Demand Response at the DSO level

Enabling DSOs to harness the benefits of demand-side flexibility

Position Paper
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Introduction

The mission of Distribution System Operators (DSOs) is to operate and manage the distribution networks - quite heterogeneous throughout Europe - in a safe and secure manner. They are also responsible for developing the distribution grids to ensure the long-term ability of the system to deliver high-quality services to grid users and other stakeholders of the electric power system.

Traditionally, this mission has been carried out through adequate network planning. However, the profound transformation of the energy system that is currently taking place in Europe creates new challenges for DSOs to deliver their responsibilities in a cost-efficient and secure manner. A significant amount of renewable energy sources (RES) is already connected and is expected to multiply in the future. Furthermore, the amount of electric vehicles (EVs) and public charging stations will see a major increase in the coming years. These trends are coupled with exponential technology evolution that allows for decentralised energy sources to be connected at lower voltages, and at the same time, enables customers to interact with the market and grid conditions. The emergence of this new environment gives rise to the development of innovative and smart ways to operate the distribution network, so as to maintain system stability and to facilitate the energy transition. It is now clear that for the European grids to be able to support the decarbonisation of the energy cost-effectively and safely, more flexibility will be required. This is where energy consumers are moving to the centre of attention, with energy use representing one of the most valuable sources of flexibility that has remained largely untapped until now. DSOs can play an important role as flexibility users.

Demand-side flexibility can be introduced in the system through providing residential, commercial or industrial consumers with control signals and/or financial incentives to adjust their consumption at strategic times. It encompasses demand-side resources, such as loads, distributed generation and storage[1]. Various types of demand-side flexibility programmes, commonly known by the all-embracing term *Demand Response*, have been in use for over 40 years in different parts of the world. Within the 2030 EU policy framework, Demand Response is regarded as key tool to achieve the targets of at least 27% for both renewable energy and energy savings by 2030. Demand Response and consumer empowerment are understood as integral parts of the

[1] EC Smart Grids Task Force (EG3) Definition of Demand Response:

"Implicit demand response (also sometimes called "price-based") refers to consumers choosing to be exposed to *time-varying electricity prices or time-varying network grid tariffs* that reflect the value and cost of electricity and/or transportation in different time periods. Armed with this information, consumers can decide – or automate the decision – to use less electricity at times of high prices and thereby reduce their energy bill. Time variable prices are offered by electricity suppliers or network operators. Examples include *time-of-use tariffs, critical peak pricing,* and *real-time pricing.*

In explicit demand response schemes (sometimes called "incentive-based") the "freed-up/ shifted" electricity is traded in electricity markets or used for other purposes. Consumers receive specific remuneration to change their consumption upon request (using more or using less), e.g. triggered by activation of balancing energy, differences in electricity prices or a constraint on the network" EG3 Report: Regulatory Recommendations for the Deployment of Flexibility, January 2015.

Energy Union's action plan, as they increase security of supply, by reducing dependence on foreign imports and supporting renewable integration[2].

The first EU provisions on Demand Response can be found already in the Directive 2009/72/EC concerning common rules for the internal market in electricity. Three years later, the European legislator voiced its strong support for Demand Response in the Efficiency Directive (EED) 2012/27/EU enabling consumer participation in retail but also wholesale, balancing, reserves and other system services markets. With respect to distribution tariffs and their impact on Demand Response, the EED requires the removal of any incentives that might hamper Demand Response participation in balancing and ancillary services, and in particular, it states that distribution tariffs should allow suppliers to improve consumer participation in system efficiency. Moreover, the Directive asks DSOs to be incentivised to improve efficiency in their infrastructure design and operation, including relying on Demand Response; a requirement also stated in the Directive 2009/72/EC. EU Member States were supposed to transpose the Directive's provisions into their national laws by 5 June 2014. As a next step, the European Commission will start compliance checks on the basis of National Energy Efficiency Action Plans (NEEAP) already submitted by the Member States.

In addition to the EU Directives, the inclusion of Demand Response in the Network Codes and Guidelines represents a critical, positive step toward widespread consumer engagement in Europe. In particular, the Network Code on Demand Connection (NC DC) allows for aggregation of demand-side resources in prequalification. Furthermore, the Guideline on System Operation and the Network Code on Emergency and Restoration validate the role of TSOs and DSOs as enablers of Demand Response for system reserves, while the Draft Network Code on Electricity Balancing states that: *"pricing methods for each standard product for balancing energy shall strive for an economically efficient use of demand-side response and other balancing resources subject to operational security limits"* (Recital 13), that "[…] *the participation of demand-side response including aggregation facilities and energy storage [is facilitated]" (Art. 10.1h)* and that *"the terms and conditions for balancing service providers shall allow the aggregation of demand-side response […]" (Art. 27.4a).*

Although the aforementioned pieces of legislation are in the right direction for enabling Demand Response in Europe, additional provisions are now required to connect the dots and complete the regulatory framework needed to unlock the full potential of demand-side flexibility.

This paper illustrates the value of demand-side flexibility as a complementary and smart option in the management of the distribution grids and discusses the changes needed in the regulatory framework to incentivise DSOs to use Demand Response when it is a cost-effective solution. Consequently, the paper outlines a set of principles for customer engagement in Demand Response. Last but not least, it addresses the role of DSOs as users of demand-side flexibility and their relationship with the other actors.

[2] Brussels, 25.2.2015 COM (2015). Energy Union Package. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank. A framework strategy for a resilient Energy Union with a forward-looking climate change policy.

1. The locational parameter & value of demand-side flexibility for DSOs

System services and the relevant products that have to be procured by network operators can be differentiated in four major groups: frequency control, voltage control, system operations and system restoration after emergency situations. The location of the flexibility resources can be an important dimension for certain services provided to network operators. This is a factor to be taken into consideration when re-considering the future of our network systems.

