Technical Report

Technical Assessment of Demand Response Management

PROMOTION OF GRID-CONNECTED RENEWABLE ENERGY IN TURKEY

T.C. ENERJİ VE TABİİ KAYNAKLAR BAKANLIĞI

On behalf of:

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giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

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1. General

The GIZ commissioned RENAC and M.P.E. to produce: Reports on the Technical Assessment of Demand Response Management and the Feasibility of Energy Storage Systems. The present report by RENAC covers: Technical Assessment of Demand Response Management. Feasibility of Energy Storage Systems is treated in a separate report by M.P.E.

This report offers a broad perspective on Demand Response types by including technical information about European and German applications (test procedure, monitoring, control, etc.).

2. Demand Response

2.1. Demand Response types

Any power system has some degree of flexibility in order to handle load variations and reliability of distribution and transmission systems. For many years, flexibility needs did not change significantly. But in recent years, power supply systems have had to increase their flexibility due to volatile power generation by wind turbines and photovoltaic modules. Due to the weather dependency of these technologies, the volatility of the residual load increases.

Demand Response is an important instrument for increasing the flexibility of energy markets and for enabling optimal use of networks. It can be based on customers' actions or on their agreement with a third party to take action on their behalf.[1] Demand Response can substantially contribute to reducing the investment in peaking generation by shifting consumption away from times of high demand.[2]

Demand Response services may be offered to the market as well as to system operators by facility owners as well as by closed distribution system operators (CDSO). Systems operators can use these services for active power control, reactive power control and management of grid constraints, for example.

Generally, demand facility owners or distribution system operators that connect demand units with the grid should ensure that the demand units used to provide Demand Response services fulfil several technical requirements. The demand units can fulfil these requirements either individually or collectively as part of demand aggregation through a third party.

[1] Commission Regulation 2016/1388, No 8
[2] Paolo Bertoldi, Paolo Zancanella, Benigna Boza-Kiss, “Demand Response Status in EU Member States, 2016”, JRC Research Centre, Ispra, page 1

Several flexible demand units can offer demand services. Flexibility is defined as the capability of consumers to change the use of electricity from their normal or current patterns of consumption. This change can be triggered by market signals such as time-variable electricity prices and incentive payments, or by activation of bids previously offered to markets by demand units. Demand units can offer Demand Response individually to a market, or an aggregator can combine several demand units and offer them to a market collectively.[3] Since many consumers are too small to trade on markets and to handle this complexity, they may require the service of an aggregator to participate.[4]

Demand Response is called **explicit Demand Response** in cases where it is sold as a product on the market. In this case it requires specific ex-ante or ex-post controls which are compared to a baseline power consumption. Explicit Demand Response is often sold directly by large industrial consumers or through Demand Response service providers. The consumers receive a specific reward to change their consumption upon request. This kind of response is sometimes called “incentive-based” or “volume-based”.[5]

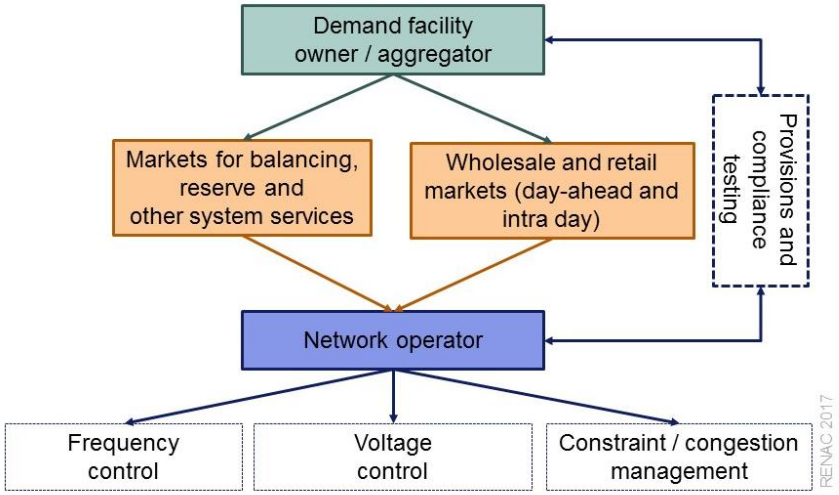

Figure 1: Explicit Demand Response: demand facilitator owner/aggregator offering Demand Response to markets for various uses.

Implicit Demand Response means that consumers change the time of power supply, e.g. via the charging/discharging of electric cars or the use of household appliances according to time-variable tariffs that are part of their power supply contracts. With these contracts, consumers accept that their electricity consumption can be shifted away from times of high prices. This shift can be affected either manually or automatically. As such, implicit Demand Response allows consumers to reduce their energy bills. The time-variable prices can range from simple

[3] CEER, “Scoping of flexible response”, Ref: C16-FTF-08-04, page 5
[4] Paolo Bertoldi, Paolo Zancanella, Benigna Boza-Kiss “Demand Response Status in EU Member States, 2016”, JRC Research Centre, Ispra, page 4
[5] EURELECTRIC, “Demand Response”, Dépôt légal D/2015/12.105/11

day and night prices to highly dynamic prices based on hourly wholesale prices or grid congestion and gird constraints.[6] Examples include time-of-use pricing, critical peak pricing and real-time pricing. Implicit Demand Response is sometimes called “price-based”. Furthermore, implicit Demand Response does not require specific checks by the network operator since the Demand Response is not activated by the network operator.

