Penta SG3

PENTALATERAL ENERGY FORUM
Penta flexibility work stream – Penta SG3 – Technical Background Paper – Demand Side Response

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DEMAND SIDE RESPONSE

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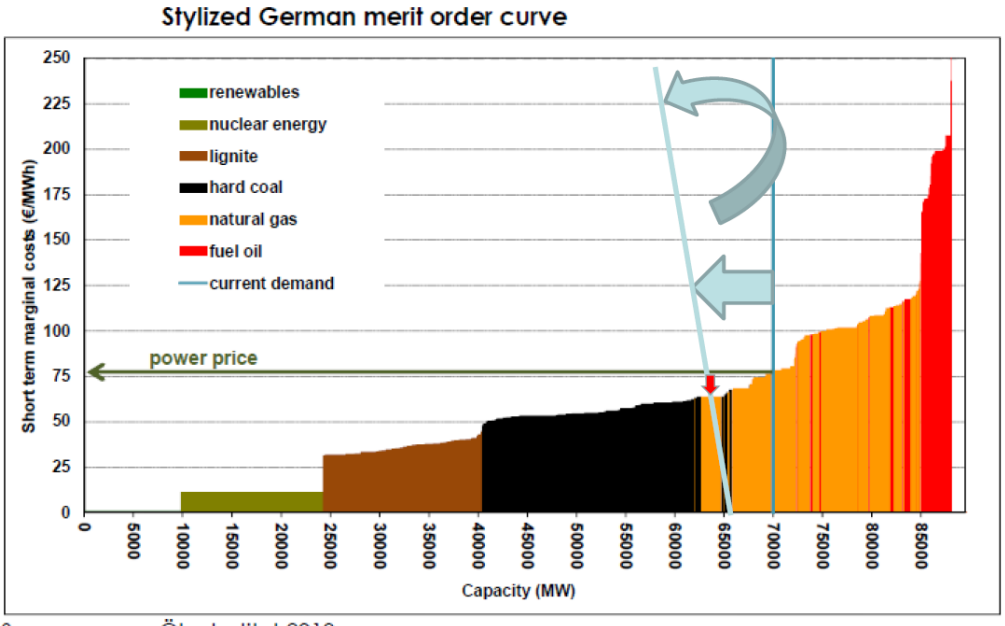
Introduction and definitions

Up until now, the demand curve for electricity has often been seen as a vertical line, with limited or almost no price elasticity (e.g. for residential consumption, which is not exposed to hourly price signals nor has the meters to measure the related consumption). Many efforts have been done in the last few years and are still ongoing towards reducing (thus shifting) the demand curve (e.g. related to energy efficiency), whereas by developing Demand Side Response, the demand curve would tilt (as can be seen in the picture below), by becoming more price elastic.



Source: Öko-Institut 2013

If both the supply and demand curves become more elastic, a more dynamic price formation will follow which in general should lead to more efficient market outcomes. This in turn would better reflect the real needs and technical capabilities that exist in the markets. Active interaction of demand and supply generally leads to more market efficiency. This could diminish (costly) overcapacity, as it would allow for a liberalized energy market to function with a total generation capacity available at the time of system peak load that might be lower than this actual system peak load, as those few hours of system peak load will be shaved away by intervention of Demand Side Response.

Over the course of the last few years distributed generation has grown and also in the coming years, more and more distributed generation is foreseen in the electricity system. These are mostly intermittent renewable sources such as photovoltaics and wind, resulting in a more volatile supply of

electricity. In situations with (increasingly) higher intermittent generation, the flexibility offered by DSR could contribute to alleviate the impact on the electricity system.

Demand Side Flexibility (DSF) is *the capacity to change electricity usage by end-use customers (including residential) from their normal or current consumption patterns in response to market signals, such as time-variable electricity prices or incentive payments, or in response to acceptance of the consumer's bid, alone or through aggregation, to sell demand reduction/increase at a price in organized electricity markets or for internal portfolio optimisation*[1]. CEER states that DSF has the potential to provide value throughout the energy system, both for markets and networks. Demand Side Response (DSR) can then be defined as the voluntary activation by a party of its Demand Side Flexibility.

