES marketplace platform creates a merit order stack from all available offer bids that enables the DSO to buy the flexibility it requires at the lowest price.

2.3.6 Dispatching instructions and activation

When a bid has resulted in a trade, the FSP is committed to changing the assets' set points according to the activation product specifications. Owing to the near real-time requirements of flexibility products, activation requires a reliable communication infrastructure to send dispatching instructions and, in some cases, directly issue activation signals to the underlying assets to trigger the specific product parameters. This may include any of the following dimensions: amount of power modulation, duration, rate of change, response time, and location (in the case of portfolio bidding).

ROLE OF PLATFORMS

The dispatching setpoint instructions and/or activation signal that the FSP receives may be issued by the T/DSO or the flexibility platform. The mode of activation may then either be manual (by the FSP) or automatic through a closed-loop control system with the T/DSO.

Flexibility is currently manually activated by the T/DSO outside of the Piclo Flex platform, typically well after procurement has taken place, although the platform plans to facilitate automatic dispatch signals from T/DSO in the future. Activation of individual assets is performed by the FSP (in this instance, an aggregator), with the platform responsible for issuing activation signals to the the FSP's pool of assets. The Crowd Balancing Platform supports near-real time bids (e.g. aFRR energy market in NL), such that aggregators receive an automatic activation signal on an asset-pool level with a product-specific time frame.

Flexibility products are currently activated manually under the mFRR standard for INTERRFACE, with some adjustments for new mFRR-based congestion management products. Whilst activation is typically dealt with in the markets, the flexibility platform provides a facility for activation of flexibility assets. For the NODES-IntraFlex and NODES-NorFlex projects, the marketplace platform operator NODES sends trade confirmations which the FSP can convert into an activation signal. This process enables flexibility to be automatically activated, and NODES lets flexibility providers set their dispatch configuration within the platform. If a ramping time is required, the asset owner may also add this to the call-back configuration. FSPs may also set up a dispatch signal via email, text, or API sent at a pre-determined time ahead of the activation requirement.

Similarly, DA/RE is responsible for generating dispatching instruction documents that are required for the relevant party (either the plant or grid operator) to activate the flexibility. The party responsible for activation depends on the characteristics of the FSP. The primary case is where the instructing network operator requests the plant owner to change the feed-in of its system, which typically applies to conventional generation units with a dedicated operator (i.e. that which modulates generating unit's output). A second case is where the instructing network operator issues activation documents to the connecting network operator (i.e. the T/DSO which operates the network connected to plant selected for redispatch) who in turn activates a change in the operating point of the system. This activation case primarily relates to redispatch instructions for RES plants that do not have a dedicated operator.

TECHNICAL SOLUTIONS

Across the platforms reviewed there are a range of communication technologies that transmit activation signals.

For NODES-NorFlex and NODES-IntraFlex, FSPs may opt to receive either SMS or email notifications which can then be converted into an activation signal for a manual activation. Alternatively, HTTP communication can be set up for immediate dispatch where the FSP needs to forward actual dispatch from within their portfolios given the parameters in the HTTP-call-back. DA/RE issues activation instructions to FSPs via Secure File Transfer Protocol (SFTP) or Email Adapter (EA).

DISPATCHING INSTRUCTIONS AND ACTIVATION

- The dispatch setpoint instructions and/or activation signal that the FSP receives may be issued by the T/DSO or the flexibility platform.
- The mode of offer activation may either be: a) manually by the FSP (Piclo Flex) or b) automatic, through a closed-loop control system with the T/DSO (the Crowd Balancing Platform) or platform operator (NODES-IntraFlex, NODES-NorFlex); or both a) and b) (eSIOS-CECRE-CoordiNet).
- In some cases, for market intermediary flexibility platforms, activation may be dealt with in the adjoining markets (INTERRFACE).

Figure 27: Summary of functions performed by flexibility platforms

2.3.7 Validation and settlement

Settlement refers to the remuneration associated with the physical exchange of flexibility between FSP and the T/DSO. A robust and reliable settlement process provides the necessary incentives for participation of DER in flexibility markets. Any single flexibility transaction may include a pool of thousands of individual assets each with different baseline and activation profiles. Flexibility transactions therefore potentially require a substantial amount of measurement data to validate delivery and perform settlement.