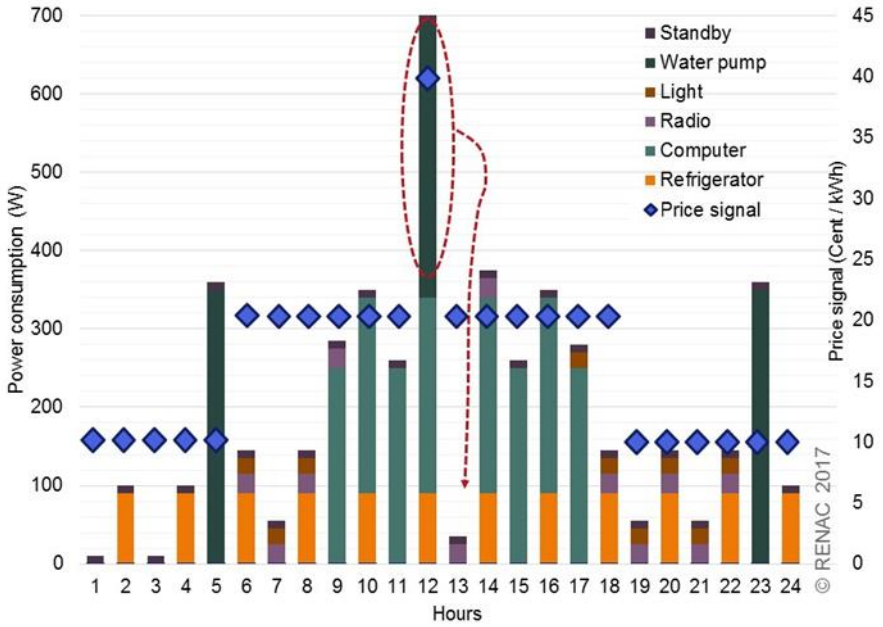

Figure 2: Implicit Demand Response: electricity consumption is shifted by the consumer either manually or automatically according to price signals.

2.2. Application and implementation of Demand Response for balancing, reserves and ancillary markets

2.2.1. Europe

Demand Response has been an active part of the European electricity system framework for years. The 3rd Energy Package/Electricity Directive (2009/72/EC) and the Energy Efficiency Directive (2012/27/EU) provide the legal basis for implicit and explicit Demand Response.

The Electricity Directive (2009/72/EC) requires that:

- network operators consider Demand Response and energy efficiency measures when planning system upgrades (Article 25.7) ; and

[6] EURELECTRIC, “Demand Response”, Dépôt légal D/2015/12.105/11

- “In relation to security of supply, energy efficiency/demand-side management [...] Member States may introduce the implementation of long-term planning, taking into account the possibility of third parties seeking access to the system.” (Article 3.2).

Major steps towards the development of Demand Response in Europe according to Energy Efficiency Directive (2012/27/EU) include that Member States shall:

- undertake an assessment of the energy efficiency potentials of their gas and electricity infrastructure, in particular regarding transmission, distribution, load management and interoperability, … and identify concrete measures and investments for the introduction of cost-effective energy efficiency improvements in the network infrastructure (Article 15.2 (a), (b));

- ensure the removal of those incentives in transmission and distribution tariffs that are detrimental to the overall efficiency [...] of the generation, transmission, distribution and supply of electricity or those that might hamper participation of Demand Response, in balancing markets and ancillary services procurement (Article 15.4); and

- ensure that network operators are incentivised to improve efficiency in infrastructure design and operation, […] that tariffs allow suppliers to improve consumer participation in system efficiency, including Demand Response, depending on national circumstances (Article 15.4).

The most important part of the Directive is Article 15.8, which requires that consumers have access to the wholesale and retail energy markets, either individually or through aggregation in a non-discriminatory manner.

Although policymakers and market participants recognise Demand Response as a resource for achieving an efficient and sustainable electricity system at reasonable costs, the Smart Energy Demand Coalition (SEDC[7]) assessed the progress of Demand Response implementation as “gradual”. According to the SEDC, “markets are slowly being opened” and “still much work [needs] to be done […] across the continent”. This opinion is published in the 2017 SEDC report. The report summarises an analysis on explicit Demand Response, analysing the regulatory framework conditions in 18 European countries. The information was gathered by SEDC through desk research, and expert interviews with transmission system operators (TSOs), distribution system operators (DSOs), retailers, aggregators, regulators and

[7]SEDC is a European industry association dedicated to making the demand side a smart and interactive part of the energy value chain. SEDC’s focus is to promote demand-centred programmes within the areas of Demand Response, energy usage feedback and information, plus smart home, in-home and in-building automation that form the heart of the Smart Grid. See: www.smartenergydemand.eu

technology providers. National market participants working with Demand Response have reviewed the national reports.[8] SEDC estimates that around only 20 GW of the Demand Response potential estimated by the European Commission to be at 100 GW rising to 160 GW in 2030 are currently activated.[9]

The SEDC country analysis is based on the following central criteria and assessments:

1. Access of Demand Response to and participation in European electricity markets

    - 5 scores: Aggregated load is accepted in a range of markets.
    - 3 scores: Aggregated load is limited to a number of markets.
    - 1 score: Aggregated load is accepted only in one or two programmes.
    - 0 scores: Load is not accepted as a resource in any market.