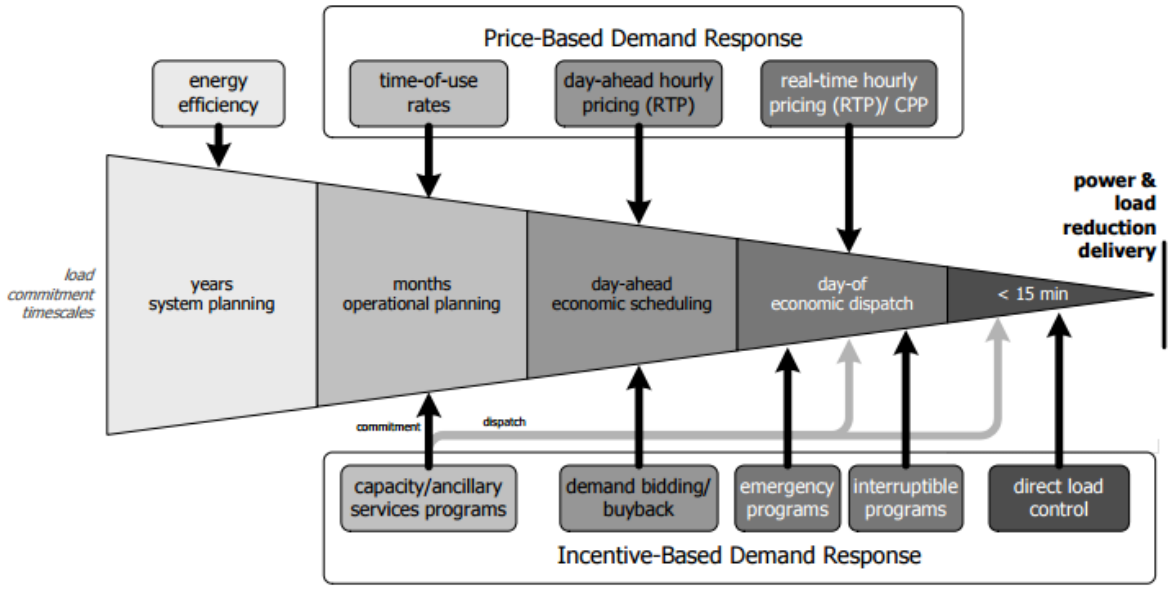


Figure 1. Role of Demand Response in Electric System Planning and Operations

Source: US Department of Energy (2006): Benefits of demand response in electricity markets and recommendations for achieving them, February 2006, p. 14, quoted by CEPA Ltd. *et al., op. cit.,* p.23.

[1] CEER Advice on Ensuring Market and Regulatory Arrangements help deliver Demand Side Flexibility, June 2014, available here

An ACER report[2] makes the following distinction between implicit DSF and explicit DSF:

- *Implicit DSF encompasses response by customers to tariffs[3], whether supply or network tariffs, which vary by time* (…)
- *Explicit DSF encompasses arrangements where a customer makes an explicit change in demand in response to an explicit request, and is specifically rewarded for the demand change.*

In the remainder of this document, a reference will only be made to DSR instead of DSF, as it is the active participation of the demand side that is discussed and not just the capability to be flexible.

Consumers represent an important source of flexibility which can be used in different manners:

- Implicit DSR encompasses consumers' reactions to time-of-use prices (which are static); Real-time pricing and Critical peak pricing. *Such tariffs are capable not only of communicating scarcity in the supply of energy, on different time-scales, but also the stress on transmission and distribution networks[4].*
- Explicit DSR encompasses consumers' reactions to wholesale, balancing, congestion, and capacity market[5] signals. Consumers receive direct payments to change their consumption (or generation) patterns upon request, triggered by, for example, actual imbalance prices, activation of balancing energy, differences in electricity prices or a constraint on the network.

There are some current practices on implicit and explicit DSR:

- Explicit DSR: there are examples of countries with adequacy issues, either at specific points in time or for specific issues, that have started to develop DSR-programs with clear signs of success[6]. These are programs in the market (day ahead, intraday or even longer timeframes)

[2] Cambridge Economic Policy Associates (CEPA) Ltd, TPA Solutions & Imperial College London, *Demand Side Flexibility, The Potential Benefits and State of Play in the European, Final Report for ACER,* September 2014, p. 20-21, available here

[3] The ACER paper refers to both supply and network tariffs and includes the following sub-categories: Time-of-Use (ToU) tariffs; Real Time Pricing and Critical Peak Pricing. It refers to electricity retail tariffs, and may also include Distribution Critical peak pricing, see trials in South Australia (report for DECC, p. 81-83); or in England (Capacity 2 Consumer project)

[4] CEPA Ltd *et al. , op. cit.,* p.21.