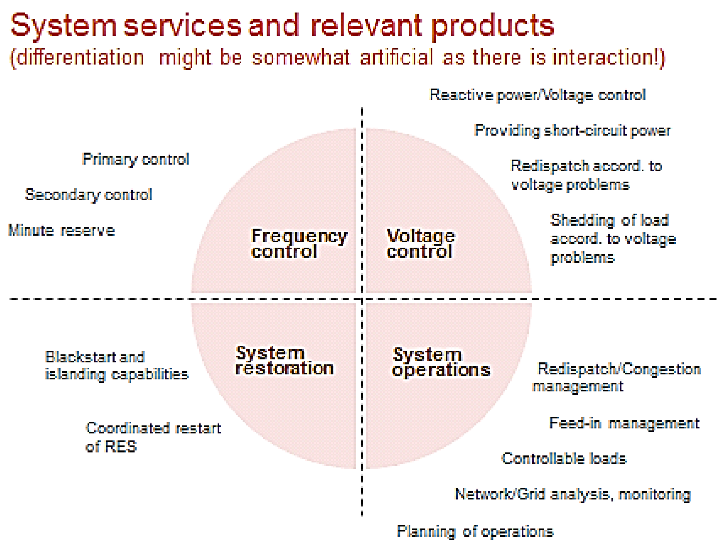

Figure 1: System Services and relevant products. Source: ADVANCED, 2014[3]

Frequency control, for example, falls in the realm of the "transmission system operators" (TSOs) today and is delivered through three dimensions defined in the Network Codes: Frequency containment reserves (FCR), Frequency restoration reserve (FRR) and Replacement reserves (RR). Frequency control is needed to keep the overall electricity system stable, i.e. to create a balance between electricity supply and demand at all times. Each TSO is responsible for frequency control in a given control area, but frequency has to be kept system wide. The location or spatial dimension of delivering this service is not very important, i.e. as long as the "source" of the reserve energy (e.g. a power station or participating load) is within the relevant control area and fulfils the technical pre-qualifications, it should be possible to provide such a system service from that source, from a strictly technical point of view. The same is true, if the reserve is used to balance a group within a control area.

[3] Deliverable 6.2 of ADVANCED: M. Miquel, M. Viana, S. Di Carlo, P. Frias, T. Schmid, R. Bachiller, O. Franz, 2014 "AD applied for system services primarily in LV-MV grids", ADVANCED project.

On the other hand, congestion management and voltage control are needed by both TSOs and DSOs. Here, unlike for frequency control, the location of the resources operated to provide flexibility services is an essential factor for the solution of the problem. Simply put, the closer the flexibility service is provided to the problem occurring, the more effective the service will be.

With regards to system restoration the services needed depend on the size and the duration of the outage occurred before the concerned network operators try to restart the system. Therefore, predefined restoration plans are necessary and emergency power supply has to be provided in order to guarantee a sufficient controllability. If a general black-out occurs, it is the TSO's responsibility to take care of the system restoration, in which they are supported by the DSOs. However, if a black-out occurs only in a distribution network area or subsystem, it is the DSO's responsibility to restore the system operation in that subsystem. Depending on the cause of the actual system failure and its size, different products will be needed by the responsible and concerned system operators.

1.1 The value of demand-side flexibility for DSOs

The possibility to make optimal use of the decentralised flexibility within their network would be a significant asset to help DSOs face the challenges of an evolving electric system. Network operators using demand-side flexibility will have a set of new tools to fulfil their mission. Before considering what are the changes in the regulatory framework that could enable DSOs to harness the benefits of demand-side flexibility, it is important to have a clear understanding of the value of demand-side flexibility for DSOs. The first question that this paper is to answer is thus: *How can DSOs benefit from Demand Response and where does the real value lie?*

1. Avoided or deferred investments in network reinforcement

Demand Response can provide a reliable way to relieve peaks in demand, compensate for large in-feeds from renewables and generally help to balance the system and stabilise the grid, deferring and in certain cases avoiding capital-intensive investments in reinforcement.

During demand growth, Demand Response can be used as a temporary or complementary solution for the management of the grid, allowing the DSO to defer investments in network reinforcement and thus giving more room for manoeuvre in the realisation of the financing. It can provide considerable option value, as it allows DSOs to defer making a commitment to invest in long-lived assets until they are sure that demand (or generation) growth is actually going to take place; For example, if demand decreases after a distribution network has experienced low voltage issues, DSOs relying on Demand Response instead of reinforcing the grid may have avoided making an investment in an asset that ends up being stranded. On the other hand, where demand is not expected to further increase, Demand Response can provide a sustainable and effective solution. Given the uncertainty of local demand and renewables' deployment in the long-term, deferring the need for expensive capital investments in distribution networks is likely to generate high value.

The extent to which demand-side flexibility can replace conventional reinforcement is determined by the local specificities (e.g. context of demand growth, increase of renewables in the energy mix, network characteristics etc.). Several studies have shown that the value of demand-side flexibility is case-specific. The examples below indicate the potential value of Demand Response:

The EU-funded Improgres project[4], realised between 2007 and 2010, demonstrated the benefits of demand-side flexibility for the integration of decentralised generation under four different scenarios in three distribution areas in the Netherlands, Germany and Spain. Of course, the benefits should be compared to the costs of deploying the smart grid infrastructure and activating flexibilities. Nevertheless, benefits are significant, as shown in Figure 2, which depicts the savings induced by the deployment of Active Network Management (ANM) in comparison with the business as usual (BAU) scenario i.e. passive behaviour of load and distributed generation (DG). With ANM the operational management changes: not all possible demand and generation situations are resolved in advance through network reinforcements, but a significant part of them are resolved in a smart way in the operational timeframe by means of ICT (Information and Communication Technologies)-related measures. In this way, bi-directional electricity flows can be controlled by measures such as condition monitoring, fault analysis and distributed generation curtailment etc. Furthermore, connected customers are enabled to contribute to optimal network operation by deploying their flexibility in either generation or consumption. The results vary significantly depending on the country and the level of DG developments, with the potential savings exceeding 30% of total distribution costs in certain cases. Here the savings encompass investment costs (CAPEX) and operational costs (OPEX) - the large majority of the savings concerns the first category.