ROLE OF PLATFORMS

Flexibility platforms play a number of key roles in the settlement and validation process. In some cases these roles are performed outside of the platform, either through a separate marketplace or the contracting T/DSO.

1. Baseline measurement

A baseline measurement methodology defines the counterfactual generation or consumption scenario against which the amount of upwards or downwards flexibility is measured. In general this estimation is based on a forecast of the business-as-usual generation or consumption profile that would have otherwise taken place over the activation period. Corrections may then be made to this forecast from flexibility activations from previous periods and planned use of flexibility for internal purposes.

The flexibility platforms reviewed in this study typically defer the definition of baseline methodologies to the market participants or, in the case of intermediaries to existing markets, to the market operators.

NODES will take the baseline value either as an input from the T/DSO or from the FSP. It is the responsibility of the market parties to agree the baseline methodology and to nominate the party responsible for uploading this baseline value to NODES. Piclo Flex also defers the negotiation of baselines to the market parties, guided by a voluntary industry standard proposed by the UK Energy Networks Association's Open Networks Project in the UK or input from T/DSOs and FSPs internationally.[61]

61 'Baseline Methodologies' December 2020 Version 1; Open Networks Project (ENA).

2. Validation

Platforms may act as an independent third-party to provide assurance to both sides of the market that settlement and validation will be consistent and fair.

A core objective of the Crowd Balancing Platform proposition to the market is to increase the level of assurance, and therefore reduce the perceived risk that flexibility procurers (i.e., TSOs) have when contracting with small-scale flexibility sources. The Crowd Balancing Platform requires aggregators to provide pool information (including baseline behaviour) from flexibility device smart meters and submit aggregated bids for the pool to enable proper imbalance settlement. In the future the Crowd Balancing Platform will explore using device measurement from the OEMs of assets to validate aggregate measurements provided by FSPs.

In the future, the Crowd Balancing Platform also aims to enable independent validation by Measurement Service Provider ('MSP')[62] using device-level measurements that are compared against the aggregated measurements from the aggregator to validate the correct delivery. Whilst NODES marketplace platform does not currently have the ability to collect the data necessary for validation prior to financial settlement, the implementation projects have deployed their own solutions. NODES-NorFlex initiative 'AssetHub' provides the platform with access to minute-by-minute baseline and meter data used for this verification process which is then transferred to NODES via an API for settlement. NODES-IntraFlex deployed an adapted version of the Flexible Power portal to collect minute-by-minute metering data from FSPs via an API.

INTERRFACE requires FSPs to upload their metering data with activated volumes for each transaction within a 24-hour window of activation before settlement is initiated. The platform then sends all the necessary information (activation order, metering data and activated volumes) to an internal settlement unit. Once the energy settlement has been calculated the settlement unit returns the settlement results to the flexibility register. These are stored in platform database and forwarded to the respective FSP through an API call. Finally, the Flexibility Register forwards the settlement results to the respective market.

For GOPACS, validation of physical delivery is handled by T/DSOs outside of the platform. Flexibility providers that register to participate in IDCONS trade on the intraday markets must first agree that the T/DSOs can use measurements of the specified EAN codes for the verification of delivery and relevant supplemental measurement data. For Piclo Flex, the verification of physical delivery is currently manually led by DSOs by using flexibility provider's meter data but validation functionality is being developed across 2021/2022.

3. Mitigations to strategic gaming

Given that financial remuneration is calculated against unobserved counterfactual behaviour there is an incentive for FSPs to engage in strategic gaming behaviour to extract rents from T/DSOs or seek arbitrage opportunities in parallel markets[63]. Flexibility platforms deploy a range of mitigating actions to reduce incentives for strategic gaming.

Independent marketplace operator NODES operates market surveillance routines to identify gaming behaviour. In particular, NODES collects historic data on assets' business-as-usual operations to inform baseline measurement and monitors prices within specified ranges. Piclo Flex explore several solutions to pre-emptively tackle strategic gaming incentives. Currently, Piclo Flex allows DSOs to enter into long-term contracts where availability and utilisation bids are agreed upfront, with the option for DSOs to cap bids at their maximum WTP.