[5] On a level-playing field with generation, consumers are contracted in advance to be available in a situation of capacity shortage, for which they receive an availability or capacity payment. In case of activation, they may receive an additional activation or energy payment to curtail their load.

[6] Examples include: For Belgium the contracting of a Strategic Demand Reserve of 96,7 MW and 358,4 MW respectively for the winters 2014-2015 and 2015-2016, the contracting of 209 MW of R3DP and 178 MW of ICH (tertiary reserve products for the demand side) and 14 MW of R1 Load (primary reserve product for the demand side) in 2016. For France, the French TSO (RTE) Demand Response Call for tender resulted in the contractualisation of up to 200 MW in residential DR and close to 1900 MW in industrial DR for 2016 (source).

or for TSO- and grid-related products, such as France (winter peak load issues) and Belgium (general adequacy issues with several nuclear outages).

- Implicit DSR: There is one example that can be found in Finland, where a retailer may offer hourly-based retail contacts together with automation of consumer devices[7].

The demand side offers a wide range of possible services to the system. Energy efficiency investments are more appropriate to solve baseload issues, by structurally reducing demand. However, automation controls which can be used in energy efficiency are often the same technologies which are used in DSR programs, offering synergies when combining the two and improved return-on-investment. DSR can help solve critical issues that arise on markets or networks on a short or longer term basis depending on consumers capabilities, the level of aggregation and automation of consumer's devices - provided they have fair access to the different markets. As any other actor capable of reacting to market circumstances demand response can also be of value to manage congestions.

Among other services, consumers, through DSR, can provide flexibility to solve the temporal (peak load) scarcity of the "top" of the (residual) load duration curve. This top encompasses the highest load on the grid, and in almost all cases shows a volume of MWs that are only consumed for a (very) limited number of hours. In an ideal flexible system, it does not make sense to build rarely used (and thus expensive) flexible generation capacity as a reserve margin, if the same flexibility can be provided by demand side response or storage at lower costs. The overall goal should be to lower the overall cost of the system, to the advantage of all users of the system, by allowing the least-costly and most (system-) efficient solution to solve this adequacy issue.

Demand response is currently often cheaper for coping with scarcity as compared to alternatives as flexible generation or storage[8]. In a liberalized market, flexibility from DSR and storage can also contribute to the adequacy equation, which could imply that less generation and import capacity is needed to cover the theoretical peak demand. This effect could even be more pronounced when the penetration of intermittent renewables in the system increases. Demand response can provide a cost-effective solution for the integration of intermittent renewables.

[7] Fortum's "Fiksu" retail contract uses hourly electricity prices in order and optimizes heating according to prices. (source)

[8] RAP and Synapse, Demand Response as a Power System Resource, May 2013, p. 40 (available here). Figure 21: "Megawatt Curtailment and Corresponding Value of Spot Market Price Reduction" shows an average reduction in average spot prices of 10-20 USD/MWh due to DSR; figure 20: "Percent Load Curtailment and Simulated Corresponding Price Reduction in Mid-Atlantic States" shows that an average reduction of around 1% in consumption leads to a 5-8% reduction in Wholesale prices

Actual situation

Many barriers and obstacles for the development of DSR in the Penta-region still exist. This section presents, a (non-exhaustive) overview of the most important remaining barriers, obstacles and open issues[9].

a. The need for scarcity prices

For Demand Side Response to become apparent, price signals revealing the abundance/scarcity on electricity markets are required, since this provides consumers with an incentive to adapt their consumption in a similar way as producers adapt their generation. This includes equal access to all market segments, including balancing (and also adequacy) mechanisms, for all players connected to the grid. Consumers will only reduce or shift their demand at prices that compensate for the non-created added value (usually a multiple of the normal electricity price[10]) or the time-shift in consumption. In cases with abundant (flexible) generation (over)capacity[11] in the market, there is little incentive for consumers to invest in making their consumption more flexible and responsive to price signals. This may change as quite some (conventional) generation is currently leaving the market. As reserve margins might be dwindling across Europe and the Penta-region[12], it may be cost-effective to look into all possible alternatives (including DSR, flexible generation and storage, the three major sources of flexibility) and create a level-playing field between them to solve issues with peak load adequacy.