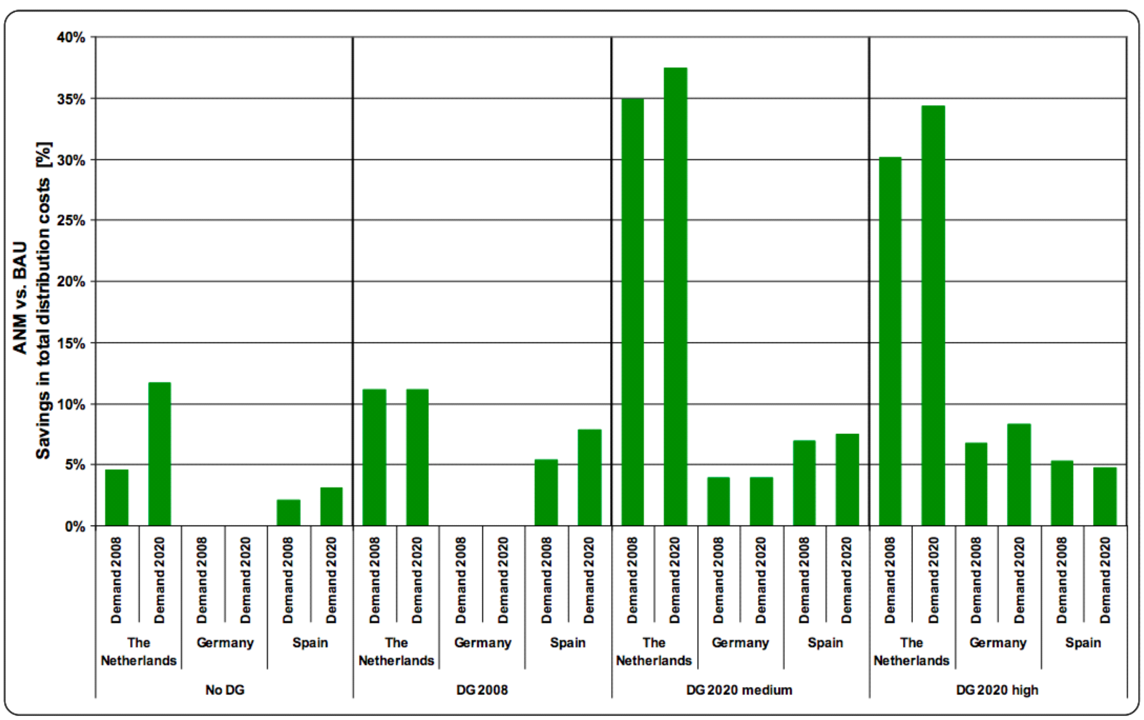

Figure 2: Savings in total distribution network costs after the implementation of advanced response options as compared to a BAU situation [%]. Improgres Project (2010).

[4] All details and available data are available at: http://www.improgres.org/

Another EU-funded project, MetaPV D3.4[5], compares the costs of a grid investment approach and a flexibility (PV reactive and active power and storage) approach, based on preliminary project data. The cost of the communication and control equipment is critical in the comparison. The research showed that where the equipment price dropped or was shared with other services, flexibility usage became the most economic approach to increase grid capacity up to 100%.

Electricity North West's project Capacity to Customers (C2C)[6] in the UK, funded by the Low Carbon Network Fund (LCNF), strengthened the evidence that in certain cases Demand Response can improve cost-effectiveness in the management of the distribution grid, delivering direct and indirect benefits to customers. By combining enhanced automation technology, non-conventional network operational practices (i.e. increased network interconnection), and commercial Demand Response contracts, Electricity North West together with its project partners managed to release a large part of the capacity of the EHV and HV circuits. The approach allowed to avoid (or defer) the cost and environmental impacts that are associated with traditional network reinforcement to accommodate future growth in demand and DG. These innovations were trialed on defined Trial circuits, representing approximately 10% of Electricity North West's high voltage (HV) system. Electricity North West's analysis shows that if the technical and commercial elements of the C2C Solution were adopted across the Electricity North West network, it would release 3.1GW of existing capacity on the HV networks, without reinforcement.

The total customer contributions for the standard solution were £7.84m, whereas the contributions required for the C2C Solution totalled only £0.37m. Therefore, the avoided reinforcement associated with new connections resulted £7.47m in savings for the customers.

The project showed that under high demand expectancy, the deployment of the C2C Solution in conjunction with traditional reinforcement forms an economically optimised strategy and has the potential to reduce total future HV network reinforcement costs (i.e. both customer and DNO funded) by approximately £50m. Under a lower demand requirement, the avoidance of future expenditure can be met with the C2C Solution delivering £60m of benefits. The project demonstrated that the C2C Method is highly transferable across Great Britain and will accelerate a low carbon future by releasing a significant amount of distribution network pre-existing capacity. This capacity can be used to play a significant part in meeting the UK's carbon emission objectives.

2. Facilitating planned maintenance and reducing losses

Besides the potential to reduce DSOs CAPEX, demand-side flexibility can also be used to reduce DSOs' OPEX:

- **Maintenance:** In order to ensure the network maintenance, DSOs operate planned outages. These operations take place during the lowest load periods in order not to affect electrical supply. Having access to demand-side flexibility, opens new ways of operational planning, which would not depend

[5] MetaPV, Deliverable D3.4: "Economic Evaluation of Grid Support from Photovoltaics: Methodology and Analysis." available online: http://www.metapv.eu/sites/default/files/PR_PR104283_D3.4_EconomicEvaluation_F.pdf (Based on preliminary data and assumptions. An updated version will be published in the final report).

