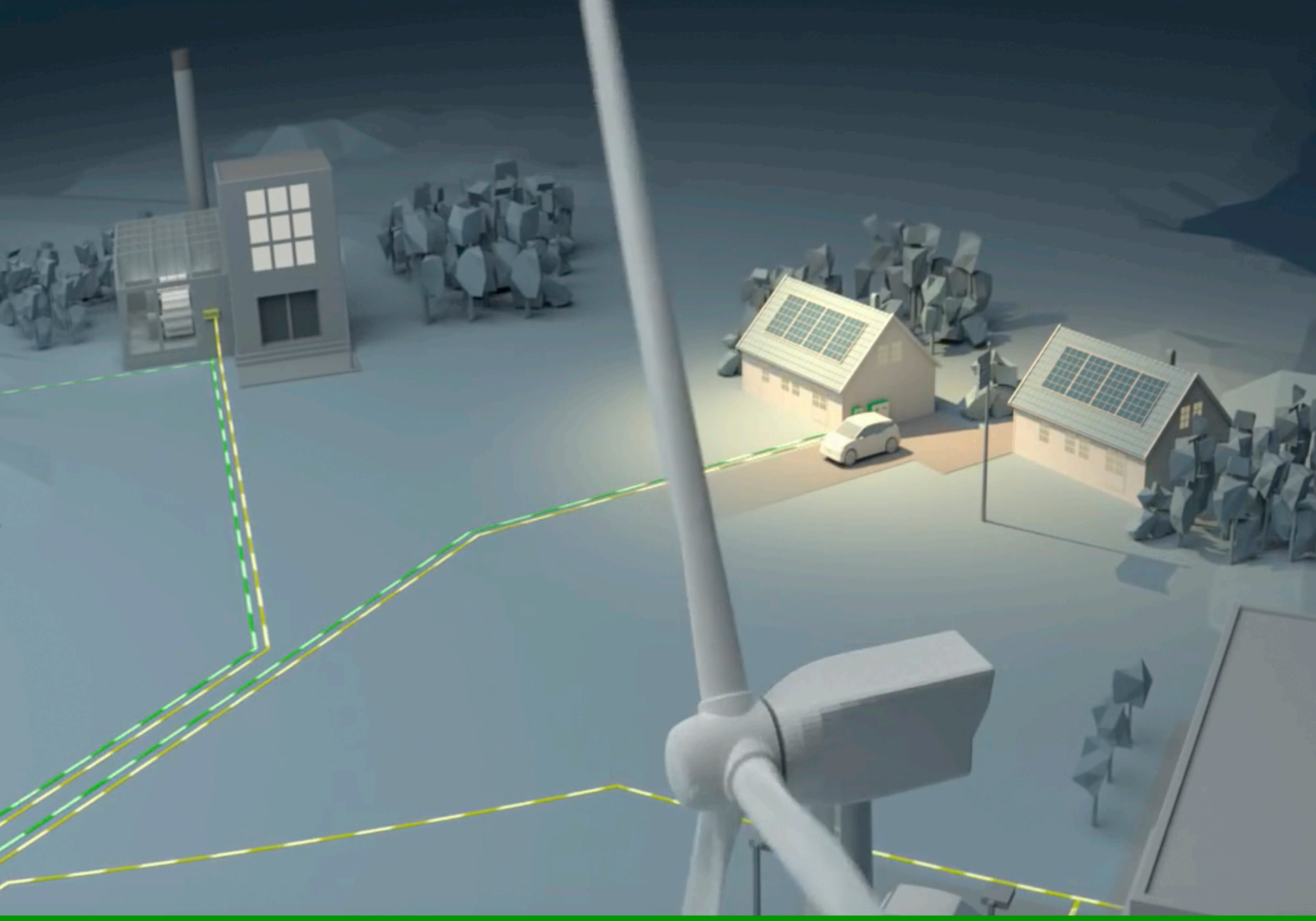

White paper

A fully integrated marketplace for flexibility

NODES

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1. Executive summary

This document is a general, high-level introduction to the market design of NODES. NODES is a universal platform for local, flexible electricity markets with features allowing for connecting to other markets.

