Demonstration of a Market-based Congestion Management using a Flexibility Market in Distribution Networks

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Abstract

This paper describes the key findings and results of two real use cases that show the feasibility and advantageousness of a market-based congestion management with offered flexibility in the distribution network. Within the project, the partners developed processes to use the flexibility of an industrial park in a real case of a congestion in the 110-kV-network of MITNETZ STROM. The feasibility and advantageousness of market-based congestion management was verified in this specific use case. In the processes, the DSO as well as the aggregator of the flexibility (Entelios) use the marketplace of NODES.

1 Background and Motivation

The increasing amount of renewable, decentralized power generation in the distribution systems in Germany leads to new challenges and requirements especially in the system operation of the grid. The number of measures for ensuring the network security has increased in recent years, which led to rising costs for compensation.

With the current operational measures for congestion management, the DSOs have limited possibilities to manage the network security. The congestion management measures causes very high costs in the current system. Therefore, the DSOs are seeking for cost effective and additional flexibility potentials and measures besides the existing operational processes for ensuring the system security.

Generation in combination with load e.g. in industrial parks is not considered in the current congestion management process because of the restrictions of the heat and steam distribution of such industrial parks. Nevertheless, the flexibility of industrial parks is used right now for other flexibility markets e.g. the balancing market or the intraday market. If there is a possibility for the DSO to plan congestion management on day-ahead basis, the restrictions of the industrial plants can be reflected and the flexibility becomes an additional and cost effective option for congestion management.

When there is an additional use of demand side management potentials in this process there is the advantage that renewable generation does not have to be curtailed in real time system operation due to network congestions. This would increase the local use of renewable energy. Another possible advantage consists in lower cost for the use of the non-obligatory flexibility compared to the use of renewable generation with the fixed feed-in tariffs.

The aim of the current project described in this paper is to demonstrate the use of the additional flexibility using the newly developed marketplace of NODES. This requires the development of new planning-based and market-based processes. Especially for the aggregator (Entelios) it is important to ensure adequate integration of the new marketplace for flexibility with existing markets such as the Intraday wholesale market for electricity. With a future perspective, for the aggregator it is possible to optimize the different flexibility potentials on the different markets.

In the project two DSOs in Eastern Germany (MITNETZ STROM, WEMAG Netz) and one aggregator of market-based demand-side-management flexibility (Entelios) work together with the provider of a market platform (NODES) to show that the use of non-obligatory flexibility potentials could result in benefits for all partners as well as an increase in economic welfare and a reduction in CO2-emissions. Flexibility is used for congestion management with the result of a real adaption of the active power flow in the 110-kV-grid of the DSO. The information process and the settlement of the real activation take place via the market platform of NODES.

In the paper, the project partner want to present the leading idea of the flexibility marketplace and the developed und partly realized processes at DSO level, aggregator level and for the provider of the market platform. In the second part, the two different analysed use cases and the results of the project are described in detail.

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2 Flexibility Marketplace

2.1 NODES Market Design

NODES' vision is to create a marketplace for the future supporting the drive to an emission free society with the mission to facilitate optimal use of flexibility in the grid by offering an open, integrated marketplace to all flexibility providers, balancing responsible parties (BRP) and grid operators.

NODES is an independent market operator who provides transparent pricing, secure trading and risk-free settlement. The company takes on the role of an independent intermediary. Independency is regarded as a key issue in order to prevent conflicts of interest between users of the platform and the marketplace operator [1].