[6] Electricity North West, "*Capacity to Customers Second Tier LCN Fund Project Closedown Report*", March 2015, p.7, available at: http://www.enwl.co.uk/docs/default-source/c2c-key-documents/c2c-closedown-report-v1-1-01-april-2015-.pdf?sfvrsn=4

on low-load periods anymore and would allow DSOs to optimise their operations according to their human and technical resources' availability.

- **Losses:** In certain countries, DSOs have an incentive to reduce losses. Joule losses depend on the square of the load; reducing power flows by a factor of 2 reduces Joule losses by a factor of 4. Demand Response programmes could reduce congestions and thereby contribute to minimising the network losses.

3. Smart Grids Societal Value

When assessing the value of demand-side flexibility it is important to take into account the overall benefits that Smart Grid technologies provide to the energy system as a whole, as the benefits often go beyond the distribution grid.

In 2012, a study[7] commissioned by the Dutch Ministry of Economic Affairs and conducted by CE Delft and KEMA assessed the benefits of Smart Grid deployment at the Dutch system's level according to different scenarios at horizon 2050. The measures assessed included innovative technologies in network management (i.e. communications infrastructure) ensuring that grid connections and grid components meet demand for power transmission and distribution in a smarter and more secure manner, including Demand Response. The study showed that Smart Grids deliver economic benefits, which ultimately translate to lower delivery prices and lower grid tariffs for residential/commercial customers and industry alike. The results were robust for various trends in the development of the energy supply: with and without climate policy, with a greater or lesser amount of distributed capacity, with or without central power storage, and with greater or lesser flexibility of central capacity. As it can be seen in the table below, these trends were clustered into three scenarios, all of which had a positive result in the Societal Cost Benefit Analysis. The three scenarios developed were:

a. Business as usual
b. Coal, CCS & Nuclear
c. Renewable & Gas

NPV (€ billion)	BAU 2050	C&N 2050	R&G 2050
Benefits	€ 7.1	€ 14.1	€ 12.5
Costs	(€ 4.6)	(€ 4.6)	(€ 4.6)
Balance (benefits-costs)	€ 2.5	€ 9.5	€ 7.9
Internal interest rate	13%	28%	31%

Figure 3: The Societal Costs and Benefits of Smart Grids. Source: Delft and DNV GL (2012)

The project highlighted that the extent to which demand will participate in the smart grid system will be the key factor in the overall societal benefits delivered. Below is a breakdown of the smart grid benefits per segment. The figure shows that in all scenarios the gain in network capacities (Transmission & Distribution) is the most significant, representing between 30-50% of the overall benefits of Smart grids.

[7] Delft and DNV GL, "*The Social Costs and Benefits of Smart Grids*", 2012, available at: http://www.ce.nl/publicatie/the_social_costs_and_benefits_of_smart_grids/1249 in Dutch, summary in English.

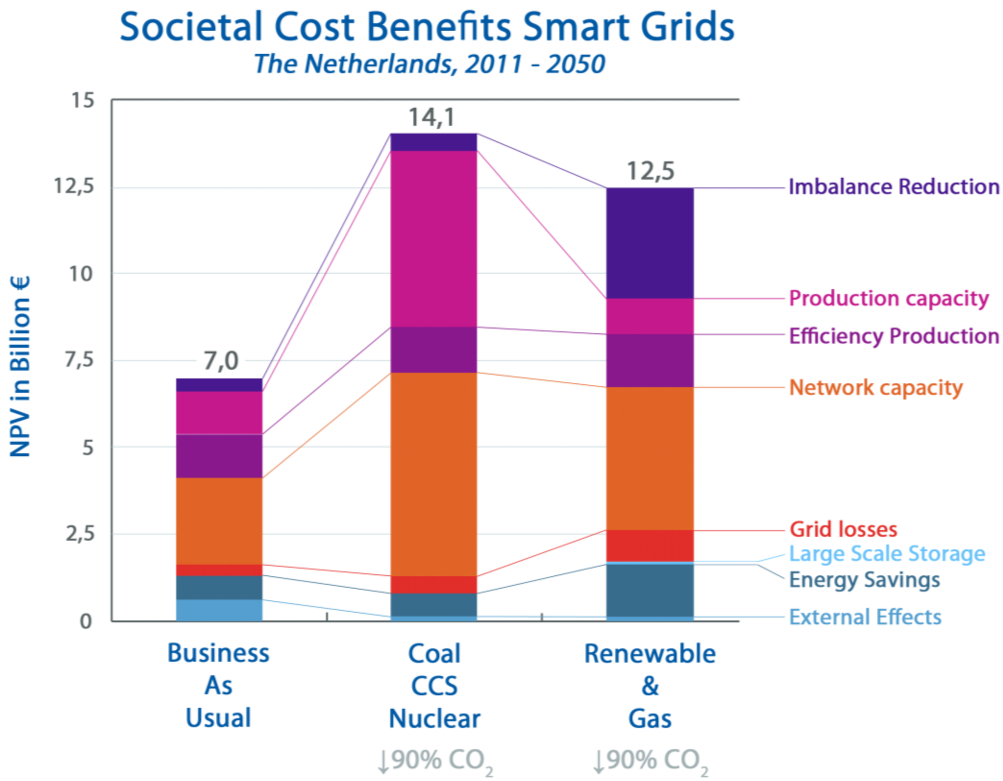

Figure 4: Breakdown of the Smart Grid benefits. Source: The Societal Costs and Benefits of Smart Grids. Source: Delft and DNV GL (2012)

1.2 Incentivising DSOs to make cost-effective use of demand-side flexibility

It is now a widespread agreement that Demand Response can be a reliable and, as described in the previous chapter, under certain conditions, a cost-effective solution, but the economic regulation framework in most European Member States still makes it more profitable for a DSO to pursue capital-intensive options. Even where the regulatory framework provides balanced treatment for equivalent supply and demand-side solutions - i.e. the DSO can earn an equal return from each - DSOs tend to favour traditional supply-side solutions. This is because they are more familiar with them, and so perceive them as less risky. Experience with demand-side solutions can help here, but it is mostly a matter of cultural change. To drive this cultural change, National Regulatory Authorities (NRAs) should incentivise DSOs to actively manage the grid in order to achieve cost-sensitive and future proof integration of distributed energy resources and grid modernisation - progress in which DSOs should be monitored. For DSOs to consider alternative options to network expansion, the revenue setting (price control) should be revised to incentivise an approach to network management that considers the total costs and benefits to the system and undertake the optimal mix of capital (CAPEX) and operating (OPEX) expenditure. In a similar manner, market structures that allow market participants to make a profit out of maintaining an optimal grid operation will help spread the investment burden.