Further, for network constraints at low voltages (230/400 V) where market liquidity is less likely, DSOs may offer fixed prices rather than run auctions (for example, an annual service fee in £/MW/year). In the future, Piclo Flex expects to introduce a data insights functions to further reduce FSP incentives for strategic gaming. This function will include FSP ratings (based on historical factors such as reliability and speed of response) and fraud detection (probabilities that actions taken by participants have been used to game the system). Such approaches have been previously deployed in other sectors (e.g., financial services).

62 Crowd Balancing Platform defines MSPs as independent parties that report actual measurements at the device level to validate data submitted by TSO and FSP. The role of the MSP is typically also the responsibility of the aggregator at present.

63 A general discussion of these issues is provided in Section 3.3.

4. Imbalance corrections

After flexibility is activated, a corresponding imbalance is created within the FSP's portfolio due to changes in energy feed-in and/or off-take relative to the counterfactual.

EU Directive 2019/944 specifies that: 'All market participants shall be responsible for the imbalances they cause in the system ('balance responsibility'). To that end, market participants shall either be balance responsible parties or shall contractually delegate their responsibility to a balance responsible party of their choice.'

Imbalance corrections may be the responsibility of the FSP, the connecting T/DSO performing the congestion management action or the TSO who combines this with the broader balancing responsibility. In practice we observe that FSPs typically retain this balance responsibility themselves, although platforms may provide an information service to support this process.

For example, in the NODES-IntraFlex project, any imbalance following activation is left for the FSP to manage. The project explored two options for supporting the balancing responsibility, including: a) an information service provided to BRPs to give oversight over activated volumes, and b) the potential for the NODES marketplace platform to automatically identify a counter trade in the intraday market to offset issues. Ultimately the latter was descoped due to a lack of interest from participants. Instead, the former option was adopted by including data on participating T/DSO's flexibility activations.

The Crowd Balancing Platform supports this information exchange for aFRR in NL.

5. Payment and penalty processing

Flexibility platforms may also play a role in the processing of payments, or hold financial settlement in escrow until such time it has validated that obligations have been satisfied. Should the validation process identify irregularities, the platforms may also implement sanctions in line with market rules.

Within the NODES-NorFlex project, market operator NODES settles trades on a monthly basis and NODES validates the dispatched flexibility against the commitment of the transaction with the DSO prior to settling the trade. The NODES-NorFlex project has implemented a reduced payment scheme established with the DSOs in the event that delivery is not consistent with the contracted amount. A performance calculation is carried out once the delivery is verified, which applies in scenarios where the volume delivered is lower than the contracted amount. Piclo Flex does not currently process payments, but is developing an automatic invoice creation functionality across 2021/22.

On NODES-IntraFlex, a performance calculation is carried out once the delivery is verified which determines whether the agreed quantity of flexibility was activated . The flexibility provider receives full payment where delivery is validated for 95 % or more of the contracted volume. Payments are reduced by 3 % of the contracted price for each percentage point the validated delivery falls below the 95 % quantity threshold.[64] There are no overpayments if delivery is validated for higher than the quantity that was contracted.

Platforms that act as market intermediaries do not typically process payments within their ecosystem. For instance, the Crowd Balancing Platform does not define the remuneration of the flexibility providers nor settle with the flexibility provider. Payments and penalties are in line with the market rules in each country adopting the platform and settlement is via the normal market processes. Similarly, on GOPACS every IDCONS is cleared and settled as a regular intraday trade by the market platform operator. INTERRFACE also forwards the settlement results to the respective market where payments are processed.

64 The formula for this calculation is: 95 % – (3 * (95 % – Delivery %)), where Delivery % = Delivery/Contract Capacity on a per minute basis.

TECHNICAL SOLUTIONS

Across flexibility platforms that are responsible for settlement, we observe a range of different data communications solutions. The NODES-IntraFlex metering portal collects meter values from FSPs to register participating assets and to validate service delivery. Piclo Flex is developing technical solutions for settlement across 2021/22. Although this functionality is not yet implemented, the Crowd Balancing Platform aims to enable independent monitoring and validation by a Measurement Service Provider (MSP) using device-level measurements from assets Original Equipment Manufacturers. The device-level measurements from the MSP can be compared against the aggregated measurements from the aggregator to validate the correct delivery.