2. Access of different service providers to European electricity markets

    - 5 scores: Standardised arrangements between involved parties are in place for all markets – aggregators do not depend on prior consent of the retailer/ balance responsible parties (BRPs).
    - 3 scores: Independent third parties may access some parts of the market without consent of retailer/BRP.
    - 1 score: Lack of standardised arrangements between involved parties and aggregators must contract with retailer/BRP to access market.
    - 0 scores: No standardised arrangement between involved parties is in place and aggregation is illegal.

3. Product requirements and development of the regulatory environment

    - 5 scores: Programme requirements enable a range of resources (supply and demand) to participate in multiple markets.

[8] SEDC, “Explicit Demand Response in Europe – Mapping the Markets 2017”, April 2017, Brussels, page 7
[9] SEDC, “Explicit Demand Response in Europe – Mapping the Markets 2017”, April 2017, Brussels, page 4

- 3 scores: Minor barriers to demand-side participation in market remain, however, participation is still possible.

- 1 score: Significant barriers remain, creating major competition issues for demand-side resource participation.

- 0 scores: Programme requirements block demand-side participation.

4. Measurement and verification, payments, financing and penalty requirements

    - 5 scores: Requirements are well defined, standardised, proportionate to customer capabilities, dealt with at the aggregated level, and payment is fair and penalties are reasonable.

    - 3 scores: Requirements are under development, but do not act as a significant barrier; payment is adequate, but unequal per MW between supply and demand; penalty structures create risk issues for service providers, but participation is still possible.

    - 1 score: Requirements act as a significant barrier to consumer participation; payment structures seem inadequate, unequal pay per MW between supply and demand, penalty structures create high risk issues.

    - 0 score: There are no measurement and verification rules for Demand Response participation; payment structure is inadequate and non-transparent; penalty structures act as a critical barrier.

The following figure summarises SEDC's assessment of explicit Demand Response development in Europe.

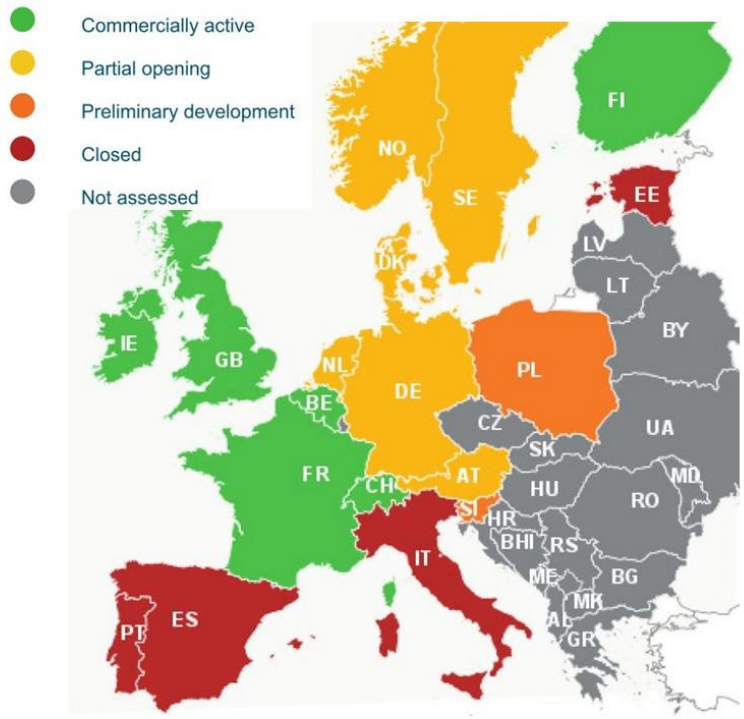

Figure 3: Explicit Demand Response implementation based on assessment of access to markets, service provider access, product requirements, measurement, verification, payment and penalties in selected countries (source: SEDC, 2017).

2.2.2. Demand Response access to power markets in Germany

Most of the power markets in Germany are open to Demand Response suppliers. They can bid in the following markets: day ahead wholesale market, intraday wholesale market, frequency containment reserve (FRR), automatic frequency restoration reserve (aFRR), manual frequency restoration reserve (mFRR) and interruptible loads. Other ancillary services for re-dispatch and voltage control (winter reserve) as well as capacity mechanism (capacity reserve) are not open for Demand Response units. Markets for distribution network services are under development but do not exist yet. For this purpose, bilateral agreements between distribution network operators and generators or loads are in place.[10]

The German TSOs issue a call for tenders each week for 750 MW of immediately interruptible loads and an equal volume of quickly interruptible loads through the TSOs' joint tendering platform (www.regelleistung.net). The German regulator (Bundesnetzagentur) is authorised to adjust the amount of tendering volume based on periodic demand analysis by the transmission system operators if necessary.

