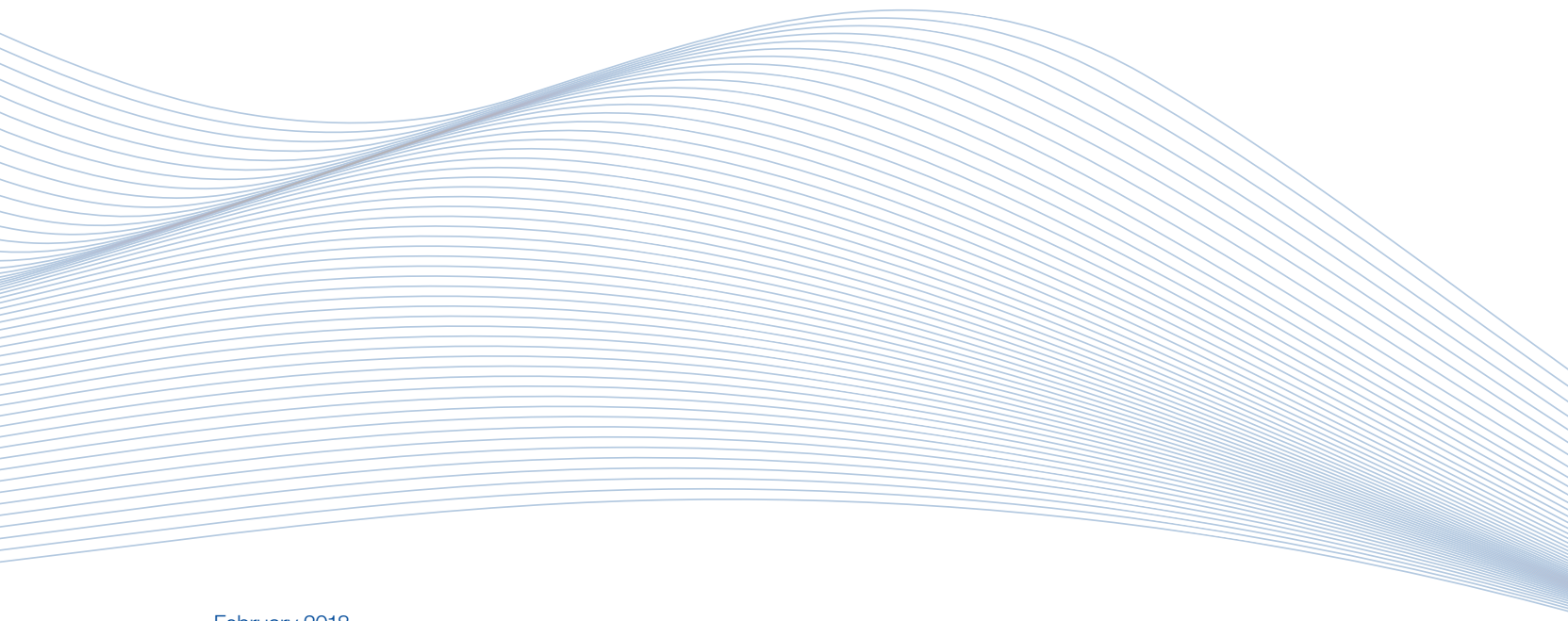
FLEXIBILITY IN THE ENERGY TRANSITION

A Toolbox for Electricity DSOs



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The biggest challenge facing the EU energy sector is to pave an effective and cost-efficient road towards decarbonisation

A. BACKGROUND

With the European energy transition demanding closer inter-DSO cooperation in the interest of customers and society at large, the European associations representing DSOs (distribution system operators) – CEDEC, EDSO for Smart Grids, eurelectric, Eurogas and GEODE – have been working together constructively now for several years.

In recognition of the fact that DSO issues are becoming of increasing interest and importance to European energy policy, the European Commission has repeatedly expressed its desire to receive trusted, expert level advice on a range of matters affecting DSOs. These include market design, DSO/TSO cooperation, flexibility patterns and procedures, integration of renewable energy sources, deployment of smart grids, demand response, digitalisation and cyber security.

With this in mind, the above associations have agreed to deepen their cooperation and are prioritising the issue of flexibility. They have established a programme of work and a committee of experts covering flexibility for both electricity and gas.

The work of both focus areas, which has run in parallel over the past year, resulted in two reports, one for electricity and another for gas. Both reports together provide a holistic overview of how DSOs can use flexibility and thus contribute to the transition towards a more decarbonised and sustainable European energy sector. They present a set of solutions to enable DSOs to use flexibility as a tool to operate their grids in a cost-efficient way.

The reports also provide clear recommendations to policymakers on how the regulatory framework should evolve to make better use of flexibility, both by the DSOs as well as by other stakeholders.

An improved regulatory framework should reward the use of flexibility – also by DSOs – and must take into account the growing role of the DSO as an active system operator and neutral market facilitator. These reports present solutions for DSOs to cope with the challenges of flexibility, an analysis of the various technologies available to provide the required flexibility services to system operators, as well as alternative ways to acquire such services.

B. EXECUTIVE SUMMARY

An integrated approach between electricity and gas

The European Union is looking at cost-efficient ways to make the European economy more climate-friendly and less energy-consuming. The biggest challenge facing the EU energy sector is to pave an effective and cost-efficient road towards decarbonisation. Energy related emissions account for almost 80% of the EU's total greenhouse gas emissions.

The energy challenge is therefore one of the greatest tests which Europe has to face. The EU energy system needs a transition to carbon neutral and sustainable energy sources. Many of these energy sources, in particular renewables tend to be volatile e.g. solar and wind energy.

Furthermore, the new generation sites using these more distributed energy sources are to a large extent connected directly to the distribution system, as opposed to traditional centralised power generation units which are usually connected to the transmission system. As a result, electricity generation is gradually moving from a centralised to a largely decentralised perspective.

On the customers' side, the demand for mobility and heating is also shifting. Traditionally, fuel for transport has been derived from oil, but this sector also has its own specific decarbonisation targets. It is highly likely that in coming years, road transport will significantly change its energy source from oil to electricity, gas and hydrogen.

The heating and cooling sector for buildings is also set to undergo important changes in the near future. Whereas heating is now achieved mostly through classic energy sources (often with natural gas) alternative technological solutions such as heat pumps and micro-cogeneration are rising.

It is therefore evident that the energy transition will not only see profound changes in the way energy is produced, but also in the way energy is used, stored and consumed. This is set to increase in the future and will have a huge impact on distribution grids.

This is where flexibility will have a critical role to play. Besides the technical grid solutions, flexibility is needed both on the generation and on the demand side. In order to benefit from the storage capabilities of natural and renewables gas it is important that the electricity and gas sectors cooperate in order to develop integrated solutions, such as power-to-gas.

The unique features of both energy systems can be complementary to each other and can contribute towards developing cost-efficient technological solutions. Gas can be an important flexibility solution for electricity. The EU DSOs in electricity and gas have agreed to collaborate and share their competencies and knowledge. This partnership will contribute towards the development of an adequate and coherent regulatory framework to improve the development and exploitation of flexibility's potential in the European energy system.

The large diversity of DSOs in the EU in terms of size, activities or organisational structure will not be able to cope with a "one size fits all" future model. However all DSOs face the same challenge: connecting more than 90% of customers and ever growing numbers of local renewable generators in a fast-changing, more decentralised and digital energy world.

The electricity flexibility report

In a joint effort advocating for smarter, flexible and digitised distribution networks, the four DSO associations, CEDEC, EDSO for Smart Grids, eurelectric, and GEODE call on policymakers and regulators to integrate these new roles for DSOs in flexibility in all future electricity market legislation.

They should ensure that DSOs, as neutral market facilitators, are able to oversee, utilise and coordinate the impacts of flexibility operations on their networks through the necessary control architectures, as part of their active system management responsibilities. Smarter distribution network tariff structures that are cost-reflective and more capacity based can support this development.

DSOs must be allowed to use flexibility to manage their network, including grid congestion, and to optimise their grid capacity for better market-functioning, irrespective of the flexibility model used and the technology chosen.

The use of these technologies should not lead to market disturbance, and whenever more efficient, a market-based solution is preferable. While storage services which can be bought by DSOs should remain a market activity, DSOs should be allowed to own and operate grid-scale storage for their needs, in order to secure the technical operation of the grid within the approved regulated activities.

For efficient market procurement, regulatory oversight is needed to avoid that flexibility providers make simultaneous offers based on the same flexibility resources through different services in the same timeframe.

Coordination and information exchange between both systems operators is key to manage one single system. This must be done to avoid double flexibility activations at the same time, as well as any kind of activation of a distribution connected grid user by TSOs without any previous notification or means in place to block any potentially damaging control signal.

DSOs should always be in control of the use of DSO congestion management services in their grids, supported by locational information and well-defined product specifications. If these services both serve TSOs and DSOs, they should be placed under mutual governance. A single flexibility marketplace for both balancing and congestion management for TSOs and DSOs is unlikely to be a sustainable solution in the future. Among others, it imposes strong restriction to aggregation and high barriers for new small market parties.

The basis for an overall functioning system is the unity of task, responsibility and decision-making. System operators (TSOs and DSOs) hold the remit for operating their own networks securely and reliably, and bear responsibility for doing so. Accordingly, each system operator must be able to make decisions in its own system. A cascaded collaboration between system operators evidently supports this principle.

Finally, the methodology and implementation of the data format and data exchange between significant distribution connected customers and the DSO or TSO, should be agreed upon between DSO and TSO. The responsibility of data quality and data delivery should lie on the system operator to whom the customer is connected, but its implementation may vary according to local and/or national circumstances and agreements, including realisation through joint DSO/DSO or DSO/TSO implementation arrangements.

C. KEY RECOMMENDATIONS

The four electricity DSO associations call on policymakers and regulators to integrate these new roles for DSOs in enabling flexibility in all future legislation as follows:

1. Ensure that DSOs, as neutral market facilitators, are able to oversee, utilise and coordinate the impacts of flexibility operations on their networks. DSOs strongly recommend that any activation of a distribution connected grid user by a TSO or a market party is only allowed where control architectures ensure that the DSO oversees operations as part of its active system management responsibilities, and, among other things, has prior notification, assessment and a means of blocking any potentially damaging control signals.

2. Allow DSOs to use flexibility to manage their network and to optimise their capacity within which the market can function. Access and use of flexibility by DSOs, such as technical solutions from DSOs' own assets, connection agreement, network tariffs and market-based procurement should be allowed. Irrespective of the flexibility model used, it should be financially viable for all concerned parties.

3. Incentivise DSOs to use flexibility for congestion management, where it is cost-effective to do so. DSOs should be able to decide on the best solution to address specific challenges, either through flexibility solutions or through network reinforcement.

