Demand Response in Europe's Electricity Sector: Market barriers and outstanding issues

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In October 2014, Europe's drive for sustainability has been further continued with the set objectives for 2030, aiming for 40% emission reduction compared to 1990 levels and at least a 27% share of renewable energy sources. For the longer term, the European Commission (EC) targets a zero CO_2 emitting electricity sector in 2050. Those objectives for the electricity sector have a large impact on the expected development of electricity generation, but also on the evolution of demand. To meet those objectives, a larger share of electricity supply will come from intermittent sources like wind turbines and solar panels.

In an electric system that is largely based on renewable electricity sources, it is desired to have higher electricity consumption in moments when more renewable electricity is being produced, and a lower consumption in times of lower renewable production. Demand response is related to the adaptability of the electricity demand to the availability of supply. The development of demand response is rooted in the need for carbon emission reductions and for efficient use of installed generation capacities with the growth of power consumption. In addition to providing flexibility to the electric system, demand response could be a direct source of revenue to households and businesses. In 2013, in the United States, businesses and homeowners earned over $2.2 billion in revenues from demand response together with other avoided investment in grid infrastructure and power plants. This source of direct revenue could also be made available in Europe and would release financial benefits to local economies (SEDC, 2014).

The reliability improvements as well as the economic and sustainability potential coming from a more responsive electricity demand are fully acknowledged. However, demand response is still immaturely developed in Europe. If Europe wants to make a step forward to a more sustainable electricity sector, the development of demand response is an inevitable one. This paper provides an outline of demand response in Europe and identifies the major barriers for its further development in Europe.

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1. How electric demand can be made flexible and responsive

Demand response reflects the ability of the demand-side to be flexible, responsive and adaptive to economic signals. More specifically, it is defined as the "changes in electric usage by end-use customers from their normal consumption patterns in response to changes in the price of electricity over time, or to incentive payments designed to induce lower electricity use at times of high wholesale market prices or when system reliability is jeopardized" (Aghaei and Alizadeh, 2013). To date, flexible generation like gas-fired or coal-fired power plants is required to supply for the inadequate production coming from renewable generation. With Europe's drive for renewable integration in electricity systems, the interest arises towards a different approach on electricity demand, from one in which normally the generation-follows-demand, towards one in which demand-follows-generation (Pérez-Arriaga et al., 2013).

Europe is determined to involve demand response in order to reach the 2020 targets and beyond. In particular, the Energy Efficiency Directive, art. 15, explicitly urges EU national regulatory authorities to encourage demand-side resources, including demand response, "to participate alongside supply in wholesale and retail markets", and also to provide balancing and ancillary services to network operators in a non-discriminatory manner (EC, 2012). The EC states also that the potential for demand response in electricity markets is high, but is currently underutilized (EC, 2013), because of different hurdles that still need to be overcome. Furthermore the European drive for demand response is confirmed by the ongoing work of ENTSOe for the adoption of a binding Demand Connection Code to support harmonized rules regarding demand response[1].

Demand response through a central controlling agent or by price signalling?

Demand response is generally divided into two categories, price-based demand response and controllable demand response (Pfeifenberger and Hajos, 2011). Price-based demand response is incentivized by exposing the user to a time-varying electricity rate, also called a dynamic rate. This price could be based on for example wholesale market prices and/or network capacity availability. Examples of such pricing methods are real-time pricing (RTP) and critical peak pricing (CPP). With RTP, the user receives a changing price per time step (for example 15 minutes) and the customer will shift electricity consumption accordingly. With critical peak pricing, only in specific hours per day a higher price is presented to the customer. Electricity customers receive an ex-ante notice of these moments in time of high prices (Koliou et al., 2013). Critical peak pricing therefore specifically incentivizes the shift of electricity consumption from one moment to another in time.