[10] SEDC, 2017

German TSOs terminology		ENTSO-E terminology	Volume	Demand Response access
EPEX Spot		Day ahead	235 TWh 1)	Yes
EPEX Spot		Intraday	41 TWh 1)	Yes
Primary control	+/-	FCR	830 MW	Yes
Secondary control	SCR +	aFRR	1260 - 2730 MW 2)	Yes
	SCR -		1070 - 2350 MW 2)	Yes
Minute reserve	MR +	mFRR	1900 - 2050 MW 2)	Yes
	MR -		1830 - 2100 MW 2)	Yes
Immediately interruptible loads, SOL		Interruptible loads	750 MW 3)	Yes
Quickly interruptible loads, SNL			750 MW 3)	Yes
Winter reserve		Other ancillary services	7000 MW 4)	No

1) Year 2016. 2) The amount varies from quarter to quarter of the year. It depends on forecast errors and weather situations during the last three years. It is calculated with a probabilistic approach for each quarter of the year (numbers are rounded). 3) According to AbLaV Ordinance. 4) Year 2017/2018.

Table 1: Access and participation of Demand Response and aggregated Demand Response to electricity markets in Germany (sources: SEDC, 2017 and www.regelleistung.net).

2.3. Test procedures, monitoring and control

2.3.1. European network code requirements

The Network Code on Demand Connection (Commission Regulation 2016/1388) lays down the obligations for ensuring that system operators make appropriate use of the demand facilities' and distribution systems' capabilities in a transparent and non-discriminatory manner in order to provide a level playing field throughout the European Union. The regulation defines different types of Demand Response for active power control, reactive power control, for transmission constraint management, for system frequency control, and very fast active power control. Title III specifies the technical details of the connection of demand units used by a demand facility or a closed distribution system to provide Demand Response services to system operators. This includes requirements for operational notification procedures, compliance testing and compliance simulation, etc.

In Article 28 and Article 41, the Network Code on Demand Connection[11] defines details of specific provision and compliance testing for demand units with Demand Response active power control, reactive power control and transmission constraint management.

Article 41 distinguishes between requirements with regard to the demand modification test and with regard to the disconnection or reconnection of static compensation facilities test.

[11] COMMISSION REGULATION (EU) 2016/1388 of 17 August 2016, “Establishing a Network Code on Demand Connection”, Official Journal of the European Union, 18.08.2016

Both tests can be deemed passed if conditions pursuant to Article 28(2)(d)(f)(g)(h)(k) and (l) are fulfilled as well. These paragraphs refer to power consumption control, adjustment time period, TSO instructions execution, demand modification during service provision, withstand capability time frame, and information transfer ability.

Demand modification test:

- The technical capability of the demand unit to modify its power consumption within the range, duration and time frame previously agreed is demonstrated.

- The test is carried out either by an instruction or alternatively by simulating the receipt of an instruction from the relevant system operator or relevant TSO and adjusting the power demand of the demand facility or the closed distribution system. An equipment certificate may be used instead of part of the tests.

Disconnection or reconnection of static compensation facilities test:

- The technical capability of the demand unit to disconnect or reconnect, or both, and its static compensation facility in the time frame expected is demonstrated.

- The test is carried out by simulating the receipt of an instruction from the relevant system operator or relevant TSO and subsequently disconnecting the static compensation facility, and by simulating the receipt of an instruction from the relevant system operator or relevant TSO and subsequently reconnecting the facility.

2.3.2. Requirements for day ahead, intraday, FCR, aFRR and mFRR markets in Germany

Main requirements for day ahead, intraday, FCR, aFRR, mFRR markets in Germany are summarised in the following tables for wholesale and balancing/ancillary markets. Information on the minimum bid size, notification time, activation and maximum product duration are listed.

Prequalification is required for these products at the asset level. For aggregated suppliers, this leads to a high effort especially for small capacities, which together could provide a valuable contribution. However, the high effort limits the participation of small Demand Response capacities in the markets.

ENTSO-E terminology	Minimum size	Notification time
Day ahead	1 MW for 15 minutes	Auction at 12 am for the following day
Intraday	1 MW for 15 minutes	Gate closure 30 minutes

Table 2: Product requirements for whole sale markets (source: EEX Leipzig, 2017).

ENTSO-E terminology	Minimum size	Notification time	Activation	Maximum product duration
FCR	1 MW	30 seconds	Automatic	1 week
aFRR	5 MW (1 MW if no other offer)	5 minutes	Automatic	4 hours, daily call for tender
mFRR	5 MW (1 MW if no other offer)	15 minutes	Automatic	4 hours, daily call for tender

Table 3: Product requirements for ancillary service markets (source: SEDC, 2017 and Bundesnetzagentur).

