D3.2.1 – State-of-the-art of regional markets from the research to the implementation level

Contributors:

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Versioning and Authors

Version control

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Executive summary

In this deliverable, different market concepts are defined. Regional flexibility market proves to be the most suitable market concept to address redispatch and voltage support. A literature review of markets of this kind, which have been experienced in Europe recently, is made. From this literature review, strengths and blind spots of each market concept are listed. It is shown that it is relevant to link a new regional flexibility market for redispatch to existing markets, for example Day-Ahead, Intraday or Balancing. Thus, higher liquidities could be available reducing market gaming. In REgions, the procurement of redispatch from distributed renewable energy resources (DER) aggregated in virtual power plant (VPP) is addressed. Then, a market closer to real-time enable to reduce forecast errors. That is why it is proposed to link a regional flexibility market to Intraday rather than other markets. Finally, two options are available to link a regional flexibility market with intraday market depending which one is upstream and which one is downstream. Deliverable D3.2.2 will detail the option chosen in Region. Regarding, voltage support, if it seems feasible to address this ancillary service through a market, as in the project Power Potential, the added value of such an option is not so clear compared to its complexity. In the project REgions, the procurement of voltage support with DER-based VPP will be tested but no market for voltage support will be simulated.

Résumé exécutif

Dans ce livrable, différents concepts de marches sont définis. Les marchés régionaux de flexibilité sont les plus pertinents pour gérer le redispatch et la gestion de la tension. Une revue de littérature des marchés de ce type, qui ont été expérimentés en Europe récemment, a été menée. Cette revue de littérature a permis de lister les forces et angles morts de chacun des marchés. Il est alors montré qu'il est pertinent de lier un nouveau marché régional de flexibilité aux marchés existants tels que les marchés en J-1, infrajournalier ou d'équilibrage. Ainsi plus de liquidités seront disponibles ce qui réduira les risques d'arbitrage sur les marchés. Dans REgions, le redispatch est réalisé par des installations renouvelables décentralisées agrégées dans des centrales virtuelles. Un marché plus proche du temps réel permettrait de réduire les erreurs de prévision. C'est pourquoi il a été retenu de lier le marché régional de flexibilité au marché infrajournalier plutôt qu'avec les autres marchés existants. Finalement, deux options restent possibles pour réaliser ce lien selon le marché qui sera en amont et celui qui sera en aval. Le livrable D3.2.2 détaillera l'option choisie pour le projet REgions. Concernant le réglage de la tension, s'il semble faisable de gérer ce service système au travers un marché, comme cela a été fait dans le projet Power Potential, la valeur ajoutée d'une telle option n'est pas évidente au vu de sa complexité. Dans REgions, la gestion de la tension par des centrales virtuelles agrégeant des installations renouvelables décentralisées sera testée par contre il ne sera pas simulé de marché pour la gestion de la tension.

Kurzfassung

In diesem Deliverable werden verschiedene Marktkonzepte definiert. Der regionale Flexibilitätsmarkt erweist sich als das am besten geeignete Marktkonzept, um Redispatch und Spannungsunterstützung zu adressieren. Eine Literaturübersicht zu Märkten dieser Art, die in Europa in letzter Zeit aktuell waren, wird erstellt. Aus dieser Literaturübersicht werden Stärken und Schwächen jedes Marktkonzepts aufgelistet. Es zeigt sich, dass es relevant ist, einen neuen regionalen Flexibilitätsmarkt für Redispatch an bestehende Märkte anzubinden, beispielsweise Day-Ahead, Intraday oder Balancing. Somit könnten höhere Liquidität verfügbar sein, was das Marktspiel reduziert. In REgions wird die Beschaffung von Redispatch aus verteilten erneuerbaren Energieressourcen (DER) aggregiert in virtuellen Kraftwerken (VPP) adressiert. Dann ermöglicht ein Markt, der näher an der Echtzeit ist, Prognosefehler zu reduzieren. Aus diesem Grund wird vorgeschlagen, einen regionalen Flexibilitätsmarkt eher mit Intraday als mit anderen Märkten zu verbinden. Schließlich stehen zwei Optionen zur Verfügung, um einen regionalen Flexibilitätsmarkt mit einem Intraday-Markt zu verbinden, je nachdem, welcher vor- und welcher nachgelagert ist. Im Ergebnis D3.2.2 wird die unter Region gewählte Option detailliert beschrieben. Was die Spannungsversorgung betrifft, so ist der Mehrwert einer solchen Option im Vergleich zu ihrer Komplexität nicht so klar, wenn es machbar erscheint, diese Zusatzleistung über einen Markt zu adressieren, wie im Projekt Power Potential. Im Projekt REgions wird die Beschaffung von Spannungsstützung mit DER-basierten VPP getestet, jedoch kein Markt für Spannungsstützung simuliert.

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0. Abbreviations

BRP: Balancing Responsible Parties

CHP: Combined Heat and Power

DAM: Day-Ahead Market

DER: Distributed Energy Resources

DSM: Demand-Side Management

DSO: Distribution System Operator

GL: Grid Location

IDM: Intra-Day Market

LFM: Local Flexibility Market

NUTS: Nomenclature des Unités Territoriales Statistiques

OPF: Optimal Power Flow

RES: Renewable Energy Sources

SO: System Operator (can be a DSO or a TSO)

TSO: Transmission System Operator

VPP: Virtual Power Plant

1. Introduction

To ensure the stability and reliability of the power system, transmission system operators (TSO) need the provision of ancillary services by most of connected devices. Firstly, the power system relies on the continuous balance between power production and power consumption. This is done through frequency monitoring and balancing when system frequency deviates from its nominal value (50 Hz in Europe). TSO are responsible for this offer-demand equilibrium whose management is more and more realized at the European scale as a result of market integration. Secondly, electricity must be transmitted from power plants to load centers through the power grid and, more recently, from distributed generation units to higher voltage levels. For this purpose, TSO are responsible for planning grid expansion regarding long term evolution of power demand and production or decommissioning of grid infrastructures. Despite this, situations during which a specific line may be congested still occur: transportation capacities of lines are sometimes insufficient to enable power transmission from one grid node to another. When such a situation occurs, TSO have access to different levers in order to manage the congestion. The TSO' first lever are so-called non-costly measures, meaning the use of phase shift transformers and line switching. Once those levers are exhausted, the TSO generally resort to redispatch which consists in reducing or increasing power production or consumption in a specific location in order to limit the current on the congested line. Lastly, voltage must remain within a defined range. Voltage variations outside this range may increase power losses or deteriorate power devices connected to the grid. DSO and TSO limit voltage variations through grid expansion planning but also by forcing power plants or consumers to adjust reactive power injection. Nevertheless, voltage variations still occur and the TSO needs to send signals to power plants and big consumers so that they can adjust the reactive power by absorbing or supplying it and thus bring back the voltage to its permitted range.

Historically, the TSO relied on a limited number of large conventional power plants or industrial consumers to provide the above-listed services. With the increasing share of distributed sources of energy, less conventional capacities are available to supply those ancillary services[1] and the management of power systems involves more actors of smaller size. Moreover, European regulation of the electricity market fosters market integration between the countries of the EU. But while electricity markets and balancing markets are well-developed and becoming more and more integrated at the European scale, ancillary services like congestion management and voltage support rely mainly on national decisions and are not necessarily provided through a market. Yet non-market-based mechanisms may lead to higher costs (loss of social welfare) as well as less transparent processes. The main difference between those services and balancing is their location-related feature: only actors close to the congestion or the voltage deviation point can effectively relieve it. Thus, designing markets for those ancillary services brings new issues:

- How market power from actors in quasi-monopolistic situation due to the local feature of such ancillary services may be prevented?
- How those new markets would be linked with more traditional ones (balancing and power market)?
- What would be the roles of DSO and TSO in those markets?
- Could products connected to the distribution grid participate in order to raise congestion or voltage issues on the transportation grid? Requiring which cooperation between DSO and TSO?

[1] Distributed energy resources per se not cause conventional generators to go offline. Rather, those generators are pushed out of the merit order because of cheap RES and are also becoming uneconomical because of currently high CO_2 prices.

- Finally, what would the main features of such markets regarding auctions (gate opening and closure time, minimum volumes of the bids, technical characteristics of offers required to participate in the auction) and compensation mechanisms?

In this deliverable we studied different market concepts that were or still are observed in Europe for the provision of local ancillary services such as redispatch and voltage support. Based on the state-of-the-art, the main strengths and drawbacks of the different options are summarized.

1.1 Definitions

In the literature different designations are used to speak about power markets or ancillary services markets whose perimeter is only a limited geographical area. In this section we propose some definitions to which we will refer in this deliverable.

Local or sub-regional markets: we call “local” or “sub-regional”, markets which have a definite geographical perimeter limited to one or several cities and which concern only the distribution grid, operates by only one DSO. From a geographical point of view, “local” or “sub-regional” corresponds most closely to hierarchical level 3 (NUTS 3) of the NUTS geocodes ("*Nomenclature des Unités Territoriales Statistiques*"). Actors, whether they are consumers, producers, or flexibility providers, must have devices located within this perimeter if they want to participate in this kind of market. All actors within the perimeter sign connections agreement with the same DSO. Thus, those markets can be linked with the smaller regional classification made in Regions deliverable D3.1.1. No ancillary service is yet provided through this kind of market only energy. Example of such markets are given in section 1.2 with further details.

Regional or inter-regional markets: we call “regional” or “inter-regional”, markets which also have a definite geographical perimeter but larger than the first kind of markets defined above. The geographical perimeter is rather the size of one or several full administrative regions but smaller than a full country, most comparable with NUTS 2 or even NUTS 1. They are related to the grid operated by one or several DSO and, depending on the country, they can also be related to the transmission grid operated by one TSO. Regarding D3.1.1 regional classification, energy but also ancillary services like voltage support or congestion management can be provided through this kind of markets. Example of such markets are given in section 1.3 with further details.

Smart markets: we call “smart”, markets with the following features:

- periodic auctions,
- intensive digital exchange of information between actors on a dedicated platform,
- the electricity grid is considered in order to assess potential constraints that could alter the merit-order classification of offers. This specific feature requires that SO calculate the “effectiveness” of the different offers, that means the degree to which an offer can help the grid solve a constraint.