An interesting example of regulatory framework that sets incentives for driving innovation at the distribution level is the one put in place by the NRA in the UK, Ofgem. Ofgem's network price control is based on a new methodology called RIIO-ED1[8]. It sets the outputs that all DSOs need to deliver for their customers and the associated revenues they are allowed to collect. This framework setting price controls for network companies was designed to ensure an increased attention to stakeholders, efficient investments, innovative strategy to reduce costs and delivering of environmental objectives. In its final assessment Ofgem estimates the potential savings from Smart Grid over the period 2015 – 2023 for the entire distribution network at £ 963 million[9].

Value of smart grids and other innovation adjustment over RIIO-ED1

DNO	Embedded benefit (£m)[39]	Adjustment (£m)	Total smart saving (£m)
ENWL	-66	-8	-73
NPgN	-39	-21	-60
NPgY	-52	-21	-74
WMID	-43		-43
EMID	-69		-69
SWALES	-20		-20
SWEST	-33		-33
LPN	-51	-29	-80
SPN	-54	-22	-76
EPN	-73	-53	-126
SPD	-25	-55	-80
SPMW	-20	-60	-80
SSEH	-28	-14	-41
SSES	-69	-39	-109
Total	**-641**	**-322**	**-963**

Figures are rounded.

Figure 5: Value of Smart Grids and other innovation adjustment over RIIO-ED1

Figure 5 shows the savings attributed to innovative solutions in the different DSOs' plans presented to Ofgem for the RIIO-ED1's period. It encompasses savings made in "*reinforcement*" and "*other areas of costs*" (asset replacement and refurbishment, trouble-call and *occurrences not incentivised* (ONIs), inspection and maintenance, operational IT and telecoms).

RIIO-ED1 may not be directly applicable in other European Member States, given the differences among European countries in the number, size and activity profile of DSOs, as well as in the technical characteristics of distribution systems and the challenges facing each network operator (especially variable RES electricity

[8] The acronym stands for: Revenue = Innovation + Incentives + Output. RIIO-ED1 covers an eight-year period, from 1 April 2015 to 31 March 2023. More info on Ofgem's website: https://www.ofgem.gov.uk/network-regulation-riio-model/riio-ed1-price-control

[9] Ofgem, "*RIIO-ED1: Final determinations for the slow-track electricity distribution companies Business plan expenditure assessment*", 28 November 2014, available at: https://www.ofgem.gov.uk/publications-and-updates/riio-ed1-final-determinations-slow-track-electricity-distribution-companies, p. 137.

generation connected to distribution networks). There is no single approach for incentivising DSOs, hence it is important that the Member States and NRAs are responsible for developing their own methodology to incentivise the cost-effective use of smart options.

2. Enabling end-customers to provide demand-side flexibility

The conceptual transition from a centrally controlled power system with vertical, unidirectional structure to a decentralised and bidirectional one is based on a profound change in the role of the end-customers and the way they perceive energy use. Increasingly, costumers want to understand and optimise their electricity consumption, as well as actively participate in Demand Response programmes.

Customers are not a homogenous group with uniform needs and behaviour, thus not all can be incentivised by the same Demand Response programmes. For example, on the one hand, residential customers are generally not very receptive to participate in Demand Response programmes if their convenience is to be disturbed. Therefore, residential programmes should be designed in such a way that does not put households in front of a dilemma to choose between providing flexibility and convenience[10]. On the other hand, large industrial customers often decide to engage in a Demand Response programme based on purely financial incentives. When customers are offered a Demand Response programme that is suitable for them, the odds of them becoming flexibility providers increases significantly. Therefore, Demand Response programmes and technology alike have to be designed to accommodate the differences between residential, commercial and industrial customers.

- Customers need to be aware of their flexibility potential and should be able to evaluate easily the different offerings. They should be also educated to understand their choices on price, on information and on automated tools. When designing Demand Response programmes, attention must be paid so that the offerings are simple and transparent.

- It is essential that demand-side flexibility is provided on a voluntary basis and that the flexibility providers are properly rewarded for their service. The compensation of customers should be market-based and market-driven, thus reflecting the quality of the service itself. Customers providing flexibility should be compensated on the basis of an overall savings approach (including grid fees etc.).

2.1 Smart Metering & Data management

Making the most of consumption data will be the key to a transition towards a sustainable energy system. Empowering customers to access their own data in a timely and user-friendly manner, as well as share their data with third parties of their choice, will spur innovation and competition, resulting in significant consumer and system benefits. Safeguarding the customers' rights to privacy and ensuring cyber-security should be a priority area for regulators and policy-makers[11]. Customers have a right to be given information regarding the

[10] Advanced technologies, are economically accessible today, coming out continually and making Demand Response ever more viable. Smart technology enhances the potential of domestic and small commercial consumers to engage in demand-side programmes.

[11] Joint ACER-CEER response to the European Commission's Consultation on a new Energy Market Design (2015).

way their data is accessed and used, to have clear information about the choices they have over the way their data is collected and used, and to have convenient opportunities to exercise those choices. It is important to find a balance between having the rich data available from the implementation of smart metering put to best use for customers and avoiding costly requirements to show extensive information on the meter display.

Different approaches exist for the management of data and the related roles. Any model chosen must be scrutinised by the NRAs before its implementation in respect to its cost-effectiveness, its capacity to guarantee data privacy and cyber-security, as well as its ability to be future-proof.