2.3.3. Requirements for Demand Response units providing immediately interruptible load (SOL) and quickly interruptible loads (SNL)

The ordinance on "Abschaltbare Lasten (AbLaV)/Interruptible Loads"[12] specifies the regulatory framework for explicit Demand Response in Germany. It regulates the obligations of transmission system operators with regard to calls for tenders for Demand Response and the acceptance offers received for Demand Response.

The AbLaV defines "interruptible loads" as consumption units which can reliably reduce their power consumption upon request by the German transmission system operators (TSO). The demand facility has to be in the physical range of operation of a node of the German transmission grid. The ordinance distinguishes between:

- immediately interruptible loads (SOL), which can be automatically controlled within 350 milliseconds when the system frequency drops below a predefined value and which can be remotely controlled without delay by the transmission grid operator; and

- quickly interruptible loads (SNL), which can be remotely controlled within 15 minutes by the transmission system operator.

The requirements on interruptible loads were modified in August 2016 to enable small loads with a capacity of at least 5 MW to participate in the prequalification process. The maximum capacity is 200 MW. The loads must have predictable load characteristics and have to fulfil certain technical criteria. After successfully passing prequalification and signing a contract with the TSOs, the suppliers have the possibility to submit an offer in the weekly call for tender.

The suppliers have to offer a Demand Response duration without interruption of at least one quarter-hour up to a maximum of 32 quarter-hours. At least 16 quarter-hours of Demand

[12] BMJ, "Verordnung über Vereinbarungen zu abschaltbaren Lasten – AbLaV", 2016

Response duration have to be offered during one week. The German transmission grid operators publish anonymised results of the weekly tendering on the internet platform www.regelleistung.net.

The prequalification process generally takes about three months to complete after submitting all the required documents and implementing the technical requirements. During this process, the potential Demand Response service suppliers furnish proof that they meet security of supply requirements. In addition to the technical suitability of the consumer facilities, the suppliers have to ensure proper provision of the Demand Response capacity under operating conditions.

The prequalification is basically carried out by the connecting TSO. For successful prequalification, the suppliers have to submit documents demonstrating compliance with the requirements to the connecting TSO. After a successful prequalification process, the TSO will provide confirmation that will also be recognised by other German TSOs.

Grid operators in Germany have defined details of prequalification procedures and compliance testing for immediately interruptible loads and quickly interruptible loads. A selection of criteria will be introduced in detail in the following. The description refers to a document published by a German TSO in German language[13]. The document is an annex to a framework contract to be signed between the Demand Response supplier and the TSO. It is strongly linked to the German ordinance on interruptible loads (AbLaV).

Place of supply for SOL and SNL:

- The supplier has to specify the location (postal address) and the place of physical supply (grid connection point) for every Demand Response unit. The grid connection point will be defined during the prequalification. It may not be changed in order to plan physical effects.

- In case the Demand Response unit is not connected directly to the grid of the connecting TSO, all the network operators affected by the capacity should also be mentioned, for example, in the form of a simple grid overview showing the connections to the high voltage grid of the connecting TSO. In this case, the grid operator Demand Response unit has to confirm that the voltage level meets defined criteria. If there are intermediate distribution system operators (DSOs), they have to provide a confirmation as well.

[13] regelleistung.net – Internetplattform zur Vergabe von Regelleistung “Abschaltbare Lasten – präqualifikations-Anforderungen”, www.regelleistung.net, zuletzt aufgerufen am16.08.2016

Aggregation/consortium for SOL and SNL:

- Suppliers offering less than 5 MW of Demand Response capacity can be prequalified by an aggregator within a control area. These Demand Response units have to be in the physical range of the same maximum voltage node of the German transmission grid.

- Adding new Demand Response units to the aggregation requires a new prequalification.

- The individual consumer facilities and the Demand Response capacities have to be mentioned. They have to show their electric power consumption using operational reports (capacity vs. time diagrams).

Technical description of the Demand Response unit for SOL and SNL:

- The supplier has to describe technical details of each Demand Response unit.

- The description should explain the design, the function and operation, the technically possible minimum and maximum duration of Demand Response provision as well as the behaviour of the electrical load during the control process.

- Limitations of Demand Response delivery have to be described.

Load characteristic description of the Demand Response unit for SOL and SNL:

- The load characteristic has to be planned in 15-minute intervals. During this time the power consumption of the Demand Response unit should not fall below a minimum. Lapses are not permitted.

- Fluctuations in the power consumption are permitted, as long as they are within a narrow band compared to the planned power consumption. This band is defined as follows: the lower limit of the power consumption band represents the reported minimum power consumption. The upper limit of the band is defined as the reported minimal power consumption plus 20% of the accepted Demand Response capacity. Within the 15-minute interval, every 1-minute average value has to be within the band.

- In the period under consideration, more than 120 quarter-hours should not be evaluated as unavailable. The supplier demonstrates the suitability via an operational

log recorded every minute for one calendar week (Monday 0:00 hrs to Sunday 24:00 hrs) and explains any breaks or violations of the limits from the permissible band.