Distribution networks are faced with increasing demands arising from the development of small-scale generation and the expected growth of electric vehicles (EVs). If left unchecked, this would trigger a need for costly network reinforcement. Meanwhile distributed storage and other sources of flexibility – EVs, batteries or (aggregated) demand response – are becoming technically and economically attractive as an alternative to network investment. Advanced communication, calculation technology and control equipment reduce cost and open new and mostly unexplored potentials for flexibility supply. Currently, flexible resources struggle to find a market for their services and attract sufficient remuneration. By introducing NODES, we want to provide an integrated marketplace with the goal of creating value for flexibility providers and incentivise investments in much-needed flexibility in the transition to a fully decarbonized power system in Europe.

The objective of NODES is to facilitate trade in flexibility, with an attention to i) the localisation of the asset and to ii) the ability of end users and suppliers to deviate from previous plans. With these two features, and in particular with the focus on localisation of the resources, NODES adds a significant feature set compared to current European day-ahead and intraday markets.

2. Background

There are three main drivers that are about to change the entire electricity system:

- Change of production mix leads to massive investments in wind and solar in the distribution grid, and at the same time to a phase-out of fossil-fuelled production connected to the transmission grid;
- Electrification of transport and large parts of the residential sector (floor heating and boilers with built-in storage capabilities);
- Smart meters, smart grid and Internet of Things (IoT) make it possible to control consumption on a scale never seen before.

The new production mix poses new challenges for system operation both at the transmission and at the distribution level. At the same time, we see new tools for solving these problems with IoT and new flexible load where the consumer is actively managing this.

New grid investments to cope with the new production mix and new consumption patterns are needed. However, to a large extent both investments and operational costs on all grid levels can be reduced by using existing flexibility and bring this into a market where it can be given a value for the seller and for the grid owner. There are many pilot projects around Europe on how to use this flexibility, but few that focus on a market mechanism as a tool for bringing more flexibility and more competition into the use of flexibility.

There are independent local Distributed Energy Resource Management System (DERMS), and there are even Local Energy Market Systems (LEMS) using market mechanisms locally, but they are not connected to the existing market mechanism like Intraday (ID) and the balancing markets organized by TSOs. Without such an integrated market concept, serving distributed flexibility, the Distribution System Operator's (DSO's) use of flexibility might be very expensive, since the DSO often only needs local flexibility a few hours a year. If the flexibility can be used elsewhere when not needed locally, it can reduce costs for the DSO and at the same time increase opportunities for the seller creating a win-win situation for both parties.

3. Roles

The marketplace NODES was established early 2018 as a joint venture between the Norwegian utility Agder Energi and the European power exchange Nord Pool. Nord Pool AS has operated a power exchange for more than 25 years and are continuously introducing new products for their customers. Agder Energi AS, as a vertically integrated utility company, has gathered valuable experience by using market mechanisms for reducing grid investments, and has also been an active aggregator and flexibility provider in several European countries. By bringing experts from the two companies together, and team these experts up with other independent experts from several European countries, the fundamental market design has been developed. The platform is now installed in two successful locations in Norway and Germany.

In full operation NODES will need to be independent from any market party, and Agder Energi will not be a major owner of such a marketplace.

NODES operates a market platform that puts a value to flexibility, and it gives a buyer of flexibility 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 flexibility. Already today, the TSO buys many kinds of reserves and balancing power from Balancing Responsible Parties (BRPs), aggregators and others. BRPs are trading with other BRPs on intraday and day ahead markets. The DSOs, however, have no marketplace to purchase local flexibility to solve local grid issues. In addition, the TSO markets are targeting larger flexibility sources meaning that most of the local flexibility is unable to participate.