With controllable or incentive-based demand response, a central actor like the system operator makes the end-user agree to automatically curtail its electricity demand under certain circumstances. These methods are for example direct load control (DLC) and interruptible load programs. Direct load control simply means that a central actor has direct access to the customer consumption and is able to reduce or increase it as needed for maintaining electricity system reliability. These approaches are more contractual and introduce constraints for the supplied flexibility, while the price-based approach leaves the customer to decide in real-time regarding supplying demand flexibility (DOE, 2006).

Turning demand response into a sustainable flexibility resource

Demand response can deliver benefits in different levels of the electricity system. Firstly, it

[1] https://www.entsoe.eu/major-projects/network-code-development/demand-connection/Pages/default.aspx

can be beneficial for network operators either through contracts (adjustment mechanism, quick reservations, primary, secondary, system services ...) or tenders, or directly via the tariff. Financial signals could incentivize customers to adjust their consumption at strategic times by shifting consumption away from peak hours. Electricity systems with network congestions for example, could apply demand response to reduce electricity demand at peak consumption moments for certain areas of the network. This issue is particularly interesting for the Distribution System Operator (DSO) and Transmission System Operator (TSO) due to the fact that demand flexibility could delay the need for investments (Bartusch and Alvehag, 2014; Bartusch et al., 2011; Batlle and Rodilla, 2009; DOE, 2006). This increases systems' efficiency and reduces the need for investment for grid reinforcement.

Secondly, demand response could benefit electricity suppliers and retailers in order to optimize their electricity portfolios and eventually could affect the need for investment and operation of peaking generation units. For example, in balancing markets, demand response can act as a cost effective and emission-free balancing resource for wind and solar generation (SEDC, 2014). Nowadays, demand response is frequently used for balancing services (in MWh) or balancing reserve (in MW) for the system. Furthermore, outside of peak consumption hours, demand response could be also valuable in moments of sudden unavailability of conventional power plants.

For demand response to be traded as a balancing service, the capacities need to be large enough. Thus, enough capacity of electricity consumption should be curtailable in order to be traded on balancing markets. These minimum trading values are called minimum bidding values (in Germany, these values are between 3 and 20 GW) (Koliou et al., 2014). Therefore, the demand response of small users cannot directly be traded; it should be bundled (aggregated) together in order to provide tradable values of demand flexibility on the different electricity market. This aggregation is done by an intermediary firm, the aggregator, with a technical and administrative role to bundle separate electricity users to provide simultaneous demand response on a specific moment in time for the market. The role of the aggregator could be played by a specific entity, an already existing retailer or theoretically even by a DSO. In France however, TSOs and DSOs could be prohibited from playing the role of the demand response operator in order to avoid any direct contracts with consumers, but discussions are ongoing to provide incentives to the consumers through the establishment of dynamic network tariffs.

Demand flexibility that results in less network congestions can indeed be directly incentivized by the TSOs and DSOs with, for example, dynamic (time-varying) transport tariffs. This is already applied for large generation and consumption units in Europe. Similar methods could be applied for residential users, through a dynamic transport tariff. This is currently applied in Sweden where at some moments of time the distribution charge is higher for some consumers (Bartusch et al., 2011).

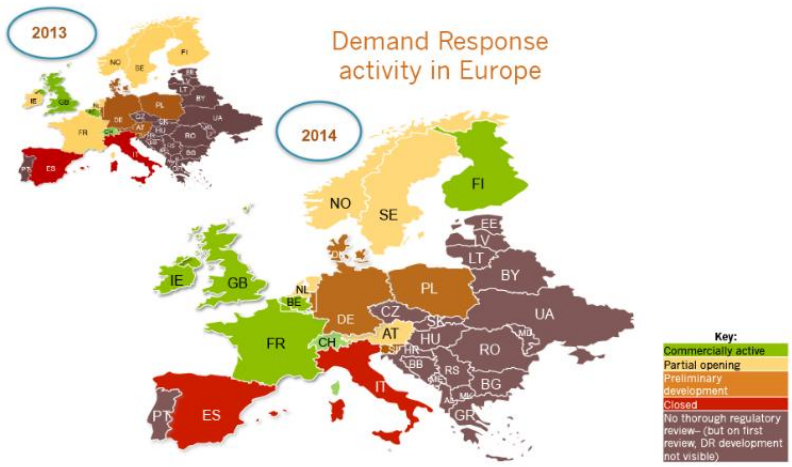
Current aggregators in Europe are mostly operating for industrial consumers. Energy Pool (France) and Flexitricity (United Kingdom) are two examples of aggregators bundling electricity from industrial users for trading on electricity markets (Energy Pool, 2015).