Sub-regional and local markets generally do not have such features today and cannot be considered as smart markets.

Flexibility markets: they are a specific kind of smart markets dedicated to the activation of flexible products. Flexible products refer to the ability of some devices to adjust their consumption or production quickly enough regarding power system needs such as participation in ancillary services. A definition of flexibility[2,3] is given as follows: "On an individual level, flexibility is the modification of generation injection and/or consumption patterns in reaction to an external signal (price signal or activation) in order to provide a service within the energy system. The parameters used to characterise flexibility include the amount of power modulation, the duration, the rate of change, the response time, the location etc." According to the definition[2], flexibility is not necessarily related to local, regional or inter-regional markets (for instance, a balancing market at the European scale can be considered as a flexibility market) but when so, they must include a supplementary feature compared to other smart markets defined above: the location of flexible offers must be provided during the market process. This information will be needed for the system operator(s) to classify the offers regarding their ability to relieve the local power system constraint.

Thus, regarding REgions case studies defined in deliverable D3.1.1, this kind of markets seems the most relevant to be studied to address voltage or congestion issues**. In section 2 of this deliverable we refer to "regional flexibility markets" to deal with regional or inter-regional markets that have features of flexibility markets.**

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eurelectric, *Flexibility and Aggregation - Requirements for their interaction in the market,* https://cdn.eurelectric.org/media/1845/tf_bal-agr_report_final_je_as-2014-030-0026-01-e-h-5B011D5A.pdf, 2014.

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Bundesnetzagentur (BNetzA), *Flexibility in the electricity system - Status quo, obstacles and approaches for a better use of flexibility,* https://www.bundesnetzagentur.de/SharedDocs/Downloads/EN/Areas/ElectricityGas/FlexibilityPaper_EN.pdf;jsessionid=69603678917BAB921D76FACB6A318FA5?__blob=publicationFile&v=2, 2017.

Kind of market	Geographical perimeter	Grid perimeter	Actors concerned	Products	Features
Local/Sub-regional	One or several cities Smaller than one administrative region	Low and medium voltage	Local providers One DSO	Energy	No specific feature
Regional/Inter-regional	One or several administrative regions Smaller than one country	Medium and high voltage	Regional providers One or several DSO and/or one TSO	Energy "Local/Regional" ancillary services (voltage support, congestion management)	No specific feature
Smart	No limit	No limit	All	All	Periodic auctions Intensive digital exchange of information Electricity grid considered
Regional flexibility	Same as regional/inter-regional markets	Same as regional/inter-regional markets	Same as regional/inter-regional markets	"Local/Regional" ancillary services (voltage support, congestion management)	Same as smart markets Local information required

Table 1 : Classification of markets used in this deliverable

1.2 Sub-regional/Local markets

Figure 1 (right) shows the areas of some arbitrarily selected, geographically clearly defined, local energy markets in Germany by indicating their reference number (references [1] to [9], see chapter 4).

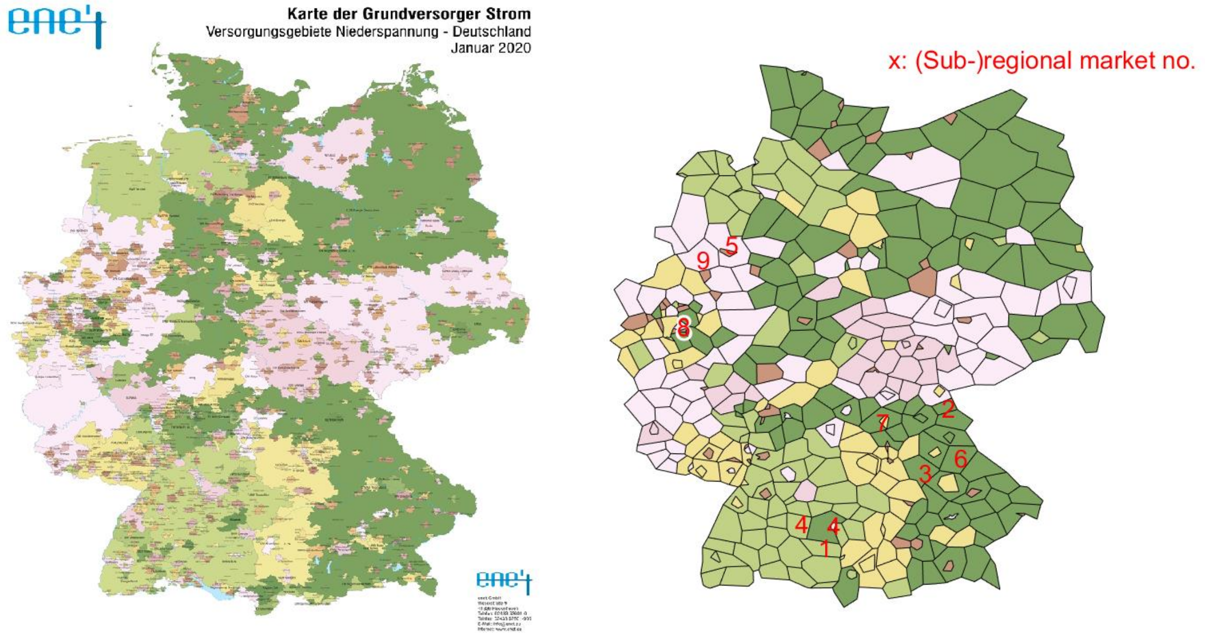

Figure 1 : Map of local power supply companies in Germany (Source : https://www.enet.eu/portfolio/karten) (left) and its reproduction using NUTS 3 (right) indicating the locations of local energy markets ([1], [2], [3], [4], [5], [6], [7], [8], [9])

Other local energy markets are not always confined to geographical boundaries and may have smaller (as reference [10]) or larger spatial extents (as references [11], [12], [13], [14], [15]). The motivation for local energy markets is in most cases the availability of distributed renewable energy sources in the area. Renewable energies feed in a distributed way and can be consumed on site avoiding electricity transports over long distances. Local electricity commercialization combines local generation and consumption, promotes local acceptance of renewable energies and concentrates the added value in the region. Bringing generation and consumption closer together can further relieve grid congestion and make the expansion of grid infrastructure unnecessary. There are several possibilities for the creation of local energy markets and brands, some of which are already offered by municipal utilities, plant operators and energy cooperatives (see [16], [17]). Although the current regulatory framework conditions make local direct marketing of electricity more difficult, the already existing local electricity markets (e.g. references [1] to [15]) show that profitable business models are possible.

One of these local energy markets shall be described for illustration purposes: In the district (Landkreis) of Steinfurt, renewable energies, i.e. about 250 wind turbines, cover almost 70 percent of the regional energy demand. Stadtwerke Steinfurt, together with three other regional municipal utilities, has developed a product for electricity customers in the district, which is marketed under the brand name "Unser Landstrom" [9]. The regional electricity product comes 100 percent from local wind turbines. This is made possible by the fact that the municipal utilities only have the "Landstrom" in their portfolio and commercialize it only on the local market; inter-regional sales are not undertaken.

Further local energy markets (such as [1], [2], [3], [4] [11], [12], [13]) are supported by a software solution from the company Lumenaza, which integrates innovative technologies and sales approaches into decentralized energy supply in a market-based way. Local players such as municipal utilities, energy cooperatives and project planners are enabled to offer their customers local electricity products from renewable energies with the "utility-in-a-box" platform developed in-house. At its core is the creation of a marketplace where producers and consumers from the same region come together. Products such as local and municipal electricity, balancing group management, direct marketing, market and billing processes, community approaches or flexible tariffs can be offered via the platform [18].

In their current implementation, local energy markets mostly only offer local producers and consumers a platform to conclude energy supply contracts, usually for a long-term period (e.g. one year). In contrast, local energy market of Tal Mark [8], for example, allows electricity consumers to select and buy their local electricity mix every 15 minutes. However, local energy markets are currently still in the development phase and consequently simplified in structure and scope; for example, there are no periodic auctions, no intensive digital exchange of information, and the electricity grid is not considered, which are characteristics that can be attributed to smart markets.

1.3 (Inter-)regional markets

While local energy markets usually do not have characteristics that are attributed to smart markets, the situation is different for regional and inter-regional energy markets. These are also still in the development phase but have the characteristics of smart markets in their conceptual design.

A prominent example of (inter-)regional markets is the large German research programme SINTEG that aims at the conceptual development and testing of regional and inter-regional smart markets. SINTEG comprises five large model regions, which together cover almost the whole of Germany and each of which is linked to a large research project, namely enera (see section 2.2), NEW 4.0, DESIGNNETZ, WindNODE and C/sells. Figure 2 shows the projects and the so-called model regions of SINTEG and assigns the market reference numbers of chapter 4.

Figure 2 : The projects and model regions of the SINTEG research programme (source: SINTEG) indicating the locations of the conceptualised flexibility markets [19], [20], [21], [22], [23]

As explained below, all smart market concepts of SINTEG are similar insofar as they are so-called flexibility markets. However, they may differ in their exact design. For example, the enera project developed the "enera Flexmarkt", which is based on the systems of the EPEX SPOT Intraday (ID) trading platform. The platform, which has been active since February 2019, supports 15-minute and 1-hour products by adopting the previous API from the IDM trading system [24]. In the case of voluntary bids on the supplier side, a distinction must be made between "conventional" and "renewable" suppliers in order to guarantee feed-in priority in accordance with EEG 2017 § 11 when the grid operator accepts the bids (in this case EWE NETZ GmbH, a local DSO). Each bid must be allocated to a market area that represents a congestion-free grid cell. However, before a flexibility bid can be placed on the platform, certification of the bidder and his flexibility is required, which ensures both the ICT connection for data exchange and verification and the exchange of master data ([20], [25], [26]). A detailed description of the NEW 4.0 energy market “ENKO” is given in section 2.1.

All smart market concepts of the SINTEG projects are aimed at relieving grid congestions by increasing power consumption (and reducing power generation) that is flexible in terms of time. The markets are therefore also referred to as ‘flexibility markets’. What they have in common is that the location of flexibility providers must be known during the market process. The criteria for selecting a particular flexibility offer are not only low costs but also high sensitivity to the grid congestion. Grid operators, i.e. DSO and in some cases in interaction with TSO, are deeply involved in the flexibility market processes. They do not only carry out the necessary grid calculations but also act as the flexibility demanders and in some cases also operate the flexibility platform.