NODES has been established to bridge this gap. The main goal is to increase value for flexibility providers, and reduce costs for the DSO, also giving the opportunity to flexibility 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 1).

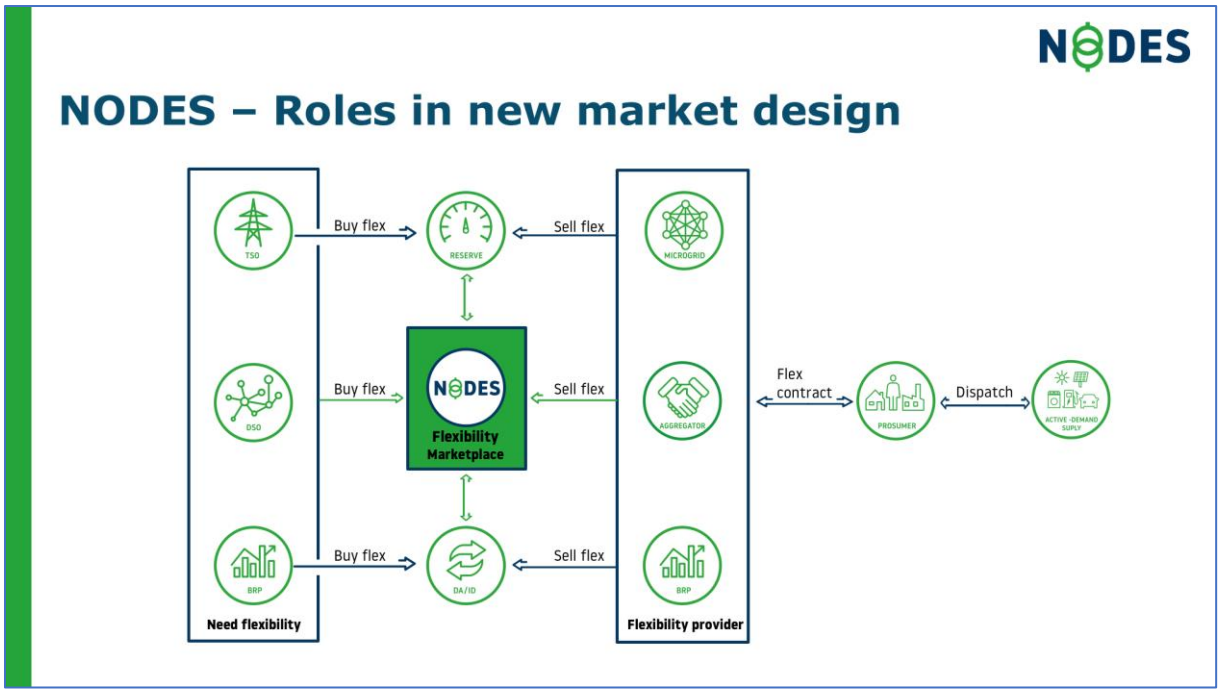

Figure 1: Roles in new market design

4. The trading timeline

A flexibility product has two main properties:

- Availability payment
- Activation payment

In the current intraday market regime, there is no availability payment – only an energy price in the ID or Day Ahead (DA) markets. At the other hand, the balancing products that are sold to the TSO in some cases includes a availability payment for the commitment to offer the agreed flexibility product. In many cases it is also possible to give voluntary energy offers without the commitment to offer. Many flexible assets sold to the TSO are already located in the distribution grid, and the DSO will in these cases have to compete for the same flexibility by paying an availability fee in competition with the TSO.

The Trading Timeline (se figure 2 below) consists of an early period of trading with capacity – or availability products. This normally lasts from years ahead and until opening of the day ahead (DA) auction. The ID market in most European countries starts after the day ahead market has closed. Here the BRPs can rebalance their portfolio continuously until gate closure (60 to 0 minutes before operating period depending on country). The TSO has several products outside the current ID market which they can use to manage congestions. Often these products can be traded into the operating period.