4. Enable DSOs to choose the best and most cost-efficient technology to operate the distribution system. Legislation shall not limit a choice of technologies available to DSOs to carry out their legal obligations. Still, DSOs have to guarantee that the use of these technologies do not lead to market disturbance. Whenever more efficient, a market-based solution is preferable. For grid-scale storage specifically, DSOs should be allowed to own and operate such devices for their needs to secure the technical operation of the grid within the approved regulated activities.

5. Support the development of new distribution network tariff structures that are cost-reflective, more capacity based and oriented to the efficient use of the distribution system capacity.

6. Prevent the double use of flexibility resources when used for congestion management in distribution network. Flexibility providers shall have the possibility to simultaneously offer flexibility services for distribution congestion management, transmission congestion management and system balancing but flexibility should be only used once in the same timeframe. The regulatory framework should clearly avoid that flexibility providers profit from the creation of grid congestion and must also be adapted to detect and prevent this.

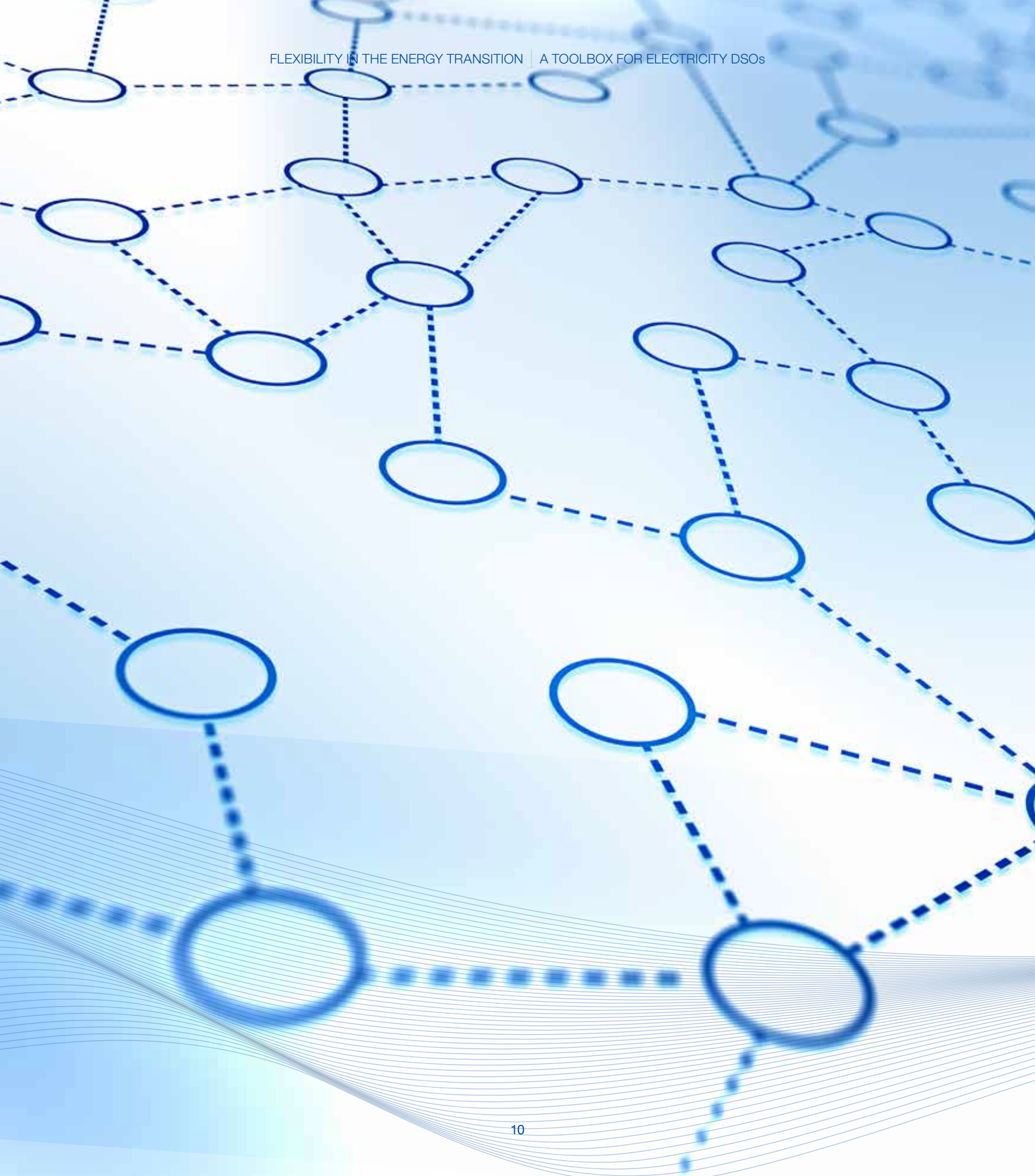
7. Allow DSOs to always be in control of the use of DSO congestion management services in their grids. If this is combined with a congestion management services for TSO, this should be placed under mutual governance. Further combining DSO congestion management services with TSO balancing services is not advisable even in those Member States with a unit-based balancing regime.

8. Ensure that the products for congestion management for DSOs include locational information. DSOs are committed to work with stakeholders to define the specifications required to guide market parties who will provide local flexibility products.

9. The basis for an overall functioning system is the unity of task, responsibility and decision-making. System operators (TSOs and DSOs), hold the remit for operating their own networks securely and reliably, and bear responsibility for doing so. Accordingly, each system operator must be able to make decisions in its own system. A cascaded collaboration between system operators supports this principle, which should therefore be anchored in EU legislation.

10. The implementation of the data exchange and data format between the DSO, the TSO and significant distribution connected customers should be agreed upon by both the DSOs and TSOs. Based on the System Operation Guideline this agreement should be reflected in the data exchange methodology, KORRR[1]. The responsibility of data quality and data delivery should also lie on the system operator to whom the customer is connected, but its implementation may vary according to local and/or national circumstances and agreements, including realisation through joint implementation arrangements (DSO/DSO or DSO/TSO).

1. KORRR: key organisational requirements, roles and responsibilities in relation to data exchange.



1. INTRODUCTION

Europe's electricity distribution system is facing an unprecedented energy transformation driven by the EU's key decarbonisation targets. The European Distribution System Operators (DSOs) are committed to this evolution and plan to tackle it in a timely, cost-effective and reliable manner.

In this new energy system, DSOs are confronted with the need to integrate highly volatile and decentralised generation (most of which is connected to the distribution networks), increased loads and capacity due to electrification of transport and heating and cooling , as well as the impact of changing customer behaviour and evolving market needs.

Shifting from predictable demand and supply patterns towards more decentralised and volatile power flows in many directions, will drastically change the shape of distribution networks. This will also require a transformation of the traditional DSO business model – from 'wires'-based to platform-based – to meet the growing expectations of customers and enable all types of market parties.

On the other hand, distributed energy resources (DERs)[2] can also provide important flexibility services to the DSOs, enabling them to operate their networks more efficiently and economically. With the use of flexibility provision from market parties or the DSOs' own technical solutions, effecting reinforcements in the networks for new needs is expected to be gradually reduced or even deferred indefinitely. However, all these actions should be promoted without endangering the provision of reliable and secure networks by system operators.

As the energy transition gathers pace, DSOs will need to increasingly perform a more active role in developing, managing and operating their networks. Clearly, the on-going transformation places new requirements on distribution networks in terms of system reliability and operational security, but it also offers opportunities for DSOs to manage their grids in a more flexible and efficient manner.

At the same time, DSOs will need to perform a neutral market facilitation role in engaging customers and facilitating new markets, including flexibility markets. It is at this crossroad of ensuring reliable and efficient system operation, while facilitating new markets, that DSOs will play a central role.

2. DERs consist of small to medium scale resources that are connected mainly to the lower voltage levels (distribution networks) of the system or near the end users.

2. PROBLEM DESCRIPTION

In order for the European electricity sector to become carbon-neutral by 2050, it is estimated that at least 27% of its energy must be drawn from Renewable Energy Sources (RES) by 2030, which will contribute to the EU's GHG emission reduction target of at least 40% by 2030 compared to 1990 levels[3]. This translates to around 50% of electricity which must be generated from RES by 2030.

The incorporation of a significantly higher share of highly volatile RES (with most of it likely connected to the distribution networks) alongside new loads such as electric vehicles or heat pumps, introduces new challenges to the design and operation of the distribution system. In this respect, increasing controllability and flexibility of the variable supply and demand, provides a key pathway towards a more robust distribution system.

DSOs are facing increased challenges in adapting the distribution network to this new reality, with the main one being the occurrence of grid constraints / **distribution congestion**[4]. This chapter will investigate the challenges facing DSOs as they play a key role in Europe's energy transition.

THE NEED FOR FLEXIBILITY

The traditional design of the electricity distribution system was largely based on the principle of 'generation follows demand'. This approach no longer applies as increasing amounts of distributed generation (e.g. wind and solar energy) are weather dependent, and therefore cannot be controlled. By contrast, the load will need to be incentivised to adapt to changes in generation, particularly on the distribution level, i.e. when local demand is lower than generated capacity.

These actions will create additional complexity and unpredictable power flows in the distribution networks, with the potential to cause local congestion that will need to be managed by the DSOs. Typically, congestion at the transmission level is handled by re-dispatching (i.e. adjusting the scheduled generation of centralised power plants). At the distribution level however, congestion has historically been dealt with through planned upgrades of distribution system components. Such upgrades however cannot follow the fast uptake of DERs in the distribution network, leading to temporary congestions.

This is where flexibility comes into play. Flexibility can be used to adjust the demand profiles to the supply peaks in renewable generation, or to the available capacity in the distribution grids.

Flexibility is defined as the modification of generation injection and/or consumption patterns, on an individual or aggregated level, often in reaction to an external signal, in order to provide a service within the energy system or maintain stable grid operation. The parameters used to characterise flexibility can include: the amount of power modulation, generation forecasts, the duration, the rate of change, the response time and the location. The delivered service should be reliable and contribute to the security of the system.

3. The 2030 climate and energy framework sets three key targets for the year 2030: At least 40% cuts in greenhouse gas emissions (from 1990 levels); at least 27% share for renewable energy: and at least 27% improvement in energy efficiency.
4. Set of actions that the network operator performs to avoid or to relieve a deviation of the electrical parameters from the limits that define secure operation. This term includes congestion management and voltage control.