b. The need to enable consumers to react to prices through implicit DSR

Consumers may valorise their flexibility through hourly or quarter-hourly wholesale market-based retail tariffs (so called “real-time pricing”). Putting in place real-time pricing requires:

- Consumer settlement to be performed using actual interval consumption data.
- Registration of consumption data to be aligned on the Imbalance Settlement Period.
- Tariff allocation and reconciliation processes being linked to the wholesale market.
- A clear framework for data management, including third-party non-discriminatory access to metering data (upon consumer approval), based on the respective (legal) roles and responsibilities of the involved parties (e.g. specifically for TSOs and DSOs).
- Enhanced price signals: the energy component represents on average only about 35% of the retail price[13] in Europe. Network fees as well taxes and levies may represent fixed components which make variations in the price of energy less noticeable for consumers.

[9] These might differ between Penta-countries, based on the diverging evolution of DSR in each of the countries
[10] This added value is (in normal conditions) higher than the cost of electricity. It is also important to note that the price on the customer bill is a multiple of the (average) wholesale market price, due to additional costs for taxes and levies, and through the addition of tariffs.
[11] Especially if subsidized, thus creating also other distortions in the merit order
[12] Penta-region political declaration of June 8th 2015 (source)
[13] Energie-Control, MEHK and VaasaETT, *Household Energy Price Index*, p. 7 (source)

c. The need for a clear market framework for explicit DSR

- **Ownership of flexibility and market constraints**: It should become clear that flexibility is owned by the party delivering the flexibility[14] (in the case of DSR the consumer, who must have the right to valorize his flexibility), until the moment that this flexibility is sold to another party, which will then be the owner; the final owner will be the user of this flexibility in real-time. This means that a Flexibility Service Provider (FSP) (such as an aggregator), a role in many countries still to be legally defined properly, will only be the owner of flexibility when he has a contract with its client (customer). As long as sufficient competition is not yet established in all countries and in all customer segments, consumers may have difficulties to find a counterpart to effectively market the ability to respond to prices. Furthermore, legal and regulated means need to be put in place to allow consumers to valorize their flexibility.
- **Consumers should be able to valorize their flexibility**: in many Penta-countries (except currently France and Switzerland), the aggregator cannot have a contract for flexibility with a customer, or sell this flexibility, without prior agreement with the affected supplier and/or his BRP, which limits the freedom of a consumer to valorize his flexibility in the market. Neither BRPs/suppliers nor aggregators should be discriminated through the process of third party aggregation. This requires putting in place a clear framework preventing retailers from blocking market access, while avoiding any significant imbalance risk for them (point below). Whether the consumer should be able to valorize his flexibility without the prior agreement of his supplier remains a fundamental point of discussion. Nevertheless, and especially in countries and market segments with insufficient competition, this point remains a clear barrier to the development of DSR if the supplier would not be interested nor inclined in allowing this to be offered to other market actors.
- **Transfer of energy and impact on balancing responsibility**: When performing a DSR-activation, an FSP, such as an independent aggregator, transfers energy from the perimeter of the BRP of the supplier of the impacted consumers to the balancing perimeter of another market party. This transfer of energy must therefore be associated with fair remuneration of the original supplier of the energy to the consumer (while preserving balancing incentives). This fairness is only possible when the metering of the DSR is sufficient and requires a proper *baseline* for consumption of the parties delivering DSR / flexibility. Several measurement methodologies are already in place in Europe and elsewhere. Defining a proper baseline could for example be done by using nominations or consumption volumes in previous quarter hours, but this topic still requires more in-depth analysis and discussion. The same applies to metering data within the timeframe of the imbalance settlement period and the transfer of this data between different parties. The exchange of all relevant data has to be defined and agreed upon in order to minimize the impact on all involved actors. To the extent that a DSR action has an impact on the operations and perimeter of the supplier and his BRP, these should have access to real time data in order to assess the impact and be able to take the

[14] Taking into account correction of the perimeters of the involved BRPs as well as compensation of the supplier for the energy

required actions. While appropriate rules should be put in place to avoid significant imbalances to BRPs, and for the settlement of the deferred or diminished consumption volume (MWh), participation to DSR should be voluntary and should not be allowed to be prohibited for the consumer by any other party (except for temporal grid security issues)[15]. Commercial and contractual constraints in energy contracts should not be allowed to lock out consumers from offering their flexibility to the markets and to regulated products from system operators for ancillary services, congestion management etcetera. This point also remains a fundamental discussion point. It requires defining a functioning model to solve the issues of the transfer of energy between the different parties, preferably similar or at least compatible in different markets, countries and timeframes.