Most European countries have a period between ID gate closure and the Operating Period. This can be seen as a "grace period" where DSO and TSO can do rebalancing and congestion management without risking being countertraded by the BRPs.

Normally, congestion management in the DSO area can be done well before the operating period. Today, it is mainly the TSO that need to rebalance within the operating period. This might, however, change in the future, as more flexibility and more intermittent production will be located at the distribution level. Therefore, it is possible that the DSO will need to do redispatch closer to the running period in the future. The NODES Marketplace is prepared for this development.

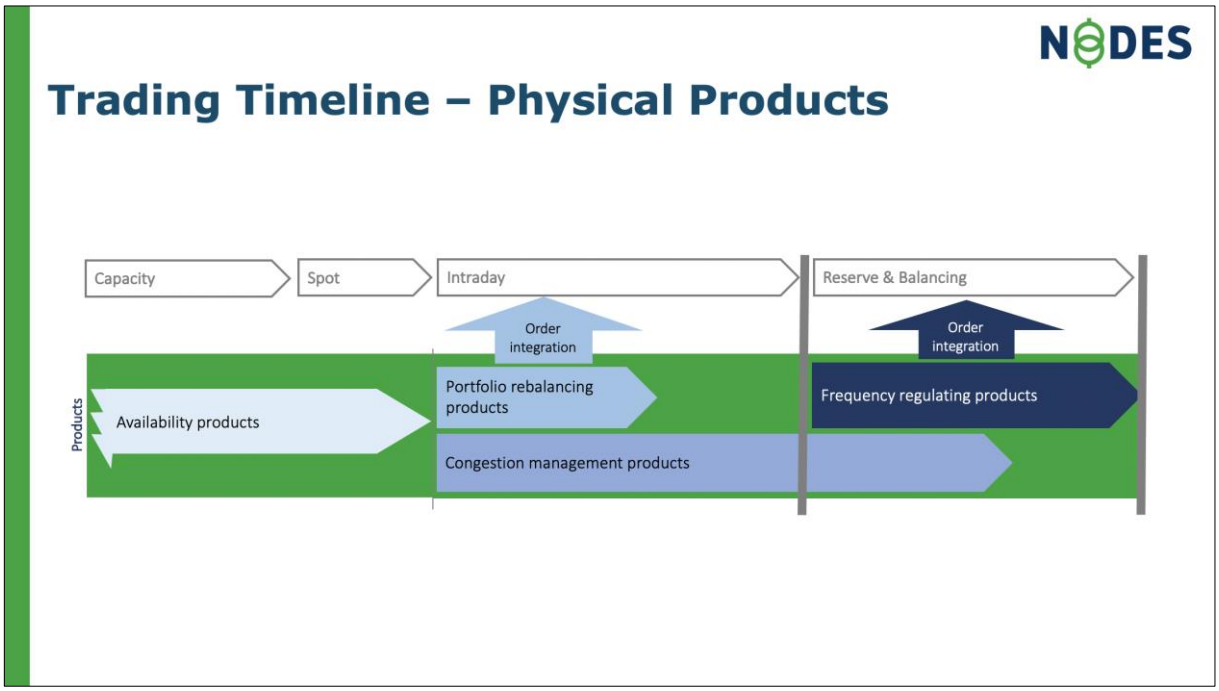

Figure 2: Trading timeline

5. NODES – "Grid Location" solving local grid management challenges

The main shortcoming with the current market design is the lack of market-based flexibility that DSOs can use in their grid management. The existing ID, DA and balancing markets are not geographically granular enough for the DSO to solve local congestions and other grid management issues.

This is illustrated in figure 3 below. 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 TSOs or the DSOs are free to decide how granular they want the offers, i.e.

how large the GLs should be. 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 DA 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 DSOs. For the Engene case (first Norwegian installation) all meters below a 132/22 kV substation were defined as a GL. NODES will establish an API for the system operators to feed in Grid Location information.