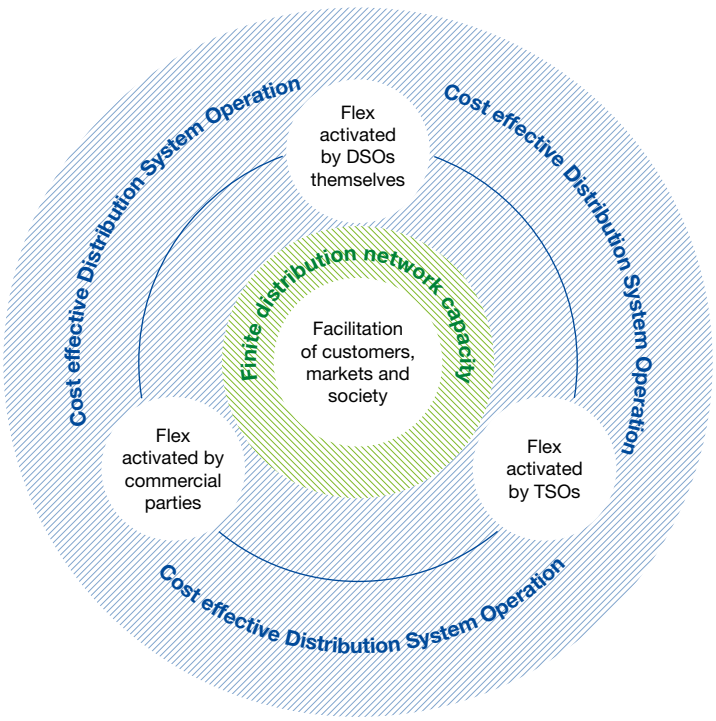
The use of flexibility can help DSOs to shift supply and demand peaks, to prevent congestion (voltage and current issues) and avoid power quality problems. Flexibility can serve as an alternative to network reinforcement when it is more cost-efficient than traditional reinforcement of the network.

Apart from the cases where flexibility brings benefits to DSOs, it should be noted that, in certain cases, the simple activation of flexibility by other market parties and other system operators can lead to issues for DSOs, for example, this could lead to distribution grid congestion.

THE USE OF A COMPREHENSIVE FRAMEWORK

DSOs are neutral market facilitators. They need to have adequate means in place to make use of flexibility resources, to oversee flexibility operations (including the need for intervention) and to make it easier and cost-effective for consumers to benefit, all the while ensuring quality of service and security of supply in a challenging environment.

Figure 1: Flexibility framework for cost-effective Distribution System operation



Source: DSO Committee on Flexibility, 2017

The players who can activate flexibility are divided into three groups: market parties (including customers), TSOs, and DSOs (see Figure 1) When activating flexibility, these can each have an impact on each other.

In providing a neutral, enabling and integrated platform for market-based services and customer interactions in the best possible way, DSOs should be able to oversee and co-ordinate the local use of flexibility. Co-ordination with commercial parties and TSOs is crucial to foster the market uptake of flexibility products and services, and to enable direct and indirect flexibility provision to the system, while ensuring that DSOs oversee the impact on their networks.

Flexibility for DSOs' own use and activated by DSOs

In order to cope with the challenges described above, and to locally manage the network load and voltages, DSOs should have access to flexibility for their own use. DSOs may increase network capacity (building a new line or reinforce an existing one), integrate storage capacity in a congested area, activate additional local demand, or even reduce the injected power by renewables at the local level.

Flexibility activated by market parties

Apart from the flexibility activated by DSOs (or TSOs), market parties can activate flexibility in reaction to market prices or for balancing purposes. This can also affect the DSO's network and can lead to congestion. For example, if a sunny or a windy afternoon is expected, the DSO may plan to use the local storage capacity owned by a commercial party, but at the same time, another commercial party might wish to use the same capacity for trading purposes. This action must therefore be properly co-ordinated between the commercial parties and the DSO, and this is only possible when the commercial parties interact directly with the DSO.

However, there are cases where flexibility may be activated by other parties who have limited or no contractual or commercial interaction with the DSOs, and this could have an impact on the distribution system. In these cases, problems may arise and co-ordination will be needed.

Flexibility activated by TSOs

Increasing Europe's renewable energy generation will lead to higher decentralised and distributed loads. This means that the system, regardless of the voltage level (transmission or distribution), will need to face more volatile and less predictable generation, as well as decreasing inertia. This will lead to situations where TSOs will become more dependent on the use of flexibility sources and services connected at the distribution level. TSOs will therefore need to procure and activate such services from DSO customers, which can cause congestion on the affected distribution network. Similarly to market parties, TSOs may cause problems in the DSO networks and there is therefore need for co-ordination.

3. ENABLING TECHNOLOGIES TO ENHANCE THE USE OF FLEXIBILITY

As neutral market facilitators, the DSO associations fully support that all flexibility resources (e.g. generation, storage and demand) compete on a level playing field, as long as they present viable options to deal with congestion and other operation related problems faced by DSOs. Barriers for market access should be as low as possible in order to ensure the most cost-efficient and technologically suitable solution.

DSOs should access flexibility services in the market in a technology-neutral manner to ensure that the most efficient resources are utilised first in serving the system's need for flexibility, also taking into account the required levels of security/reliability in grid management.

Smart grid technologies and solutions are expected to drastically change the distribution of electricity, calling for a more active role from DSOs in managing the distribution system, incorporating demand, as well as decentralised generation. There are several technologies and techniques that can be used to solve or prevent distribution congestion.

SMART GRIDS

As part of the clean energy transition, the energy sector is currently in the process of undergoing three major transformations relating to grid and network development:

- improvement of infrastructure (strengthening the grids);
- addition of the digital layer, which is the essence of the smart grid; and
- business process transformation, necessary to capitalise on investments in smart technology.

Much of the work that has been going on in electric grid modernisation, especially substation and distribution automation, is usually included under the general concept of the smart grid.

Key features of the smart grid:

- **IT / data communication:** Adding more IT capabilities, ensuring interoperability and data communication is core to a smart grid. The grid is the link between the producers and the consumers. It is therefore vital to the further development of flexibility that production units can interact with consumption units and that they can adjust their production or consumption accordingly.

- **Smart meters:** They are an essential part of the smart grids. Indeed, the increased data granularity will be used either by the DSO or by the market parties. Transparency of the flexibility activations and that of the individual behaviours will make it possible for all the parties, end grid user included, to create and capture the value of flexibility.

- **Control and monitoring of the grid:**
  Grid control and monitoring systems will enable:

  > **Flexibility in network topology:** Next-generation distribution infrastructure will be better able to handle possible bidirectional energy flows, mass rollout of photo-voltaic (PV) installation, wind turbines, EVs, heat pumps, storage facilities and power-to-gas. Flexibility in network topology combined with automatic control systems will enable automatic network reconfiguration in the future.
  > **Load adjustment / Load balancing:** An example here is the electric vehicle (EV) 'smart charging' concept. Smart charging can help to adjust the charging profiles to the supply of energy and/or grid capacity, without overloading transformers due to simultaneous EV charging. How the load is best balanced depends on many factors such as the capacity of the charging station, the location, the capacity of the connected EVs, the state of the charging, the duration of the charging etc.

- **Peak curtailment:** Curtailment capabilities provide DSOs with the ability to reduce consumption or production by communicating to devices directly in order to prevent system overloads. DSOs should have the ability to manage loads based on the type of usage and customer. This can increase efficiency in grid planning, ensure secure operation (voltage, current) and could even prevent outages, damages or a blackout for all connections in a certain area.
- **Improve reliability:** The smart grid makes use of technologies that improve fault detection and allow automated reconfiguration of the network without the intervention of technicians. This ensures more reliable supply of electricity and reduced vulnerability to natural disasters.

- **Cyber-security:** Improving grid resilience through cyber-security by securing the grid from cyber attacks and protecting data that is used for network operation and market facilitation.

- **Flexible storage:** storage facilities are an important part of the smart grids, as it is explained in the next section.

Smart grids technologies will allow DSOs to access flexibility from DERs, including dispatchable generation, storage and demand response, while improving the efficiency and sustainability of the system and reducing the need for grid reinforcement. These technologies can also help to enable new markets.

ENERGY STORAGE

As the share of renewables rises, and the electrification of the heating and cooling sector and the increase in electric vehicles (EVs) continues, the growing need for flexibility in the energy system will benefit from new storage solutions. The value of energy storage is substantial and will significantly increase going forward, affecting the entire energy value chain, increasing energy efficiency and reducing greenhouse gas emissions.

In addition to RES integration and arbitrage, there is a wide range of energy storage applications at all levels of the electricity system ranging from energy generation, transmission, and distribution down to the customer or load site. Concretely, the usage of energy storage for network purposes has vast potential. In the past, this was already technically possible, but not economically feasible on a large scale. The development of installed energy storage capacity has increased considerably globally[5].

There will be many new opportunities to use energy storage for grid stability services. The response time (ramp up time) of energy storage system is generally very fast. This makes energy storage extremely suitable for the frequency containment reserve (primary reserve) of balancing services and voltage control services, as both require a rapid response time. It is, therefore, very likely that energy storage will play an important role in the future.

5. http://ease-storage.eu/wp-content/uploads/2017/10/EASE-EERA-Storage-Technology-Development-Roadmap-2017-HR.pdf

With their potential for battery storage and flexible demand, EVs can be considered as mobile energy storage units; the number of storage units could be vast. The characteristics of transportation demand allow fleets of EVs to be used as flexibility options in two key operational models that have huge potential in terms of bringing additional flexibility to the grid: 'grid-to-vehicle' (G2V)[6] by shifting charging to periods of lower electricity demand, and 'vehicle-to-grid (V2G)[7]' by discharging power from the car battery to the grid. It should be noted that the latter can involve additional costs to enable bidirectional power flows between the charging station and EVs.

From a DSO point of view, energy storage as many other technologies can be used for:

- **Capacity support**, e.g. from peak to base load periods, to reduce maximum currents flowing though constrained grid assets.
- **Increase hosting capacity, e.g. for smart charging infrastructures in cities.**
- **Contingency grid support** to reduce the impacts of the loss of a major grid component.
- Distribution **investment deferral** to defer distribution infrastructure upgrades.
- Distributed **voltage support** to maintain the voltage profile within acceptable limits, which increases the quality of supply (less probability of black out or interruptions).
- Distributed generation to reduce the amount of curtailment in congested areas.
- Dynamic, local **voltage control** to maintain the voltage profile within admissible contractual or regulatory limits.
- **Limitation of disturbances** they may cause on upstream high voltage grids to contractual values.
- **Reactive power compensation** to the grid's reactive power balance.

GAS BASED RESOURCES

Power-to-Gas (P2G)[8] technology

The P2G technology provides an innovative solution by transforming surplus supplies of electricity from wind and solar sources into synthesized gas (SNG), a carbon-neutral gas that can be injected in full into the natural gas network.

The benefits of P2G technologies are:

- Transforming electric power into hydrogen or SNG allows the use of energy at any time – independent from its production – by using the well-developed gas infrastructure.
- The gas network is itself a large energy storage system. The transformed energy (hydrogen or SNG) can be stored in the grid and be transported when and where it is needed.

6. "grid-to-vehicle" or (G2V) is the availability of some batteries of electric vehicles to be discharged and feed power to the grid in addition to charging.
7. "Vehicle-to-grid" or (V2G) is the availability of some charging points to provide bi-directional charging, which means that for short periods the EV battery could also release electricity and feed it back into the grid.
8. Power-to-Gas refers to chemical energy storage, namely the use of electric energy to create fuels.