VALIDATION AND SETTLEMENT

- Flexibility platforms may play a role in validation of delivery against a measured baseline and settling payments.
- Baseline measurement is typically the responsibility of market participants to agree and nominate a responsible party for uploading values to the platform.
- In some cases, flexibility platforms may collect baseline and metering data for validation within 24-hour window of activation (INTERRFACE) or on a minute-by-minute basis (NODE-NorFlex, NODES-IntraFlex). In other cases, validation may be handled by the T/DSOs outside of the platform (Piclo Flex, GOPACS).
- In the case of market intermediary platforms, settlement and remuneration is handled by the relevant market. Marketplace flexibility platforms settle transactions after validating delivery and may impose penalty scheme for discrepancies (NODES-IntraFlex, NODES-NorFlex).
- Beyond validation and settlement, flexibility platforms may also deploy actions to mitigate incentives for FSPs to engage in strategic gaming behaviour. These include payment caps and longer-term contracts that better align the incentives of both sides of the market (Piclo Flex), as well as platform-operated market surveillance routines that monitor abuses of market power signalled through market prices (NODES-NorFlex).

Figure 28: Summary of functions performed by flexibility platforms

3 POLICY ISSUES

This section provides a high-level discussion of some of the key policy issues that have emerged during this study and the ways in which flexibility platforms help stakeholders to overcome these challenges. We structure this under the following themes:

- Challenges to DER integration;
- Challenges to TSO and DSO coordination; and
- Challenges to market design.

3.1 CHALLENGES TO DER INTEGRATION

Through the course of our research, we have identified several challenges to the integration and deployment of DER as sources of flexibility for network operators and to other stakeholders through wholesale and system services markets. We discuss each of these in turn below with reference to the role that flexibility platforms play in overcoming these challenges:

1. DERs may be precluded from participating on an individual basis in existing energy and system services markets due to technical prequalification requirements. For example, minimum capacity thresholds and other technical criteria may preclude individual participation by DER, whilst aggregation of smaller units may be possible. Commercial aggregators and intermediary platforms may provide a means by which DER can access existing energy and system services markets.

2. DERs could face proportionately high entry and transaction costs in order to participate in energy and system services markets. Whilst minimum participation thresholds are falling, and aggregation solutions are helping to alleviate this barrier, there is further scope to reduce the relative costs of compliance with technical and data exchange requirements for owners of small assets. By standardising (at least at national level) and streamlining information exchange and validation processes, aggregators and intermediary platforms may help to further reduce these participation costs. Similarly, greater cross-border (across national markets) alignment of prequalification requirements for similar capabilities is likely to increase overall participation.

3. DERs may have weak participation incentives due to the incremental nature of associated revenue streams, reinforced by the penalty arrangements associated with non-delivery and perceived potential downside risk to DER core business activities. The terms of participation set by aggregators and facilitated by intermediary platforms may provide asset owners with some assurance against down-side risk from the operational impacts of activation and penalties for failure to deliver.[65]

4. There is an asymmetry between the needs of T/DSO, who require assurance in relation to matters of system security, and DER who may consider flexibility service revenues as secondary to those from their primary functions. Platforms can support this through providing access to pools of flexibility that build in redundancy, facilitating eligibility checks, and by providing data (and process support) in relation to actual performance levels over time.

5. In recent years the observability and controllability of both generation (including storage) and demand connected at the distribution level has begun to increase as a result of the implementation of network codes for Connections and System Operation (SOGL), notably the implementation at national level of the methodology pursuant to SOGL article 40(6). However, in the past, some TSOs (and even DSOs) have had limited knowledge of flexible resources connected to the distribution grid. Platforms can help improve transparency in relation to the availability and location of smaller sources of flexibility, often by way of so-called 'flexibility registers'.

65 For instance, aggregators may stipulate that penalties will only be deducted from the revenue DER have earnt, but will never leave the provider with an overall downside risk of participating.