The supplier can decide whether he wants to pre-qualify his Demand Response unit as immediately interruptible load (SOL) or quickly interruptible load (SNL). The supplier has to describe as to how the delivery will be ensured over the minimum and maximum duration of the demand. The supply has to describe any intermediate activation times and why any activation times outside this cannot be delivered.

For an immediately interruptible load the ability to provide the capacity in relation to the level and duration has to be demonstrated via a gradient report and a report for assessing the quality of delivery.

Gradient report for immediately interruptible load (SOL):

- Each switch-off takes place within one second after the starting time of the delivery or as soon as possible within 350 milliseconds in case of frequency triggering to the level of prequalified switch-off capacity.
- The switch-off procedure is documented by a capacity/time graph with a suitable minimum time interval.
- Capacity measurements have to be provided to the transfer points, e.g. to the upstream grid operator for checking the plausibility.

Report for quickly interruptible loads (SNL):

- The supplier has to show for each quickly interruptible load that the switch-off takes place within 15 minutes after the start time communicated by the TSO. This includes the level of Demand Response capacity.
- Capacity measurements have to be provided to the transfer points, e.g. to the upstream grid operator for checking the plausibility.

Report for delivery quality evaluation for SOL and SNL:

- The delivery during a switch-off is proper if every minute-average of the Demand Response capacity within the delivery phase is between 100% and 120% with respect to the approved or demanded capacity.

- The supplier demonstrates compliance in the form of a complete operational log. The operational log includes the period starting from 15 minutes before reducing the power consumption to 15 minutes after reaching the full power consumption.

- The operational log should have the following data in tabular and graphical form:
  1) Time (in hh:mm)
  2) Power consumption (1-minute average value; MW with three decimal places)
  3) Planned minimum power consumption of the concerned 15 minutes (constant over the 15 minutes, 1-minute average value; MW with three decimal places)
  4) Target value of the Demand Response capacity (1-minute average value; MW with three decimal places)
  5) Demand Response capacity provided as the difference between (3) and (2)

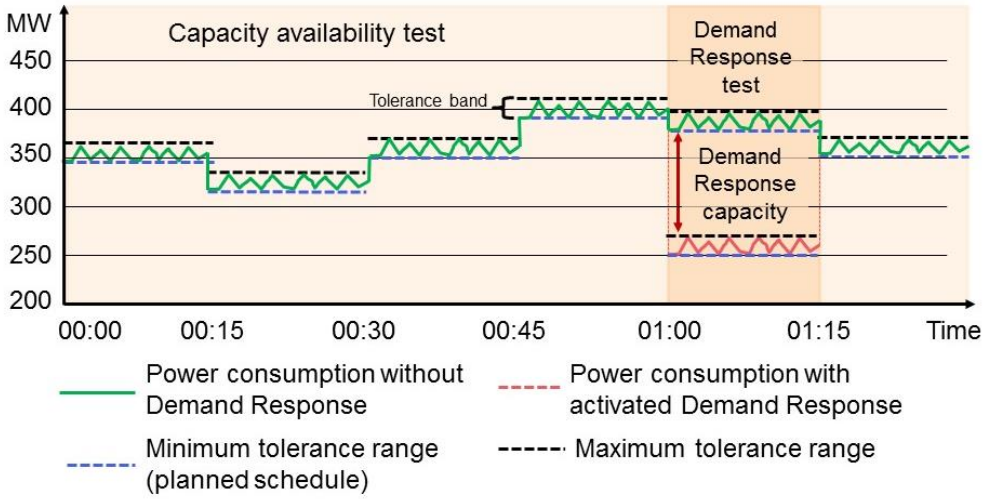

Figure 4: Example of a Demand Response test for a 15-minute Demand Response activation (source: Wiedemann, Transnet BW).

Further requirements for SNL and SOL:

- The supplier has to demonstrate that it cannot provide the SNL in a time period less than 15 minutes.

- The supplier has to provide the SNL in the minimum possible time and with maximum possible gradient. This possible gradient will be used if needed.

- The supplier of SNL and SOL has to demonstrate the technically possible minimum individual Demand Response duration. This demonstration shall be based on the operational logs. If the duration is longer than 15 minutes, the supplier has to explain

the reasons for the technical limitation.

- The supplier of SOL has to demonstrate the proper functioning of the switch-off devices for frequency-based switch-off and remote-controlled switch-off via a qualified electrician. For frequency-based switch-off, the supplier has to meet the requirements described in the annex: “requirements for frequency-based switch-off devices for interruptible loads”. The supplier has to agree to test the proper functioning of the remote-controlled triggering together with the TSO it is connected to. Physical switch-off is not required during this test (triggering is "bypassed").

- The supplier of SNL has to describe how the switch-off happens after receiving the activation signal from the TSO and also has to demonstrate that it is able to detect and implement the activation release by the TSO. The supplier has to agree to test the remote-controlled switch-off together with the TSO it is connected to. Physical switch-off is not required during this test (triggering is "bypassed").

- The supplier of SOL and SNL has to confirm that the Demand Response can be supplied for at least 16 quarter-hours in the delivery period.

- The supplier of SOL and SNL has to confirm that the Demand Response capacity can be basically made available for all 15-minute durations up to 120 quarter-hours per week (minimum technical availability).