- Methane and hydrogen have a wide range of potential applications, including industrial use and fuelling heavy goods transport, which can be supported by distributing them through existing gas infrastructure.
- Peaks in RES-production can efficiently and sustainably be used by transforming this energy into SNG and hydrogen. RES-curtailment becomes less necessary and system stability is strengthened.

Combined heat and power (CHP)

Cogeneration is the simultaneous production of electricity and useful heat (combined heat and power "CHP"-systems). Usually, in other typical power plants, the heat produced in the generation of electricity is lost, often through the chimneys. Cogeneration plants, however, use this heat and can achieve energy efficiency levels of around 90%.

Large gas-fired CHP plants, typically located in the load centres (where electricity and heat are required), have the potential to be an important part of the energy supply of the future. They can be a relevant source of supply for district heating grids of metropolitan areas and contribute to safeguard security of supply of the electricity grids.

The Micro-CHP systems are currently powered by natural gas, biogas, bio-methane, bio-fuels or liquefied petroleum gas (LPG).

Micro-CHP appliances are similar in size and shape to ordinary, domestic boilers. So they can be wall-hung or floor-standing. The only difference to a standard boiler is that they are able to generate electricity while they are heating water.

First experiments on flexibility were focused on power solutions (e.g. batteries and curtailment) but new cases are currently investigated based on gas solutions. Indeed, recent and smart gas solutions like micro-CHP, hybrid systems or fuel cells can be used to offer flexibility services to the power network: micro or mini-CHP solutions can be monitored to offer local electricity production, hybrid solutions allows to trade-off between gas and power consumption depending on technical or price signals.

SECURITY
PRIVACY
PROTECT
SAFETY
DATA
STOP
TERRORISM

4. SOLUTION SPACE

This solution space can be seen as a DSO's 'toolkit' which can be used to assist DSOs to operate and plan their networks more 'flexibly'. The tool, or combination of tools, which a DSO is able to use depends on the regulatory framework in the country, the degree of decentralisation and the local situation. Each solution has its own advantages and disadvantages. Legislation should therefore be open to a range of models that enable DSOs to access and use flexibility, and to avoid only one solution but a combination of them. Irrespective of the flexibility model used, they should be financially viable for all concerned parties.

DSO TECHNICAL SOLUTIONS

A DSO will first use all the technical solutions at its disposal (i.e. that it owns) before using other solutions. The difference between technical solutions and other solutions is that technical solutions will usually not result in an inconvenience for the grid users, they are therefore not visible and the firmness is guaranteed. Overall the technical solutions could enhance the efficiency of the grid and the system.

These DSO technical solutions address technical problems such as voltage (V), current (I) and reactive (Q) problems in the distribution networks as shown in the **Table 1** below.

Table 1: Technologies to address "Q, V and I" problems in distribution networks

Category	Technology	Voltage	Current	Reactive Power
Core IT-Components	Metering/Sensors	Basic requirement		
	Communication			
	Control Center (SCADA)			
	Database			
Local smart components	Adjustable local grid transformers	X		
	MV-on-load tap changer	X		
	Reactive power compensation unit			X
	Battery storage	X	X	
Advanced smart grid control	Agent based intelligent P-Control	X	X	
	Wide area control for transformer stations	X		
	DSteady State transformers	X		
	Q-Control based on FACTS	X		X
	Low Impact Operation Mode	X		

Source: EWE NETZ GmbH (2016)

These technologies could be used as solutions to address specific problems in the distribution grids. Decisions should be made to determine the best solution economically available and to ensure the safety and reliability of the network.

Grid Reconfiguration

Reconfiguration in distribution networks refers to a change in the grid structure (in low voltage) by changing the status of the normal-open switches and some normal-close switches. This is done in order to operate the grid more efficiently and safely or more suitably for the delivery of power to customers. Opening or closing circuit breakers remotely is possible at the transmission level. This technology is also available at medium voltage level but in limited amounts compared to the transmission network. However, this is expected to change in the future and it will also become available at low voltage levels of the system. Remote operation of circuit-breakers also requires remote monitoring of the grid.

Reconfiguring a widely interconnected system is a daunting challenge. Most DSOs oversee large power generating units and important distribution lines through a Supervisory Control And Data Acquisition (SCADA) system. This system of sensors and controllers provides three critical functions: data acquisition, control of some grid assets, and alarm display. It allows operators who sit at central control station to perform limited tasks, such as opening or closing a circuit breaker.

The DSO forecasts congestion in different timeframes (year ahead, month ahead, week ahead and day ahead). Such forecasts will become more precise when more information becomes available like weather information or metering values. The expected congestion will first be prevented if possible through grid reconfiguration.

In the day-ahead timeframe, it is still possible to alter the predicted energy flows. If congestion is expected, it is still possible to reconfigure the grid.

In general, network capacity is mainly limited by:
- the maximum load on a distribution asset or parts of an asset (depending on the number of connections and the simultaneity of loads) and the respective current in points of the network/of the network components;
- the voltage-range limitations or impacts on existing connections (i.e. in terms of local generation); and
- security and safety margins to operate the distribution or transmission system close to or in real time after gate closure (red phase).

Grid-scale storage facilities

As explained in Chapter 3.2, energy storage can provide flexible solutions to solve grid related problems. Storage has become a key part of the new DSO 'toolkit' of flexibility solutions. However, offering and providing storage services, which can be bought by the DSOs, should remain a market activity. Nevertheless, DSO should be allowed to own and operate such devices for their needs to secure the technical operation of the grid within the approved regulated activities. DSOs should never provide services to the market by trading storage services or energy volume.

DSO TARIFF SOLUTIONS

Generally, a tariff solution is a solution to prevent congestion and not a solution to solve a congestion situation. However, through an appropriate network tariffs structure, network users could be incentivised to use the networks as efficiently as possible, for example, by charging their EVs slowly after midnight instead of fast charging during network peak hours.

Therefore, network tariff structures are needed that really reflect the cost incurred by the behaviour of the connected customer. The one who is inducing extra costs should pay more than today and more than the one who does not induce these extra costs. This principle incentivises the use, and increases the value, of flexibility. It can stimulate the development of devices and services that can help the customer to save money by using flexibility. A well-designed tariff can be the accelerator of the development of flexibility.

There are multiple elements of a tariff structure:

- **Tariff basis**
  - > Capacity: a capacity tariff reflects better the cost for the network. It can be the installed capacity or the used capacity;
  - > Energy consumption: an energy based tariff provides more stimulation to energy saving measures.

- **Timing**
  - > Fixed timing (e.g. discount if usage in evening peak hours, 17:00-19:00, is avoided);
  - > Dynamic (e.g. depending on the current state of the network / area / market)

- **Direction**
  - > Consumption;
  - > Production;

- **Location**
  - > A tariff structure per DSO area;
  - > A locational tariff.

These tariff structure elements can also be combined. The simpler a tariff structure is, the easier it is for a customer to understand, and the more effective it usually is. Most EU Member States currently have a network tariff based on used consumption. However this no longer correctly reflects the real costs of the network. The real costs are caused by the required peak capacity.

An example of an alternative, being explored by DSOs, is a tariff structure where the customer is given a certain symmetrical capacity bandwidth (e.g. -3 kW up to +3kW). For example, the monthly tariff of the customer depends on his agreed bandwidth. If the customer exceeds the bandwidth limits he is automatically charged with an extra fee. This way the customer is incentivised to stay as much as possible within the bandwidth of the agreed capacity and e.g. to charge an EV smoothly during night hours. The above is just one example of an alternative network tariff, many variations and other solutions could be discussed. Tariffs could for instance also give simple but effective signals to market parties to use the customer's flexibility in a network friendly way.

A well-designed tariff structure should stimulate the development of flexibility instead of blocking it. An example of a tariff structure that blocks the development of flexibility is 'net metering'. Net metering (or net energy metering) allows customers who generate some or all of their own electricity to use that electricity at any time, instead of when it is generated. Net metering could be applied monthly or annually. In general, the longer the period the lesser it stimulates the self- consumption of the customers own produced energy. Net metering puts the burden of stabilising the production and consumption at system operators and market parties and does not stimulate the further development of flexibility.

Most important of all is the need to further investigate the development of 'smart' network tariffs, i.e. with incentives to use the network efficiently.

CONNECTION AGREEMENT SOLUTIONS

A solution for DSO to prevent congestion is to access to flexibility through connection agreements.

Some DSOs are implementing connection agreement solutions, or similar forms of arrangements, in certain countries today. These models could be called 'variable network access', or might be designated by 'flexible network connection agreements', as well as various other names along the same theme.

If the right conditions are applied, these arrangements can help reduce network investments, and create a win-win situation between network users and the DSOs. For example: instead of planning the grid to provide generators and consumers with a firm physical connection to the grid 100% of the time, contractual agreements could introduce a variable network access or flexible connection agreement for certain generators or consumers. Based on financial incentives (e.g. cheaper connection costs) these parties could agree to limited access when the network is constrained. It should therefore be an option for grid users to subscribe to such a contract.

Moreover, the limitations to grid access must be transparent and predictable for grid users. This could be executed either via direct connection contracts between DSOs and generators/load or indirectly between DSOs and the flexibility service provider (FSP)[9]. Some forms of variable network access for generators already exist, e.g. in the UK (known as non-firm access), and the concept is also currently being experimented with in France.

Depending on their national circumstances, regulators can work together with DSOs to establish general criteria that the DSOs should follow when designing, implementing and through such connection agreements, in order to make the process transparent, objective and non-discriminatory.

The way to remunerate DSOs, and to ensure that customers benefit, should be properly designed by regulators in order to avoid endangering the economic sustainability of the regulated network tariff system. In doing so, such models are likely to remain beneficial for both the connected user and the DSO, and therefore, for the system overall. The type of connection agreement mentioned here may be mostly useful for large customers who can adequately value the right balance between the service that they can provide to DSOs, firmness, flexibility and price.

RULES-BASED SOLUTION

Another technique for enabling DSOs to access flexibility may be through rules-based solutions. By rules-based solution we refer to compulsory rules in network codes and regulation to impose flexibility technical requirements. An example could be that PV infeed is curtailed if certain technical limits are reached.

A rules-based solution can also be the result of a market failure and therefore should be seen as an exception. Such an approach can be justified when there are not enough voluntary offers to prevent a blackout. As a general rule, a rules-based solution should not be used where a market approach is viable.

A rules-based solution may for example prescribe limits of feeding in produced electricity when congestion occurs in the network. Potential compensation mechanisms for loss of revenue and loss of opportunity costs of providing flexibility from generators whose production is curtailed, should be determined by the regulator. For generators these costs include operation costs, foregone market revenues and potentially the costs for balancing responsible parties. For demand response, these costs are hard to determine. In addition, merely compensating parties with opportunity costs does not provide any specific incentives to provide flexibility.