Today, in most European Member States DSOs are responsible for the collection of metering data on consumption. When DSOs have data directly from smart meters, they should have a special responsibility to act impartially and to make available necessary data to other parties, while respecting data protection legislation. When responsible for providing such data to other parties, as authorised by regulators or customers, DSOs should be responsible for providing good quality data (i.e. complete, correctly identified and accurate). Eligible entities should be able to access commercial data in a standardised format that is provided with sufficient frequency, timeliness, granularity and reliability to facilitate the provision of permissible products and services.

It is important that data handling systems track eligibility for access to data by data type and by authorised party. This will allow each of the different stakeholders to be sent only the data which they are entitled to receive, according to applicable regulations or consumer authorisation. To track such eligibility, the entity managing the data will have to know who the consumer is, because the consumer will control who receives their commercial data beyond the DSO and the Retailer (for billing).

Data exchanges will be key for the system and communication protocols, and thus standards have to be chosen, guaranteeing security for all parties and functions. Communication architectures and interfaces should be standardised in order to benefit from scale effects, to overcome technical barriers and to give flexibility programmes the chance to reach substantial size. The current issue of standardisation, having no suitable standards and technical rules available in some fields makes the landscape of demand-side flexibility utilisation, technology integration and Smart Grid complex, hard to adapt to and expensive. Development and adoption of common standards would most certainly reduce costs of available technology, speed up customer acceptance and, consequently, technology deployment. Last, but not least, it should always be ensured that standards do not hamper, but rather foster interoperability and certification of deployed solutions with regard to device authentication and identification.

2.2 Incentivising customer participation in explicit Demand Response programmes

Most customers need help from an aggregator to efficiently offer their flexibility services to DSOs. Aggregators “aggregate” customers’ flexibility, to “build” reliable Demand Response services: they negotiate agreements with industrial, commercial and residential electricity customers to aggregate their capability to reduce energy and/or shift loads on short notice. They create one “pool” of aggregated controllable load, made up of many smaller consumer loads, and sell this as a single resource. These loads can include fans, electric heating and cooling, water boilers, grinders, smelters, water pumps, freezers, etc.

Aggregation services can be provided either by an energy supplier or by an independent aggregator. The independent aggregator represents a new role within European electricity markets. The introduction of this role into a market creates critical momentum around the growth of Demand Response. Competition between service providers will drive innovation and attract private investment. Defining the role and responsibilities of the independent aggregator is therefore not an end in itself; rather, it is important due to its positive outcomes.

The aim of a programme design for services to the distribution system should be to allow as much participation as possible, while meeting the needs of the DSO. In order to develop the most effective and efficient Demand Response programmes, the capabilities of customers have to be taken properly into account. The figure below illustrates a range of choices when designing Demand Response programmes and how different choices impact on likely levels of participation by the demand side.

Figure 6: Range of choices of demand-side programme design. Source: EnerNOC

DSO needs often differ, depending on the kind of problem on the network. For example, in some networks, the key issue may be peak demand during hot summer or cold winter days. In other networks, the large in-feeds of renewables may cause stress for the network. It is therefore important to be clear on the purpose of the programme upfront. It may be advisable to develop a number of different programmes for different DSO needs, instead of designing a one-size-fits-all programme.

For example in New York, US, the distribution system operator “ConEdison” has designed two programmes for different needs: a Distribution Load Relief Programme (DLRP) and a Commercial System Relief Programme (CSRP). The DLRP is a contingency program with only 2 hours notice period that can be activated between 6am and midnight. In contrast, the CSRP is a peak shaving programme that is driven by heat and therefore predictable. It has a notice period of 21 hours, and activated for a four hour fixed call window based on location. These two programmes serve different needs and will attract different kinds of customers to participate.

2.3 Distribution tariffs & demand-side flexibility

Network tariffs should contribute to fostering the provision of flexibility. Network tariffs and all other market vehicles (contract, national market, etc ...) should be considered as complementary levers that should aim at increasing incentives to meet the system needs in a context of increasing variability.
However, in some European markets, network tariffs are designed in a way that inadvertently discourages the provision of flexibility (e.g. German distribution tariffs encourage large C&I customers to keep their consumption stable, and thus indirectly “penalise them” for participating in Demand Response programmes)[12]. Incentivising flat consumption through network tariffs was a sensible approach for system optimisation when the electricity generation was also predictable and stable. Today, with increasing variable and distributed generation in the energy mix, it becomes more efficient to consider DSOs’ asset optimisation in line with the system’s optimisation. Therefore, in this new context, distribution tariffs should serve two missions:

1. Ensure full cost recovery for DSOs; and
2. Contribute to the overall efficiency of the system.

To this end, NRAs should ensure that distribution tariffs allow customers to actively respond to wholesale market signals and/or participate in TSO-led programmes, contributing to the overall efficiency of the electricity system. As a first step -and in accordance with the Energy Efficiency Directive, Art. 15.4- distribution tariffs should certainly not hamper Demand Response.

[12] Stromnetzentgeltverordnung” (StromNEV), §19 (2).

3. DSOs as users of demand-side flexibility & their interaction with the other actors

As the bulk of electricity consumers are connected to the distribution grid, DSOs have an important role to ensure that decentralised resources -including demand-side resources- can reach the market. To this end, the DSO should provide a transparent and non-discriminatory access to its networks to all users and for all its products, whatever their physical source (generation, storage, demand response, etc.) or the actor (suppliers, aggregators, etc.). To ensure the necessary neutrality, it is fundamental that the DSO is effectively unbundled, as per the Electricity Directive 2009/72/EC.
DSOs can procure demand-side flexibility through various different economic vehicles (e.g. at the planning and connection timeframe through a call for tender[13], through distribution tariffs and/or from a local distribution constraints market). Irrespective of the vehicle(s) developed, it is essential that the market design for the procurement of demand-side flexibility complies with the DSO’s regulated and market neutral activity and fulfils transparency obligations.

