Bundesverband
Neue Energiewirtschaft e.V.
Hackescher Markt 4
D-10178 Berlin

Fon: +49 30 400548-0
Fax: +49 30 400548-10
mail@bne-online.de
www.bne-online.de

bne

»Decentralized Flexibility Market 2.0«

A market based solution for organizing access to flexibility on the local distribution network

July 2016. Building on its *Decentralized Flexibility Market* model released in early 2015, bne has advanced the conceptual details and parameters on how to unlock flexibility on the local distribution network in a market based manner. The *Decentralized Flexibility Market 2.0* aims at allowing new market services to develop in a non-discriminatory environment while Distribution System Operators (DSOs) are granted a high degree of freedom in actively managing the distribution system.

Introduction

The European energy system is in a period of profound change and transformation. Since the adoption of the Third Internal Energy Market Package, policy decisions have enabled competition and increased cross-border flows of electricity. With the introduction of market coupling and flow-based capacity allocation, electricity can be traded more efficiently across Europe. At the same time, we are transitioning away from a power system in which controllable power stations follow electricity demand, to an overall efficient power system where flexible producers, flexible consumers and storage systems respond to increasing intermittent supply of wind and solar power. In addition, most of the new generators (both in number and capacity) are being connected to the distribution networks. Under these new conditions, flexibility[1] is at the core of synchronizing generation and consumption at all times. Current market regulations are less well suited to facilitate flexibility as they were designed for a system based on centralized generation. As stated by the

[1] Flexibility describes the general concept of elasticity of resource deployment (demand, storage, generation) providing ancillary services for the grid stability and / or market optimization (change of power consumption, reduction of power feed-in, reactive power supply etc.) [SG-CG/E]

Council of European Energy Regulators (CEER), market arrangements will need to be developed in many countries for the offering and pricing of flexibility services.[2]

Linking wholesale and retail markets and ramifications for distribution networks

The increasing use of flexibility options, enabled by growing volatile price signals on the wholesale markets, coupled with the suggested linking of wholesale and retail markets to deliver a new deal for consumers[3] will lead to changing demand patterns on low and medium voltage levels. Many network users (= end consumers) will increasingly respond to market price signals at the same time and with similar consumption patterns. This change and the related increase of simultaneous consumption can lead to an increase in distribution network reinforcement needs, especially if load substantially includes new types of consumers, such as electric vehicles (EVs), battery storage or smart home automation systems for example. Thus far, low voltage planning rules and operational principles do not account for integrating EVs and battery storage combined with different levels of distributed generation (DG) such as solar and wind. Furthermore, the spot market price may send a signal (e.g., low commodity prices) in opposite direction to the current local weather and DG situation in specific regions (i.e., peaks in the local networks) which may aggravate the problem. In order to manage the resulting challenges related to capacity constraints on the local distribution grid in a cost-effective way, it is crucial to develop a market-based instrument which will be **applicable in a decentralized way** while **at the same time** it is **minimizing impacts on the price signal of the wholesale market**: the *Decentralized Flexibility Market (in short: De-Flex-Market).*

The Decentralized Flexibility Market – solution for conflicting signals and congestion management

The *De-Flex-Market* Model suggests, in addition to the existing central markets, such as power exchanges (including futures markets, day-ahead and intra-day markets), over-the-counter and balancing markets, the introduction of a decentralized market for flexibility options which can be used by the distribution network operators to address local capacity constraints while avoiding or deferring network reinforcement, if this is the most efficient option.

The advanced 2.0 version of the concept is fleshing out a detailed proposal[4] which originally has been developed in the German context of specifying the so-called "*Demand Response Management -Provision*" that has been included in the Energy Industry Act (*Energiewirtschaftsgesetz - EnWG*) in section 14a in 2011. For context,

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[2] CEER: Future role of the DSO – consultation paper, page 16.
[3] As outlined in the EU Commission's Communication on Launching a public consultation process on a new energy market design in July 2015: Prices should reflect variations in wholesale prices.
[4] bne-Positionspapier: „Flexibilitätsverordnung" (Juli 2016)

Section 14a of the Energy Industry Act specifically provides for using flexibility on the low voltage distribution network and offers network tariff reductions to incentivize a favorable behavior. However, the current technical framework as well as the incentive scheme are both very inelastic and thus, are not sufficient and well-equipped to respond to the future system needs with high shares of renewable energy. These traditional schemes essentially need to be re-designed to work in a more flexible manner (e.g., allowing for the use of flexibility also during day time). Today substantial network tariff reductions steer the consumption patterns of the concerned appliances into the night hours (that traditionally used to have a low load profile). The steering mechanism nowadays only works in relation to fixed restrictions given by the DSOs. The current regulations and business practices need to be transformed into a future proven system. Such a system eventually will have to work with direct incentive payments rather than network tariff reductions.