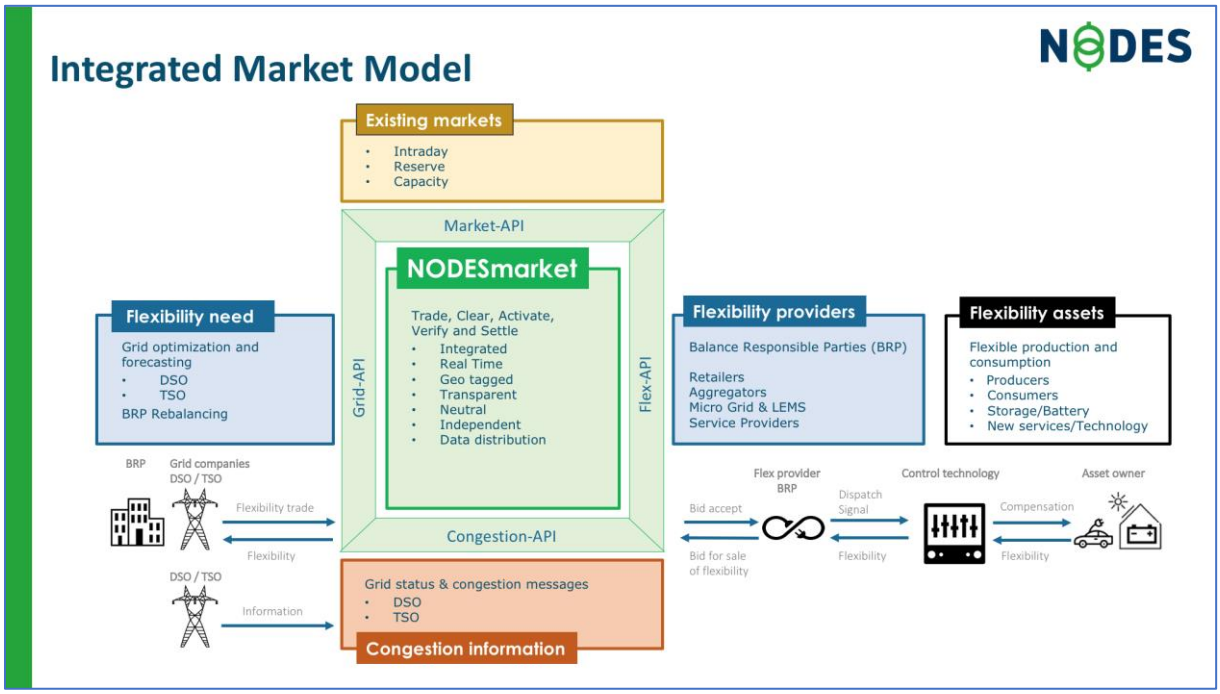

Figure 3: The integrated market model

To the left in the figure above are those who **need flexibility**: DSO and TSO. In addition, BRPs might re-trade committed flexibility with other BRPs which offer cheaper flexibility. These buyers will have to define their willingness to pay for activation of flexibility at 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 ID market 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. Selling locally at one specific GL in many cases can be riskier, as there are fewer alternatives if the seller needs to rebalance due to unforeseen unavailability of some assets. Contractual positions in the ID market are much easier to rebalance. Thus, the price for flexibility is foreseen to be cheaper in the ID market than at a specific GL.

The flexibility providers will register their portfolios linked to actual meters or similar at each GL to be able to verify delivery. 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. DSOs might in some cases prefer increased consumption instead of ramping down renewables. TSOs might have preferences to activation time and ramping when products are sold in their balancing markets. 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 (see figure 4), and it is these parameters that buyers of flexibility can use to filter on.