Flexibility markets are not only designed in the SINTEG framework. The German "Grid Integration" project for example, aims to design, implement and validate a holistic concept for the integration of smart market participants in "smart grid" systems. In doing so, the market participants should be able to act as freely as possible and only intervene in critical grid situations by an automation system. In this way, all flexibilities in the electrical distribution grids are to be optimally used and thus the costs of the energy transition reduced overall. The functionality of the developed system was validated in a field test in a real low-voltage grid [27].

Another smart market platform has been developed in the German "FlAixEnergy" project. The aim of the project is the realisation of an "ICT platform", which should enable several industrial consumers to market their demand flexibility on the regional electricity market via clustering into virtual power plants. The platform aims to synchronise regional energy demand and distributed energy generation at the distribution grid level. With the help of the flexibility of industrial consumers, which results from the temporal adjustment of production processes, positive effects for the grid can be achieved, e.g. through local direct marketing. The project is aimed at a large untapped potential for the commercialisation of industrial flexibility. According to [28], however, this requires that energy consumption of production processes is measured product-dependently and can be planned very precisely, and that at least flexibility costs are covered. Unscheduled production changes must be dealt with, e.g. by maintaining redundancies in the portfolio/cluster. The FlAixEnergy-Platform addresses not only industrial consumers, but also operators of virtual power plants as flexibility marketers - in order to enable smaller industrial companies to gain a better market access in favour of their flexibility and to use their flexibility potential economically; operationally by optimising operational planning and strategically when making investment decisions. According to [28], a cloud-based communication infrastructure forms the basis of the interactions between the market players.

2. Literature review of regional flexibility markets concepts

2.1 Northern German flexibility market, ENKO

Context

In 2018, 2 860 GWh of renewable energy was curtailed in Schleswig-Holstein, the most northern state of Germany with a very high penetration of wind energy. This resulted in costs of 295 million Euros excluding redispatch costs. A solution for this challenge could be the use of distributed flexibility for congestion management. However, this would require knowledge of the condition of the electrical grid, the occurrence of congestions and the impact of individual flexibility providers on precisely these congestions. This requires a level of coordination, which is not given by today's markets. In order to make a market-based grid congestion management attractive for flexibilities, the so-called ENKO concept [19] was developed as part of the NEW 4.0 project to meet the challenges in Northern Germany in particular. The ENKO concept, which only addresses electricity consumers as flexibilities, was expanded in [29] to include electricity generators and price bids, resulting in a concept for an inter-regional flexibility market.

Description of the market

The North German flexibility market concept corresponds to the flexibility platform described in [30] . Appropriately, Northern Germany meets the requirements of this smart market class for wind-dominated regions with flexibility potential, such as power-to-heat plants, combined heat and power (CHP) plants, and high congestion occurrence in the high and extra-high voltage levels mainly caused by a substantial wind energy infeed. The market concept is described in [29] as follows: "For the investigated market concept three types of actors are relevant. These are the flexibility providers, the flexibility market and the distribution system operator (DSO), which can also be seen from Figure 3. The DSO calculates congestions on basis of the day-ahead schedules and shares this information with the market. In case the DSO anticipates congestions, the market tenders the required flexibility via direct requests from relevant flexibility providers. Those respond with an offer of available flexibility and the related flexibility cost. Based on their cost and sensitivity, which means their effective impact on the congestion, the market computes a merit order and accepts suitable bids. The day-ahead congestion forecast is based on day-ahead schedules calculated at 12:00. Accepted flexibility providers are informed about their bids success at 14:30 that day. The concept aims at reducing curtailment in the regarded region at costs lower than curtailment itself and to increase the feed-in of renewable energy." [29]

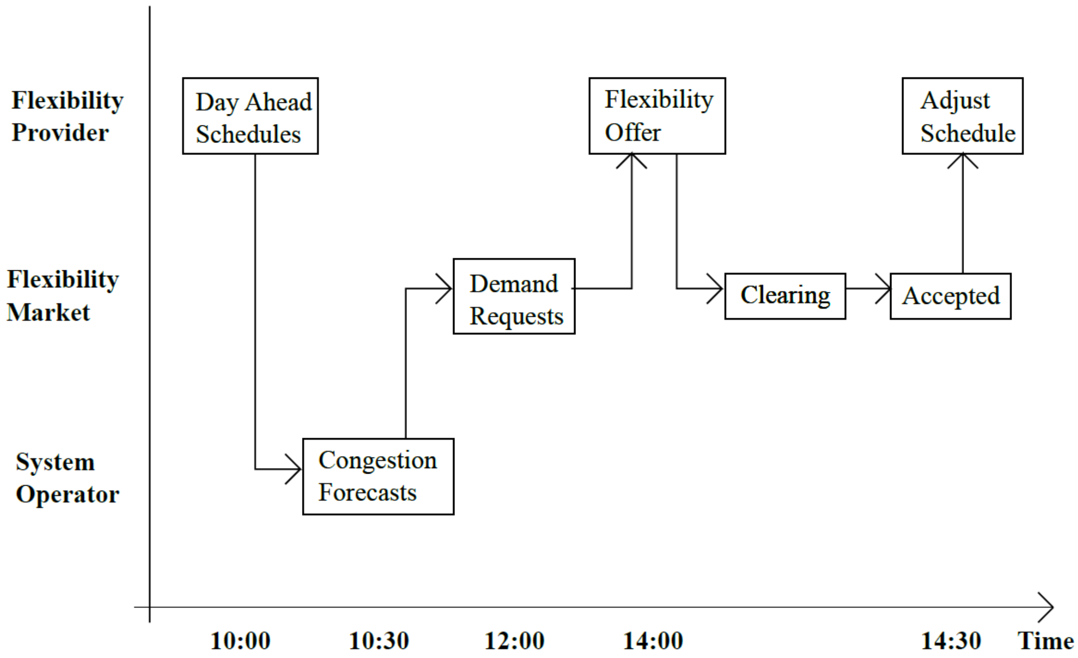

Figure 3 : Information flow of the North German flexibility market concept [29]

<u>Evaluation of the concept</u>

In order to evaluate this concept, an extensive data set was developed, which models the power generation and consumption in Northern Germany in the years 2025, 2030 and 2035. For each of these three years, two different regulatory frameworks were applied, which differ in their favour of the use of flexibility. The data set contains a total of 13 power generation technologies and 19 power consumption types. It has a temporal resolution of 15 minutes and a spatial resolution of the high and extra-high voltage nodes of the region. The underlying grid models were developed specifically for this purpose and differ for the scenario years. The weather day-ahead forecasts and conditions of the year 2012 are used as a basis for the simulation of the day-ahead forecasts and feed-in of weather-dependent power producers and the temporal profile of power consumers. The unit commitment of the remaining producers and flexible consumers is realised by modelling both the day-ahead and the intraday market.

This extensive data set provides the framework for the simulation and evaluation of the North German flexibility market concept. Assumed participants in the flexibility market are wind farms, large and small combined heat and power (CHP) plants, large batteries, industrial demand-side management (DSM) units and electrolysers. A first evaluation of the market concept will be completed in May 2020.

<u>Main learnings</u>

- Settling a market-based congestion management.
- Settling a platform linking TSO/DSO to flexibility providers.
- Two approaches: 1. Real existing platform (ENKO) for solving congestions using consumers only ([19]), and 2. Scientific co-simulation of flexibility market for solving congestions using producers and consumers ([29]).

<u>Blind spots</u>:

- If abusive consumers can cover so-called “sham flexibility” (“Scheinflexibilität” in German), i.e. parts of their base load, via the flexibility platform, they bypass the regular electricity market and are placed in a better position at the expense of the overall system. The ENKO platform relies on a random component in the plant selection as well as a downstream validation of all time series in order to avoid trading with sham flexibility. In this way, voluntary flexibilities can be used for congestion management without the risk of increasing overall system costs due to strategic bidding. [31]

2.2 Enera (DE)

Context

Enera is a joint project between the power exchange EPEX SPOT, one of the German TSO TenneT DE and the German DSO Avacon Netz and EWE NETZ.

The Enera experiment takes place in the northwest of Germany, which is a windy region where many congestions occurred in the past. It is a coordinated platform within the SINTEG project.

The idea is to open of "on-demand" locational order books on the Intraday continuous market to solve congestion issues. This settle a market-based congestion management system where flexibility providers trade with local TSO and DSO as it is described in the Figure below. In this figure, OBK is the name of the locational order book where flexibility providers place bids. A same volume can be placed on both the global market (here EPEX intraday market) and a locational order book.

This local flexibility market is designed for small-scale actors. Big actors are remunerated at their production cost as in classic redispatching.