3.2 CHALLENGES TO TSO-DSO COORDINATION

We have identified the following challenges to TSO-DSO coordination in the procurement and management of DER flexibility:

1. Information sharing between TSOs and DSOs may enable both to identify and deploy DER for the provision of system services. However, the integration of distribution constraints in grid security analysis, and the identification of relevant DER for grid services, requires the timely retrieval and processing of data across different operating systems. Flexibility platforms built upon an open API infrastructure can enable stakeholders to automate and scale-up the necessary data retrieval protocols for managing flexibility, and improve interoperability between the different information systems.

2. Traditionally, the procurement of flexibility has been a TSO-led function in support of active system management responsibilities (e.g., balancing). As such, TSO's are equipped with the necessary know-how and systems for needs-assessment and flexibility procurement. In contrast, the use of flexibility for congestion management by DSOs is at a more nascent stage and their procurement processes and associated infrastructure have started developing more recently. This first-mover advantage may mean that resources providing services to the TSO are prevented from providing congestion management services to the DSO even when they are technically able to do so. Similarly, it is important that providers in nascent DSO developments can participate in other markets and are not locked into local ones, in line with Art. 31(9) of Directive 2019/944. As flexibility is increasingly sourced from assets connected to the distribution grid, effective collaboration will be supported by greater sharing of tools and competencies between T/DSOs. Flexibility platforms have a key role to play in providing DSOs with the tools to more actively manage their networks[66] through effective deployment of DER to resolve distribution grid constraints. Further, in acting as an intermediary between TSOs and DSOs, flexibility platforms may improve assurance between procurers of flexibility by facilitating information sharing and agreeing common protocols.

3.3 CHALLENGES TO MARKET DESIGN

There is currently significant variation in how flexibility platforms across the EU are designed. This report outlines several points of difference between platforms we have studied in more detail, including:

1. Across the platforms reviewed, we observe variation in the scope of platform services taken up by T/DSOs. T/DSOs may choose to fully outsource each step of the procurement process (from FSP prequalification to settlement) or may opt to only outsource specific functions (e.g., advertisement of requirements) whilst sourcing the remaining functions elsewhere (e.g., an in-house tendering process). Flexibility platforms are responding to variation in T/DSO requirements by offering modularised suite of services as opposed to a one-size-fits-all model.

2. Unlike balancing and system services markets, there is currently limited alignment of product specifications for congestion management purposes in the EU. Whilst standardised products for congestion management have begun to emerge,[67] non-standard products are also adopted. Proponents of a EU-wide product alignment highlight the benefits for commercial parties active in several countries to have a common terminology and ease of understanding. Such an alignment may be particularly beneficial in markets where market liquidity and competition for units of trade is limited because of physical and local character of the system services market. Furthermore, greater product alignment can be expected to bring benefits to intra-zonal redispatch system process (e.g., by removing conflicting rules and reducing likelihood of contradictory activation) as well as improving coordination amongst procuring T/DSOs. Proponents of non-standardised products note that markets are better able to respond to local system needs through flexible product parameterisation and that this also provides the opportunity for the market to innovate around the product designs that work best for users by trialling different options (rather than pre-empting this through standardization).

66 As defined by ENTSO-E, Active System Management (ASM) is a key set of strategies and tools for cost-efficient and secure management of the electricity systems. It involves the use of smart and digital grids, operational planning and forecasting processes and the capacity to modulate generation and demand to tackle challenges impacting system operation..

67 The UK Energy Networks Association (ENA) has established a set of four product-standards (Sustain, Secure, Dynamic, Restore) across multiple parameter dimensions. Figure 7 provides a summary of these products.

3. A prominent debate in the literature related to flexibility markets is the possibility for strategic gaming behaviour by FSPs as a response to ex ante publication of network constraints by flexibility market operators alongside parallel wholesale markets. Under these circumstances FSPs may exploit arbitrage opportunities by first increasing their planned generation schedules in the wholesale markets and then reducing these schedules within the parallel flexibility markets.[68] Whilst successful gaming behaviour is expected to increase system service costs, proponents of market-based flexibility argue that the publication of grid constraints is necessary to increase the overall pool of resources for system management and that the preconditions for gaming observed at the transmission level are not directly applicable to distribution networks.[69] Nevertheless, flexibility platforms have the option to deploy a range of mitigating actions to reduce incentives for strategic gaming. These include: longer-term contracts that better align the incentives of both sides of the market, payment caps, platform-operated market surveillance routines that monitor compliance, abuses of market power signalled through market prices and FSP performance ratings.