Monitoring and control of Demand Response:

The supplier of the Demand Response capacity has to fulfil technical information requirements to ensure the safety and reliability of the power supply system. It has to confirm that it has implemented and is operating the IT communication link between his control centre and the system management control centre of the connecting TSO. The supplier must also provide the following data online via the communication channels in accordance with the minimum IT requirements:

- Status notification per bid: bid available for retrieval yes/no.

- Status notification per bid: status indicator in accordance with annex 6c of the framework contract.

- Power consumption in MW with three decimal places.

- Minimum power consumption of the concerned quarter-hours (constant over the quarter-hour and identical to the prior mandatory notification; 1-minute average; MW

with three decimal digits).

- Remaining demand utilisation duration according to the offered individual activation utilisation duration.

- Remaining interval after activation utilisation or marketing.

- Status of the weekly remaining activation utilisation account indicated in terms of time.

Organisational requirements for SOL and SNL:

- The supplier has to nominate one point of contact for the connecting TSO, who is accessible via phone in a timely manner before and constantly during the delivery period and via email.

- If the Demand Response is provided by a consortium of several Demand Response units, then the consortium leader as a supplier has to demonstrate that the Demand Response capacity requested/automatically utilised by the TSO is physically provided in the defined duration. For this purpose, the contact point of the consortium leader has to manage the communication and organisation of the consortium. The consortium leader is responsible for monitoring the delivery and provision and has to shift the unavailable Demand Response capacity to other Demand Response units in the consortium in the event of failure or non-availability of Demand Response units in the consortium. For every Demand Response unit, the consortium leader has to describe how the load can be activated by the contact point (e.g. by phone call, automatic setting of start-up/shutdown command, remote-control). The implementation of these requirements has to be demonstrated by the supplier in the form of appropriate concepts.

- The supplier names a balancing group (supplier balancing group) to the TSO in the control area of the connecting TSO for which the supplier is the responsible balancing group manager.

- The power consumption of the Demand Response unit is recorded using measuring devices and meters. The activation signal is the basis for determining the electrical power that is not utilised by the Demand Response unit when activated. The supplier delivers the energy demand as per schedule to the connecting TSO.
- The supplier has to inform the TSO about the availability of the Demand Response unit for the next day daily until 14:30 hrs. Times of non-availability have to be announced.

2.4. Summary

In recent years, power systems have had to adapt to increased weather dependent - and thus volatile – renewable power generation by becoming more flexible. Within this process of adaptation, Demand Response represents an important instrument for increasing the flexibility of energy markets and for enabling optimal use of networks by alleviating the pressure on power systems by shifting consumption of single major consumers, or aggregations of smaller consumers, away from times of high demand.

Demand facility owners and transmission system operators (TSOs) are the central actors responsible for ensuring the compliance of Demand Response services with a set of distinct European and national regulations on test procedures, monitoring, and control. Actors wishing to enter the Demand Response markets on an individual or aggregated level are subject to a rigorous process of prequalification.

The Network Code on Demand Connection (Commission Regulation 2016/1388) lays down the obligations for ensuring that system operators make appropriate use of the demand facilities' and distribution systems' capabilities in a transparent and non-discriminatory manner to provide a level playing field throughout the European Union.

In Germany, requirements for day ahead, intraday, Frequency Containment Reserves (FCR), automatic Frequency Restoration Reserves (aFRR), manual Frequency Restoration Reserves (mFRR) for wholesale and balancing/ancillary markets are defined. Information on the minimum bid size, notification time, activation and maximum product duration are published at www.regelleistung.net. Prequalification is required for these products at the asset level. For aggregated Demand Response suppliers, this leads to a high effort especially for small capacities, which together could provide a valuable contribution.

The ordinance on “Abschaltbare Lasten (AbLaV) / interruptible loads” specifies the regulatory framework for explicit Demand Response in Germany. It regulates the obligations of transmission system operators with regard to calls for tenders for Demand Response and the acceptance offers received for Demand Response.

While the European legal framework has mandated all Member States to incorporate Demand Response in system upgrades and introduce concrete measures toward the improvement of network infrastructures, the pace of implementation in this area appears to be gradual at best. The German system provides a comparatively positive example where markets are open to Demand Response suppliers on a variety of markets for bidding.

Glossary and abbreviations

BRP – Balance Responsible Party.

Balance Responsible Party – A party which is responsible that the supply of energy corresponds to the anticipated consumption of energy in its balance area during a given time period and financially regulates for any imbalance that arises[14].

CDSO – Closed Distribution System Operator.

CEER – Council of European Energy Regulators.