Regulators should ensure that, where possible, DSOs procure demand-side flexibility from the market and do not operate into the area of competitive demand-side services. As explained in CEER’s conclusions paper on the future role of DSOs, the reasoning behind this is twofold: firstly, competition is considered the best means of meeting customer demands in the most cost efficient way; secondly, the DSO has a low-risk profile due to its core monopoly activity and the fact its costs are normally covered by regulated tariffs[14].

A market centralising offered local flexibilities in order to solve specific network constraints on the distribution grid could be an option that may facilitate the provision and selection of these flexibilities in a cost-effective and technically feasible manner. Such a market must be carefully designed to fit the DSO's granularity in terms of location, power and format, to allow sufficient value locally in order to enable the offer of flexibility to emerge, all whilst remaining cost-effective. There are two ways to organise a market for local flexibility:

1. An extension of the existing TSO balancing market, or
2. An independent market mechanism (but coordinated with the established markets).

The advantage of the first option (i.e. extension of the TSO balancing market) is that it allows grid operators to use a unique national market platform. The use of such a unique platform facilitates the cooperation between grid operators and ensures that the activation of a service delivered on the distribution grid takes place in coordination with the relevant system operator of that grid. Additionally, the use of a unique platform could

[13] An example is the “non-firm grid access contract with power limitation“. The objective of the service is to offer new types of connection options. These new connection options are characterised by a temporary active power limitation (such as non-firm access), different from a firm connection offer. This offer is provided to grid users in exchange for reduced connection costs and time. EvolvDSO, D1.4 – Assessment of future market architectures and regulatory frameworks for network integration of DRES – the future roles of DSOs.
[14] CEER (2015). Conclusions on the Future Role of DSOs.

simplify flexibility needs and procurement efforts (e.g. in situations when an overlapping of flexibilities needed for transmission and distribution system level occurs). In sum, the use of a unique platform can promote a more efficient use of flexibilities and flow of information (i.e. DSO-TSO cooperate in order to pool resources and avoid conflicts).

A common framework for demand-side flexibility by TSOs and DSOs will be central for enabling investment. Such framework could include the processes related to requesting, bidding, accepting, activation payment and settlement of flexibility, common measurement methodologies, as well as standardised signal infrastructure between TSOs, DSOs and market participants. Finally, given that wholesale and balancing markets are operated differently in European member states, it will be important in the long-run to reach a certain level of convergence and harmonisation on a European level.

3.1 Ensuring safe integration of Demand Response

In the future, as the energy transition progresses and the penetration of renewable energy sources increases, market prices will become more volatile. In this new context -and provided that prices reflect scarcity and abundance of energy properly- part of the customers are expected to start adapting their behaviour to price signals. It has been argued that this change in circumstances could encourage a part of the load to move simultaneously to low price points, potentially contributing to a congestion issue on the distribution network. It should be noted that for demand-side flexibility to contribute to a congestion problem at a given distribution network, very high levels of Demand Response must be assumed. It is therefore essential that relevant assessments are based on realistic projections. That said, even if Demand Response reaches significant levels in certain areas, well-designed coordination mechanisms and cooperation among the actors will ensure that Demand Response not only does not put the distribution system at risk, but in fact, it enhances system security and improves efficiency.

The key to avoiding local congestions associated with Demand Response is found in **appropriate data exchange** and in **clarification of the roles and responsibilities of all the involved actors.**

Data exchange: When there is a potential risk on distribution grid associated with Demand Response, all involved actors should be responsible for providing the DSO with the data necessary for the safe and secure operation of the distribution grid on a *need to know* basis. This information will help in the relevant simulations and network calculations, which will lead to the detection of constraints and the selection of appropriate measures. Where data exchange is essential, all the involved actors should be responsible for providing the best possible data to support the DSO in its responsibilities, but no one shall be made responsible neither for the exhaustiveness nor for the accuracy of such data.

Roles & Responsibilities: The interactions between DSOs, TSOs and wholesale markets, all of which are potential buyers of Demand Response, should be clearly defined. Generally, where Demand Response is sold to parties other than the DSO (e.g. the TSO, or wholesale markets), the resulting dispatch tends to lessen any congestion on the DSO's network: at times of high demand, Demand Response activations are most likely to reduce power flows on distribution networks; at times of high variable decentralised generation, demand increases are likely to reduce power flows in distribution networks. However, in some circumstances, it is possible that Demand Response activations for TSO or wholesale market purposes could exacerbate congestion on a DSO's network. To avoid such cases, clear coordination rules between the TSO and the DSO should be put in place.

TSO – DSO coordination: TSOs must be cognisant of the security of the distribution system, and the DSO's instructions in this regard, when dispatching Demand Side Units (DSUs). Similarly, taking in consideration that the TSO is in charge of the security, energy balancing and frequency control of the whole power system, it should be informed of any DSO request for Demand Response services, which could have impact on the electricity system operation (and also on the transmission grid).
TSOs should put in place measures to ensure that a DSU is dispatchable up to the Demand Response not associated with distribution system security issue. However, it is not appropriate that a congestion issue that only manifests itself under certain conditions should restrict the TSO's ability to dispatch DSU under all conditions, especially when those conditions are unlikely to occur, or occur only infrequently. The DSOs must therefore clearly identify the conditions under which a Demand Response activation may cause a congestion issue and develop a set of instructions, which can be applied by the TSO to avoid dispatching a DSU under conditions where a potential risk to system security exists. Any such instructions should be fully justified, published and the potential risks to system security clearly explained.

Eventually it is the DSO's responsibility to buy flexibility services to manage the congestion. Consumers own their flexibility – within the limits given by their connection agreement – and they should be free to sell it into any market or to any buyer of their choice. If an arrangement is made whereby a DSO can prohibit a consumer's dispatch in exceptional circumstances, then the affected consumers should be compensated for their lost revenue.