2. Demand response started in Europe's industrial sector

In some European countries, industrial electricity users have the possibility to participate to demand response programs (as the case may be, through aggregators). Figure 1 presents current status of demand response activity in Europe, showing the green indicated countries

(France, Ireland, United Kingdom, Belgium, Switzerland and Finland), where demand response is commercially active as a flexibility resource. In these countries, there is a legal framework allowing the use of demand response. In most other European countries however, regulatory barriers remain an issue and hinder market growth of demand response (SEDC, 2014), as often demand response is not acknowledged in the regulation of electricity markets.

Figure 1: Demand Response map of Europe 2013-2014 (SEDC, 2014)



France and UK are important frontrunners regarding demand response developments. In France, already before sector liberalization, demand response activity was triggered by EDF, both for residential and industrial electricity customers. France had an estimated share of demand response capacity of 1000 MW in 2014. In April 2014, France reduced the bidding values for balancing services from 50 to 10 MW in order to motivate the entrance of smaller entities on balancing mechanisms (SEDC, 2014). Furthermore RTE, the French TSO organizes an annual tender dedicated to demand response capacities. Since 2014, the NEBEF mechanism in France enables direct trade of demand response in the day-ahead market. In UK, balancing markets are open for aggregators, retailers and single consumers to supply demand response services.

In Belgium, another country with commercially active demand response, the total capacity of demand response in 2013 was 261 MW and 351 MW for balancing in 2014 (i.e. around 3% of the peak demand in 2014). In the Netherlands, the TSO estimated that up to 1500 MW of flexibility might be present in the Dutch market (ENTSO-E, 2007). In Denmark, while aggregated demand response is allowed by the legal framework, demand response aggregation is not operating yet in balancing services (SEDC, 2014).

Spain and Italy are countries with large regulatory barriers for demand response to develop. In Spain, demand response does not have access to any market and is therefore an “illegal” source of flexibility. Only direct load control programs exist in Spain, which are centrally managed by the TSO. Those interruptible load programs do not allow aggregation and are solely limited to large industrial consumers. Participants in the interruptible load program are directly contracted with the TSO via their IT system. These programs represent an available capacity of 2000 MW of demand reduction in peak hours.

3. The residential and commercial sector in Europe remains an untapped source of demand response

Beside industrial consumers, residential and commercial electricity consumers are potential providers of demand response. With households' consumption levels of 29.7% of total electricity consumption in Europe, the residential sector holds significant potential for demand response provision. All consumers have an addressable demand response potential, but their individual expectations are different (Energy Pool, 2015). A large development of demand response for Europe's smaller electricity users has not yet been triggered, despite a few experiences presented below.

Sweden for example is one of the few countries in Europe with 100% smart meter roll-out (Eurelectric, 2013). A part of the customers from the DSO Sala Heby Energi Elnät AB, receives a dynamic distribution network tariff. This tariff consists of a fixed access charge (SEK/yr.), and a variable distribution charge (SEK/kW), calculated on the average of the five highest hourly meter readings in peak hours. As the need for demand response is most critical at times of cold climate, the rate is considerably higher in winter seasons. With this dynamic tariff, the customers are able to reduce or increase their electricity consumption accordingly (Bartusch et al., 2011).