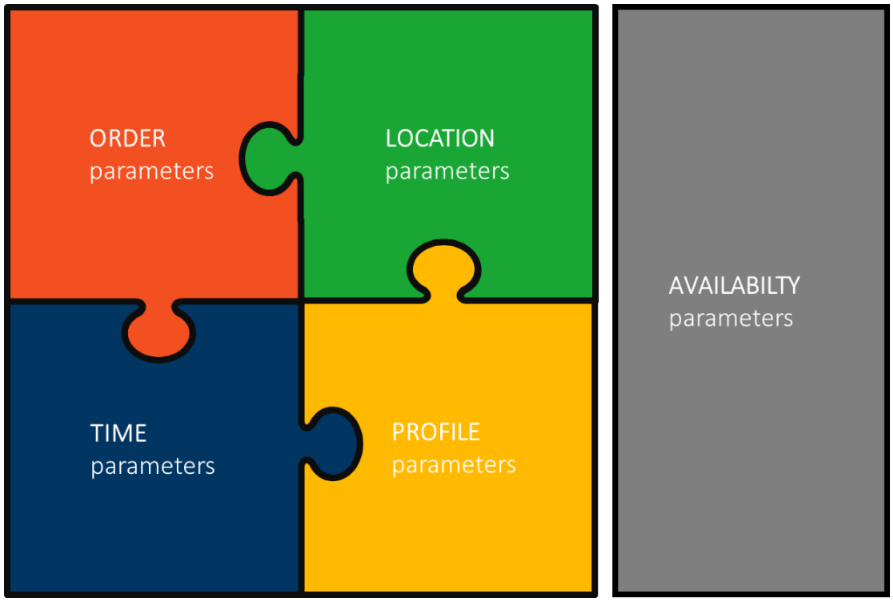

Figure 4: Product parameters at NODES

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. NODES will also connect distributed flexibility to the TSO markets.

6. NODES – bringing major benefits for many players

6.1 Welfare gains for society

Intermittent renewable electricity generation and electrification of transport and other sectors requires flexibility. Through a transparent, integrated marketplace:

- NODES reveals existing flexibility
- NODES facilitates investments in new flexibility

Market data will be collected and stored, and access will be granted to all parties who need it. Transparency is key to manage an integrated flexibility marketplace.

Flexibility can reduce both grid investment and operational grid costs. There are many initiatives for promoting flexible resources, but few that focus on using a market mechanism to let supply and demand meet, and let local flexibility integrate with intraday and balancing markets.

EU and national authorities are making heavy investments in flexibility projects. We believe that these investments are necessary to reach the climate targets. NODES' focus is to give a fair market value to flexibility assets and easy access to flexible resources for the DSOs. In addition, NODES has initiated various workstreams to work together with regulators and other stakeholders to make the true value of flexibility visible through an efficient, integrated marketplace.

6.2 A gateway to all flexibility

Flexibility providers are today rewarded through existing day-ahead, intraday and balancing markets. There is no market where a local resource is remunerated or can offer flexibility for solving congestion and other challenges at the distribution grid. NODES aims to promote extra value to this distributed flexibility through an integrated market place, and has already proven this value and the solution through test installations in Norway and Germany.

At the local level, flexibility has a high extra value in certain hours, and zero value in many other hours. Therefore, NODES will function as a gateway to the existing, central markets when value is higher there than at the local market.

When flexibility is activated locally, the seller of the flexibility will be exposed to an imbalance. This imbalance could be solved through a simultaneous trade in the ID market via NODES. Alternatively, the seller of flexibility could do the re-balancing through his own portfolio through self-balancing. Both options will be available at NODES.

We also observe that yet another market platform, on top of the existing ones, might be cumbersome for smaller flexibility providers that not necessarily are part of the other markets. This is also a reason for

why we will offer NODES as a gateway to the existing intraday and balancing markets and the automatic rebalancing of the flexibility provider's portfolio.

For existing flexibility providers, NODES offer additional value to their existing portfolio. NODES will significant lower the entry barrier for new flexibility providers. NODES has developed APIs to serve all platforms used by flexibility providers, and we will invite these as partners into this process to make sure that NODES' APIs fit their platforms.