Summary - Key Recommendations

The locational parameter

- In certain system services, such as congestion management and voltage control, the location of the resources operated to provide flexibility services is an essential factor for the solution of the problem. This is a factor to be taken into consideration when re-considering the future of our network systems.

The value of demand-side flexibility for DSOs

- Demand-side flexibility can provide a reliable way to relieve peaks in demand, compensate for large in-feeds from renewables and generally help to balance the system and stabilise the grid.

- In doing so, it can help DSOs to defer and, under certain conditions, even avoid capital-intensive investments in reinforcement (CAPEX). Demand Response could also help DSOs to reduce their operational costs (OPEX) by opening new ways in the planning of outages and by reducing technical losses on the distribution networks.

- The extent to which demand-side flexibility can replace conventional reinforcement is determined by the local specificities (e.g. context of demand growth, increase of renewables in the energy mix, network characteristics etc.). Several studies have shown that the value of demand-side flexibility is case-specific.

Incentivising DSOs to make cost-effective use of demand-side flexibility

- National Regulatory Authorities (NRAs) should incentivise DSOs to actively manage the grid in order to achieve cost-sensitive and future proof integration of distributed energy resources and grid modernisation - progress in which DSOs should be monitored.

- For DSOs to consider alternative options to network expansion, the revenue setting (price control) should be revised to incentivise an approach to network management that considers the total costs and benefits to the system and undertake the optimal mix of capital (CAPEX) and operating (OPEX) expenditure.

Enabling end-customers to provide demand-side flexibility

- Customers are not a homogenous group with uniform needs and behaviour, thus not all can be incentivised by the same Demand Response programmes. Demand Response programmes and technology alike have to be designed to accommodate the differences between residential, commercial and industrial customers.

- Customers need to be aware of their flexibility potential and should be able to evaluate easily the different offerings. They should be also educated to understand their choices on price, on information and on automated tools. When designing Demand Response programmes, attention must be paid so that the offerings are simple and transparent.

- The expansion of Demand Response requires that end-users have appropriate metering in place to record their consumption timely and user-friendly access to their data to be able to respond to price signals.

- Safeguarding the customers' rights to privacy and ensuring cyber-security measures should be a priority area for regulators and policy-makers.

- Communication architectures and interfaces should be standardised in order to benefit from scale effects, to overcome technical barriers and to give flexibility programmes the chance to reach substantial size.

- It should always be ensured that standards do not hamper, but rather foster interoperability and certification of deployed solutions with regard to device authentication and identification.

- It is essential that demand-side flexibility is provided on a voluntary basis and that the flexibility providers are properly rewarded for their service.

- The role of aggregation of demand-side resources -including independent aggregation- is essential to unlock the full potential of the demand side flexibility.

- It may be advisable to develop a number of different programmes for different DSO needs, instead of designing a one-size-fits-all programme.

Distribution tariffs & demand-side flexibility

- In the new energy landscape, distribution tariffs should serve two missions: i. Ensure full cost recovery for DSOs; and ii. Contribute to the overall efficiency of the system. To this end, NRAs should ensure that distribution tariffs allow customers to actively respond to wholesale market signals and/or participate in TSO-led programmes, contributing to overall electricity system efficiency. As a first step -and in accordance with the Energy Efficiency Directive, Art. 15.4-, distribution tariffs should certainly not hamper Demand Response.

DSOs as users of demand-side flexibility & their interaction with the other actors

- DSOs should provide a transparent and non-discriminatory access to its networks to all users and for all its products, whatever their physical source (generation, storage, demand response, etc.) or the actor (suppliers, aggregators, etc.). To ensure the necessary neutrality, it is fundamental that the DSO is effectively unbundled, as per the Electricity Directive 2009/72/EC.

- DSOs can procure demand-side flexibility through various different economic vehicles (e.g. at the planning and connection timeframe through a call for tender, through distribution tariffs and/or from a local distribution constraints market). Irrespective of the vehicle(s) developed, it is essential that the market design for the procurement of demand-side flexibility complies with the DSO's regulated and market neutral activity and fulfils transparency obligations.

- Regulators should ensure that, where cost-effective, DSOs should procure demand-side flexibility from the market and do not operate into the area of competitive demand-side services.

- A market centralising offered local flexibilities in order to solve specific network constraints on the distribution grid could be an option that may facilitate the provision and selection of these flexibilities in a cost-effective and technically feasible manner.

Data management

- Empowering consumers to access their own data in a timely manner and share their data with third parties of their choice will spur innovation and competition, and can result in significant consumer and system benefits.

- Different approaches exist for the management of data and the related roles. Any model chosen must be scrutinised by the NRAs before its implementation in respect to its cost-effectiveness, its capacity to guarantee data privacy and cyber-security, as well as its ability to be future-proof.

- When DSOs have data directly from smart meters, they should have a special responsibility to act impartially and to make available necessary data to other parties, while respecting data protection legislation and the fact that consumers own the right allow access to their consumption data.

- When responsible for providing such data to other parties, as authorised by regulators or customers, DSOs should be responsible for providing good quality data (i.e. complete, correctly identified and accurate).

- Eligible entities should be able to access commercial data in a standardised format that is provided with sufficient frequency, timeliness, granularity and reliability to facilitate the provision of permissible products and services.

Ensuring safe integration of Demand Response

- Well-designed coordination mechanisms and cooperation among the actors will ensure that Demand Response not only does not put the distribution system at risk, but in fact, enhances system security and improves efficiency. The key to avoiding local congestions associated with Demand Response is found in appropriate data exchange and in clarification of the roles and responsibilities of all the involved actors.

- When there is a potential risk on distribution grid associated with Demand Response, all involved actors should be responsible for providing the DSO with the data necessary for the safe and secure operation of the distribution grid on a need to know basis.

- Consumers own their flexibility – within the limits given by their connection agreement – and they should be free to sell it into any market or to any buyer of their choice. If an arrangement is made whereby a DSO can prohibit a consumer's dispatch in exceptional circumstances, then the affected consumers should always be compensated for their lost revenue.