In France, an example of residential demand response is found by means of direct load control and dynamic pricing. Direct load control is applied by the aggregator Voltalis in Brittany. Customers contracted with Voltalis receive a free box installed in their home, named Bluepod, which automatically reduces their heating device operation in short time intervals when Voltalis receives a signal from the TSO. This signal is mostly related to endangered electricity supply in Brittany. The main advantage of this type of demand response is that it is easy to implement as it does not require any additional tariff settlement. This demand response provides an opt-out possibility; customers with a Bluepod are automatically enrolled, but can opt-out at any time by pushing a button on the device and use their heater as usually. The users do not receive an additional financial benefit, but simply observe a reduction of their normal electricity bill due to those interruptions in electricity consumption for heating, usually around 5-10%. However, after a long analysis of consumers' behaviour, the "rebound" effect is observed, i.e. consumption levels increase after the curtailment periods.

The French DSO, ERDF also recently tendered different companies (Landis+Gyr, Itron, Sagemcom, ZIV, MAEC and Elster) for an amount of almost €250 million to install the Linky meters (communicating electricity meters) starting from the second semester of 2015 in French households. The objective is to replace 35 million meters in France between 2014 and 2021. These Linky meters would allow to have better insight of consumption patterns, to present options for suited (dynamic) electricity rates and other online options like electricity consumption comparison with similar users.

Furthermore, in France a combination of critical peak pricing and time of use pricing is applied for customers that are assigned for the Tempo Tariff. Already in 2010, EDF had around 350,000 residential customers and more than 100,000 small business customers using the Tempo tariff (Torriti et al., 2010). Within this tariff scheme, days are identified on a yearly basis according to a colour system which reflects the electricity price. Customers can adjust their consumption either manually or by selecting a program for automatic connection and disconnection of separate water and space-heating circuits. It has been estimated that for the average 1 kW French house, the Tempo tariff brought about a reduction in consumption of 15% on ‘‘white’’ days and 45% on ‘‘red’’ days. This means that customers saved 10% on average on their electricity bills (Torriti et al., 2010).

4. Obstacles for demand response development

Even though demand response provides both economic and sustainability benefits, a large share of industrial and residential users is still left inactive for demand response provision. Several barriers hindering the demand response development in Europe have been identified.

Demand response is still not allowed due to the regulatory framework in many markets

In many European systems, the demand side is not legally allowed to be commercially active in electricity markets for trading upward or downward consumption flexibility. Due to the traditional organization of the electricity sector, flexibility providers are mainly generation units or some large industrial units on a mandatory basis (like in Spain). As said, main developments are found in France, Ireland, UK, Belgium, Switzerland and Finland where demand response is commercially active as a flexibility resource. The Energy Efficiency Directive led to some improvements, but rules might need further enforcement to become effective in other Member States. For Energy Pool, one of Europe’s aggregators, demand response is a change of paradigm requiring strong political support. Policy should therefore be concerned with removing market barriers for aggregators and harmonizing market rules between countries (Energy Pool, 2015).

Load aggregation is not sufficiently facilitated

Due to the fact that small electricity users like households provide too little capacity to be tradable in electricity markets, there is a need to aggregate this demand flexibility. For many smaller consumers, load aggregation is an inevitable step before demand response can take place for near-to-real-time trading purposes. In many places, load aggregation is still seen as an “illegal” source of flexibility and therefore a major barrier for smaller users to supply demand response (SEDC, 2014). In some places however, the demand can provide balancing services through aggregation, but this is predominantly accessed by large industries, leaving out aggregators for commercial and residential demand. In this case of trading demand response in balancing markets, the main identified barriers are related to the ability for aggregators to provide balance service provision and the need for adjusted rules for imbalance settlement. Furthermore, in order for aggregators of residential demand to trade flexibility in balancing markets, lower minimal bidding values should be set in order to enable first movers to enter (Koliou et al., 2014). For example, in France in April 2014, the bidding values were reduced from 50 to 10 MW for Frequency Restoration Reserves, which already is a step in the good direction in order to support the initial trading possibilities of aggregators (SEDC, 2014).