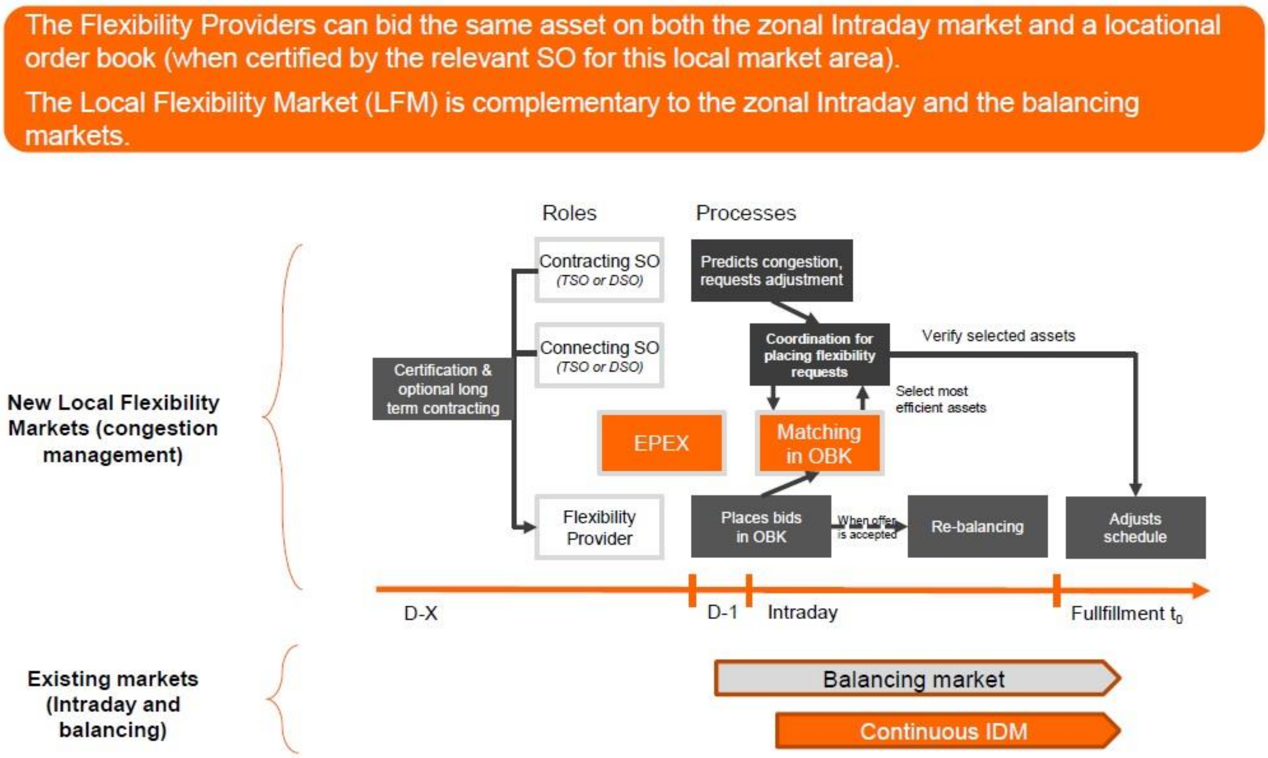

Figure 4: Local flexibility markets in Enera

Main features of the Enera market

Remuneration: Dispatch payment

Pricing rule: Pay-as-bid

Price formation: Free[4] with regulated elements for big actors.

Continuous market

Illustration of Enera process through the example of the first trade on Enera

First trade on Enera happened on 04/02/2019 at 15h25 with a contract for delivery on the same day at 17h00-18h00 in the market area SOET1. After EWE NETZ has forecasted a congestion in a few hours due to high feed-in, they sent a flexibility demand order for 2 MW downward flexibility at -45.50 €/MWh in the market SOET1 for delivery from 17h00 to 18h00[5]. Audi had an available Power-to-Gas asset whose flexibility is marketed. They saw a flexibility demand at an acceptable price from a system operator in the area where their plant is located. They submitted a matching flexibility offer order via the same interface. 2MW have been traded at -45.50€/MWh. The orders were matched in the trading system and the transaction was executed.

Main Learnings

- Settling a market-based congestion management where local markets interact with existing intraday markets.

2.3 GOPACS (Netherlands)

Context

GOPACS stands for Grid Operators Platform for Congestion Solutions. GOPACS is owned and operated by the Dutch TSO Tennet and four Dutch DSO (Stedin, Liander, Enexis Groep and Westland Infra). GOPACS was launched in 2019.

GOPACS takes place in the Netherlands. This is not a market platform but rather a link with offers posted on the ETPA intraday platform. GOPACS enables a link between offers on the ETPA intraday platform and the participating TSO/DSO. They are currently having talks with other market platforms to connect these to GOPACS as well (EPEX Spot and Nord Pool). One feature is to accept small-scale electricity actors as participants.

Description of the market

Based on up-to-date information, the grid operators determine where and when congestion can be expected. The congestion situation is entered into GOPACS, and a market message is issued. Market parties with a connection in the affected area can then place an order on a participating market platform (currently only ETPA). However, the balance in the electricity grid at a national level is not to be disturbed. This is why the lower amount of electricity in the congestion area is combined with an opposite order from a market party outside of the congestion area. GOPACS quickly checks if this order will not cause any problems elsewhere in the electricity grid. If all lights are green, the grid operators will pay the price difference (the spread) between the two orders. In this way the two orders are matched on the market platform and the congestion situation can be solved.

GOPACS follows a process in which supply and demand are continuously matched, based on the trading procedures in many European intraday markets.

Main features of the GOPACS platform

Remuneration: Dispatch payment

Pricing rule: Pay-as-bid

Price formation: Free

[4] The price is not regulated. Bidders can set their price to any value.
[5] That means EWE NETZ accepts to be paid at least 45.5€/MWh for a production decrease.

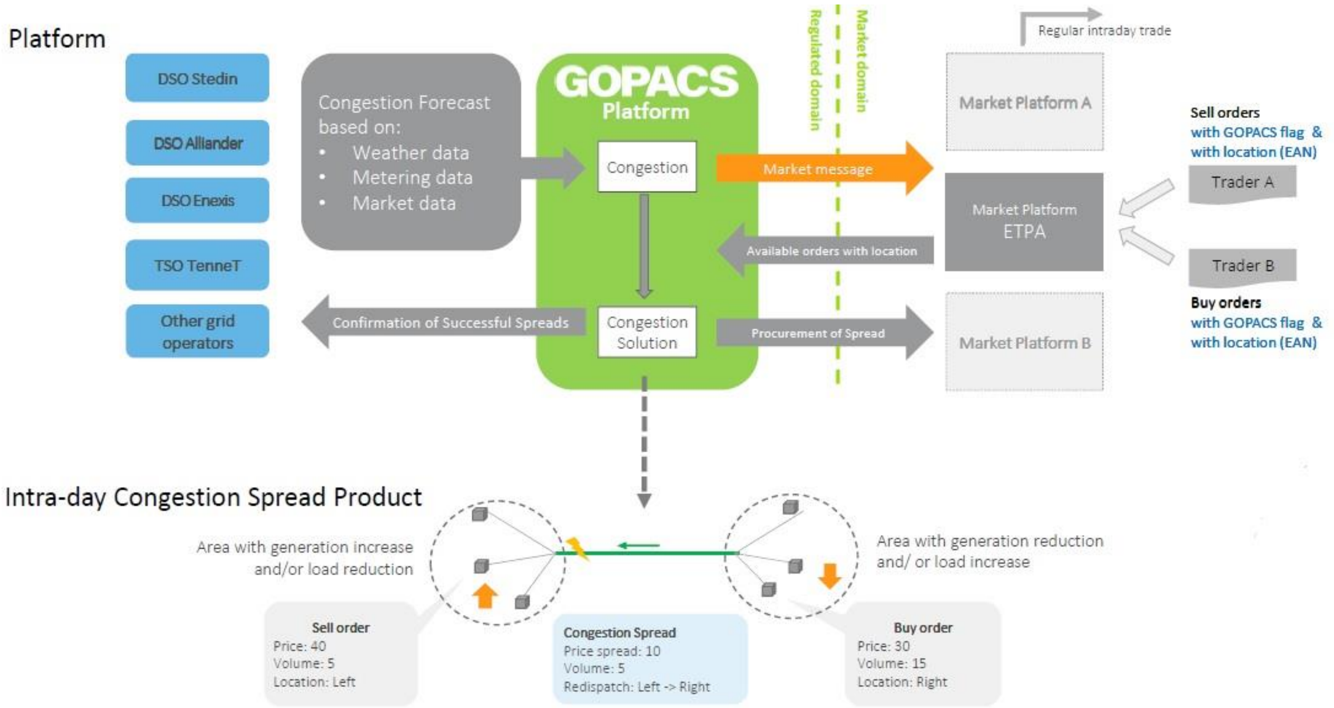

Figure 5: GOPACS process to solve congestion

Summary of the activation of flexibilities in GOPACS

1- TSO/DSO publish request for bids. Each bid has a location tag,

2- GOPACS platform requests to ETPA, evaluates cost-effectiveness, avoid worsening congestion elsewhere and send orders to TSO/DSO,

3- Grid operator activates bids,

4- Market parties are notified and settled through ETPA.

Main Learnings

- Settling a platform linking TSO/DSO to flexibility providers through existing intraday markets.
- Solving congestions by matching both upward and downward bids in the same time, only paying for the spread.

2.4 NODES (Norway)

Context

NODES is a joint venture between the Norwegian utility Agder Energi and a European power exchange, Nord Pool.

Established at the beginning of 2018 and active in two pilots: One is Norway with DSO Agder Energi Nett and another one in the TSO area of 50Hertz with the DSO Mitnetz Strom.

Description of the market

NODES operates a market platform that puts a value on flexibility, and gives a buyer of flexibilities a right to change consumption or production according to a contract. The key feature in the NODES marketplace is to identify and give value to local flexibilities.

Nodes gives the opportunity to flexibilities not used locally to be sold to the TSO and/or BRPs at the transmission grid to solve imbalance issues there. NODES aims to link the Flexibility Marketplace described below with the existing platforms that operate intraday and balancing markets. This will thereby create a fully integrated marketplace for flexibility.