The Traffic Light Concept

In essence, the traffic light is a metaphor for the question how flexibility on the low voltage distribution network can be addressed in accordance with the electricity markets. The green phase constitutes the normal operating state. In this phase, there are no restrictions as regards to consumption (load) or distributed generation. The red phase on the contrary, is indicating an unsecure operation status, including emergency cases. In strictly defined emergency cases, the DSO would be able to manage distributed renewable generation or load, to implement grid efficiency improvement measures, and to control the isolation and restoration of outages. This is the last measure taken by the DSO when every other option has failed to restore system integrity.

Of great interest and at the same time highly debated is the design of the so-called yellow phase. Yellow is the equivalent to alert state, which means that the DSO has an emerging congestion and actively engages with the market (distributed generation or load) to procure flexibility for relieving grid constraints. The core question which needs to be solved in this context is how capacity constraints caused by simultaneous consumption situations can be prevented by a market based instrument, while at the same time there is no violation of the competitive nature of the electricity market.

The following concept proposal is addressing these questions and offers a solution that seeks to find an optimum with respect to the involved interests of different stakeholders.

Decentralized Flexibility Market 2.0: Definitions

- **Contracting Timeframe:** Timeframe in which the end consumer (typically represented by his flexibility service provider or energy supplier) commits to offer his flexibility to the Distribution System Operator (DSO).

- **Operational Period:** Timeframe in which *restriction requirements* related to using the electric grid apply (yellow phase = alert state). The contracted end consumers or respectively their service providers receive the information on any *restriction requirements* for the relevant *operational periods* in due time.

- **15min-Operational Period**: Specific quarter of an hour in which electric grid usage *restriction requirements* apply.

- **Restriction Requirement**: Requirement which mandates the restricted use of a given capacity by the network user (= end consumer) for the *contracting timeframe*. Normally, such a *restriction requirement* entails either a command and control option or a pre-defined switch option, which is reserved for a third-party, in this case either the flexibility service provider or the energy supplier. Furthermore, the *restriction requirement* limits the possibility to use the electric grid compared to the allowed and technically possible capacity at the point of interconnection with the local distribution grid, thereby reducing the degree of freedom for using the electric grid by the end consumer. If *restriction requirements* are executed, the operational status of the electric grid is pursuant to the so-called yellow phase of the traffic light concept.

- **Level of Restriction Requirement**: The *level of restriction requirements* defines how the threshold of the *restriction requirement* is changing in certain *15min-Operational Periods.*

- **Intervention**: Means the direct access of the DSO in charge of operating a certain distribution grid area to the controllable appliance (load or distributed generation) located in this area. In the logic of the traffic light concept, this state is concurring with the so-called red phase.

- **Aggregated Distribution Grid Area:** Based on grid topological considerations, an area or segment of the distribution grid chosen by the responsible DSO for applying a consistent and uniform *restriction requirement.* A coherent *aggregated distribution grid area* can also consist of several physically disconnected distribution grid areas operated by different DSOs; as long as there is a similar grid topological situation with respect to distributed generation and consumption (load) in the different areas and the DSOs cooperate.[5] Albeit the *aggregated distribution grid areas* physically do not have to be connected, their optimal definition requires a superb knowledge of the network infrastructure on part of the DSO.

- **Flexibility Premium:** The *flexibility premium* is granted to the end consumer for meeting the *restriction requirements* during the agreed *contracting timeframe*.
- **Separate Metering Point:** The controllable appliance is required to have a separate metering point. A virtual metering point is sufficient.

Core Scheme and Suggestions for Implementation

Parameter 1: Contracting Timeframe

Initially, the *contracting timeframe* should be at least **one year**. The network user (= end consumer) who is offering his flexibility to the DSO is obliged to comply with the *restriction requirements* for an entire calendar year. The possibility to sign a contract following the defined conditions is open to all network users (= end consumers).

Justification: A shorter *contracting timeframe* would corrupt the projectable use of the instrument. On the basis of a full year contract flexibility potentials can be used in a way which avoids high seasonal fluctuations.