4. Across the platforms reviewed we observe a broad range of ownership structures. This includes platforms that are fully independent of regulated entities (e.g., Piclo Flex), independently operated but implemented in partnership with T/DSOs (e.g., NODES-NorFlex, NODES-IntraFlex) and those completely owned by TSOs (e.g., the Crowd Balancing Platform, eSIOS-CECRE-CoordiNet) or DSOs. As a consequence there are differences in the division of functions between commercial and regulated domains. Some stakeholders have raised concerns regarding regulated entities (e.g., T/DSOs) taking on tasks (e.g., aggregation) that would otherwise readily fall within commercial domain. This is likely to be an area where additional guidance may be required from regulators in the future.

5. A key point of difference within flexibility market design is that between platforms that act as self-contained local markets for congestion management and platforms that act as intermediaries to existing national (and international) wholesale and system services markets.

   Proponents of a local market model note that locally delineated markets are better able to respond to variation in local system needs, improve access for DSOs and provide faster response to demands for increased network capacity, and are better able to cater to the needs of specific types of FSPs that may be concentrated in a particular region.

   Proponents of platforms that integrate with established national or cross-border markets argue that the resulting market clearing prices can internalise whole-system needs leading to a more efficient overall allocation of flexibility. It is noted that fragmented local markets for flexibility may create liquidity problems (and consequently the exercise of market power in the most illiquid markets) and require increased level of coordination across markets to manage imbalances created by activation. Furthermore, better integrated local and national flexibility markets may improve FSP's ability to 'stack' revenues across both local and national schemes which may incentivise greater levels of overall participation.

   Moving forward, platforms will need to continue engaging with their stakeholders (both T/DSOs and FSPs) to understand and adapt to their respective business cases. In parallel, regulatory authorities may need to be increasingly mindful of the evolving requirements of flexibility platforms and possible unintended consequences that their activities may have (e.g., impacts on market liquidity).

68 The so-called 'inc-dec' bidding strategy described in Hirth, L., Schlecht, I., Maurer, C., & Tersteegen, B. (2019). Cost- or market-based? Future redispatch procurement in Germany. Berlin.
69 For further discussion, see NODES (2020) 'Market-based redispatch in the distribution grid. Why it works'