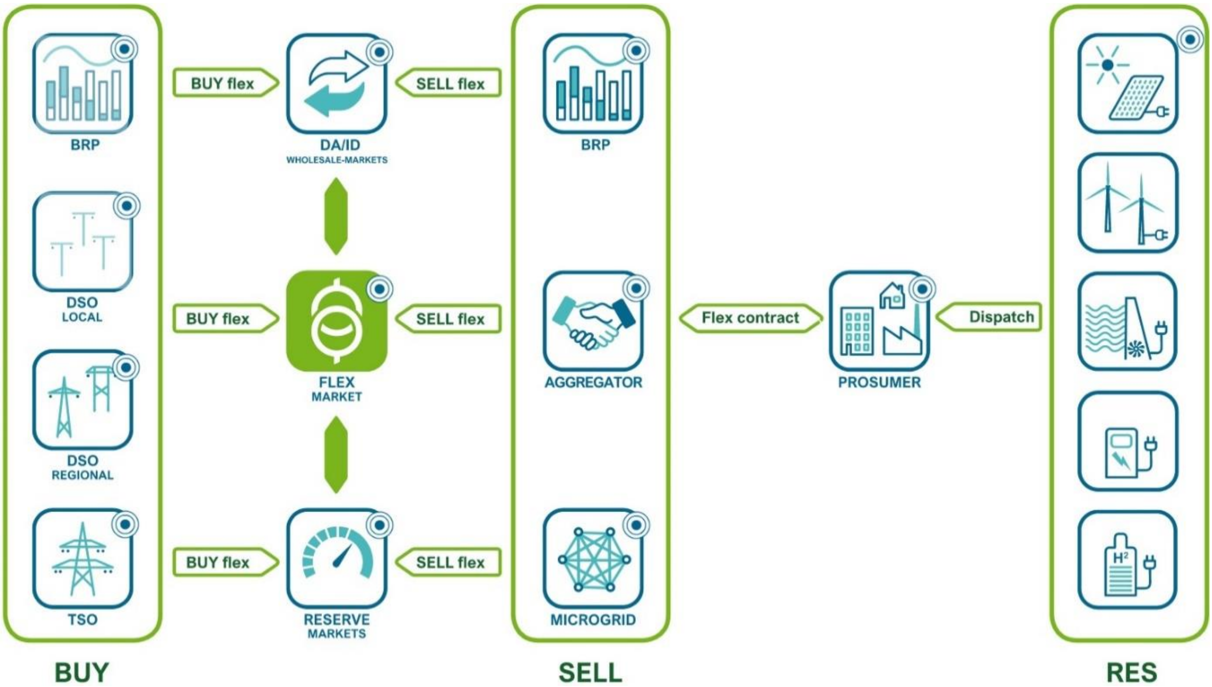

Figure 6: NODES flexibility marketplace design and interaction with reserve and intraday markets

Regarding the trading timeline, congestion management products are traded from the intra-day to the operating time.

All flexibility assets need to be tagged with their location. As an example: in one pilot both meter-ID and GPS coordinates were used. Another alternative is the postal code. All flexibility within a Grid Location (GL) can be aggregated by the flexibility provider to one or more offers into NODES. The TSO or the DSO are free to decide how granular they want the offers. In principle, a DSO can define a GL to be all units below a feeder. For the TSO, a relevant GL can be a geographical area under a Highest voltage/ high voltage transformer - significantly smaller than for day-ahead price area - but much larger than what the DSO needs. A GL initiated by the TSO can be an aggregate of GLs initiated by the DSO.

DSO, TSO and BRPs will have to define their willingness to pay for activation of flexibilities in particular GLs and feed this information continuously into NODES via an API. The flexibility is made available by the flexibility providers who will act on behalf of the owners of the flexibility assets and feed these offers into NODES via another API. The flexibility providers will need to have a business model with the asset owners in place, and technology that make it possible to activate the flexibility by those who have bought it. For the majority of operating hours during a year the flexibility is not needed locally at the actual GL – often it is needed only a few hundred hours a year. But it can still have a value in the rest of the system, for balancing purposes by the TSO or in the IDM for the BRPs. NODES will establish an interface that makes the flexibility available for these markets. The flexibility providers can also differentiate their offers depending on whether the flexibility assets are sold locally or centrally.

It will be possible to define several portfolios within each GL and differentiate the price and other properties as ramping capability (max/min), source, production, consumption, max/min activation time and max/min activation duration etc. NODES will have filters that buyers of flexibility can use when they are optimizing their grid costs according to their actual need of flexibility quality. An offer of flexibility in NODES is given by a combination of parameters, and it is these parameters that buyers of flexibility can use to filter on.

From the buyer side, a DSO can create a template that predefines some of the available parameters. This will give the DSO the opportunity to define their own local products that they can use when requesting flexibility. These templates can then serve as a basis for the DSO to enter availability contracts according to their specific needs. NODES will also be able to handle bilaterally purchased (outside NODES) availability contracts and just handling the activation of the flexibility.

Main features of the NODES market

Remuneration: Dispatch and availability payment

Pricing rule: Pay-as-bid

Price formation: Free

Main Learnings

- Settling a market platform linked with day-ahead, intraday and balancing markets. NODES can propose on those markets its bids if there are not used to solve congestions. Therefore, flexibility providers may only bid on NODES to have access to day-ahead, intraday and balancing markets.
- DSO/TSO can fix the granularity they need for flexibility location.

2.5 Power potential (UK)

Context

The South-East region of the transmission network in Great Britain has been experiencing a high penetration of DER. Due to the availability of wind and solar resources in the area, connection volumes have grown rapidly in recent years. As the number of distributed generators increases, displacing conventional transmission connected plants, there is a need to investigate the manner in which they can provide network support both at the distribution and transmission level. This requires an increased coordination between National Grid (TSO) and UK Power Networks (DSO). [32]

Measure	Data	% of industry
End customers	8.2m	28%
Population served	c.20m	-
New metered connections per annum	46,000	32%
Distributed generation connected	9.1GW	31%
Energy distributed	84.8TWh	28%
Peak demand	16GW	N/A
Number of substations	147,000	-

Figure 7: UK power Network overview [33]

The response from each DER at the transmission level is aggregated into a virtual power plant, which is controlled by a newly developed software platform called DERMS (Distributed Energy Resources Management System, Figure 7). This platform assures the communication (technical, control and commercial) between National Grid and UK Power Networks. Distribution network constraints will be solved first by the DSO before the remaining available DER capacity is offered to TSO as transmission services. Using this bottom-up incremental approach, the use of DER reactive services by TSO via DERMS will not violate distribution constraints in the Power Potential area. [34]

Two services can be provided through DERMS:

- **Active power service**: constraint management and system balancing

- **Reactive power service**: dynamic voltage support (high and low voltage conditions), equivalent to an SVC or STATCOM reactive compensation device which is connected to the transmission network.

Four locations where the transmission network interfaces with the distribution network in the South East area are considered within the scope of the Power Potential project. These grid supply points (GSPs) are: Bolney, Ninfield, Sellindge and Canterbury North. (Figure 8)

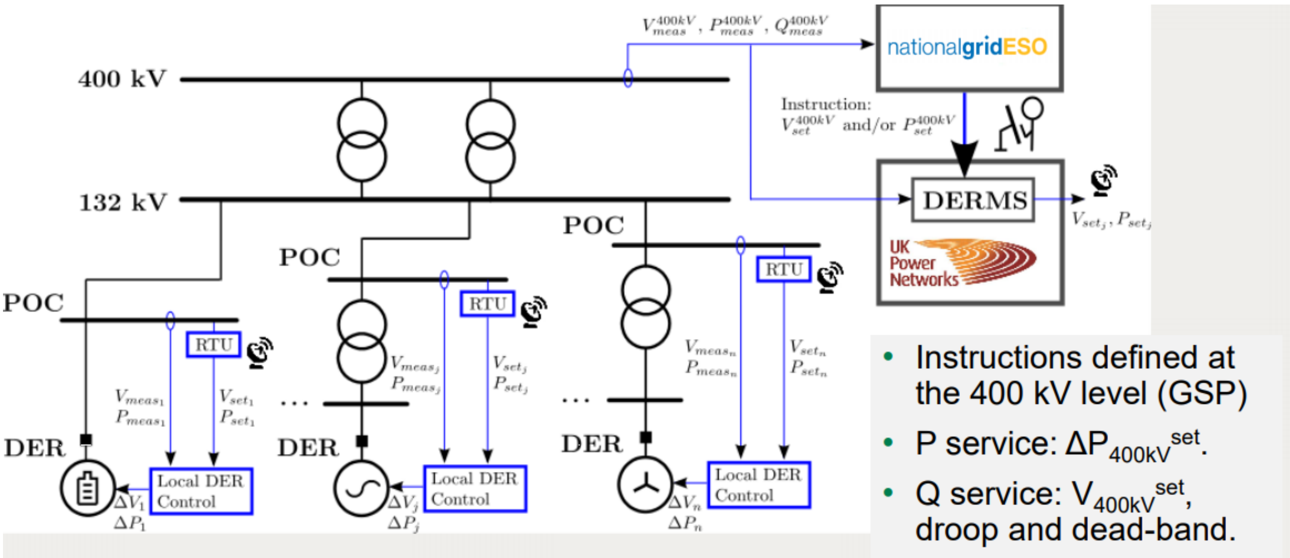

Figure 8: For the active power service, National Grid will instruct a MW volume (ΔP_{400kV}set). For the reactive power service, National Grid will instruct a voltage target set-point (V_{400kV}set) with a droop characteristic and a dead-band to be delivered at each grid supply point [32].

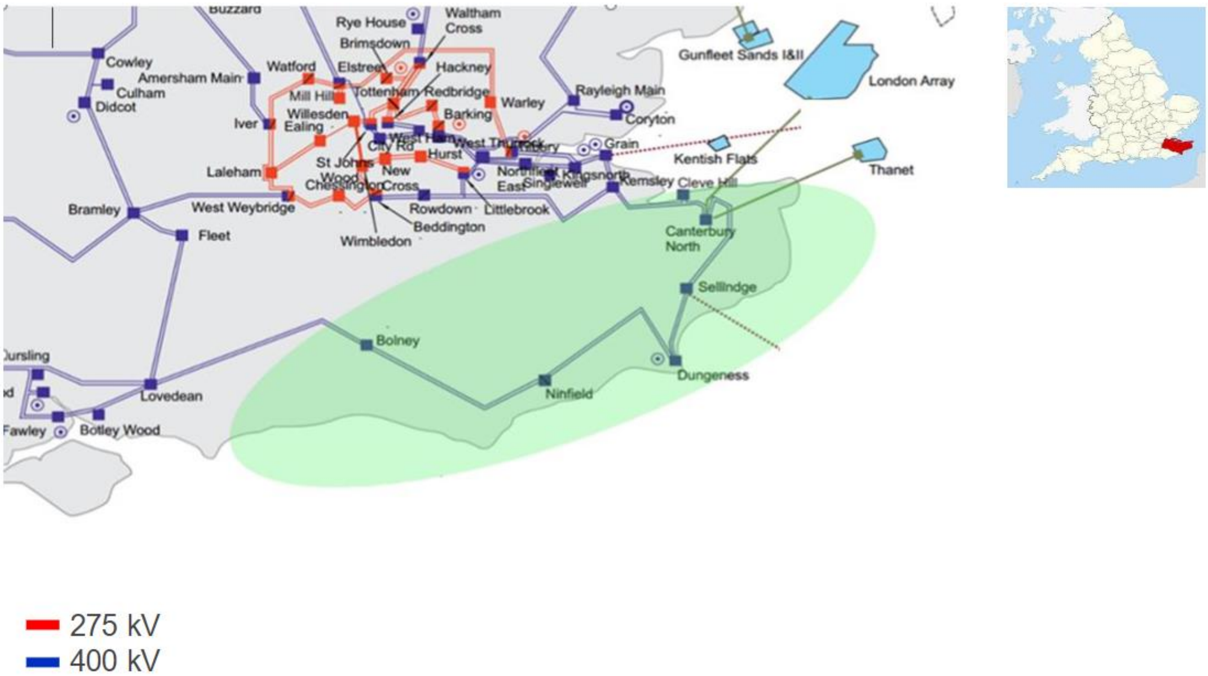

Figure 9: location and GSPs of the Power Potential project [32].