- **Lack of clear definitions on roles and responsibilities of flexibility service providers:** It is important to define and allow new roles[16], such as those of flexibility service providers (e.g. aggregators and Energy Services Companies (ESCOs)). Allowing Flexibility Service Providers to participate should increase competition and unlock the potential of large ranges of (small) demand facilities to find their way to the markets and regulated products.
- **DSOs and TSOs should work in close cooperation**: Even more close cooperation between DSOs and TSOs is needed in the future to make sure that solving balancing issues on a control area or regional level does not negatively impact the grid security on distribution grids.

d. The need for non-discriminatory access to all markets

- **DSR should be allowed in all market time frames and all regulated products**: DSR can participate in both the energy market (in different timeframes, from intraday over day-ahead to longer timeframes) as well as regulated products from system operators (such as ancillary services, congestion management services or strategic reserve products). Nevertheless, many of these markets and products have (historically) been tuned to the locally available (central) generation assets (and to a lesser extent demand assets). It is of utmost importance that all markets and products allow for both generation and demand participation, including aggregated demand, in order to increase competition and lower the overall cost of the system[17].
- **Barriers to aggregation should be abolished**: Rules for participation into the different market segments and programs should take into account the possibility for a pool of load to be bid as single resource. The inclusion of aggregated loads is crucial for the participation of smaller

[15] A contract between a consumer and a supplier/BRP is binding. However, a consumer should not be prohibited to change contracts, meaning that in case a consumer wants to market its flexibility but cannot under its contractual arrangement with his supplier, he can change supplier/contract in order to get this ability to market his flexibility. Nevertheless, a legally recognized right to valorize flexibility will supersede any contractual arrangements and limitations on this point

[16] "*Need for clearly defined roles for market participants: This is clearly an issue which presents stakeholders with difficulties, though there are differing views among them on the exact delineation between roles. The lack of clarity regarding the role of aggregators as well as the relationship between TSOs, DSOs and market operators is problematic*" (CEER, 2014, p. 18, available here)

[17] Taking into account the requirements that exist for specific regulated products.

consumers in electricity markets, encompassing a vast volume of DSR as illustrated in the graph below[18].

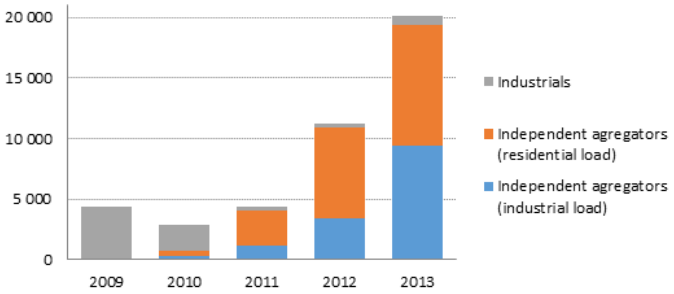


Figure 2: Activated DSR bids in the French Balancing Market (MWh/y)
Source: RTE

Such an approach lies in line with the intention of national initiatives that are currently being taken within the Penta-region as well as elsewhere) and should enable the cheapest solutions to emerge.

- **Discrimination between generation, load and storage in product requirements** in tendering for balancing products, strategic reserves, and other flexibility markets/products should be abolished whenever possible without jeopardizing system security, opening the market for full competition to the benefit of all consumers by lowering the total cost of the system. Currently, the product requirements are still focused on conventional generation and therefore often ask too much such that DSR cannot (easily) participate. All regulated products should be purchased in such a way that the maximum number of players can participate. Product requirements should be made technology agnostic, so that also other (new) sources, like DSR, can deliver the service and comply with the requirements. Product requirements should be based on the needs of the system and not on any specific generation patterns. Under no circumstances, it can be accepted that the overall system security is compromised.
- **DSOs should be allowed to purchase flexibility to solve congestion problems**: Today TSOs usually have market based options to solve congestion problems on the high voltage levels of the system. But with the upcoming renewable production facilities at the lower voltage levels of the system (medium voltage to low voltage) DSOs usually do not have many options to solve congestion problems other than the curtailment of portions of the grid. DSOs should be allowed to solve congestion issues on the medium and low voltage levels of the system by acquiring flexibility offered by market parties. New product definitions and markets need to be defined by the DSOs and other involved parties.