The rules-based approach might be helpful if it imposes minimum requirements to enable flexibility in the system and provides a framework to allow and promote solutions. For example, the Network Code on Demand Connection already establishes minimum technical requirements for the provision of certain demand response services to network operators. The Network Code on Requirements for Generators could be seen as an enabler for generator flexibility services as they must fulfil dedicated technical requirements. Nevertheless, some of these network codes may need to be adjusted to adapt to the emerging realities of the networks.

9. Flexibility Service Providers (FSP) are market parties (suppliers, aggregators, ESCOs, ...) with a commercial role to purchase explicit flexibility from grid users and sell it to a Flexibility Requesting Party (FRP).

A rules-based approach resembles the traffic light concept. In the green phase, no flexibility services are required by the DSO, and in the orange phase flexibility services from customers and market parties are required. However, if there are not enough flexibility services offered a rules-based approach is needed to prevent a black-out (red phase).

MARKET-BASED SOLUTIONS

Market -based solutions can deliver cost-efficient and innovative solutions driven by competition for the provision of services when they are locally available. Market-based procurement can deliver cost-efficient and innovative solutions driven by competition for the provision of services. When there is sufficient availability (in numbers and volume) locally, market mechanism can be developed and be helpful.

A market mechanism provides the right conditions for several players to compete to provide the most efficient (flexibility) solutions to DSOs, this of course when a sufficient number of players are locally available to make competition. This approach also has large potential to trigger innovation and to benefit from standards established in existing energy markets.

There are several options to implement such a market mechanism, e.g. via a competitive tender or a market platform. For such a market, different flexibility service providers (FSP) [10] compete to provide flexibility services to the DSO. These services are called 'ancillary services' and refer to a range of functions which system operators may contract so that they can guarantee system security at best cost to the customer.

In order to implement that market, it is important to clarify how the interaction of market parties and network operators will be. The traffic light concept provides a concept for discussion as to how this interaction may be established. Using the logic of a traffic light, between the green market phase, in which the power grid functions for the marketplace without restrictions and the red phase in which the system stability is jeopardised.

In today's power grid, there is only the green phase (market phase) that can, in extreme situations, suddenly become red (grid phase). As the transition from one phase to the other will become increasingly significant in future, it is important to describe an amber intermediate stage, the amber phase - i.e. the interaction of market and grid.

The amber phase is entered if a potential network bottleneck exists in a defined network area. In the amber phase, distribution system operators call upon the flexibility offered by market parties in that network segment in order to prevent a red phase situation. This will generally be affected indirectly through measures agreed with suppliers/aggregators or in exceptional cases, should such measures be lacking, directly according to direct contractual arrangements.

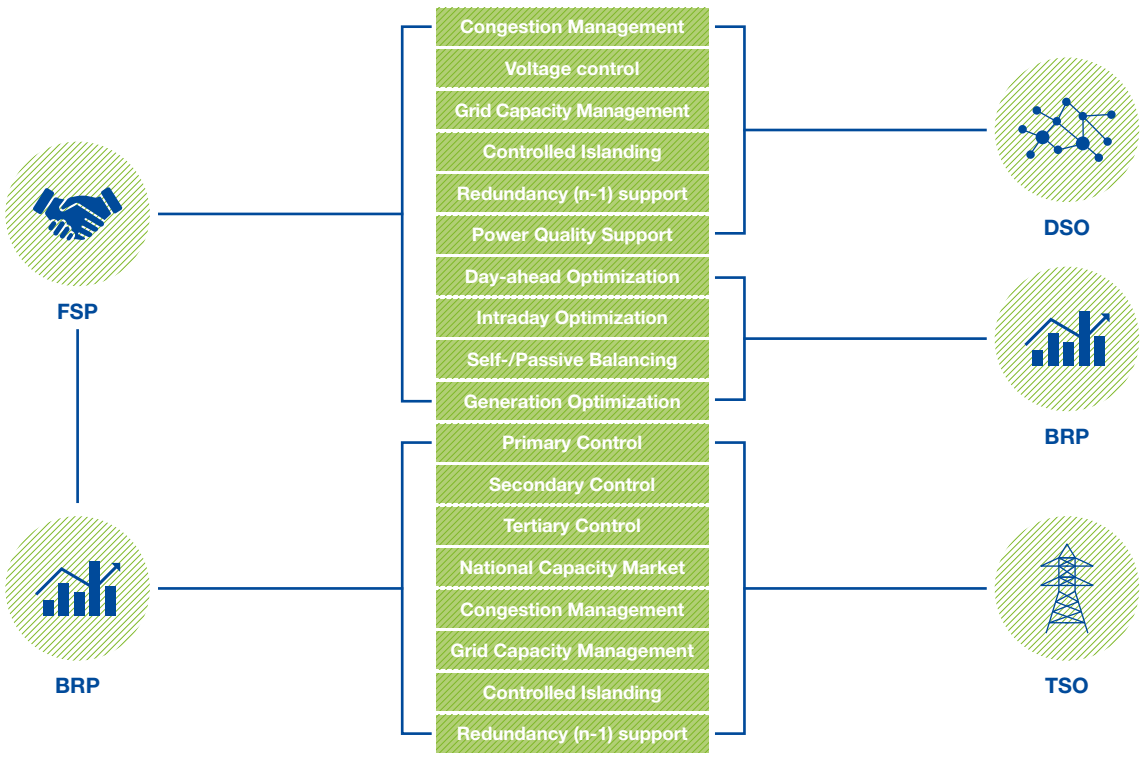
In this context, the involvement of the balance responsible party is necessary and a model for distributing the costs incurred should be found. The flexibility services providers must ensure that due accounting procedures are followed. Interventions during the amber traffic light phase are always associated with payment for the flexibility by the network operator.

10. Flexibility service provider is a market role which can be taken by a market party or an end user

As a result, network users can adjust their behaviour and profit from the contribution to securing system stability. On the basis of e.g. historical values and the up-to-date system forecasts, the responsible network operators report the forecast need for flexibility to the market participants with which it has contractual agreements for the right to utilise flexibility.

There exist different flexibility services and products that market parties could provide to DSOs in order to avoid a red phase. An example for that is coming from Universal Smart Energy Framework (USEF), in 2015. USEF published a paper[11] where an overview of the flexibility value model was depicted. Figure 2 provides an overview of the activities for which flexibility products and flexibility services are presented, and potential actors.

Figure 2: The solution space of flexibility services, possible buyers and sellers

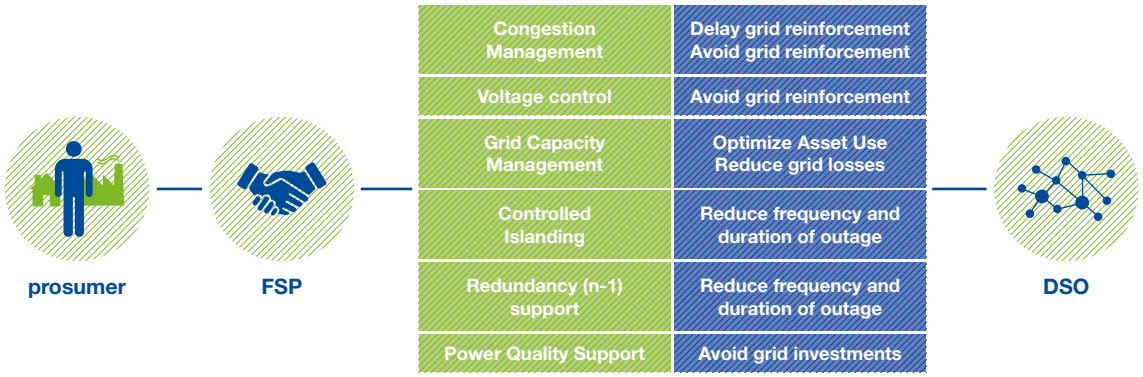


Source: USEF, 2015

11. http://www.usef.energy/download-the-framework/

Flexibility Service Providers could support the DSO offering a variety of services as illustrated in Figure below 3.

Figure 3: The solution space of flexibility services, possible buyers and sellers



Source: USEF, 2015

Service requirements

Ancillary services can include balancing services (system frequency), congestion management services, emergency and restoration services (e.g. black start services), provision of reactive power, voltage control services, etc. Each service can be bought separately, but it is interesting to investigate whether certain services can be bought in combination (e.g. combining congestion management services with balancing services), which is commonly known as stacking services. This is however not possible for all services due to technical reasons. Some services require a completely different product, such as reactive power services, which are not possible to combine with other services. Further details about combing the balancing market with the new distribution level congestion management are provided in Chapter 6.3 (procurement options).

Certain services are location-specific, such as congestion management and voltage control services. The location can cover a certain area of a city, an area serviced by a substation or even an individual street. Some services are emerging, for example solving congestion at distribution level, while some services are well established, like balancing services.

For system operators and especially for congestion, market-based solutions result in some big challenges: liquidity of the market and the firmness of the bids. A market-based solution therefore requires a clear product definition and preferably sufficient providers (liquidity). A liquid market is also a competitive market. More competition leads to lower prices and therefore lower costs to society.

The following actions can increase the liquidity of a congestion management market:

- **Infrastructure in place:** for example, if a standard smart meter can be used for measuring the delivered service no special measuring equipment is needed.
- **Standardisation of products:** general products that can be used for one or more services increase liquidity. The more buyers use the same product specification, the more providers are able to deliver the standard product.
- **Investment security:** higher investment security will attract more providers. This can be achieved with a high frequency of product requests. Product standardisation and generalisation also increases the frequency of product requests. Also, a long term contract with an availability reward will stimulate market parties to invest in providing solutions to system operators. Once a long-term contract is signed between a service provider and a system operator, the service provider has an obligation to deliver. Investment security can be increased if service providers can trade these obligations among each other.
- **Technology neutral:** if the product specification does not exclude certain technical solutions it is more likely that more providers will be able to offer their services.
- **Aggregation:** if a certain service request can be fulfilled by multiple units it is more likely that more providers can participate.
- **Portfolio bids:** if a service provider is not required to specify which unit will contribute, and the amount, to the request of a specific service, the service provider has more options to choose from. This will also increase the firmness of the bid. If a unit were to fail, another unit in that same portfolio can be used to take over the obligation to fulfil the request.
- **Larger area:** if a large area can participate in solving a congestion issue, it is more likely that more providers are able to provide their services.
- **It should co-exist well with the existing markets:** the activation of products should not have a negative impact on other markets or other parties in other markets.
- **Clear market timeframes:** it is attractive for service providers to participate in different markets. The timeframe for offers on the different markets must be aligned as much as possible between the different markets. It should also be possible for service providers to withdraw bids while the bid is not selected yet.
- **Low entry and exit barriers:** it should be easy (and cheap) to enter or leave the market.
- **Interoperability between different types of markets and regions** will increase the liquidity and efficiency

Since there are different system operators who buy services from multiple market parties for different purposes, a situation may arise whereby, for example, a TSO buys a balancing service from a balancing service provider which activates a unit in an already congested DSO area. Such situations should be avoided to the extent possible, or at the very least co-ordination must occur between the affected parties.