Description of the market

Besides a technical solution to resolve transmission voltage and thermal constraints, the Power Potential innovation project aims to develop a new power market for DER with the aim of resolving conflict of services while creating additional revenue.

DER participation

Before participation to the Power Potential innovation market a DER has to fulfill the following steps [35]:

1) Submission of technical characteristics
2) Signature of a framework agreement including service parameters
3) After tests and acceptance, DERs are assigned to a GSP stack, representing the GSP to which they are most effective (Figure 10). Whilst DERs will be initially assigned at the commissioning stage, they could be reassigned during the trial due to network/load flow changes or improved calculations showing that effectiveness is higher at another GSP or if participation is insufficient to ensure a functioning market (see assessment factors).
4) DER technical characteristics are coded into DERMS

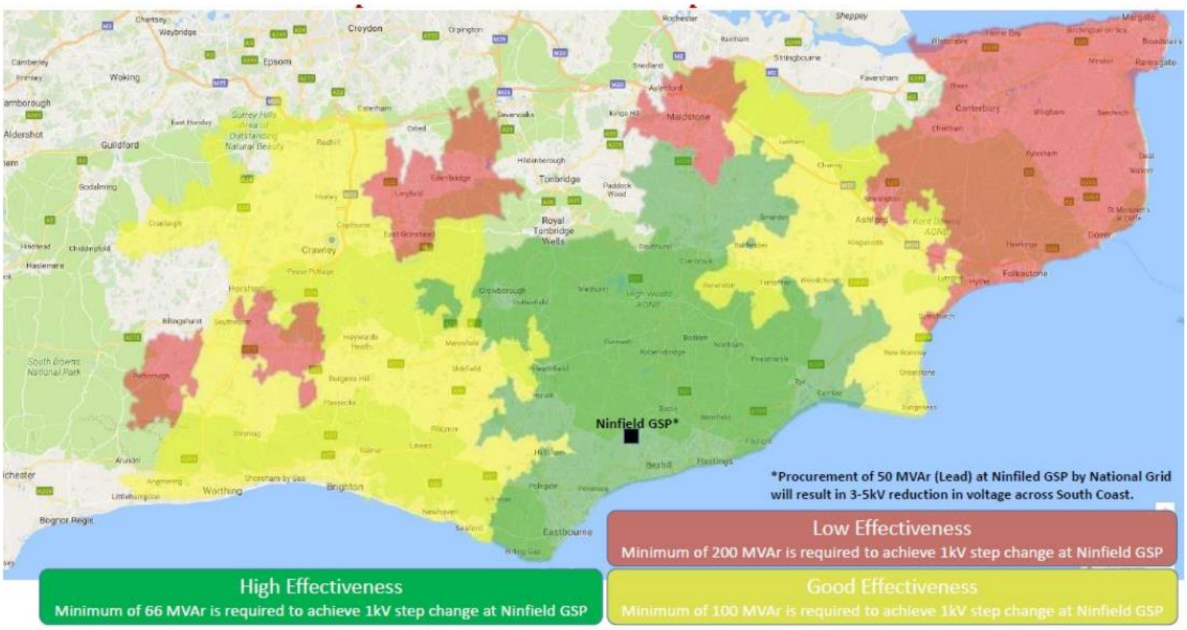

Figure 10: example of heatmap for effectiveness [36]

Bidding and settlement

DER reactive service providers will receive [35]:

- Availability payments (£/Mvar/hr) for reactive power availability
- Utilisation payments (£/Mvarh) for reactive power response.

These prices will be submitted by providers as bids for service windows (Figure 11) at the day-ahead stage, and will be paid on a pay-as bid basis.

Service window	Time on	Time off
1	23:00	03:00
2	03:00	07:00
3	07:00	11:00
4	11:00	15:00
5	15:00	19:00
6	19:00	23:00

Figure 11: Active and Reactive Power service windows for wave 2 of the Power Potential project [35]

The total Availability Payments received will be adjusted for DER performance by comparing the settlement periods in which the DER was accepted and deemed available to the total number of settlement periods for which the DER was accepted (=Relevant Proportion of availability achieved). If the Relevant Proportion is less than 80% in a month, it will be assigned a Performance Factor equal to the Relevant Proportion. This gives the following availability payment:

Total Availability Payments = Duration (hr) X Reactive Power Availability Volumes (MVar) x Reactive Power Availability Prices (£/MVar/hr) x Performance factor

DER **active service** providers will receive Utilisation Prices for Active Power Response volumes accepted based on the prices submitted into the Power Potential Auction. There is no availability payment for Active Power. Active power utilisation is measured in terms of the deviation from a baseline level of active power output.

The Power Potential trial acceptance and bidding flowchart is given in Figure 12.

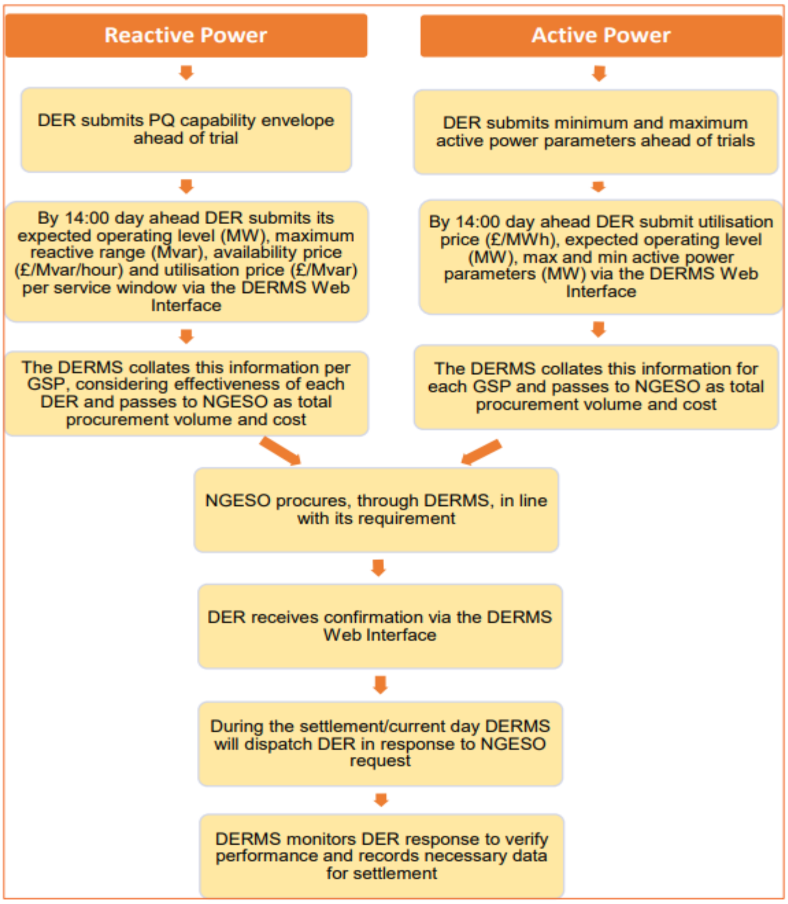

Figure 12: trial acceptance and bidding flowchart [34]

Acceptance

Bids will be assessed in line with the counterfactual cost of alternative actions. National Grid will only accept the DERMS's volumes where the price is as cost effective as alternatives available to it, meaning that DERs (VPPs) will have to reduce their bids to a competitive level. [35]

In order to do so the trial is run in stages in which the acceptance criteria vary.

- In an **initial stage**, the counterfactual cost is based on the long-run cost of investing in alternative transmission network infrastructure to address reactive power requirements. A bid may be accepted if it is higher than the cost of dispatching flexible assets on the transmission network, but not if it would have been more cost-effective to resolve the constraint through network reinforcement. If it is clear that the service is competitive with these options already available on the transmission system, the following stage can begin.
- In this **commercial stage**, the counterfactual cost is based on the total cost of other system actions available immediately to National Grid (not including alternative transmission network infrastructure).

Besides the bid price there are two other assessment factors, only for reactive power services:

1) **Expected Reactive Power range**
   If the DER's active power forecast implies a relatively low reactive power range, the DERMS will use that reduced volume when building the availability stack for presentation to National Grid. The effective price of that volume would therefore be higher than if more reactive power was expected to be available. [35]
2) **Effectiveness with respect to GSP or sensitivity value**
   Sensitivity value is an indicator of the effectiveness of a DER's reactive power injection in a particular GSP. Allocation of a DER to a GSP is done according to where this value is shown to be maximum (GSP reactive power variation QGSP vs DER reactive power variation of QDER). It may be that a provider with a low bid, but low sensitivity value, is rejected in favour of a provider with a higher bid but high sensitivity value. [35]

<u>Evaluation of the concept</u>

The project is still ongoing (technical trials completed) so the trial results have not yet been published. Initial modelling results show the following [37]:

- Using the VPP concept, the aggregated capability of resources and network within the VPP can be quantified and used without violating local distribution network constraints – Individual DER bids can also be accounted in the cost function.
- The value of reactive power support varies in time and with location -depending on the system conditions
- Allocation of DER services to support Distribution and Transmission networks will depend on the adopted approach – Sequential (DN first and then TN) may be different from fully Integrated approach (combined DN and TN). The Power Potential project uses the sequential approach DSO-TSO incremental approach (Power Potential concept). It delivers a balance between complexity, practicality, transparency, and optimality of the results. DERs will have a higher locational impact on local distribution compared to transmission; therefore, solving the distribution problem first seems is a reasonable approach.