ANNEX A
DEFINITIONS

Expression / Term	Description
Aggregator	An entity that combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market, as defined by Article 2(18) of Directive 2019/944.
Balancing	All actions and processes on all timelines through which TSOs ensure, in a continuous way, maintaining the system frequency within a predefined stability band, as defined by Commission Regulation (EU) 2017/2195 of 23 November 2017.
Congestion Management	The requirement for TSOs and DSOs to limit or avoid exceeding network congestion driven by the need to mitigate the risks posed by overload, as defined by Commission Regulation (EU) 1222/2015 of 24 July 2015.
Distributed Energy Resource (DER)	Small, geographically dispersed generation resources, installed and operated on the distribution system at voltage levels below the typical bulk power system, as defined by ENTSO-E Position Paper 31 March 2021
Distribution System Operator (DSO)	The entity responsible for operating, ensuring the maintenance of and, if necessary, developing the distribution system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity.
Flexibility Service Provider (FSP)	The entity responsible for providing energy or capacity for the flexibility use cases.
Flexibility Products	The units that define a flexibility transaction, characterised through various technical, commercial and operational parameters (so-called 'dimensioning parameters').
Flexibility Platform	Digital platforms that facilitate the provision of flexibility services to System Operators from Distributed Energy Resources.
Flexibility marketplace	Platforms that perform the essential functions of a marketplace such as running auctions, clearing transactions and settling payments between T/DSOs and FSPs .
Frequency response	Any product (standardised or non-standardised) which has the intended purpose of balancing the continuous flow of generation and demand in the transmission and/or distribution networks.
Frequency Containment Reserve (FCR)	Frequency Containment Reserve (FCR) refers to the active power reserves available to contain system frequency after the occurrence of an imbalance. FCR is a standardised frequency response product dispatched for frequency deviations in less than 30 seconds. This product is traded via a capacity price (and possibly also utilisation price) and is dispatched automatically by contracted flexibility provider on command of the grid operator.
Frequency Restoration Reserve (FRR)	Frequency Restoration Reserve (FRR) active power reserves available to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value. FRR is a standardised frequency response product dispatched for frequency deviations that last between 30 seconds and 15 minutes. This may include both automatic (aFRR) and manual (mFRR) activation. aFRR is traded via a capacity price (and possibly also utilisation price) and is dispatched automatically by contracted flexibility provider on command of the grid operator.
Imbalance	An energy volume representing the difference between the allocated volume attributed to a balance responsible party and the final position of that balance responsible party, as defined by Commission Regulation (EU) 2017/2195 of 23 November 2017.
Measurement Service Provider (MSP)	Independent parties that report actual measurements at the device level to validate data submitted by T/DSO and FSP, as defined by Crowd Balancing Platform.
Power Exchange	An existing established Nominated Electricity Market Operator (NEMO) designated by the competent authority of the European Union Member State to participate in single day-ahead coupling or single intraday coupling (e.g. EPEX SPOT, NordPool, IBEX etc.). This category includes both national and cross-border power exchanges.
Restoration Reserve (RR)	Replacement Reserve (RR) are the active power reserves available to restore or support the required level of FRR to be prepared for additional system imbalances, including generation reservesis. RR is a standardised frequency response product that supports the required level of FRR for additional imbalances with an activation time of over 15 minutes.
Transmission System Operator (TSO)	A natural or legal person responsible for operating, ensuring the maintenance of and, if necessary, developing the transmission system in a given area and, where applicable, its interconnections with other systems, and for ensuring the long-term ability of the system to meet reasonable demands for the transmission of electricity (Directive (EU) 2019/944 of the European Parliament and of the Council of 5 June 2019 on common rules for the internal market for electricity and amending Directive 2012/27/EU, Article 2(35).
T/DSO	Either a TSO and/or a DSO.
Voltage control	A product that dispatches reactive power reserves in real-time to maintain the voltage level within the specified range of the synchronous area.

ANNEX B
OVERVIEW OF PLATFORMS REVIEWED

Platform	Operator	Project jurisdiction	Platform type	Motivation
Piclo Flex	Independent software company	UK	Marketplace; (Market intermediary)	Modularised outsourcing model
NODES	Independent power exchange	UK (IntraFlex)	Marketplace; Market intermediary	Fully outsourced procurement
NODES	Independent power exchange	Norway (NorFlex)	Marketplace; Market intermediary	Fully outsourced procurement
eSIOS-CECRE-CoordiNet	TSO	Spain	Marketplace	Coordinated procurement for congestion management and balancing
Crowd Balancing Platform	TSO	Netherlands	Market intermediary	Improve liquidity in existing TSO markets
Crowd Balancing Platform	TSO	Austria	Market intermediary	Improve liquidity in existing TSO markets
Crowd Balancing Platform	TSO	Italy	Market intermediary	Improve liquidity in existing TSO markets
Crowd Balancing Platform	TSO	Germany	Market intermediary	Improve liquidity in existing TSO markets
GOPACS	T/DSO	Netherlands	Market intermediary	Leverage existing markets for CM use cases
INTERRFACE	T/DSO	Nordic-Baltic	Market intermediary	Improve liquidity in existing TSO markets; Leverage existing markets for CM use cases
DA/RE	TSO	Baden Wuerttemberg (Germany)	Administrative dispatch	Coordination and optimisation of administrative redispatch for CM