Lack of enabling technologies like smart-metering

Traditionally, electricity metering with unidirectional meters has been sufficient for charging the traditional electricity consumer. However, in a future situation when the consumer can also provide a service back to the grid, like demand response, smart-metering would be needed to measure and compensate the consumer for these services. For flexibility to be tradable and profitable, metering and control is needed to check performance of real provided demand response per user (Energy Pool, 2015).

The Third Energy Package required Member States to ensure the implementation of smart metering. This implementation has been subject to a long-term cost-benefit analysis (CBA). In cases where the CBA for smart meter deployment was positive, a roll-out target of 80% market penetration for electricity by 2020 has been set. More than half of European Member States had a positive outcome for their conducted CBA[2]. Current developments in smart-meter installation for residential users are however not promising yet outside of regional pilot projects. In Europe, most of the users are still not metered in real-time, but with a traditional electricity meter. Only Italy and Sweden have 100% roll-out of smart meters, while in other countries, smart-metering often exists in pilot stages only.

Privacy concerns with smart-meters

In the Netherlands, the previous European Directive[3] led to a national law proposal for mandatory smart meter roll-out, with even a far-reaching sanction of 6 months' imprisonment for consumers refusing to have a smart meter installed (Cuijpers and Koops, 2012). This law proposal led to protests, due to privacy issues for the consumer with the frequent meter reading intervals that would transmit too much information about the household activities to commercial parties. Eventually, this proposal was abolished, and currently end users have the right to refuse a smart meter, without risking a fine or imprisonment. Due to the sudden character of this law, this led to counterproductive reactions for the willingness of users to install a smart meter. Therefore, a crucial issue to be taken into account for the design of smart metering systems is the need for a privacy impact assessment (in line with the privacy and data protection law). There is also a need to clearly revisit the either mandatory or voluntary character of smart meters roll-outs (Cuijpers and Koops, 2012).

Price communication with in-home displays and in-home automation

In addition to smart-meters, which register electricity consumption and production, the installation of in-home displays would be needed to clearly reflect the price of electricity and incentivize the end-user (see Figure 2). Home-automation is a way by which some appliances in a household could automatically react on lower prices and operate in such moments (also referred to as smart-appliances). Suited devices for such type of automation can be shifted to other moments without decreasing the comfort of living, like electric heaters, dishwashers, washing machines and refrigerators for example.

Figure 2: Example of an interface of an in-home display in The Netherlands (Kohlmann, van der Vossen, Knigge, Kobus, & Slootweg, 2011)

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2 http://ses.jrc.ec.europa.eu/smart-metering-deployment-european-union

3 Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services http://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:32006L0032.

The initial investment to enable active demand and split incentives

The installation of smart-meters, in-home displays and home automation devices is costly. For example, solely the installation of a smart-meter in Europe is on average between € 200-250[4]. An important question with installation of those devices is: who bares the cost of installation, the consumer, the retailer, the aggregator, or the DSO? This common split incentives problem is related to the fact that costs involved with installation versus benefits from a flexible demand should be split between the user and the enabling actor, in view of creating a viable business case for both the end-user and the installer (Hakvoort and Koliou, 2014). Without any clear business model for an actor to perform those investments, the first move will not be made by any actor. It is important that those benefiting from demand response, directly or indirectly pay for the costs (Energy Pool, 2015). Consequently, the value of demand response should be distributed along the electricity supply chain, together with incentives for participation for each agent and finally clear business models for demand response should be elaborated (Hancher et al., 2013). In France, different boxes are being provided which could enable demand response, however the investment ranges between €200 and 300. It is questionable who will be willing to bare the investment cost from demand response devices, if no direct prospects of pay-back are ensured or if those pay-back times are ranging to 10 years or more[5].