[18] E.g. France, where for the period 2009-2013, the part of activated bids provided by industrials (directly, and not through an aggregator) decreased dramatically between 2009 (100%) and 2013 (less than 5%) towards aggregator volumes

e. The need for a long-term regulatory framework at EU-level

- **Lack of consistency between legislations/regulations & lack of harmonization of (national) grid codes**: DSR development across Europe is hampered by the lack of consistency between supranational, national, regional and local legislation and regulations, making it difficult to leverage solutions and experiences from one case to the next. Lack of harmonization of (national) grid codes introduces differences in technical requirements. National grid codes often still represent thresholds for market access, as they are generally based on generation needs and capabilities, which should be adapted to take into account the specifics and capabilities of DSR, if necessary by adapting the definition of standard products. The lack of consistency and harmonization between legislations and regulations leads to a lower overall efficiency and increases the cost for the development of DSR. The end goal would be to establish competition in the markets for electricity supply and end consumer services in all Member States. Legal and regulated means need to be put in place to allow consumers to valorize their flexibility and ensure sufficient competition in all countries and all customer segments. However, it should be clear that harmonization is not a goal in itself but should create more value in the total system.
- **Lack of cross-border competition:** Cross-border and internal market lead times and gate closure times differ. This leads to situations where foreign market players cannot compete effectively with national players.

f. Other barriers

- **Insufficient awareness & forward visibility & regulatory uncertainty**: Consumers should be made aware of the potential value of their flexibility. For decades, industrial load was invited (and in some cases incentivized) to be stable or at least predictable. However, in a market environment flexibility has a value, which increases with reserve margins disappearing and the share of intermittent renewables in generation increasing. In general, consumers should be free to consume electricity at the moment of their choice. Non-consumption at certain moments requires consumers' anticipation, planning and often also investments, such as buffers, measuring equipment, investments in making consumption units flexible, investments to keep installations in standby, etcetera, and comes with a cost, such as non-energetic costs during periods of load reduction as well as organizational costs for catering to DSR participation. In order for consumers to invest in DSR, a stable framework with a fair[19] remuneration is required. This relates to regulatory uncertainty: rapid changes to energy policies decrease market actors' trust and thus sustainability of DSR solutions[20], which may leave consumers with exposure to lost investments and a generally higher level of risk for the development of DSR solutions. Moreover, consumers should also get exposed to a (price) signal to which they can react. This requires also access to meters that allow to monitor their

[19] In a competitive environment, fair prices are set by the market. In a regulated environment, prices can be set either based on a market or by the regulator or other decision making entity.
[20] Regulatory uncertainty plays in general for all market participants in all the different markets and segments of the electricity markets

reaction to these price signals. It needs to be underlined that the metering data remains in all circumstances the property of the consumer and can in principle only be communicated to other involved and relevant commercial parties if approved by him, or through law/regulation based on roles and responsibilities.

- **Lack of incentives for upward participation in flexibility:** The relationships between reducing/increasing peak/off-peak demand and system balancing are fluid, but DSR can also be used to increase demand when that is desirable for an increasingly unpredictable generation portfolio and balancing (CEER). DSR can also be conceived to cater not only for lowering consumption but also for increasing consumption if so required, for example in moments of higher than expected intermittent power generation, based on adequate (price) signals. This however should require also taking into account the (potential) negative effects of such higher consumption on for example (peak) grid tariffs[21], which could provide barriers (in timeframes when there is abundant transport capacity) to the development of symmetric DSR products.
- **Lack of a framework for accounting the full (reservation and activation) cost of flexibility products in regulated products[22]**: When comparing different sources of flexibility for regulated products, the overall costs should be considered, both reservation and activation costs, as the opportunity (activation) costs of DSR actions can be very high (often a multiple of the average power price), while the investment and related reservation costs are often much lower than for generation facilities. A level-playing field taking into account the full cost of the different sources of flexibility in regulated products should thus be put in place.