Source: Frontier Economics

Product type	Product name	Procurers	Providers	Functionalities
Standard	ENA definitions	DSO	Any	Open API architecture, market-clearing algorithm; GUI
Non-standard	ShortFlex	DSO	Any	Geo-location flexibility register; API to metering data hub; market clearing algorithm, settlement unit, GUI
Non-standard	ShortFlex; LongFlex; (mFRR)	DSO	Any	Geo-location flexibility register; API to metering data hub; market clearing algorithm; settlement unit; GUI
Non-Standard	Redispatch instructions issued in MWh blocks of upward/downward energy	TSO;DSO	Generating/storage units that have a capacity (or pooled-capacity). Demand participation under development.	API architecture
Standard	aFRR	TSO; DSO	Commercial aggregators	Open API architecture; Blockchain
Standard	aFRR	TSO; DSO	Commercial aggregators	Blockchain, Open APIs
Standard	RR	TSO; DSO	Commercial aggregators	Blockchain, Open APIs
Standard	Redispatch	TSO; DSO	Commercial aggregators	Blockchain, Open APIs
Standard	Reserve Power Other Purposes (ROD)	DSO; TSO	BSP registered on a participating energy exchange	Blockchain, APIs to markets
Standard	aFRR; FCR; mFRR (for CM purpose as using locational information)	DSO; TSO	BSP registered on the flexibility platform	API data exchange; pre-activation congestion check; Flexibility Register (GUI, user and resource registration),
Non-standard	Any redispatch dimensioning	DSO; TSO	Generation and storage facilities with a capacity greater than 100 kW	Data exchange architecture; redispatch optimisation algorithm, activation documents

ANNEX C
OVERVIEW OF USE CASES ASSOCIATED WITH FLEXIBILITY PLATFORMS

Operator	Project Name	Frequency response	Congestion management	Voltage control	Energy trade	Network reinforcement deferral	Post-fault restore	Inertia
Independent operator	NorFlex (NODES)	✔	✔	✘	✘	✘	✘	✘
	Cornwall Local Energy Market	✔	✔	✘	✔	✘	✘	✘
	Enera (from SINTEG)	✔	✔	✘	✘	✘	✘	✘
	Pebbles	✔	✔	✘	✔	✘	✘	✘
	INTERRFACE – Single Flexibility Platform (IEGSA)	✔	✔	✘	✘	✘	✘	✘
	Sthlmflex (NODES)	✔	✔	✘	✘	✘	✘	✘
	Intraflex (NODES)	✘	✔	✘	✘	✘	✘	✘
	PicloFlex	✘	✔	✘	✘	✔	✘	✘
	FLEXITRANSTORE: Wholesale and Clearing Market	✔	✘	✘	✘	✘	✘	✘
	Orsted - Renewable Balancing Reserve	✔	✘	✘	✘	✘	✘	✘
	Equigy	✔	✘	✘	✘	✘	✘	✘
	Flexity	✔	✘	✘	✘	✘	✘	✘
	eBalance Plus	✔	✘	✘	✘	✘	✘	✘
Network operator	ARGE FNB - 50Hertz	✔	✘	✔	✘	✘	✘	✘
	bne Flexmarkt	✔	✘	✘	✘	✔	✘	✘
	Baltic CoBa	✔	✔	✔	✘	✘	✘	✘
	Coordinet	✔	✔	✔	✘	✘	✔	✔
	CROSSBOW: Regional DSM Integration platform, wholesale, and ancillary market toolset	✘	✔	✔	✘	✘	✘	✘
	DA/RE	✘	✔	✘	✘	✘	✘	✘
	Dynamo Flexmarkt in Nijmegen-Noord	✘	✔	✘	✘	✘	✘	✘
	Euniversal (German demo)	✘	✔	✔	✘	✘	✘	✘
	Euniversal (Polish demo)	✘	✔	✔	✘	✘	✘	✘
	Euniversal (Portuguese demo)	✔	✔	✘	✘	✘	✘	✘
	FUSION	✘	✔	✘	✘	✘	✘	✘
	GOPACS	✘	✔	✘	✘	✘	✘	✘
	IGCC: imbalance netting project	✔	✘	✘	✘	✘	✘	✘
	MARI: mFRR balancing project	✔	✘	✘	✘	✘	✘	✘
	NEBEF (Block Exchange Notification of Demand Response)	✔	✘	✘	✘	✘	✘	✘
	SIOS-CECRE Participation of distributed flexibilities in the balancing/congestion management market	✔	✔	✘	✘	✘	✘	✘
	PICASSO: aFRR balancing project	✔	✘	✘	✘	✘	✘	✘
	Platone	✔	✔	✔	✘	✔	✘	✘
	ReFlex (Enedis)	✘	✔	✘	✘	✘	✘	✘
	TERRE: RR balancing project	✔	✘	✘	✘	✘	✘	✘
	X-flex	✘	✔	✔	✘	✔	✘	✘

Source: Frontier Economics

ANNEX D
CONTRIBUTORS

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