The firmness of a market-based solution is very important, especially for congestion with local consequences. Once a service provider has sold a service to a system operator, the system operator must be able to rely on the delivery of that service. If the service is not delivered, usually the service provider should incur a high penalty. The right balance must be found for the level of the penalty. Too high a penalty will result in more risk for the service provider. Keeping in mind that a unit can also fail because of technical problems, if the risk of a penalty is too high, the service provider will not enter the market. On the other hand, the penalty cannot be too low as the service provider will simply pay the penalty if he can earn more money with the specific unit in another market.

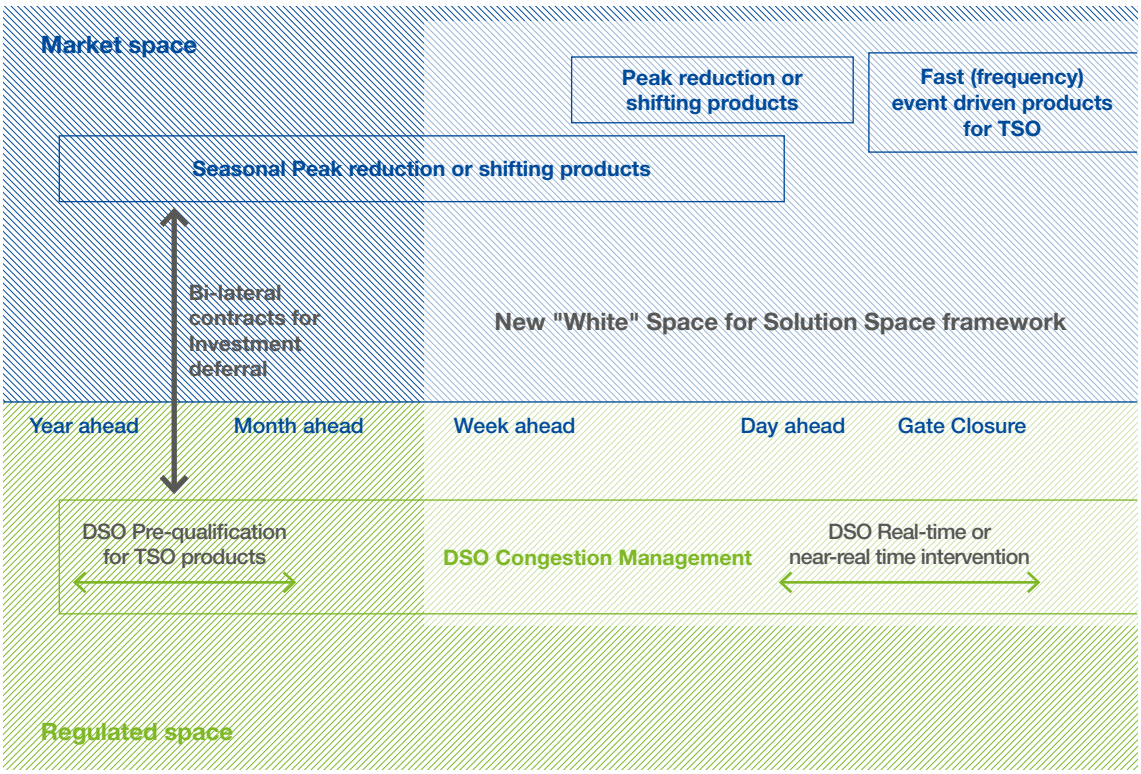
It is also worth mentioning that once flexibility is used by the DSOs, the market knows where grid constraints are present at that particular moment. Regulations should ensure that gaming by market parties through the unauthorised use of that knowledge is avoided.

Timeframes for congestion management

The solution space will necessarily span both the regulated space in which System Operators reside, and the un-regulated market space. It will also necessarily span a range of timeframes from potentially several years ahead up to real-time or near real-time. Some examples of this are depicted in Figure 4 below.

- Bi-lateral contracts between a DSO and large customers which deliver for instance, investment deferral, could run for periods of several years.
- Pre-qualification assessments for the participation of distribution connected customers in System Services for TSOs could run at a frequency which is synchronised with the procurement timeframes, which could be of the order of months.
- Within that, furthermore granular management of congestions arising from the activation of such services could be implemented at day-ahead or near real-time, if sufficient observability and appropriate systems are in place.
- Similarly, seasonal peak reduction or shifting products could be activated daily but over a longer period of say, winter months.
- Fast frequency or event driven products, by definition activated in real-time.
- A notional new “white space” for the implementation of congestion management with a suitable platform, involving regulated and market actors, is also shown graphically.

Figure 4: The solution space to foster markets and enable DSOs to facilitate power system functioning based on a traffic light scheme



Source: DSO Committee on Flexibility, 2017

5. ENHANCED TSO–DSO COOPERATION

Cooperation between system operators (DSOs and TSOs) in the electricity system will become more important in the future as electricity flows are set to change significantly. This chapter investigates the cooperation and the principles to govern required data exchange between TSOs and DSOs.

EVOLVING COOPERATION

The traditional electricity system was designed to transport electricity from power plants connected at the high voltage level of the system to consumers connected on high, medium and low voltage levels of the system. This is increasingly no longer the case anymore. In the future, a relatively high volume of electricity production will take place at the medium and low voltage levels of the system. This will have a significant effect on the future roles and responsibilities of system operators at all levels.

At the moment TSOs usually manage and operate the highest voltage level of the system while DSOs usually manage and operate the high, medium and low voltage levels of the system. However, the thresholds between high, medium and low voltage levels can vary between different EU Member States.

While a TSO usually deals with hundreds of large industrial consumers and producers, a DSO usually deals with thousands of mid-size commercial customers as well as millions of household customers. Today it is normal to have, at the distribution level, hundreds of mid-size producers (e.g. solar PV, wind turbines etc.) and hundreds of thousands of small producers (e.g. PV panels) active at the medium and low voltage levels of the system. These numbers vary in different Member States and regions. However, it is clear that in the future the production of electricity and the electrification on distribution level is set to increase.

As mentioned above, the electrical system was not originally designed with such distributed generation in mind, and this leads to significant stress at the distribution level of the system to cope with this new situation. Previous chapters have shown that DSOs will need more tools besides grid reinforcement to cope. However, stronger cooperation between TSOs and DSOs will also be needed to guarantee the current level of security of supply.

More and more balancing reserve capacity is moving from the transmission level to the distribution level. Since the balancing of the overall system is a TSO task, it requires access to the balancing reserve capacity located at the distribution level. This generally causes no problems, however sometimes problems arise in different time frames.

Each reserve category can cause its own problems.

- **Frequency Containment Reserves (FCR),** also called **primary reserves**, are activated very frequently and can cause frequency drops and peaks in the distribution grids.
- **Frequency Restoration Reserves (FRR),** also called **secondary reserves**, usually have a much higher energy volume and therefore can cause congestions. An FRR can be activated **automatically (aFRR)** and **manually (mFRR).** An aFRR is generally activated much more frequently and usually for a shorter duration period than an mFRR. An aFRR and mFRR can cause peaks besides congestion problems in the distribution grids.
- **Replacement Reserve (RR),** also called **tertiary control**, is used less frequently than FRR but usually has higher volumes of energy. RR in distribution grids can cause congestion problems.

These balancing services can be procured months in advance or close to real time while their activation is usually very close to real time.

Whether the TSO knows which units will be activated to balance the system depends largely on the product specifications of the balancing services and the design of the balancing market. If the design of the balancing market is portfolio based, the Balancing Service Provider (BSP) can decide which units it would like to activate in the imbalance area (usually this takes place at MS level). The BSP will use the cheapest units in his portfolio first. If the TSO does not know which units are activated it will obviously not be able to inform the concerned DSO.

In the new European Network Codes the concept of Significant Grid User (SGU) is defined. Each Member State should define its own thresholds for which users are considered as SGUs. SGUs which provide demand response services must inform the system operator to which the user is connected to, about their production or consumption plans.

CASCADING PRINCIPLE IN OPERATION AND DATA EXCHANGE

As described in the TSO-DSO data management report which was published by ENTSO-E and the EU DSO associations in September 2016[12], TSOs and DSOs agreed on three possible ways for TSOs to access data from users connected to the distribution grid:

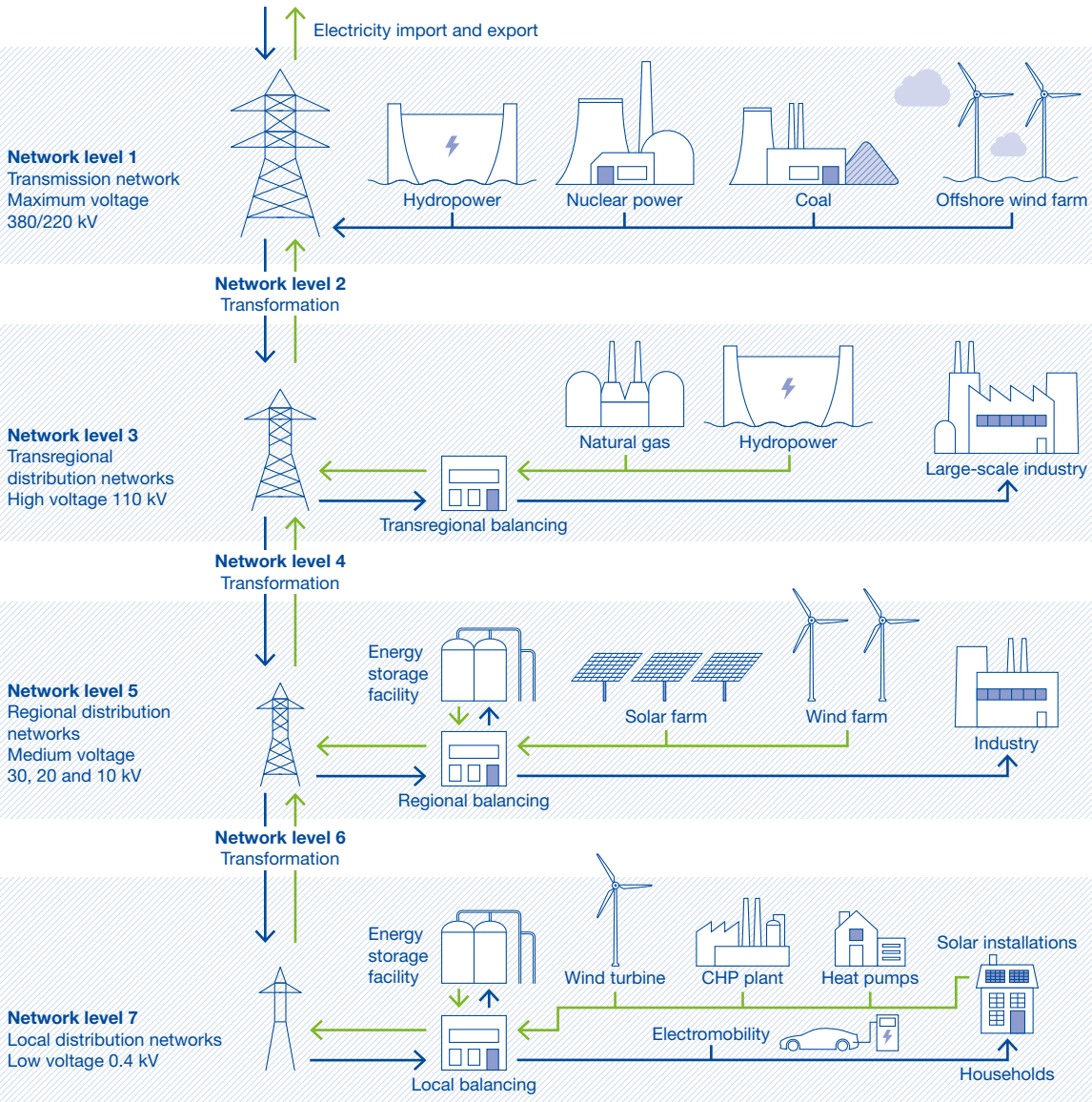
- TSOs could have access to the required data from a DSO-connected grid user through an aggregator or balance service provider. However, data integrity and visibility must be ensured for TSOs, DSOs and other market players.
- DSOs pass on relevant data in an efficient and timely way to the TSO (cascading principle).
- For specific needs and under specific conditions, discussed and agreed upon with DSOs, TSOs should be able to have access to this data through a direct technical solution of the TSO with DSO-connected grid users, without transferring the DSO metering responsibility.