Furthermore, it is imperatively important to develop a uniform standard for service products offered in areas as large as possible (at least on a country basis). From bne's point of view, it is not an option to give each DSO a choice whether they want to implement such an instrument or not. Having each DSO (and especially the smaller ones) operating their own market area or platform would lead to great problems with respect to liquidity and acceptance of such a market based instrument. Also, transaction costs on part of the service providers operating throughout Germany would be unreasonable high. In addition, with increasing electrification and higher shares of renewable energy generation in the electricity system, there will be a need for a consistent and standardized instrument which aims at avoiding increased concurrency on the low voltage distribution network. Even those DSOs which have no congestion problems at the moment, will reach their limits with increasing digitization and automation of controllable appliances,

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[5] For example, an aggregated distribution grid area could be composed of similar urban areas, such as in Munich and Nuremberg, or of several rural areas located apart from each other, e.g., in Brandenburg and Mecklenburg-West Pomerania.

including both distributed generation and load. Alternatively, distribution grid planning and design would have to accommodate concurrent maximum supply by distributed generation as well as maximum consumption situations at all times. In turn, this would lead to greatly oversized distribution grids and cause extremely high costs.

Parameter 2: Length of Operational Period

In the beginning of using such a market framework, we suggest the *length of the operational period* to be no longer than **one month**. For the future, even shorter *operational periods* will be required.

Parameter 3: Design of Aggregated Distribution Grid Area

The DSO is free to choose the size of an *aggregated distribution grid area* according to congested areas and his flexibility needs. It is possible to cooperate with other DSOs in order to share expenses or use one single and uniform communication system for aggregating controllable appliances located in several service areas, thereby forming one single *aggregated distribution grid area*. DSOs should not face any restrictions in designing *aggregated distribution gird areas*.

Example: There are ten controllable appliances (e.g., electric vehicles or electric heating appliances) registered and connected to a single distribution feeder in a DSO's service area. In the morning and evening hours the responsible DSO is dependent on not having all end consumers simultaneously using their maximum network capacity on this single feeder. By allocation to the *different aggregated distribution grid areas* the DSO is able to bundle the network users according to his specific needs. To ensure that there is no preference for specific customers (e.g., those customers that are served by the energy supplier of the integrated DSO – note: in Germany all DSOs that serve less than 100.000 customers are not fully unbundled), the DSO on the one hand is required to offer a uniform contract to all network users (= end consumers) that operate controllable appliances on their premises. Concerning the *contracting timeframe*, this uniform contract is required to entail the same conditions for all network users. On the other hand, the DSO is obliged to define the *restriction requirements* according to the capped maximum extent as outlined in parameter 7. Individually, end consumers can be affected by *restriction requirements* during different *operational periods*. However on a collective basis, the *restriction requirements* ensure that each single end consumer is not restricted excessively and the use of flexibility is spread evenly among all end consumers as much as possible.

Parameter 4: Communication of 15min-Operational Periods

On an annual basis, the DSO allocates a classification to a controllable appliance for an *aggregated distribution grid area* (in combination with an identification number of the *aggregated distribution grid area*).

The following information has to be communicated to each metering point which includes controllable appliances within the respective *aggregated distribution grid area*:

DSO	**Aggregated Distribution Grid Area**	**15min-Operational Periods** (with 31 days per month, there are 2976 consecutive quarter hours)	**Level of Restriction Requirement**
I	1	64-72; 150-152; etc.	64-66 (0); 67-69 (0,8); 70-72 (0,1); etc.
I	2	66-78; 160-168; etc.	66-68 (0,7); 69-72 (1.5); etc.
II	1	64-72; 150-152; etc.	64-66 (0); 67-69 (0,8); 70-72 (0,1); etc.

The energy supplier or the responsible flexibility service provider receives the access authorization for those *aggregated distribution grid areas* where he has registered metering points which include controllable appliances. Furthermore, this option would require a fix deadline for all DSOs to announce and transmit the required information for their *aggregated distribution grid areas*. For example, such a fix deadline could be set on the 16th of each previous month at 0:00, or respectively (in the case of shorter *contracting timeframes)* on a specific day during the previous week.

The mechanism of the communicated information and its effects are illustrated in the following fictional example for a certain *15min-operational period*: The *level of restriction requirement* for a metering point which includes a heat pump receives for its *aggregated distribution grid area* for a certain *15min-operational period* is 0. This means the network user (= end consumer) would have to comply with the defined maximum threshold (compare parameter 7), e.g., 4 kW maximum load. In case he receives a *restriction requirement level* of 0,7 for a certain *15min-operation period* this would equal an allowed maximum load of <u>4 kW + 0,7*4 kW= **6,8 kW**</u>.

In case the controllable appliance is a PV system or a storage unit, the maximum injection for a metering point could be defined by using a simple negative value. <u>Example:</u> The metering point receives *the restriction requirement level* (-0,8). On the basis of the defined maximum threshold of 4 kW, this would mean a maximum injection to the network in a certain 15min-operational period of <u>0,8*4 kW= **3,2 kW**</u>.