- Benefits of smart operation of distribution network assets may reduce reactive power control costs to TSO.
- In the systems studied, distribution networks can facilitate full access to DER capacity, but outages of distribution network assets may affect access to DER, which lead to implications on market design.

2.6 Synthesis of the different regional flexibility market analyzed

Existing or R&D market	Service provided	Link with other existing markets	Specific features (*gate opening and closure time, minimum duration and volume of offers etc.*)	Compensation mechanism
French “balancing mechanism”[6]	Redispatch	Balancing market (mFRR and RR)	Mandatory for all power plants connected to transportation grid (>12 or 17 MW) and opened for consumers and smaller power plants (minimum capacity: 1 MW)	Pay-as-bid Variable remuneration for all the participants and capacity compensation only for mandatory power plants
ENKO North German Flex Market	Redispatch	Day-Ahead	Day-Ahead: Opening: 12 AM Closure: 2.30 PM	The compensation for participation in ENKO is regulated in the SINTEG regulation. The cosimulation of the North German flexibility market uses the pay-as-bid approach [29].
Enera	Redispatch	Intra-Day market (EPEX) Bids proposed for IDM and for redispatch Platform that prevents bids to be used on both markets	Standardized prequalification procedure (especially dedicated to wind turbines)	Pay-as-bid Dispatch payment
NODES	Redispatch	Bids no used for congestion management are proposed to connected markets (balancing and intraday)	Aggregation of flexibility providers within a “grid location”	Pay-as-bid Dispatch and availability payment
GOPACS	Redispatch	Bids proposed for the IDM can be used to relieve congestion	Need to compensate increase or decrease of production in the congestion area by an opposite offer outside the congestion area	Pay the spread between both orders
Power Potential	Redispatch and Voltage support	Balancing “mechanism”: redispatch integrated in this mechanism	Sensitivity value for voltage support Proposed availability Comparison of the prices of bids with counterfactual costs	Reactive power: availability and utilization payment Active power: utilization payment

Table 2: Main features of regional markets analyzed in this document

[6] We added the French mechanism as comparison with other markets described in details within this deliverable. For further insights regarding this mechanism, please refer to the REgions deliverable D3.3.1

3. Main learnings from the state-of-the art

3.1 Main strengths and drawbacks of the market designs analyzed

Redispatch

From the different markets analyzed in this document, the following market concepts can be proposed for redispatch:

- Design a specific market for redispatch that is not directly related to other markets
- The “NODES solution”: participants make flexibility offers for congestion management purpose that are also available for other connected markets if they are not used to relieve congestion
- The “GOPACS solution”: DSO/TSO can use flexibility offers made on other market for congestion purpose

The strengths and drawbacks of those different options are summarized in table 2.

Main market concepts for redispatch	**Strengths**	**Drawbacks**
Specific market	• Transparent: actors can bid on one or another market	• Risk of gaming due to lack of participants on redispatch market • Risk of conflicts between redispatch market and other markets
NODES solution	• Easy participation: ensures participants that their bids can be used to another market • Close to real time	• Bids from other markets can recreate congestion • Only used by DSO: would need a complex infrastructure to be used by TSO since priority is given to DSO • Complicated matching due to bids defined by many parameters
GOPACS solution	• Easy participation: connection to an existing market (local IDM) • Close to real time	• Bids from other markets can recreate congestion

Table 3: Strengths and drawbacks of the main market concepts used for redispatch

Finally, the analysis of the market designs studied in Section 2 this report reveals a number of common features:

- a market platform where flexibility providers can place bids then selected by SO,
- locational information, and sometimes other technical features, are required of the flexibility providers so that the SO is able to calculate the effectiveness of the bids based on the network situation,

- a bid-based compensation mechanism (rather than cost-based),
- a link to other short-term electricity markets and a coherence in the gate-opening and closure times with the ones of the other markets,
- the possibility to aggregate small offers connected at the same grid location through an aggregator
- flexibility can be provided either to the local DSO or to the TSO or both.

Those features will be accounted for in the design of the modelling tools developed in task 4.7 of REgions. They also have to be compared to the recommendations provided in deliverable D3.3.1. That is the objective of deliverable D3.2.2.

<u>Voltage support</u>

Regarding voltage support, Power Potential is the only project addressing this ancillary service. This is not a surprising result as *"There are limited or non-existent competitive mechanisms for the procurement of reactive power (some exceptions are Australia and GB)"* [38]. This is due to the following reasons:

- There is only limited number of potential flexibility providers;
- There are modelling issues as a complex Optimal Power Flow (OPF) problem that need to be solved to send the good information to flexibility providers;
- Procurement of reactive power on a half-hour clearing market could not be profitable for providers.

The reference [38] provided the following analysis of the different procurement methods for voltage support used by different DSO/TSO.

Country	SO	Procurement method		Type of payment						Periodicity
		Compulsory /Mandatory	Tenders	Capability	Availability	Enabling	Utilisation	Opportunity costs	Others	
USA	CAISO	✓						✓		variable
	NYISO	✓		✓				✓	✓	variable
	PJM	✓		✓				✓		variable
	ISONE	✓		✓				✓	✓	variable
Australia	AEMO (GM)		✓		✓			✓	✓	variable
	AEMO (SCM)		✓			✓			✓	variable
GB	NG (ORP)	✓					✓			variable
	NG(ERP)		✓		✓		✓			every six months, with term contract minimun 1 year and then in six-month increments

GM: generation mode, SCM: synchronous condensor mode. Others include: testing charges, cost of energy used to energise equipment that provides voltage support.

Source: AEMO (2017a), ISO Tariffs, NG Reactive Power Service Guides

Table 4: Reactive power procurement and payment methods

This analysis shows that very few countries procure reactive power in a market-based way. The only examples of such tenders so far are observed in Australia and in the UK. Mostly, however, reactive power is mandatory and procured through connection agreements by limiting grid users' power factor. Nevertheless, this situation could change in the future as classical reactive procurement methods from large conventional power plants could become insufficient to solve voltage issues as the share of distributed energy sources increases. For instance, the European Directive on common rules for the internal market for electricity recently stated that "the distribution system operator shall procure the non-frequency ancillary services needed for its system in accordance with transparent, non-discriminatory and market-based procedures" (chapter 5, article 31, §7).

Based on the insights obtained from Power Potential (see Section 2.5), the procurement of voltage support can be implemented as follows:

- similar to redispatch, it seems technically feasible to address voltage support through a market platform,
- similar to redispatch, locational information is required of flexibility providers to assess their effectiveness in solving voltage issues at a specific grid location,
- one important difference from redispatch is that reactive power does not need to be procured for the purpose other than voltage support so a future reactive power procurement market is more independent from other electricity and ancillary services markets, i.e. it does not need to observe time and resources dependencies with other marketplaces,
- however, reactive power procurement capabilities are linked to the level of active power so the link between this procurement and active power procurement still needs to be analyzed to avoid unexpected effects.

3.2 Blind spots of the analysis

<u>Redispatch</u>

Some questions remain regarding the market design that would be the most relevant (cost-effective, transparent and easy to implement) for redispatch.

- There is currently a lack of prequalification procedure for redispatch (for instance there is not the same duration of activation between redispatch and balancing).
- So that flexibility offers participate in a market dedicated to congestion management, they need some clear and transparent information regarding congestion (volume, duration, frequency, location) that must be provided by TSO. Future regulation will have to clarify TSO obligations regarding the level of information they should provide.
- The risk of locational market power seems not to be really addressed in the different projects. Indeed, auctions realized to relieve some local grid constraints may face a small number of actors able to participate. Some actors could then take advantage of their position to affect market results. Designing such markets requires proper design to avoid gaming.
- The studied projects do not clarify how the participants ensure the fulfillment of their balancing responsibility before the TSO, e.g. if activated by the TSO or if redispatched. Since this issue has implications for imbalance costs of market participants, it needs to be addressed in Regions.

<u>Voltage support</u>

The only project dealing with voltage support we had the opportunity to analyze is still on progress. Currently, it is still not clear what will be the value of such a market design for voltage support purpose. As described in the section on Power Potential (2.5), bids will be compared to grid reinforcement costs and should be cheaper to be accepted by the DERMS platform. A first analysis will have to assess the savings realized through this market and ponder it with its complexity. Then, a second question will be the value of DER participation in voltage support compared to large power plants.

3.3 Discussion on market design

A specific market for regional flexibility products face a major issue of gaming since only a few actors would be likely to participate. Thus, it seems an interesting option to connect a regional flexibility market with other existing markets such as day-ahead, intraday or balancing markets. In this section, the benefits and drawbacks of such market coupling is outlined. Further details on markets interaction and the issues raised by such coupling are provided in Regions deliverable D3.3.1.

Regarding market design for redispatch purpose:

- Connection between redispatch and balancing market is the option chosen by the French TSO, RTE. Nevertheless, this could become more complicated in the near future with new regulation from the Clean Energy Package: it is still possible to use balancing capacity bids to relieve congestions but then, they have to be removed from merit order and cannot be proposed on the future common European platform for balancing. Indeed, the bids used for redispatch cannot be used to set the price for balancing energy. Moreover, the TSO will not have the opportunity to use the balancing energy bids provided to the common European Platform for redispatch because those bids will not contain any locational information. Finally, new balancing market closure time (h-1) may occur too late to manage internal congestions for TSO.
- Connection between redispatch and day-ahead or intraday market would have the advantage to beneficiate from high liquidities. In Regions we specifically adress variable renewable energy sources (RES) participation in such markets. Forecats errors are then one of the biggest issue to be tackled for their participation. Regarding forecast issues intraday market is better than day-ahead market as participants can still bid every hour, or even less, before real time. RES producers are willing to provide firmer forecast for the products they propose on the intraday market than on the day ahead market. In conclusion, intraday market seems a reasonable option for designing market coupling with redispatch.

Regarding market design for voltage purpose, the lack of examples found of such markets as well as the complexity of the modelling required to design it[7], call for a pragmatic approach within the Regions project: the participation of DER to voltage support through a VPP still needs to be tested but the modelling of a dedicated market related to voltage support should be considered less relevant than the redispatch market modelling.