As stated above, it is only in specific cases that TSOs should access directly data from distribution connected grid users, and those cases should be discussed and agreed upon with the DSOs. This is crucial, as the system gets more complex and more market participants are involved. Data exchange is crucial for the flexibility market and must fit to the decentralised market.

12. http://www.eurelectric.org/media/285585/tso-dso_dm_rep-2016-030-0382-01-e.pdf

The Figure 5 below gives an example of the complex layered (cascaded) and decentralised structure of the German electricity system.

Figure 5: Example of the complex layered (cascaded) and decentralised structure of the German electricity system



Source: Verband kommunaler Unternehmen (VKU), May 2015

It is clear that direct access to unrestricted data from DSOs' grid users without any further discussion or agreement with DSOs puts at risk the operation and security of the distribution system. This direct access is better known as the "non-cascading principle". This approach could also disconnect DSOs in information exchanges and reduces the ability of the DSO to intervene when transactions lead to congestion in distribution networks.

In addition to recommending that direct data exchange between TSOs and distribution connected grid users is to be avoided as an inefficient and insecure approach, we strongly recommend that any activation of a distribution connected grid user by a TSO is only allowed where control architectures ensure that the DSO has prior notification and a means of blocking any potentially damaging control signals. This is fundamental to ensuring the continued secure operation of the distribution system, while fully enabling and ensuring the promotion of flexibility sourced from the distribution system.

DSOs emphasise that most of the existing distribution connected grid users are currently not exchanging data, and if it is the case, it is mainly with their DSO. Also for (significant) grid users, especially the smaller ones connected to a distribution grid, it is more efficient if they only need to send the information once (to the connecting DSO) and not twice (to the DSO and TSO). Duplicated data requests can lead to out-of-sync situations or communication failures and enhance risks regarding data responsibility and quality.

The data format and implementation of the data exchange should be agreed upon by both the TSO and DSO, according to the System Operation Guideline Article 40(7):

"each TSO shall agree with the relevant DSOs on effective, efficient and proportional processes for providing and managing data exchanges between them including, …, the provision of data related to distribution systems and SGUs (significant grid users)".

Therefore, each Member State should decide how to implement the data exchange between SGUs, DSO and TSO.

A range of options are available which could prove the most efficient, including creating common data formats and collaborative sharing between DSOs and TSOs. It is unlikely that an EU-wide system could be agreed in the foreseeable future, so Member States should design their own systems while allowing interoperability with cross-border parties.

6. SERVICES ACQUISITION

This chapter explores how flexibility services can be acquired, the requirements that can be implemented, and the options that can be used for procurement.

REQUIREMENTS NEEDED FOR FLEXIBILITY SERVICE DEVELOPMENT AND IMPLEMENTATION

A flexibility product should be designed in a manner that makes it fit for purpose with the highest (expected) liquidity. In chapter 4.5.1, a list of possible actions for liquidity improvement is given. The product specification should find the right balance between these actions.

The DSO congestion management market should also fit into the current market design as much as possible. For example, a Balance Responsible Party (BRP) can be impacted by the activation of a congestion management service. If this is the case, the BRP should be compensated appropriately. If other market parties are also impacted by the activation of congestion management services, the market model should ensure that these parties are also compensated.

However, it is always up to the end customer to choose the service providers he wishes to contract. If the market model does not provide a solution for the compensation of impacted market parties, the risk is placed at the customer. This is only reasonable if the customer understands the situation properly and has several options too choose from.

For congestion management services, it is very likely that aggregation is vital to the liquidity of the market. To enable aggregation a special market role can be designed for aggregators, also called Flexibility Service Providers (FSP). This new market role should co-exist well with already existing market roles.

Designing a new market role for a FSP enables new and existing market parties to take up this role. This will likely increase the liquidity of the congestion management market. Creating a separate market role FSP also enables the possibility for a FSP not to take up the role of a BRP itself, but enables it to outsource this to an existing BRP. This could lower the entry barrier for new FSP market parties.

PRODUCT SPECIFICATIONS

Market products for the services procured ensuring effective participation of all market participants including RES, demand response, and Flexibility Service Providers (e.g. aggregators, suppliers, prosumers) should be created. The products must include the locational information. DSOs are committed to work with stakeholders to define the specifications required to guide market parties who will provide local flexibility products.

The specifications of a congestion management service can be classified into three groups. Examples of the various elements are provided below by way of illustration. It is possible that a specification can contain fewer or even more elements.

General congestion management product requirement:

- Minimum / maximum bid size (e.g. 1 MWh or 10kW)
- Minimum / maximum duration (e.g. 15 min / 60 min)
- Definition of congestion point (identification of the congested area)
- Bidding period: time granted to the market parties to offer bids.
- Selection period: time required by the system operator to select the bids which will be activated.
- Activation period: time before activation signal and ramp up period (1h, 15 min, 0 sec)
- Maximum ramping period (15 min, 5 min, …)
- Minimum full activation period (15 min, 30 min, …)
- Mode of activation (automatic, manual)
- Availability window (per day, per week, per year)
- Frequency: Maximum number of activations (per day, per week, per yaer)
- Recovery time: Minimum time between activations
- Recovery conditions
- Baseline methodology
- Measurement requirements
- Pooling allowed (Yes / No)
- Penalty for non-delivery (fixed or dependant on the bid size and/or duration, €10.000, €1.000, …)

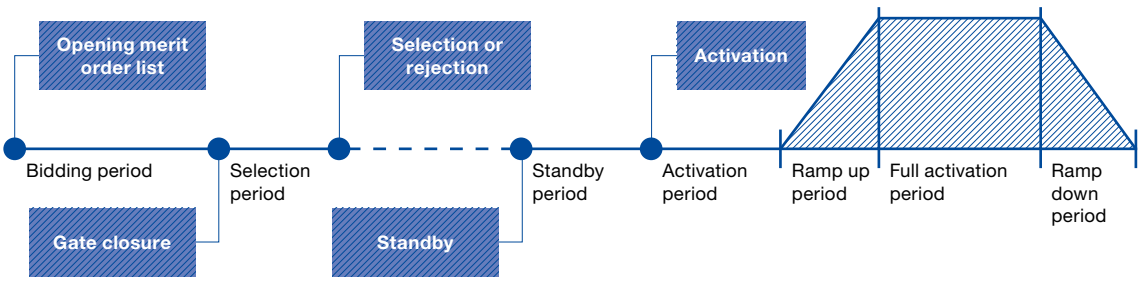
Congestion management request:

- Requested product (e.g. according to the product specifications, capacity, energy, …)
- Starting time (e.g. 12 January 2018 - 17:00h)
- Duration (e.g. 2h)
- Location (e.g. Nijmegen Noord)

Congestion management bid:

- Location(s)
- Starting time (e.g. 12 January 2018 - 17:30h)
- Duration (e.g. 30 min)
- Amount (e.g. 100 KW)
- Price (e.g. €20)
- Divisibility: possibility for a system operator to use only a part of the bid, either in terms of amount or time duration
- Minimum duration between the end of deactivation period and the following activation

Figure 6: Timeline congestion management service acquisition



In the Picture 6 above, the timeline of the congestion manageent service acquisition is explained. It starts with a request from the DSO for offers from the market. A merit order list is being opened. This list is open for a certain period (bidding period).

Example (only for illustrative purpose):

- Congestion is expected for the upcoming winter.
- The bidding period could start months in advance (opening a merit order list) and ends at gate closure time. For example after 4 weeks.
- The DSO needs, by way of example, 1 week to select the right offers. After that week the market parties are informed if their offer has been accepted or not.
- If the period is quite long, like in this example, selected market parties receive a signal whether their service is required or not for a certain day (standby signal). The longer this time is before activation the more opportunities market parties have to sell their service in another market.
- If the congestion actually occurs they receive (for example) 15/10/5 minutes before activation a signal to activate.
- Market parties need a certain ramp-up time to activate their resources (5/1 min). After the ramp up time the units delivers the full activation of their offer.
- When the offered energy or capacity is delivered market parties stop their units which require a certain ramp-down period (5/1 min).

The timing of the procurement is a crucial element of the service product specifications. If a DSO predicts that the consumption or production will raise above the safety limits of the grid which is installed, the DSO would traditionally plan to reinforce the grid if the reinforcement is reasonable. However the reinforcement work will take usually a considerable time because of required permits etc., and could take for instance up to four years or more.

Meanwhile, flexibility services can be used if new customers ask to be connected in shorter timeframes. If these new customers are connected, the DSO will want to ensure the delivery of flexibility to support the connections. This can be achieved if the availability of flexibility is contracted well in advance. While it is possible to buy the availability of flexibility through a tendering procedure, European tendering procedures require the tendering of all expected flexibility needs at once. This is not convenient for this process. It would be more convenient to tender for the new flexibility as and when there is more certainty of when it will be required.

PROCUREMENT OPTIONS

As discussed in the chapter 5.5.1, combining the balancing market with the new distribution level congestion management market could provide high liquidity for the congestion management market. However, this is not always possible.