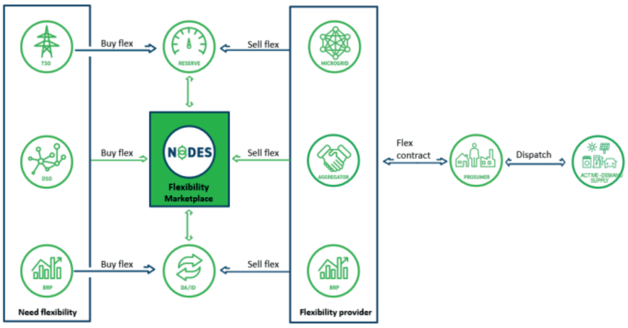

Figure 1 NODES in the market framework [1]

The key features of the NODES marketplace are the possibilities to identify (through a location tag) and give a value (by putting a price tag on flexibility) to flexibility providers. This opens new opportunities for grid operators. DSOs are enabled to contract local flexibility to solve grid issues, while TSOs get access to smaller flexibilities that are currently excluded from traditional TSO markets. The integrated approach (**Figure 1**) ensures that flexibility can be purchased and activated where it has the highest value, for local congestion in the DSO grid, balancing market for the TSO or for a BRP that needs to rebalance its portfolio.

Through the integration of the local flexibility market to the existing intraday market and, in the future, reserve markets, NODES makes sure that the flexibility can be traded even if the local grid does not have an imminent need for the flexibility. In this way, the flexibility owner (Prosumer) and the Aggregator/BRP have a better chance of a decent return-on-investment, thus incentivizing flexibility providers to enable more flexibility in the system.

Flexibility can be offered and contracted through a combination of availability (capacity) products and activation products. Availability products provide grid operators with the possibility to secure flexible capacity for a certain time period. Activation products are contracted closer to physical delivery and trigger an altered unit commitment. The energy can be handled inside or outside of the marketplace.

2.2 Process for Grid Congestion Management

In the showcase demonstration project, according to **Figure 1**, NODES serves as the intermediary specifically between the DSO and the flexibility aggregator. A process flow has been established that reflects operational requirements both on the aggregator and on the DSO ends, and ensures efficient congestion management at the same time.

Figure 2 illustrates the exemplary process flow as implemented between MITNETZ, NODES and Entelios. It can be regarded as a reference process flow in similar settings, potentially with other system operators and other or additional aggregators. Grid operators may be DSOs or TSO. It is also possible to connect the marketplace to a common DSO/TSO data-coordination system.

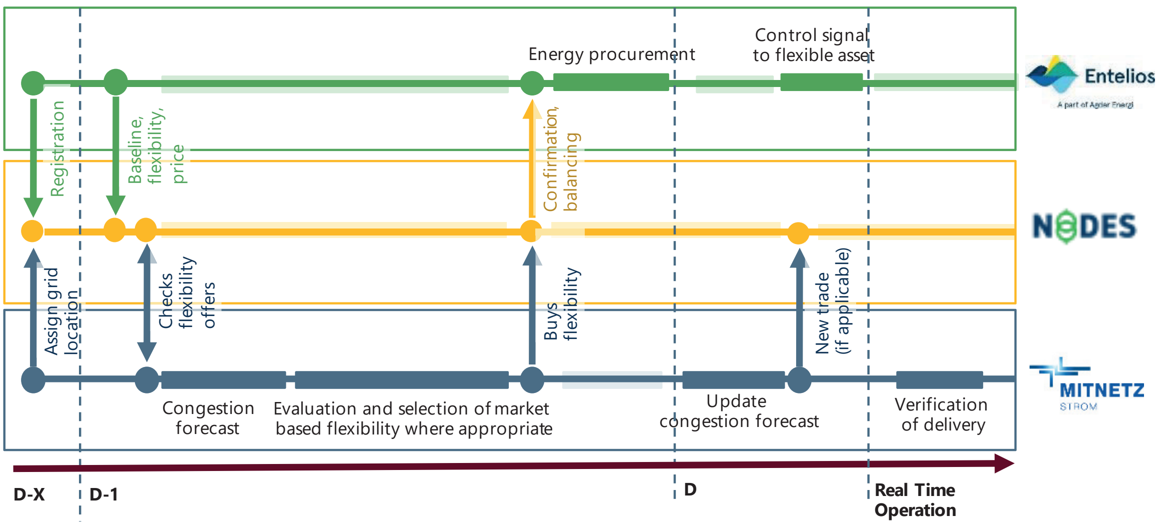

Figure 2 Process flow between relevant actors (MITNETZ implementation)

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3 Use Cases

3.1 Overview

The feasibility and advantageousness of market-based congestion management was tested in specific use cases in the project (see **Figure 3**).