Desired solutions

At present, we are still evolving from regulated electricity systems with large reserve margins (e.g. 15-20%) towards liberalized electricity systems where demand response (up to a certain point) covers a non-negligible share of peak demand and can help in balancing the electricity system, including peak-shaving. If DSR is to develop properly in the future, we need the following elements to coincide:

- In principle anyone connected to the grid is balancing responsible. This can be self-organized or outsourced. Outsourcing can be done in many different ways in a competitive market.

[21] E.g. monthly or yearly consumption peak tariffs by consumers. Deferring consumption to a later point in time or increasing consumption to alleviate incompressibility issues might lead to higher monthly or yearly peak loads, thus resulting in higher grid costs over long periods (e.g. months or years) that erode or even annihilate the benefits for the consumer from DSR participation, despite the benefits of this DSR to the stability of the system.
[22] It is important to ensure a balance between the overall cost of all regulated products for the system and the efficiency of acquiring the required reserves by system operators. Nevertheless, it is important to note that the Network Code Electricity Balancing explicitly foresees a separation of balancing capacity and balancing energy pricing Balancing capacity is a general 'insurance' to the system, and should be borne by all system users (through tariffs), while balancing energy is a cost linked to imbalance of specific BRP(s) and should be allocated to BRP(s) through the imbalance settlement price.

- In a well-functioning market, competition (and not an authority) drives investments (in generation or demand-response capacity) as well as the technology mix choice. Any government intervention is to be considered a market distortion;
- No (unused) (over)capacity[23] should be imposed to the system, since this can increase the system cost while at the same time reducing scarcity and scarcity price signals, which in that case would cannibalize demand response. The overall cost of non- or very unfrequently used reserve capacity will create an extra burden to energy consumers as compared to a system with built-in flexibility for keeping the balance between supply and demand;
- In principle, every consumer has the right to valorize his flexibility in the market or by participating in grid operator programs (e.g. balancing, strategic reserve) or enter into any form of commercial contract;
- Notwithstanding the above point, the responsibility of the BRP is essential. Every BRP must eligible for his forecasted net position with the actual measured position.

[23] As described in the introduction, if both the supply and demand curves become more elastic, a more dynamic price formation will follow which should lead to more efficient outcomes and in a liberalized market could diminish the need for costly (unused) (over)capacity, as the few hours of system peak load will be shaved away by intervention of DSR.

Path to reach desired solutions

The following points should be addressed in the Penta-region:

- Integrate markets to the full extent (Cf. the balancing and intra-day papers)
- Find ways to guarantee end consumers the right to valorize their flexibility in a competitive market without any barriers imposed by external parties. This would require:
    - Establishing competition[24] in all the segments of the end consumer market in all Member States, in order to allow the consumer to contract with suppliers allowing them to valorize their flexibility with the (contractual) counterparty of their choice. As long as sufficient competition is not yet established in all countries and all customer segments, legal and regulated means need[25] to be put in place to allow consumers to valorize their flexibility, such as a legally recognized right of valorization of his flexibility for the consumer.
    - A solution for the transfer of energy issue (preferably harmonized over the Penta-region, to leverage solutions).
    - Free choice for the consumer to offer DSR either directly or through an FSP of its own choice.
- Facilitate participation of end consumers in day ahead, intraday, balancing, congestion and other near-real-time markets
    - Under the principle that a MW is a MW, whatever the origin (flexible generation, DSR or storage), on a level-playing field.
    - Facilitate the designation of multiple BRPs per connection, for example where one BRP takes care of the baseload imbalances related to the "normal'" consumption of the consumer and a different BRP can become active whenever flexibility is activated. This different BRP is the one who takes the imbalance of the flexibility activation in his perimeter. This would allow more parties, such as even for example the consumer himself[26] to assume the full role of BRP with all its obligations but only for a more limited volume (the volume of the activated flexibility) and during a limited number of hours (the hours when the flexibility is activated), thus reducing the (financial and economic) burden of becoming a BRP for actors currently not assuming BRP responsibilities (including the consumer himself). This could increase competition and might facilitate participation of consumers to DSR.

[24] Competition is an essential but not sufficient condition for the development of DSR. A competitive supply market may consist of various suppliers providing with none providing DSR services. (Explicit) DSR should be made competitive and open to FSPs other than the supplier, to provide options to all consumers and market segments,

[25] This point is still a discussion point within this document.

[26] This would in principal be the case for all consumers, but would generally only be practically feasible for large (industrial) consumers