In any case, of utmost importance for any interim solution is that the data sets are automatically readable.

Proposed communication for the future: Ideally, a more short-term communication solution (than signals on a monthly basis) is needed. With the implementation and roll-out of the so-called intelligent metering system (in Germany, this means the combination of a basic smart metering system with a smart meter gateway), it should be possible to directly feed the values of *operational periods* for the concerned *aggregated distribution grid areas* into the smart meter gateways. The smart meter gateways will then distribute the appropriate data sets to the IT systems of each authorized energy market actor.

Parameter 5: Maximum number of 15min-Operational Periods

Proposed restriction for Germany: In general, <u>the DSO is not allowed to define more than 12 quarter hours per day as *operational periods* for a certain *aggregated distribution grid area*.</u> The restriction refers to 12 fully restricted *15min-operational periods* (which corresponds to the *restriction requirement level* of 0). If the DSO is communicating a different *restriction requirement level,* the minimum limit is calculated as follows:
The number of allowed *15min-operational periods* results from the remaining difference between 12 and the added values consisting of the *restriction requirement level* of the respective quarter hours summed with the maximum value of 1.
<u>Example:</u> **Five** 15min-operational periods with the value 0, **three** with the value 0,6, **four** with the value 0,8 make: 5+3+4=12-(3*0,6+4*0,8=5)=7. The remaining 15min-operational periods that could be fully restricted (at the value of 0) are **five**.

During all quarter hours that are not specified as operational periods the flexibility would be free for use on other markets, such as balancing or intra-day. The energy markets would greatly profit by receiving additional flexibility resources.

Basis for setting up such a cap on the nomination of the overall possible *15min-operational periods* should be the number of hours in each DSO service area that are relevant for distribution grid planning and design (and thereby relevant for concurrency). In the planning principles it should be established that the instrument should be used for capping peak load.

According to existing experience, the instrument would be effective if it were available for at least 50 hours (200 quarter hours) on an annual basis. For comparison, the proposed restrictions as outlined above would more or less grant the DSO each month the amount of *15min-operational periods* that he actually needs during the entire year.

In other EU member states the restrictions could be set according to the relevant DSO needs. In addition, an incremental procedure which would allow more *operational periods* in a first phase and then gradually lead to less allowed *operational periods* could be a design option, too.

Parameter 6: Design of Flexibility Premium

Different design options for the *flexibility premium* are possible. The most simple and straightforward mechanism for transferring an economic benefit consists in a direct incentive payment. Another possibility consists in network tariff reductions, which is the approach currently used in Germany. Eventually however, it is advisable to put a system in place which is based on direct incentive payment structures rather than network tariff reductions. Incentive payment structures allow for broader participation, including aggregators and other service providers. This is a clear advantage over network tariff reductions.

In any case, the *flexibility premium* needs to be defined in relation to the local context and framework conditions. It certainly needs to be adjusted to the specific regulatory framework in each country.

Parameter 7: Arrangement of Restriction Requirements

Proposal explained by using an example of the low voltage distribution network:

	Used network capacity, cos phi = 0,9	**Apparent power**
GROUP 1	up to 21 kW >21 to 30 kW >30 to 39 kW >39 to 49 kW >49 to 62 kW	up to 23 kVA >23 to 33 kVA >33 to 43 kVA >43 to 54 kVA >54 to 68 kVA
GROUP 2	>62 to 77 kW >77 to 99 kW	>68 to 85 kVA >85 to 110 kVA
GROUP 3	> 99 to 124 kW >124 to 140 kW >140 to 155 kW	>110 to 137 kVA >137 to 155 kVA >155 to 172 kVA

The DSO is defining the *restriction requirement* based on a percentage of the overall network capacity available at the point of interconnection. In the case of Germany, such a *restriction requirement* has to be set between **15 and 35 percent** of the overall available capacity. This value is the basic value, if the *restriction requirement level* is set at 0. Depending on the actual network capacity used (see column 2 in the table above) a security markdown of 10 percent of the maximum value of each group has to be included in the calculations. The result will then be rounded.

One illustrative example for GROUP 1 (up to 62 kW): The DSO is defining the *restriction requirement* at 25 percent. Hence, the following restricted capacity during *operational periods* is calculated:

> 62 kW – 10% markdown =
> 55,8 kW x 25% restriction requirement = 13,95 kW = <u>**14 kW**</u>

In this case, the network user (= end consumer) would be required to not use more than 14 kW of his overall available capacity during the *operational periods* with a *restriction requirement level* set at 0.