Closed distribution system – A distribution system classified pursuant to Article 28 of Directive 2009/72/EC as a closed distribution system by national regulatory authorities or by other competent authorities, where so provided by the Member State, which distributes electricity within a geographically confined industrial, commercial or shared services site and does not supply household customers, without prejudice to incidental use by a small number of households located within the area served by the system and with employment or similar associations with the owner of the system.[15]

Demand aggregation – A set of demand facilities or closed distribution systems that can operate as a single facility or closed distribution system for the purposes of offering one or more Demand Response services.[16]

Demand facility – A facility that consumes electrical energy and is connected to the transmission or distribution system at one or more connection points. A distribution system and/or auxiliary supply of a power generating module do not constitute a demand facility.[17]

Demand Response – An instrument for increasing the flexibility of the internal energy market and for enabling optimal use of networks. It should be based on customers' actions or on their agreement for a third party to take action on their behalf.[18]

Demand Response active power control – Demand within a demand facility or closed distribution system that is available for modulation by the relevant system operator or relevant TSO, which results in active power modification.[19]

[14] www.teamwork.dke.de, 28 August 2017
[15] EC 2016/1388, Article 2, No 5
[16] EC 2016/1388, Article 2, No 19
[17] EC 2016/1388, Article 2, No 1
[18] EC 2016/1388, No 8
[19] EC 2016/1388, Article 2, No 16

Demand Response reactive power control – Reactive power or reactive power compensation devices in a demand facility or closed distribution system that are available for modulation by the relevant system operator or relevant TSO.[20]

Demand Response system frequency control – Demand within a demand facility or closed distribution system that is available for reduction or increase in response to frequency fluctuations, made by an autonomous response from the demand facility or closed distribution system to diminish these fluctuations.[21]

Demand Response transmission constraint management – Demand within a demand facility or closed distribution system that is available for modulation by the relevant system operator or relevant TSO to manage transmission constraints within the system.[22]

Demand Response unit document – A document, issued either by the demand facility owner or the CDSO to the relevant system operator, for demand units with Demand Response and connected at a voltage level above 1000 V, which confirms the compliance of the demand unit with the technical requirements set out in the regulation and provides the necessary data and statements, including a statement of compliance.[23]

Demand Response very fast active power control – Demand within a demand facility or closed distribution system that can be modulated very fast in response to a frequency deviation, which results in a very fast active power modification.[24]

Demand Response unit – An indivisible set of installations containing equipment which can be actively controlled by a demand facility owner or by a CDSO, either individually or collectively as part of demand aggregation through a third party.

DRUD – Demand Response Unit Document.

DSF – Demand Side Flexibility.

DSO – Distribution System Operator.

Dynamic pricing – Dynamic prices reflect variations in wholesale market prices. They can go to different lengths in terms of granularity, from hourly prices set and announced one day in advance to consumers, to real-time pricing directly tracking wholesale market prices.

FCR – Frequency Containment Reserves.

Flexibility – The ability of a power system to adapt to the growing fluctuations of supply and demand while at the same time maintaining system reliability.[25]

[20] EC 2016/1388, Article 2, No 17
[21] EC 2016/1388, Article 2, No 20
[22] EC 2016/1388, Article 2, No 18
[23] EC 2016/1388, Article 2, No 22
[24] EC 2016/1388, Article 2, No 21
[25] CEER, “Scoping of flexible response”, Ref: C16-FTF-08-04, page 5

Frequency Containment Reserves – The active power reserves available to contain system frequency after the occurrence of an imbalance.[26]

Frequency Restoration Reserves – The active power reserves available to restore system frequency to the nominal frequency and, for a synchronous area consisting of more than one LFC area, to restore power balance to the scheduled value.[27]

FRR – Frequency Restoration Reserves.

aFRR - automatic Frequency Restoration Reserves

mFRR - manual Frequency Restoration Reserves

Load – Power demand of consumers connected to the grid.

Real-time pricing – Different price levels usually applied to different time periods on an hourly or sub-hourly basis.

Replacement Reserves – The active power reserves available to restore or support the required level of FRR to be prepared for additional system imbalances, including operating reserves.[28]

Reserve Replacement Process – A process to restore the activated FRR and, additionally for GB and IE/NI, to restore the activated FCR.[29]

Residual load – The load left after subtracting power generated by variable renewables like wind, solar and hydro from the power demand of consumers connected to the grid.

RR – Replacement Reserves.

RRP – Reserve Replacement Process.

SEDC – Smart Energy Demand Coalition.

SNL – Quickly interruptible loads.

SOL – Immediately interruptible loads.

Time-of-Use pricing – Instead of a single flat rate for energy use, time-of-use rates change for broad blocks of hours: they are higher when electric demand is higher (as reflected in wholesale prices). The price for each period is pre-determined and constant. Time-of-Use network tariffs also exist in some countries to reflect different states of the network.

Time-varying/time-based pricing – Pricing rates that are not flat and change over different time periods.

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[26] www.entsoe.eu/data/data-portal/glossary, 26.5.2017
[27] www.entsoe.eu/data/data-portal/glossary, 26.5.2017
[28] www.entsoe.eu/data/data-portal/glossary, 26.5.2017 and entso-e System Operation Guideline
[29] www.entsoe.eu/data/data-portal/glossary, 26.5.2017 and entso-e System Operation Guideline

ToU – Time-of-Use.

TSO – Transmission System Operator.

Withstand capability – The quantified ability of a system, sub-system, equipment, process, or procedure to continue to function during and after a natural or human-made disturbance.

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