6.3 An efficient tool for grid management

New, intermittent production capacity is now being installed at the distribution grid in a massive scale. EV-charging and electrification of other sectors like heating will impose new challenges for the distribution grid in the years to come. New, smart, controllable assets will have to be made available in order to reduce new grid investments and secure stability in the grid. New flexibility, with a location tag attached, will have to be given a fair market value through a marketplace for distributed flexibility. In the release of the commercial platform early 2019, NODES will link its marketplace for distributed flexibility with the existing central intraday and balancing markets. For the ID market we will use market makers that are already active in existing ID markets. The link to the TSO market will be based on agreements with relevant TSOs.

NODES has already proven to be a useful tool for DSO congestion management. The installations in Norway and Germany have shown that it is possible to save both investment and operational cost by using local flexibility. There will be several new installations of NODES in the time to come. NODES aim to have another 25 new installations of its platform during 2019.

The product that DSOs will contract is up or down regulation denominated in MW ("change of load/ generation"). The resulting imbalance for the flexibility provider will be handled either by self-balancing or closed automatically by a simultaneous trade in the ID market via NODES.

NODES is under continuous development, and NODES is developing the marketplace together with the partners that are using it. This process gives valuable knowledge for the participating DSOs, in addition to the cost advantages from more efficient congestion management where the NODES platform is installed. In the future we also see possibilities for using NODES as a tool for voltage control, to reduce losses and by including parameters for production that could create value for the market players (like identifying the "green" quality of the production).

6.4 Opportunities for TSOs to access new sources of flexibility

There are currently many initiatives from TSOs to access distributed flexibility. In fact, most of the new flexibility is at the distribution level, and many of the existing sources at the transmission grid is being closed down

TSO and DSO will in the future compete for the same flexibility in order to complete their mission. NODES believe that to the extent possible this "competition" should be through the value given in a flexibility market within the Grid Location decided by the DSO or TSO. Where distributed flexibility has the highest value for the DSO and the local congestion management, flexibility stays local. And vice versa.

NODES will provide transparency on how flexibility resources are contracted. This and other features of the NODES platform will contribute to efficient coordination between DSO and TSO.

NODES want to cooperate with TSOs to improve the existing platform and introduce new features useful for the TSO grid management, like linking the NODES platform with the TSO platform for balancing markets.

6.5 Competition in local markets

NODES is often met with the argument that market power is more likely to occur in a local marketplace with potentially lower liquidity and less competition than on wholesale markets.

NODES effectively counters the abuse of market power by relying on the following principles:

1. Current tools for congestion management are not being substituted by NODES, but rather complemented: If the grid operator finds a more economical way to manage congestions with non- market based instruments, he will still be able to apply them without any limitation.
2. A market for distributed flexibility will increase transparency. An attempt to abuse market power will be easier to discover, allowing for effective counter measures.
3. The major advantage of a new market for distributed flexibility is that a lot of new flexibility will be offered into the market, and, most likely, from a lot of new players. This new market will attract new players that we have not seen before, companies with new technology on IoT and with new business models compared to the current retail companies.

7. Development trough partnership

The most efficient way to develop the integrated marketplace for flexibility, is through partnerships between all future players. The existing NODES platform is being developed together with the partners

(DSOs, aggregators, other service providers) in the installations in Norway and Germany. There are currently two live installations. One by the German DSO Mitnetz Strom which is situated in the 50Hertz TSO area. Here the local flexibility is used to reduce the costs for emergency measures (EinsMan) caused by a potentially overloaded 110 kV line. The other installation is with the Norwegian DSO Agder Energi Nett and is related to a potentially overloaded 132/22 kV transformer. NODES is used to buy flexibility under that transformer, and by this it has been possible to postpone investment in a new transformer.

These two cases are quite different, but they use the same flexibility platform. In the years to come NODES want to **cooperate with more DSOs** to test and adjust the NODES platform under different conditions with respect to grid level, and for situations with either too much production or too little production.