Flat prices and demand response?

Demand shifting is mostly interesting if this shift would result in cost reductions and/or delays in required investments. However, if market prices of electricity are relatively flat in the electricity spot market, demand shifting is not economically interesting. This is the case when electricity production is for a large share coming from similar priced generation units (like with the large share of combined cycle gas turbines in Spain), making market prices similar throughout the day, leaving little value for demand shifting. This issue is different when the electricity generation mix is made up by very diverse units with increasing marginal costs for supplying increasing shares of the demand. A controversial issue with demand response in this case is that it can be a substitute for traditional electricity (peaking) units. In many places, renewable energy sources already cause cost recovery problems for such peaking units, which operate few times per year. The question that remains is: would demand response further enhance this problem?

However, next to the day-ahead markets, demand response could be valuable in other markets as well, such as the market for balancing and ancillary services. The price for demand response would here be influenced by the marginal price for flexibility coming from other conventional flexibility providers like stand-by generation units.

Post implementation challenges of demand response

Once demand response programs are implemented, there are some possible problems that could arise. The first one is called the “coordination problem” (Hakvoort and Koliou, 2014). This problem refers to the fact that, at a certain point in time, some actors involved with electricity supply could require the demand to be adjusted upwards, while other(s) would actually require downward demand adjustments. This could lead to opposing incentives for customers to increase or decrease consumption, as in cases when large wind production reduces the market price for electricity while simultaneous network capacity limits might

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44 http://ec.europa.eu/energy/en/topics/markets-and-consumers/smart-grids-and-meters

5 http://www.actu-environnement.com/ae/news/box-energie-smart-consommation-energie-domotique-maison-20716.php4

result in very high transmission costs (Germany). This leads to opposing signals from the TSO and electricity market. Therefore, policy should prioritize the demand response needs and incentivize it in such way that is both economically and technically viable.

In addition to the coordination problem, another important issue with demand response is the rebound effect. As mentioned, this effect signifies that an electricity price drop could lead to a higher electricity consumption at those periods in time (Geelen et al., 2013; Sorrell, 2007). Therefore in some cases, demand response programs could result into an overall shifted and even higher peak, instead of peak reduction.

5. Conclusion

In the next years, renewable energy sources are expected to provide for a significant part of Europe's electricity supply. Systems with a large share of renewable energy require back-up electricity generation for reliable electricity supply. An adaptive and flexible electricity demand could further benefit reliability and cost efficiency. Demand response has large potential to increase system flexibility, reduce carbon emissions and could reduce investment needs for both electricity generation and transport.

Even though demand response can be provided by the entire range of electricity customers, relatively few European countries promote an active demand. Industrial demand response is already commercially provided in France, Ireland, UK, Belgium, Switzerland and Finland. France can be seen as one of the precursors of demand response, already providing dynamic tariffs to industrials in the early 1950s. Most of European experiences are present with large industrial users, leaving a large share of both commercial and residential users inactive. This paper described several factors that can explain the delay in demand response developments. In many countries, the regulatory framework for electricity markets is not incentivizing demand flexibility and furthermore little advancement is taking place regarding (smart)-metering of electricity consumers. The electricity system in those countries is maintained balanced by traditional ways with flexible generation units, while metering of customers is still being done with traditional uni-directional meters.

Even though these and many other barriers exist, the EU legislation is aiming to involve demand response in electricity markets and to communicate a more transparent price to the end-user. Promoting demand response could be simply done by providing it priority access in markets (for example in balancing and reserves markets) with a supportive regulatory context and clear business models for aggregators and other related actors in the value chain. This would, in many systems, create environmental and financial benefits for the sector.

However, do we economically need demand response when there is in many systems spare capacity of generation? And further, what should we do with the substitution character of demand response for conventional units that already cope with cost recovery problems? These economic questions remain open and require that policy-makers define a consistent set of objectives.

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