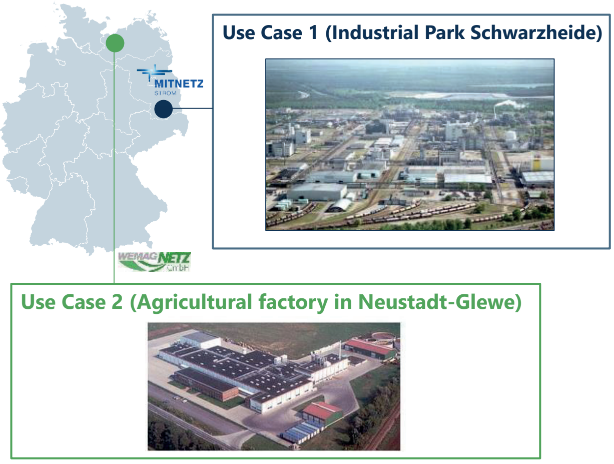

Figure 3 Overview of Use Cases

In Use Case 1, the developed processes were applied in real operation of the 110-kV-network of MITNETZ STROM. The flexibility of an industrial park was used for congestion management and thereby the curtailment of renewable energy sources was avoided.

Use Case 2 shows the theoretical possibility of congestion management with a load-based flexibility. Due to the fact that an increase in the consumption load leads to disproportionately high costs in the current regulatory framework, this use case was not shown in real operation.

3.2 Use Case 1 (Industrial Park)

The network situation at the 110-kV-System of MITNETZ STROM is characterized with high infeed of renewable energy (wind and photovoltaic) especially in the network areas of Brandenburg and Saxony-Anhalt. This results in a surplus of the summarized generated power in these network areas. The DSO has to take up the generated power and transport it to the points-of-common-coupling with the extra-high-voltage (EHV) system. For this purpose, the DSO needs to strengthen the existing grid with new connection points to the EHV grid and new lines with higher transmission capacity.

As a daily task, the DSO needs to guarantee a secure network operation. Until the completion of the grid expansion, congestion management measures are necessary. Currently renewable energy generation with high feed-in-tariffs are reduced and almost completely financially compensated. This leads into high cost for congestion management measures.

In the pilot project, the project partners want to show that the costs can be reduced with the use of non-obligatory flexibility potentials. In the grid of MITNETZ STROM, an industrial park in southern Brandenburg was identified as a possible flexibility potential. In the first step, the DSO analyzed the network situation and the basic applicability of the flexibility system. **Figure 4** shows the concerned network area and the location of the flexibility (in relation to [2]). It appears that in the network area extensive grid expansion is necessary, which results in the need for congestion management measures.

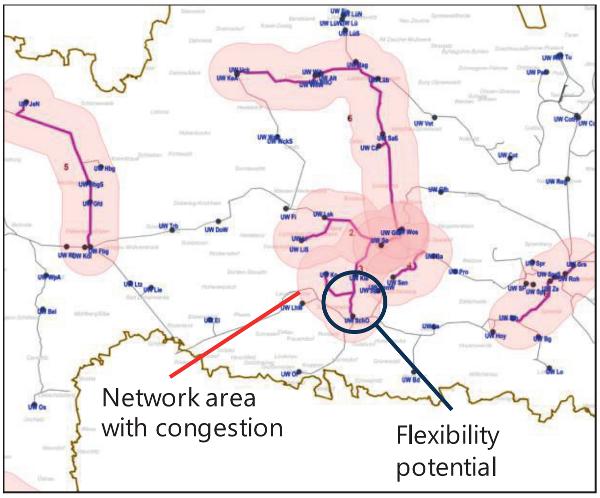

Figure 4 110-kV-grid of MITNETZ STROM in Brandenburg with location of flexibility potential

In the second step, the DSO look into the effectiveness of the power adaption in relation to the concerned congestions in this area. In principle, the 110-kV-grid in Germany is largely operated as a meshed system. This means, that every adaption of power at one node on the grid only leads to a partly power adaption at branch elements (line, transformer). The Power Transfer Distribution Factor (PTDF) between node and branch element shows the effectiveness of a power adaption in the grid. The system for congestion management calculates the PTDF and choose the effective generation units for power adaptation to resolve the congestion. The **Figure 5** shows the order of flexibility potentials with the PTDF for the congestion in the grid.