NODES strongly support to use distributed flexibility also outside the actual Grid Location. Therefore, we already have **invited TSOs** to test how local flexibility offered in NODES can be made available for the current TSO market platforms.

To provide more flexibility into the ID market, we **invite incumbent BRPs** to act as market makers and mirror prices in the existing ID markets in the relevant price area into NODES. The purpose for this is both to increase opportunities for flexibility providers if the flexibility is not sold to the TSO or DSO, and for giving the aggregators the opportunity to rebalance their energy position if they sell up- or down-regulation to the DSO.

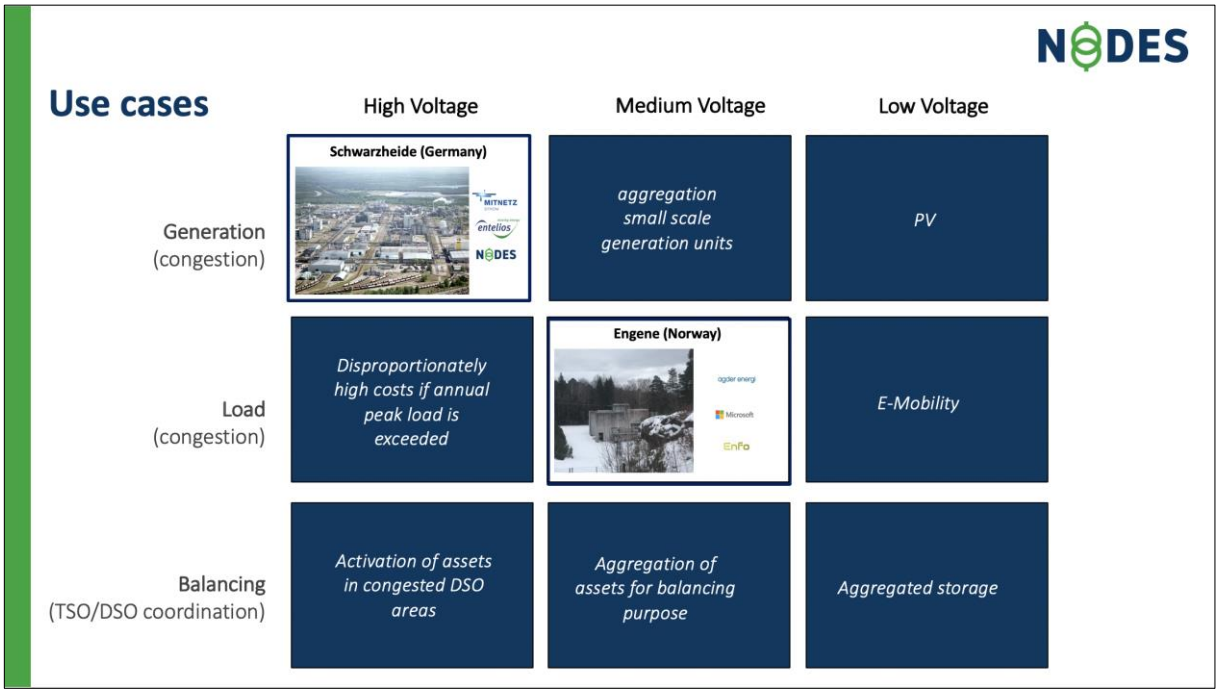

Figure 5: Development through partnership

Aggregators will be an important partner to bring local flexibility to the market. In joint projects with the TSO and the DSO we will give the aggregator the opportunity to test different business models that works

for both the asset owner, the relevant system operator and the aggregator. There will be no flexibility market unless all these three conditions are met.

DSOs have traditionally not been used to purchase services in an organized market. We also see that many DSOs need partners to bridge the gap between their existing grid tools and the offers they place in the market when purchasing flexibility. NODES wants to **partner up with several professional consultants and service providers** in different countries to help DSOs become more commercial with respect to their participation in the new flexibility market.