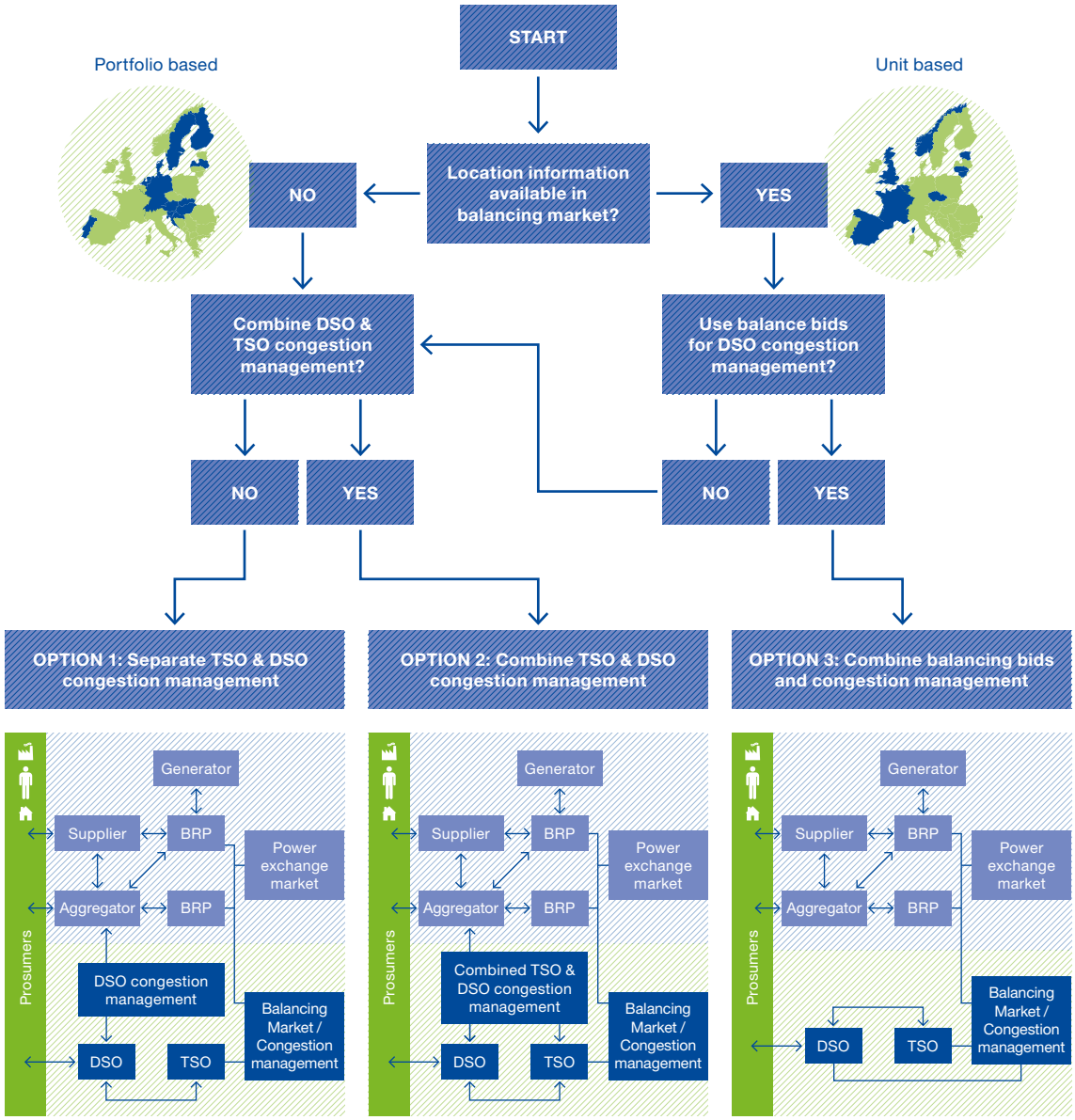
Depending on the balancing service procurement by TSOs in the European Union, we could distinguish between three different balancing processes which are in place in the EU.

- **Central dispatch:** central dispatch means a dispatch arrangement where the transmission system operator (TSO) determines the commitment and output of a majority of generation or demand facilities and issues dispatch instructions directly to them. For example in Italy, Poland or Ireland.
- **Self-dispatch - portfolio based:** a portfolio of generators follow an aggregated schedule of actions to start/stop/increase output/decrease output in real time. For example in Portugal, Germany, The Netherlands, Denmark or Austria.
- **Self-dispatch - unit based:** generators following their own schedules of actions to start/stop/ increase output/decrease output in real time. For example in France, the UK, Spain, Belgium or Norway.

In Member States with self-dispatch processes it is more likely that a market-based solution for congestion management is pursued. Where a 'self-dispatch unit based' balancing process is implemented, the balancing bids can in principle be used for congestion management because the location information is included in the bid. However, these balancing bids are usually only bids for units connected at transmission level.

Figure 7 below helps to understand better the different ways of procuring congestion management services based on the locational information. This includes the possibility of combining it with balancing, or the possibility of combining transmission and distribution congestion management.

Figure 7: Model overview for congestion management acquisition



If locational information is available in the balancing bids, which is the case in 'self-dispatch unit based' balancing processes; the Member State has the option to use balancing bids for congestion management. However, as explained above, these balancing bids are usually only bids for units connected at transmission level and therefore, a choice must be made as to whether the balancing bids serve the needs of the DSO for congestion management purpose.

When the units are connected on the medium and low voltage (mainly at the distribution level) they will have to be aggregated in order to participate in the balancing market. The aggregated bids are less suitable for congestion management purposes at the distribution level because locational information is essential. In order to use the same balancing bids for congestion management purposes at the distribution level strong restrictions to the aggregation area of the bids must be imposed or a very low threshold for the bid size must be possible. Therefore, combining DSO congestion management with TSO balancing services (option 3) is unlikely to be a sustainable solution into the future and is therefore not advisable. A separate market for congestion management purposes at the distribution level should be developed. This solution can satisfy both needs of DSOs and TSOs while minimising total system costs.

If the locational information is not available, which is the case for Member States with a self-dispatch portfolio based balancing process, the balancing bids cannot be used for congestion management purposes. This means that a separate market with its own merit order list (MOL) must be set up. Since it is possible to have a separate product specification for congestion management, independently of the balancing product specifications, it is possible to combine congestion management on transmission and distribution level (option 2). Such a measure could raise the liquidity of the congestion management market. This solution of combining congestion management services between DSOs and TSOs is only possible if the same (or similar) product specification can be used for solving congestion on transmission level and on distribution level.

Once a separate congestion management market is set up, a product specification for the congestion management services is required (product specifications were elaborated in chapter 6.2). Further analysis is required in this field.

If it is not possible to combine TSO and DSO congestion management markets, separate markets will have to be created (option 1).

Next to an independent market for DSO congestion management, a digital market model may arise. This digital market will consist in peer-to-peer (P2P) solutions that can use platform business models (most common) and blockchain business models (not very mature at the moment). A bottom up development should aim to integrate P2P business models, whether they are platform or blockchain based. Blockchain technology would probably be part of the back-office services before it is used as a business model. Blockchain technology is already in use today used very efficiently to exchange information not connected to currency.

The different options for the procurement of congestion management services have their own advantages and disadvantages and they all should be evaluated. It is up to the Member State to decide on the design and implementation of congestion management services for DSOs, however, EU legislation should be established to clarify the principles highlighted in this report.

It must be clear that the DSO should always be in control of the congestion management services in its system. If this DSO congestion management is combined with congestion management services for TSO, this should be placed under mutual governance. Further combining DSO congestion management with TSO balancing services is unlikely to be a sustainable solution into the future and therefore, it is not advisable even in those Member States with a unit-based balancing regime.

Coordination and information exchange between both systems operators is key to manage one single system. A market for congestion management for DSO should be integrated in the current balancing and congestion management market for TSOs. This must be done to avoid double flexibility activations at the same time, as well as any kind of activation of a distribution connected grid user by TSOs without any previous notification or means in place to block any potentially damaging control signal.

See below the advantages and disadvantages of each model.

TSO & DSO congestion management:

OPTION 1: separate DSO & TSO congestion management

Advantages

- Flexibility to change product requirements and timing: Products can be tailored for distribution level congestion management without taking care of transmission level specific requiremen
- Low entry barriers for small local market parties (aggregators): The product will be tailored for small local market parties like aggregators or Flexibility Service Providers.
- Clear governance: No agreement is needed between TSO and DSOs

Disadvantages

- Probably less liquidity (small markets): The markets are smaller. Market parties can only participate in the DSO congestion management market.
- Participation for aggregators on TSO and other DSO congestion markets is more difficult: Participating in the TSO market for congestion management result in other product definitions and other IT systems.
- Coordination between TSO & DSO is more difficult: Coordination between TSO & DSO requires an interface between different systems which should be updated constantly.

OPTION 2: combined DSO & TSO congestion management

Advantages

- More liquidity (leads to lower costs)
- Easy access for aggregators on allcongestion markets.
- Coordination between TSO & DSO is easier.

Disadvantages

- More difficult to agree on product specifications / requirements (governance)

OPTIONS 1 AND 2: Separate TSO balancing & (TSO and or DSO) congestion management market

The advantages of Option 3 can be seen as disadvantages of Options 1 and 2 and vice versa.

Advantages of Options 1 and 2:

- Flexibility to change product requirements and timing
- Clear congestion management costs
- Easier for aggregation / aggregators
- Low barriers for new entries
- Easier governance

Disadvantages of options 1 and 2

- Probably higher costs for congestion bids
- Less liquidity
- Possibly extra systems (e.g.: IT) for existing market parties

Between the choice of Option 1 (separate DSO congestion management market) and Option 2 (combined TSO DSO congestion management market) also advantages and disadvantages can be distinguished.

OPTION 3: Combining TSO balancing & TSO & DSO congestion management:

Advantages:

- **Cost of congestion bids:** Because congestion management bids can be merged with a well-established balancing market the cost for congestion management bids are likely to be low.
- **Liquidity:** The balancing market is well-established therefore the liquidity is high, however, the location can reduce the number of eligible providers.
- **Easy access existing market parties:** Existing market parties are familiar with this market therefore they have an easy access to the congestion management market.

Disadvantages:

- **Flexibility to change product requirements:** It is very difficult to change the existing products of the well-established balancing market.
- **Mixing balancing costs and congestion management costs:** It is difficult to distinguish costs for balancing and costs for congestion management. This is a problem if different parties have to pay the different costs (like BRPs and SOs).
- **Complex for aggregation:** By design unit based balancing systems are not designed for aggregation.
- **High barrier for new small market parties:** Usually the barriers for entering the existing balancing market is relatively high.
- **Timing:** Balancing is usually as close to real time as possible. This is not well suited for congestion management. Usually in congestion management it is preferable to have certainty the day before.
- **Complex governance:** Since the balancing market is well-established an agreement between market parties, TSOs and DSOs is more complex.

ANNEX

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