For the chosen flexibility of maximum 10 MW in the demonstration project the analysis of the PTDF shows that in the case of a congestion the power adaptation of the flexibility (green) can reduce the amount of power adaptations in the whole grid cause of the high PTDF in relation to the other potentials. That means that for example wind turbines with higher distance to the congestion do not have to be adapted. The location of non-obligatory flexibility potential in the grid is advantageous for the congestion management in this case.

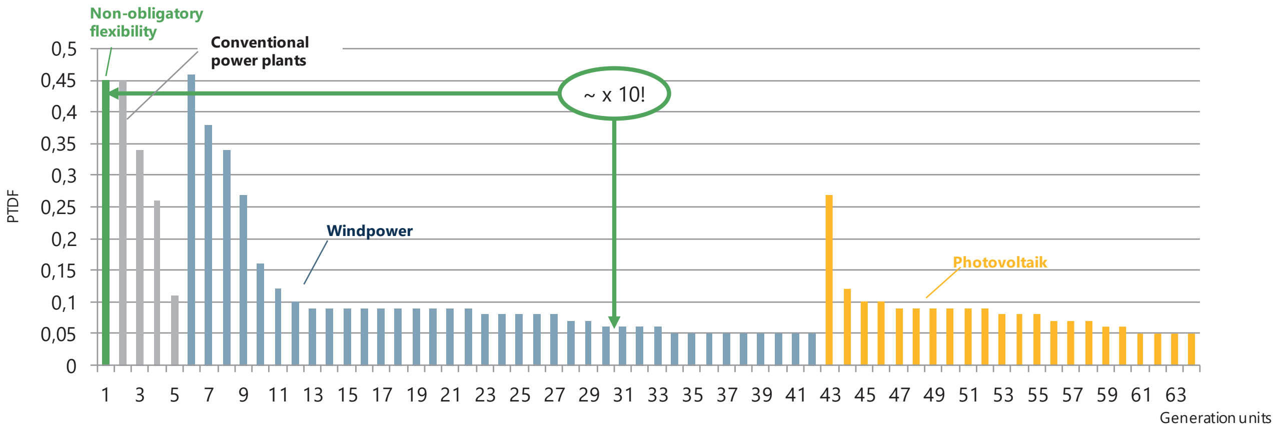

Figure 5 Order of flexibility potentials with PTDF

Important for the use of the non-obligatory flexibility potentials of an industrial park are the special requirements. The industrial production requires heat and steam provision of the generation units. The use of the electrical flexibility for the grid should not lead to a restriction of the steam and heat supply. That why the scheduling of the use of the flexible units in the industrial park and share of the information via the operator is necessary. From the DSO point of view, it is not important whether the flexibility is delivered by reducing the infeed of generation or by increasing the electricity demand. The electrical effect in the grid location is the same. The DSO needs to plan the operation of the grid based on forecast of renewable energy generation and load as well. In the demonstration project, the processes for identifying of the congestions and planning of the counter measures based on forecast data were implemented and tested for the DSO. The planning process is an important component of a future market-based congestion management and an efficient network operation in the distribution system.

3.3 Use Case 2 (Agricultural factory)

Within the framework of the project, it was also examined whether market-based congestion management by using flexible loads is suitable for reducing or preventing required congestion management measures. For this use case the effectiveness of the flexible load at the time of a real congestion at WEMAG Netz was analyzed. The congestion of a 110-kV-overhead line caused by renewable generation could be released by increasing the power consumption of 1 MW. **Figure 6** shows the 110-kV-grid of WEMAG Netz and the location of the flexibility potential in this use case.