Finally, as explained in section 2.5 on Power Potential, regarding DER participation in any market there are specific issues that need to be adressed:

- How shall the design take into account the fact that DER flexibility may be used to solve issue both at the distribution and transportation network levels? Sequentialy (first on the distribution level and then the remainder made available to the TSO), as is the case in Power Potential, or simultaneously, based on predefined sharing rules?
- Is there an additionnal value for the TSO to have the opportunity to select bids from flexibility providers connected to the distribution grid regarding their ratio cost/effectiveness? Indeed, it is not so clear if this kind of providers could propose competitive bids compared to bigger and more centralized assets connected to the transportation grid.
- What is then the added value of a VPP that is able to gather different providers to place bids on markets?

[7] Indeed, assessing the ability of reactive power bids to solve a voltage issue required to solve a complex OPF problem

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Annex

Table 5 : Characteristics of the regional energy markets analyzed

Name	Country	"R&D project / Regional Market in place"	Services concerned (Congestion management / Voltage Control)	"Objectives / Type of constraints In case of projects: What are the questions to which the project aims to answer? Specific design for RES ? "	"Geographical perimeter Voltage levels REgions' definitions (sub-regional, regional, inter-regional, ...) "	Actors bidding (DSO-producers, TSO-producers, DSO-consumers, TSO-consumers, etc.)	Main learnings	Reference
RINGO	FR	R&D project	Congestion	How storage may contribute to raise congestion issues? What kind of grid data RTE may provide to actors to help them install storage devices on congested area of the grid and participate in congestion management?	"HTB1 transportation grid (63 kV - 90 kV) linked with French schemes (""S3REnR"") to plan VREs integration to medium voltage distribution grid (""HTA"") Regions' perimeter: regional"	TSO-producers and storage actors		
REFLEX	FR	R&D Project	Congestion + Volt var control					
Power Potential	GB	R&D project/Commercial deployment	DVR/Active power reserves	To create a regional reactive power market for DER connected to the distribution network to provide Dyn. Voltage control and active power support for constraint management and system balancing to the Great Britain (GB) System Operator:	"Sout-East boundary of GB (UK Power Networks=DSO) Modeled VPP grid supply points at 132 kV Regions' perimeter: ? I would say regional even if the voltage level is higher than 1010 kV"	"PV power plants Wind farms Batteries and storage sites; Synchronous generators; Aggregators"	"1) a commercial framework using market forces to create new services from distributed energy resources to National Grid via UK Power Networks 2) a platform known as	"https://www.nationalgrideso.com/innovation/projects/power-

							Distributed Energy Resources Management System (DERMS) to support technical and commercial optimisation and dispatch. "	potential https://www.nationalgrideso.com/document/130246/download"
COORDINET-1	ES - 1	R&D Project	Congestion management	The main objective of BUC ES-1 is to procure flexibility from resources connected at both TSO and DSO networks in a coordinated manner to solve transitory congestions that can occur at both networks. More active participation of resources including DER in the congestion management market, as well as more frequent procurement of flexibility by DSO require a boost of the current congestion management market and operational procedures so that processes that are currently performed manually can be performed in a semi-automated manner and ensuring that the needed	"Network under Study: HV, MV, LV. Resources connected to Iberdrola's network: 1. Murcia: Municipality buildings (significant demand loads). 2. Alicante: Industrial load of a cement factory. 3. Murcia and Albacete account for more than 1 GW of installed renewable (RES) capacity. Resources connected to Endesa's network: 4. Malaga: Demand Response (DR) from municipalities buildings and generation resources from wind farms will provide flexibility for congestion management 5. Cadiz: wind and solar photovoltaic (PV) will	Grid congestion management provided to the TSO and DSO under the scope of a common market mechanism	Ongoing project. Some results are available.	https://coordinet-project.eu/

				information is available to both the TSO and the affected DSO. The product traded would be to increase or decrease energy to solve grid congestions, the possibility to have a capacity product would be explored in a second stage of the demo.	participate in congestion management (86 MW) Resources connected to REE's network: 6. In Murcia and Albacete more than 800 MW of installed wind generation capacity participating is connected to the transmission network. These units can also be used in the demos to provide flexibility for distribution network uses. 7. Cádiz: around 130 MW of wind plants connected to the transmission network are participating."			
COORDINET-2	ES - 3	R&D Project	Voltage control	BUC ES-3 Voltage control provided to the TSO and DSO under the scope of a common market mechanism. Currently, in Spain, there is not a voltage control services market, only power factor control. Therefore, a suitable market mechanism has to be design from scratch.	"Resources connected to Iberdrola's network: 1. Murcia and Albacete account for more than 340 MW of installed renewable (RES) including wind, mini-hydro and CHP (combined heat and power) capacity. 2. Alicante: Industrial load of a cement factory Resources connected to REE's network: 3. In Murcia and Albacete, more than 800 MW of installed wind generation capacity participating is connected to the transmission network.	Voltage control provided to the TSO and DSO under the scope of a common market mechanism.	Ongoing project. Some results are available.	https://coordinet-project.eu/

					These units can also be used in the demos to provide flexibility for distribution network uses. Resources connected to Endesa’s network: 4. Cadiz: wind and solar photovoltaic (PV) plants will participate in congestion management (86 MW). 5. Cádiz: around 130 MW of wind plants connected to the transmission network are participating."			
COORDINET-3	GR	R&D Project	Voltage control	"BUC GR-1a: Voltage Control – Multi-Level Market Model ------ BUC GR-1b: Voltage Control – Fragmented Market Model In the BUC, based on the Fragmented Market Model, DSO and TSO can procure flexibility only from the flexible resources connected to distribution and transmission system, respectively. The flexibility resources connected to DS can be used indirectly for the elimination of voltage violation in transmission system through the proper power exchange between them. Thus, cooperation and	two greek demo areas, namely Kefalonia and Mesogia. In kefalonia: Voltage violations are examined for three basic HV elements of the Argostoli Substation: The HV Bus of 150kV, the power circuit breaker of HV connection line to Myrtos Substation and the power circuit breaker of HV connection line to Zante. one wind farm with a rated power of 39MW will participate in the pilot. Also wind farms with a total rated power of 25.1MW connected to the DS will be used in the demonstration.	TSO, DSO, producers	Ongoing project. Some results are available.	https://coordinet-project.eu/

				information exchange between the DSO and the TSO is crucial for deciding the power exchange. The objectives of this BUC are the following: • To ensure non-discriminatory access to the market for all agents that provide system services. • To enable coordination and information exchange between SOss in order to improve the efficiency of the system and eliminate voltage violations • To ensure a secure operation of the transmission and distribution systems. • To minimize RES curtailment for security reasons and due to operational limits."	Photovoltaic stations and wind farms with a total rated power of 3.743MW and 25.1MW, respectively, will be used in the Greek Demo.			
SMARTNET	ES	R&D project	Congestion management for the DSO, Frequency control for TSO	"participation of small-scale storage systems information in local flexibility markets, operated by the DSO both to solve constraints in the distribution grid and to maintain a scheduled exchange profile at the TSO-DSO interconnection. No RES in demonstrator, only storage"	The DER involved in the pilot were radio base stations for providing communications services, in Barcelona region . Base stations are equipped with back-up batteries which could provide AS to the DSO.	DSO-consumers	it was demonstrated that the DSO can run a “quasi-real time” market with technical constraints (in contrast to other approaches that solve technical restrictions after clearing the market for balancing) by	http://smartnet-project.eu/

							running an optimisation algorithm that allows complying with the balance at the TSO-DSO interconnection, while avoiding congestions at distribution level	
serveral names, several markets	DE	Regional Market in place	Offering locally generated electricity	Specific design for RES	Sub-regional, districts (Landkreise) in Germany	Local producers - local consumers		[1], [2], [3], [4], [5], [6], [7], [9], [10], [11], [12], [14], [15]
Talmarkt	DE	Regional Market in place	Offering interactively selectable, locally generated electricity every 15 minutes.	Specific design for RES	Sub-regional, district (Landkreis) in Germany	Local producers - local consumers		[8]
CommunityStrom	DE	Regional Market in place	Offering locally generated electricity and heat	Specific design for RES	Sub-regional, district (Landkreis) in Germany	Local producers - local consumers		[13]
North German flexibility market (ENKO)	DE	R&D project / Regional Market in place	Platform for day-ahead bidding and contracting of local flexibilities to reduce grid congestions	Usage of otherwise curtailed renewable energy	Inter-regional, North Germany	TSO/DSO-consumers		[19], [29]

Enera Flexibilitätsplattform	DE	R&D project / Regional Market in place	Processing of intraday, local order books and verification management for the acquisition of flexibility by grid operators, considering the spatial assignment of active power suppliers to congestion-free market areas. Cooperation with EPEX SPOT	Usage of flexibilies to relieve grid congestions	Inter-regional, North-West Germany	DSO-consumers		[20], [24], [25], [26]
ALF – Altendorfer Flexmarkt	DE	R&D project	Process concept of C/sells flexibility platforms: Registration, offer placement, coordination with grid operators (flexibility demand and grid constraints), matching process planning and execution, settlement.	Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[21]
ReFlex – Regionale Flexibilitätsplattform Dillenburg	DE	R&D project		Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[22]
comax-Plattform	DE	R&D project		Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[39]
WindNODE Flexibilitätsplattform	DE	R&D project / Regional Market in place	Provision of a platform to offer day-ahead and intraday flexible loads with indication of the location, which are checked by the grid operator for grid relief potential and selected according to the specified costs.	Usage of flexibilies to relieve grid congestions	Inter-regional, East Germany	DSO-consumers		[23], [40]

Grid Integration	DE	R&D project		Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[27]
FlAixEnergy - Energieflexibilitätsplattform	DE	R&D project		Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[28]
NODES	NOR	R&D project		Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[41]
Flex4Energy	DE	R&D project		Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[42]
Flex2Market	DE	R&D project		Usage of flexibilies to relieve grid congestions	Inter-regional	DSO-consumers		[43]
e	NL	Implemented market in Netherlands	Congestion management	Usage of flexibilies to relieve grid congestions	Inter-regional	TSO/DSO-producers/consumers		
Piclo flex	UK	Implemented market in UK	Capacity market also used to reserve reactive capacity	Usage of flexibilities to different system services	Regional	DSO-producers/consumers		