The percentage rate for the *restriction requirement* is set in a way that windfall profits normally are excluded. In Germany, an average household typically has a network connection of 21 kW. With an annual consumption starting at 2.000 kWh and higher, the maximum output of an average household is around 7 to 8 kW. A 30 percent reduction according to the formula introduced above would be equivalent to 5,67 kW. This ensures that the network user (= end consumer) has to react in order to guarantee compliance with the *restriction requirements* during *operational periods*. The same applies to all other fuse sizes accordingly.

By which activity the concerned end consumer is guaranteeing compliance with the *restriction requirements* is up to him or respectively his service provider (e.g., operation of storage device, heat pump or any other approach). This condition would highly encourage the development of market based approaches for activating demand side flexibility.

Parameter 8: Non-compliance control and Penalization

By comparing the metering data points (showing the actual network usage) with the *restriction requirements* during *operational periods* (which are known by a certain due date) compliance can be verified. If the end consumer is violating the *restriction requirements*, he either is losing the granted network tariff reductions or he has to pay a penalty fee.

Parameter 9: Pooling

In general, the market model should allow pooling. However, only controllable devices located in the same *aggregated distribution grid area* should be admitted for pooling in the same pooling unit. A standardized communication protocol between the flexibility service provider and the DSO for transmitting the information on which metering points are participating in any pooling unit will be required.

The proposed logic would allow for simple handling. For example, a flexibility service provider or energy supplier has five registered customers in a certain *aggregated distribution grid area* (exemplary capacity limits are 5 kW, 5 kW, 7,5 kW, 20 kW and 20 kW: in sum 57,5 kW). Now the flexibility service provider or energy supplier is required to ensure that during the *15min-operational periods* the capacity limit of the end consumers in sum is not exceeding the overall capacity limit (which in this case is 57,7 kW).

Parameter 10: Intervention by the DSO

In case of emergency (= red phase), the DSO has to have direct access to the controllable appliance in order to prevent black outs and other disturbances.

In addition, rules for compensation have to be elaborated. In the so-called yellow phase, the flexibility service provider or energy supplier is responsible to ensure that his customer (= end consumer) is complying with the specified *restriction requirements* during the *operational periods*. How he is organizing this should be determined by market conditions. Outside of the *operational periods* the flexibility service provider or energy supplier is free to use his customer's flexibility in order to optimize the system and maximize the customer's benefits. If the DSO is acting and taking over control outside of the *operational periods*, there are direct consequences in the balancing group of the flexibility marketer (which could either be an independent aggregator/flexibility service provider or the energy supplier). These consequences are a result of the fulfilment obligation of balancing requirements (so-called imbalance penalties can apply). There are also direct consequences for the procurement costs of electricity. Both problems have to be addressed and compensation rules need to be elaborated. In principle, a similar logic to the solution for compensation of energy quantities between an independent aggregator and an energy supplier (which are currently under development) could be applied to the relation between a DSO and the energy supplier or the flexibility marketer.

The option for intervention should not exceed a certain, well defined range. This range clearly has to be less than what the basic model allows (as outlined in this concept). It needs to be organized like an "emergency button". This emergency button would in contrast to the so-called yellow phase aim at individual controllable appliances where the DSO has direct access and in case of emergency can send command and control signals.

Conclusion and Key Messages

- A DSO should be able to use flexibility to solve capacity constraints on the local distribution network and to avoid or defer reinforcement, if this is the most efficient option. At the same time, a clear framework which is setting the conditions and boundaries on how the DSO is allowed to use flexibility is needed in order to keep market mechanisms functioning.
- The *De-Flex-Market 2.0* concept aims at presenting a market based solution for organizing access to flexibility on the local distribution network. It is not a market model by classic understanding. However, it is a market-based instrument which is applicable in a decentralized way while at the same time it is minimizing impacts on the price signal of the wholesale market.
- The instrument allows for creating a level playing field and developing new market services in a non-discriminatory environment.
- Each DSO is granted a high degree of freedom for determining *restriction requirements* while at the same time, liquidity problems and the potential for abuse are addressed.
- Participating end consumers have guaranteed quarter hours where their flexibility can be operated based on the wholesale and balancing market needs.
- Further discussions, including all market roles concerned, will have to take place and continuing refinements need to be carried out in order to advance the concept and its implementation.

Who we are: Bundesverband Neue Energiewirtschaft e.V. (bne) / Association of Energy Market Innovators – a strong voice for independent energy companies

bne represents the interests of grid-independent energy suppliers and energy service companies in Germany. Unlike suppliers with a connected grid, bne-members are free of monopoly interests: They are committed to fair competition and a diverse energy market.

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