For an optimal minimization of the congestions with the use of the flexibility, besides the electrical effect (PTDF), the availability of the flexible load is important. For an effective use, a bundling of several flexible units is necessary, because the structure of the load in the rural network area of WEMAG Netz is characterized by small and medium-sized customers.

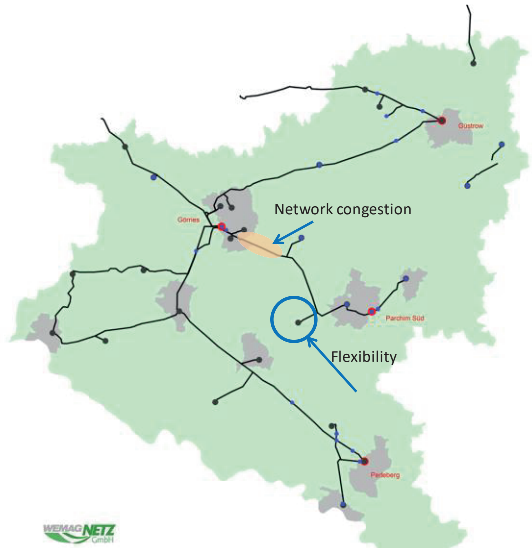

Figure 6 110-kV-grid of WEMAG Netz with the location of the flexibility potential

In this case, the use of flexible load of an agriculture factory was analyzed in detail. The flexibility can be provided via a time shifting of the required production of cold, with the result that no additional energy consumption is necessary. The flexible proportions of the energy consumption will be shifted to support the grid in times of overload and congestions. Besides the dependencies of the production of the customer, the maximum flexibility potential depends on the regulatory and contractual framework. In the context of digitalization, the possibility and availability of flexibility potentials will increase and allow bundling of several loads for optimal impact of congestions in the grid.

The market-based congestion management was only simulated in this use case, because at the time of a congestion, exceeding of the annual peak load at the customer would have led to disproportionately high grid fees. The real use of the flexible load would result in a new maximal peak load. This would lead in an exceeding of normal peak load of 500 kW and would caused additionally cost of 65k € in the actual financial year. The analysis shows

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that the use of flexible load could be an appropriate possibility to reduce or avoid congestion management measures. The success of the practical realization depends of the scalability of the digitalization and the regulatory and contractual framework.

4 Results of the project

4.1 Feasibility

The suitability of the developed processes for congestion management of network operators was demonstrated in this pilot project. The marketplace for flexibility of "NODES" has been tested with all market roles and the pilot with a real power adaption shows that the flexibility products offered on NODES are suitable for congestion management. Existing market processes can be used.

The DSO is able to forecast congestions and flexibility offers can be evaluated and weighed against other measures. The concept is open and allows in principle the coexistence of various market platforms.

4.2 Advantageousness

The flexibility, which was offered voluntary in this pilot, has a significantly higher effect on network congestions than conventional RES curtailment. This led to potential savings of around 40k € and 240 t CO_2 on one day by using the flexibility market (see **Figure 7**). On one side, the flexibility potential is more effective in the physical impact on the congestion with the result that the energy is reduced for the time of the congestion. On the other side the cost for the non-obligatory flexibility potential are lower than compared to the RES curtailment. This leads to a reduction of the whole costs for the congestion management measure by factor 14 in this use-case.

The potential revenue for the flexibility provider provides sufficient incentives to invest in additional flexibility where needed from the networks point of view. The abuse potential of the market position of the flexibility provider is low even with low liquidity, since the cost comparison with RES curtailment is carried out by grid operators.

4.3 Need for action

The current regulatory framework needs to be further developed since the use of flexibility is harmed in the current framework, although it would help to save costs for network operation. Increasing the electrical load of the flexibility provider for example can lead in the current regulatory framework to a disproportionately high increase in network charges (e.g. § 19 (2) StromNEV). Regulations for the treatment of the costs for the distribution system operator are also to be developed.

5 Conclusion and Outlook

The demonstration project for using flexibility potentials with a market-based congestion management approach shows a basic feasibility of the concept. The advantages of lower costs and less power adaptions compared to conventional RES curtailment were shown in the project. However, the results give also the need for a regulatory and contractual basis for a nationwide application.

In the next steps in the project, the project partner will carry out more tests to gain experience for use of the flexibility with the new processes. Furthermore, other use-cases with different flexibility potential in other network areas will be investigated and further tested to identify specific requirements to the future congestion management process. Another possible use case could be the integration of the developed market-based process into the Redispatch-process in the transmission system with new potentials in the distribution system. In this case, the DSO evaluate the congestions and the need for measures in the distribution system and provides the additional available potentials at the points-of-common-coupling to the transmission system.

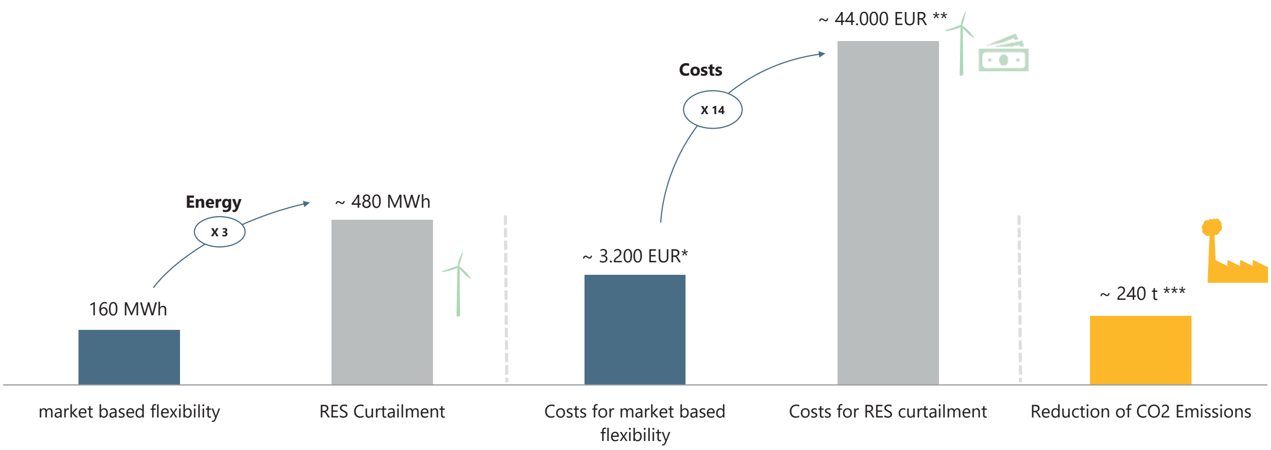

Figure 7 Results of the project

The activation of the flexibility potentials by the aggregator is done through the market platform. Important for this possible use-case is the coordination between the DSO and TSO as Bottom-up principle via a common data coordination system.

Another possible use case could be the congestion management of the DSO in the medium-voltage level. Especially the increasing amount of flexible load of small industry, solutions for heating supply and electric vehicles in combination with renewable generation are a future challenge for the secure operation of the grid in the low and medium voltage level. In the next steps the DSO need to study the possible use of the developed market-based process with these new flexibility potentials.

The project shows that distribution system operators can use new technologies and processes to guarantee a secure operation of the grid in an efficient and cost reducing way. In the project, the first technical and organizational processes were tested practically. In addition, requirements and challenges especially for the regulatory framework were identified. These impulses build up a good basis for further discussions for the use of grid-related flexibility.

6 Literature

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[2] Gemeinsamer Netzausbauplan der Arbeitsgemeinschaft der ostdeutschen 110-kV-Flächennetzbetreiber 2017 (NAP 2017), https://www.mitnetz-strom.de /unternehmen/netzausbau/netzausbauplan-ost, 2017

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